STUDIES ON PHYSIOLOGICAL AND BIOCHEMICAL CHANGES ASSOCIATED WITH FLOWER SENESCENCE IN SOME ORNAMENTAL MEMBERS OF FAMILY AMARYLLIDACEAE

THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR
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BY

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DEPARTMENT OF BOTANY

THE UNIVERSITY OF KASHMIR, SRINAGAR.

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CERTIFICATE

This is to certify that Fahima Gul has worked under our joint supervision for her Ph.D programme. The data contained in this thesis is a bonafide work of the candidate. The dissertation entitled, *"Studies on physiological and biochemical changes associated with flower senescence in some ornamental members of family Amaryllidaceae"* is forwarded herewith for evaluation.

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CONTENTS

List of Abbreviations

AOA	=	aminooxyacetate
BAP	=	benzyl amino purine
CHI	=	cycloheximide
DW	=	distilled water
% FM	=	percent of fresh mass
m	=	meter
mn	=	million
mg g^{-1} FM	=	milligram per gram fresh mass
mg g^{-1} DM	=	milligram per gram dry mass
mg $flower^{-1}$	=	milligram per flower
GA_3	=	gibberellic acid
8-HQS	=	8 – hydroxy quinoline sulphate
h	=	hours
KIN	=	kinetin
LSD	=	least significant difference
$P_{=0.05}$	=	probability
PHDS	=	postharvest dry storage
PHWS	=	postharvest wet storage
STS	=	silver thiosulphate
SUC	=	sucrose
Wm^{-1}	=	watts per meter square

Introduction

Flowering represents the heart of plant biology being the principal organs of reproduction for sexual reproduction flowers represent the ultimate site for genetic recombination. Since ages flowers have attracted the interest of mankind for being a symbol of beauty and peace. Displaying flowers in the homes is as important as it was in 2nd century A.D. Ikebana, the Japanese art of formal flower arrangement began early in 7th century, the Aztecs of the 14th to 16th century illustrated the desire for flowers. About 2000 years ago, the fragrant sweet violet growing in the Mediterranean region was linked to Aphrodite, the Greek goddess of love. To Greeks, the *Iris* represented goddess of the rainbow and *Narcissus* a youth turned into flower for falling in love with his own reflection. Today fresh flowers are used in daily life to exchange greetings, to convey messages of love, at memorials for the departed, to improve surroundings, in drawing rooms, in office buildings and conference halls. Use of fresh flowers in one's every day life represent a symbol of an improved quality life style being termed as "lifestyle floriculture".

Floriculture as an industry began in the late 1800´s in England, where flowers were grown on a large scale on the vast estates. The present day floral industry is a dynamic, global fast-growing industry, which has achieved significant growth rates during the past few decades. In the 1950´s, the global flower trade was less than US$3 billion. By the dawn of 21st century the global exports of floriculture products stood at US$ 12.39 billion in the year 2004. Developed countries in Europe, America and Asia account for more than 90% of the total world exports in floriculture products. The Netherlands continues to dominate the world floricultural exports. It was estimated that in 2006 almost 64% (US$ 2911.253 mn) of world floricultural exports came from the Netherlands and every year out

of 1800 new varieties that enter the European market, 65 percent originates from The Netherlands alone. Countries like Columbia and Ecuador follow next with 14% and 7% share in the world flower export. The world imports of floriculture products stood at US$ 12.61 billion in 2006. Germany (US$ 2,231 mn) was the largest importer followed by USA (US$ 1,607 mn), United Kingdom (US$ 1,604 mn) and France (US$ 1,254 mn). With an 8 % annual growth rate, world exports are expected to reach US$ 16 – 18 billion by the end of 2010.

The floriculture industry essentially consists of three major components, i.e. growing, packaging and transportation of the flowers and flower products to the end consumer. The floricultural supply chain is thereby closely interconnected, and demands an intense cooperation of all its players. Together they constantly are able to find answers to new market demands and deliver a stunningly wide range of innovative products. Successful and innovative floriculture is the out come of specialization and quality control of the breeder, besides the technologically controlled growing conditions which include temperature, moisture and illumination and last of all the market strategies of the seller where by a broad range of flowers is made available for the consumers all the year round.

Previously flowers were christened only as an element of interior design for the consumer; however today the consumer is not only interested in the type of flower but also pays curious attention to the quality of the flowers and their ability to retain freshness. Current floricultural business strategies, focus on the emotions that flowers represents, besides its implication on thoughts and meanings which will become the basis of all new communications. Recent studies in the floral business concentrate on the product behavior, i.e. how a consumers perceives and uses a product. Principal determinants of product behavior in

the floral markets were first analyzed and suggestions were made; that promotion of a positive attitude toward flowers is essential in encouraging consumers to become regular flower users and that the intended use of flower products, whether for personal use or as gifts were the main factors affecting the frequent purchase of flowers (Huang, 2005). Toady the use of flowers span from emotional conditioning to an effective means of showing care and curiosity fulfillments. Besides having flowers at work places is the new subject of research. It is being concluded that having flowers in the workplace are especially beneficial for fatigued employees and those with health problems. The positive effects of plants on the health and well-being of employees are due mainly to the recuperative potential that flowers provide. Flowers have a positive effect on psychological well-being; people recover more quickly from tiredness and stress.

At the turn of the 1st decade of the 21st century, floriculture has not been curtailed with the cultivation of flowering and ornamental plants only but it is also being viewed as a raw material generator for cosmetic or perfume industry as well as for the pharmaceutical sector. Moreover emphasis on floriculture is not just in creating exotic species for decorative and commercial purposes but also for improving regular varieties and developing mass cultivation techniques for increased productivity. Today flower industry aims to export not only flowers, but also equipment and technology to produce flowers, marketing programmes, cultural traditions and attitudes about flowers which include floral designs, uses of floral products, appreciation of flowers, development of flower promotion strategies and formulation of innovative solutions capable of supporting global sustainability. Floriculture products mainly consist of cut flowers, pot plants, cut foliage, seeds bulbs, tubers, rooted cuttings and dried flowers or leaves. Fresh cut flowers imports account to nearly 94.6% of the total imports, with roses dominating the world market. Carnations and

Orchids follow next. The other important floricultural crops in the international cut flower trade are *Chrysanthemum, Gerbera, Gladious, Gypsophila*, *Liastris, Nerine*, *Orchid*, *Alstromeria*, *Anthurium, Tulip* and *Lilies*.

Floriculture in India, is being viewed as a sunrise industry with 100% export oriented status. India ranks 23rd amongst world exporters of floriculture products and its share in world exports stands at around 0.38% (US$ 47 mn). Being endowed with diverse agro- climatic conditions like good quality soils, suitable climate, abundant water supply and low labour cost floriculture industry in India slowly pushing its way to the global platform.Commercial floriculture is becoming important from the export angle. It has been found that in India, commercial floriculture has higher potential per unit area than most of the field crops and is, therefore a lucrative business. The liberalization of industrial and trade policies paved the way for development of export oriented production of cut flowers. The Government is offering various incentives, enabling setting up of a number of floriculture units for producing and exporting flowers. Most of these are located near Mumbai, Bangalore and Delhi. These units have obtained technical know-how from Dutch and Israeli consultants. Tax benefits are offered to new export oriented floriculture companies in the form of income-tax holidays and exemption from certain import duties. Apart from this various authorities like Agricultural and Processed Food Products Export Development Authority (APEDA), National Horticultural Board (NHB), Central Institute of Post-Harvest Engineering and Technology (CIPHET), National Agricultural Bank for Rural Development (NABARD), Indian Council of Agricultural Research (IARI) and Council of Scientific and Industrial Research (CSIR) etc are working tirelessly for export promotion and development of floriculture in India. The thrust is specifically laid on crop improvement, standardization of agro-techniques

including improved propagation methods, plant protection and post harvest management. These centers are providing grants, subsidies for establishing cold storage, precooling units, refrigerated vans, green houses and air freight subsidy to exports. Besides, Government of India has plans to promote, assist and facilitate the setting up of Agri Export Zones (AEZ) in association with selected State Governments with the objective of providing remunerative returns to farming community in a sustained manner and to increase their competitiveness. Six Agri Export Zones are already operational. According to a report of the APEDA, the total area under flower crops was estimated around 34,000 hectares, which included 24,000 hectares under traditional flowers such as marigold, jasmine, aster, rose, chrysanthemum, tuberose and 10,000 hectares under modern flowers like carnation, rose, gerbera, gladiolous, anthurium. Returns from floricultural products were estimated at Rs.205 Crores, which included Rs.105 Crores from traditional and Rs. 100 Crores from modern flowers.

Rose is the principal cut flower grown all over the country. Gladiolus is the next most important cut flower crop in the country. Tuberose, a very popular cut flower crop in India is grown mainly in the eastern part of the country i.e. West Bengal, and also in northern plains and parts of south. Both single and double flower varieties are equally popular. Tuberose flowers are also sold loose in some areas for preparing garlands and wreaths. The other main cut flower item is orchid. Among the traditional crops grown for loose flowers, the largest area is under marigold, grown all over the country. Jasmine flowers in view of its scent are also very popular as loose flowers and for use in garlands and *Veni* (ornament for decoration of hair by women). The chrysanthemum, particularly the white varieties are much in demand as loose flowers during the autumn period of October-December.

The floriculture in the valley of Jammu and Kashmir is still in its infancy stage. Being endowed with ample resources including soil, water, diversity in topography and rich natural flora with a mean rainfall of 660 mm in Jammu and 1069 mm in Kashmir, also the average temperatures varying within 24.5 and 13.3°C, highly dissected terrain with an average altitude from 500 to 3500 m both Jammu and Kashmir are ideal centers for flower farming. State Government intends to propagate floriculture as an important economic activity. Stating floriculture trade at Rs. 5 Crore in the year 2008 the State government is pressing hard on development. The department of floriculture is engaged in establishing demonstrative units, training facilities and supplying other possible infrastructures to the flower growers. Asia's largest Tulip garden is spread over an area of 100 kanals with around 12 lakh Tulips being cultivated has come up in Srinagar. The garden is being upgraded with the technical assistance from the Netherlands. A *Lilium* production centre is also being developed over an area of 30 kanals at Nuner Ganderbal. The centre aims to develop export quality *Lilium* and meet the world–wide demands. Jammu, winter capital of Jammu and Kashmir State, is now being christened as the garden city with the largest seasonal flower garden of the country coming up at the suburbs of the town at Bhour Camp, Jammu. The seasonal flower garden based on the pattern of Netherlands in Europe is spread over an area of five hundred sixty three kanals of land amidst surroundings with a rivulet flowing on the one side and green pastures on the other side it was made operational in March 2008. However, there is an urgent need for setting up of cold storage facilities at the state International Airport, which will minimize the estimated loss of 34% during transportation.

The present study was undertaken on some ornamental members of Amaryllidaceae (Daffodil or *Amaryllis* family) a cosmopolitan,

predominantly pantropical family of petaloid monocots. Family Amaryllidaceae represents a huge stock of ornamental plants comprising of 59 genera (850 species) with major centres of diversity in South America (28 genera) and South Africa (18 genera) (Simpson, 2006).

Amaryllidaceae was first described by Jean Henri Jaume St. Hilaire in 1805, the family is named after "Amaryllis", a pretty shepherdess mentioned by Theocritus, Virgil and Ovid. Amaryllidaceae members are close relatives of Alliaceae (the onion family) and Agapanthaceae (the agapanthus family). Majority flowers of Amaryllidacea qualify as beautiful cut flowers because of delicacy and in some cases fragrance such as, *Amaryllis* (belladonna lily), Crinum, *Galanthus* (snowdrop), *Hippeastrum* (amaryllis), *Leucojum* (snowflake), *Lycoris* (spider-lily) and *Narcissus* (daffodil). The potential value of family Amaryllidaceae has not been exploited as yet. These plants are commonly grown and have become well adapted to the climatic conditions of the Valley. It is in this perspective that the present study has been undertaken to unravel the mechanism of senescence, to develop adequate storage and handling techniques as also formulations for holding solutions to enhance the vase life of some ornamental plants of family Amaryllidaceae.

FLOWER BULBS: A REVIEW.

1. BULBS : INTRODUCTION AND IMPORTANCE IN CUT FLOWER TRADE.

Bulbs have been of vital interest ever since they made their first appearance on earth 35 million years ago (Binney, 1998). Flower bulbs often referred to as ornamental geophytes constitute a diverse group of varied morphological, developmental and physiological growth forms among the plant kingdom (Raunkiaer, 1934; Rees, 1989; Halevy, 1990; De Hertogh and Le Nard, 1993b). Horticulturally, today world wide bulb production and utilization have increased about three fold over the last 20 years; besides the spectrum of bulbs being researched and commercially grown is expanding greatly (De Hertogh and Le Nard, 1992). Extensive literature pertaining to bulbs has appeared in scientific journals and in trade publications. The fact that about nine International flower bulb symposia have been conducted under the auspices of International Society for Horticultural Science (ISHS), highlights the increasing importance of bulbs in world floriculture (Schenk, 1971; Rees and van der Borg, 1975; Rasmussen, 1980; Bogers and Bergman, 1986; Doss *et al.,* 1990; Saniewski *et al.,* 1992; Lilien-Kipnis *et al.,* 1997; Littlejohn *et al.,* 2002; Okubo *et al.,* 2005).

A bulb in common usage may mean a tuber, corm or a true bulb (Trivedi, 1987). The word "bulb" is used as a general term by gardeners for any of the flowers planted at the fall and may even include some corms (crocus), tubers (anemones) or tuberous roots (ranunculus); but actually in spring, the most spectacular flowers are produced by the true bulbs. In horticultural sense, a bulbous plant is a herbaceous or perennial ornamental species that produces fleshly storage organs which may be a true bulbs, corms, tubers, rhizomes or tuberous roots. To a botanist a bulb is an underground storage organ with a vertical stem axis surrounded by swollen leaf bases. In strict botanical terms the word “bulb” is used for an

underground vertical shoot bearing modified leaves that are used as food storage organs by a dormant plant. A baby bud surrounded by the scales is located at the basal central portion of the bulb. In true bulbs, the scales contain all the food required by the bulb to flower and thrive. Anchoring the scales and the floral stalk also holding the bud is the basal plate which sustains the roots of the plant. The entire package is protected by a thin outer skin called the tunic; however some families such as Liliacaea possess “non-tunicate" bulbs. True bulbs are mostly found among the monocotyledonous species particularly in members belonging to Liliaceae and Amaryllidaceae.

The cultivation of flower bulbs for commercial purposes started in Haarlem, Holland about 400 years ago. Later the cultivation spread to the north and then more especially to the south. The area between Haarlem and Leiden eventually became known as 'De bollenstreek' - the bulb district. For many years a large part of the population earned their living from bulbs whether in nurseries, export or in industries that supplied the sector. The town of Lisse regarded itself as the centre of the bulb-growing area and boasted a postmark that declared: "Lisse, the centre of the bulb district". Alongside this bulb-growing district, a second one developed during World War I in the most northern area of the province of North-Holland, the Anna Paulowna Polder and after World War II there was a massive expansion in the cultivation of flower bulbs there. After 1945 a new centre emerged in the Noordoostpolder (the North-East Polder); where mainly tulips, lilies and gladioli were cultivated. Today the Dutch flower bulb industry is a highly dynamic enterprise.

Importance of bulbs: The cultivation of bulbs have surpassed the other flower sources; as the bulb are easy to store, require minimal attention and respond to varied soil conditions. Also bulbous plants are sought after for varied natural compounds obtained from them. Large number South

African traditional healers over many centuries have increasingly used bulbous plants mainly belonging to the Amaryllidaceae and Hyacinthaceae families. A number of such plants have particular uses as disinfectants and anti-inflammatory agents (Louw *et al.,* 2002). Bulbous plants of family Amaryllidaceae particularly those belonging to genus *Narcissus* have been reported to contain up to 0.1% of galanthamine used in the treatment of Alzheimer's disease (Lopez *et al.,* 2002). Besides Narcissus, rich contents of galanthamine have also been extracted form the bulbs of *Galanthus* and *Leucojum* (Sener *et al.,* 1999).

Status of bulbs in cut flower trade: Bulb flowers occupy a significant position in world-wide production and trade in cut flowers. The total acreage of flower bulbs have been reported to be about 32,153 hectares world wide. Out of this about 22.987 hectare has been reported to be under bulb cultivation in Netherlands alone which was about 14.265 hectares in 1980. The top five types of bulbs which are sold world over are: tulips, lilies, narcissi, hyacinth and gladioli. The Netherlands accounts for about 65% of the total production area for flower bulbs in the world and therefore remains the leader in this sector. The export value of Dutch bulbs has doubled in the past 25 years while the total export value of ornamental produce is five times bigger.

Many types of bulb flowers particularly tulips and lilies are exported from the Netherlands. The major markets being Germany, United Kingdom, France and United States. Costa Rica exports lilies to the value of about 5.5 million euros to the US. In addition countries such as Chile (2.4 million euros) and Mexico (0.8 million euros) export lilies to US market. Tulips are undoubtedly the largest cultivated bulbs. Production of tulips takes place in some 15 countries world-wide, with the largest production area in the Netherlands with 10,800 hectares (88%). The other five main countries are Japan 300 hectares, 2.5%; France 293 hectares,

2.4% ; Poland 200 hectares, 1.6% ; Germany 155 hectares, 1.3% and New Zealand 122 hectares, 1% (Buschman, 2005).

2. BULBS : EVOLUTION, GEOGRAPHICAL EXPANSES AND CONDUCIVE CONDITIONS FOR GROWTH.

Evolution of bulbous habit of growth: Originally the evolution of geophytic or bulbous lifestyle developed as a protective mechanism to allow plants to get through hard times especially drought and cold. Accordingly bulbs fall into two groups: spring-flowering (which are planted in the fall) and summer-flowering (which are planted in the spring). Spring-flowering bulbs such as tulips, crocuses, hyacinths, daffodils, and irises are the universal symbols of spring. Their vibrant and colorful flowers are the first to bring life back to a barren winter landscape. Summer-flowering bulbs (dahlias, begonias and anemones) bring variety, texture, unique color and long flowering times to summer gardens.

A more accurate grouping however divides bulbs into hardy and tender varieties. As a rule spring- flowering bulbs are hardy bulbs. These bulbs are planted in the fall generally before the first frost and can survive the cold winter months. Many hardy bulbs such as daffodils perennialize well and can be left in the ground to flower year after year. Most summer-flowering bulbs such as *Dahlia*, *Hippeastrum, Hymenocallis, Gladiolus, Polianthes, Zantedeschia* are tender bulbs. These bulbs cannot survive harsh winter conditions and must be planted in spring after the last frost of the season. To enjoy these bulbs year after year they must be dug up in fall and stored indoors over the winter.

Geographical expanses of bulbous habit: Subtropical zone has been primarily represented to be the main evolutionary line of bulbous habit, later the bulbous habit has been shown to have branched naturally to varied ecological regions in both temperate and arid regions (Khokhryakov, 1975; Merrow, 2002). Geographically the bulbous habit of growth occurs almost

exclusively in temperate parts of the world i.e. beyond 30 degrees north and south latitude. The common natural habitats of bulbous plants are the Mediterranean; South Africa; West Asia especially Turkey and Iran, Central Asia and Afghanistan; the areas around the Black Sea and the Caucasus besides the Pacific coast of North and South America. Fewer bulbous genera have been shown to be indigenous to Japan, Great Britain, North East America, tropical and North Africa (Bryan, 2002). The evolution of geophytes in climatic areas with marked seasonal changes has led to their adaptation to periods of high and low temperatures, drought and to significant changes in the plant's morphological structure as also the annual developmental cycles of growth and dormancy. Not surprisingly most bulbous species are native to either grassland habitats or mountainous regions. There have been reports about the suitability of mountainous condition for the bulb development in lilies (Xia *et al.,* 2005).

In grasslands, bulbs are usually spring-blooming with foliage dying down by early summer. In mountainous areas the bulbs flower quickly during spring mature their foliage during the short summer and then disappear below ground during the long cold winter. Most common bulbs which grow and flower well in the hills include *Agapanthus, Anemone, Cylamen, Eurycles, Fritillaria, Iris, Ixia, Hyacinth, Moraea, Montbretia, Nerine, Paeonia, Kniphofia, Ornithogalum, Ranunculus, Tulip, Watsonia, Sparaxis, Zantedeschia* and *Begonia* etc. Although some hardy types of *Freesia, Narcissus, Gloxinia* and *Lilium* may flower in plains but they do not show very attractive display of colour and often fail to flower in the second year.

Conducive conditions for bulb growth: The optimum conditions for most bulbs are a cold dry winter often covered with snow, water ready rains in spring followed by a dry summer with cool or dry autumn (Furse, 1971). Mediterranean region is the suitable location for this type of climate

and as such Holland appears to lead the world bulb production. However the cultivation of ornamental bulbs is no longer limited to countries with a moderate climate. Species without chilling requirements such as Narcissi and *Amaryllis* are increasingly becoming more suitable for commercial bulb production in areas with warm climate; besides thermo-periodic bulbs such as *Tulipa, Allium, Eremurus* can also be grown successfully. Moreover the potential for flower production in these regions is evident due to high light intensity and appropriate winter temperatures (Kamenetsky, 2005).

The plants have evolved various mechanisms to ensure that the bulbs to positions in the soil most favourable for their growth (Galil, 1981). Bulbous plants can adjust the position of their storage organs to the optimal depth ensuring the plant survival. With the increase in planting depth the percentage of emerging plants has been shown to be reduced. The number of developing shoots, leaves, flowering stems, daughter bulbs besides fresh and dry weights of bulbs have been shown to be negatively correlated with the planting depth. Some plants have been shown to emerge from depths of 0 to 30 cm: *Anemone*, *Ranunculus* and *Crocus*; some are capable of emerging from 0 to 60 cm : *Iris*, *Allium*, *Aconitum* and *Hyacinthus* whereas some plants have been reported to emerge from 0 to 90 cm: *Narcissus* and *Ornithogalum* (Hagiladi *et al*., 1992).

Bulb weight or size is one of the critical factors affecting the vegetative growth and flowering of bulbous species. The weight of bulb bears a direct effect on flowering, size and quality of flowers as also on blooming. Bulbs with higher weight have been found to expand the period of flowering and also bear a considerable effect on blooming capacity. In *Herbaria lahue* heavier bulbs produce more and bigger flowers per plant. However the bulb weight does not seem to have an effect on the multiplicative ability. Use of larger bulbs allows the producer to obtain

adequate flowering and produce flowers of good quality for a long period (Morales *et al*.**,** 2009). Larger bulbs in plants such as *Leucocoryne coquimbensis* have been shown to produce more cut flower stems (Kim *et al.,* 1998). Studies on *Cytranthus* have shown that the increased bulb size is correlated with the increase in flower numbers per stem and stem number per bulb (Clark *et al.,* 2002).

Bulb spacing or bulb density has been listed as one of the major factors affecting bulb production of ornamental geophytes (Le Nard and De Hertogh, 2002). Obvious commercial interests are reflected for the determination of ideal bulb spacing during sowing. Bulb spacing also holds economic importance against land availability and aims for successful bulb production at high densities. The effect of bulb density does not seem to play a major role in plants where flowering is independent of leaf development. However bulb density reduces flower number either due to suppression of already formed flowers or to the failure of flower initiation in the smaller bulbs produced at high densities (Rees, 1968). Under greenhouse conditions carnation production per plant has been shown to decrease with the increase in plant density; however on unit area basis production of flowers increased due to high densities in the first three months (Durkin *et al.,* 1966). In *Narcissus* under low density major proportions of bulbs flowered and at high densities longer flower stems were obtained without any reduction in flower quality (Rees, 1968). Alteration of plant densities had no effect on the number of flowers produced per plant and longer flower stems were obtained at high densities in *Zantedeschia aethiopica* (Luria *et al.,* 2005).

3. BULB PERIODICITY : DORMANCY, FLOROGENESIS, HORMONES AND TEMPERATURE.

Bulb periodicity: A bulbous plant has generally three phases during an annual growth cycle i.e. vegetative, flowering and dormancy. Vegetative

growth may precede flowering as in *Gladiolus* or succeed it as in *Amaryllis* or *Haemanthus*. After growth and flowering the plants in most cases enter into dormancy. The bulbs contain regulatory factors which maintain the periodic phenological developments in the plants. The basic developmental functions including the onset and release of bulb dormancy, vegetative growth and florogenesis are timed for hide and display by harmonious integration of a multifactorial design comprising of changes in levels of endogenous growth hormones, respiratory substrates, nucleoproteins and gene activation besides environmental transmissions of light and temperature. An understanding of the mechanism and factors governing the bulb periodicity is imperative for developing modulation designs for realizing the potential of bulbous plants. With regard to bulb periodicity four groups are distinguished in the bulbous plants:

1. Tropical zone species: This group involves species of subtropical origin. Exploiting the tropical set of light intensity or temperature these species continue a year round growth at varying rates producing vegetative and reproductive organs autonomously. These species defy the specifications for photoperiod or temperature requirements for growth and florogenesis. Well known examples include *Clivia, Crinum, Hippeastrum* and *Zephyranthes* (Hartsema, 1961; Rees, 1972; Du Plessis and Duncan, 1989).

2. Temperate zone species: In consonance with depleted light and decreased temperatures species of temperate zone undergo a pause in terms of visible external growth for a winter rest. Throughout the year plants renew bulbs, develop leaves and flower but slow down these processes in response to low winter temperature. During the winter rest the bulb develops leaf primordial. A long photoperiod is however a prerequisite for transition to flower induction and flower development. *Lilium* is a principal

bulbous plant recognized in the group (Miller, 1993; Kamenetsky and Rabinowitch, 2002).

3. Mediterranean zone species: In these species thermoperiodic cycle with summer and winter dormancy is observed. These species cease underground growth at relatively high temperatures but release from dormancy and further flowering requires a period of low temperatures. During dormancy meristems are able to produce vegetative and reproductive organs inside the bulb. Examples include *Tulipa, Narcissus*, *Hyacinthus* (Hartsema, 1961; Le Nard and De Hertogh, 1993).

4. Arid zone species: In these species a perfect summer rest period is observed. To avoid high summer temperatures these geophytes enter a prolonged dormancy period and their vegetative meristems within the bulb remain in a "stagnation" state with no visible activity. Plants are released from dormancy when temperatures decrease. These plants then sprout and develop leaves as also inflorescence during the mild winter. No cold induction is required for floral development and stalk elongation. Examples include *Cyclamen*, *Pancratium*, *Bellevalia* (Wildmer and Lyons, 1985; Kamenetsky and Fritsch, 2002).

Bulb dormancy: Studies pertaining to dormancy have been conducted by several authors (Wareing and Saunders, 1971; Kamerbeek *et al.,* 1972; Rees, 1972; Villiers, 1972; Rudnicki, 1974; Amen, 1986; Chope *et al*., 2008). Dormancy is used to describe the natural phenomenon of growth cessation marked by partial metabolic arrest with its induction and termination under hormonal control. Growth and development are temporarily suspended during the dormant period (Lang *et al*., 1985; Junttila, 1988). Dormancy has also been reflected to represent a period of intrabulb development (Kamenetsky, 1994) ; however some bulbs like *Lilium longiflorum* are devoid of dormancy due to continuous initiation of

new scales by meristem producing leaf or flower primordial throughout the year (Blaney and Roberts, 1966; Miller, 1993).

The phenomenon of dormancy appears to be elusive as the process itself; besides it is difficult to describe dormancy as an active or passive period in life cycle. How a metabolically active plant suspends its activities and resumes growth after the conditions become favorable point to the possible existence of a dormancy clock (Rees, 1992; Kwon *et al.,* 2007). The physical environment exerts a marked influence on dormancy which is usually broken by a period of cold treatment depending on plant species. Altered environmental conditions during the dormancy period have been suggested to trigger the developmental processes leading ultimate dormancy release (Bewley, 1997). Dormancy can be regarded to be one of the most important factor that has made bulbous plants capable of growing in varied range of climates (Rudnicki, 1974). Bulbs are capable of timing themselves for dormancy. Spring bulbs become dormant in summer and summer bulbs become dormant in winter. Understanding bulb dormancy therefore seems to be a prerequisite for developing efficient propagation methods as dormancy directly affects storage capacity of bulbs. Predetermined rate of sprout emergence in post-dormancy is supposed to be one of the major determinants of storage capacity; besides understanding the mechanisms involved in the regulation of dormancy are important as the dormant geophytes are more resistant to environmental stresses (Borochov *et al*., 1997; Carter *et al.,* 1999).

Dormancy has a direct effect on regulation of germination, growth and reproductive development of the plant and often the temporal extent of dormancy has been described by ‘dormancy depth’ (Kamerbeek *et al*., 1972; Kwon *et al.*, 2007). Romberger, (1963) has identified ‘correlative inhibition’, ‘rest’ and ‘quiescence’ as three phases of dormancy and same have been referred to as ‘Ecodormancy’, ‘Endodormancy’ and

'Paradormancy' by Lang *et al.*, (1987). These concepts have been applied to the seeds and buds in general and to geophytes up to some extent. Depending on 'dormancy depths' three types of dormancy have been identified in different bulbous species viz. lily type dormancy, tulip type dormancy and bulb types without true physiological dormancy (Kamerbeek *et al.*, 1972). In the "lily type" dormancy the bulbs go through a longer depth during which the differentiation of new organs or elongation is completely arrested. The dormancy release takes place slowly spanning over several months and low temperature treatment is a prerequisite for its completion. This dormancy is similar to seed dormancy observed in plants form temperate climates and has been recorded in bulbs like lilies, onions and gladioli. "Tulip type" dormancy is induced soon after flowering and prevents stem elongation. It is characteristic of tulips, daffodils and hyacinths. The third type of dormancy found in plants such as irises is largely driven by environmental factors such temperature and humidity rather than true physiological requirements and the growth of plant resumes upon the return of favorable conditions. It can be argued that dormancy is an inbuilt and environmentally sustained physiological process; besides the regulation of dormancy can be related to the varied effects of hormones, temperature and light.

Hormones and dormancy: The onset and release of dormancy is regulated by the levels of growth inhibitors and promoters which in turn control growth and differentiation (Overbeek, 1966; Addicott and Lyon, 1969; Galston and Davies, 1969; Abeles, 1972; Hall, 1973; Jones, 1973; Sheldrake, 1973; Rudniki, 1974; Amen, 1986; Wu *et al.*, 1996). Dormancy induction or release is a collaborative process involving several plant hormones. Exogenous plant growth regulators have also become available for commercial use on flower bulbs; besides a range of physiological processes influenced by PGRs include the control of flowering in Dutch

Irises; control of leaf yellowing in lilies; control of marketable plant heights of daffodils, tulips and lilies; and propagation by tissue culture or stem cuttings (North Carolina Agricultural Chemicals Manual, 2008).

Auxins have been found to increase during sprouting of bulbs of *Polianthese tuberose* (Nagar, 1995). IAA-like activity was detected in tulip bulbs during sprouting suggesting the role of auxins in dormancy (Ito *et al*., 1960; Syrtanova *et al*., 1973). The increase in gibberellin and auxin activity has also been recorded during sprouting of stored onion bulbs; the gibberellin activity was however maintained at a higher level with well developed sprouts, whereas the auxin activity was noticed mainly in early sprouts (Thomas, 1969). Gibberellin-like substances have also been identified in bulbs of *Allium cepa*, *Hyacinthus orientalis*, Wedgwood Iris, *Lilium longiflorum*, *Narcissus tazetta*, *Tulipa gesneriana* and *Lilium speciosum* (Aung *et al*., 1969; Ohkawa, 1977); in vitro studies on *Lilium speciosum* have revealed that addition of Paclobutrazole an inhibitor of GA synthesis reduced dormancy levels in bulblets (Gerrtis *et al.,* 1992), suggesting that GA levels are related to dormancy. In many bulbous plants quantitative changes in gibberellins have been reported during bulb development in tulips, irises, daffodils and hyacinths (Aung and De Hertogh, 1968; Aung *et al*., 1969; Einert *et al*., 1972; Rees, 1972; Alpi *et al.,* 1976; Rudnicki and Nowak, 1976). Possible relation between dormancy and GA levels is still obscure. Whether GA functions through the synthesis of hydrolytic enzyme during dormancy release or increases the thermal sensitivity of bulbs to changed environmental conditions require a through investigation.

Cytokinins and ethylene have been reported to break dormancy in corms of plants such as Gladiolus and Freesia (Tsukamoto, 1972; Ginzberg, 1973; Masuda and Asahira, 1978, 1980). Ethylene has been found to be effective in breaking dormancy of *Fressia* corms

(Imanishi, 1997). Smoke treatment for dormancy release by eliciting exogenous ethylene production has been found to be effective in *Freesia* corms (Uyemura and Imanishi, 1983). In contrast, exogenous application of ethylene has been found to inhibit the sprouting in onion bulbs indicating the role of endogenous ethylene in the regulation of dormancy and sprouting (Bufler, 2009).

Dormancy release in various bulbous crops has long been associated with abscisic acid (Djilianov *et al*., 1994; Kim *et al*., 1994; Nagar, 1995; Yamazaki *et al*., 1995, 1999 a, b). Endogenous levels of ABA have been attributed to play a major role in dormancy development in lily bulbs (Kim *et al.,* 1993). The decrease in the endogenous ABA level during bulb storage of *Lilium rubellum* has been correlated with dormancy-release (Rong *et al.,* 2006). Similar findings about decline in ABA content during storage has also been reported in onion bulbs (Chope *et al*., 2008). Dormant bulbs of *Iris* have been reported to contain high levels of ABA, which declines at the release of dormancy (Okubo, 1992). ABA has been found to be involved in induction and maintenance of dormancy in bulbs of *Polianthes tuberose* (Nagar, 1995).

It appears that dormancy involves synchronous participation of endogenous hormones along with temperature and light however regulation of endogenous plant growth regulators at genetic level is still a matter of investigation in bulbous plants.

Temperature and dormancy: Various physiological aspects of low and high temperature treatments have been studied extensively in the major geophytes with the aim of standardizing commercial bulb storage and production; however the mechanism of dormancy release with temperature manipulation is still unclear. Similar effects of temperature have been marked in both seed and bulb dormancy, but the latter cannot be reversed suggesting a different physiological mechanism and an uncommon genetic

basis of bulb dormancy (Fortanier and van Brenk, 1975). The temperature and period required for the release from dormancy differs between various species and genotypes (Beattie and White, 1993). Temperature treatments have been extensively used to alter the dormancy or vegetative growth periods to obtain desired flowering of bulbous plants. Varying low degrees of temperatures have been developed as successful protocols for bulb storage. High temperatures have been found to play a role in the release of dormancy in *Iris* bulbs (Tsukamoto and Ando, 1973). By placing *Iris* bulbs at a high temperature after lifting, leaf production was found to continue without flower formation; but if high temperature treatment was followed by reduced temperature flowering was induced (Alpi *et al.,* 1976). These findings suggest that high temperatures reduce dormancy promoters thereby enabling flowering. Dormancy release by a particular temperature seems to be specific for each plant. Several extensively studied bulbous plants such as iris and tulip differ in their dormancy release temperatures. In Iris flower initiation occurs at relatively low temperature of 13ºC; while as at high temperature of 26ºC the bulbs remain vegetative. In contrast flower initiation in tulips occur at relatively high temperature of 20ºC and at low temperatures ranging from 5 to 9 ºC the plant ensures proper rooting and flower stalk elongation (Hartsema, 1961; Aung and De Hertogh, 1967). Temperature along with light and hormones appear to regulate the dormancy cycle; besides temperature rather than photoperiod has been suggested to play a primary role in the regulation of bulb dormancy (Phillips *et al.,* 2004).

Termination of dormancy has been shown to be marked by an increase in the activity of various hydrolytic enzymes and breakdown of stored reserves in bulb tissue (Nowak *et al*., 1974). It has been shown that α-amylase activity and sucrose content increased during the cold storage period in hyacinth shoots (Sato *et al*., 2006). Storage of iris bulbs at

10-13º C not only stimulated development of new buds and flower initiation but also an increased starch hydrolysis, respiration and peroxidase activity (Halevy *et al.,* 1963). It appears from the studies that bulbs require a minimum critical mass before dormancy release ensuring storage of enough reserve material for development. Maintenance of low oxygen tension has also been found to be effective in breaking bulb dormancy in *Lilium* and this method has been preferred to conventional hot water soaking of vernalised bulbs (Wakakitsu, 2005.) The flavonoids present as glycosides have been ascribed to play an important role in the release of dormancy (Saniewski and Horbowicz, 2005). Differential levels of endogenous polyamines in tuberose (*Polianthes tuberosa*) have been suggested to alter dormancy. Maintenance of high free putrescine, besides low spermine and spermidine levels have been associated with initial stages of dormancy whereas high spermine and spermidine levels have been shown to be associated with the release of dormancy (Sood, 2005). Water status has been shown to register an increase during dormancy release and the storage polysaccharides are cleaved to low-molecular weight sugar molecules (Kamenetsky, 2002). Dormancy release initiates a metabolism upsurge with the constant input of sugars for maintaining the processes of growth and development.

The induction of bulb dormancy has often been correlated with the process of bulb formation by identifying the genes expressed during bulb formation (Maehara *et al.,* 2005). Studies on *Iris*, *Hyacinthus*, *Lilium* and *Hippeastrum* have suggested that the induction of bulb formation and that of bulb dormancy seem to be the same processes (Okubo, 1992). It has also been reported that during bulb formation endogenous ABA content increased with concomitant increase in the rate of bulb formation suggesting that bulb formation is induced by low temperature and regulated by ABA (Li *et al.*, 2002).

Bulb florogenesis: Flowers are the important commodities obtained from bulbs. Induction, initiation, differentiation, floral stalk elongation, maturation of floral organs and anthesis mark the important steps involved in bulb florogenesis or flower formation (Halevy, 1990; Bernier *et al*., 1993; Le Nard and De Hertogh, 1993). Transition from vegetative or dormant phase to flowering is greatly affected by the genetic make up of the bulb and the surrounding environmental set up. Both these factors together alter the biochemical and molecular processes resulting in transition form juvenile or dormant state to a flowering state. As is the case with other plants developed from seed, a certain physiological age or accumulation of critical mass is to be ensured before induction of florogenesis. The duration of the juvenile stage or physiological age ranges from a few months (e.g., *Ornithogalum*, *Allium*.) to several years (e.g., *Tulipa*, *Narcissus*). Amount of reserves in the bulb also enable or disable the bulb from flowering. Varying critical diameters or circumferences have been identified in various bulbous plants. Circumferences needed for flowering may vary between 3-5 cm (*Triteleia*, *Freesia*, *Allium neapolitanum)* to 12-14 cm (*Tulipa*, *Narcissus*) and even 20-22 cm (*Allium giganteum*) (Le Nard and De Hertogh, 1993; Kamenetsky and Fritsch, 2002). In addition, flowering competence may also depend on the size of the apical meristem (Halevy, 1990; Le Nard and De Hertogh, 1993).

Many bulbous species develop inflorescences (multiple flowers, flower clusters). The ornamental value of number of bulbous species is based on their multiflowered inflorescences which sometimes include up to 200-500 flowers (e.g., species of *Allium*, *Eremurus*, *Scilla*). However, some ornamental bulbs produce only a few large flowers per inflorescence (e.g., *Lilium*, *Narcissus*, *Hippeastrum*, *Amaryllis*). Morphological variability of the inflorescence of flower bulbs is remarkable. Inflorescences are usually terminal and indeterminate and represent spike,

raceme, corymb, panicle, umbel or cyme types. Organogenesis refers to the formation of infloresecence which is composed of individual flowers with all the accessories of sepals, petals, stamens or carpels. The differentiation of sporogenous tissues in the pollen and embryo sac formation is one of the most important steps as far as commercial floriculture is concerned.

Environmental conditions especially temperature and photoperiod can have a profound effect on florogenesis in bulbous plants (Hartsema, 1961; Halevy, 1990; Rees, 1992; De Hertogh and Le Nard, 1993). Various factors controlling flower initiation and differentiation can be different from those controlling subsequent development until the commencement of anthesis. Several studies have demonstrated that flower initiation takes place at different times of the year and at different stages during bulb development in various species and varieties (Hartsema, 1961; Halevy, 1990; De Hertogh and Le Nard, 1993). Based on the available literature the flower bulbs can be divided into following florogenetic types:

1. Flower initiation is usually autonomous and occurs alternatively with leaf formation during the whole assimilation period *(Hippeastrum*, *Zephyranthes* and other species mainly natives of the subtropics). Both young developing flower buds and year-old larger flower buds at the point of flowering can be present in the same bulb. Optimal growth temperatures for these species are 20-28ºC. The highest quality flowers have been shown to be produced at 22/18°C (day/night) under a long photoperiod (Okubo, 1993; De Hertogh and Gallitano, 2000).

2. Flower formation takes place in advance during the growth of the parent plant (*Convallaria*, *Galanthus*, *Leucojum*). Flower initiation in plants such as *Galanthus* takes place immediately after anthesis of the parent plant when temperatures are still relatively low e.g., 3-10ºC (Langeslag, 1989). Flower differentiation in plants such as *Leucojum* require relatively high temperatures e.g., 20-25ºC (Mori *et al*., 1991a). The temperature of about

13-15ºC was found to be favorable for elongation and anthesis in *Leucojum* and *Convallaria* (Mori *et al.*, 1991b; Le Nard and Verron, 1993).

3. Flower formation takes place after bulb maturation and harvest during the storage period (*Tulipa*, *Hyacinthus*, *Crocus*). The transition from the vegetative to the reproductive phase occurs at the end of the growth period or during the 'rest' period without cold induction and warm temperatures are required for flower differentiation later a prolonged cold period of 4-9ºC is required for dormancy release (Hartsema, 1961; Rees, 1992). Optimal temperatures for elongation of flower stalks after planting and anthesis are 15-20ºC (Le Nard and De Hertogh, 1993).

4. Flower formation takes place during winter storage (*Lilium*, *Galtonia*, *Allium cepa*). Flower differentiation in plants such as *Lilum longiflorum* responds positively to a wide range of temperatures e.g., 13 – 27ºC and a long photoperiod supports flower development (Miller, 1993).

5. Flowers formation takes place after planting in the spring (*Gladiolus*, *Freesia)*. Flower initiation occurs in growing plants following the formation of several green leaves. Mild temperatures and long photoperiod are usually essential for floral initiation and stalk elongation (Halevy, 1985).

Modeling bulb florogenesis: Like dormancy flowering in bulbous plants is influenced by temperature. Low temperature is an essential part in the life cycle of many bulbous plant species (Rietveld *et al.,* 2000). Many bulbous plants have highly specific low temperature requirements for flower initiation and flower stalk elongation or for both the processes (Aung and Hertogh, 1968). Storage temperature of bulbs during dormancy can directly affect bulb performance both under natural or forced conditions and the temperature treatments can play a significant role in managing the flowering time as also in determining the bloom quality.

Duration of temperature treatment and the degree of temperature are two important factors affecting bulb florogenesis. Longer duration of cold temperature treatment has been found to decrease the number of days from planting to flowering and increase in the number of flowering bulbs in tulips (Rees, 1967; Rudnicki *et al* ., 1976; Xu, 2005). A storage temperature of 4 and 10°C has been found effective in delaying flowering in *Cytrantus* (Clark *et al.,* 2002). Bulbs of some plants such as *Veltheimia bracteata* stored for a period of eight weeks at 15 and 20°C delayed vegetative growth and flowering which were otherwise accelerated at 25 and 30°C along with loss of 50 percent bulbs (Ehlers *et al.,* 2002). For obtaining quality flowers and ensuring proper stalk elongations in hyacinths, daffodils and tulips the bulb are dependent on an extended low temperature treatment prior to plantation (Aung and De Hertogh, 1967; De Hertogh and Le Nard, 1993; Rietveld *et al*., 2000). Recent findings on tulips show that chilling not only influences stalk elongation but also pollen development (Xu *et al.,* 2005).

The mechanism of sensing low temperature in bulbous plants is still unclear. In some bulbous plant species like iris low temperature determines both flower initiation and stalk elongation (De Munk and Schipper, 1993). The role of low temperature treatment during flower formation in tulips has been shown to be restricted to stalk elongation only and as such tulips have been used as a model system for isolation of genes involved in low temperature regulation and auxin sensitivity (Rietveld *et al*., 2000). In tulips elongation of flower stalks has been shown to occur due to cell extension (Gilford and Rees, 1973). The use of modified low oxygen atmosphere of approximately 1% for bulb storage has been reported to inhibit early sprouting and produce superior quality flowers in lily bulbs (Legnani *et al.,* 2002). Development of anaerobic conditions during storage extend the shelf life of certain Asiatic hybrid lily cultivars by inhibiting

shoot elongation and flower bud development while producing a flowering plant that is acceptable to the consumer (Legnani *et al.,* 2006).

Hormones and flowering: Bulbous plants maintain growth and developmental phases in association with changes in the activities of endogenous growth regulators. De Munk and Gijzenberg, (1977) suggested that the natural balance between growth substances controls the flower bud development in tulips and imbalance of hormonal activity resulted in bud abortion. In many bulbous plants it has been shown that the application of exogenous synthetic growth regulators resulted in a modification of developmental processes such as acceleration of growth, substitution of the cold requirement, acceleration of flowering period, stimulation of tissue differentiation and an increased vegetative propagation (Rees, 1972).

Endogenous growth regulators in bulbs monitor the natural developmental life cycle of the plant, whereas as the exogenous application of plant growth regulators can improve growth and flowering. Exogenous application of gibberellins has been shown to prevent ethylene induced flower bud blasting in tulip (De Munk and Gijzenberg, 1977; Moe, 1979). Besides exogenous gibberellin has been shown to effect other developmental activities of tulip by interacting with endogenous auxin (Saniewski *et al*., 1999). The involvement of gibberellins in the regulation of stem elongation and flowering has been implicated in various cold requiring plants such as tulips (Rebers, 1992). Recent findings suggest that low temperature increases auxin sensitivity in tulips and proper stalk elongation can result from interactions between auxins and gibberellins (Rietveld *et al*., 2000).

Use of gibberellic acid is an effective option for replacement of cold requirement of the bulbs. GA_3 content has been shown to increase at the end of cold treatment in tulip bulbs further establishing relation between cold treatment and GA_3 concentration (Alpi e*t al.,* 1976). As early as 1964,

Rodrigues concluded that two groups of GA_3- like growth promoting compounds extracted from iris buds were correlated to organogenesis rather than to flower induction. In combination with 2,3,5- triiodobenzoic cid (TIBA), GA_3 promoted growth and flowering in tulips depending on the time of treatment. Use of Naphthylphthalamic acid (NPA) along with GA_3 showed almost similar effects as that of TIBA application in tulips (Geng *et al.,* 2005). Direct application of gibberellic acid to iris bulbs promoted flower formation when applied after flower initiation (Halevy and Shoub, 1964). All these findings suggest that gibberellins are important for growth of flower primordia besides, floral organs have been shown to be the site of GA_3 biosynthesis (Marre, 1964; Alpi et *al.,* 1976). Gibberellic acid (GA_3) has been shown to accelerate growth and flowering on application to dormant hyacinth bulbs over a range of storage periods at low temperatures (Tymoszuk *et al.,* 1979).

Application of Indole -3- acetic acid to cooled tulip bulbs at cut surface of flower bud after complete defoliation promoted internode elongation (Saniewski *et al.,* 2005). The flowering percentage of Dutch iris increased proportionally to the duration of exposure to ethylene or to the number of ethylene applications. At higher levels propylene, acetylene and carbon monoxide had almost the same effect as ethylene. Exposing bulbs to smoke or ethylene during storage induced a higher percentage of flowering besides early flowering in *Narcissus tazetta* and Dutch iris, not only in normal bulbs with a critical mass but also in bulbs too small to flower. Application of ethylene at vegetative phase ensured and advanced flowering in tulips (Imanishi, 1997). Endogenous levels of cytokinins have been reported to be involved in flower formation in plants such as iris (Gregorini, 1983).

Plant growth regulators can be supplied as foliar sprays, soil drenches or a combination of both (Barrett, 1999). Bulb dips have become

increasingly popular with commercial growers. Bulb dips can be manifested by either quick dips or extended soakings. The mode of exogenous hormone application and the type of PGR used depends on species, cultivar, bulb size, and the desired physiological response. A large number of bulbs can be treated quickly not only prior to planting but also prior to packaging and distribution for sale. Soaking of bulbs in the solutions of ethephon or benzylaminopurine was found to be little less promotive than exposure to ethylene (Imanishi and Yue, 1986). It is important to determine the safe dosage of ethylene at the cultivar level besides effective dosage of gibberellins should be predetermined as excess of gibberellins have been reported to cause severe bud damage in Asiatic lilies and low levels of gibberellin treatments increased the longevity of inflorescence (Ranwala and Miller, 2002). Growth retarding chemicals such as ancymidol, paclobutrazole and uniconazole given as a foliar sprays, bulb dips or soil drenches have been effectively used to control plant height and give a better display in a number of bulbous plants (Larson *et al*., 1971; Hasek *et al.,* 1971; Gill, 1974; Sanderson *et al.*, 1975; Seeley, 1975; Lewis and Lewis, 1980; Miller *et al*., 2002).

Molecular aspects of bulb florogenesis: The information on physiological mechanisms of floral transition of bulbous species is extensive, the molecular aspects of this process in ornamental geophytes are not clearly understood. Studies on *Arabidopsis* suggest that the transition of the shoot apical meristem from the vegetative to reproductive phase is regulated by a large group of flowering – time genes (Corbesier and Coupland, 2006; Kanno *et al*., 2007). The process is controlled by internal and external cues including photoperiod, temperature and plant growth regulators. These integrated signals lead to the activation of a small group of floral identity genes (Benlloch *et al.,* 2007). The meristem identity genes – APETALA 1 (AP_1) and LEAFY (LFY) activate the floral

organ identity genes which specify the various floral cell types as also tissues (Zik and Irish, 2003; Bernier and Perilleux, 2005; Moon *et al.,* 2005; Benlloch *et al*., 2007; Corbesier *et al*., 2007; Kanno *et al*., 2007). Recently, LFY homologues were also identified in some geophytes. These genes include NLF in *Narcissus tazetta,* gaLFY in *Allium sativum* and LcLFY in *Lilium candidum* (Noy- Porat *et al*., 2007; Rotem *et al*., 2007; Zaccai *et al*., 2008).

The genetic control of floral organ identity in most popular model dicot species *Arabidopsis thaliana* and *Antirrhinum majus* was explained by "ABC" model (Coen and Meyerowitz, 1991). The model proposes that class A, B and C organ identity genes act in an overlapping domains to determine the flower patterns. The expression of class A genes specifies sepal and petal determination, the combination of class A and B genes specifies the formation of petals in the second whorl, the class B and C genes specifies stamen formation in the third whorl and the expression of class C genes alone determines the formation of carpels in the fourth whorl. Van Tunnen *et al*., (1993), proposed a modified "ABC" model for *Tulipa gesneriana* in which the expression of B-class genes is extended to the first floral whorl. Further studies in geophytes such as tulip, *Agapanthus pracecox, Muscari armeniacum, Phalaneopsis equestris* and *Dendrobium crumenatum* support this model (Kanno *et al* ., 2003; Nakamura *et al*., 2005; Nakada *et al.,* 2006; Tsai *et al*., 2004, 2005; Xu *et al* ., 2006). The "AP3" and "PI" class B gene homologues have been shown to be expressed in petaloid sepals in the first whorl of a dicot species *Aquilegia alipna* (Kramer *et al* ., 2003). The expansion of class "B" gene expression into the first whorl is consistent with the floral morphology of these species.

Theissen, (2001) extended "ABC" model to the "ABCDE" model in which the "E" function genes together with B and C genes control stamen

formation, the C and E genes regulate carpel formation and the D genes are involved in ovule development. In *Lilium longiflorum*, LMADS2 a new MADS- box gene form was described as a D-functional gene on the basis of sequence comparison and phylogenetic analysis (Tzeng *et al* ., 2002). LMADS2 is specifically expressed in the lily carpels. E- function- related genes LMADS3 and LMADS4 have also been characterized from *Lilium longiflorum* (Tzeng *et al* ., 2003). Both LMADS3 and LMADS4 mRNAs have been detected in the inflorescence meristem in floral buds at different developmental stages and in all 4 whorls of flower organs (Benedito *et al.,* 2004 b). These data indicate that in ornamental geophytes flower development may be controlled differently than I the classical model plants. There is enough scope for research to understand the floral organ identity genes in ornamental geophyte species. Besides, the studies on genetic transformation in florogenesis of flower bulbs, manipulation of the juvenile period by over expression of early floral- meristem – identity genes and genetic manipulation of flower structure shall allow the creation of new varieties of ornamental bulbous crops with modified flower phenotype.

Bulblet formation: Various factors directly affect bulblet formation in vivo and many factors can be manipulated to induce or reduce bulblet formation. Light treatments markedly affect bulblet formation. The light treatments effectively prevented the young bulbs from becoming dormant besides hyacinth bulbs grown under blue light were found to be smaller but more differentiated than in darkness (Gude and Dijkema, 1992). Besides light, cooling of mother bulbs i.e. temperature is another important factor regulating formation of daughter bulbs. Daughter bulbs in tulips have been shown to form when mother bulbs are stored for extended periods (about seven months) at 5°C in tulips besides in most of the daughter bulbs that were formed under these conditions, flower bud differentiation took place

but flowering occurred during the next season after sufficient cooling (Saniewski and Horbowicz, 2005). In-vitro cultures have given an insight into the regenerative or bulblet formation capabilities of plants. Higher rates of regeneration were demonstrated in Liliaceae and Amaryllidaceae (Yanagawa, 2005). Somatic embryogenic cell culture system has been effectively used for the mass production of bulblets. Bulblets of Oriental lilies having high quality and uniformity have been produced in bulk in relatively short periods using embryogenic cell cultures (Kim and Ahn, 2005). The isolation of genes expressed during bulb formation provides an understanding in the relationship between the induction of bulb formation and the induction of bulb dormancy. In vitro bulb formation of hyacinth was shown to be induced by low temperature and regulated by ABA, besides the regulation of gene expression by cold treatment has been shown to start at an early stage during or before the commencement of bulb formation (Li *et al.,* 2002).

Developing effective propagation techniques commence with the plantation strategies of bulbs. Proper planting density can be manipulated along with planting time to maximize the gains (Clark and Burge, 2002). Besides, in order to improve bulb productivity and ornamental characteristics it is necessary to increase genetic variation by using breeding techniques such as overcoming interspecific barrier, rescue of abortive embryos and induction of polyploids (Okazaki, 2005). The regeneration potential of species and varieties varies amongst species and this factor is important as an evaluation criterion in bulb breeding programme. Tissue age can affects both the number of buds formed and the size of bud or bulblet. Young tissues have been proved to be the best source for tissue culture in various studies (Niederwieser and Ndou, 2002).

Temperature: Temperature plays a predominant role in the regulation of bulb periodicity. On the basis of response to temperatures genera have

been classified into various groups with the ultimate aim to study the effects of temperature on bulb periodicity (Imanishi *et al.,* 2002). Some species do not have a low temperature requirement for flowering. The storage temperature for the bulbs plays an important role in the development of bulbs and an optimum storage temperature can be determined for each species (Kodaira and Fukai, 2005). Flower bud initiation and development of *Eucrosia bicolor* following the storage of bulbs at temperatures ranging from 10 to 20° C suggested that vegetative growth was maintained in bulbs stored at 10° C for two months, whereas the bulbs stored at 20°C flowered in sixty days (Roh *et al.,* 1992). Storage of bulbs at the temperature of 5°C has been found to inhibit flowering in *Erythronium* for two to four weeks and as the chilling periods increased; the flowering percentage, number of florets and flower stem length increased significantly (Shinoda and Murata, 2005). Correlations can help in predicting the effect of meteorological factors i.e. the daily minimum temperature, besides hours of sunshine on growth rate and economic outcome of the marketable bulbs (Amano *et al*., 2005). Another factor to affect bulb output is the specificity of bulbs to shade and in plants such as *Cytranthus* shade has been found to delay flowering (Clark *et al.,* 2002).

4. BULBS : FORCING, PACKING, DISEASES AND FUTURE TRENDS.

Bulb forcing: Flower bulb forcing is the "flowering of a bulb using other than naturally occurring conditions". It can also be described as interference in natural bulb periodicity for desired flowering. From horticultural point of view forcing may be defined as an operation or treatment to the plant after it reaches the ripeness-to-flower stage in order to stimulate flowering at a desired date. One of the earliest types of forcing pertains to hyacinths maintained in greenhouse conditions so that they would flower earlier than in the open fields (Blaauw and Kronenberg,

1937). As early in 1910, Nicolaas Dames introduced the system for early "lifting" of Dutch-grown hyacinths to "prepare" them for very early forcing in greenhouses, a system that still is used today (Dwarswaard, 2006). Subsequent studies were conducted on various genera and cultivars in order to develop the essential requirements for forcing of flower bulbs (Blaauw, 1920; Hartsema, 1961; Hartsema and Luyten, 1962).

Studies related to various aspects of commercial forcing have been reviewed by various authors (De Hertogh, 1974; Le Nard and De Hertogh 1993 a; Theron and De Hertogh, 2001). The studies have revealed that flower bulb forcing comprise production, programming, greenhouse marketing and consumer. The production phase comprises bulb production and it terminates with the harvesting of the bulbs. The programming phase comprises handling of the bulbs from harvesting until they are placed under greenhouse conditions. The greenhouse phase is the accelerated development of the bulbs until anthesis or marketing of the plants. Marketing and consumer satisfaction are important and closely linked aspects of the whole process. All these processes are interlinked with the ultimate aim of off-season production on specified dates. Forcing enables the maintenance of flower production on the events when the demand for cut flowers is generally very high such as New year, Christmas, Mother's day, Memorial day, Valentine day or during the off-season period. The physiological developments pertaining to bulb forcing are beneficial for farmers and floricultural business as a whole because the production of cut flowers during the off-season period in fetching higher price, besides academically helping in understanding the mechanism of flowering.

Forcing is controlled by genetic and environmental factors. Temperature has been regarded to be the most important factor in forcing which affects the time and rate of flower initiation besides development. Some of the earliest and inexpensive forcing techniques of equipments

comprised of rooting beds, cold frames, plastic hoops, non-temperature controlled bulb cellar (Anon, 1963). Some recent developments in forcing technology include controlled-temperature rooting rooms for spring-flowering bulbs, specialized facilities to freeze-in lily and Dutch iris bulbs, greenhouses with rolling benches, hydroponic systems for cut tulips. Bulb forcing has become a global business based on an extensive scientific database.

De Hertogh, (1996) has divided the forcing systems into two basic types; controlled temperature rooting room forcing for many spring flowering bulbs such as tulips, hyacinths, daffodils, hydroponic tulips and non-rooting room forms which includes special precooling (SPC) at 5^{o}C for plants such as tulips, freesias and lilies. With bulbs such as Dutch irises and lilies the two systems can be partially combined. After being programmed the bulbs are planted in trays, rooted in controlled temperature rooting rooms and then placed in greenhouses. During forcing bulbing and flowering processes must be regulated, besides the flower abortions need to be prevented. Forcing can not only be utilized for obtaining flowering but also in obtaining plants with desirable heights. A cold regime starting from mid October comprising 12 weeks at 9°C + 3 weeks at 5°C + 3 weeks at 2°C results in good flowering with short plants; whereas, a cold regime of 3 weeks at 9°C + 3 weeks at 5°C + 12 weeks at 2°C results in good flowering with tall plants in *Fritillaria imperialis* (van Leeuwen *et al.,* 2002). Flower forcing can also be achieved by adjusting photoperiod, temperature and humidity, besides chemical methods or by conventional mechanical methods. Under indoor forcing conditions the seasonal temperature patterns are simulated under a strict regime to ensure early flowering and quality blooming (Aung and Hertogh, 1967). At present two systems are used for the storage of bulbs for forcing. These systems differ in storage conditions i.e. the way in which the bulbs

are stored after planting on the forcing boxes (de Vroomen and van der Linden, 1983). In case of field storage the bulbs are planted in large boxes (100 × 100 or 100 × 150 cm) which are covered with straw and stored in the open. This method can only be applied where the conditions permit the use of heavy tractors for transportation of the boxes to greenhouse during the winter. In case of indoor storage the bulbs are planted in smaller boxes (60 × 40 or 75 × 50 cm) and stored in air-conditioned rooting rooms. Some of these bulbous plants are temperate in origin and require low temperature treatment for dormancy release, flower induction and floral stalk elongation. Due to lack of outdoor chilling temperatures in the tropics the use cool chambers (3–5°C) is practised for various propagative materials. The thermoperiodicity of bulbous plants, besides the use of ethylene or silver thiosulphate offer possibilities for reduction in the energy costs accompanying the forcing of bulbous plants (De Munk, 1984). Ordinarily the use of growth regulators in flower bulb forcing has been minimal due to the high cost of the chemicals (Waithaka, 1986).

Various other cooling techniques such as case cooling (CC), controlled temperature forcing (CTF) and interrupted cooling (IC) have been used in plants such as Easter lily (*Lilium longiflorum*) bulbs to obtain uniform emergence and flowering in the spring and to maintain flowering all the year round. In case cooling the bulbs are packed in a wooden case together with moist peat moss exposed to cool temperatures at 5-6°C for six weeks and then planted. In controlled temperature forcing the bulbs are planted in a pot, rooted for 2-3 weeks under controlled temperatures (15-18°C) and then the pots with bulb are moved to a cooler place where they are maintained at 6-7°C for six weeks prior to forcing in the greenhouse. Interrupted cooling is based on a combination of CC and CTF. Forcing treatment has not been restricted to cooling of bulbs. Hot water treatment along with low Oxygen concentration has been found to be effective for

forcing of Easter lily bulbs. The cut flower quality of bulbs maintained in anaerobic conditions was found to be better than those of bulbs soaked in hot water (Wakakitsu *et al.,* 2005). Apart form hot or cold temperature treatment illumination with additional light has been found to be effective for the forcing of Asiatic lilies during the winter period. Additional light prevents flower bud abscission and flower bud blasting in tulips (van Tuyl *et al.,* 1986).

Bulb packing: Bulbs remain the most successful commodity for flower agencies as bulb packing for transportation has no significant effects of on floral stalk length, number of flowers produced per stalk, flower diameter, strength of the first floral stalk or leaves and overall plant quality (Hertogh and Gallitano, 1998). Besides bulb packing forms an important aspect for the realization of commercial outcome of the bulbous plants. Usually perforated cardboard boxes, perforated polyethylene bags and perforated cardboard boxes are used for bulb packaging. However bulbs can be subjected to high temperature stress due to equipment failure or mishandling. Heat induced injuries often lead to the production of endogenous ethylene. Bulbs are treated with ethylene antagonist 1-methylcyclopropene (MCP) to over come the loss (Liou *et al.,* 2005).

Diseases of ornamental geophytes: The ultimate aim of bulb study is to ensure production of healthy and disease free bulbs capable of flowering at desired time without any physiological disorders. Varied groups of organisms (bacteria, fungi, nematodes) have been known to cause diseases in flower bulbs (Byther and Chastagner, 1993). Plants of hyacinths and *Zantedeschai* are highly susceptible to bacterial diseases (Van Aartrijk, 1995). Two major bulbs diseases are caused by *Pectobacterium carotovora* and *Xanthomonas hyacinthi*; the former causes bacterial soft rot and the later causes yellow disease in hyacinths (Kamerman, 1975). A large number of fungi affect flower bulbs and at least 26 genera of fungi have

affect cause flower bulb diseases (Byther and Chastagner, 1993). Some are aerial while others are soil borne. In addition some fungal diseases are preferentially more prevalent in the field while others are observed under greenhouse conditions. Major fungal diseases are caused by *Botrytis, Fusarium oxysporum*, *Penicillium, Phytophthora, Rhizoctonia tuliparum, Stagonosporopsis curtisi, Stromatinia gladioli* and *Trichoderma viride*. Of these diseases, *Fusarium* bulb rot of tulips causes not only the loss of the bulb but also the infected bulb produces ethylene which causes many physiological disorders including flower abortion (Kamerbeek and De Munk, 1976). Nematodes represent another class of organisms mostly occurring in aerial parts, besides roots. At least forty different viruses of varying types have been identified in ornamental geophytes (Bergman, 1983; Byther and Chastagner, 1993). Various insect vectors such e.g., aphids, thrips, and nematodes can transmit viruses.

Mostly pest management methods are preferred over chemical applications for diseased bulbs. Zayeen *et al.,* (1986), have reported that some fungal diseases and weeds can be controlled by flooding for six weeks. These include black slime caused by *Sclerotinia bulborum*, grey bulb rot caused by *Rhizoctonia tuliparum* and the perennial weeds way thistle caused by *Cirsium arvense*, coltsfoot caused by *Tussilago farfara* and couch grass caused by *Agropyron repens*. Managing disease free bulbs is important aspect floriculture across the world.

Future trends: The competition for existing flower bulb markets has been constantly increasing underscoring the demand for high quality bulbs and bulb flowers. The globalization of horticultural trade has led to the advances in the transfer of knowledge and economic progress particularly in the developing countries. The bulb production and bulb flowers of high quality in regions with warm climates have become significant during the last decade. The production of bulbs has been promoted by relatively

inexpensive land, low labor costs and the expansion of international trade. Multidisciplinary research approaches are needed for the improvement of existing crops and their development into new commercial crops. Studies on external and internal cues related to the regulation of geophyte development are required to understand the process.

The need to broaden the research on bulbous plants is evident. The work on following lines is required to evolve future strategies on research and development in bulbous plants:

1) Search, evaluation and the utilization of new crops.
2) Issues related to environment and integrated pest management.
3) Production of propagation materials.
4) Studies on dormancy and sprouting.
5) Florogenesis and stalk elongation.
6) Breeding especially for disease resistance.
7) Selection of model plants for molecular and genetic research.
8) Studies on longevity, postharvest handling and transportation.
9) Studies on effective propagation systems.
10) Establishment of a global network system for bulb researchers, growers, marketers and consumers leading to effective data base.

The research programmes on the above lines shall benefit the floricultural industry, ensure a healthy environment and uplift the well-being of humanity.

Materials And Methods

Plant material:

The plants used in the present study belonged to four genera of the family Amaryllidaceae. Following species were used during the current study:

1) *Narcissus tazetta* cv. Kashmir Local.
2) *Narcissus pseudonarcissus* cv. Emperor.
3) *Narcissus poeticus* cv. Pheasant's Eye.
4) *Hippeastrum aulicum* cv. Platifolium.
5) *Amaryllis belladonna* cv. Rosea.
6) *Nerine sarniensis* cv. Red.

Isolated flowers and intact scapes were used for the study. The flowers or scapes were obtained from the plants growing in the University Botanic Garden. The material was harvested in the morning and immediately brought to the laboratory. Isolated flowers of Narcissi, *Hippeastrum, Amaryllis* and *Nerine* were harvested at different stages of development (Stage I to Stage VI) to study the changes during development and senescence. The stages have been designated separately for each plant species in the respective experimental sections. Scapes of Narcissi, *Amaryllis* and *Nerine* were harvested at tight bud stage for different temperature treatments and at loose bud stage for other postharvest treatments. The scapes of Narcissi were placed in distilled water for 1h for draining off slime. The basal few centimeters of scapes were cut under water to obtain a uniform length of 20 cm in case of Narcissi, 27 cm in *Amaryllis* and 30 cm in *Nerine* respectively. The samples were transferred to test solutions in the laboratory. Only the healthy plant material was selected for the experimentation.

Various temperature treatments were tested for studying the optimal storage temperature for cut scapes of Narcissi, *Amaryllis* and *Nerine.* Two different storage treatments were used; postharvest wet storage (PHWS) and postharvest dry storage (PHDS) at three temperature regimes (Room temperature (RT), 10 and 5^{o}C). In PHWS, the samples were held in plastic buckets or borosil glass beakers containing distilled water and kept at various temperature regimes for 24 h or 72 h. In PHDS, the samples were wrapped in moistened filter papers and kept at different temperature regimes for 72 h. After 24 h or 72 h the scapes were transferred to the holding solutions for assessing their postharvest performance. The detailed procedures of PHWS and PHDS have been described separately in the experimental section of the particular plant species.

The chemicals tested for the efficacy in enhancing the vase life and improving the postharvest performance included sugar source; Sucrose (SUC), metallic ions known to act as germicides or ethylene inhibitors, viz. Cobalt chloride, ($CoCl_2$), Aluminum sulphate, $Al_2(SO_4)_3$, biocide (8-Hydroxyquinoline sulphate; 8-HQS), ethylene antagonists (Silver thiosulphate; STS and Aminooxyacetic Acid; AOA), protein synthesis inhibitors (Cycloheximide; CHI) and growth regulators – Benzyl amino purine (BAP), Kinetin (KIN) and Gibberellic acid (GA_3). The chemicals were used singly or in different combinations and were supplied either continuously in the vase solutions or as pulse treatments. The mode of application and respective concentrations of various chemicals are described separately for each treatment in the respective experimental section.

The required dilutions of various chemicals were made from the stock solutions that were already prepared at the time of experiment. Sucrose was always prepared freshly at the start of the experiment. STS was prepared according to Downs *et al.,* (1988). 0.5mM STS was prepared

by mixing equal volumes of 1mM silver nitrate ($AgNO_3$) and 4 mM sodium thiosulphate ($Na_2S_2O_3$).

The test solutions were placed in 250 ml borosil flasks containing 200 ml of holding solution. The flasks were thoroughly washed with the detergent and rinsed with distilled water before persuing the experiment. The glassware was oven dried for 48 h at 80^{o}C prior to experimentation. Each treatment was generally represented by 5 replicates, with each flask containing two scapes. The day of transfer of samples to various test solutions was designated as day zero. A separate set of 5 flasks containing respective blank test solutions were kept along each set of flasks with samples to monitor the volume of the solution evaporated on a particular day.

Visible effects:

Visual changes occurring in flowers during the course of development and senescence besides the apparent changes during postharvest life were recorded at periodic intervals. These included the time and pattern of flower opening, colour change (if any) and senescence patterns.

Postharvest life:

Vase life of scapes and individual life of a flower was measured in days starting from the day of transfer of the scapes to test solutions (day zero). Vase life was regarded to be terminated when 50% florets senesced on each scape in case of *Narcissus tazetta* and when flowers lost their display value characterized by loss of turgor and wilting in *Narcissus pseudonarcissus*. In *Amaryllis belladonna* vase life was considered to be terminated when 70 % florets had senesced after blooming. In *Nerine sarniensis* vase life was considered to be terminated when the flowers had lost display value and reached stage IV (curly tepal stage) as described in table 1.

Table 1: Assessment of vase life of *Nerine sarniensis* cv. Red by assigning a particular status based on the display values.

Status(S)	Description	Display
S_1	Smooth tepal, red anthers.	Slightly attractive
S_2	Curvy tepals, yellow anthers.	Attractive
S_3	Curvy tepals, yellowish brown anthers.	Most attractive
S_4	Curvy tepals with faded colour and turgor loss, brownish anthers.	Less attractive
S_5	Senescent tepals and stamens.	Unattractive

Number of buds or blooms:

Number of buds, blooms and the number of buds bloomed per scape was recorded regularly by counting the number of buds bloomed on a particular day on each scape and was averaged for every day in each plant. Total number of buds on each scape was also counted to express the data on percentage basis.

Solution uptake:

The volume of holding solution absorbed was recorded at regular intervals and was averaged for every two, four and six days in each plant. The volume of holding solution absorbed was calculated by measuring the volume of solution on a particular day and subtracting it form the initial quantity of the vase solution kept in the flasks, taking into account the volume of solution evaporated by using blank flasks in triplicate (containing particular vase solution without scapes) along side the flasks with scapes.

Fresh and dry mass:

Fresh mass of five to ten flowers from each treatment was recorded at regular intervals in each experiment. The flowers were kept in paper

bags and dried in an oven at 70°C for 48 h. The material was put in a dessicator over dry $CaCl_2$ for 24 h before recording the dry mass.

Moisture content:

Moisture content of the samples was computed as the difference in fresh and dry mass of the flowers. Percent moisture content of the fresh tissue was also calculated.

Flower diameter:

Flower diameter was measured as the mean of two perpendicular measurements across a flower and was expressed in centimeters (cm).

Membrane permeability:

Membrane permeability was studied by measuring ion leakage from the should be tepal discs (5 mm in diameter) incubated in the dark in 15 ml glass distilled water for 15 h at 20°C. The discs were punched from the flag region of tepals of 5 flowers. The discs were floated with their abaxial surface downwards and were removed with a brush after 15 h of incubation. Conductivity of leachates was measured by CM- 180 ELICO Conductivity meter and was expressed in μS.

Fixation of plant material:

Fixation of the material was done by chopping 0.5 g to 1 g of tepal tissue in triplicate in hot 80% ethanol. The material was then macerated in a glass pestle and mortar and centrifuged at 3000xg for 20 minutes. The supernatants were pooled and made to a uniform final volume. A suitable aliquot from the supernatant was used for the determination of tissue constituents (sugars, α- amino acids and phenols). For the determination of soluble proteins fresh material was directly used.

Determination of soluble protein content:

Proteins were extracted from 0.5 g or 1 g tepal tissue by homogenizing the tissue in 5 ml of 5% sodium sulphite (w/v) adding 0.1 g of polyvinyl pyrrolidone (PVP) and centrifuged at 4000xg for 20 minutes in a refrigerated centrifuge. Proteins were precipitated from a suitable volume of cleared supernatant with equal volume of 20% trichloroacetic acid (TCA), centrifuged at 2000xg for 15 minutes and the pellet redissolved in 4 ml of 0.1 N NaOH. Proteins were estimated from a suitable aliquot by the method of Lowry *et al*., (1951). The aliquot was made to 1 ml with distilled water, followed by the addition of 2 ml of mixed alkaline copper reagent (copper sulphate solution: alkaline tartarate in the ratio of 1:100) (GENEI protein estimation kit). After 10 minutes 0.2 ml of solution III (Folin- Ciocalteau reagent) was added and optical density measured after 20 minutes at 700 nm in a Photochem-8 absorptiometer. A standard calibration curve was prepared using bovine serum albumin (BSA, GENEI) as the standard.

Determination of sugar fraction:

Reducing sugars

Reducing sugars were estimated by the method of Nelson (1944). A suitable aliquot from the supernatant (obtained after fixation) was made to 5 ml with distilled water, followed by the addition of 1ml of mixed copper reagent, A and B in the ratio 50:1. The mixture was heated to 100^{o}C for 20 minutes over a water bath. After cooling 1ml of arsenomolybdate reagent was added. The mixture was thoroughly shaken and the volume made to 25 ml with distilled water. Absorbance was measured at 520 nm in a Photochem-8 absorptiometer. D-Glucose was used as the standard for the preparation of calibration curve.

Total sugars

Total sugars were estimated by the method of Nelson (1944) after enzymatic conversion of non-reducing sugars into reducing sugars with invertase. To a suitable aliquot 1ml of 0.2% invertase concentrate (BDH) was added. A drop of toluene was layered on the solution and kept overnight at 25^{o}C. D-Glucose was used as the standard for the preparation of calibration curve.

Non reducing sugars

Non-reducing sugars were calculated as the difference between total and reducing sugars.

Determination of α-amino acid content:

α-amino acids were estimated by the method of Rosen (1957). A suitable aliquot of alcohol soluble fraction was made to 1ml with distilled water and 0.5 ml of cyanide – acetate buffer (pH=5.4) was added followed by 0.5 ml of 3% ninhydrin freshly prepared in ethylene glycol mono ethyl ether (methyl cellusolve). The contents were heated for 15 minutes at 100^{o}C over a boiling water bath. After removing the tubes from the water bath 5 ml of isopropyl alcohol: water (1:1 v/v) diluent was immediately added and the contents shaken vigorously. The tubes were allowed to cool at room temperature. Absorbance was measured at 570 nm in a Photochem-8 absorptiometer. Calibration curve was prepared using glycine as the standard.

Determination of total phenolic content:

Total phenols were estimated by the method of Swain and Hillis (1959). A suitable aliquot of alcohol soluble fraction was diluted to 7 ml with distilled water followed by the addition of 0.5 ml of Folin – Denis reagent. After 3 minutes 1 ml of saturated solution of sodium carbonate was added and the total volume was made to 10 ml with distilled water.

Absorbance was measured after 30 minutes at 725 nm in a Photochem-8 absorptiometer. Gallic acid was used as the standard for the preparation of calibration curve.

Procedure for SDS-PAGE:

1 g tepal tissue was homogenized in 1 ml of 0.1 M phosphate buffer (pH= 7.2 – 7.4) adding 0.1 g of PVP. The mixture was centrifuged at 5000xg at -5^{o}C in a refrigerated centrifuge (Remi K-24) for 15 minutes. The supernatant was collected in eppendorf tubes and used for SDS-PAGE. The extracted protein mixture was denatured by mixing equal volumes of protein mixture and 2X sample loading buffer (0.5 M Tris pH 6.8, 10% SDS, 10% glycerol, 5% β- mercaptoethanol, 0.1% bromophenol blue). The mixture was incubated in boiling water for 5-7 minutes. The concentration of the protein was determined in both the original extracts and the TCA precipitated samples by the method of Lowry *et al.,* (1951) using BSA as the standard.

One dimensional vertical gel electrophoresis was carried out according to the method as described by Ausbel *et al.,* (1989). Slab gels 0.7 mm thick contained 12% resolving gel {(Acrylamide + bisacrylamide), (1.5 M Tris pH 8.8), 10% SDS, TEMED, 10% Ammonium persulphate (APX)} and 3% stacking gel {(Acrylamide + bisacrylamide), (0.5 M Tris pH 6.8), 10% SDS, TEMED, 10% APX}. 80 µl of the SDS- denatured protein extract was loaded into each lane. Electrophoresis was carried out at room temperature with a constant voltage of 50 V during stacking and 150 V during running. GENEI molecular weight standards were used for determining approximate molecular weights {Myosin, Rabbit muscle 205,000; phosphorylase b 97,400; Bovine serum albumin 66,000; Ovalbumin 43,000; Carbonic anhydrase 29,000; Aprotinin 6,500; Insulin (α and β chains) 3,000}. Following electrophoresis the gels were stained overnight in 0.25% coomassie brilliant blue in 45% methanol: 10% acetic

acid. Gels were destained in 45% methanol: 10% acetic acid, then in 7% methanol: 5% acetic acid.

Statistical analysis of the data:

The values given in the tables represent the mean of several independent replicates. Standard deviation has been computed as $\delta = \sqrt{\frac{\Sigma x^2}{N-1}}$ Differences between various treatments have been calculated by simple analysis of variance and least significant difference (LSD) computed at $P_{0.05}$ using Minitab version 11.

RESULTS

Flower Senescence and Regulation of Vase life in *Narcissus tazetta* cv. Kashmir Local.

Narcissus is a genus of hardy, spring-blooming, bulbous plants in the family Amaryllidaceae. Some species also bloom in autumn like *Narcissus serotinus* flowering at the end of September. *Narcissus viridiflorus* is another autumn flowering species with green flowers. It grows in rocky places found chiefly in Spain, Morocco and Gibralter where it requires a warm dormant period prior to flower. Several plurals are commonly used for the group viz. "Narcissuses", "Narcissi", and "Narcissus". “Daffodil” is the common English name, sometimes also used for all varieties and is the common name of horticultural prevalence.

There are two derivations of the name *Narcissus*. One is that of the youth of Greek mythology called Narcissus, who became so obsessed with his own reflection as he kneeled and gazed into a pool of water that he fell into the water and drowned. In Greece these flowers are commonly found growing near pools of water and since the flowers naturally face down, it appears as though they are staring at their own reflections. The other derivation is that the plant is named after its narcotic properties. Also the term “Narcissism” in Psychology refers to the personality trait of egotism, which includes the set of character traits concerned with self-image ego.

Narcissi are primarily native to the Mediterranean region and are most commonly found growing in the wild in Europe, particularly in Spain and Portugal. As early as the sixteenth century, people especially the English and the Dutch become interested in the *Narcissus.* Today, the two countries are known world-over as the leaders in Narcissi cultivation.

The *Narcissus* flower is perceived quite differently in the east than in the west. Whereas in the west, the *Narcissus* flower is seen as a symbol of vanity, in China, the same flower is seen as a symbol of wealth and good fortune. As the flower blooms early spring, it has also become a symbol of Chinese new year. *Narcissus* bulb carving and cultivation is even an art akin

to Japanese Bonsai. Having, one of the sweetest fragrances of any flower it is highly revered in the Chinese culture. In some countries the yellow variety of *Narcissus* is associated with Easter.

Earlier reports suggested that the genus *Narcissus* contained around 26 wild species (Third, 1976). The number has been reported to be between 50 and 100 including species variants and wild hybrids (Brent and Becky, 2001). The range of forms in cultivation have been heavily modified and extended with new variations available from specialists almost every year. All the species of *Narcissus* have a central trumpet, bowl, or disc shaped corona surrounded by a ring of six floral leaves called the perianth which is united into a tube at the forward edge of the tri-locular ovary. The seeds are black, round and swollen with hard coat. The three outer segments are sepals, and the three inner segments are petals. Though no such distinction is followed and petals and sepals are collectively termed as tepals.

The genus *Narcissus* is divided on the basis of floral attributes into: the Ajax group of daffodils with long trumpets; the short cupped Poeticus group; the bunch-flowered Tazettas; the Incomparabilis, intermediate between Ajax and Poeticus; the Poetaz, between Poeticus and Tazetta; and the jonquils.These plants grow in hills in sun and partial shade, especially in valleys which have well drained soil that is adequately supplied with water throughout the growing season. Propagation is by offsets when dormant or from seeds when ripe, the later taking four years for flowering. Narcissi can be planted from August to November at appropriate depths from 15-20 cm with illumination ranging from full sun to full shade. Narcissi colourfully dress the hills, gardens of the Kashmir valley during spring.

Narcissi are more versatile in the garden than tulips and hyacinths and can get well adjusted as perennial plants in the garden. Narcissi provide elegant diplay when combined with early-flowering perennial plants such as *Euphorbia, Primula, Pulmonaria, Pulsatilla, Alchemilla Brunnera* and late-

flowering species of *Helleborus*. Lovely combinations can be realized by planting Narcissi with shrubs that flower simultaneously. Narcissi can also be planted in the neighbourhood of evergreen shrubs and conifers. Here, their bright yellow and white colours provides a cheery contrast.

The genus *Narcissus* is not only sought after for its beautiful flowers but also for the varied quality medicines and alkaloids. In kampo (traditional Japanese medicine) wounds are treated with *Narcissus* root and wheat flour paste. Roman physician Aulus Cornelius Celsus listed *Narcissus* root in *De Medicina* among medical herbs, described as emollient, erodent and "powerful to disperse whatever has collected in any part of the body". Bulbs of almost all *Narcissus* varieties contain the poisonous alkaloid lycorine. One of the most common dermatitis problems for florists, "Daffodil itch" involves dryness, fissures, scaling and erythema in the hands, often accompanied by thickening of the skin beneath the nails.

During the present study experiments have been conducted on principal species belonging to the basic Tazettas i.e. *Narcissus tazetta* cv. Kashmir Local, the Ajax group i.e. *Narcissus pseudonarcissus* cv. Emperor and the Poeticus group i.e. *Narcissus poeticus* cv. Pheasant's Eye.

The species *Narcissus tazetta* derives its name from the word "Tazetta" which in Italian means "little cups" with reference to the centrally placed little yellow corona cups. It is the most widespread species of the genus *Narcissus* found in region with Meditteranean type of climate extending from Spain, Iran, Kashmir to China and Japan (Coats, 1971). Ancient Egyptians used "Tazetta" in their funeral wreaths, 3000 year old specimens of flowers have been found preserved in tombs. It is also called new year lily, sacred lily, good luck flower or water – fairy flower.

Beauty, delicate fragrance and presence of a multi floret head places "Tazetta" superior to other Narcissi species. The bunch flowered "Tazetta" bears an average of 2 to 7 flowers per scape, entitling them to be pronounced

as “Polyanthus Narcissus” also. In Kashmir *Narcissus tazetta* grows wild and is one of the earliest spring blooming species.

Narcissus tazetta has extensive potential to qualify as an ornamental cut flower. It was in this perspective that the work was undertaken to identify the pattern of flower development and senescence in this species. Attempts were made to develop efficient storage techniques by studying the effect of short term cool storage in the species. The effect of protein synthesis inhibitor viz. cycloheximide (CHI) was studies on vase life and postharvest performance as a future strategy to modulate protein synthesis or degradation.

Experiment 1.1

Physiological and biochemical changes associated with the flower development and senescence in *Narcissus tazetta* cv. Kashmir Local.

Experimental

Flowers of *N. tazetta* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were designated as tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI) (Plate 1.1.1, Figs. 1- 2). Visible changes were recorded throughout flower development and senescence. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the electrical conductivity of leachates (μS) from tepal discs (5mm in diameter) punched from outer regions of perinath of five different flowers incubated in 15ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents 1g chopped material of tepal tissues, was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times at 1000 rpm. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α- amino acids and total phenols as described in materials and methods. Soluble proteins were extracted from 1 g of the tepal tissue drawn separately from five different flowers at each of the six stages and suitable aliquots were used for the estimation as described in material and methods. Electrophoretic profiles were studied at various stages of flower development and senescence. 80 μL of the SDS- denatured protein extract was loaded into each lane. Each value represented in the tables corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: In *N. tazetta* the greenish buds open into white flowers and flower senescence was marked by the turgor loss in the perianth followed by complete wilting. The average life span of an individual flower after it opens fully is about 5 days (Plate 1.1.1, Figs. 1- 2).

Floral diameter: Flower diameter increased as the flower development progressed up to stage IV to V and declined sharply thereafter as the floral development progressed to senescence up to stage VI (Table 1.1.1; Text Fig.1.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage V and registered a sharp decline thereafter as the senescence progressed up to stage VI. The water content at various stages of floral development and senescence was found to be more or less same when the data was expressed on percent fresh mass basis (Table 1.1.1; Text Fig.1.1.1, B, C and D).

Membrane permeability: Membrane permeability estimated as electrical conductivity of ion leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages. Almost consistent steady increase in the conductivity of ion leachates was registered up to stage V after which there was a considerable increase in ion leachates during final phase of senescence at stage VI (Table 1.1.1; Text Fig.1.1.1, E).

Reducing Sugars: The tissue content of reducing sugars increased consistently during flower development up to stage IV and declined thereafter (Table 1.1.2; Text Fig.1.1.2, F). When expressed on per flower basis the reducing sugar content in the tepal tissues increased progressively from stage I to stage V after which a sharp decline was noticed in the reducing sugar content at stage VI (Table 1.1.2). On dry mass basis a progressive increase in the reducing sugar content was noticed up to stage IV which was followed by a steady decline thereafter. The decline in the

reducing sugar content was marked as the flower senescence progressed from stage V to VI (Table 1.1.3).

Non-reducing sugars: The non-reducing sugar content decreased consistently up to stage V followed by a slight increase thereafter at stage VI (Table 1.1.2; Text Fig.1.1.2, G). When the data was expressed on per flower basis the non-reducing sugar content was more or less maintained up to stage III, followed by a slight increase thereafter up to stage V and decline at stage VI (Table 1.1.2). On dry mass basis the non-reducing sugar content was by and large maintained up to stage V followed by a decline thereafter (Table 1.1.3).

Total sugars: The total sugars increased during flower development from stage I to IV and declined thereafter (Table 1.2; Text Fig.1.1.2, H). On per flower basis the total sugar content increased progressively from stage I to stage V and declined thereafter during senescence (Table 1.1.2). On dry mass basis the total sugar content increased progressively from stage I to IV and declined thereafter as the senescence progressed from stage IV to VI (Table 1.1.3).

Soluble proteins: The concentration of soluble proteins registered a consistent decline during flower development up to stage IV followed by an increase at stage V after which a decline in the soluble protein concentration was noticed at stage VI (Table 1.1.2; Text Fig.1.1.3, I). On per flower basis the soluble protein content showed an increasing trend up to stage V followed by a decrease thereafter at stage VI (Table 1.1.2). On dry mass basis the soluble protein content was more or less maintained up to stage V followed by a sharp decline during senescence at stage VI (Table 1.1.3)

α- amino acids: The α-amino acid content increased up to stage IV followed by a slight decrease at stage V and an increase thereafter during senescence at stage VI (Table 1.1.2; Text Fig.1.1.3, J). On per flower basis the amino acid content increased consistently up to stage V followed by a decline

thereafter at stage VI (Table 1.1.2). On dry mass basis α-amino acid content showed a progressive increase from up to stage IV, followed by a slight decrease at stage V and an increase thereafter at stage VI (Table 1.1.3).

Phenols: The concentration of total phenols decreased as the flower development progressed from stage I to stage V and increased thereafter at stage VI (Table 1.1.2; Text Fig.1.1.3, K). When expressed on per flower basis the concentration of phenols showed a decrease up to stage III followed by an increase up to stage V and a decline during senescence at stage VI (Table 1.1.2). On dry mass basis the concentration of total phenols was maintained up to stage II, followed by a decline thereafter during flower development and senescence (Table 1.1.3).

Electrophoretic profile: The SDS-PAGE of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent throughout the various stages of flower development and senescence particularly polypeptides of 95.4, 54.9 and 25.1 kDa. Some polypeptides decreased significantly up to stage IV include polypeptides with molecular mass of 11.4 and 9.5 kDa. A new polypeptide having the molecular mass of 7.5 kDa showed up as a bright band at stage VI (Plate 1.1.2).

Table 1.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Narcissus tazetta* cv. Kashmir Local (Each value is a mean of 10 independent replicates, figures in parentheses represents values on percent basis).

Stages of flower development	Floral diameter (cm)	Fresh mass flower $^{-1}$ (g)	Dry mass flower $^{-1}$ (g)	Water content flower $^{-1}$ (g)	Conductivity of leachates (µs)
I (tight bud stage)	0.50 ± 0.08	0.278 ± 0.005	0.050 ± 0.0008	0.228 ± 0.004 (82.04)	5.16 ± 0.15
II (loose bud stage)	0.82 ± 0.08	0.335 ± 0.001	0.054 ± 0.001	0.280 ± 0.002 (83.73)	6.96 ± 0.41
III (half open stage)	1.06 ± 0.13	0.437 ± 0.005	0.068 ± 0.0005	0.368 ± 0.006 (84.37)	8.10 ± 0.20
IV (fully open stage)	3.44 ± 0.08	0.554 ± 0.004	0.076 ± 0.0021	0.478 ± 0.006 (86.28)	10.56 ± 0.50
V (partially senescent stage)	4.24 ± 0.25	0.679 ± 0.025	0.093 ± 0.002	0.586 ± 0.025 (86.30)	13.93 ± 0.37
VI (senescent stage)	2.96 ± 0.11	0.384 ± 0.002	0.063 ± 0.002	0.321 ± 0.004 (83.59)	20.70 ± 0.72

Table 1.1.2: Sugars, proteins, α-amino acids and total phenols (expressed as mg g^{-1} fresh mass during development and senescence in flowers of *Narcissus tazetta* cv. Kashmir Local (Each value is a mean of 5 independent replicates, figures in parentheses represents values on mg $flower^{-1}$ basis).

Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	9.92 ± 0.32 (2.75)	15.41 ± 0.16 (4.28)	25.33 ± 0.28 (7.04)	4.33 ± 0.19 (1.20)	0.15 ± 0.01 (0.044)	9.29 ± 0.19 (2.58)
II	13.22 ± 0.97 (4.43)	12.60 ± 0.66 (4.22)	25.83 ± 0.57 (8.65)	3.87 ± 0.12 (1.29)	0.20 ± 0.01 (0.067)	8.66 ± 0.31 (2.90)
III	16.53 ± 0.80 (7.22)	10.96 ± 0.52 (4.79)	27.50 ± 0.86 (12.01)	3.45 ± 0.14 (1.51)	0.25 ± 0.004 (0.110)	5.91 ± 0.26 (2.59)
IV	18.02 ± 0.18 (9.98)	10.97 ± 0.35 (6.07)	29.00 ± 0.50 (16.06)	3.16 ± 0.07 (1.75)	0.26 ± 0.007 (0.147)	5.62 ± 0.12 (3.11)
V	17.06 ± 0.18 (11.58)	9.76 ± 0.25 (6.63)	26.83 ± 0.28 (18.21)	3.91 ± 0.07 (2.65)	0.22 ± 0.004 (0.152)	4.95 ± 0.14 (3.36)
VI	15.25 ± 0.36 (5.85)	11.08 ± 0.33 (4.25)	26.33 ± 0.28 (10.11)	2.91 ± 0.07 (1.12)	0.30 ± 0.015 (0.117)	6.0 ± 0.33 (2.30)

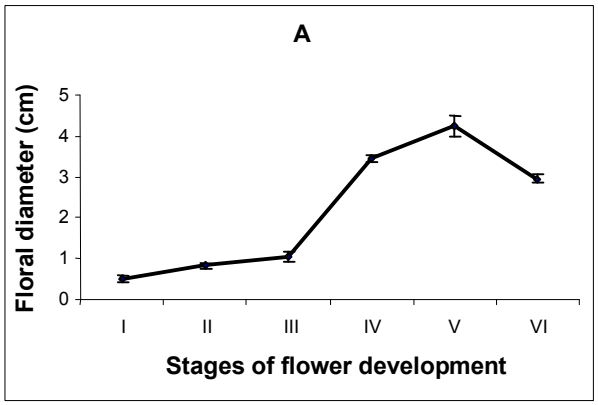
Table 1.1.3: Sugars, proteins, α-amino acids and phenols expressed as on dry mass basis (mg g^{-1} DM) during development and senescence in flowers of *Narcissus tazetta* cv. Kashmir Local (Each value is a mean of 5 independent replicates).

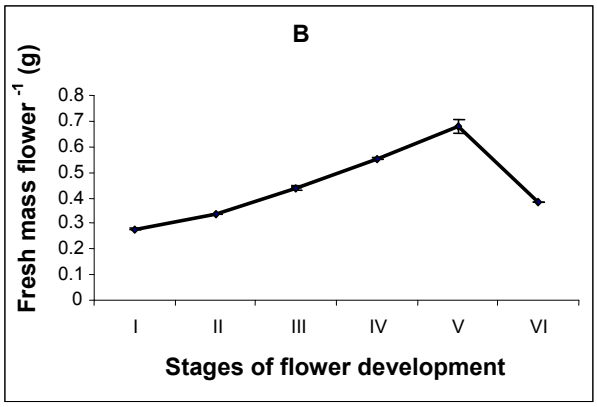
Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	55.15 ± 1.77	85.69 ± 0.89	140.85 ± 1.60	24.09 ± 1.06	0.88 ± 0.06	51.66 ± 1.06
II	82.05 ± 6.06	78.20 ± 4.09	160.26 ± 3.58	24.03 ± 0.77	1.24 ± 0.07	53.76 ± 1.95
III	106.25 ± 5.17	70.47 ± 3.39	176.72 ± 5.56	22.22 ± 0.92	1.62 ± 0.02	38.02 ± 1.67
IV	131.40 ± 1.34	79.98 ± 2.56	211.39 ± 3.64	23.08 ± 0.52	1.94 ± 0.05	41.0 ± 0.91
V	124.60 ± 1.34	71.30 ± 1.84	195.91 ± 2.10	28.59 ± 0.52	1.63 ± 0.03	36.20 ± 1.05
VI	92.97 ± 2.25	67.53 ± 2.05	160.50 ± 1.75	17.77 ± 0.43	1.86 ± 0.09	36.57 ± 2.01

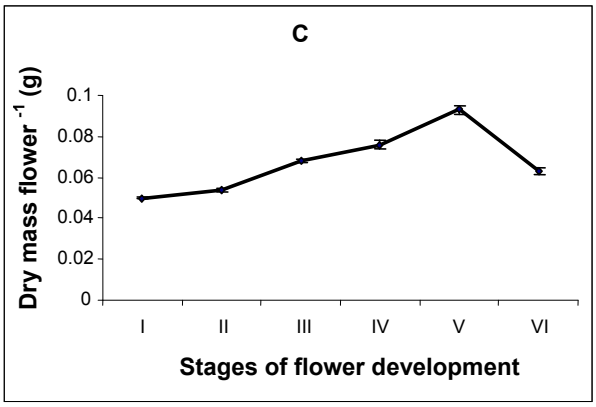
Fig. 1.1.1

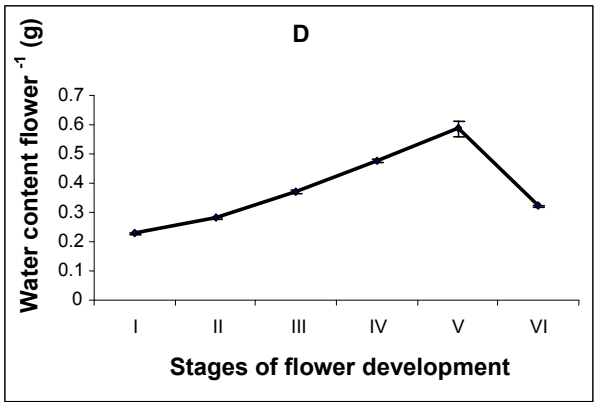
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in flowers of *Narcissus tazetta* cv. Kashmir Local at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
0
1
2
3
4
5
I
II
III
IV
V
VI
Stages of flower development


B
Fresh mass flower -1 (g)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower -1 (g)
0
0.02
0.04
0.06
0.08
0.1
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
I
II
III
IV
V
VI
Stages of flower development

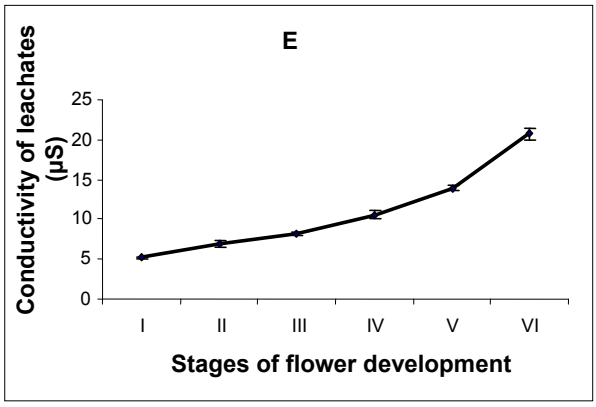

E
Conductivity of leachates (µS)
0
5
10
15
20
25
I
II
III
IV
V
VI
Stages of flower development

Fig. 1.1.1

Fig. 1.1.2

Changes in reducing sugars (F), non – reducing sugars (G) and total sugars (H), in tepal tissues in flowers of *Narcissus tazetta* cv. Kashmir Local at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

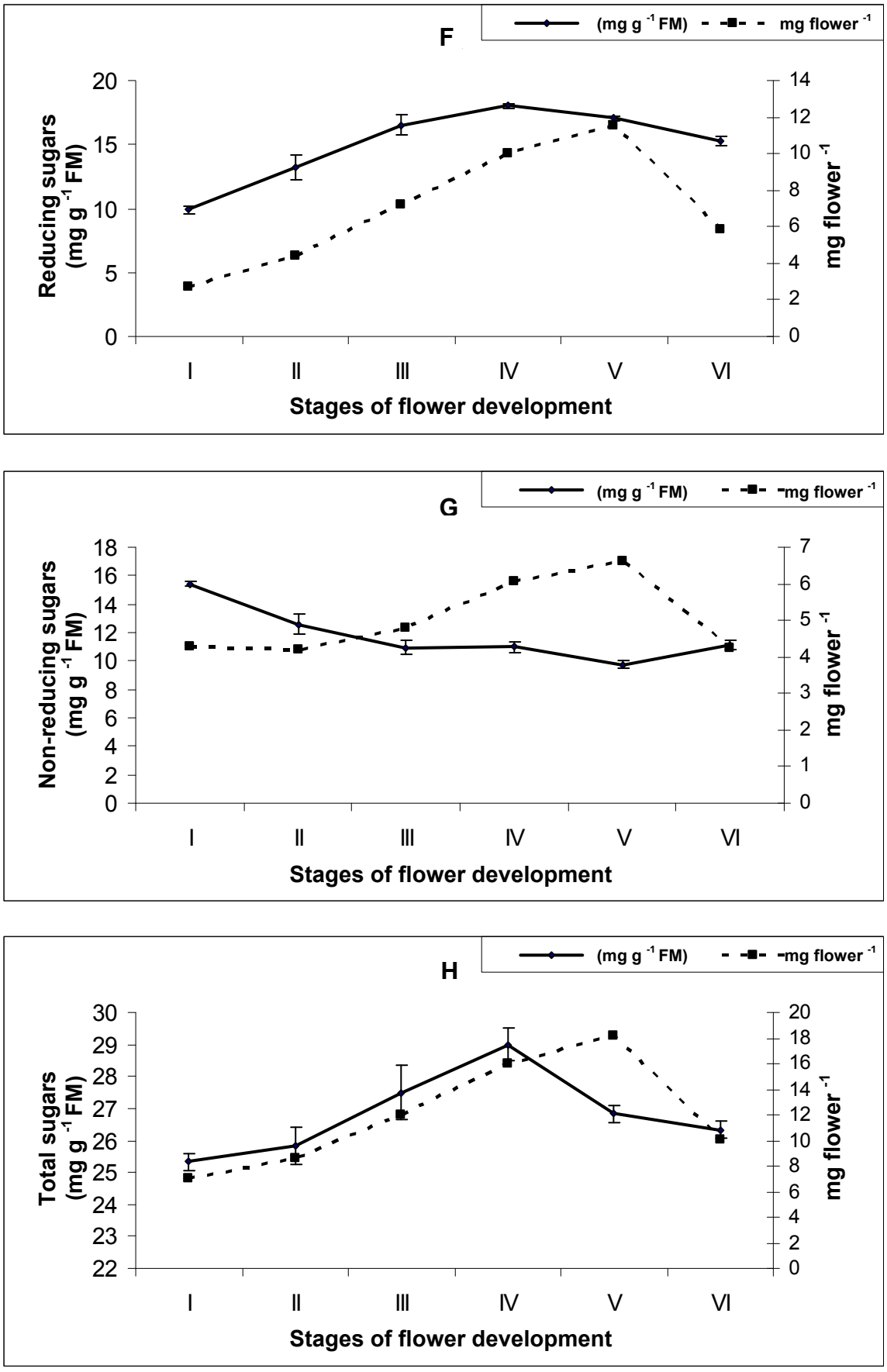

F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
H
(mg g -1 FM)
mg flower -1
Total sugars (mg g -1 FM)
mg flower -1
Stages of flower development

Fig. 1.1.2

Fig. 1.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in tepal tissues in flowers of *Narcissus tazetta* cv. Kashmir Local at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

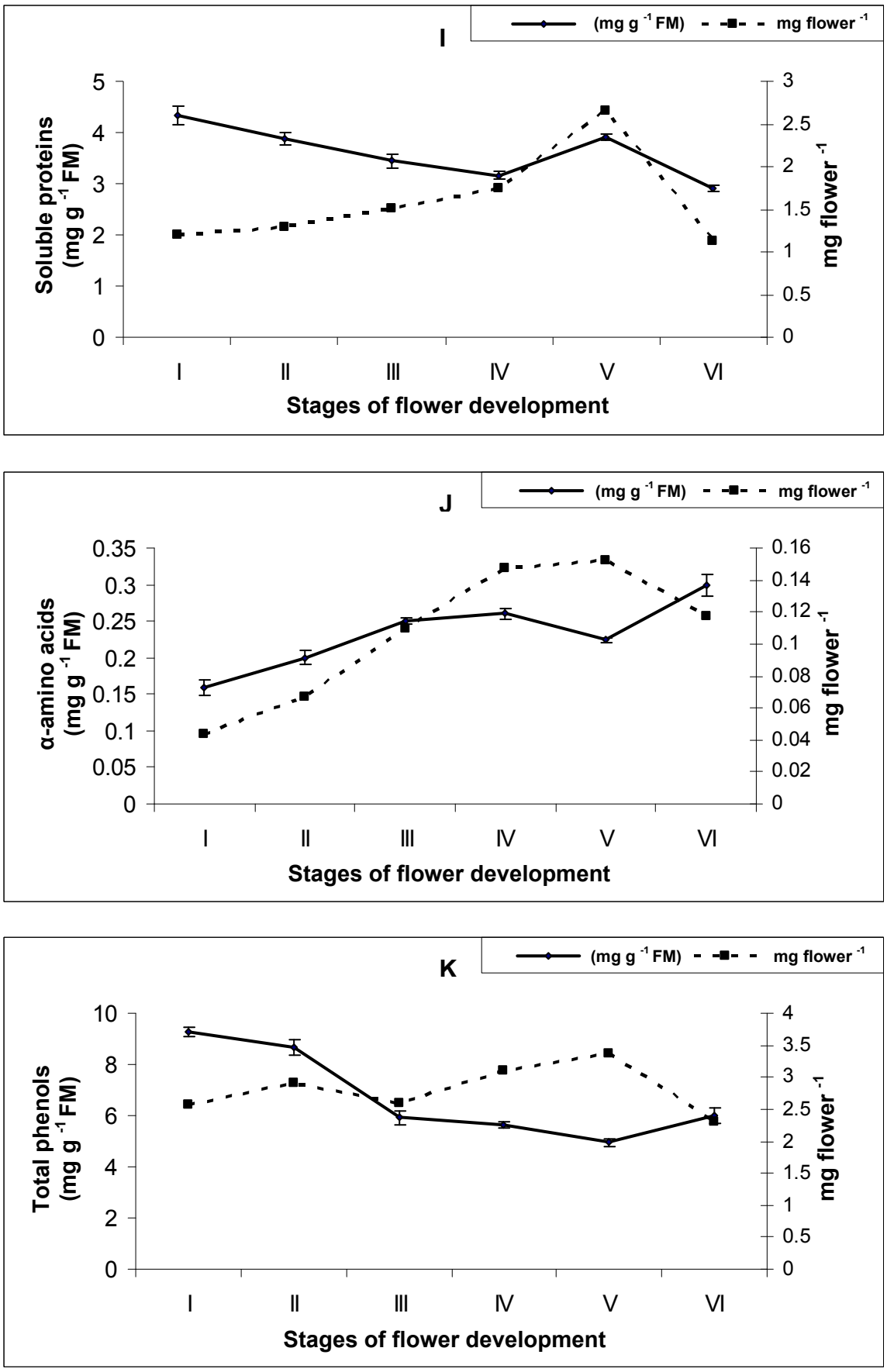

I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
0
0.5
1
1.5
2
2.5
3
I
II
III
IV
V
VI
Stages of flower development
J
(mg g -1 FM)
mg flower -1
α-amino acids (mg g -1 FM)
mg flower -1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
I
II
III
IV
V
VI
Stages of flower development
K
(mg g -1 FM)
mg flower -1
Total phenols (mg g -1 FM)
mg flower -1
0
2
4
6
8
10
0
0.5
1
1.5
2
2.5
3
3.5
4
I
II
III
IV
V
VI
Stages of flower development

Fig. 1.1.3

Plate 1.1.1

Fig. 1: Stages of scape development in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged scapes at successive stages of development and senescence. Stage I to VI in the figure represent, green spathe stage (I), open spathe stage (II), tight bud stage (III), loose bud stage(IV), open flower stage (V) and senescent stage (VI).

Fig.2: Stages of flower development and senescence in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged flowers at successive stages of development and senescence. Stages I to VI in the figure represent, tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI).

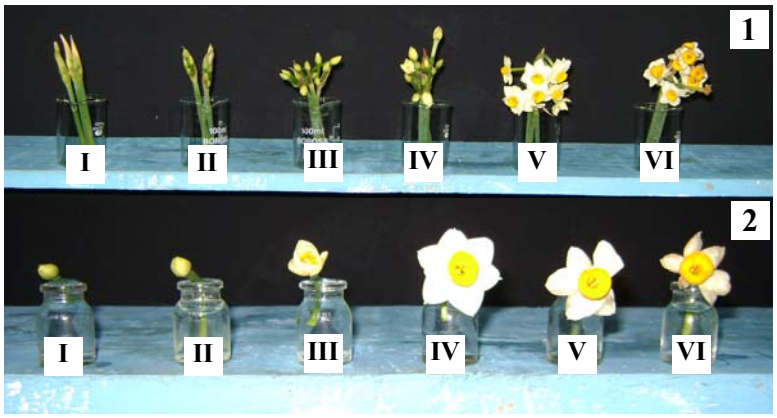


Plate. 1.1.1

Plate 1.1.2

Fig.: 12% SDS – PAGE, profile of equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Narcissus tazetta* cv. Kashmir Local. The gel was stained coomassie blue. Number above the lanes corresponds to developmental stages. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

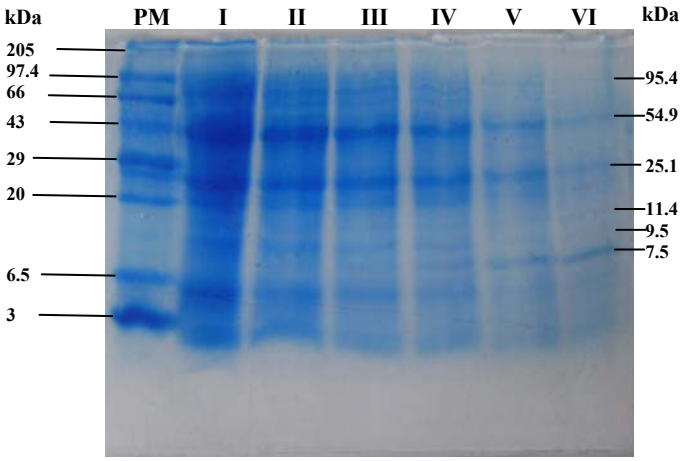

kDa
PM
I
II
III
IV
V
VI
kDa
205
97.4
66
43
29
20
6.5
3
95.4
54.9
25.1
11.4
9.5
7.5

Plate. 1.1.2

EXPERIMENT 1.2

Effect of postharvest wet storage (PHWS) at different temperatures regimes 5, 10 and room temperature (RT = 12 ± 2^0C) for 72 h and subsequent transfer to distilled water (DW), sucrose, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Experimental

Scapes of *N. tazetta* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 20 cm. The scapes were held in distilled water (DW) in separate buckets and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (12 ± 2^0C). After 72 h the scapes were kept at room temperature and transferred to 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC (0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and a relative humidity RH of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to holding solution and was assessed to be terminated when 50 % flowers had senesced which was characterized by loss of turgor followed by wilting of tepals. Number of blooms per scape was recorded up to day 5 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates form tepal discs, fresh and dry mass of flowers were recorded on day 4 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and

phenolics were also estimated on day 4 after transfer. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: The scapes wet stored at RT had already bloomed during the storage and senesced by day 6 of the transfer (Plate. 1.2.1; Figs. 1-2). Blooming during storage was least in the scapes previously wet stored at 5 and 10^{o}C and showed tepal senescence on the day 9 and 12 of transfer to a particular holding solution (Plate. 1.2.2; Figs. 1- 3). Senescence was assessed when 50% of flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals (Plate.1.2.3; Figs. 1- 3).

Vase life: The average vase life of scapes previously wet stored at different temperature regimes i.e. RT, 10 and 5^{0}C before transfer to DW was 3, 7 and 10 days respectively whereas the vase life of scapes transferred to SUC was 5, 8 and 11 days respectively. Vase life of scapes stored at each of the temperature regimes was significantly enhanced when transferred to SUC + 8-HQS and was 6, 9 and 12 days respectively (Table 1.2.1; Text Fig 1.2.1, A).

Number of blooms per scape: The number of blooms per scape as also the percent blooming increased in all the treatments with progression in time irrespective of the transfer to various holding solutions. The scapes previously wet stored at RT and 10^{o}C for 72 h exhibited approximately 100 percent blooming by day 2 of the transfer irrespective of the various holding solutions. Maximum and sustained blooming up to day 5 was recorded in scapes wet stored at 5^{0}C especially in SUC + 8-HQS (Table 1.2.1; Text Fig. 1.2.1, B)

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression from day 2 to 6 of transfer of scapes to various holding solutions irrespective of the particular

temperature regime and holding solution. The solution uptake was found to be higher in scapes previously wet stored for 72 h at 5 and 10 °C as compared to RT irrespective of the holding solution. A higher solution uptake was recorded in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment (Table 1.2.1; Text Fig. 1.2.2, C); however maximum solution uptake was noticed in scapes previously wet stored at 5°C for 72 h transferred to (SUC + 8- HQS).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs registered a decrease in samples previously wet stored for 72 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of holding solution. However at each of the temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8- HQS as also SUC as compared to samples from corresponding scapes held in DW (Table 1.2.2; Text Fig. 1.2.2, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously wet stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from the corresponding scapes held at RT irrespective of the holding solutions. However, at each of the temperature regimes both fresh and dry mass was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW. The maximum value for fresh and dry mass was recorded in samples from scapes previously wet stored at 5°C for 72 h and transferred to SUC + 8-HQS (Table 1.2.2; Text Figs. 1.2.3, E & F).

Reducing sugars: The reducing sugar content of samples form scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the

temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 1.2.3; Text Fig. 1.2.4, G). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases, but the differences were some what apparent on these particular reference bases (Tables 1.2.3 and 1.2.4). Maximum reducing sugar content was noticed in samples from scapes wet stored at 5^0C for 72 h and transferred to SUC +8-HQS.

Non-reducing sugars: Generally the non-reducing sugar content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes, the non-reducing sugar content was found to be highest in samples form scapes held in SUC+8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 1.2.3; Text Fig. 1.2.4, H). Generally similar trends were obtained when the data was expressed on per flower basis (Table 1.2.3). On dry mass basis the non-reducing sugar content showed a profound increase in samples from scapes previously stored at 5^oC before transfer to sucrose followed by SUC + 8-HQS as compared to the corresponding scapes transferred to DW (Table 1.2.4).

Total sugars: The total sugar content of the samples from scapes previously wet stored at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the total soluble sugar content was found to the be highest in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 1.2.3; Text Fig.1.2.5, I). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis but the differences were profound particularly on dry mass

basis (Table 1.2.4). Maximum total sugar content was registered in samples from scapes previously wet stored for 72 h at 5 °C and transferred to SUC +8-HQS irrespective of the reference base.

Soluble proteins: The soluble protein content of the samples from scapes previously wet stored at 5 and 10^0C for 72 h registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the soluble protein content was found to be higher in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 1.2.3; Text Fig. 1.2.5, J). Almost similar trends were noticed when the data was expressed on per flower basis as also on dry mass basis but the differences showed up clearly on these reference bases (Table 1.2.4). Maximum soluble protein content was found in samples previously wet stored at 5°C for 72h and transferred to SUC +8-HQS.

α-amino acids: A lower content of α- amino acids was maintained in samples from scapes previously wet stored at 5^oC for 72 h as compared to the samples from corresponding scapes held at 10 °C and RT. At each of the temperature regimes lower content of α-amino acids was maintained in samples from scapes held in SUC + 8-HQS (Table 1.2.3; Text Fig. 1.2.6, K). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis (Table 1.2.3 and 1.2.4). The lowest values for amino acid content were generally maintained in samples from scapes previously wet stored at 5°C and transferred to SUC +8-HQS.

Total phenols: A lower content of phenols was registered in samples from scapes previously wet stored for 72 h at 5 and 10°C as compared to the samples from scapes held at RT. At each of the temperature regimes the phenolic content of the samples was more in scapes held in SUC + 8-HQS

followed by SUC as compared to the corresponding scapes held in DW (Table 1.2.3; Text Fig. 1.2.6, L). When the data was expressed on per flower basis or dry mass basis the trends became somewhat more prominent (Tables 1.2.3 and 1.2.4).

Table 1.2.1: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	**Vase life (days)**	**No. of blooms per scape**						**Volume of holding solution absorbed per scape (ml)**		
		Days after treatment								
		0	1	2	3	4	5	2	4	6
RT→DW	3	4.50 (90)	5.00 (100)	-	-	-	-	0.52	1.29	3.34
10 °C→DW	7	3.11 (62)	4.01 (80)	4.90 (98)	-	-	-	1.26	3.06	4.23
5 °C →DW	10	0.11 (2.50)	1.50 (30)	3.09 (62)	4.13 (82)	4.68 (93)	5.00 (100)	1.56	3.30	4.48
RT→SUC(0.15M)	5	4.65 (90)	4.91 (98)	5.00 (100)	-	-	-	1.72	1.78	3.53
10°C→SUC(0.15M)	8	2.90 (62)	4.10 (80)	4.92 (99)	-	-	-	1.76	3.54	4.78
5°C→SUC(0.15M)	11	0.10 (2.51)	1.75 (35)	4.02 (80)	4.65 (93)	4.81 (96)	5.00 (100)	2.30	4.03	4.93
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	6	4.80 (90)	4.94 (99)	5.00 (100)	-	-	-	2.01	3.97	5.25
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	9	2.91 (62)	4.30 (86)	4.90 (97)	-	-	-	2.12	4.26	5.68
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	12	0.10 (2.50)	1.90 (38)	4.10 (82)	4.80 (96)	4.96 (99)	5.00 (100)	2.50	4.58	6.19
LSD at $P_{=0.05}$	0.70	0.05	0.05	0.03	0.03	0.04	-	0.06	0.04	0.02

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 1.2.2: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 of the transfer of cut scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Conductivity of leachates (µS)	Fresh mass (g flower^{-1})	Dry mass (g flower^{-1})
RT→DW	21.00	0.445	0.044
10 °C→DW	14.66	0.489	0.055
5 °C →DW	8.33	0.559	0.057
RT→SUC(0.15M)	19.33	0.509	0.053
10°C→SUC(0.15M)	13.33	0.519	0.064
5°C→SUC(0.15M)	6.66	0.589	0.073
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	16.33	0.522	0.063
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	10.66	0.542	0.068
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	4.66	0.647	0.077
LSD at $P_{=0.05}$	0.80	0.02	0.004

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Table 1.2.3: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 of the transfer of cut scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	2.66 (1.18)	0.79 (0.35)	3.46 (1.54)	5.58 (2.48)	0.66 (0.29)	8.33 (3.70)
10 °C→DW	7.46 (3.65)	0.86 (0.42)	8.32 (4.07)	6.16 (3.01)	0.68 (0.33)	6.06 (2.96)
5 °C →DW	6.93 (3.87)	2.40 (1.34)	9.33 (5.21)	6.58 (3.68)	0.59 (0.32)	5.00 (2.79)
RT→SUC(0.15M)	6.13 (3.12)	0.81 (0.41)	6.93 (3.52)	6.08 (3.09)	0.62 (0.31)	9.06 (4.61)
10°C→SUC(0.15M)	10.66 (5.53)	2.93 (1.52)	13.60 (7.05)	7.08 (3.67)	0.61 (0.31)	6.93 (3.59)
5°C→SUC(0.15M)	8.05 (5.02)	9.33 (5.49)	17.86 (10.52)	7.83 (4.61)	0.50 (0.29)	6.26 (3.69)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	8.50 (4.45)	4.00 (2.08)	12.53 (6.54)	7.33 (3.82)	0.59 (0.30)	9.93 (5.18)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	13.33 (7.22)	2.13 (1.15)	15.46 (8.37)	7.91 (4.28)	0.55 (0.29)	7.73 (4.18)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	14.93 (9.66)	4.80 (3.10)	19.73 (12.76)	9.58 (6.20)	0.44 (0.28)	7.33 (4.74)
LSD at $P_{=0.05}$	0.44	0.18	0.62	0.24	0.01	0.52

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Figures in parentheses represent values on $flower^{-1}$ basis.

Table 1.2.4: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 of the transfer of cut scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	26.96	7.89	35.06	56.46	6.70	84.28
10 °C→DW	66.38	7.46	74.03	54.82	6.08	53.93
5 °C →DW	67.99	23.50	91.52	64.56	5.86	49.36
RT→SUC(0.15M)	58.90	7.77	66.58	58.42	5.99	87.07
10°C→SUC(0.15M)	86.50	23.78	110.28	57.47	4.59	56.22
5°C→SUC(0.15M)	68.85	75.30	144.15	63.20	4.09	50.56
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	70.67	33.14	103.82	60.73	4.88	82.27
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	106.34	16.97	123.22	63.04	4.38	62.61
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	125.47	40.33	165.81	80.52	3.71	60.62
LSD at $P_{=0.05}$	0.49	0.52	0.23	0.18	0.25	0.76

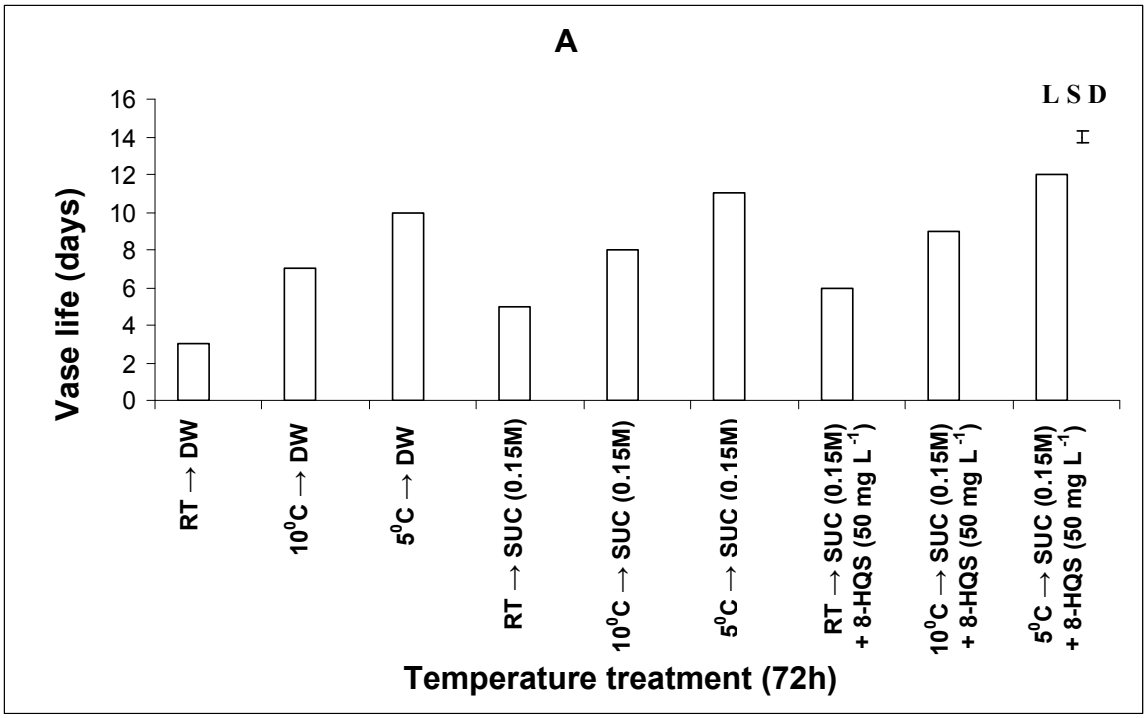
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Fig. 1.2.1

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at P $_{= 0.05.}$


A
L S D
Vase life (days)
16
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

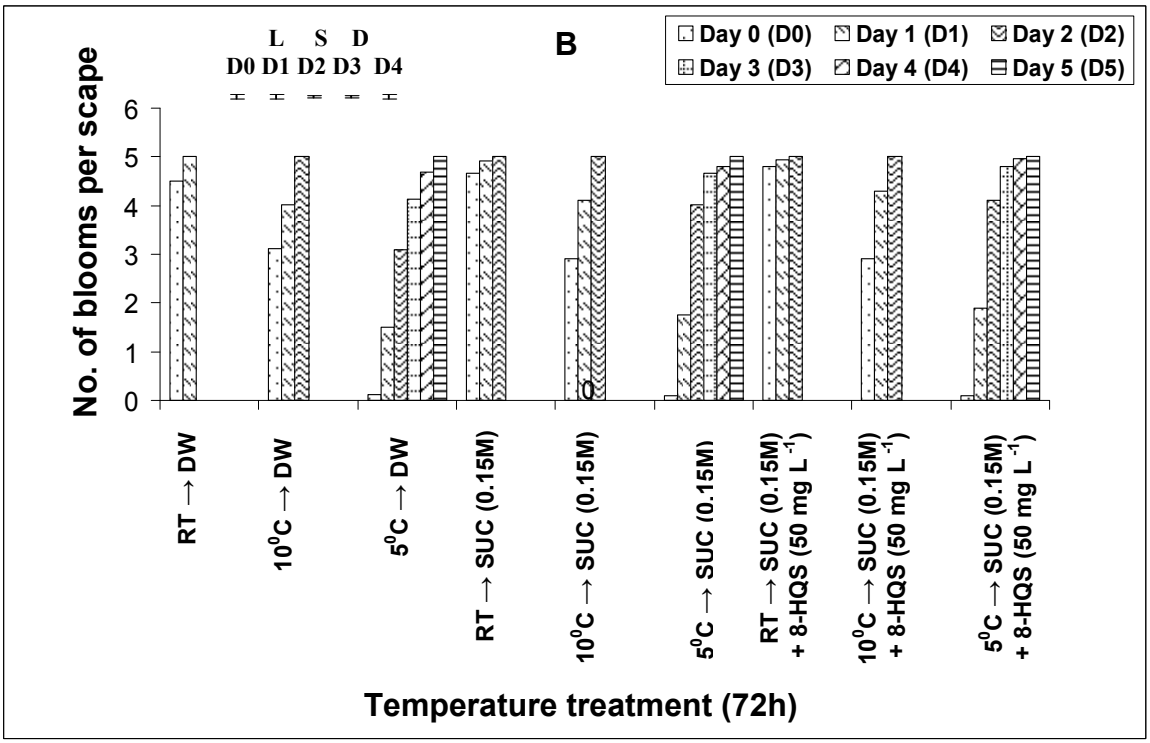
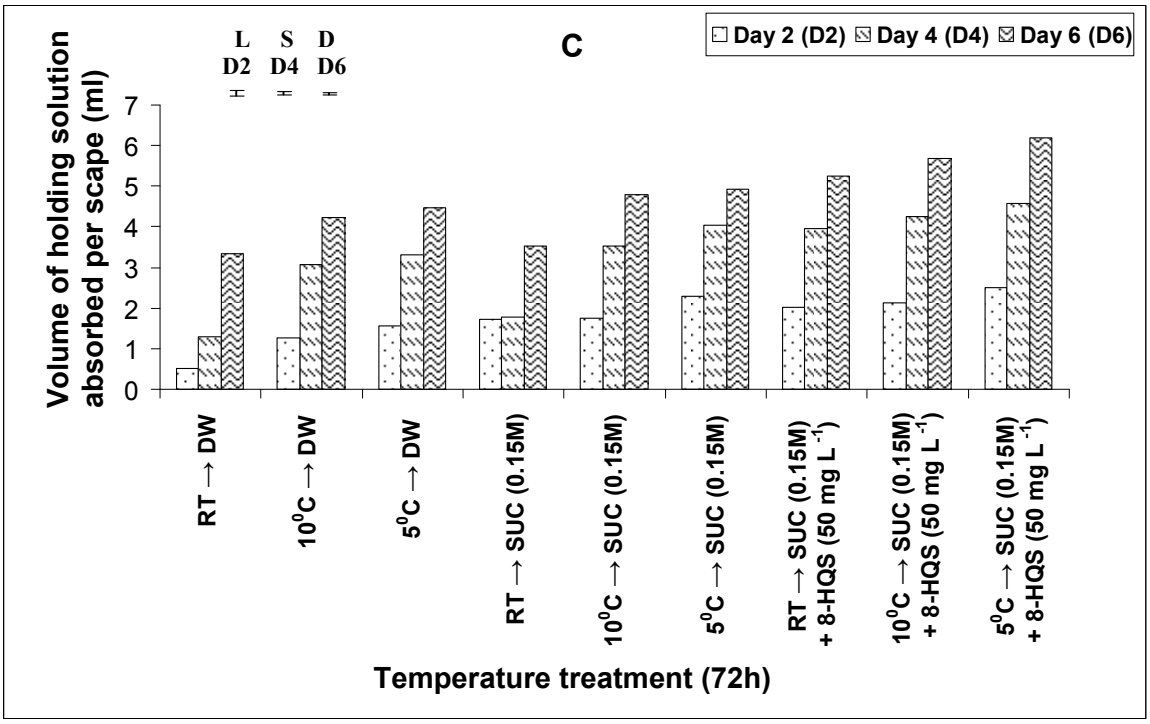

B
L S D
D0 D1 D2 D3 D4
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
Day 5 (D5)
No. of blooms per scape
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.2.1

Fig. 1.2.2

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at P $_{= 0.05.}$


C
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
L D2 H
S D4 H
D D6 H
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
6
7
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

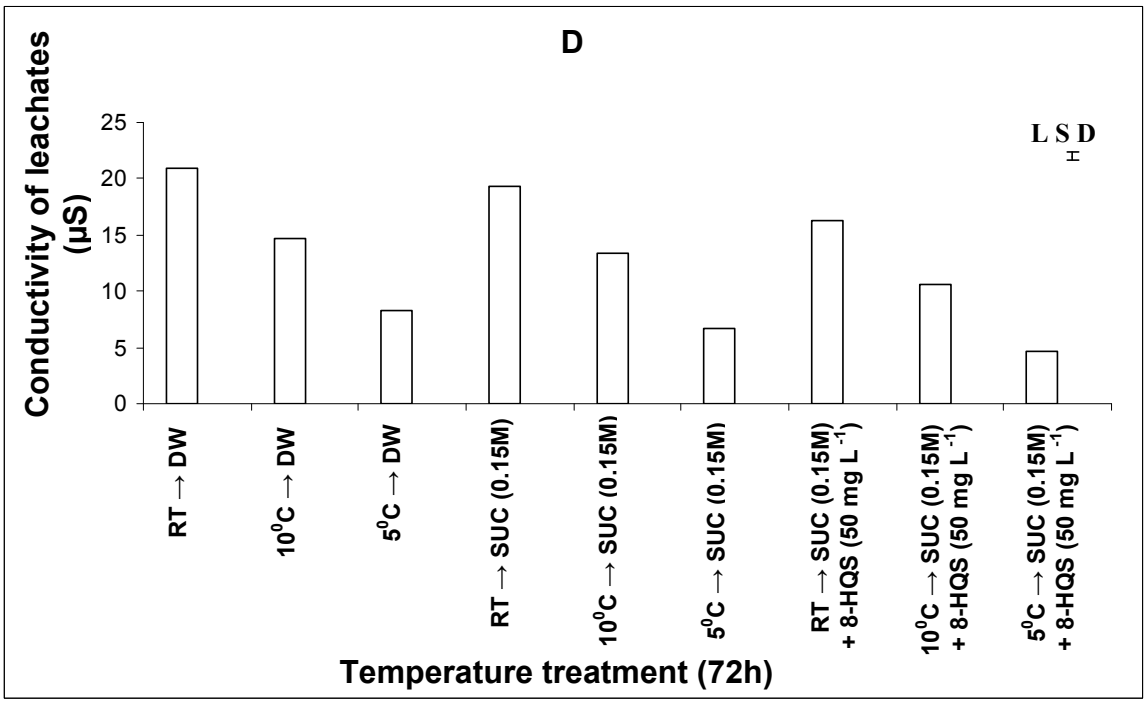
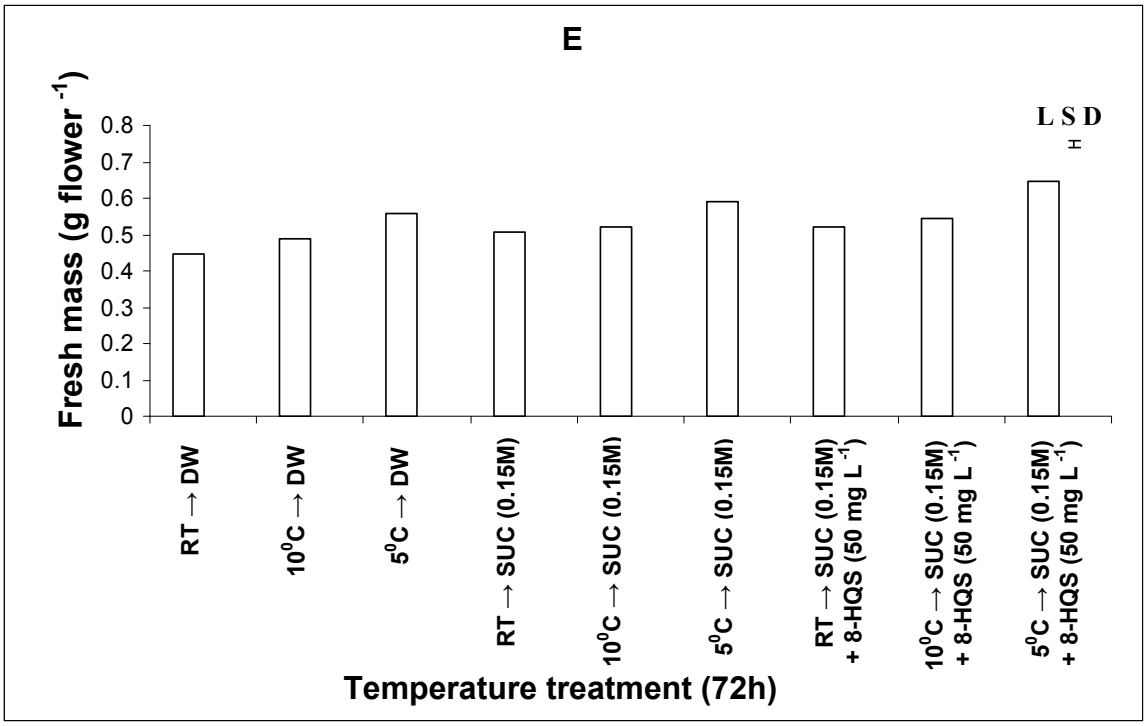

D
Conductivity of leachates (µS)
0
5
10
15
20
25
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.2.2

Fig.1.2.3

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Fresh mass (g flower -1)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
L S D
H
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

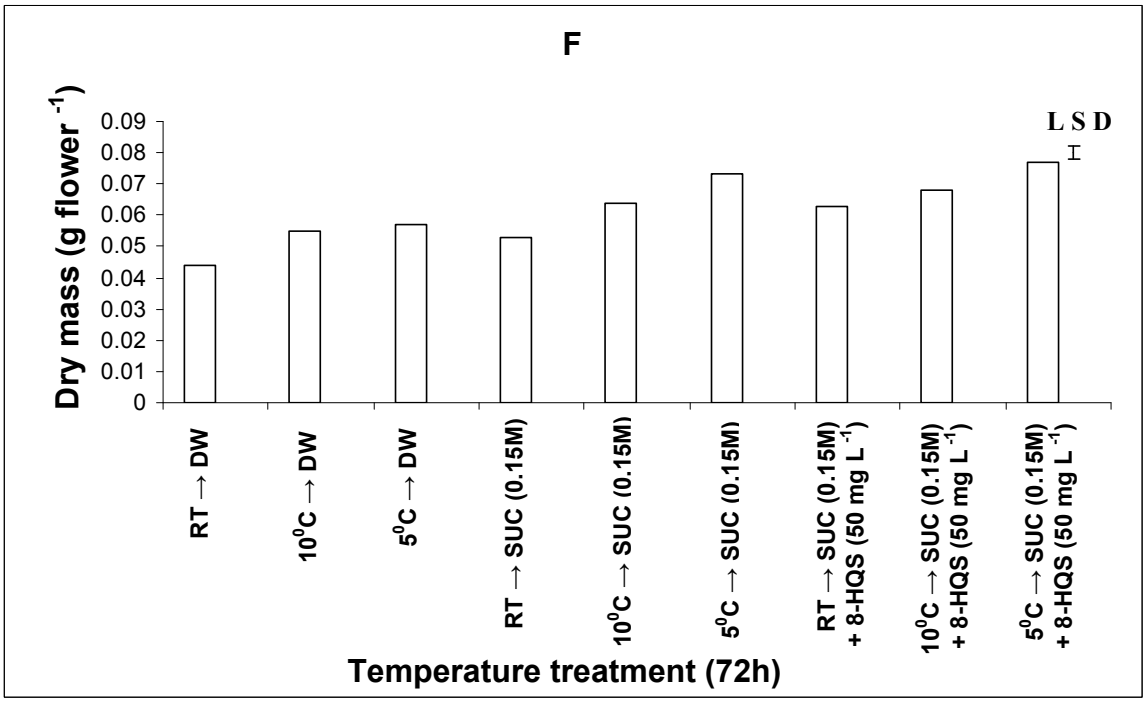
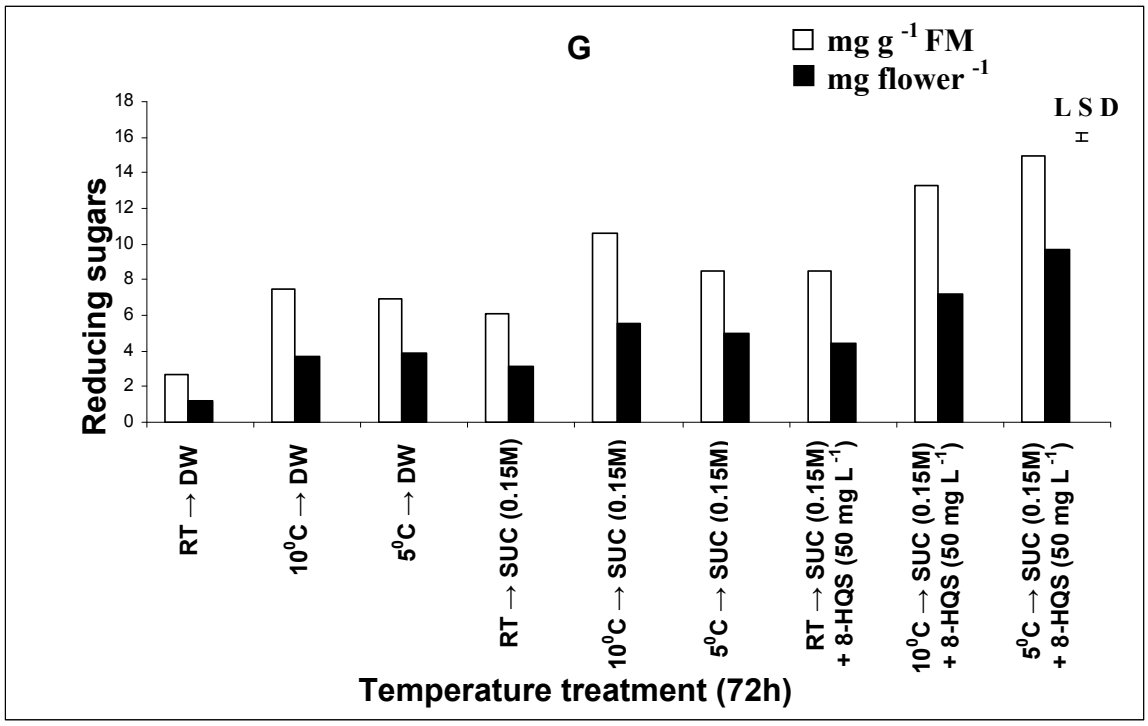

F
Dry mass (g flower -1)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
L S D
I
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.2.3

Fig. 1.2.4

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


G
mg g -1 FM
mg flower -1
L S D H
Reducing sugars
18
16
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10°C → SUC (0.15M) + 8-HQS (50 mg L -1)
5°C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

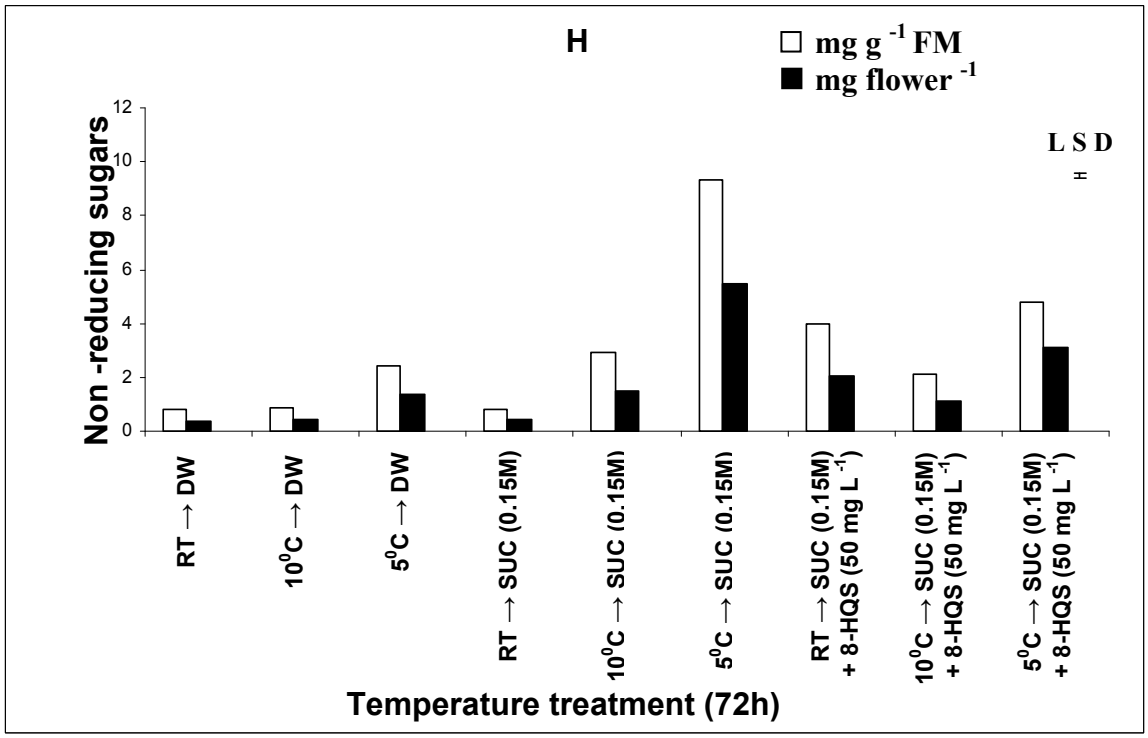
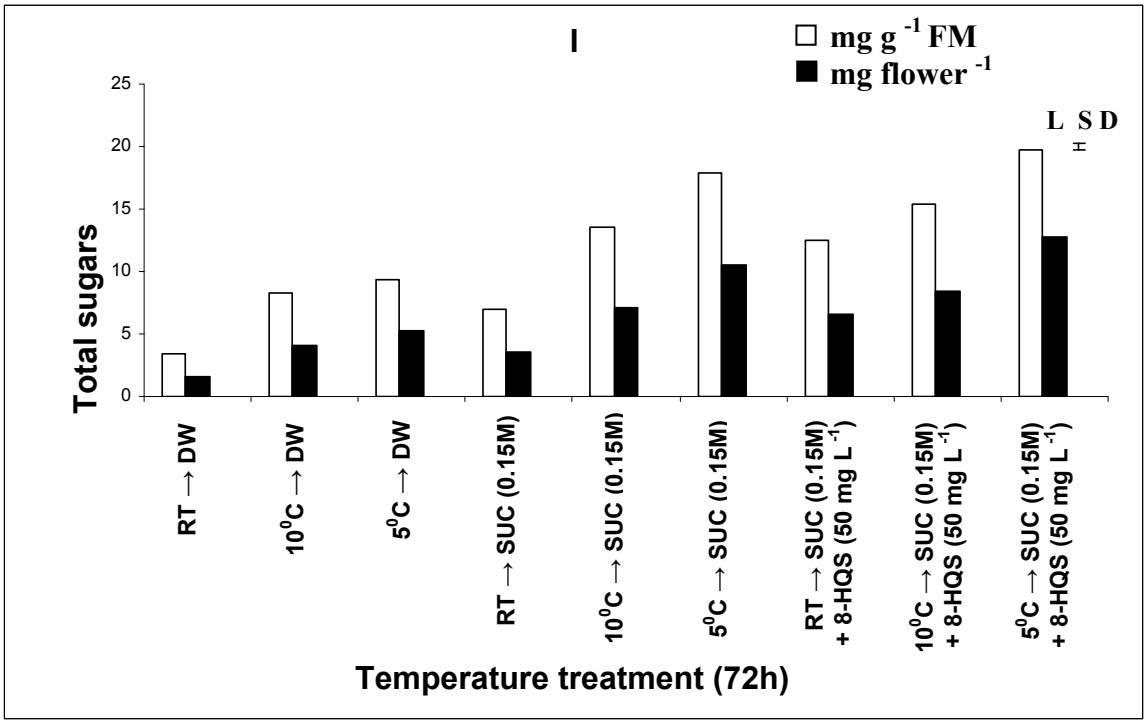

H
mg g -1 FM
mg flower -1
L S D H
Non -reducing sugars
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10°C → SUC (0.15M) + 8-HQS (50 mg L -1)
5°C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 1.2.4

Fig. 1.2.5

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


I
mg g -1 FM
mg flower -1
L S D
H
Total sugars
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10°C → SUC (0.15M) + 8-HQS (50 mg L -1)
5°C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

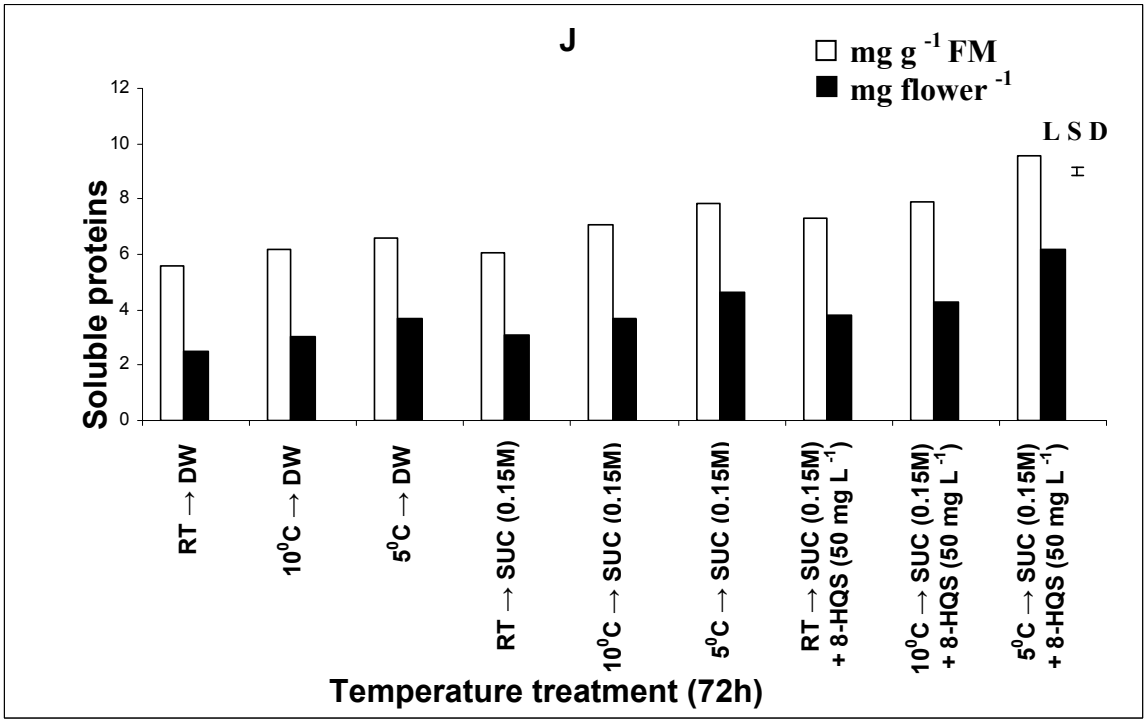
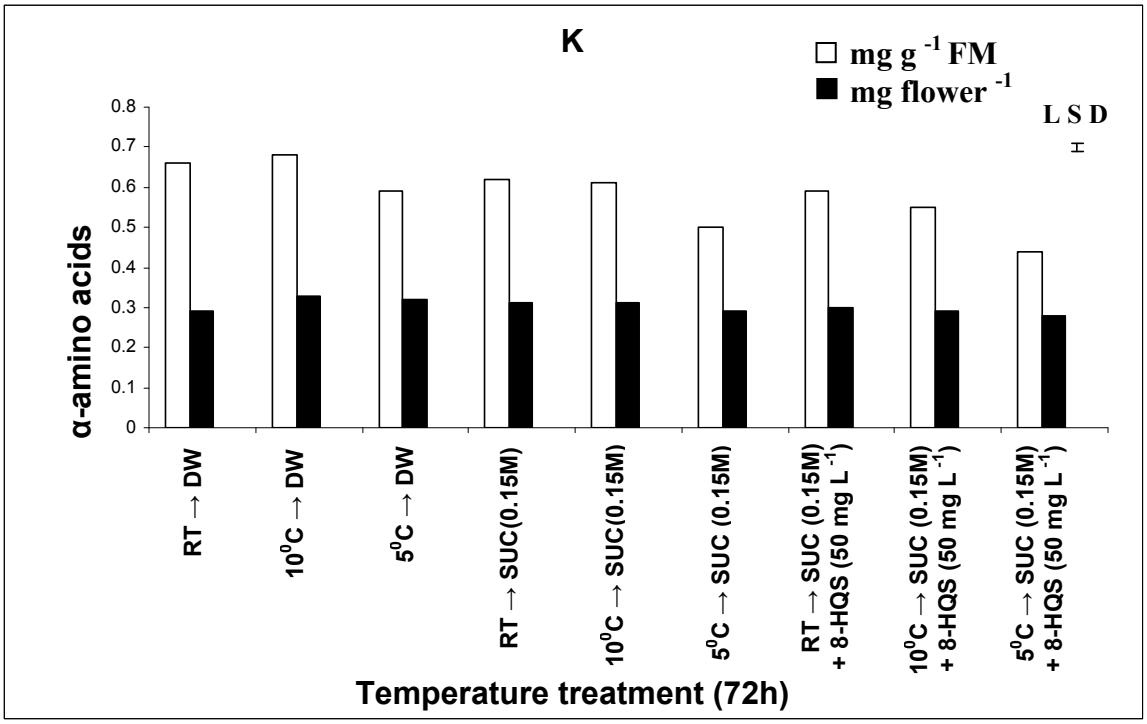

J
mg g -1 FM
mg flower -1
L S D
H
Soluble proteins
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10°C → SUC (0.15M) + 8-HQS (50 mg L -1)
5°C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 1.2.5

Fig. 1.2.6

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


K
mg g -1 FM
mg flower -1
L S D
α-amino acids
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

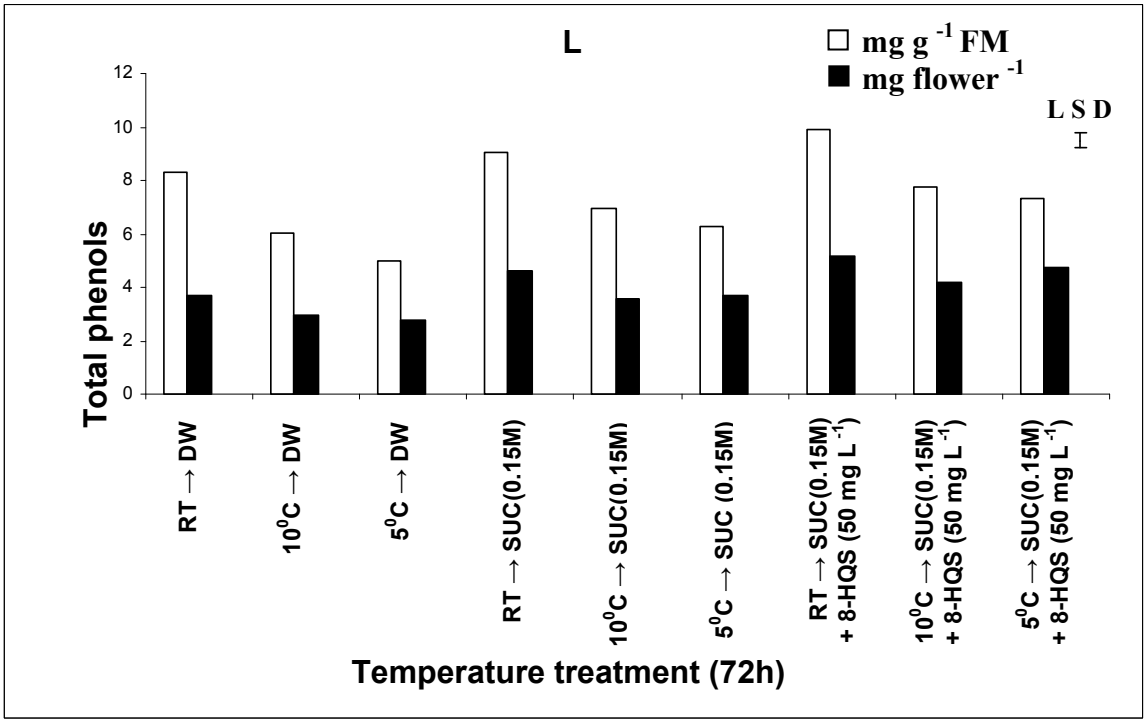

L
mg g -1 FM
mg flower -1
L S D
Total phenols
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.2.6

Plate 1.2.1

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C, before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Fig.1: From left to right are arranged scapes before wet storage for 72 h.

Fig.2: From left to right are arranged scapes after wet storage for 72 h.

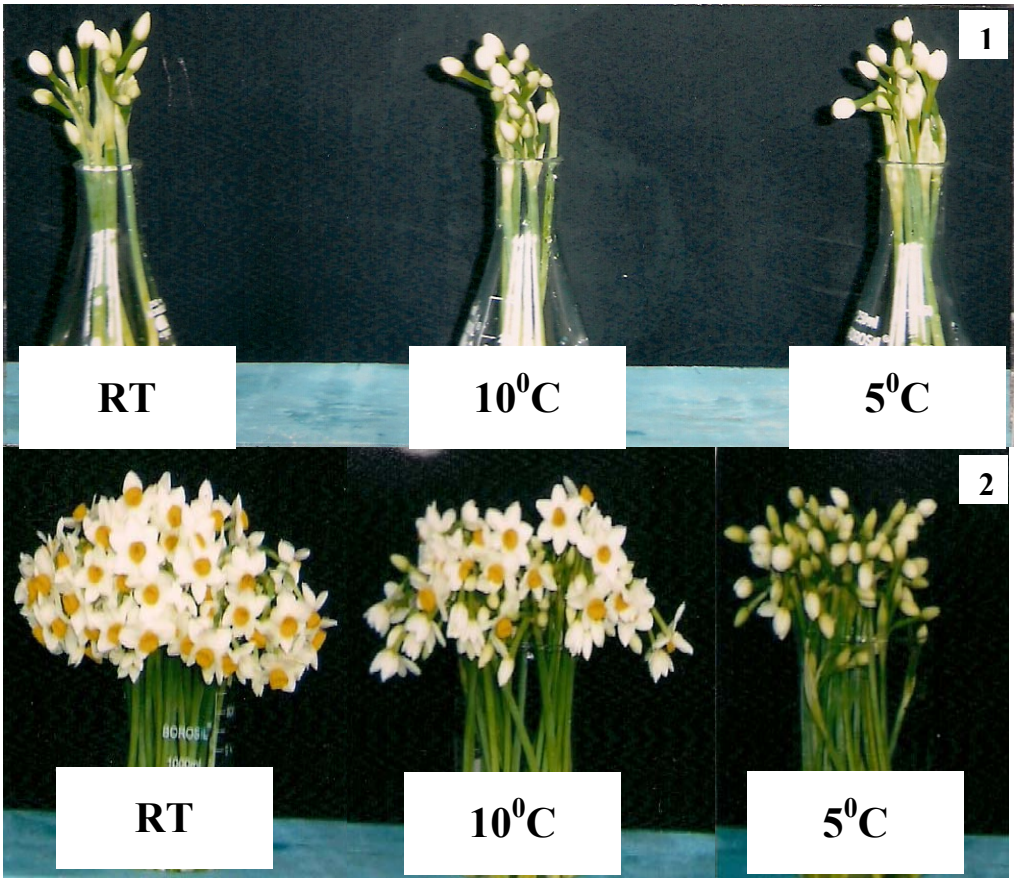


Plate. 1.2.1

Plate. 1.2.2

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C, before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged flasks containing scapes stored at RT (12 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C, and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

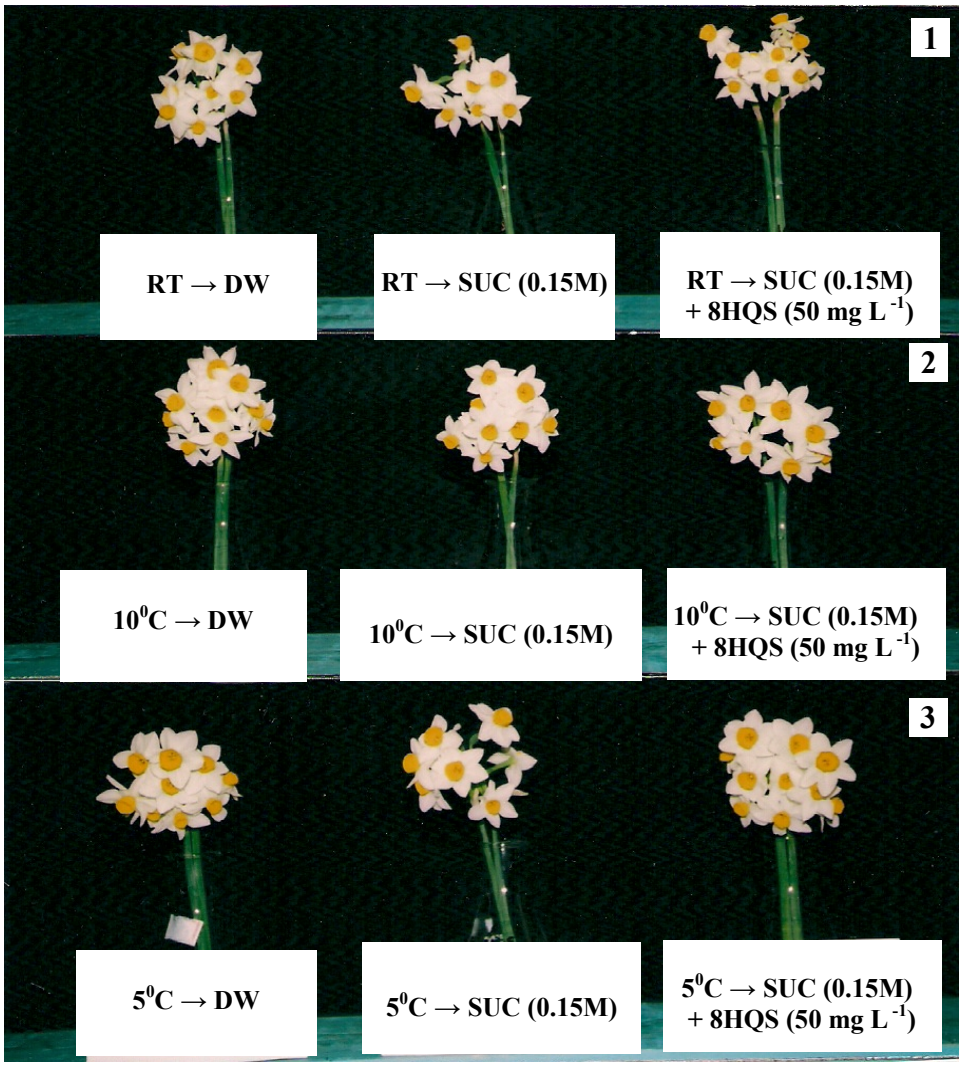

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M) + 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 1.2.2

Plate. 1.2.3

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C, before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged flasks containing scapes stored at RT (12 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

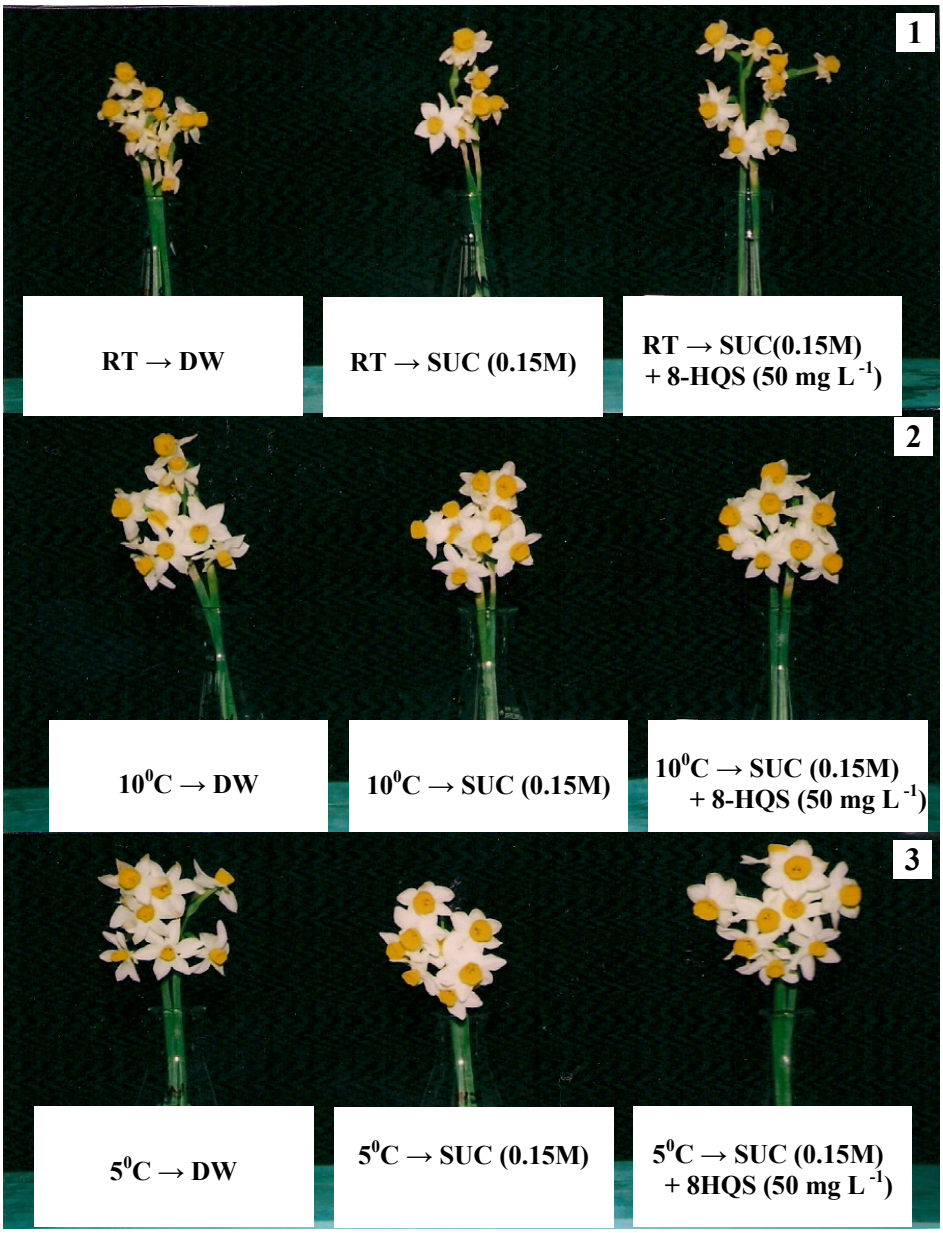

1
RT → DW
RT → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 1.2.3

EXPERIMENT 1.3

Effect of postharvest dry storage (PHDS) at different temperatures regimes: 5, 10 and room temperature (12 ± 2°C) for 72 h and subsequent transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Experimental

Scapes of *N. tazetta* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 20 cm. The scapes were completely wrapped in moistened filter papers, and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (12 ± 2^{0}C). After 72 h all the scapes were kept at room temperature and transferred to 250 ml conical flasks containing 200 ml of distilled water (DW),sucrose (SUC 0.15M) and SUC(0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The scapes where kept under cool white fluorescent light with the mix of diffuse natural light (10 Wm^{-2}) 12 h a day and a relative humidity of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to a particular holding solution and was assessed to be terminated when 50 % flowers had senesced which was characterized by loss of turgor and wilting. Number of blooms per scape was recorded up to day 5 of the transfer. Volume of holding solutions absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and phenolics were also estimated

on day 4 after transfer. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes dry stored for 72 h at RT had already bloomed during the storage and senesced by day 4 of the transfer (Plate. 1.3.1; Figs. 1-2). Blooming was least in the scapes previously dry stored at 5 and 10 ^{o}C before transfer to holding solutions and showed tepal senescence on the day 8 and 5 of transfer to a particular holding solutions (Plate. 1.3.2; 1, Figs.1- 3) Senescence was assessed when 50% of open flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals (Plate. 1.3.3; Figs. 1-3).

Vase life: The average vase life of scapes previously dry stored at different temperature regimes; RT, 10 and 5^{0}C before transfer to DW was 2, 4 and 5 days respectively, whereas the vase life of scapes transferred to SUC was 3, 5 and 6 days respectively. The maximum vase life was recorded in corresponding scapes previously dry stored at RT, 10 and 5^{0}C before transfer to SUC + 8-HQS and was 4, 5 and 8 days respectively (Table 1.3.1; Text Fig.1.3.1, A).

Number of blooms per scape: The number of blooms as also the percent blooming increased in all treatments irrespective of the transfer to various holding solutions. Scapes previously dry stored at RT and 10^{o}C exhibited 100 percent blooming by day 2 and 3 after transfer respectively; whereas complete and sustained blooming was exhibited in scapes previously dry stored at 5^{0}C by day 4 irrespective of the transfer to various holding solutions (Table 1.3.1; Text Fig. 1.3.1, B).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression from day 2 to 6 of transfer of scapes to various holding solutions irrespective of the particular

temperature regime and holding solution. The solution uptake was found to be higher in scapes previously dry stored for 72 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of the holding solution. A higher solution uptake was recorded in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment (Table 1.3.1; Text Fig. 1.3.2, C). The maximum solution uptake was noticed in scapes previously dry stored at 5°C for 72 h and transferred to (SUC + 8- HQS).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs registered a decrease in samples previously dry stored for 72 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of holding solution. However, at each of the temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8 - HQS followed by scapes held in SUC as compared to samples from corresponding scapes held in DW (Table 1.3.2; Text Fig. 1.3.2, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously dry stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from the corresponding scapes held at RT irrespective of the holding solutions. However, at each of the temperature regimes both fresh and dry mass was found to be higher in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW. Maximum value for fresh and dry mass was recorded in samples from scapes previously dry stored at 5°C for 72 h and transferred to SUC + 8-HQS (Table 1.3.2; Text Figs. 1.3.3, E & F).

Reducing sugars: The reducing sugar content of samples form scapes previously dry stored for 72 h at 5 and 10 °C registered a significant increase as compared to the samples from corresponding scapes held at RT

irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.4, G). Almost similar trends were obtained when the data was expressed on per flower basis but the differences showed up clearly on these particular reference bases (Tables 1.3.3 and 1.3.4). Maximum reducing sugar content was noticed in samples from scapes dry stored at 5°C for 72 h and transferred to SUC +8-HQS.

Non-reducing sugars: Generally the non-reducing sugar content of samples from scapes previously dry stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes, the non-reducing sugar content was found to be highest in samples form scapes held in SUC + 8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.4, H). Generally similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis but the differences were sharp and apparent (Tables 1.3.3 and 1.3.4). Maximum non-reducing sugar content was noticed in samples from scapes dry stored at 5 °C for 72 h and transferred to SUC + 8-HQS.

Total sugars: The total soluble sugar content of the samples from scapes previously dry stored at 5 and 10°C registered a marked increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solution. However, at each of the temperature regimes the total soluble sugar content was found to be highest in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.5, I). Almost similar trends were obtained when the data was

expressed on per flower basis as also on dry mass basis but the differences showed up clearly on these particular reference bases (Tables 1.3.3 and 1.3.4). Maximum total sugar content was registered in samples from scapes previously dry stored for 72 h at 5 °C and transferred to SUC +8-HQS irrespective of the reference base.

Soluble proteins: The soluble protein content of the samples from scapes previously dry stored at 5 and 10 °C for 72 h registered a significant increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the soluble protein content was found to be higher in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.5, J). Almost similar trends were noticed when the data was expressed on per flower basis as also on dry mass basis but the differences showed up clearly on these reference bases (Tables 1.3.3 and 1.3.4). Maximum soluble protein content was found in samples previously dry stored at 5 °C for 72 h and transferred to SUC + 8-HQS.

α- amino acids: A lower content of α-amino acids was maintained in samples from scapes previously dry stored at 5^{o}C for 72 h as compared to the samples from corresponding scapes held at 10°C and RT. However, at each of the temperature regimes the amino acid content was found to be lower in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.6, K). When the data was expressed on per flower basis the amino acid content was more or less maintained over all the temperature regimes irrespective of the transfer to various holding solutions (Table 1.3.3). However, differences were apparent when the data was expressed on dry mass basis (Table 1.3.4). The lowest content of α-amino acids was noticed in

samples from scapes dry stored at 5^{o}C for 72 h and transferred to SUC+8-HQS.

Total phenols: A lower content of phenols was generally maintained in samples from scapes previously dry stored at 5 and 10°C for 72 h as compared to the samples from corresponding scapes held at RT. At each of the particular temperature regimes the phenolic content of the samples was more in scapes held in SUC+8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 1.3.3; Text Fig. 1.3.6, L). When the data was expressed on per flower basis or dry mass basis the trends became sharp and apparent (Tables 1.3.3 and 1.3.4).

Table 1.3.1: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Vase life (days)	No. of blooms per scape					Volume of holding solution absorbed per scape (ml)		
		Days after treatment							
		0	1	2	3	4	2	4	6
RT→DW	2	4.75 (95)	4.90 (98)	5.00 (100)	-	-	1.41	2.08	3.08
10 °C→DW	4	3.51 (70)	4.02 (80)	4.90 (98)	5.00 (100)	-	1.54	2.45	3.56
5 °C →DW	5	0.26 (5)	1.25 (25)	2.60 (52)	3.91 (78)	5.00 (100)	1.87	3.00	4.20
RT→SUC(0.15M)	3	4.73 (95)	4.96 (99)	5.00 (100)	-	-	1.35	2.33	3.28
10°C→SUC(0.15M)	5	3.52 (70)	4.27 (86)	4.93 (99)	5.00 (100)	-	1.62	2.79	4.00
5°C→SUC(0.15M)	6	0.25 (5.0)	1.51 (30)	3.11 (62)	4.45 (89)	5.00 (100)	1.95	3.79	4.65
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	4	4.76 (95)	4.98 (99)	5.00 (100)	-	-	1.80	2.70	3.49
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	5	3.53 (70)	4.51 (90)	4.99 (99)	5.00 (100)	-	1.87	3.00	4.20
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	8	0.25 (5.0)	1.76 (35)	3.55 (71)	4.51 (90)	5.00 (100)	2.83	4.66	5.41
LSD at $P_{=0.05}$	0.30	0.02	0.04	0.04	0.04	-	0.12	0.12	0.18

Each value is a mean of 5 independent replicates.

Room temperature RT = (12 ± 2°C).

Figures in parentheses represent percent blooms.

Table 1.3.2: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on conductivity of leachates (μS), fresh mass and dry mass of flowers on day 4 of transfer of cut scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment(72h)	Conductivity of leachates(μS)	Fresh mass (g flower^{-1})	Dry mass (g flower^{-1})
RT→DW	30.66	0.247	0.038
10 °C→DW	13.00	0.418	0.041
5 °C →DW	9.66	0.470	0.047
RT→SUC(0.15M)	22.33	0.283	0.043
10°C→SUC(0.15M)	11.33	0.442	0.050
5°C→SUC(0.15M)	8.33	0.500	0.057
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	13.66	0.326	0.049
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	10.33	0.465	0.056
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	7.33	0.605	0.068
LSD at $P_{=0.05}$	0.66	0.040	0.006

Each value is a mean of 5 independent replicates.

Room temperature RT = (12 ± 2^{o}C).

Table 1.3.3: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 of transfer of cut scape to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	1.86 (0.46)	0.80 (0.19)	2.66 (0.65)	2.16 (0.53)	0.74 (0.18)	5.46 (1.34)
10 °C→DW	3.46 (1.44)	1.16 (0.48)	4.63 (1.93)	3.16 (1.32)	0.46 (0.19)	3.06 (1.27)
5 °C →DW	5.33 (2.50)	0.70 (0.32)	6.13 (2.88)	4.58 (2.15)	0.42 (0.19)	1.80 (0.84)
RT→SUC(0.15M)	3.73 (1.05)	0.53 (0.15)	4.26 (1.20)	2.83 (0.80)	0.67 (0.19)	6.86 (1.94)
10°C→SUC(0.15M)	5.06 (2.23)	2.50 (1.10)	7.56 (3.41)	4.66 (2.06)	0.41 (0.18)	3.53 (1.56)
5°C→SUC(0.15M)	6.66 (3.33)	3.46 (1.73)	10.13 (5.06)	5.91 (2.95)	0.37 (0.18)	2.73 (1.36)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	5.86 (1.91)	1.04 (0.34)	6.93 (2.26)	4.16 (1.35)	0.55 (0.18)	8.26 (2.69)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	8.26 (3.84)	1.00 (0.46)	9.33 (4.34)	5.41 (2.51)	0.34 (0.15)	4.20 (1.95)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	9.86 (5.96)	2.65 (1.60)	12.53 (7.58)	7.25 (4.38)	0.32 (0.19)	3.40 (2.05)
LSD at $P_{=0.05}$	0.40	0.18	0.72	0.50	0.016	0.18

Each value is a mean of 5 independent replicates.

Room temperature RT = (12 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 1.3.4: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 of transfer of cut scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	12.13	5.15	17.33	14.08	4.87	35.53
10 °C→DW	35.27	11.82	45.86	31.36	4.68	30.44
5 °C →DW	53.30	7.00	61.30	45.73	4.20	18.00
RT→SUC(0.15M)	24.57	3.51	28.08	18.62	4.42	45.19
10°C→SUC(0.15M)	44.78	22.10	68.33	41.25	3.67	31.20
5°C→SUC(0.15M)	58.47	30.35	88.77	51.90	3.26	23.97
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	39.03	6.91	46.90	27.72	3.69	54.99
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	68.64	8.30	77.47	44.97	2.84	34.87
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	87.78	23.57	111.50	64.50	2.82	30.25
LSD at $P_{=0.05}$	1.21	1.42	0.62	0.66	0.90	1.02

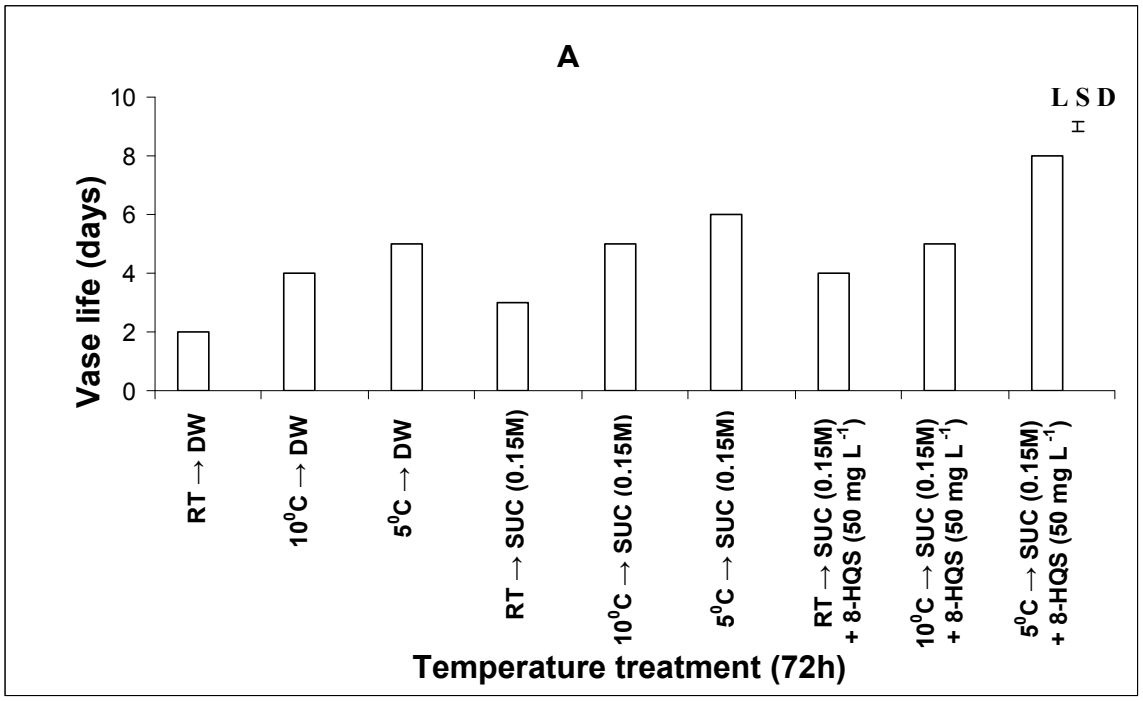
Each value is a mean of 5 independent replicates.

Room temperature RT = (12 ± 2^0C).

Fig. 1.3.1

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at P $_{= 0.05.}$


A
L S D
Vase life (days)
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

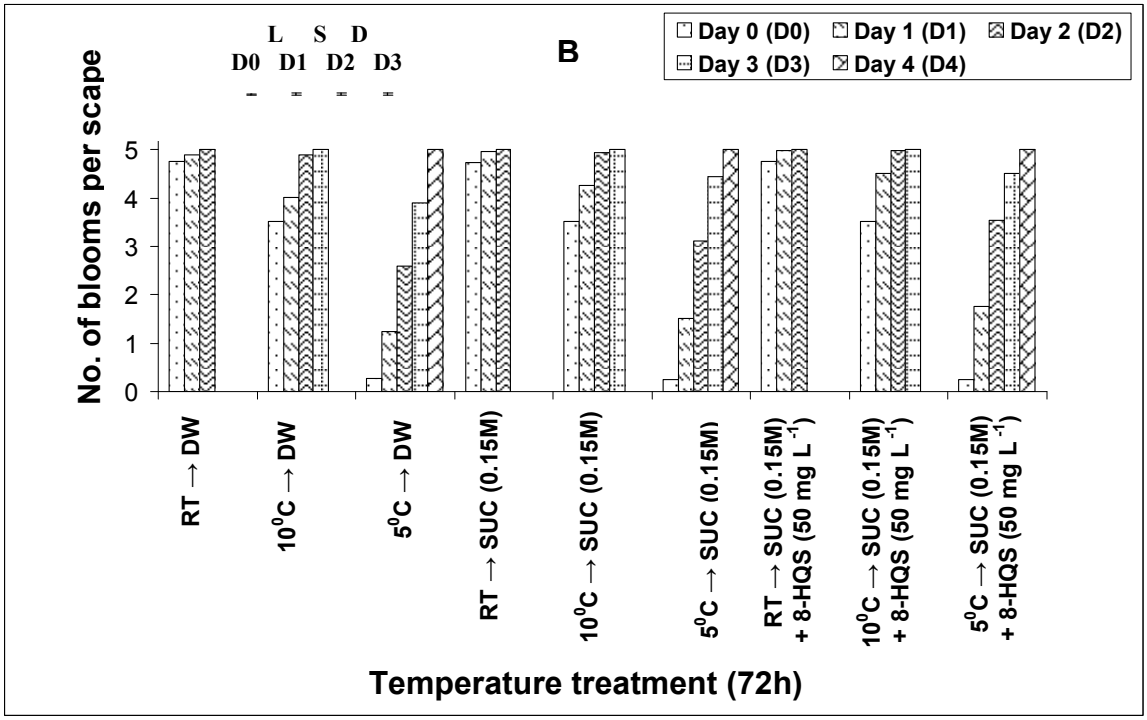
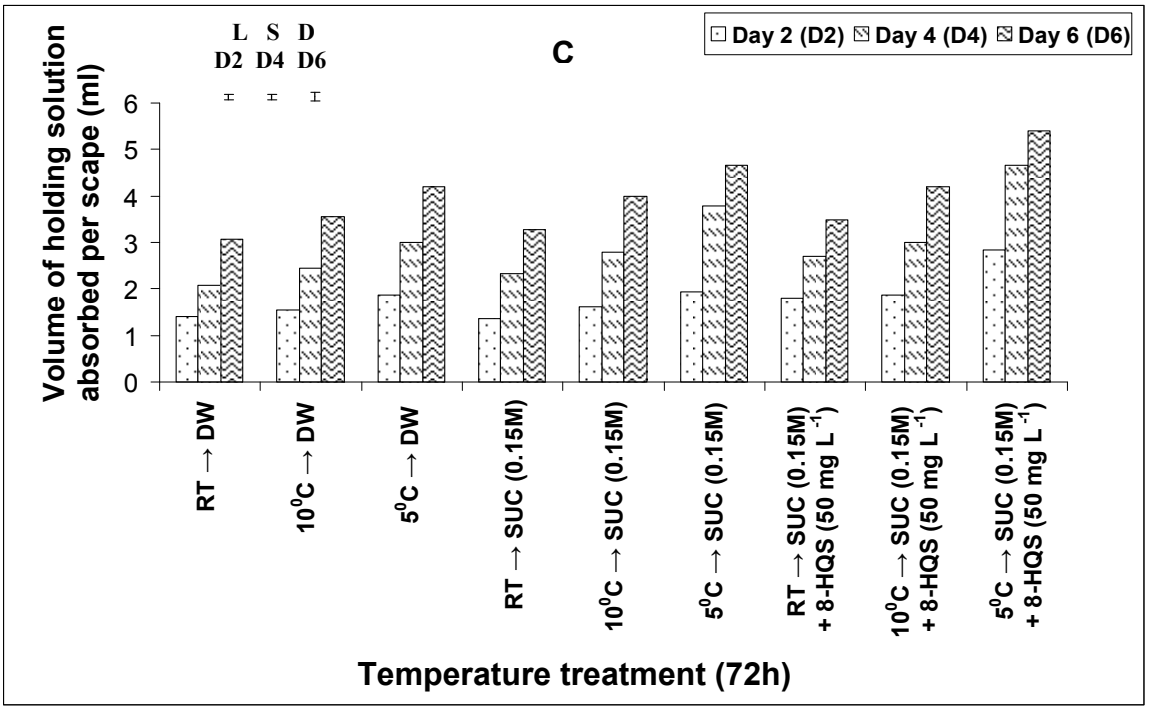

B
L S D
D0 D1 D2 D3
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
No. of blooms per scape
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.3.1

Fig. 1.3.2

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at P $_{= 0.05.}$


C
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
6
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

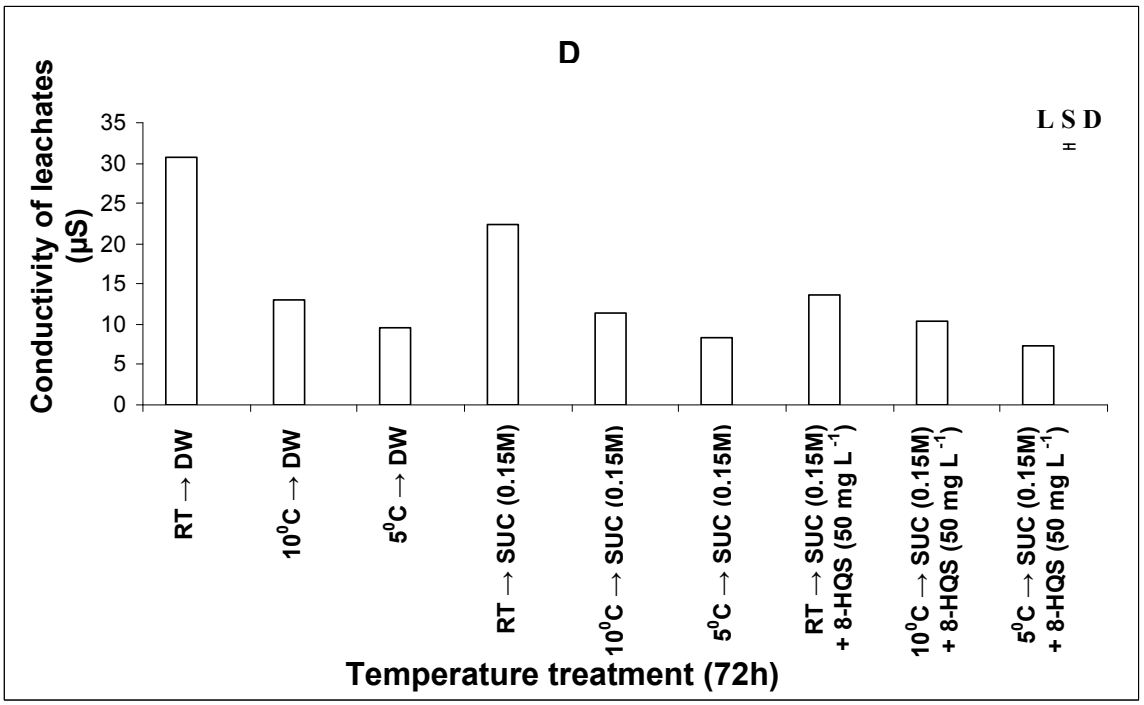
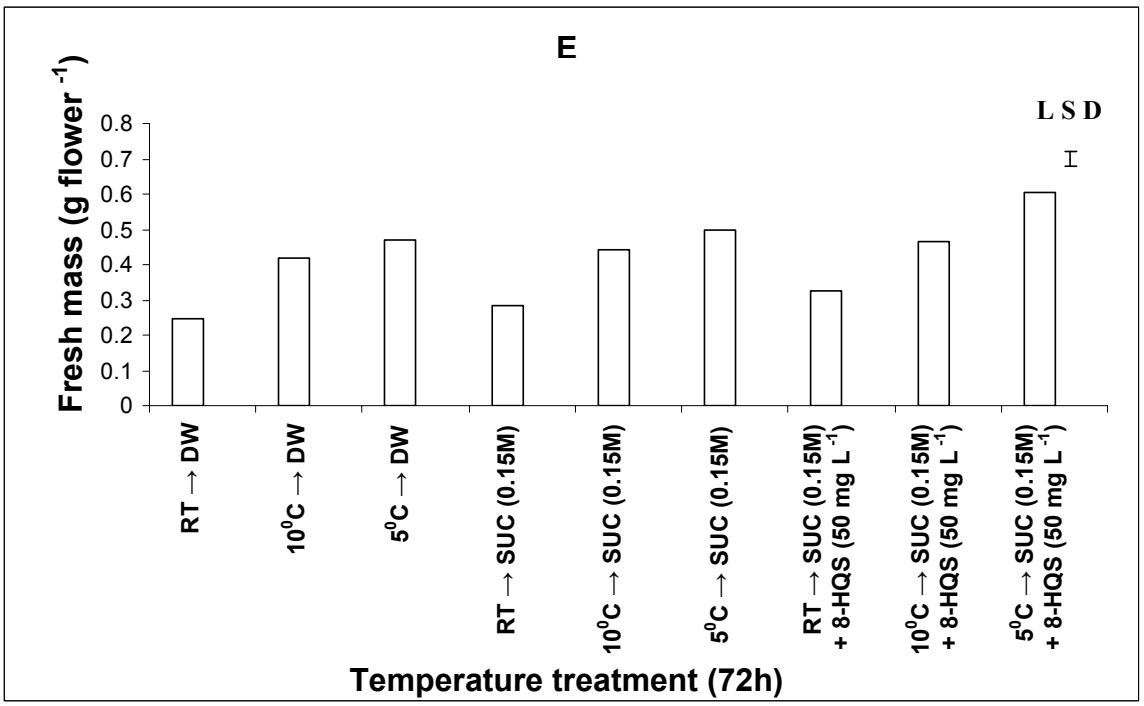

D
L S D
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.3.2

Fig. 1.3.3

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Fresh mass (g flower -1)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
L S D
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

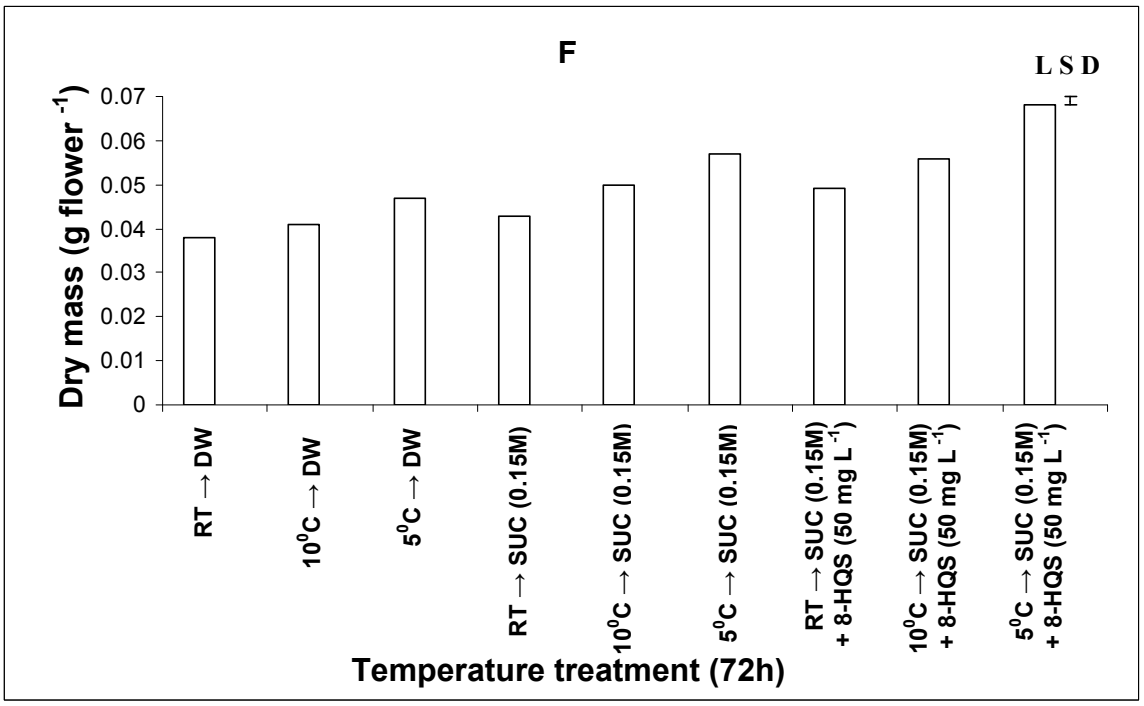
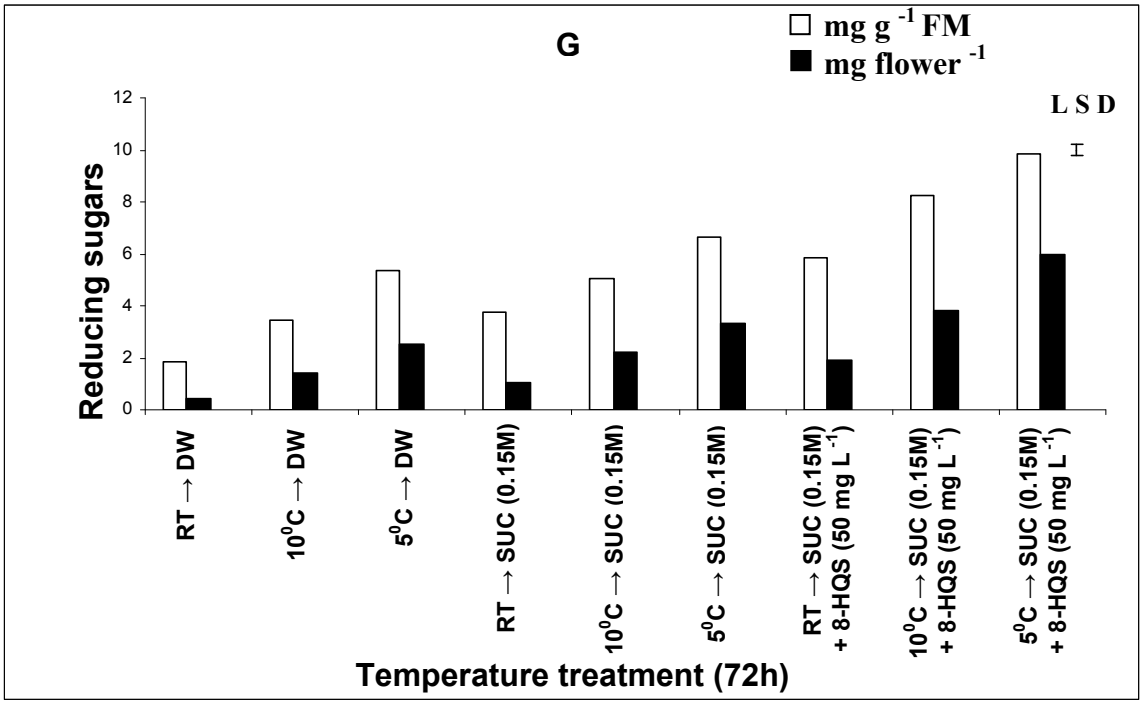

F
Dry mass (g flower -1)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
L S D
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.3.3

Fig. 1.3.4

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


G
mg g -1 FM
mg flower -1
L S D
Reducing sugars
0
2
4
6
8
10
12
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L -1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

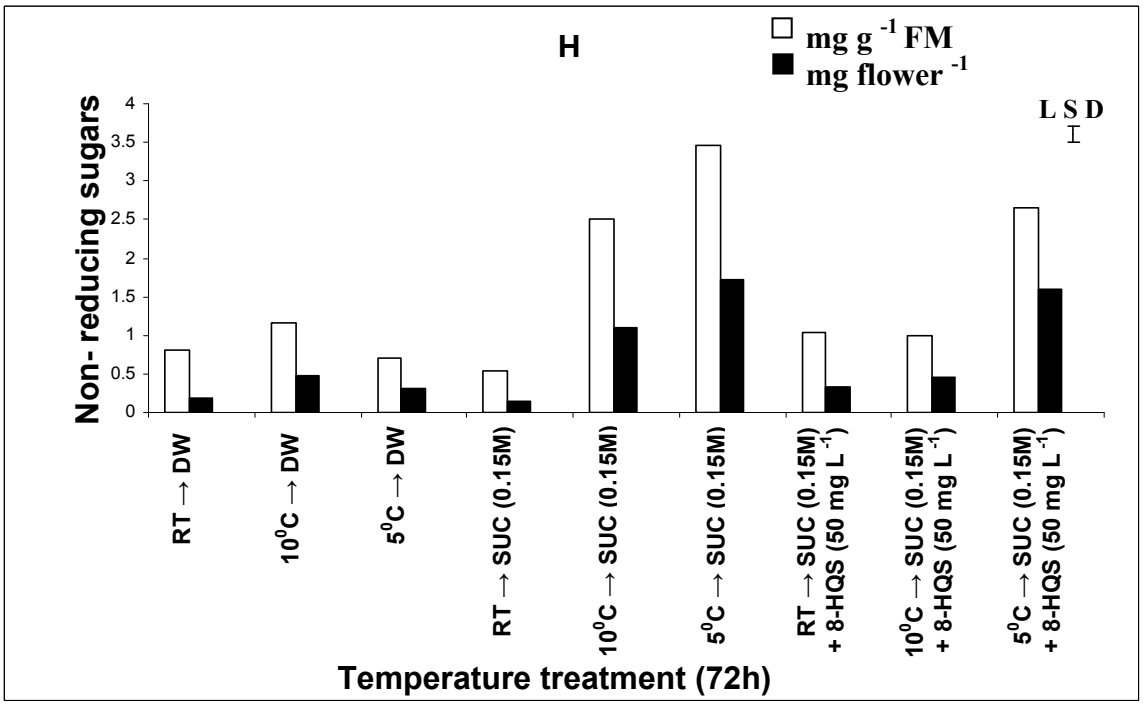
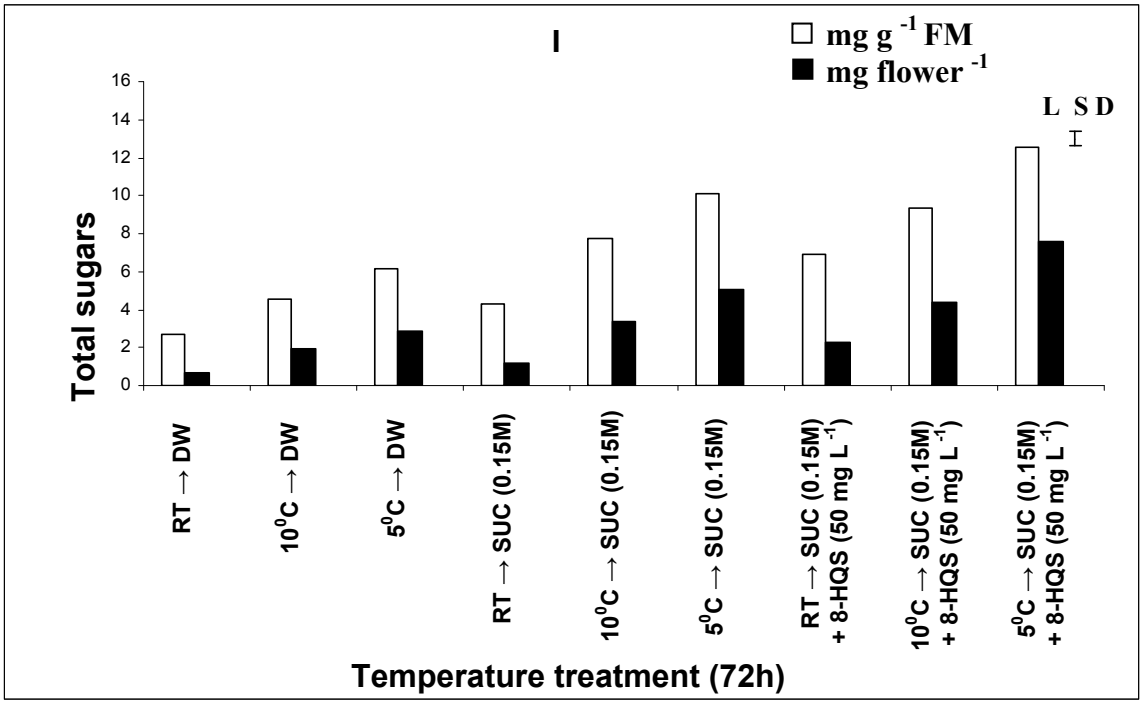

H
mg g -1 FM
mg flower -1
L S D
Non- reducing sugars
0
0.5
1
1.5
2
2.5
3
3.5
4
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L -1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L -1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 1.3.4

Fig. 1.3.5

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


I
mg g -1 FM
mg flower -1
L S D
Total sugars
16
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

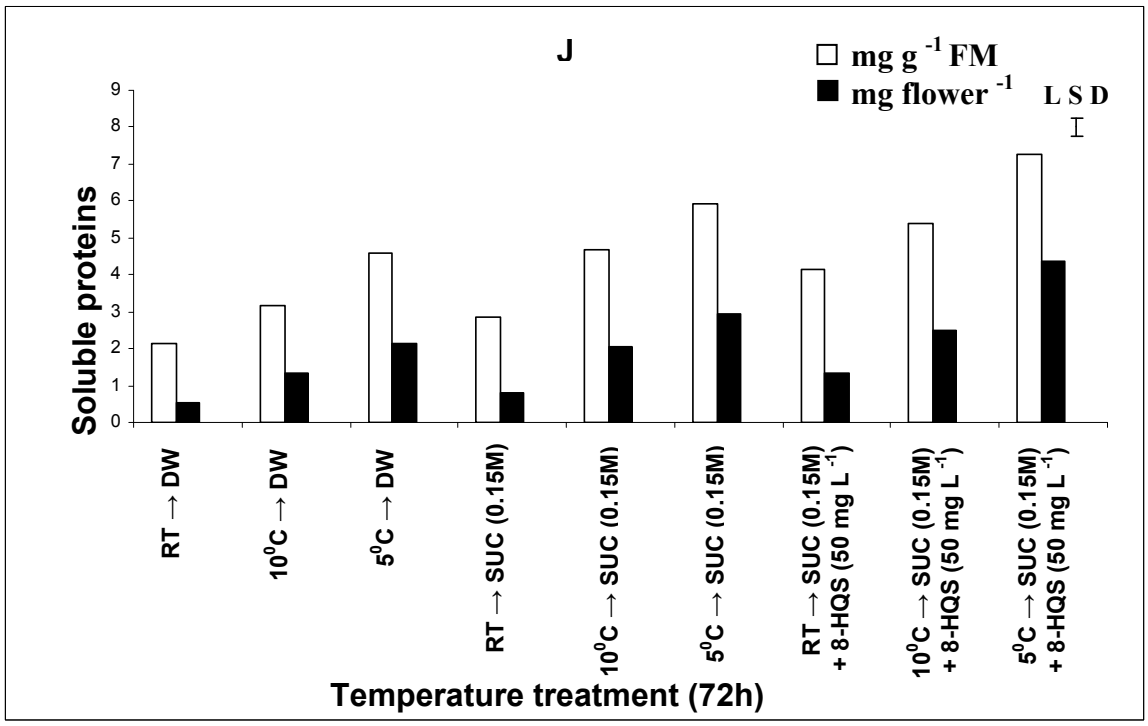
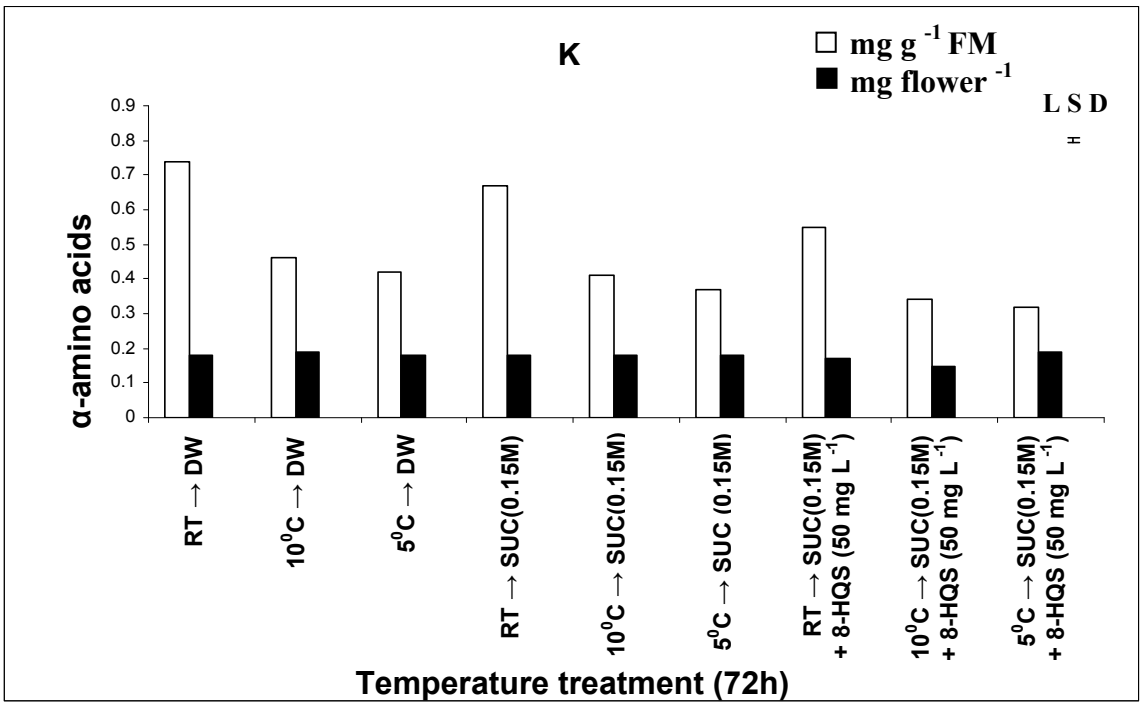

J
mg g -1 FM
mg flower -1
L S D
Soluble proteins
9
8
7
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 1.3.5

Fig. 1.3.6

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


K
mg g -1 FM
mg flower -1
L S D H
α-amino acids
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10 0C → DW
5 0C → DW
RT → SUC(0.15M)
10 0C → SUC(0.15M)
5 0C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10 0C → SUC(0.15M) + 8-HQS (50 mg L -1)
5 0C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

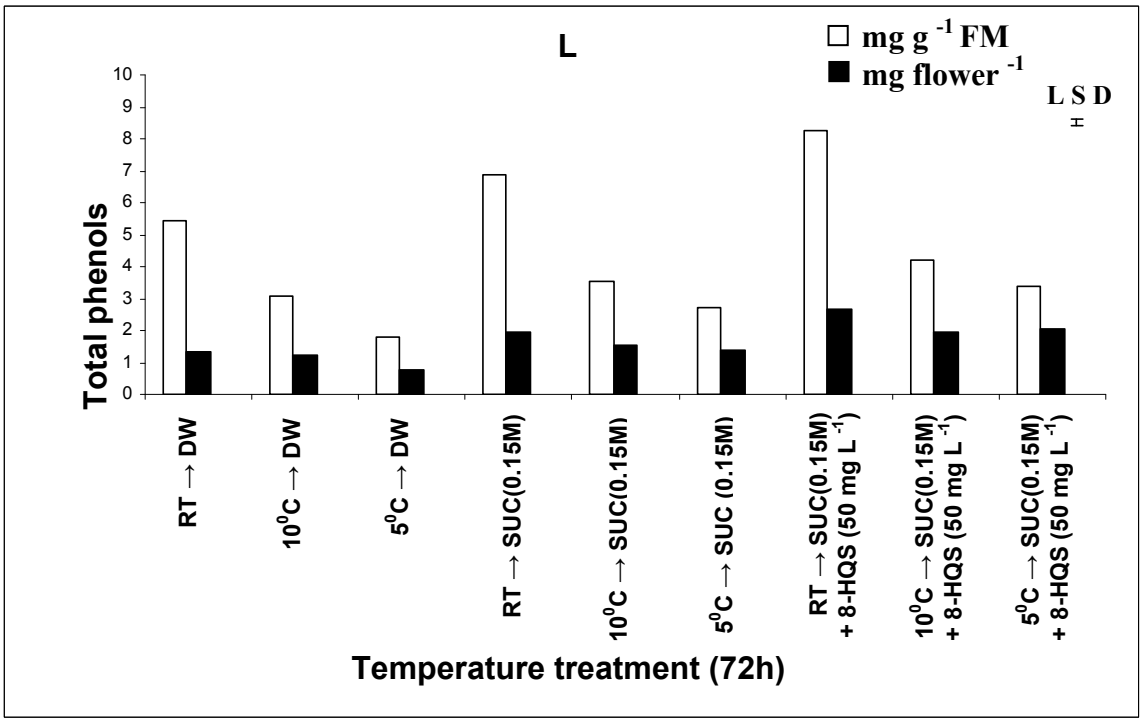

L
mg g -1 FM
mg flower -1
L S D H
Total phenols
10
9
8
7
6
5
4
3
2
1
0
RT → DW
10 0C → DW
5 0C → DW
RT → SUC(0.15M)
10 0C → SUC(0.15M)
5 0C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10 0C → SUC(0.15M) + 8-HQS (50 mg L -1)
5 0C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 1.3.6

Plate 1.3.1

Effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Fig.1: From left to right are arranged scapes before dry storage for 72 h.

Fig.2: From left to right are arranged scapes after dry storage for 72 h .

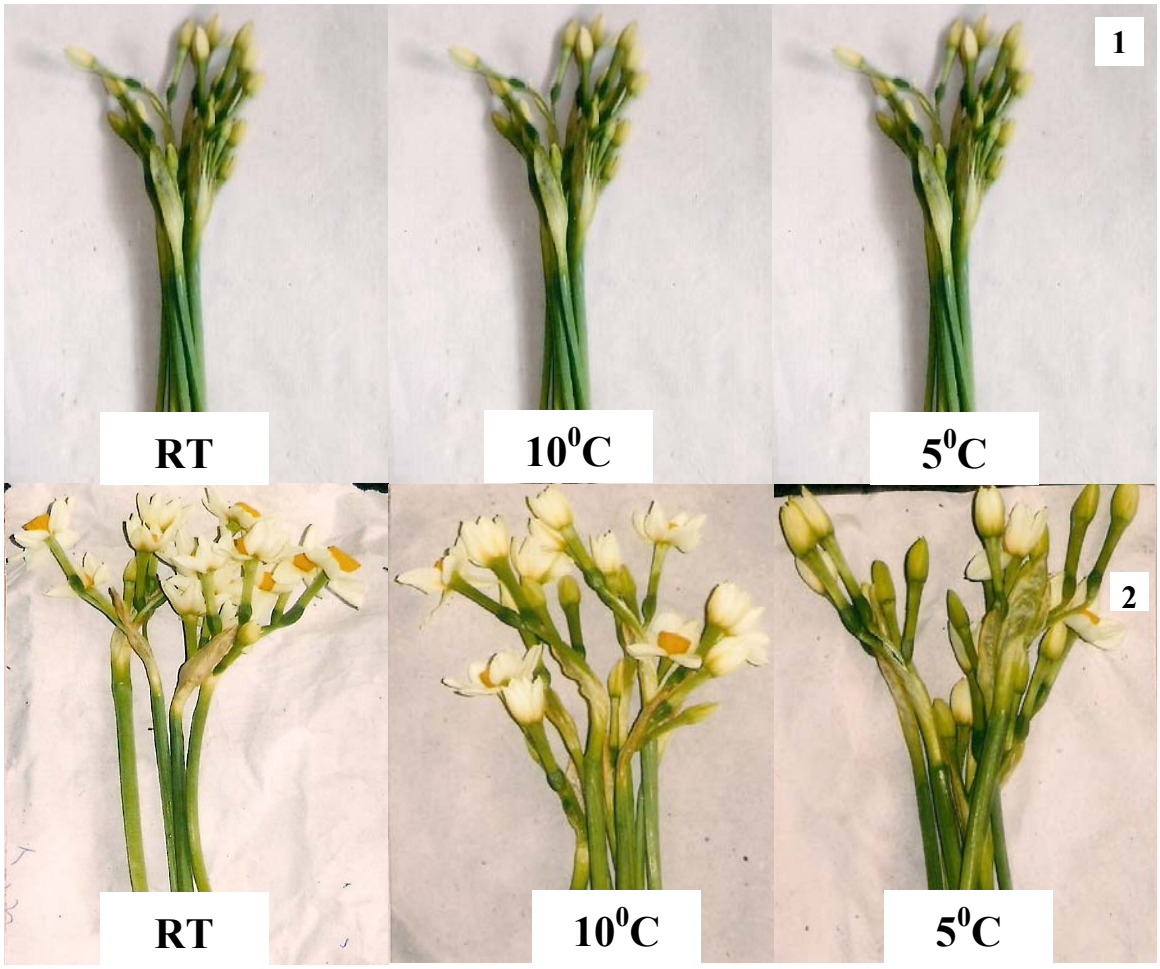


Plate. 1.3.1

Plate. 1.3.2

Effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged flasks containing scapes stored at RT (12 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes dry stored at RT, 10 and 5^0C, and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

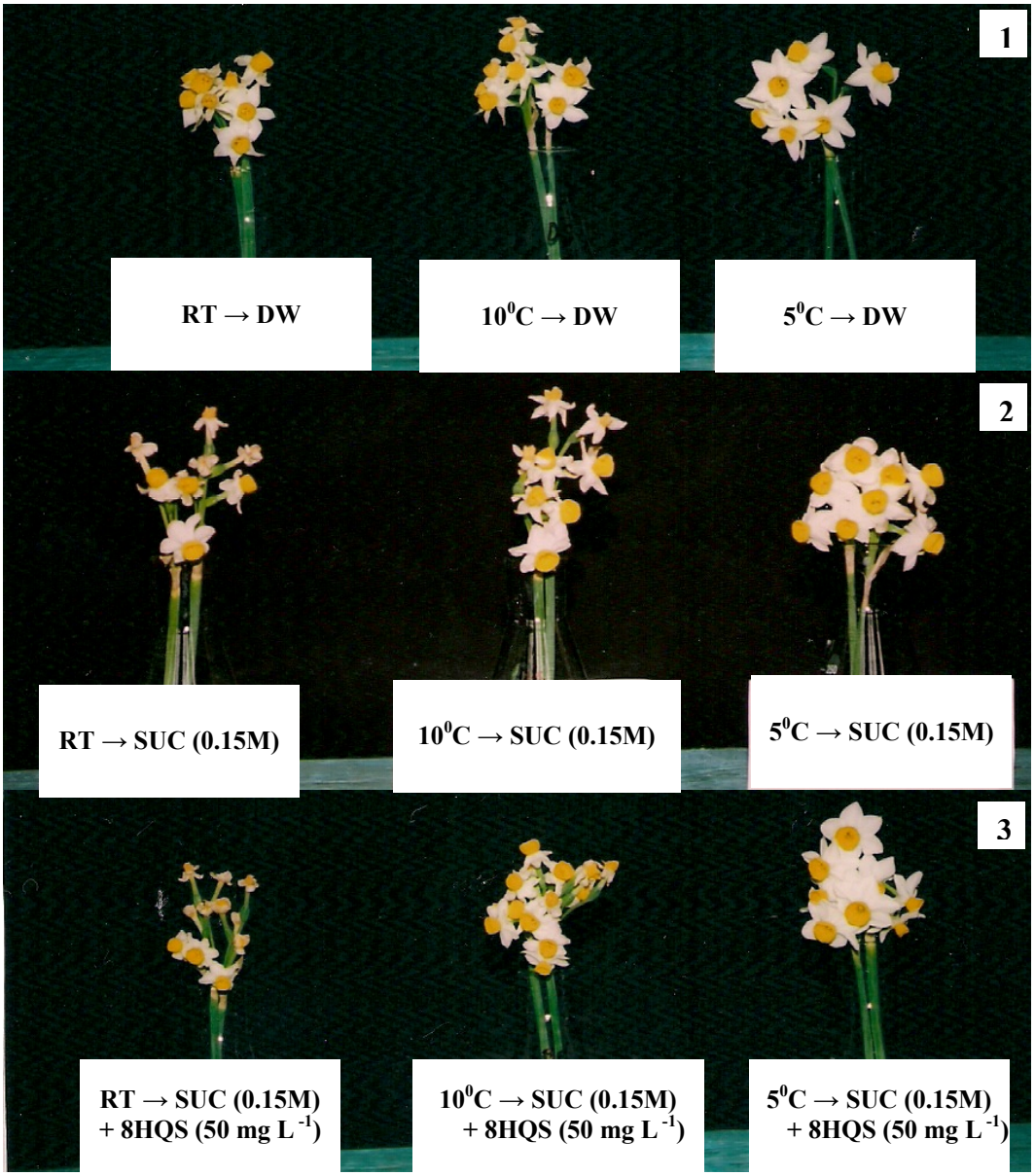

1
RT → DW
10⁰C → DW
5⁰C → DW
2
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
3
RT → SUC (0.15M) + 8HQS (50 mg L -1)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 1.3.2

Plate. 1.3.3

Effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged flasks containing scapes stored at RT (12 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes dry stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

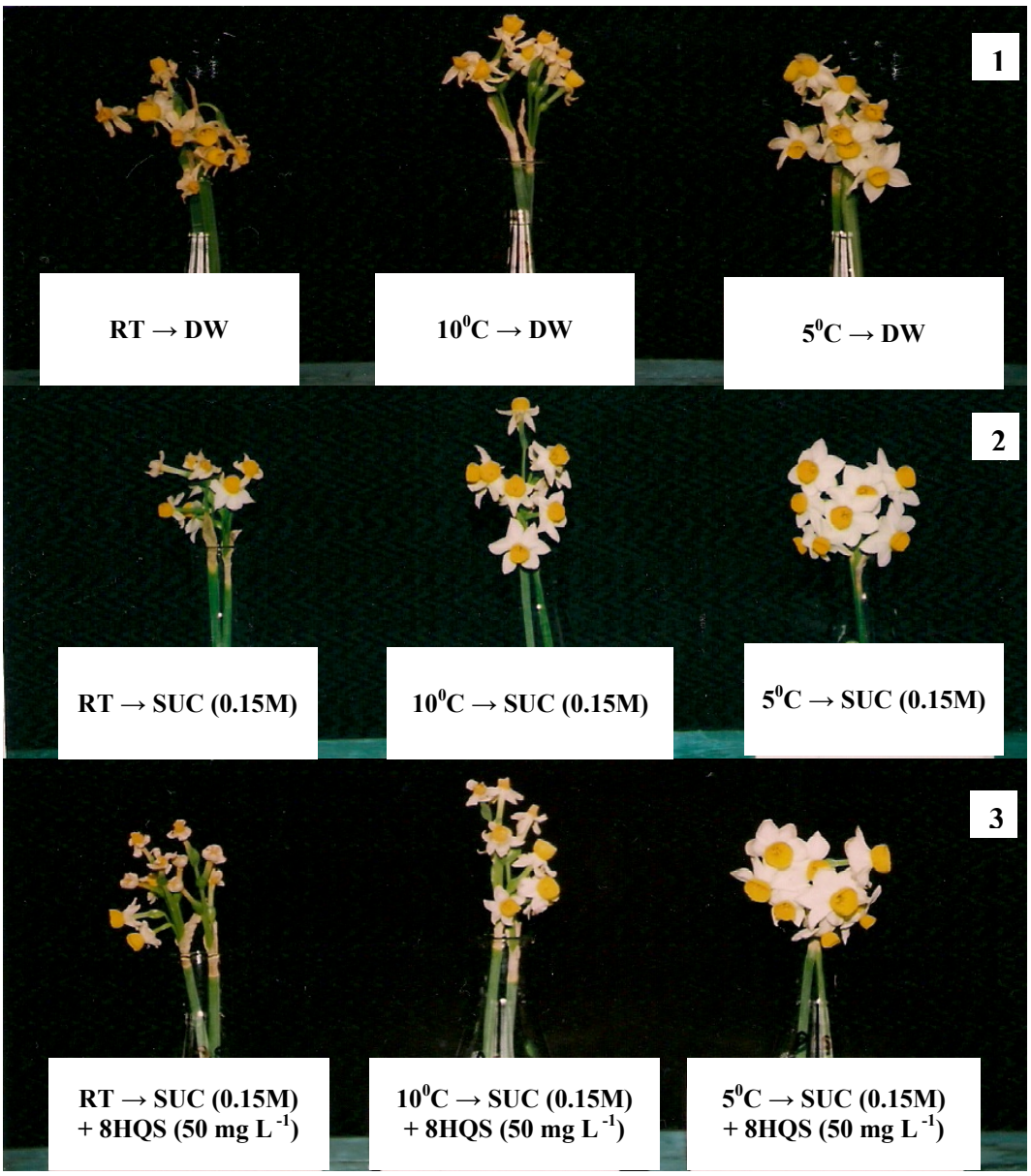

1
RT → DW
10⁰C → DW
5⁰C → DW
2
RT → SUC (0.15M)
10⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
3
RT → SUC (0.15M) + 8HQS (50 mg L -1)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 1.3.3

EXPERIMENT 1.4

Effect of pretreatment with varying grades of CHI (1h pulse) and subsequent transfer to distilled water (DW) set (A) and sucrose SUC (0.15M) set (B) on cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Experimental

Scapes of *N. tazetta* growing in the University Botanic garden were used for the study. The scapes were harvested at 08.00 h when the scapes were at mature stage. The scapes were brought to the laboratory and cut to a uniform scape length of 20 cm. The scapes were held in distilled water in 1000 ml borosil beakers for 1h containing CHI at 0.01, 0.05, 0.5 and 1.0 mM. After pulsing, the scapes were transferred to 250 ml conical flasks containing 200 ml of DW and SUC (0.15M) in triplicate. The unpulsed scapes transferred to DW represented the control. Pulsed scapes transferred to water (DW) represented set (A) and the scapes transferred to SUC (0.15M) represented set (B). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the scapes were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solution and was assessed to be terminated when 50 % of the open flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals. Numbers of blooms produced per scape were recorded up to day 6 after the transfer. Volume of holding solution absorbed was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs of flowers, fresh mass and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to DW or SUC. Changes in tissue

constituents including sugar fractions, soluble proteins, α- amino acids and the concentration of total phenols were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data has been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions, DW or SUC (0.15M) except in scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM). The scapes pretreated with CHI before transfer to DW (set A) or SUC (set B) showed bending on subsequent day of transfer to holding solutions but the bending was more in flowers pretreated with 0.5 and 1.0 mM CHI (Plate. 1.4.1, Figs. 1- 4). The flower senescence was delayed in the scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) by 4 to 7 days in set A and by 3 and 7 days in set B. Scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) failed to open and wilted quickly by day 4 and 2 of the treatment (Plate 1.4.2, Figs. 1 to 4).

Vase life: The average vase life of flowers from scapes pretreated with 0.01 and 0.05 mM CHI before transfer to DW (set A) increased by an increment of 4 and 7 days respectively, whereas the average vase life of flower from scapes transferred to SUC (set B) was enhanced by an increment of about 3 to 7 days respectively as compared to the flowers from untreated scapes which exhibited vase life of about 8 days in DW and 10 days in SUC (0.15M). The vase life of flowers decreased with an increase in CHI concentration and the decrease was pronounced in flowers from scapes pretreated with 0.5 and 1.0 mM CHI before transfer to DW or SUC (Table 1.4.1, Text Fig. 1.4.1, A).

Number of blooms per scape: The number of blooms as also the percent blooming per scape increased with progression in time irrespective of

transfer of scapes to either DW or SUC. Progressive blooming was noticed in the unpulsed scapes and scapes pretreated with lower grades of CHI (0.01 and 0.05 mM), which achieved complete blooming by day 6 of the transfer. However blooming was arrested in scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) and the closed buds wilted as such on the scapes (Table 1.4.1, Text Fig. 1.4.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes to various holding solutions irrespective of the treatment however, the increase at each 2 , 4 and 6 days of transfer was higher in scapes pretreated with 0.01 and 0.05 mM CHI as also untreated scapes before transfer to either DW or SUC. Pretreatment of scapes with higher grades of CHI (0.5 and 1.0 mM) before transfer to holding solution particularly SUC (set B) resulted in a corresponding decrease in the volume of holding solution absorbed as compared to the untreated scapes and scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) (Table 1.4.1, Text Fig. 1.4.2, C).

Conductivity of leachates (µS): The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer to either DW (set A) or SUC (set B). The concentration of ion leachates was found to be significantly higher in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) before transfer to either DW or SUC. At lower grades of CHI (0.01 and 0.05 mM) the concentration of ion leachates was maintained in the samples from pretreated scapes transferred to either DW or SUC (Table 1.4.2, Text Fig. 1.4.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers decreased with progression in time from day 4 to day 8 of transfer of untreated scapes as

also scapes pretreated with higher grades of CHI (0.5and 1.0 mM) before transfer to either DW (set A) or SUC (set B). A higher fresh and dry mass was, however maintained in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) particularly in scapes transferred to SUC as compared to the corresponding scapes held in DW (Table 1.4.2, Text Figs. 1.4.3, E & F).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the reducing sugar content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The reducing sugar content registered a significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both DW or SUC (Table 1.4.3, Text Fig. 1.4.4, G). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 1.4.3 and 1.4.4). The highest content of reducing sugar was maintained in samples from scapes pretreated with 0.05 mM CHI before transfer to either DW or SUC.

Non-reducing sugars: The non-reducing sugar content registered an increase with progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), the increase was however, pronounced in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) are (Table 1.4.3, Text Fig. 1.4.4, H). When the data was expressed on per flower and on dry mass bases the differences were much sharp and apparent (Tables 1.4.3 and 1.4.4). The highest non-reducing sugar content was registered in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) and transferred particularly to SUC (set B), as compared to untreated samples held in either DW or SUC.

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to DW (set A), however, an increase in the content of total sugars was noticed in samples from scapes transferred SUC (set B) over the period of time. The total sugar content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM of CHI in scapes transferred to DW (set A) and increased significantly in scapes transferred to SUC (set B) (Table 1.4.3, Text Fig. 1.4.5, I). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 1.4.3 and 1.4.4). The highest total sugar content was registered in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the soluble protein content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The soluble protein content registered a significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both in DW or SUC (Table 1.4.5, Text Fig. 1.4.5, J). Almost similar trends were obtained when the data was expressed on mg per flower and on dry mass bases but the differences were sharp and apparent (Tables 1.4.5 and 1.4.6). The highest soluble protein content was marked in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to DW (set B), as compared to corresponding samples held in SUC and untreated samples.

α-amino acid: The amino acids content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the amino acid content was generally

maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The amino acid content registered a sharp increase in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both in DW or SUC (Table 1.4.5, Text Fig. 1.4.6, K). When the data was expressed on per flower and on dry mass bases the differences were sharp and apparent (Tables 1.4.5 and 1.4.6). The lowest amino acid content was marked in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

Total phenols: The content of total phenols registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B) , however the phenolic content was more or less maintained over a period of time in samples from scapes pretreated with varying grades of CHI. (Table 1.4.5, Text Fig.1.4.7, L). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 1.4.5 and 1.4.6). The highest content of total phenols was registered in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) as compared to untreated samples held in either DW or SUC.

Table 1.4.1: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) and subsequent transfer to DW (A) or SUC (B) on vase life, blooming and solution uptake in the cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Vase life (days)	No. of blooms per scape						Volume of holding solution absorbed per scape (ml)		
		Days after treatment								
A		1	2	3	4	5	6	2	4	6
DW	8	2.00 (40)	11.30 (57)	12.00 (60)	16.10 (80)	20.00 (100)	-	1.25	3.60	5.12
CHI 0.01mM	12	1.75 (43)	9.84 (62)	12.80 (80)	15.38 (96)	15.96 (100)	-	0.70	1.81	4.50
CHI 0.05mM	15	1.87 (34)	11.06 (14)	14.49 (65)	17.27 (78)	19.31 (100)	-	0.97	2.75	3.62
CHI 0.5mM	5	1.63 (38)	7.15 (42)	7.82 (46)	8.51 (50)	9.69 (57)	9.69 (57)	0.42	1.31	2.75
CHI 1.0mM	3	0.87 (19)	4.51 (25)	4.95 (27)	5.45 (30)	6.46 (36)	6.82 (38)	0.37	1.26	2.31
B										
SUC (0.15M)	10	1.87 (41)	10.80 (60)	13.86 (77)	16.11 (93)	18.20 (100)	-	0.92	3.01	4.25
CHI 0.01mM	13	1.62 (35)	8.84 (11)	11.39 (67)	13.60 (80)	15.90 (100)	-	1.18	3.43	4.62
CHI 0.05mM	17	1.61 (25)	9.48 (43)	13.67 (62)	18.05 (82)	21.10 (100)	-	1.08	3.71	4.56
CHI 0.5mM	4	1.56 (34)	5.14 (39)	5.00 (42)	5.89 (95)	6.73 (52)	6.73 (52)	0.40	2.56	3.00
CHI 1.0mM	2	0.75 (15)	4.02 (21)	4.76 (25)	5.67 (30)	6.28 (33)	6.28 (33)	0.45	1.76	2.43
LSD at $P_{=0.05}$	0.55	0.62	0.35	0.42	0.53	0.67	0.74	0.09	0.12	0.10

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^{o}C).

Figures in parentheses represent percent blooms.

Table 1.4.2: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	11.66	23.33	0.476	0.427	0.044	0.045
CHI 0.01mM	13.83	21.60	0.527	0.561	0.059	0.069
CHI 0.05mM	12.33	13.33	0.605	0.630	0.077	0.083
CHI 0.5mM	16.33	21.00	0.516	0.474	0.054	0.067
CHI 1.0mM	17.00	24.00	0.512	0.385	0.053	0.035
B						
SUC (0.15M)	9.66	20.66	0.591	0.473	0.072	0.065
CHI 0.01mM	11.65	16.33	0.565	0.607	0.066	0.075
CHI 0.05mM	10.80	12.66	0.645	0.656	0.087	0.091
CHI 0.5mM	13.16	17.66	0.584	0.430	0.071	0.051
CHI 1.0mM	17.33	25.66	0.484	0.365	0.049	0.030
LSD at $P_{=0.05}$	0.62	1.22	0.02	0.02	0.004	0.010

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Table 1.4.3: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	4.26 (2.02)	2.26 (0.96)	0.40 (0.19)	0.44 (0.18)	4.66 (2.21)	2.71 (1.15)
CHI 0.01mM	4.80 (2.52)	1.46 (0.81)	0.93 (0.49)	1.46 (0.81)	5.73 (3.01)	2.92 (1.63)
CHI 0.05mM	4.00 (2.42)	1.86 (1.17)	1.20 (0.72)	2.66 (1.67)	5.20 (3.14)	4.52 (2.84)
CHI 0.5mM	3.46 (1.78)	1.06 (0.50)	2.53 (1.30)	1.46 (0.69)	5.99 (3.09)	2.52 (1.19)
CHI 1.0mM	3.20 (1.63)	0.93 (0.35)	1.06 (0.54)	3.20 (1.23)	4.26 (2.18)	4.13 (1.59)
B						
SUC (0.15M)	4.93 (2.91)	3.46 (1.63)	1.73 (1.02)	0.66 (0.31)	6.66 (3.93)	4.12 (1.94)
CHI 0.01mM	6.26 (3.53)	5.46 (3.31)	2.50 (1.41)	10.53 (6.39)	8.76 (4.94)	15.99 (9.70)
CHI 0.05mM	6.66 (4.29)	4.26 (2.79)	2.73 (1.76)	7.20 (4.72)	9.39 (6.05)	11.46 (7.51)
CHI 0.5mM	5.06 (2.95)	6.26 (2.69)	5.20 (3.03)	12.93 (5.55)	10.26 (5.99)	19.19 (8.25)
CHI 1.0mM	4.66 (2.25)	8.40 (3.06)	2.51 (1.21)	16.13 (5.88)	7.17 (3.47)	24.53 (8.95)
LSD at $P_{=0.05}$	0.13	0.11	0.22	0.34	1.09	0.98

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (1 2 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 1.4.4: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	46.09	21.44	4.32	4.17	50.41	25.62
CHI 0.01mM	42.87	11.87	8.30	11.87	51.18	23.74
CHI 0.05mM	31.43	14.12	9.42	20.19	40.85	34.31
CHI 0.5mM	33.06	7.499	24.18	10.33	57.23	17.83
CHI 1.0mM	30.91	10.23	10.24	35.20	41.15	45.43
B						
SUC (0.15M)	40.47	25.18	14.20	4.80	54.66	29.98
CHI 0.01mM	53.59	44.19	21.40	85.22	74.99	129.40
CHI 0.05mM	49.38	30.71	20.24	51.90	69.61	82.61
CHI 0.5mM	41.62	52.78	42.77	109.00	84.39	161.80
CHI 1.0mM	46.03	102.21	24.79	196.21	70.82	298.41
LSD at $P_{=0.05}$	1.08	2.79	1.66	2.05	1.92	1.34

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Table 1.4.5: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	2.58 (1.22)	2.12 (0.90)	0.33 (0.15)	0.58 (0.24)	2.33 (1.10)	1.93 (0.82)
CHI 0.01mM	6.73 (3.54)	5.55 (3.11)	0.11 (0.05)	0.14 (0.07)	3.73 (1.96)	3.13 (1.75)
CHI 0.05mM	6.33 (3.82)	5.11 (3.15)	0.12 (0.07)	0.18 (0.11)	2.96 (1.79)	2.76 (1.73)
CHI 0.5mM	4.80 (2.47)	4.23 (2.00)	0.22 (0.11)	0.28 (0.13)	2.43 (1.25)	2.31 (1.09)
CHI 1.0mM	4.75 (2.43)	4.21 (1.54)	0.26 (0.13)	0.30 (0.11)	3.23 (1.65)	1.06 (0.40)
B						
SUC (0.15M)	3.21 (1.89)	2.43 (1.14)	0.30 (0.17)	0.48 (0.22)	2.80 (1.64)	2.26 (1.06)
CHI 0.01mM	5.25 (2.96)	4.96 (3.01)	0.19 (0.10)	0.21 (0.12)	4.13 (2.33)	4.03 (2.44)
CHI 0.05mM	4.91 (3.16)	4.66 (3.05)	0.21 (0.12)	0.25 (0.16)	3.43 (2.21)	2.96 (1.94)
CHI 0.5mM	3.75 (2.19)	2.61 (1.12)	0.28 (0.16)	0.39 (0.17)	4.46 (2.60)	3.33 (1.43)
CHI 1.0mM	2.08 (1.00)	1.59 (0.58)	0.38 (0.18)	0.66 (0.24)	3.76 (1.81)	3.51 (1.27)
LSD at $P_{=0.05}$	0.18	0.22	0.018	0.026	0.40	0.34

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 1.4.6: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	27.91	20.12	3.57	5.50	25.20	18.31
CHI 0.01mM	60.11	45.12	0.98	1.13	33.31	25.45
CHI 0.05mM	49.73	37.95	0.94	1.36	23.25	20.95
CHI 0.5mM	45.86	29.93	2.10	1.98	23.22	16.34
CHI 1.0mM	45.88	44.00	2.51	3.30	31.20	11.66
B						
SUC (0.15M)	26.26	17.68	2.46	3.49	22.98	16.45
CHI 0.01mM	44.94	40.14	1.62	1.70	35.35	32.62
CHI 0.05mM	36.40	33.59	1.48	1.80	25.42	21.34
CHI 0.5mM	30.84	22.01	2.30	3.28	36.68	28.08
CHI 1.0mM	20.54	19.35	3.75	8.03	37.14	42.58
LSD at $P_{=0.05}$	2.18	1.52	0.88	0.62	1.11	1.37

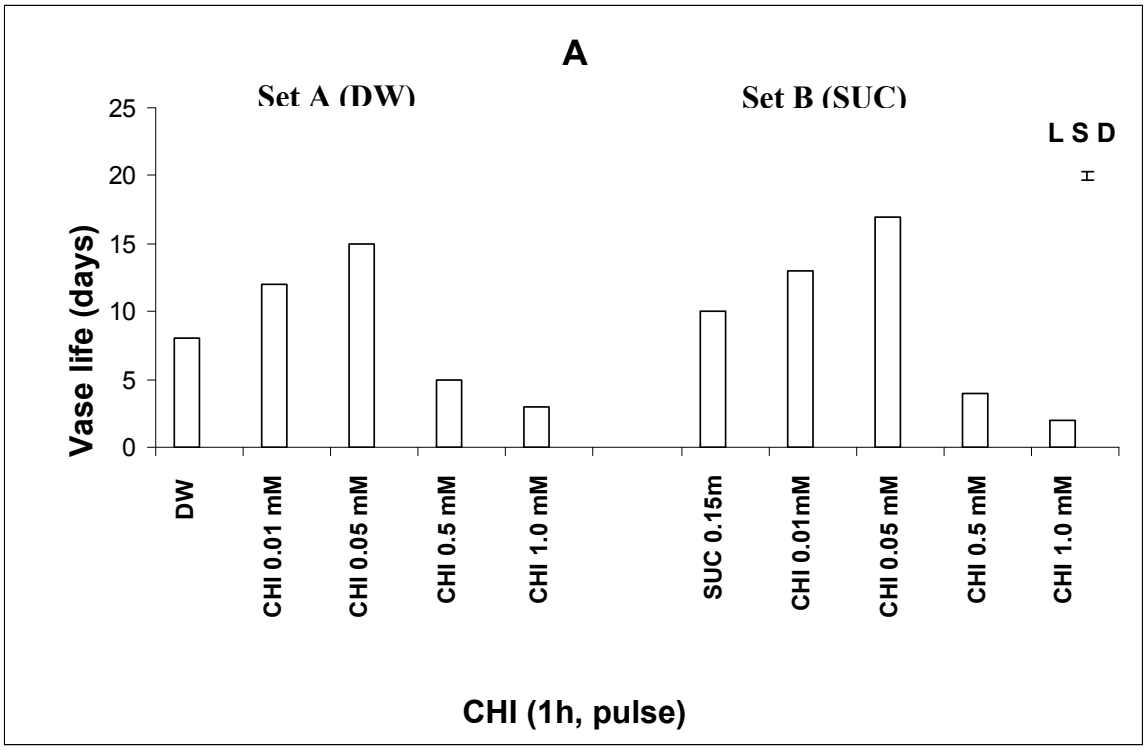
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (12 ± 2^0C).

Fig. 1.4.1

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) before transfer to DW (A) or SUC (B) on vase life (A) and number of blooms per scape (B) in cut scapes of *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{=0.05}$.


A
Set A (DW)
Set B (SUC)
L S D
Vase life (days)
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

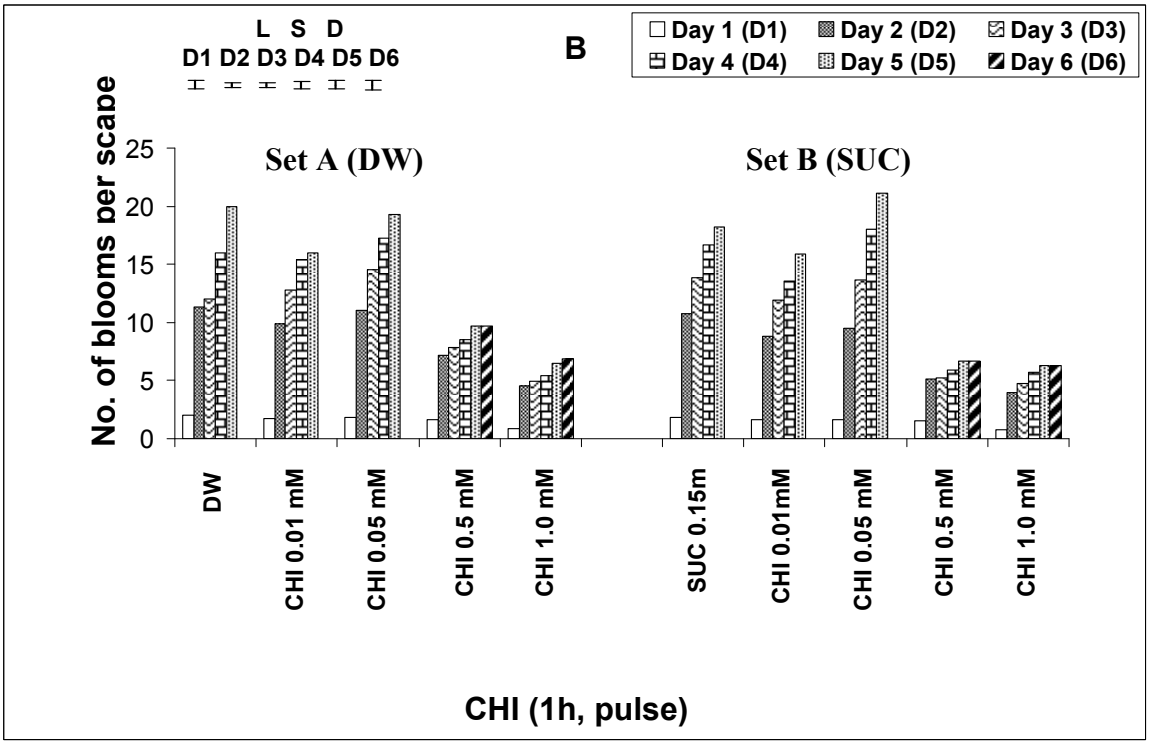
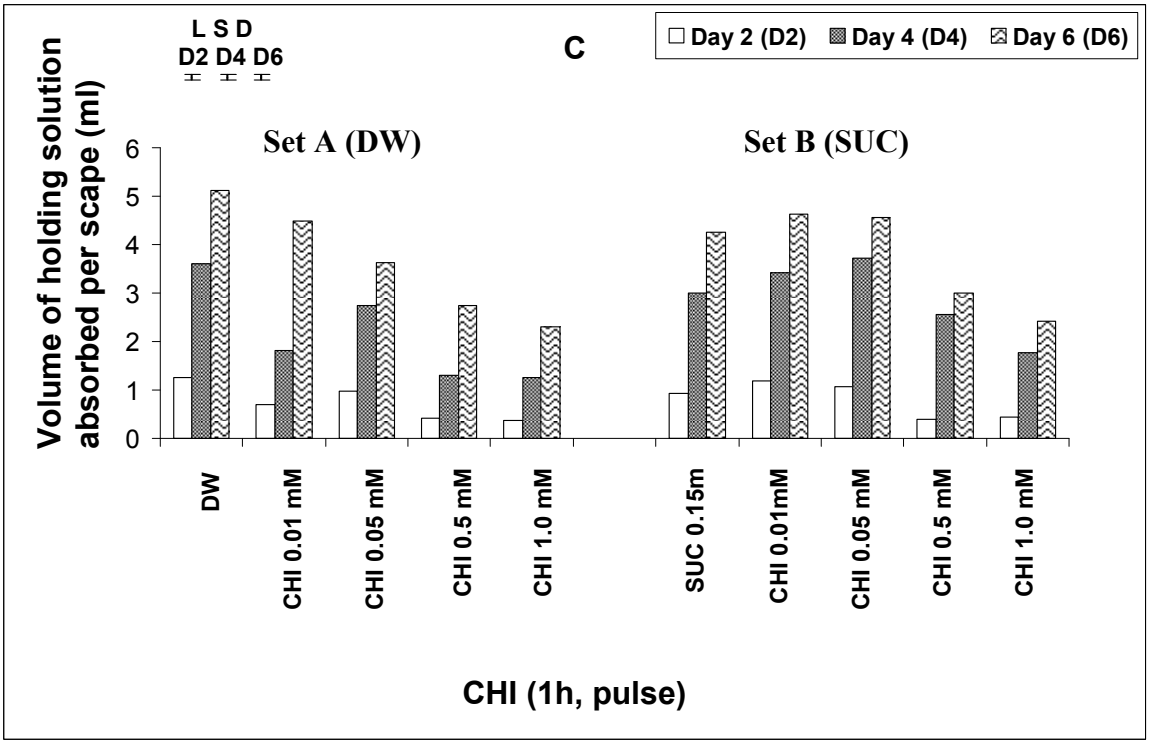

B
L S D
D1 D2 D3 D4 D5 D6
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
Day 5 (D5)
Day 6 (D6)
Set A (DW)
Set B (SUC)
No. of blooms per scape
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.1

Fig. 1.4.2

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on volume of holding solution absorbed per scape ml (C) and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
Set A (DW)
Set B (SUC)
0
1
2
3
4
5
6
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

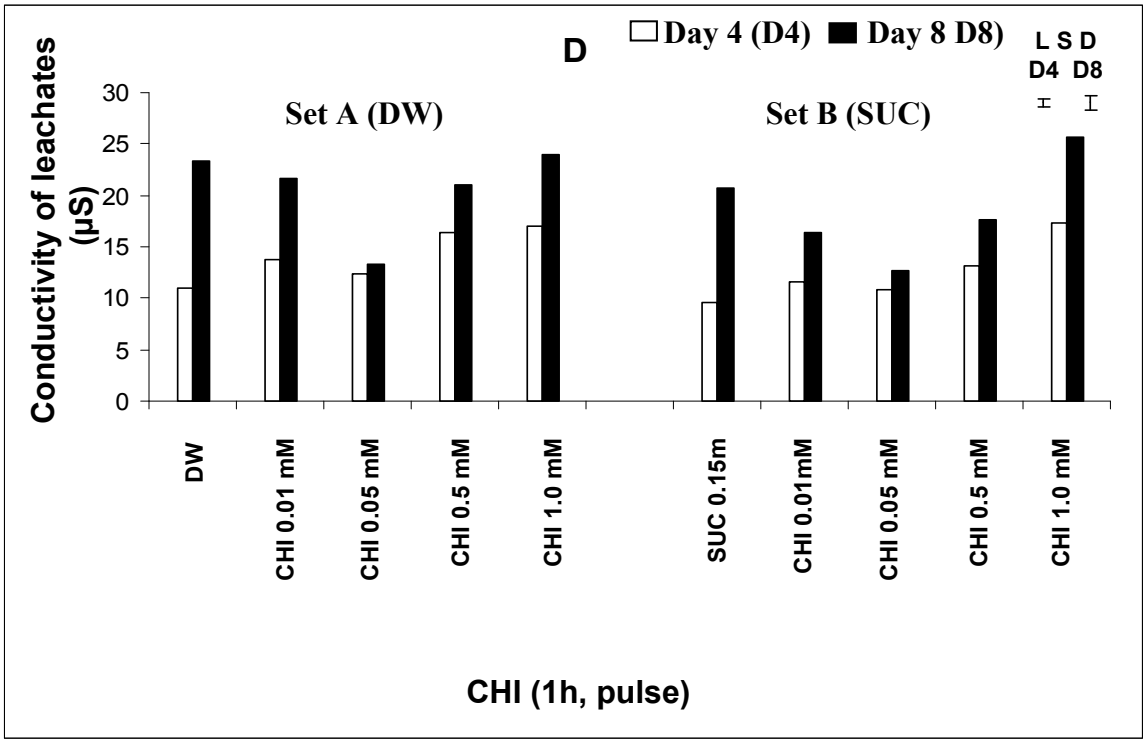
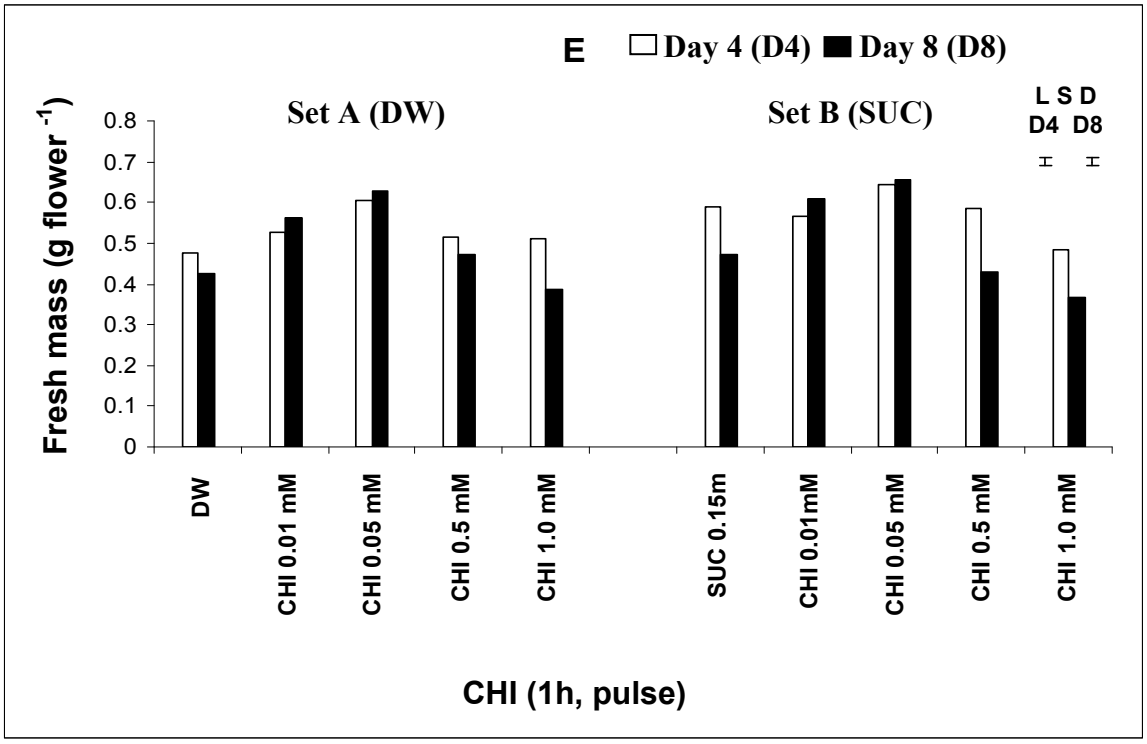

D
Day 4 (D4)
Day 8 D8)
L S D
D4 D8
Conductivity of leachates (µS)
Set A (DW)
Set B (SUC)
0
5
10
15
20
25
30
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.2

Fig. 1.4.3

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{=0.05}$.


E
Day 4 (D4)
Day 8 (D8)
Set A (DW)
Set B (SUC)
L S D
D4 D8
Fresh mass (g flower -1)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

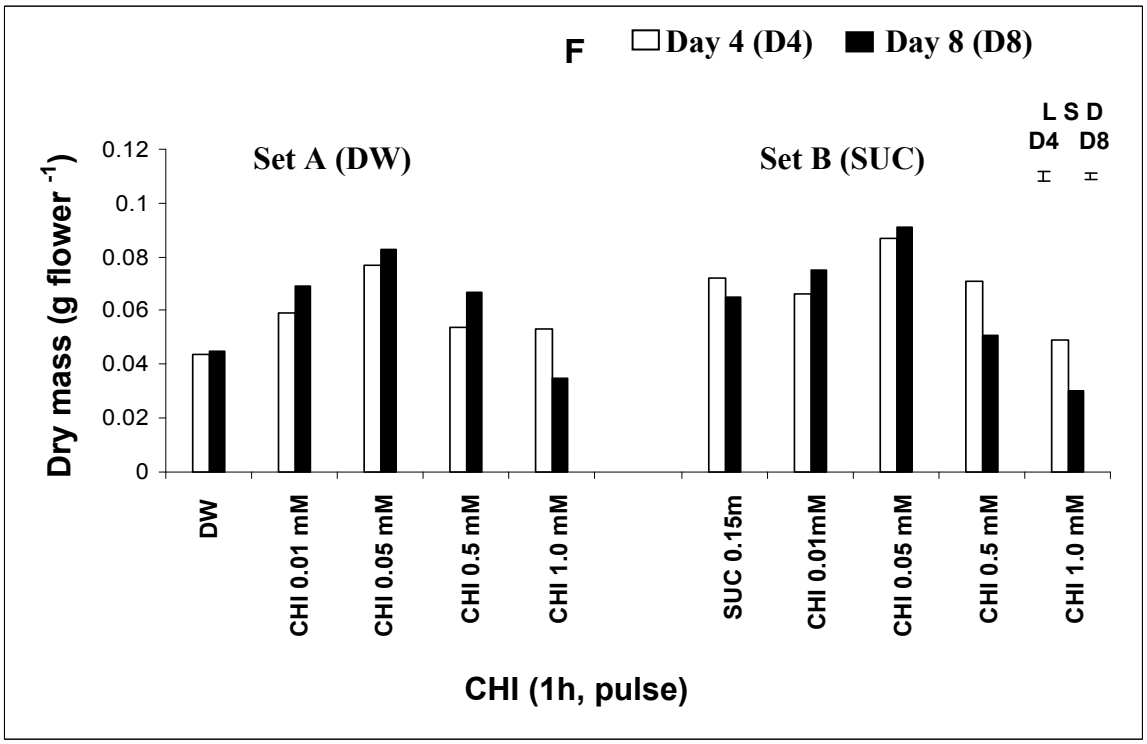
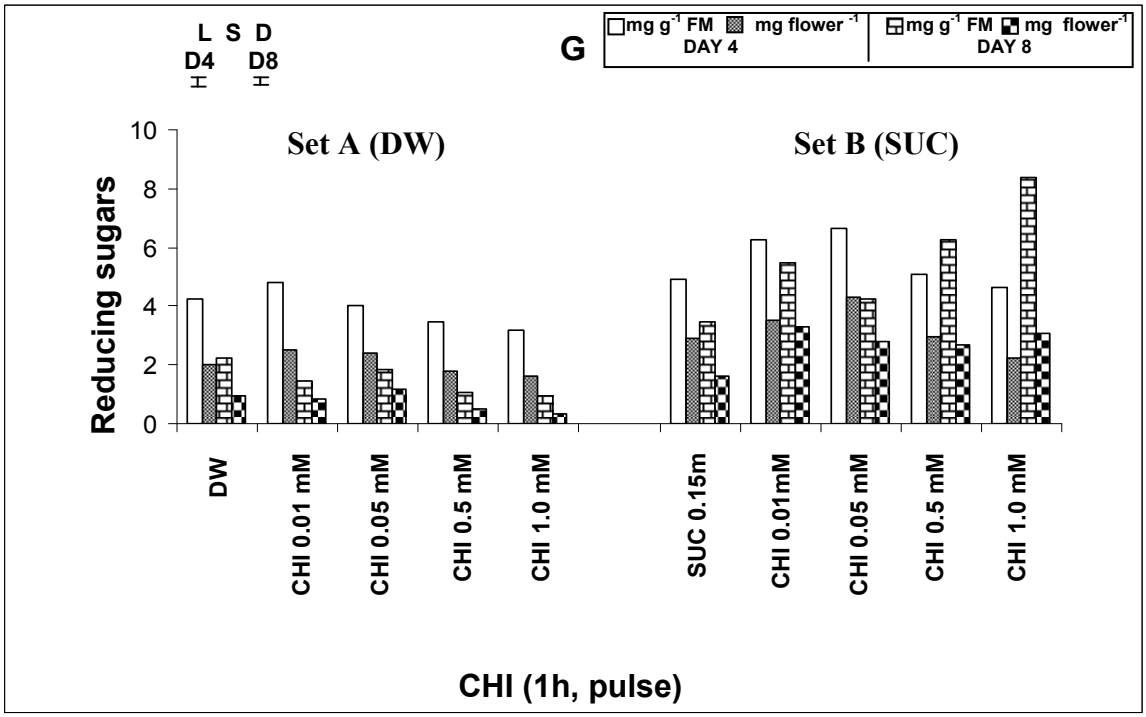

F
Day 4 (D4)
Day 8 (D8)
Set A (DW)
Set B (SUC)
L S D
D4 D8
Dry mass (g flower -1)
0.12
0.1
0.08
0.06
0.04
0.02
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.3

Fig. 1.4.4

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{=0.05}$.


G
L S D
D4 D8
H
mg g-1 FM mg flower-1
DAY 4
mg g-1 FM mg flower-1
DAY 8
Set A (DW)
Set B (SUC)
Reducing sugars
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

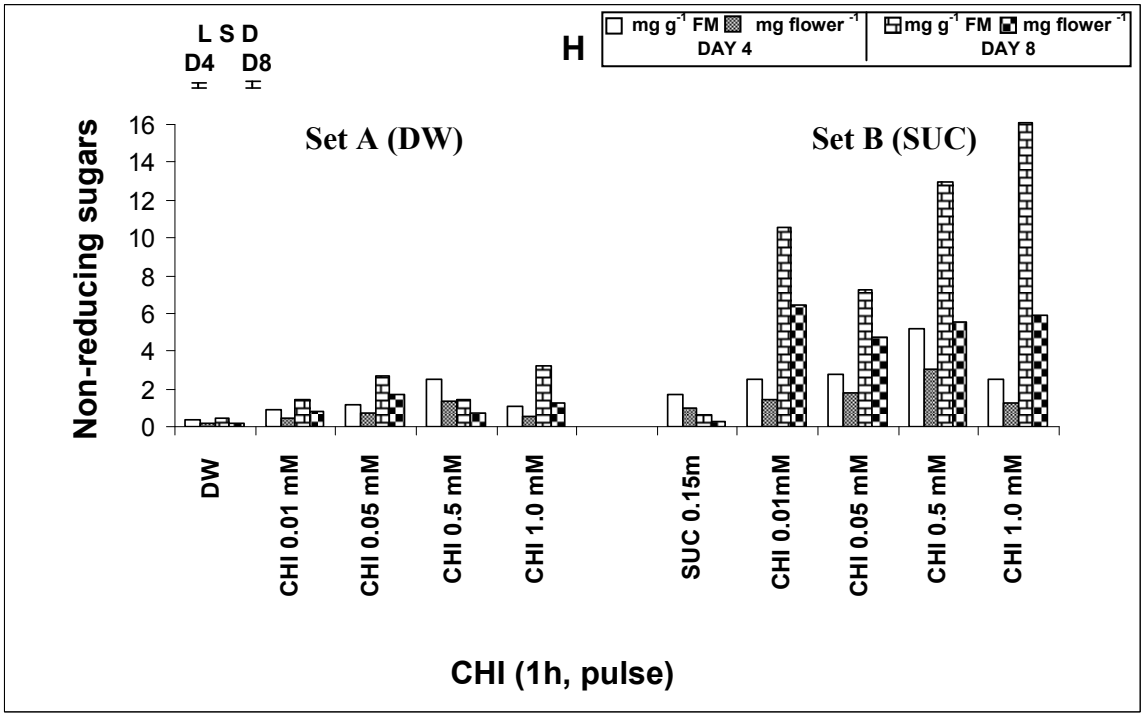
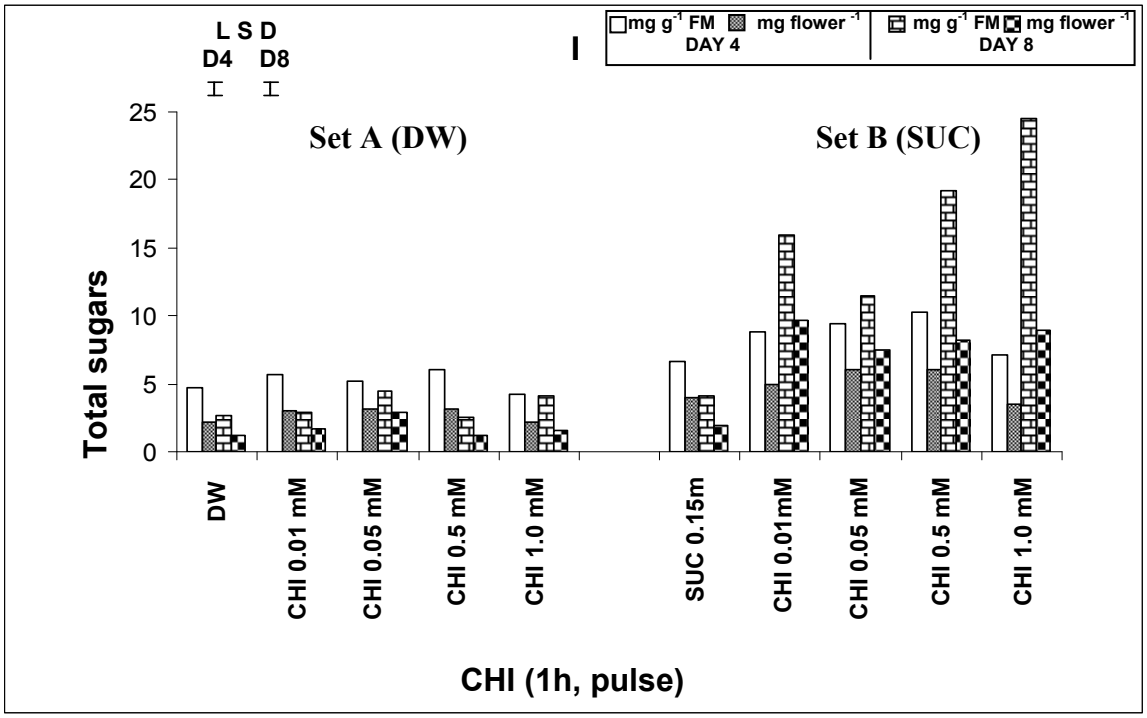

H
L S D
D4 D8
H
mg g-1 FM mg flower-1
DAY 4
mg g-1 FM mg flower-1
DAY 8
Set A (DW)
Set B (SUC)
Non-reducing sugars
16
14
12
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.4

Fig. 1.4.5

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{=0.05}$.


I
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Total sugars
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

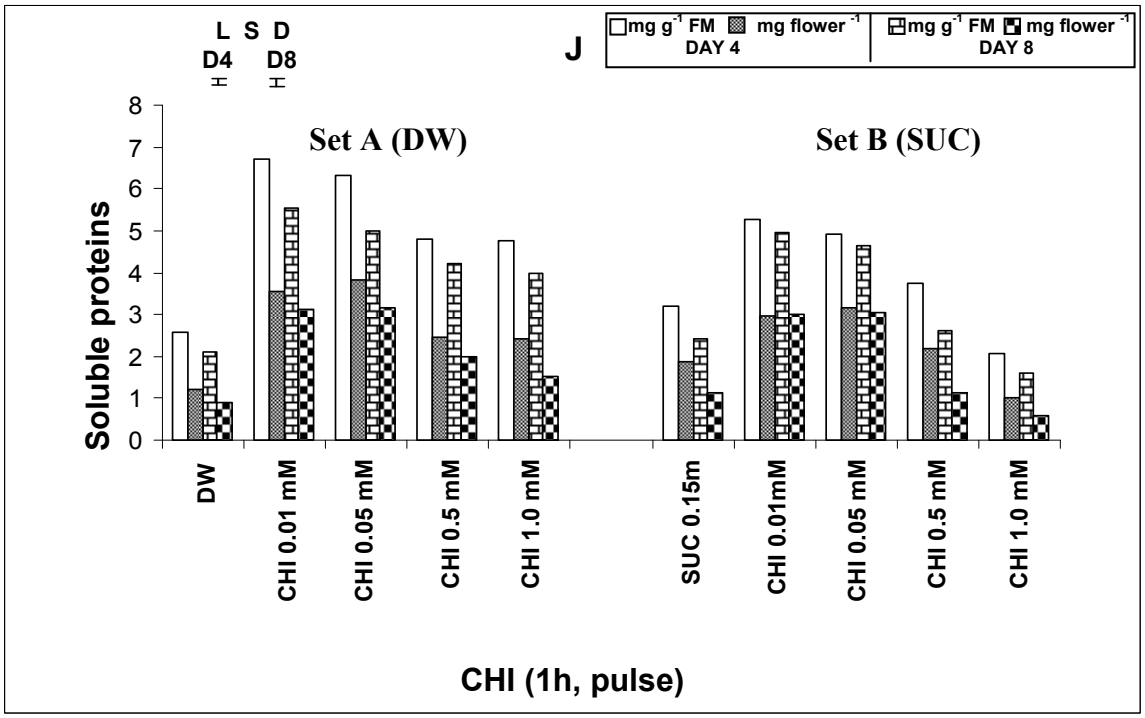
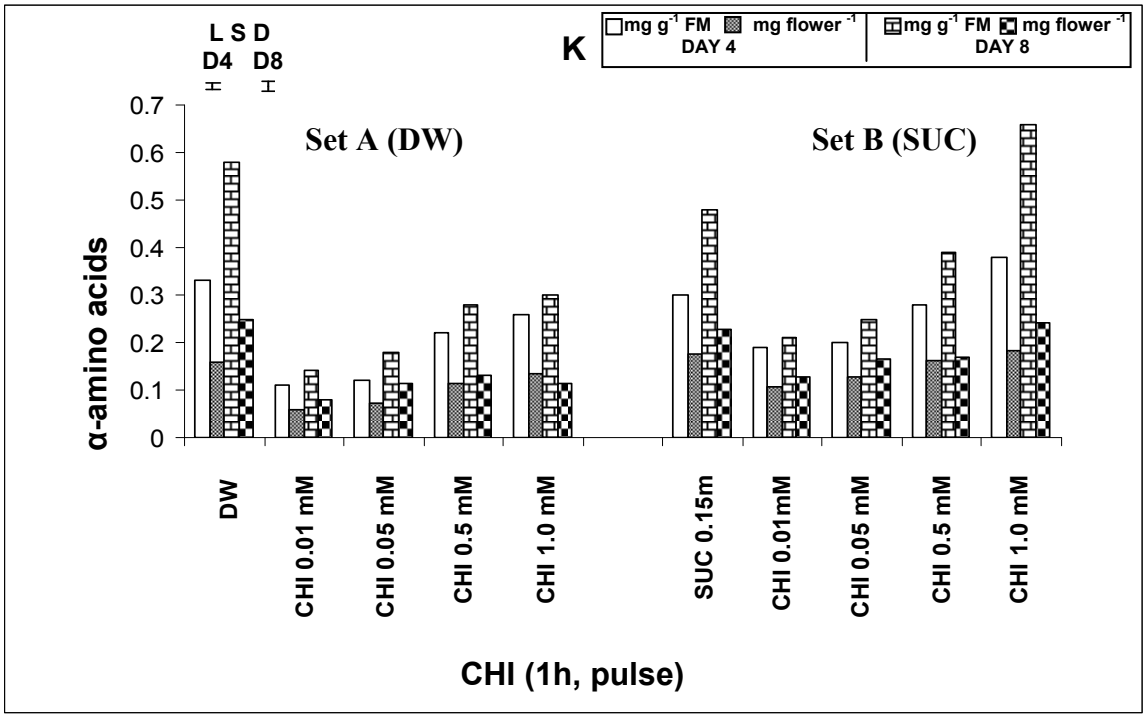

J
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Soluble proteins
8
7
6
5
4
3
2
1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.5

Fig. 1.4.6

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on α- amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

Vertical bars represent LSD at $P_{= 0.05.}$


K
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
α-amino acids
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

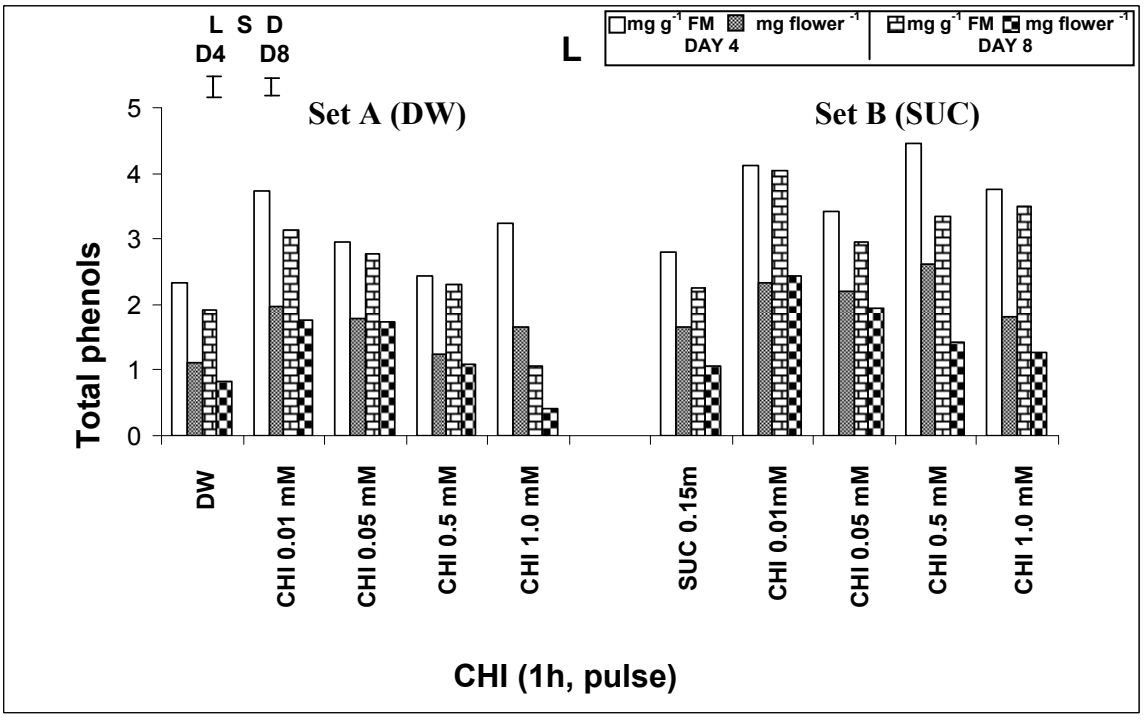

L
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Total phenols
5
4
3
2
1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 1.4.6

Plate. 1.4.1

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 4 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15 M), CHI (0.01 mM) → DW and CHI (0.01 mM) → SUC (0.15 M).

Fig.2: DW, SUC (0.15 M), CHI (0.05 mM) → DW and CHI (0.05 mM) → SUC (0.15 M).

Fig.3: DW, SUC (0.15 M), CHI (0.5 mM) → DW and CHI (0.5 mM) → SUC (0.15 M).

Fig.4: DW, SUC (0.15 M), CHI (1.0 mM) → DW and CHI (1.0 mM) → SUC (0.15 M).

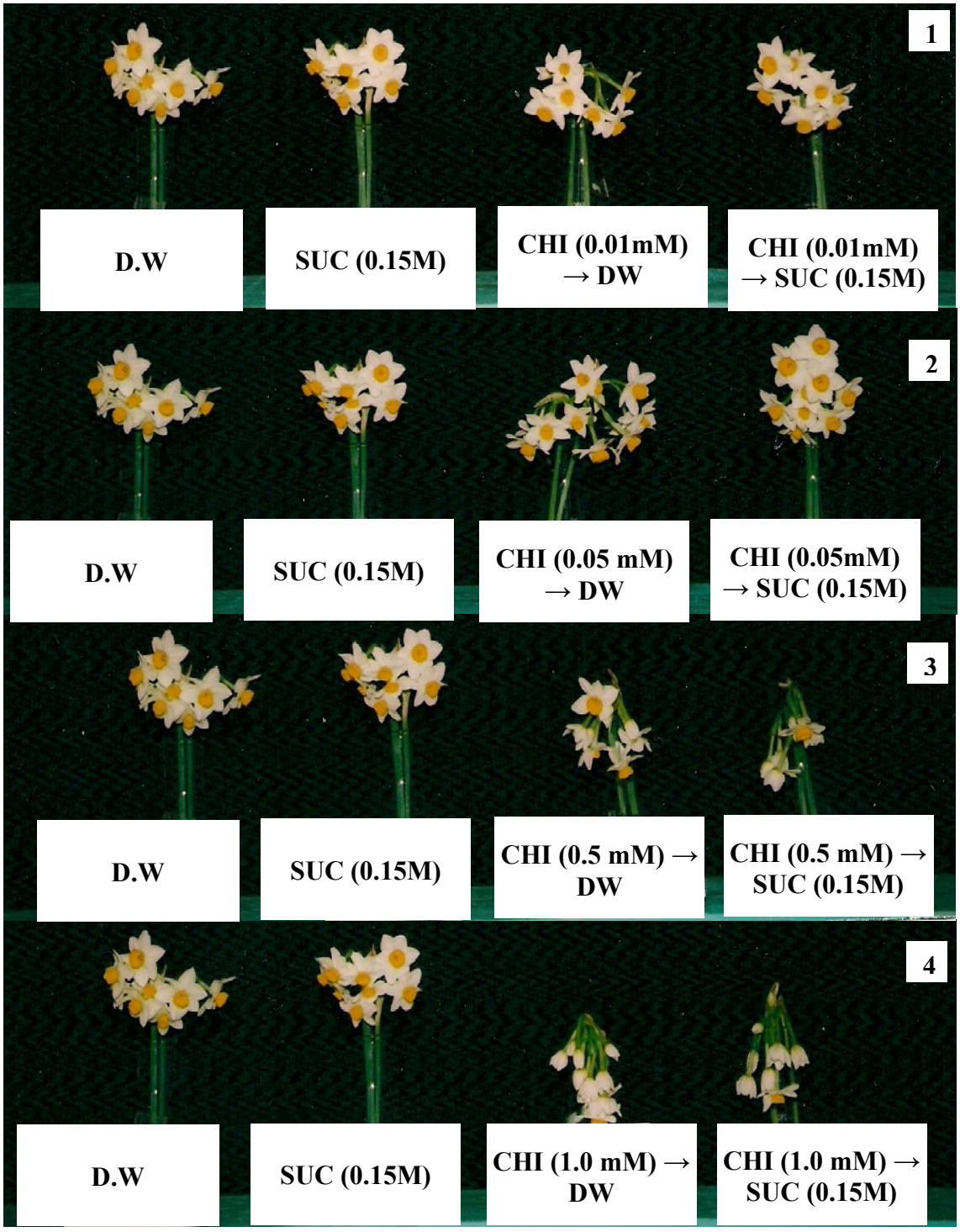

1
D.W
SUC (0.15M)
CHI (0.01mM) → DW
CHI (0.01mM) → SUC (0.15M)
2
D.W
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05mM) → SUC (0.15M)
3
D.W
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)
4
D.W
SUC (0.15M)
CHI (1.0 mM) → DW
CHI (1.0 mM) → SUC (0.15M)

Plate. 1.4.1

Plate. 1.4.2

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 8 of transfer of scapes to holding solutions in *Narcissus tazetta* cv. Kashmir Local.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15 M), CHI (0.01 mM) → DW and CHI (0.01 mM) → SUC (0.15 M).

Fig.2: DW, SUC (0.15 M), CHI (0.05 mM) → DW and CHI (0.05 mM) → SUC (0.15 M).

Fig.3: DW, SUC (0.15 M), CHI (0.5 mM) → DW and CHI (0.5 mM) → SUC (0.15 M).

Fig.4: DW, SUC (0.15 M), CHI (1.0 mM) → DW and CHI (1.0 mM) → SUC (0.15 M).

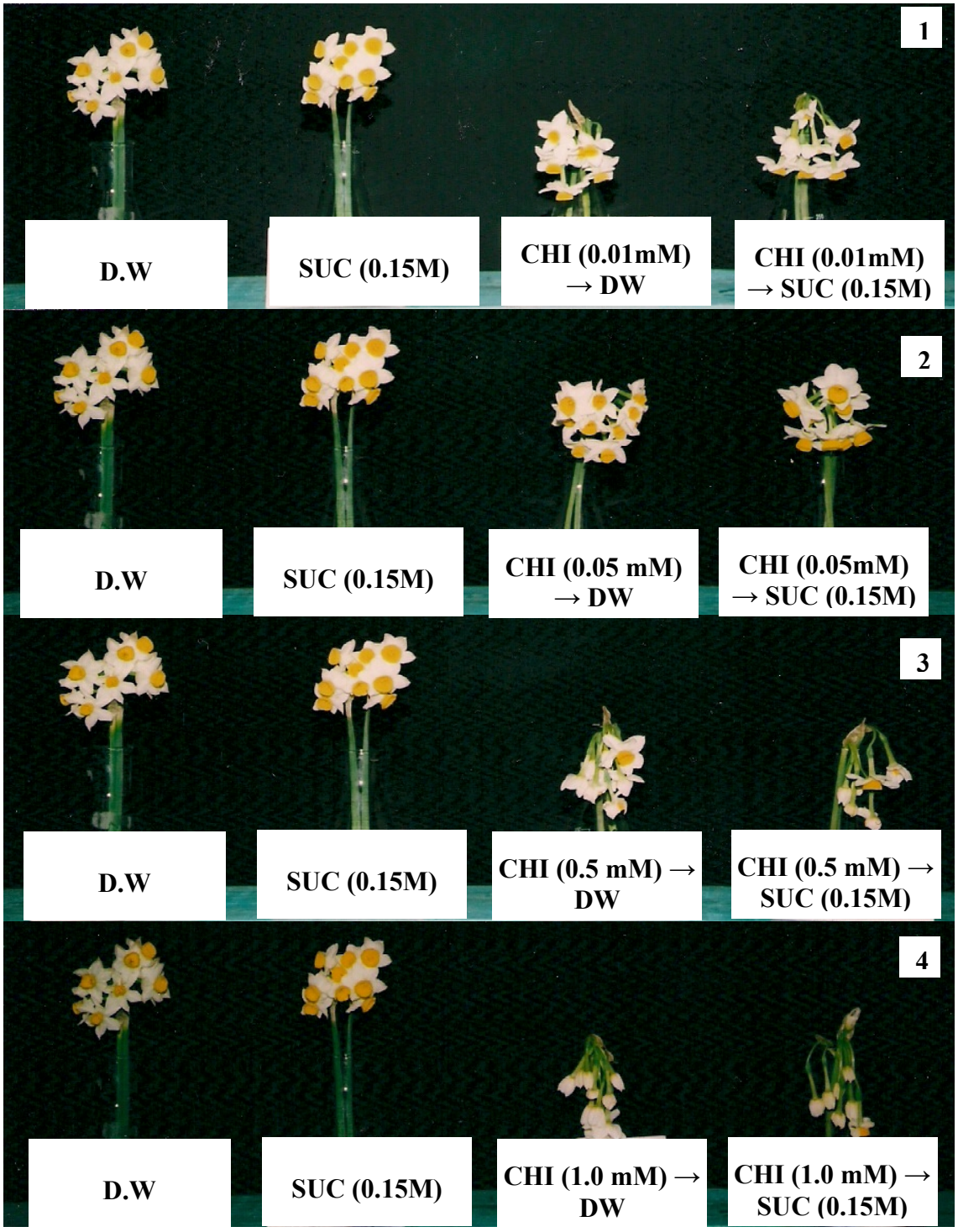

1
D.W
SUC (0.15M)
CHI (0.01mM) → DW
CHI (0.01mM) → SUC (0.15M)
2
D.W
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05mM) → SUC (0.15M)
3
D.W
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)
4
D.W
SUC (0.15M)
CHI (1.0 mM) → DW
CHI (1.0 mM) → SUC (0.15M)

Plate. 1.4.2

CHAPTER 2

Flower Senescence and Regulation of Vase life in *Narcissus pseudonarcissus* cv. Emperor.

Interestingly one of the most popular species of genus *Narcissus* is termed as *pseudonarcissus* i.e. a false narcissus, as the true daffodils are only the ones with short cups (corona).The old name for daffodil was 'Affodyle' believed to originate from the Old English 'Affo dyle', meaning "that which cometh early." Later on ‘D’ was prefixed. *Narcissus pseudonarcissus* is commonly known as daffodil and has attracted the interest of mankind since time immemorial. Daffodils were first written about by the Greek writer Theophrastus around 300 BC in his 'Enquiry into Plants'

Narcissus pseudonarcissus is a perennial bulbous species of the genus *Narcissus.* It has pale yellow flowers with a darker central trumpet and is therefore also called as “Trumpet Daffodil”. The species is native to Western Europe ranging from Spain and Portugal to Germany, England and Wales. It is commonly grown in gardens and populations have become established in many other parts of the world. In Kashmir *Narcissus pseudonarcissus* grows in wild and is also grown at homes as a prized flower. The daffodil is the national flower of Wales, and also the county flower of Gloucestershire.

People across the world have established farms or societies meant for development of the plant. John Bartram, at Philadelphia maintained a daffodil collection on his six acre farm in the 1730’s. This is the earliest collection of American grown daffodils. The Maryland Daffodil Society was organized in 1922. The American Daffodil Society was organized in 1955 to promote wider interest in daffodils; to encourage scientific research and education on daffodil culture. The 50th anniversary "National" show for the American Daffodil Society was held in 2004 by the Washington Daffodil Society.

Being one of the important and popular species of the genus *Narcissus,* an initiative was made to study the overall pattern of flower development and senescence. Attempts were made to determine optimal

harvest maturity stage for short term cool wet or dry storage. Response to protein synthesis inhibitors (CHI) and to ethylene antagonists (STS) was also studied to develop formulations for enhancing the vase life and improving the overall postharvest performance of the species.

EXPERIMENT 2.1

Physiological and biochemical changes associated with the flower development and senescence in *Narcissus pesudonarcissus* cv. Emperor.

Experimental

Flowers of *N.pesudonarcissus* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were designated as tight bud stage (I), loose bud stage (II), half open stage or goose neck stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI) (Plate 2.1.1). Visible changes were recorded throughout flower development and senescence. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the electrical conductivity of leachates (μS) from tepal discs (5 mm in diameter) punched from outer regions of tepals of five different flowers incubated in 15 ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents from tepal tissues, 1g chopped material was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α- amino acids and total phenols as described in materials and methods. Non-reducing sugars were calculated as the difference between total and reducing sugars. Soluble proteins were extracted from 1 g of the tepal tissue drawn separately from five different flowers at each of the six stages. Electrophoretic profiles were studied at various stages of flower development and senescence. 80 μL of the SDS-denatured protein extract was loaded into each lane. Each value represented

in the tables corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: The greenish buds open into bright yellow flowers with a prominent corona at the centre and the flower senescence in *N. pseudonarcissus* is marked by the turgor loss starting at the margins of the tepals and progressing towards corona. It is followed by complete wilting and concomitantly the size of the ovary increases as the tepal senescence progresses. The average life span of an individual flower after it opens fully is about 3 days (Plate 2.1.1).

Floral diameter: Flower diameter increased as the flower development progressed up to stage IV to V and declined sharply thereafter as the floral development progressed to senescence from stage V and VI (Table 2.1.1, Text Fig. 2.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage IV and registered a decline thereafter as the senescence progressed up to stages VI. However, the water content at various stages of floral development and senescence was found to be more or less constant when the data was expressed on percent fresh mass basis (Table 2.2.1, Text Figs. 2.1.1 B, C & D).

Membrane permeability: Membrane permeability estimated as conductivity of leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages. Slight decrease was noticed in the membrane permeability as the flower development progressed from stage I to II, followed by a gradual increase up to stage V, however a sharp increase was noticed thereafter from stage V to VI (Table 2.2.1. Text Fig.2.1.1, E).

Reducing sugars: The tissue content of reducing sugars increased consistently during flower development up to stage IV and declined thereafter as the flower development progressed to senescence (Table 2.1.2, Text Fig.2.1.2, F). When expressed on per flower basis the reducing sugar content increased progressively from stage I to stage IV after which a sharp decline was registered in the reducing sugar content at stages V and stage VI (Table 2.1.2). On dry mass basis a progressive increase in the reducing sugar content was noticed up to stage IV which was followed by a sharp decline, the decline in the reducing sugar content was however marked as the flower senescence progressed form stage V to VI (Table 2.1.3).

Non-reducing sugars: The non-reducing sugar content decreased up to stage IV, followed by a slight increase thereafter at stages V and VI, a sharp decrease was however noticed at stages III and IV (Table 2.1.2. Text Fig. 2.1.2,G).When expressed on per flower basis, the non-reducing sugar content decreased up to stage III followed by an increase up to stage IV, however a sharp decrease in non-reducing sugar content was noticed after stage II (Table 2.1.2). On dry mass basis the non-reducing sugar content showed a steady decrease up to stage III, followed by an increase from stage IV to stage VI (Table 2.1.3).

Total sugars: The tissue content of total sugars increased up to stage II and decreased slightly at stage III, followed by a slight increase at stage IV and a gradual decline thereafter up to senescent stage, stage VI (Table 2.1.2, Text Fig.2.1.2,H). On per flower basis the total soluble sugar content increased consistently up to stage IV and declined thereafter (Table 2.1.2). When expressed on dry mass basis the total soluble sugar content increased from stage I to stage II, followed by a decrease again at stage III , a sharp increase in the total sugars was noticed thereafter at stage IV, which was followed by a decline up to stage V; however the total sugar content decreased during the final stage of senescence at stage VI (Table 2.1.3).

Soluble proteins: The concentration of soluble proteins increased as the flower development progressed from stage I to stage III and declined thereafter up to stage VI (Table 2.1.2, Text Fig.2.1.2, I). On per flower basis, the soluble protein content increased gradually up to stage IV and declined thereafter (Table 2.1.2).When expressed on dry mass basis, the soluble proteins increased progressively up to stage IV and declined thereafter during senescence (Table 2.1.3).

α- amino acids: The α-amino acid content registered an initial increase during flower development up to stage II, followed by a slight decrease up to stage IV, and sharp increase thereafter during final stages of senescence from stage V to stage VI (Table 2.1.2, Text Fig.2.1.2, J). When expressed on per flower basis, the amino acid content increased consistently from stage I to stage VI (Table 2.1.2). On dry mass basis the amino acid content increased sharply up to stage II, followed by a slight decrease at stage III and a progressive increase thereafter up to stage VI (Table 2.1.3).

Phenols: The content of total phenols decreased consistently from stage I to stage IV, followed by a sharp increase thereafter up to stage VI (Table 2.1.2, Text Fig.2.1.2,K). When expressed on per flower basis, the concentration of phenols increased progressively during the final stage of flower development and senescence up to stage VI (Table 2.1.2). On dry mass basis, the total phenolic content increased during initial stages of flower development up to stage II, followed by a progressive increase thereafter up to stage VI (Table 2.1.3).

***Electrophoretic profile*:** The SDS-PAGE of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent from stage I to VI particularly polypeptides of 95.4, 39.8 and 31.6 kDa. Some new polypeptides could be identified as faint bands during flower senescence with a molecular weight of 12.5, 10, 7.9 and 6.3 kDa (Plate 2.1.2).

Table 2.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Narcissus pseudonarcissus* cv. Emperor (Each value is a mean of 10 independent replicates, figures in parentheses represents values on percent basis).

Stages of flower development	Floral diameter (cm)	Fresh mass flower^{-1} (g)	Dry mass flower^{-1} (g)	Water content flower^{-1} (g)	Conductivity of leachates (µs)
I (tight bud stage)	2.12 ± 0.21	1.53 ± 0.03	0.280 ± 0.003	1.25 ± 0.03 (81.74)	11.63 ± 0.61
II (loose bud stage)	3.2 ± 0.23	1.94 ± 0.08	0.316 ± 0.005	1.62 ± 0.08 (83.55)	9.0 ± 0.70
III (half open stage)	8.0 ± 0.35	2.33 ± 0.21	0.396 ± 0.003	1.94 ± 0.21 (82.93)	15.76 ± 0.68
IV (fully open stage)	10.78 ± 0.3	3.38 ± 0.34	0.486 ± 0.005	2.89 ± 0.33 (85.52)	17.1 ± 0.79
V (partially senescent stage)	9.28 ± 0.35	2.97 ± 0.24	0.401 ± 0.006	2.57 ± 0.24 (86.44)	18.46 ± 0.80
VI (senescent stage)	4.20 ± 0.27	2.30 ± 0.21	0.330 ± 0.011	1.97 ± 0.22 (85.52)	27.96 ± 0.61

Table 2.1.2: Sugars, proteins, α-amino acids and total phenols expressed as fresh mass (mg g^{-1} FM) during development and senescence in flowers of *Narcissus pseudonarcissus* cv. Emperor (Each value is a mean of 5 independent replicates, figures in parentheses represents values on mg $flower^{-1}$ basis).

Stages of flower development	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	5.33 ± 0.57 (8.16)	20.5 ± 1.32 (31.36)	25.83 ± 0.76 (39.52)	1.12 ± 0.12 (1.72)	0.097 ± 0.008 (0.149)	5.33 ± 0.14 (8.16)
II	16.16 ± 0.76 (31.36)	11.50 ± 0.50 (22.31)	27.66 ± 0.28 (53.67)	1.50 ± 0.12 (2.91)	0.127 ± 0.004 (0.246)	5.08 ± 0.38 (9.86)
III	22.66 ± 0.57 (52.81)	1.33 ± 0.28 (3.10)	24.0 ± 0.50 (55.92)	2.29 ± 0.19 (5.33)	0.119 ± 0.004 (0.277)	4.50 ± 0.25 (10.48)
IV	24.66 ± 0.57 (83.37)	1.38 ± 0.28 (4.50)	26.0 ± 0.50 (87.88)	2.04 ± 0.07 (6.90)	0.111 ± 0.004 (0.375)	3.91 ± 0.14 (13.23)
V	20.33 ± 0.76 (60.39)	3.0 ± 0.50 (8.91)	23.33 ± 0.57 (69.30)	1.66 ± 0.14 (4.95)	0.157 ± 0.01 (0.466)	4.83 ± 0.28 (14.35)
VI	14.66 ± 0.57 (33.73)	3.66 ± 0.28 (8.43)	18.33 ±0.76 (42.16)	1.41 ± 0.07 (3.25)	0.211 ± 0.008 (0.485)	9.33 ± 0.38 (21.46)

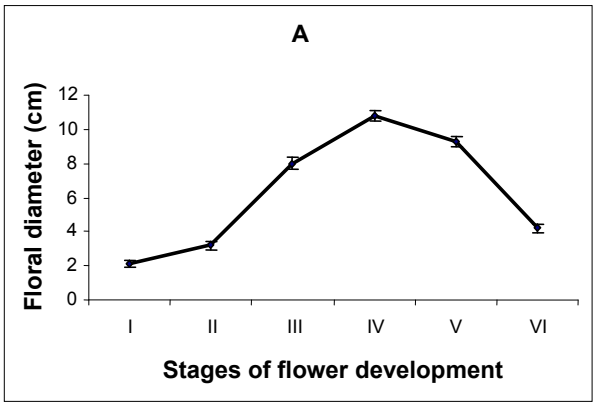
Table 2.1.3: Sugars, proteins, α-amino acids and phenols as expressed on dry mass basis (mg g^{-1} DM) during development and senescence in flowers of *Narcissus pseudonarcissus.* cv. Emperor (Each value is a mean of 5 independent replicates).

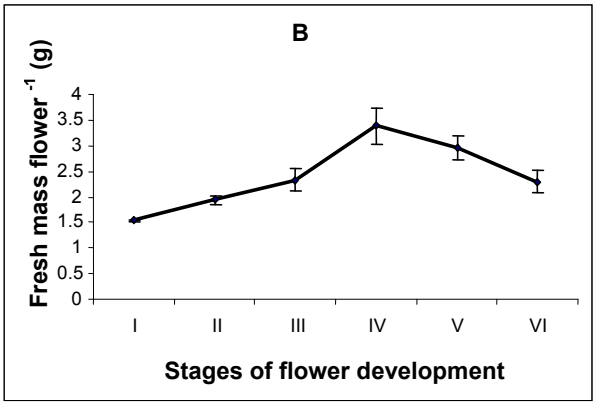
Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
I	29.14 ± 3.15	112.01 ± 7.22	141.16 ± 4.16	6.14 ± 0.68	0.532 ± 0.04	29.14 ± 0.78
II	99.25 ± 4.68	70.60 ± 3.06	169.85 ± 1.77	9.20 ± 0.76	0.781 ± 0.02	31.20 ± 2.34
III	133.36 ± 4.49	7.84 ± 1.69	141.21 ± 2.94	13.48 ± 1.12	0.701 ± 0.02	26.47 ± 1.47
IV	171.55 ± 4.01	9.27 ± 2.00	180.82 ± 3.47	14.19 ± 0.50	0.772 ± 0.03	27.23 ± 1.00
V	150.59 ± 5.65	22.21 ± 3.70	172.81 ± 4.27	12.34 ± 1.06	1.16 ± 0.125	35.79 ± 2.13
VI	102.22 ± 4.02	25.55 ± 2.01	127.77 ± 5.32	9.87 ± 0.50	1.47 ± 0.05	65.05 ± 2.66

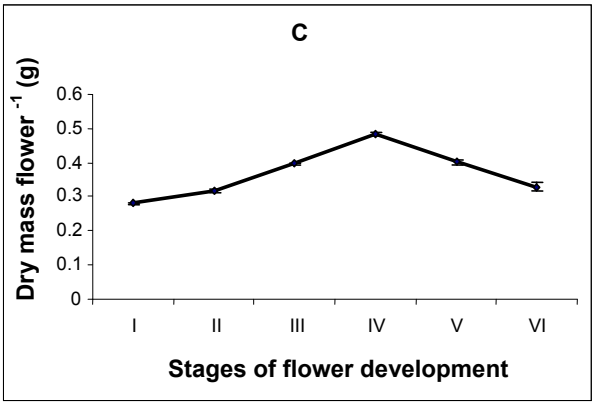
Fig. 2.1.1

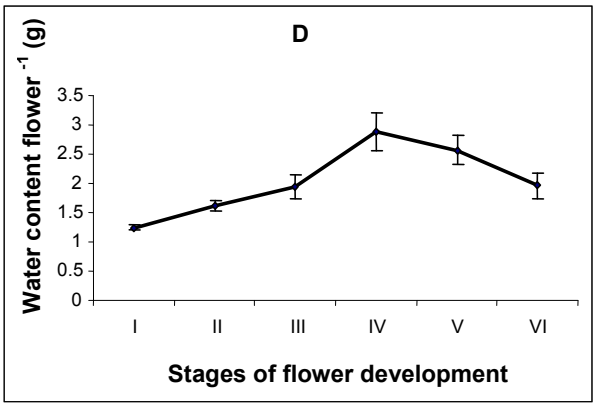
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in tepal tissues from flowers of *Narcissus pseudonarcissus* cv. Emperor at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
0
2
4
6
8
10
12
I
II
III
IV
V
VI
Stages of flower development


B
Fresh mass flower -1 (g)
0
0.5
1
1.5
2
2.5
3
3.5
4
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower -1 (g)
0
0.1
0.2
0.3
0.4
0.5
0.6
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
0
0.5
1
1.5
2
2.5
3
3.5
I
II
III
IV
V
VI
Stages of flower development

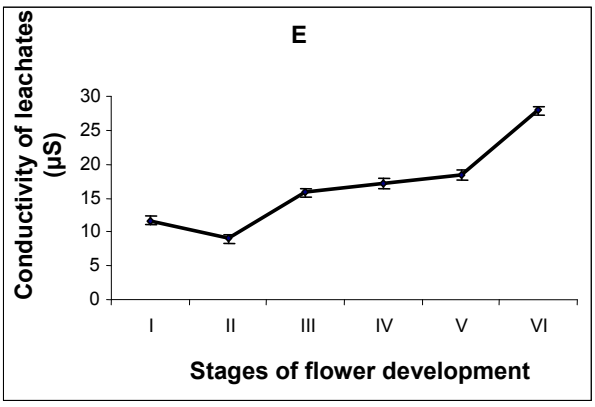

E
Conductivity of leachates (µS)
0
5
10
15
20
25
30
I
II
III
IV
V
VI
Stages of flower development

Fig. 2.1.1

Fig. 2.1.2

Changes in reducing sugars (F), non – reducing sugars (G), total sugars (H), in tepal tissues in flowers of *Narcissus pseudonarcissus* cv. Emperor at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

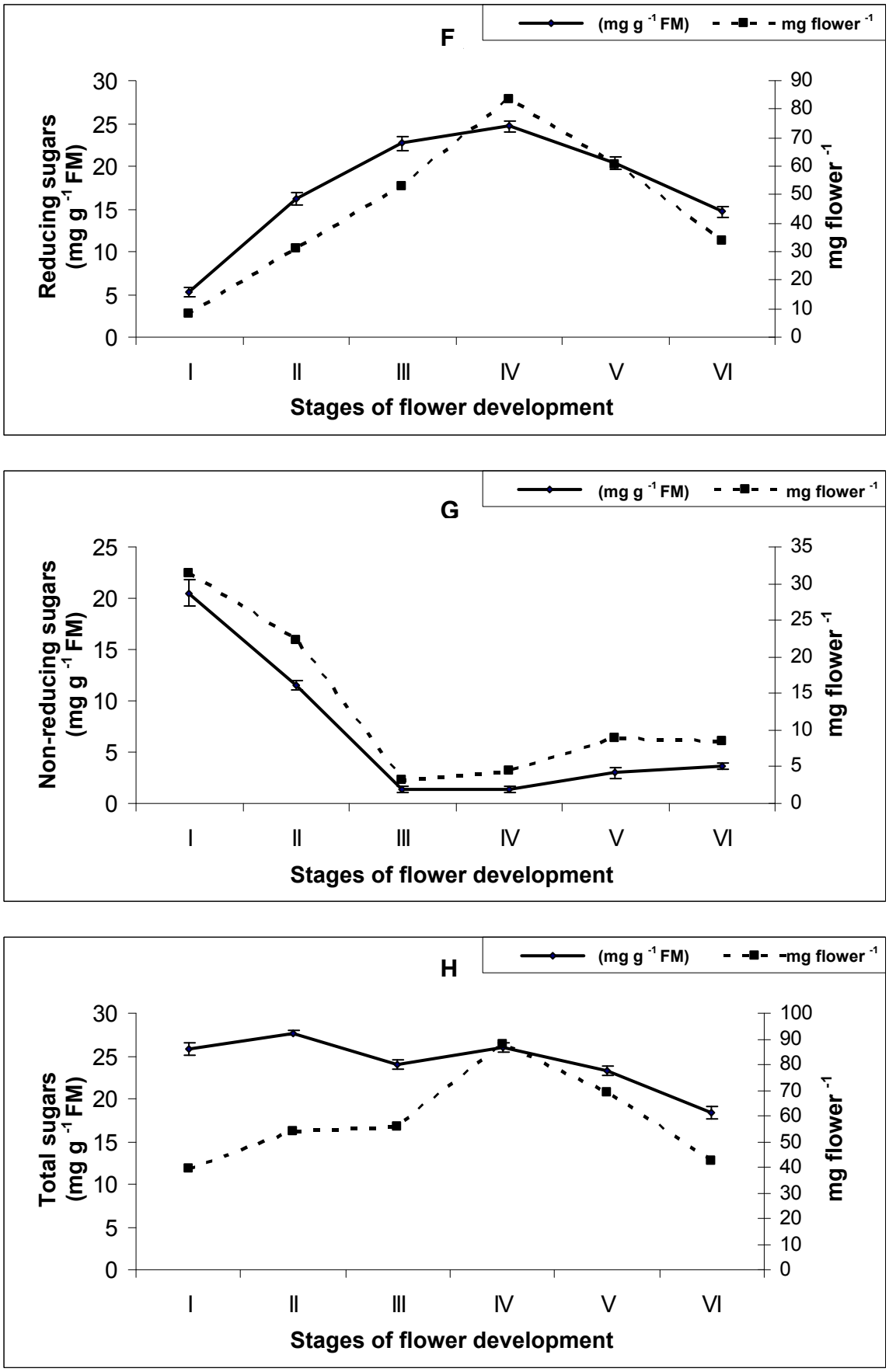

F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
H
(mg g -1 FM)
mg flower -1
Total sugars (mg g -1 FM)
mg flower -1
Stages of flower development

Fig. 2.1.2

Fig. 2.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in tepal tissues in flowers of *Narcissus pseudonarcissus* cv. Emperor at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

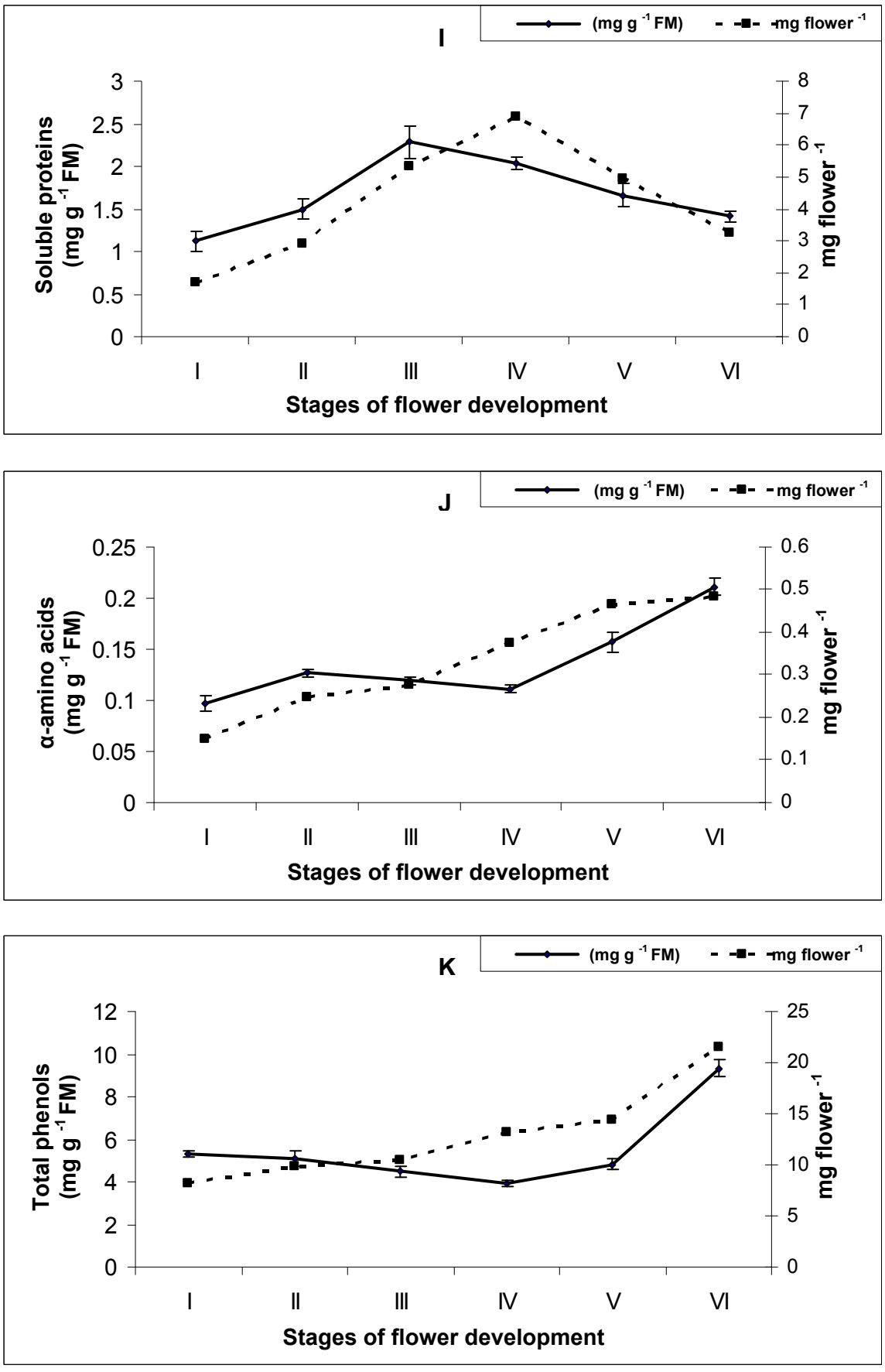

I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
Stages of flower development
J
α-amino acids (mg g -1 FM)
K
Total phenols (mg g -1 FM)

Fig. 2.1.3

Plate 2.1.1

Fig.1: Stages of flower development and senescence in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged flowers at successive stages of development and senescence. Stages I to VI in the figure represent flowers at tight bud stage (I), loose bud stage (II), half open stage or goose neck stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI).

Plate. 2.1.1

Plate 2.1.2

Fig.: 12% SDS – PAGE, equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Narcissus pseudonarcissus* cv. Emperor. The gel was stained with coomassie blue. Number above the lanes corresponds to developmental stages. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

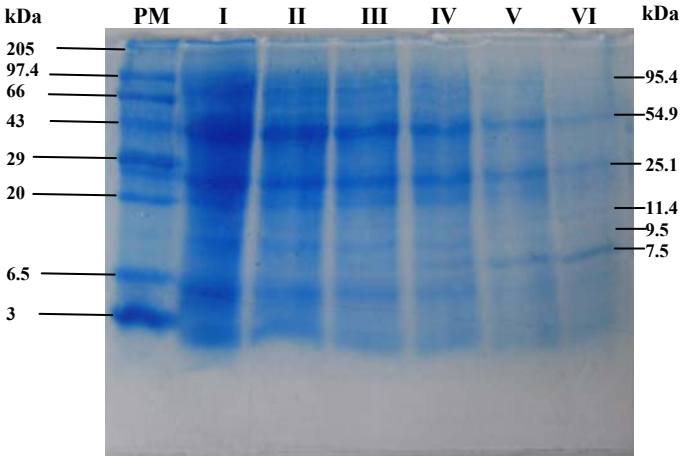

kDa
PM
I
II
III
IV
V
VI
kDa
205
97.4
66
43
29
20
6.5
3
95.4
54.9
25.1
11.4
9.5
7.5

Plate. 1.1.2

EXPERIMENT 2.2

Effect of postharvest wet storage (PHWS) at different temperature regimes; 5, 10 and room temperature (RT = 15 ± 2^{o}C) for 72 h before transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Experimental

Scapes of *N. pseudonarcissus* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform scape length of 25 cm. The scapes were held in distilled water (DW) in separate buckets and kept at 5 and 10 ^{o}C. A separate set of scapes was kept at room temperature (RT=15±2^{o}C). After 72 h all the scapes were held at room temperature and transferred to 250 ml conical flasks containing 200 ml of DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. The average vase life of flowers was counted from the day of transfer to a particular holding solution and was assessed to be terminated when the flowers had lost their display value which was characterized by turgor loss followed by wilting of petals. Volume of solution absorbed was recorded on day 2 and 4 after the transfer of scapes to holding solutions. Fresh mass, dry mass and electrical conductivity of leachates from tepal discs of flowers were recorded on day 4 of transfer of buds to holding solutions. Changes in tissue constituents comprising sugar fractions, soluble proteins, α- amino acids and phenolics were also estimated

on day 4 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: The scapes wet stored for 72 h at different temperature regimes; (5 ^{o}C, 10 ^{o}C and RT) had already bloomed during the storage. (Plate 2.2.1, Figs. 1-2). The scapes previously wet stored at (RT) before transfer to holding solution showed symptoms of tepal senescence on the day 1 of transfer to a particular holding solution. Flower senescence was characterized by turgor loss followed by wilting of tepals (Plate 2.2.2, Figs.1-3).

Vase life: The average vase life of scapes previously wet stored at 5 and 10^{o}C before transfer to holding solution was about 3 and 2 days respectively irrespective of the transfer to a particular holding solution, whereas the vase life of scapes previously held at RT before transfer to a particular holding solution was about 1 day (Table 2.2.1, Text Fig. 2.2.1, A).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression in time from day 2 to 4 of transfer of scapes to various holding solutions irrespective of the particular temperature regime and holding solution. Generally the solution uptake was found to be higher in scapes previously wet stored for 72 h at 5 and 10 °C as compared to RT in the respective holding solutions. A higher solution uptake was recorded in scapes held in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment, however maximum solution uptake was noticed in scapes previously wet stored at 5°C for 72 h and transferred to (SUC + 8- HQS) (Table 2.2.1, Text Fig. 2.2.1,B).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs registered a decrease in samples

previously wet stored for 72 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of the holding solution. However, at each of the temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8- HQS as also in SUC as compared to samples from corresponding scapes held in DW (Table 2.2.2, Text Fig. 2.2.2, C).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously wet stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from the corresponding scapes held at RT irrespective of the holding solutions. However , at each of the temperature regimes both fresh and dry mass was found to be higher in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW , however maximum value for fresh and dry mass was recorded in samples from scapes previously wet stored at 5 °C for 72 h and transferred to SUC + 8-HQS (Table 2.2.2, Text Fig. 2.2.2, D,Text Fig.2.2.3, E).

Reducing sugars: The reducing sugar content of samples from scapes previously wet stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the reducing sugar content was found to be higher in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 2.2.3, Text Fig. 2.2.3, F). Similar trends were obtained when the data was expressed on per flower and dry mass bases but the differences showed up clearly on these particular reference bases (Tables 2.2.3 and 2.2.4). Maximum reducing sugar content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC +8-HQS (Table 2.2.4).

Non-reducing sugars: Generally the non-reducing sugar content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions .However , at each of the temperature regimes, the non-reducingsugar content was found to be higher in samples from scapes held in SUC+8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 2.2.3, Text Fig. 2.2.4, G).Generally similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis particularly in samples from scapes previously held at 5°C (Tables 2.2.3 and 2.2.4). Generally higher non-reducing sugar content was noticed in samples from scapes previously wet stored at 5°C for 72 h and transferred to SUC +8-HQS (Table 2.2.3 and 2.2.4).

Total sugars: The total soluble sugar content of the samples from scapes previously wet stored at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However at each of the temperature regimes the total soluble sugar content was found to be higher in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 2.2.3, Text Fig. 2.2.4, H). The differences showed up clearly when the data was expressed on per flower basis as also on dry mass basis (Tables 2.2.3 and 2.2.4). Maximum total sugar content was registered in samples from scapes previously wet stored for 72 h at 5 °C and transferred to SUC +8-HQS irrespective of the reference base.

Soluble proteins: The soluble protein content of the samples from scapes previously wet stored at 5 and 10°C for 72 h registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However at each of the temperature regimes the soluble protein content was found to be higher in

samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 2.2.3, Text Fig. 2.2.5, I). Almost similar trends were noticed when the data was expressed on per flower basis as also on dry mass basis but the differences showed up clearly on these reference bases (Tables 2.2.3 and 2.2.4). Maximum soluble protein content was found in samples previously wet stored at 5 °C for 72 h and transferred to SUC +8-HQS(Table 2.2.4).

α- amino acids: A lower content of α- amino acid was maintained in samples from scapes previously wet stored at 5^{o}C for 72 h as compared to the samples from corresponding scapes held at 10 °C and RT. However the tissue concentration of α-amino acid was maintained in samples from scapes previously wet stored at 5 °C for 72 h irrespective of the transfer to various holding solutions (Table 2.2.3, Text Fig. 2.2.5, J). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis (Tables 2.2.3 & 2.2.4). Lowest values for amino acid content were maintained in samples from scapes previously wet stored at 5°C and transferred to SUC +8-HQS (Table 2.2.4).

Phenols: A lower content of phenols was registered in samples from scapes previously wet stored at 5 and 10 °C for 72 h as compared to the samples from scapes held at RT. At each of the temperature regimes the phenolic content of the samples was more in scapes held in SUC+8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 2.2.3, Text Fig. 2.2.6, K). When the data was expressed on per flower or dry mass bases the trends became sharp and apparent (Tables 2.2.3 and 2.2.4).

Table 2.2.1: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life and solution uptake in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	**Vase life (days)**	**Volume of holding solution absorbed (ml) per scapes. Days after harvest**	
		2	**4**
RT→DW	1	0.79	1.29
10 °C→DW	2	1.02	1.76
5 °C →DW	3	1.14	1.96
RT→SUC(0.15M)	1	1.27	2.01
10°C→SUC(0.15M)	2	1.28	2.20
5°C→SUC(0.15M)	3	1.49	2.05
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	1	1.31	2.12
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	2	1.52	2.27
5°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	3	1.53	2.36
LSD at $P_{=0.05}$	0.01	0.004	0.003

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^{O}C).

Table 2.2.2: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 of the transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment(72h)	Conductivity of leachates(µS)	Fresh mass (g flower^{-1})	Dry mass (g flower^{-1})
RT→DW	15.33	2.33	0.247
10 °C→DW	9.33	3.15	0.313
5 °C →DW	7.1	3.60	0.359
RT→SUC(0.15M)	14.66	2.37	0.278
10°C→SUC(0.15M)	8.66	3.24	0.344
5°C→SUC(0.15M)	6.73	3.81	0.409
RT→SUC(0.15M) +8-HQS(50mg l^{-1})	12.33	2.60	0.298
10°C→SUC(0.15M) +8-HQS(50mg l^{-1})	7.66	3.33	0.359
5°C→SUC(0.15M +8-HQS(50mg l-1)	5.66	4.19	0.451
LSD at $P_{=0.05}$	0.08	0.04	0.01

Each value is a mean of 5 independent replicates.

Room temperature = (RT) (15 ± 2^0C).

Table 2.2.3: Effect of postharvest wet storage (PHWS) for 72 h on at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 of the transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	9.86 (22.98)	8.00 (18.64)	17.86 (41.62)	3.66 (8.54)	0.56 (1.32)	19.33 (45.04)
10 °C→DW	11.46 (36.12)	7.46 (23.52)	18.93 (59.64)	4.58 (14.43)	0.45 (1.43)	13.33 (42.00)
5 °C →DW	14.13 (50.88)	11.73 (42.24)	25.86 (93.12)	5.16 (18.60)	0.36 (1.29)	12.13 (43.68)
RT→SUC(0.15M)	12.26 (29.07)	12.00 (28.44)	24.26 (57.51)	5.58 (13.23)	0.44 (1.06)	21.86 (51.82)
10°C→SUC(0.15M)	15.73 (50.97)	6.40 (20.72)	22.13 (71.71)	5.91 (19.17)	0.40 (1.30)	15.46 (50.11)
5°C→SUC(0.15M)	18.66 (71.12)	12.26 (46.73)	30.93 (117.85)	6.33 (24.13)	0.35 (1.34)	14.26 (54.35)
RT→SUC(0.15M) +8-HQS(50 mg l^{-1})	16.53 (42.98)	13.33 (34.33)	29.86 (77.65)	6.66 (17.33)	0.41 (1.05)	23.73 (61.70)
10°C→SUC(0.15M) +8-HQS(50 mg l^{-1})	21.06 (70.15)	12.00 (39.96)	33.06 (110.11)	7.33 (24.42)	0.38 (1.27)	17.33 (57.72)
5°C→SUC(0.15M +8-HQS(50 mg l-1)	22.13 (92.73)	20.00 (83.80)	42.13 (176.53)	8.25 (34.56)	0.32 (1.36)	18.26 (76.35)
LSD at $P_{=0.05}$	0.03	0.07	0.02	0.01	0.005	0.02

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.2.4: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 of the transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	93.07	75.46	168.53	34.58	5.36	182.37
10 °C→DW	117.39	73.14	190.54	46.12	4.59	134.18
5 °C →DW	132.84	110.28	306.71	68.02	3.56	160.77
RT→SUC(0.15M)	104.57	102.30	206.87	47.59	3.81	186.41
10°C→SUC(0.15M)	148.18	60.27	208.48	55.72	3.77	145.67
5°C→SUC(0.15M)	173.88	114.26	288.15	58.99	3.28	132.89
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	144.25	116.33	260.58	58.16	3.67	207.06
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	195.40	111.30	306.71	68.02	3.56	160.77
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	205.62	185.80	391.43	76.64	3.03	169.70
LSD at $P_{=0.05}$	0.30	0.80	0.97	0.36	0.05	0.06

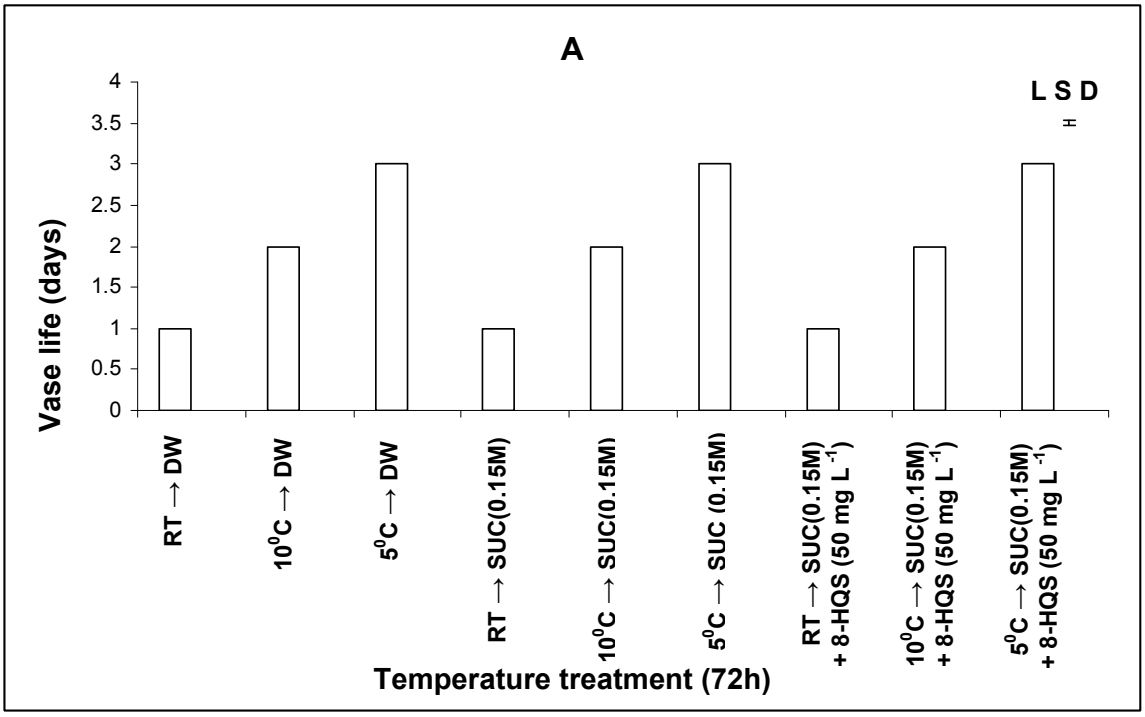
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Fig. 2.2.1

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and volume of holding solution absorbed per scape ml (B) on day 2 and 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


A
L S D
Vase life (days)
4
3.5
3
2.5
2
1.5
1
0.5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

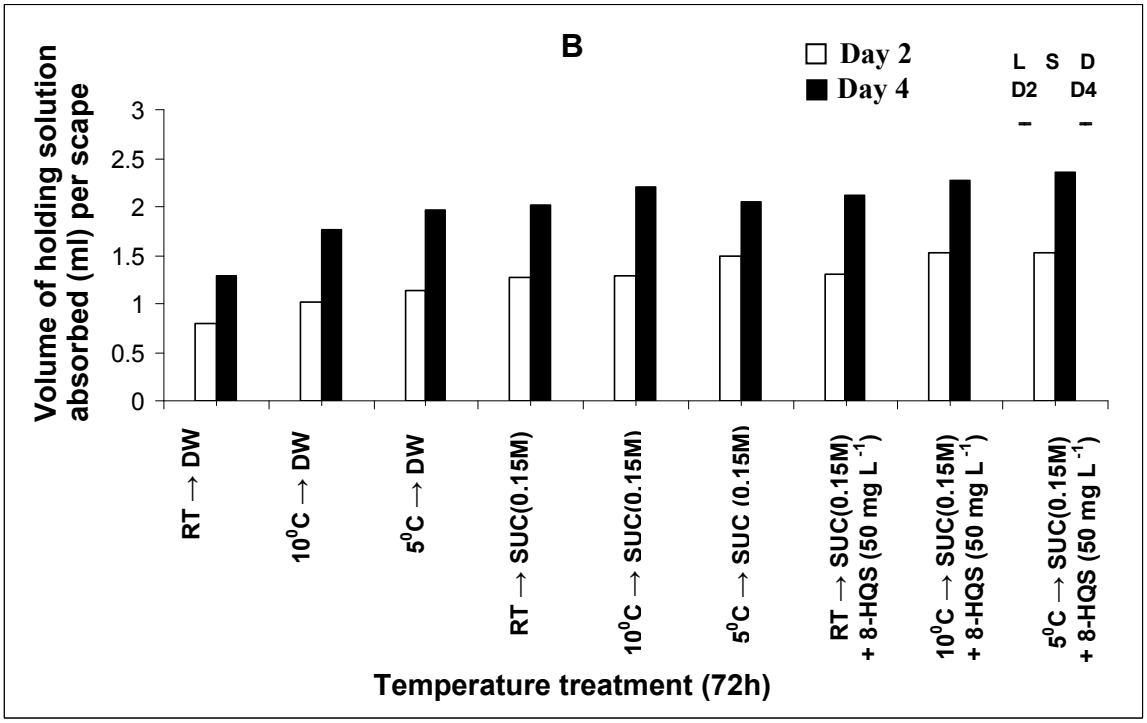
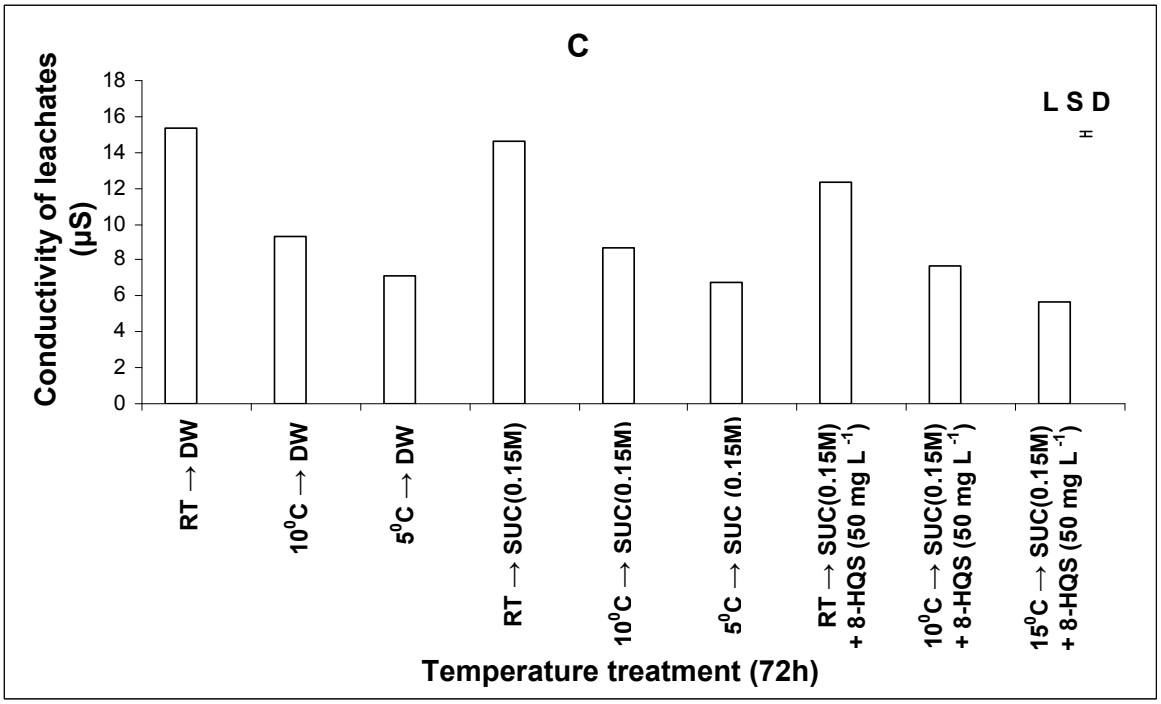

B
Day 2
Day 4
L S D
D2 D4
Volume of holding solution absorbed (ml) per scape
3
2.5
2
1.5
1
0.5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.2.1

Fig. 2.2.2

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on conductivity of leachates (C) from tepal tissues and fresh mass (D) of flowers on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


C
Conductivity of leachates (µS)
18
16
14
12
10
8
6
4
2
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
15°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

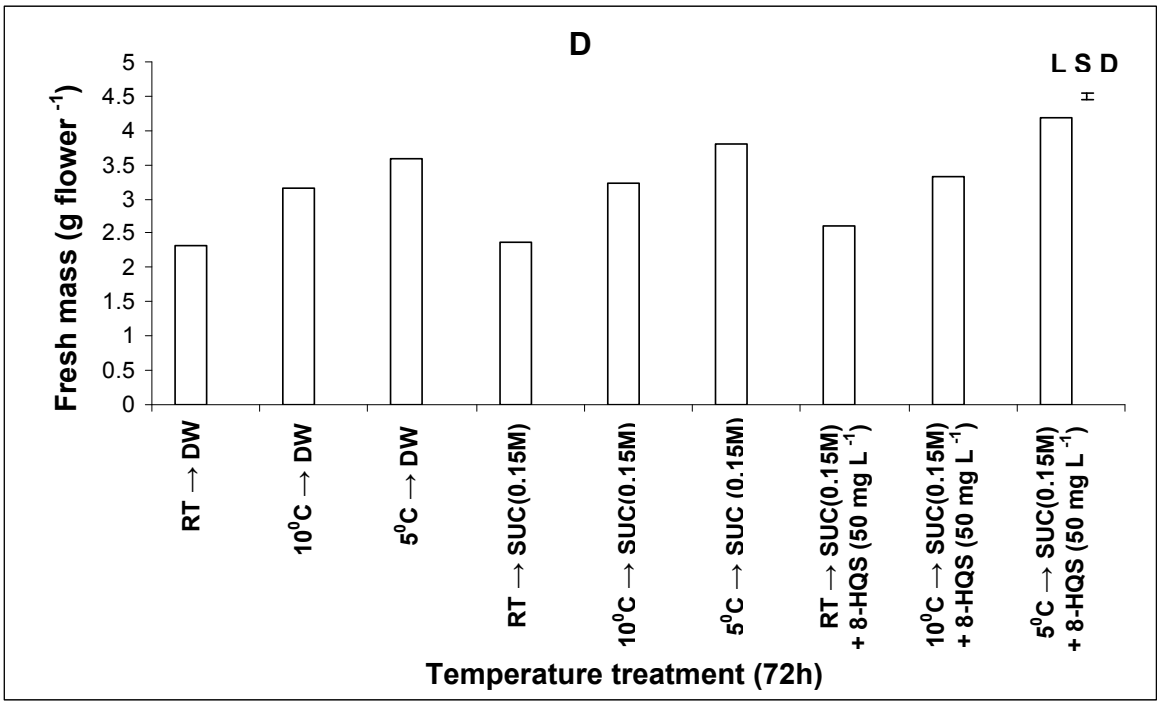
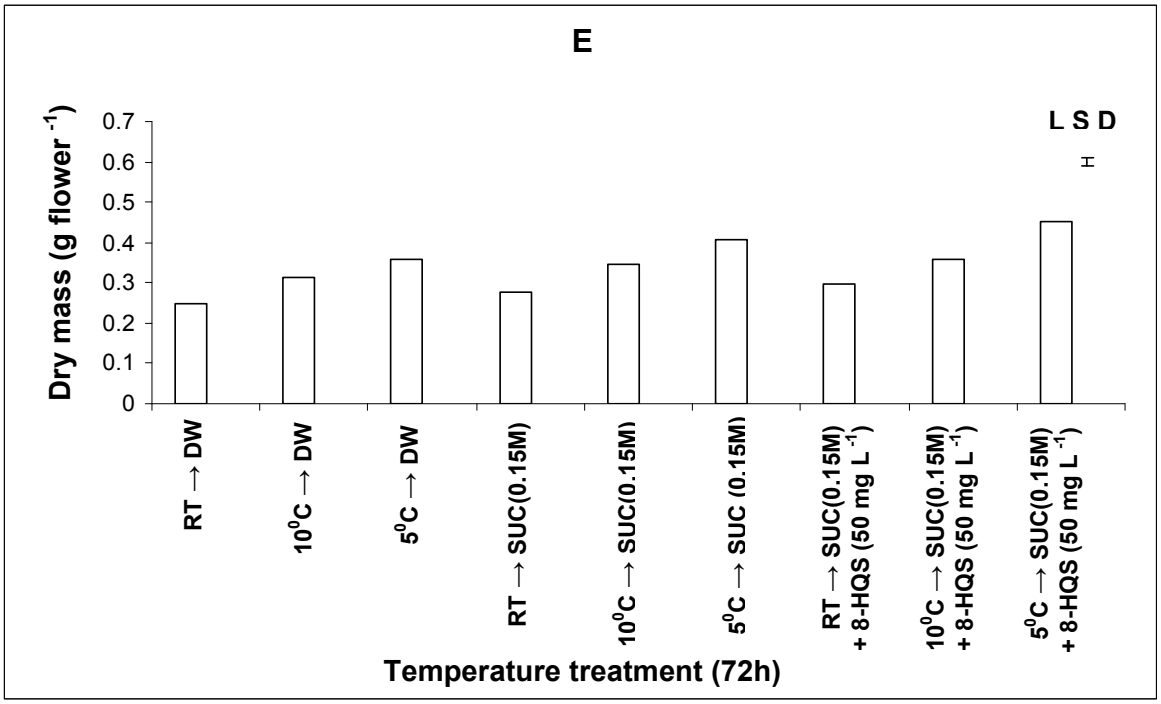

D
Fresh mass (g flower -1)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.2.2

Fig. 2.2.3

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on dry mass (E) of flowers and reducing sugars (F) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05}$.


E
Dry mass (g flower -1)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
L S D
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

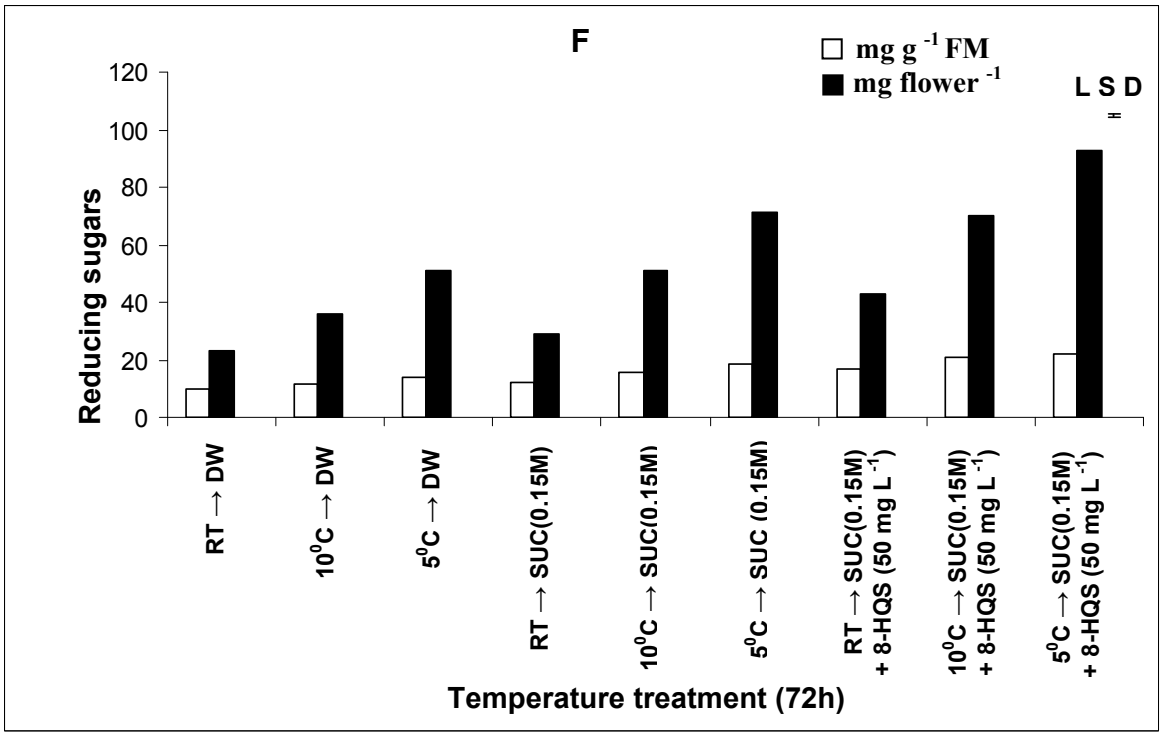
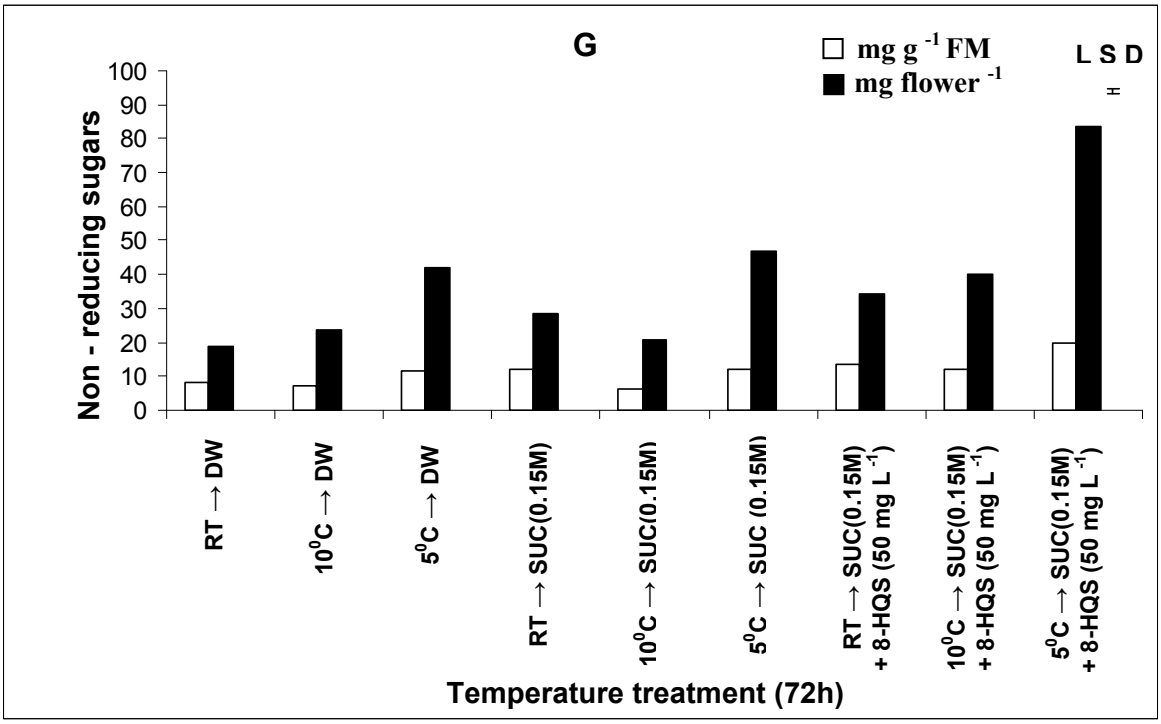

F
mg g -1 FM
mg flower -1
L S D
Reducing sugars
120
100
80
60
40
20
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig.2.2.3

Fig. 2.2.4

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on non-reducing sugars (G) and total sugars (H) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


G
mg g -1 FM
mg flower -1
L S D H
Non - reducing sugars
100
90
80
70
60
50
40
30
20
10
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10⁰C → SUC(0.15M) + 8-HQS (50 mg L -1)
5⁰C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

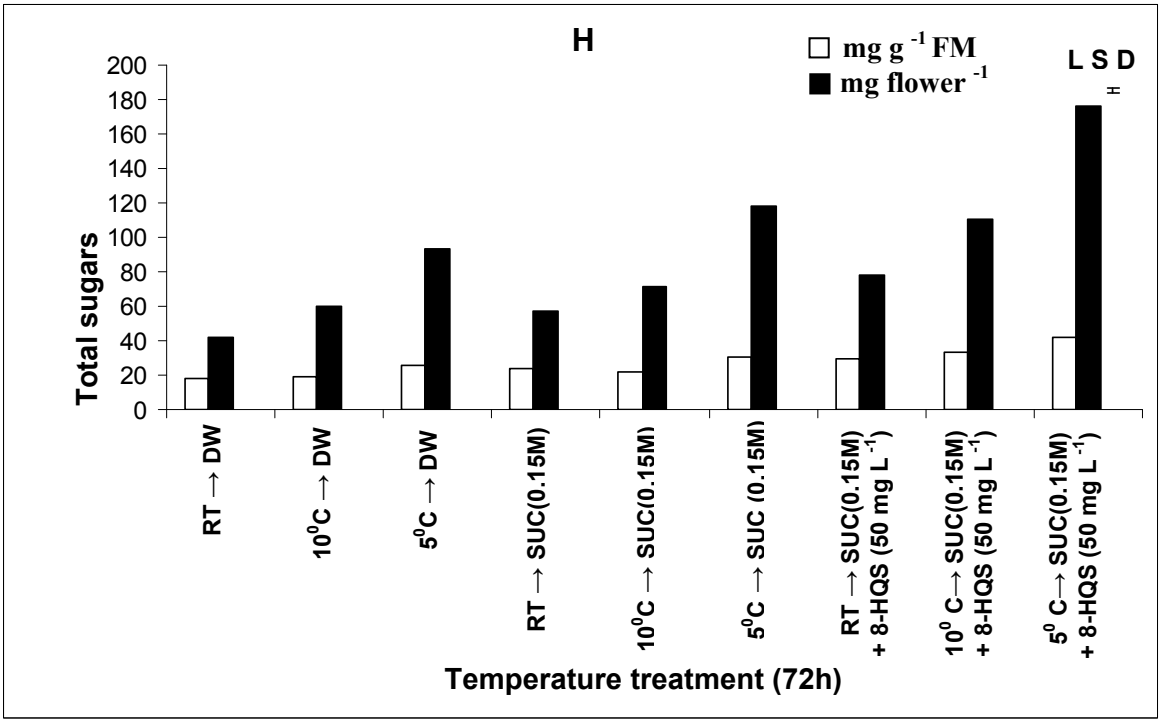
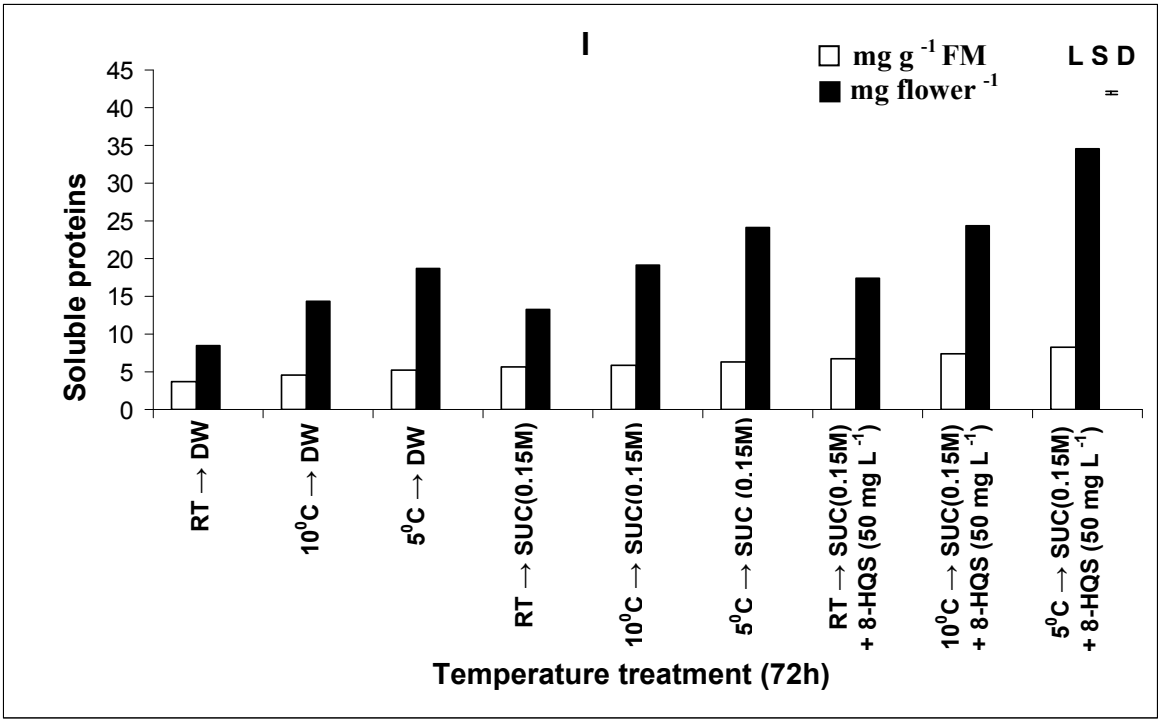

H
mg g -1 FM
mg flower -1
L S D H
Total sugars
200
180
160
140
120
100
80
60
40
20
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10⁰ C→ SUC(0.15M) + 8-HQS (50 mg L -1)
5⁰ C→ SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 2.2.4

Fig. 2.2.5

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on soluble proteins (I) and α-amino acids (J) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


I
mg g -1 FM
mg flower -1
L S D
=
Soluble proteins
45
40
35
30
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

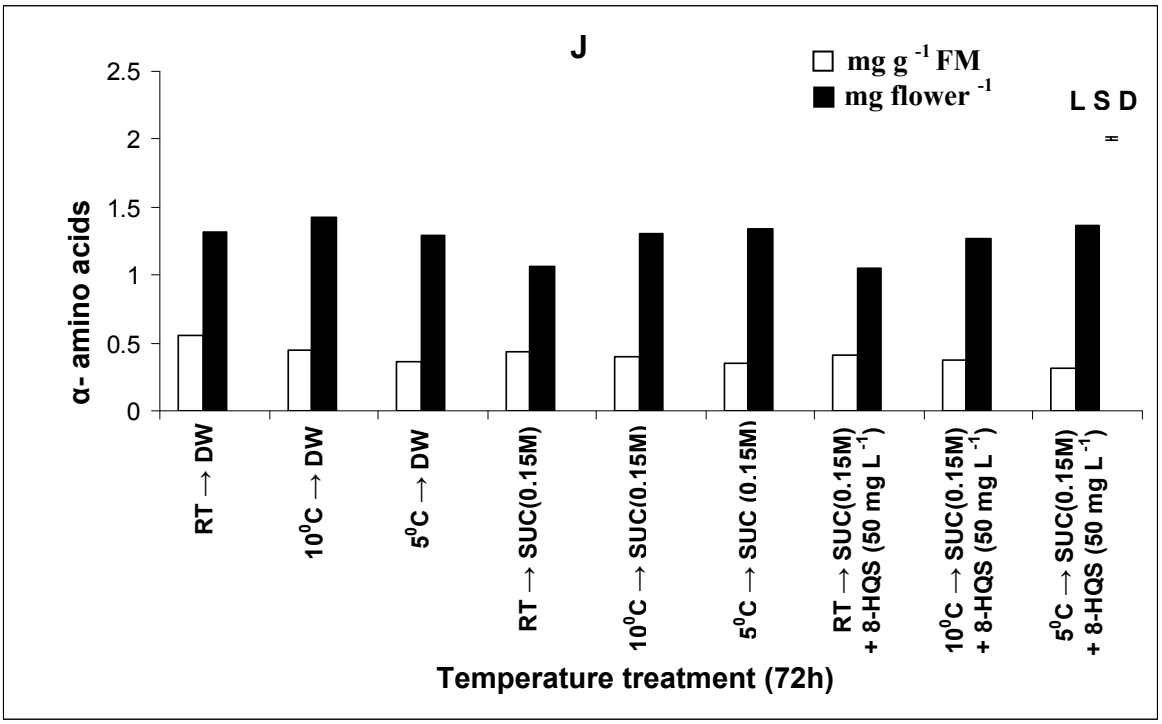

J
mg g -1 FM
mg flower -1
L S D
=
α- amino acids
2.5
2
1.5
1
0.5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 2.2.5

Fig. 2.2.6

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total phenols (K) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$

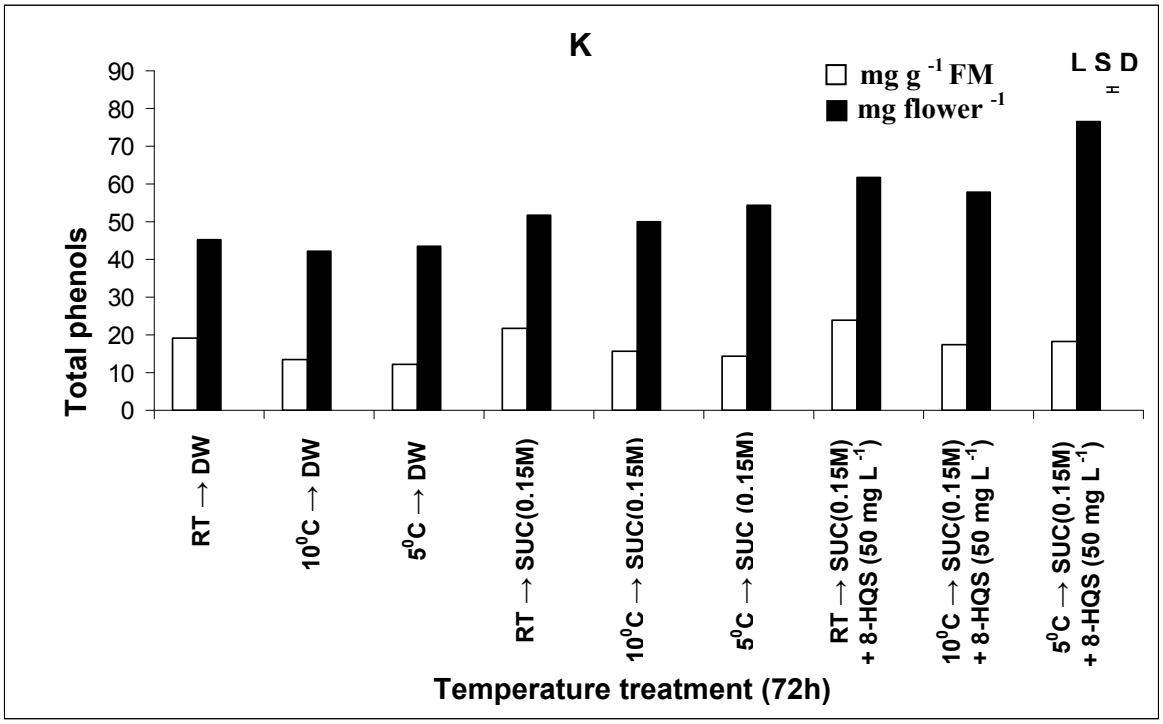

K
mg g -1 FM
mg flower -1
L S D H
Total phenols
90
80
70
60
50
40
30
20
10
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.2.6

Plate 2.2.1

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Fig.1: From left to right are arranged scapes before wet storage for 72 h.

Fig.2: From left to right are arranged scapes after wet storage for 72 h.

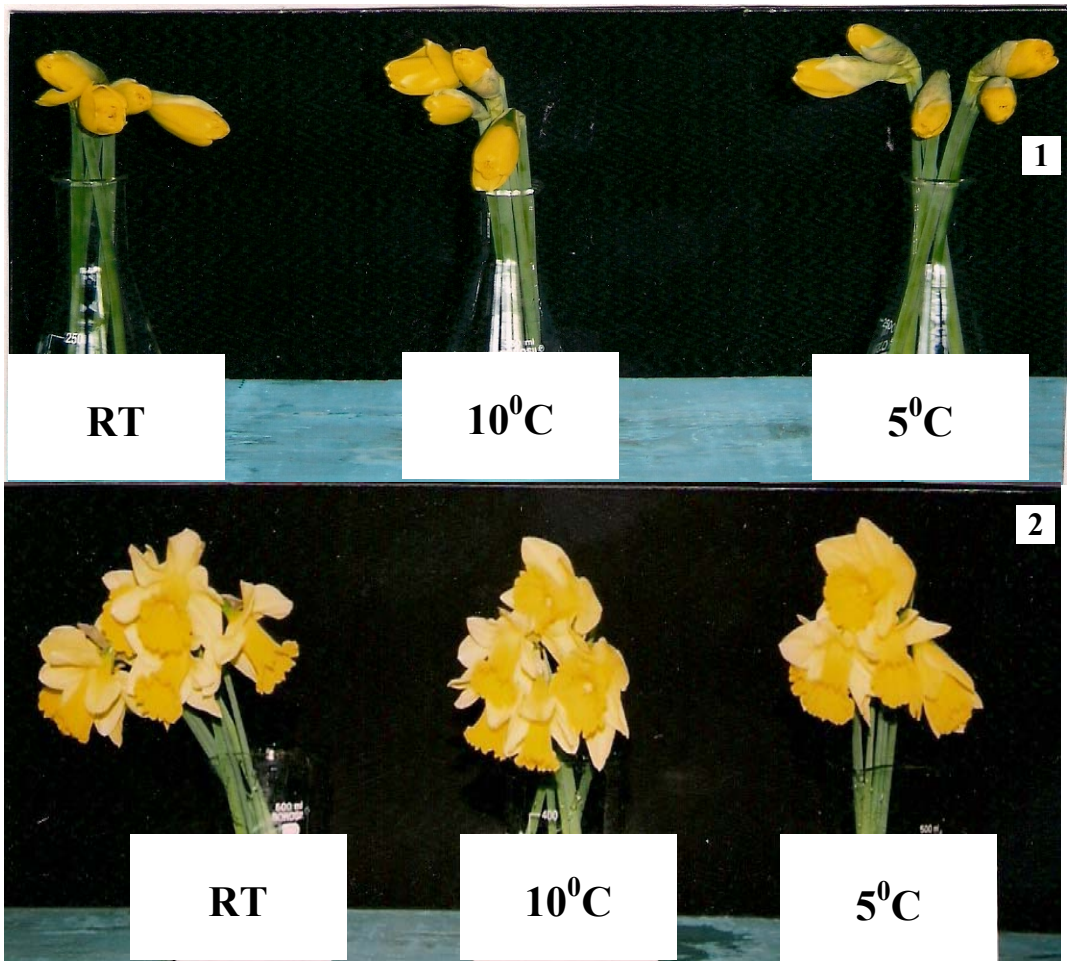


Plate. 2.2.1

Plate. 2.2.2

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged flasks containing scapes stored at RT (15 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

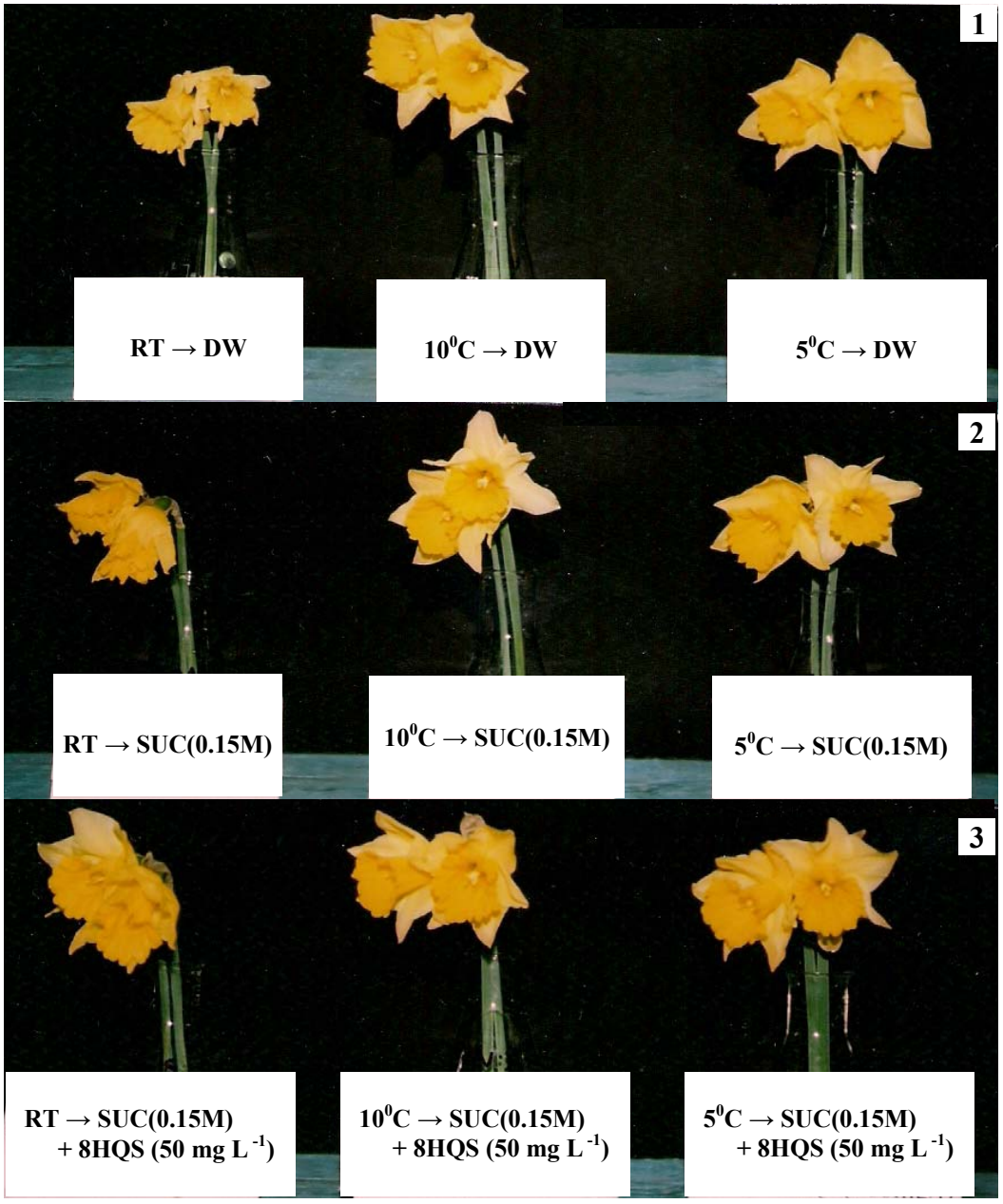

1
RT → DW
10⁰C → DW
5⁰C → DW
2
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC(0.15M)
3
RT → SUC(0.15M)
+ 8HQS (50 mg L -1)
10⁰C → SUC(0.15M)
+ 8HQS (50 mg L -1)
5⁰C → SUC(0.15M)
+ 8HQS (50 mg L -1)

Plate. 2.2.2

EXPERIMENT 2.3

Effect of postharvest dry storage (PHDS) at different temperature regimes 5, 10 and room temperature (RT=15±2°C) for 72 h before transfer to distilled water (DW), sucrose, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Experimental

Scapes of *N. pseudonarcissus* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform scape length of 25 cm. The scapes were completely wrapped in moistened filter papers and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (RT=15±2^{o}C). After 72 h all the scapes were held at room temperature and transferred to 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC(0.15M) + 8-HQS (50 mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. The average vase life of flowers was counted from the day of transfer to a particular holding solution and was assessed to be terminated when the flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals. Volume of solution absorbed was recorded on day 2 and 4 after the transfer of scapes to holding solutions. Fresh mass, dry mass and electrical conductivity of leachates from tepal discs of flowers were recorded on day 4 of transfer of scapes to holding solutions. Changes in tissue constituents comprising sugar fractions, soluble proteins, α- amino acids and phenolics

were also estimated on day 4 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes dry stored for 72 h at different temperature regimes 5 ^{o}C, 10 ^{o}C and RT had already bloomed during the storage (Plate. 2.3.1; Figs. 1-2). The scapes previously dry stored at RT before transfer to holding solution, showed symptoms of tepal senescence on the day 1 of transfer to a particular holding solution (Plate. 2.3.2; Figs. 1-3). Flower senescence was characterized by turgor loss followed by wilting of tepals.

Vase life: The average vase life of scapes previously dry stored at 5 and 10^{o}C before transfer to holding solution was about 2 days each irrespective of the transfer to a particular holding solution, whereas the vase life of scapes previously held at (RT) before transfer to a particular holding solution was about 1 day (Table 2.3.1, Text Fig. 2.3.1 A).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression in time from day 2 to 4 of transfer of scapes to various holding solutions irrespective of the particular temperature regime and holding solution. Generally the solution uptake was found to be higher in scapes previously dry stored for 72 h at 5 and 10 °C as compared to RT in the respective of the holding solution. A higher solution uptake was recorded in scapes held in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment, however maximum solution uptake was noticed in scapes previously dry stored at 5°C for 72 h transferred to (SUC + 8- HQS) (Table 2.3.1, Text Fig. 2.3.1 B).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs registered a decrease in samples previously dry stored for 72 h at 5 and 10 °C as compared to the

corresponding scapes held at RT irrespective of holding solution. However at each temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8- HQS as also in SUC as compared to samples from corresponding scapes held in DW (Table 2.3.2; Text Fig.2.3.2, C).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously dry stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from the corresponding scapes held at RT irrespective of the holding solutions. However, at each of the temperature regimes both fresh and dry mass was found to be higher in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW, however maximum value for fresh and dry mass was recorded in samples from scapes previously dry stored at 5°C for 72 h and transferred particularly to SUC + 8-HQS (Table 2.3.2; Text Fig 2.3.2, D and 2.3.3, E).

Reducing sugars: The reducing sugar content of samples form scapes previously dry stored for 72 h at 5 and 10 °C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 2.3.3; Text Fig.2.3.4, F). Almost similar trends were obtained when the data was expressed on per flower and dry mass basis but the differences showed up clearly particularly on dry mass basis (Tables 2.2.3 and 2.3.4). Maximum reducing sugar content was noticed in samples from scapes dry stored at 5°C for 72 h and transferred to SUC +8-HQS.

Non-reducing sugars: Generally the non-reducingsugar content of samples from scapes previously dry stored for 72 h at 5 and 10°C registered a

decrease as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes, the non-reducingsugar content was found to be highest in samples form scapes held in SUC+8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 2.3.3; Text Fig. 2.3.4, G). Generally similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis particularly in samples from scapes previously held at 5°C (Tables 2.3.3 and 2.3.4). Maximum non-reducingsugar content was noticed in samples from scapes previously dry stored at 5°C for 72 h and transferred to SUC +8-HQS.

Total sugars: The total soluble sugar content of the samples from scapes previously dry stored at 5 and 10°C registered a decrease as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the total soluble sugar content was found to be highest in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 2.3.3, Text Fig. 2.3.5, H). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis but the differences showed up clearly particularly on dry mass basis (Tables 2.3.3 and 2.3.4). Maximum total sugar content was registered in samples from scapes previously dry stored for 72 h at 5°C and transferred to SUC + 8-HQS irrespective of the reference base.

Soluble proteins: The soluble protein content of the samples from scapes previously dry stored at 5 and 10°C for 72 h registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. However, at each of the temperature regimes the soluble protein content was found to be higher in samples from scapes held in SUC+8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW (Table 2.3.3; Text Fig.

2.3.5, I). Almost similar trends were noticed when the data was expressed on per flower basis as also on dry mass basis but the differences showed up clearly on these reference bases (Tables 2.3.3 and 2.3.4). Maximum soluble protein content was found in samples previously dry stored at 5°C for 72 h and transferred to SUC +8-HQS.

α- amino acids: A lower content of α- amino acid was maintained in samples from scapes previously dry stored at 5^{o}C for 72 h as compared to the samples from corresponding scapes held at 10 °C and RT. The tissue concentration of amino acid was generally maintained in samples from scapes previously dry stored at 5 °C for 72 h irrespective of the transfer to various holding solutions (Table 2.3.3; Text Fig. 2.3.6, J). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis (Tables 2.3.3 & 2.3.4). The lowest values for amino acid content were maintained in samples from scapes previously dry stored at 5°C and transferred to SUC + 8-HQS.

Phenols: A lower content of phenols was registered in samples from scapes previously dry stored at 5 and 10 °C for 72 h as compared to the samples from scapes held at RT. At each of the temperature regimes the phenolic content of the samples was more in scapes held in SUC+8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 2.3.3; Text Fig. 2.3.6,K). Almost similar trends were obtained when the data was expressed on per flower and dry mass basis but the trends were prominent on dry mass basis (Tables 2.3.3 and 2.3.4).

Table 2.3.1: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, and solution uptake in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	**Vase life (days)**	**Volume of holding solution absorbed (ml) per scape.**	
		Days after harvest	
		2	**4**
RT→DW	1	1.47	1.77
10 °C→DW	2	1.68	2.30
5 °C →DW	2	1.79	2.52
RT→SUC(0.15M)	1	1.56	2.66
10°C→SUC(0.15M)	2	2.01	2.80
5°C→SUC(0.15M)	2	2.28	3.02
RT→SUC(0.15M) +8-HQS (50 mg L^{-1})	1	1.75	2.77
10°C→SUC(0.15M) +8-HQS (50 mg L^{-1})	2	2.51	3.34
5°C→SUC(0.15M +8-HQS (50 mg L^{-1})	2	2.87	3.76
LSD at $P_{=0.05}$	0.12	0.14	0.10

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Table 2.3.2: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 of the transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	Conductivity of leachates (µS)	Fresh mass (g flower^{-1})	Dry mass (g flower^{-1})
RT→DW	18.66	1.53	0.143
10 °C→DW	11.66	1.73	0.150
5 °C →DW	10.66	1.92	0.162
RT→SUC(0.15M)	15.66	2.07	0.179
10°C→SUC(0.15M)	8.20	2.33	0.217
5°C→SUC(0.15M)	7.73	2.46	0.225
RT→SUC(0.15M) +8-HQS (50 mg L^{-1})	13.66	2.43	0.202
10°C→SUC(0.15M) +8-HQS (50 mg L^{-1})	7.60	2.72	0.238
5°C→SUC(0.15M +8-HQS (50 mg L^{-1})	7.20	3.20	0.258
LSD at $P_{=0.05}$	0.54	0.10	0.010

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^{0}C).

Table 2.3.3: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 of the transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	7.83 (11.83)	20.00 (30.60)	27.72 (42.43)	2.66 (4.08)	0.65 (0.99)	16.13 (24.68)
10 °C→DW	6.66 (11.53)	16.46 (28.45)	23.12 (38.29)	4.08 (7.06)	0.42 (0.73)	12.26 (21.22)
5 °C →DW	12.26 (23.55)	11.46 (22.01)	23.73 (45.56)	5.66 (10.88)	0.34 (0.65)	8.53 (16.38)
RT→SUC(0.15M)	9.86 (20.42)	23.20 (48.02)	33.06 (68.44)	3.83 (7.93)	0.56 (1.14)	17.33 (35.88)
10°C→SUC(0.15M)	13.06 (30.44)	18.93 (44.11)	32.00 (74.56)	4.41 (10.29)	0.38 (0.89)	14.40 (33.55)
5°C→SUC(0.15M)	15.46 (38.04)	15.66 (38.52)	31.12 (76.56)	6.16 (15.17)	0.31 (0.77)	10.13 (24.92)
RT→SUC(0.15M) +8-HQS (50 mg L^{-1})	13.86 (33.69)	38.13 (92.66)	52.00 (126.36)	4.83 (11.74)	0.40 (0.98)	19.86 (48.27)
10°C→SUC(0.15M) +8-HQS (50 mg L^{-1})	16.53 (44.97)	22.66 (61.65)	39.20 (106.62)	5.16 (14.05)	0.27 (0.74)	15.33 (41.70)
5°C→SUC(0.15M +8-HQS (50 mg L^{-1})	21.06 (67.41)	16.26 (52.05)	37.30 (119.46)	6.83 (21.86)	0.24 (0.78)	10.93 (34.98)
LSD at $P_{=0.05}$	1.16	1.93	1.88	0.16	0.014	0.70

Each value is a mean of 5 independent replicates.

Room temperature (RT)= (15 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.3.4: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions, soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Temperature treatment (72h)	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
RT→DW	82.74	213.98	296.72	28.53	7.01	172.61
10 °C→DW	76.88	189.83	266.65	47.09	4.92	141.47
5 °C →DW	145.38	135.90	281.28	67.16	4.07	101.13
RT→SUC(0.15M)	114.10	268.29	382.39	44.32	6.54	200.44
10°C→SUC(0.15M)	140.30	203.29	343.59	48.00	4.12	154.61
5°C→SUC(0.15M)	169.10	171.21	340.31	68.00	3.44	110.79
RT→SUC(0.15M) +8-HQS(50mg l^{-1})	166.81	458.73	625.54	58.14	4.89	238.99
10°C→SUC(0.15M) +8-HQS(50mg l^{-1})	188.95	259.04	448.00	59.04	3.13	175.23
5°C→SUC(0.15M +8-HQS(50mg l-1)	261.29	201.75	463.04	84.75	2.97	135.60
LSD at $P_{=0.05}$	0.51	0.15	0.84	0.53	0.06	0.27

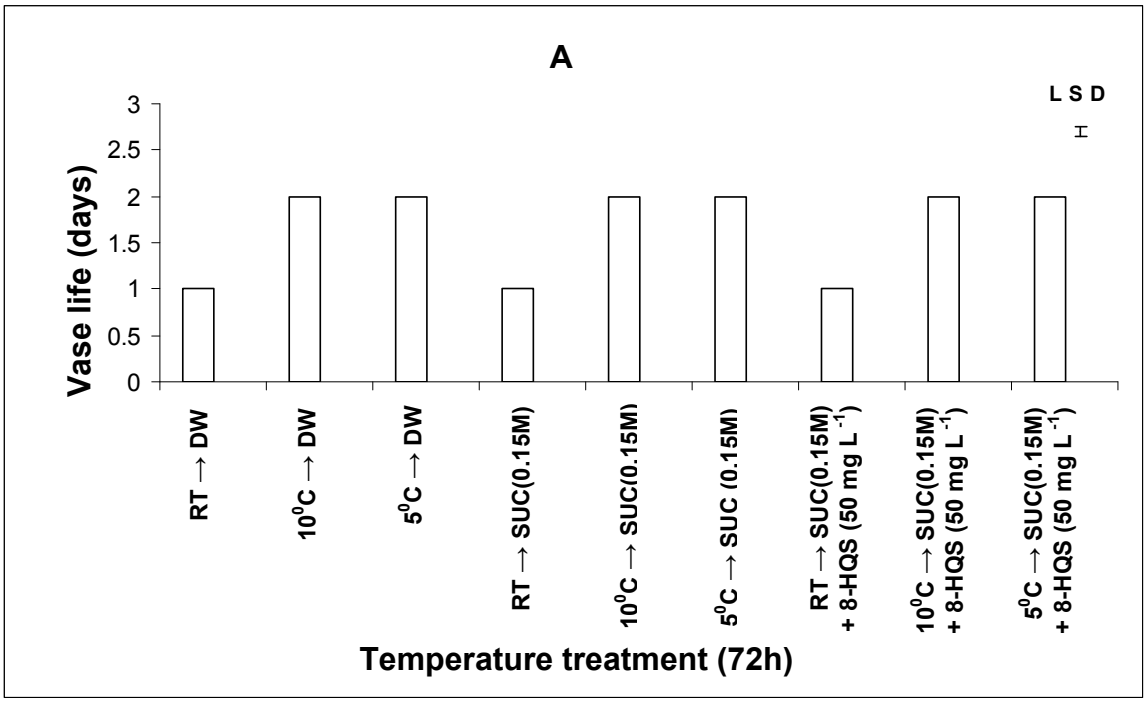
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Fig. 2.3.1

Histograms showing effect of postharvest dry storage (PHDS) for 72h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and volume of holding solution absorbed per scape ml (B) on day 2 and 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


A
L S D
Vase life (days)
3
2.5
2
1.5
1
0.5
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

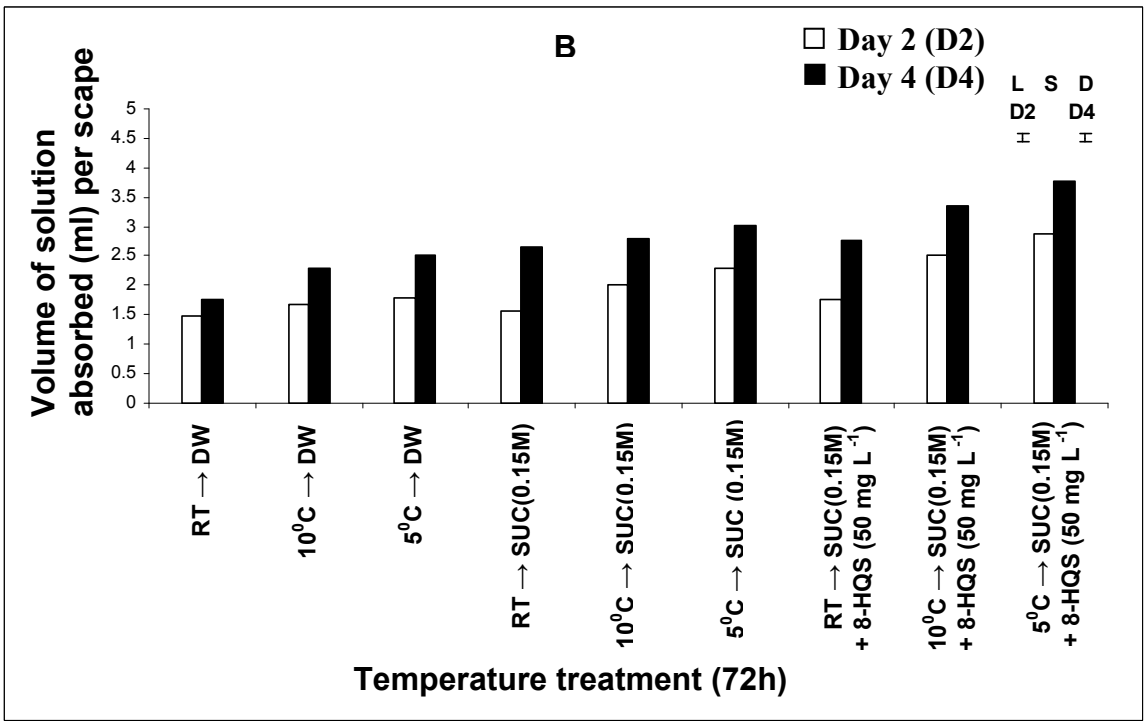
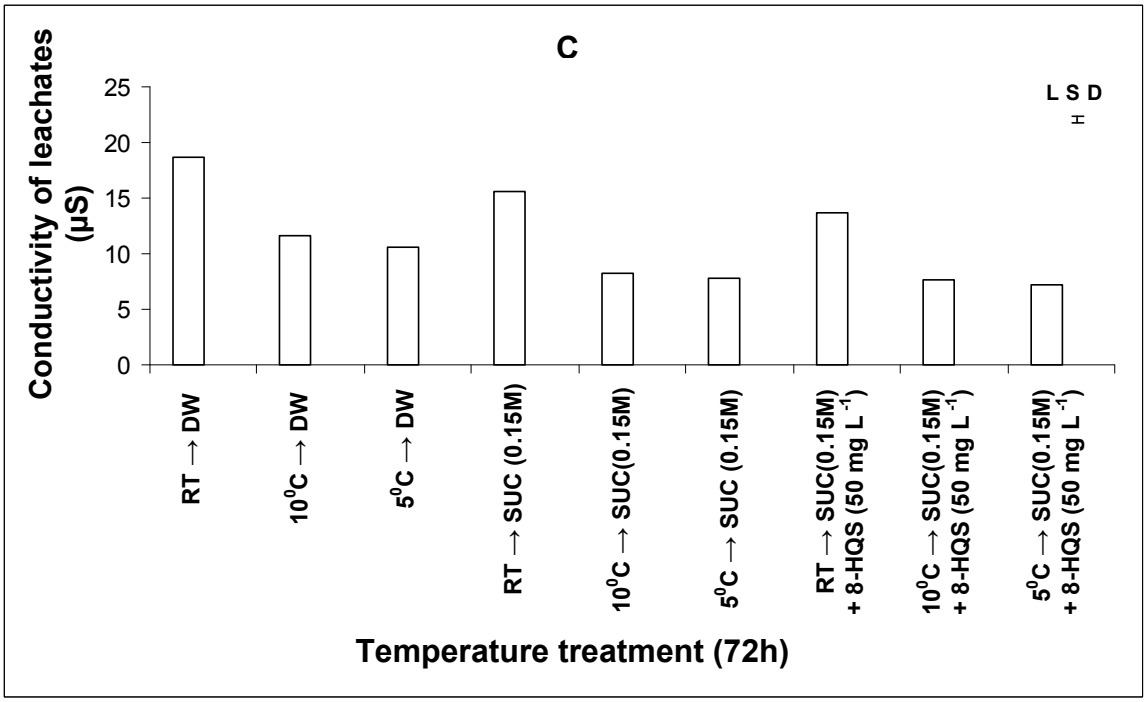

B
Day 2 (D2)
Day 4 (D4)
L S D
D2
D4
Volume of solution absorbed (ml) per scape
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

Fig. 2.3.1

Fig. 2.3.2

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on conductivity of leachates (C) from tepal tissues and fresh mass (D) of flowers on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


C
Conductivity of leachates (µS)
25
20
15
10
5
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

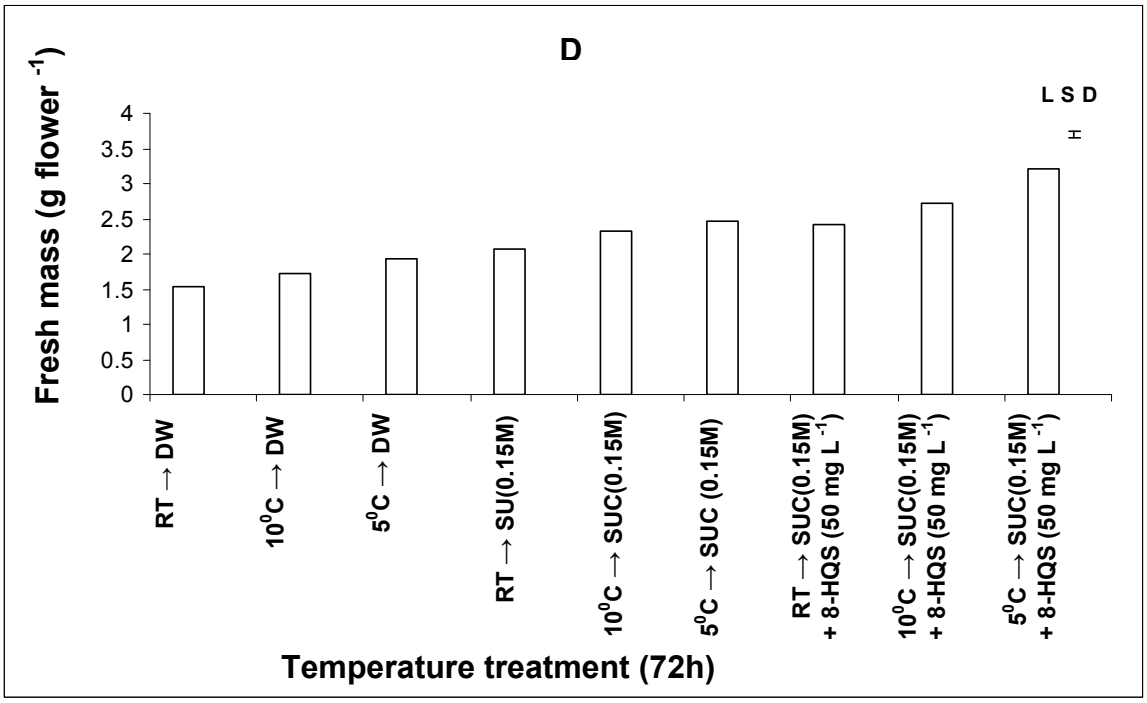
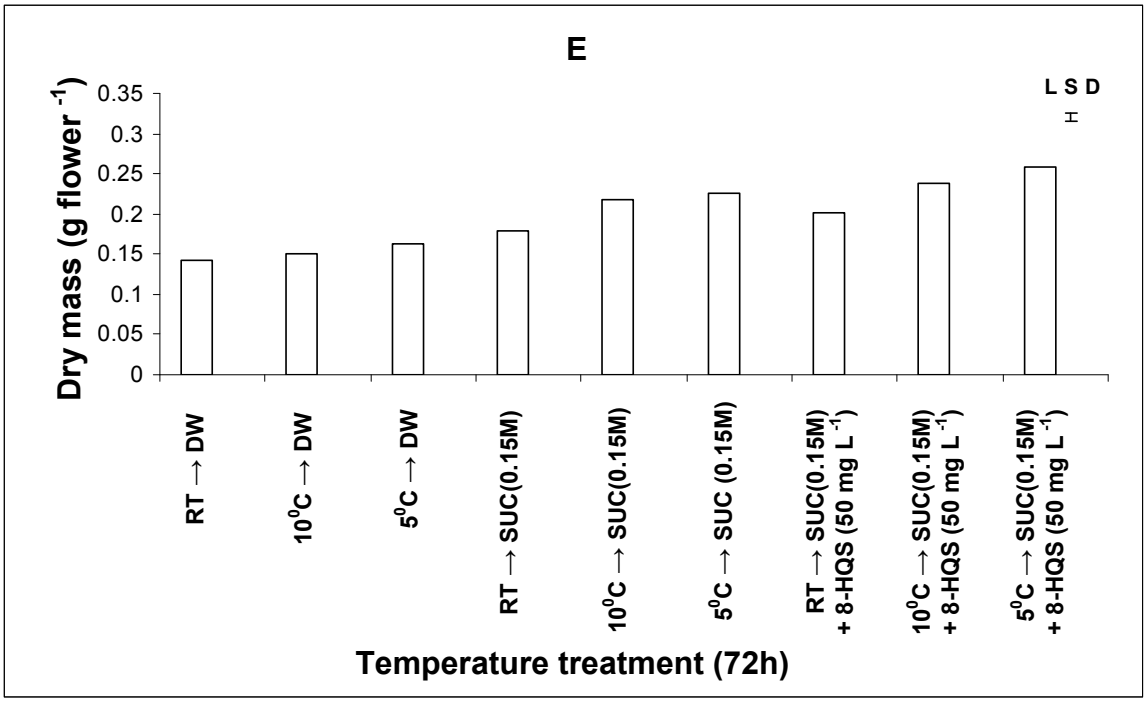

D
Fresh mass (g flower -1)
4
3.5
3
2.5
2
1.5
1
0.5
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SU(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.3.2

Fig. 2.3.3

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on dry mass (E) of flowers and reducing sugars (F) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Dry mass (g flower -1)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

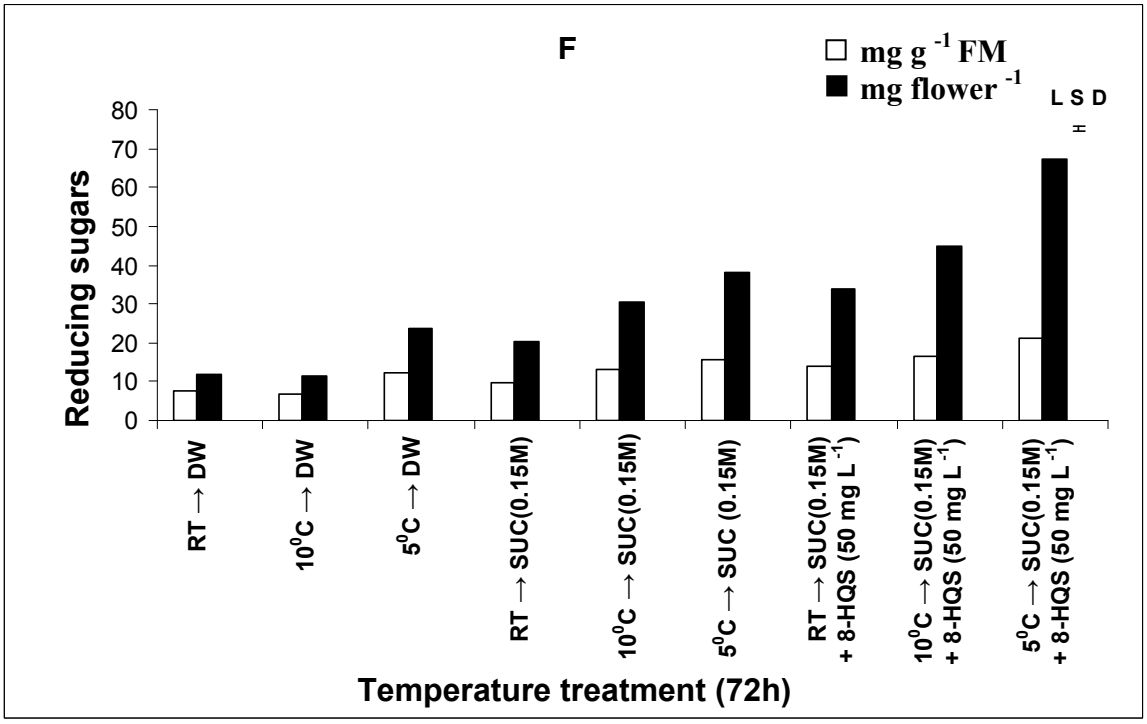
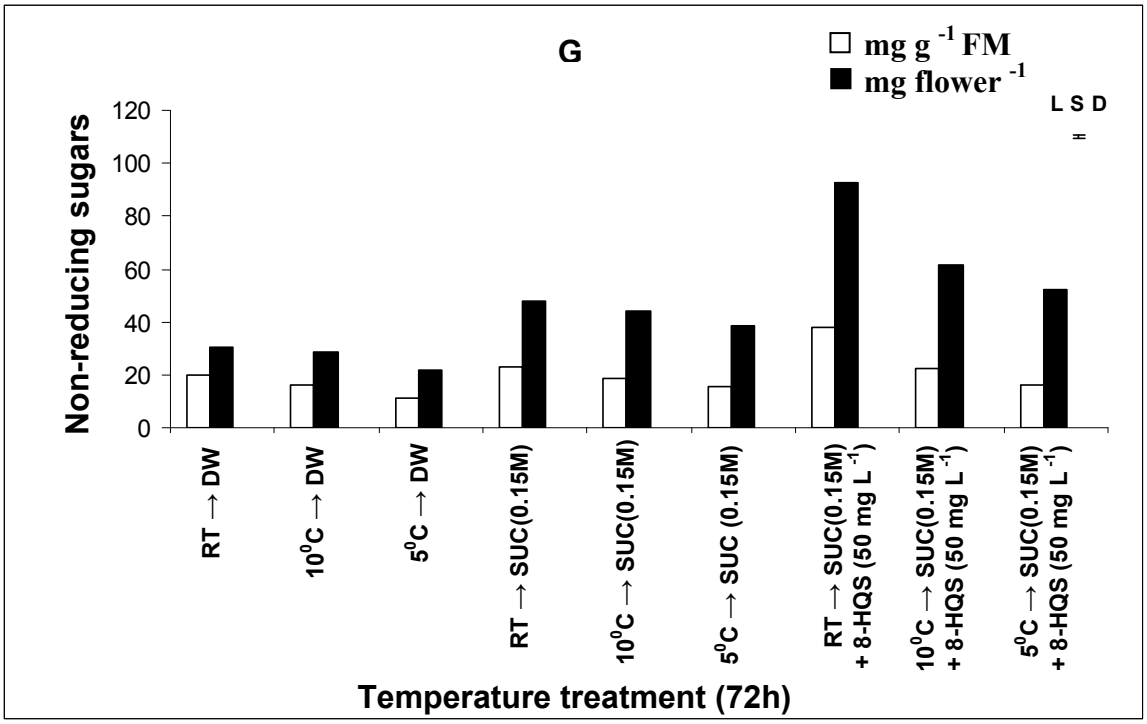

F
mg g -1 FM
mg flower -1
Reducing sugars
80
70
60
50
40
30
20
10
0
L S D H
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.3.3

Fig. 2.3.4

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on non-reducing sugars (G) and total sugars (H) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


G
mg g -1 FM
mg flower -1
L S D
=
Non-reducing sugars
120
100
80
60
40
20
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

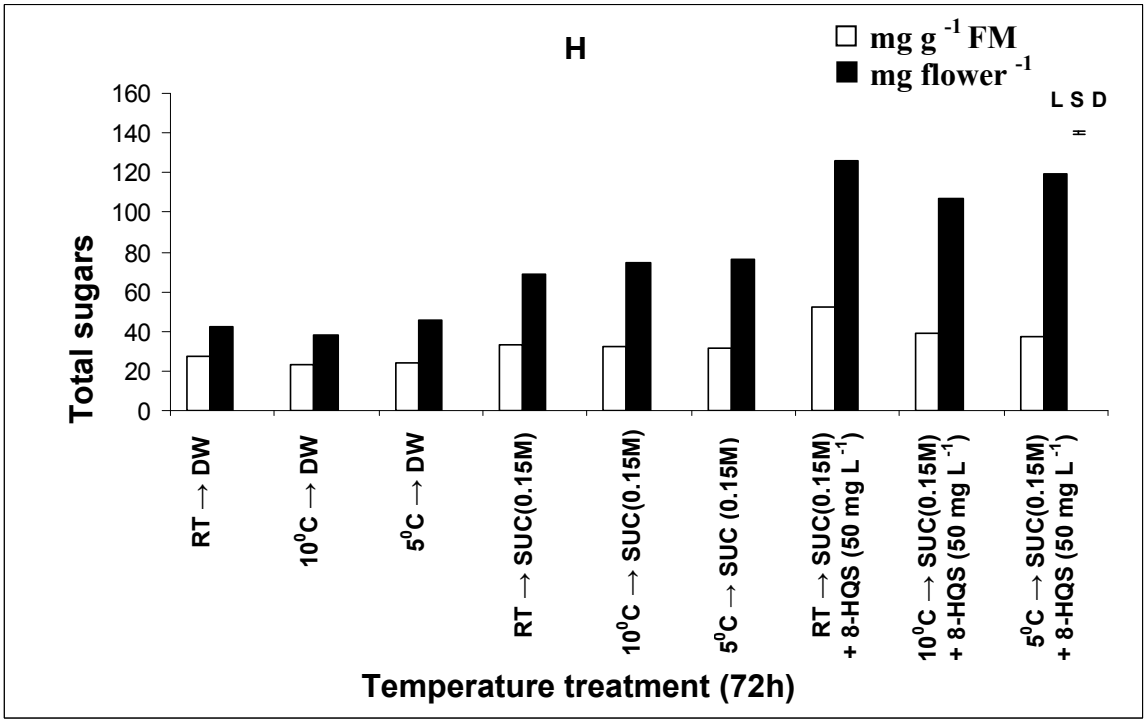
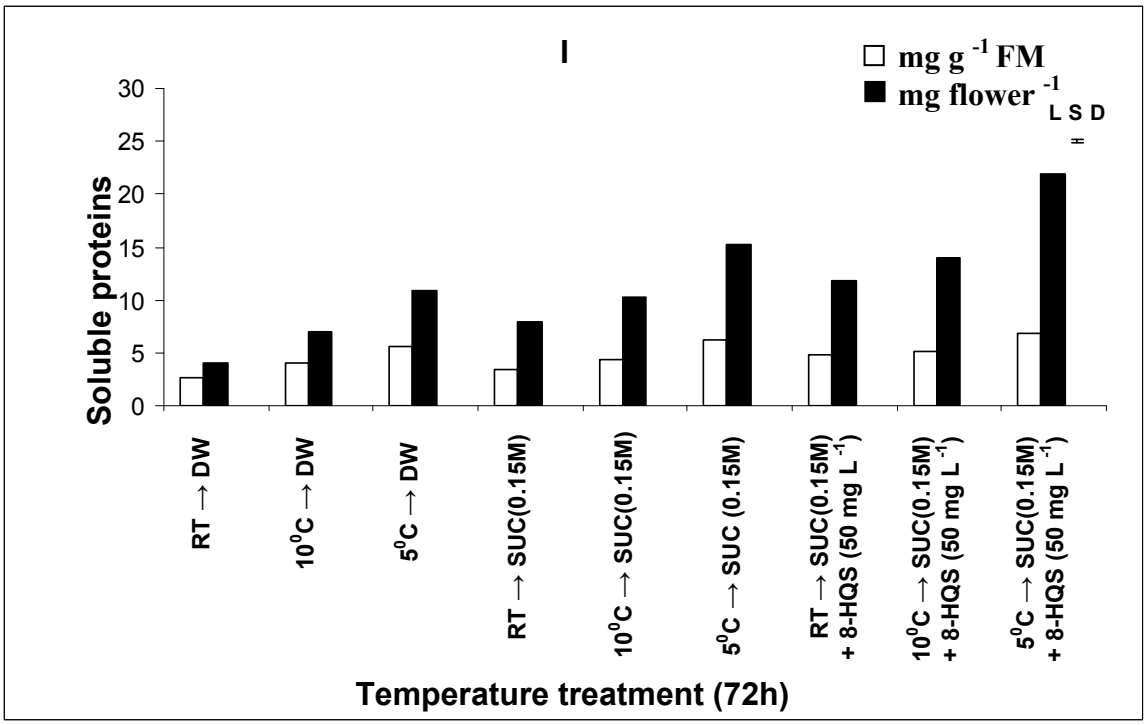

H
mg g -1 FM
mg flower -1
L S D
=
Total sugars
160
140
120
100
80
60
40
20
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 2.3.4

Fig. 2.3.5

Histograms showing effect of postharvest dry storage (PHDS) for 72h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on soluble proteins (I) and α-amino acids (J) in tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


I
mg g -1 FM
mg flower -1
L S D
Soluble proteins
30
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

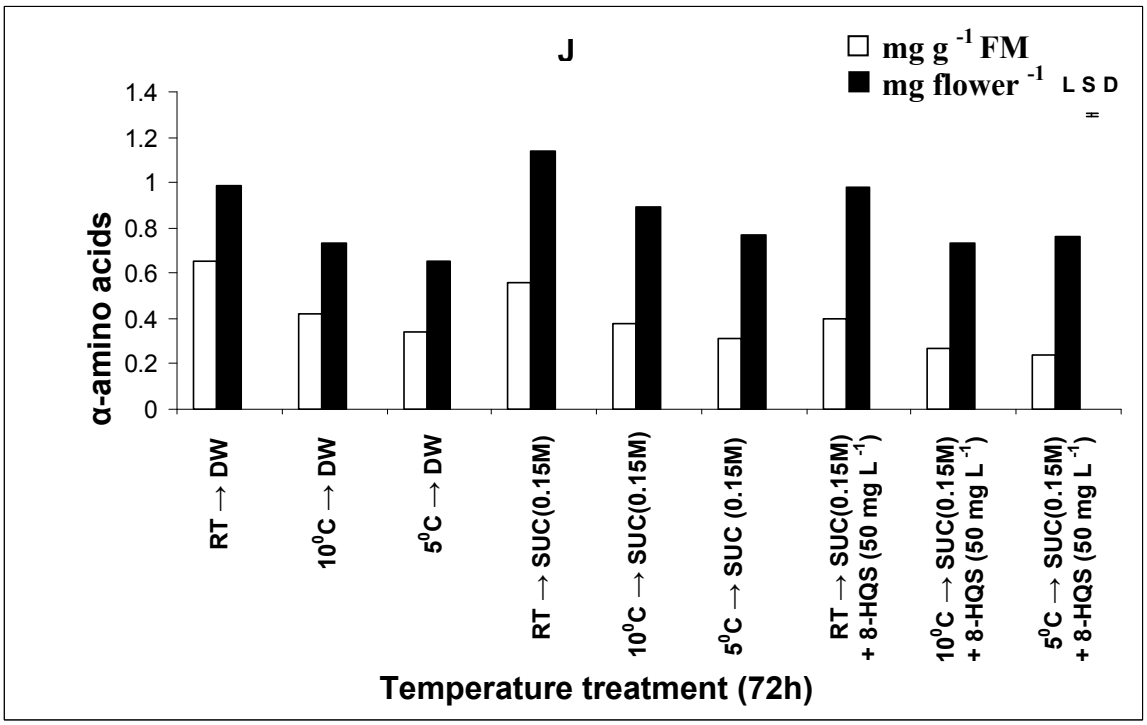

J
mg g -1 FM
mg flower -1
L S D
α-amino acids
1.4
1.2
1
0.8
0.6
0.4
0.2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.3.5

Fig. 2.3.6

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total phenols (K) from tepal tissues on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05}$.

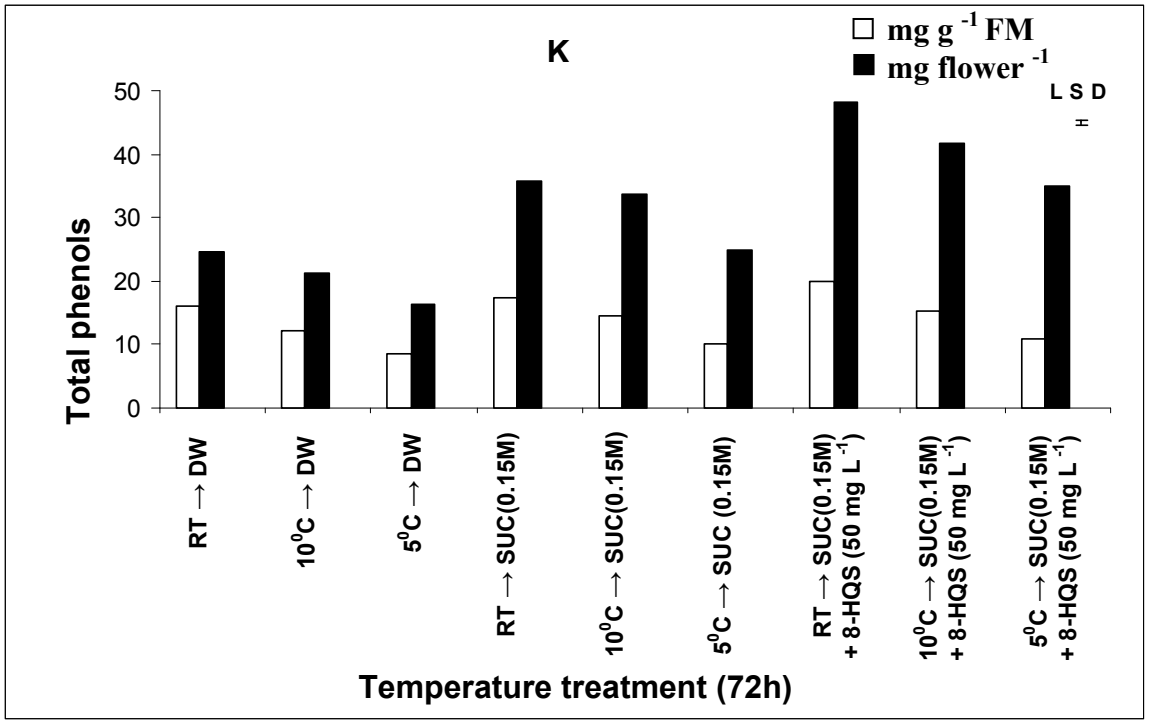

K
mg g -1 FM
mg flower -1
L S D H
Total phenols
50
40
30
20
10
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 2.3.6

Plate 2.3.1

Effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Fig.1: From left to right are arranged scapes before dry storage for 72 h.

Fig.2: From left to right are arranged scapes after dry storage for 72 h.

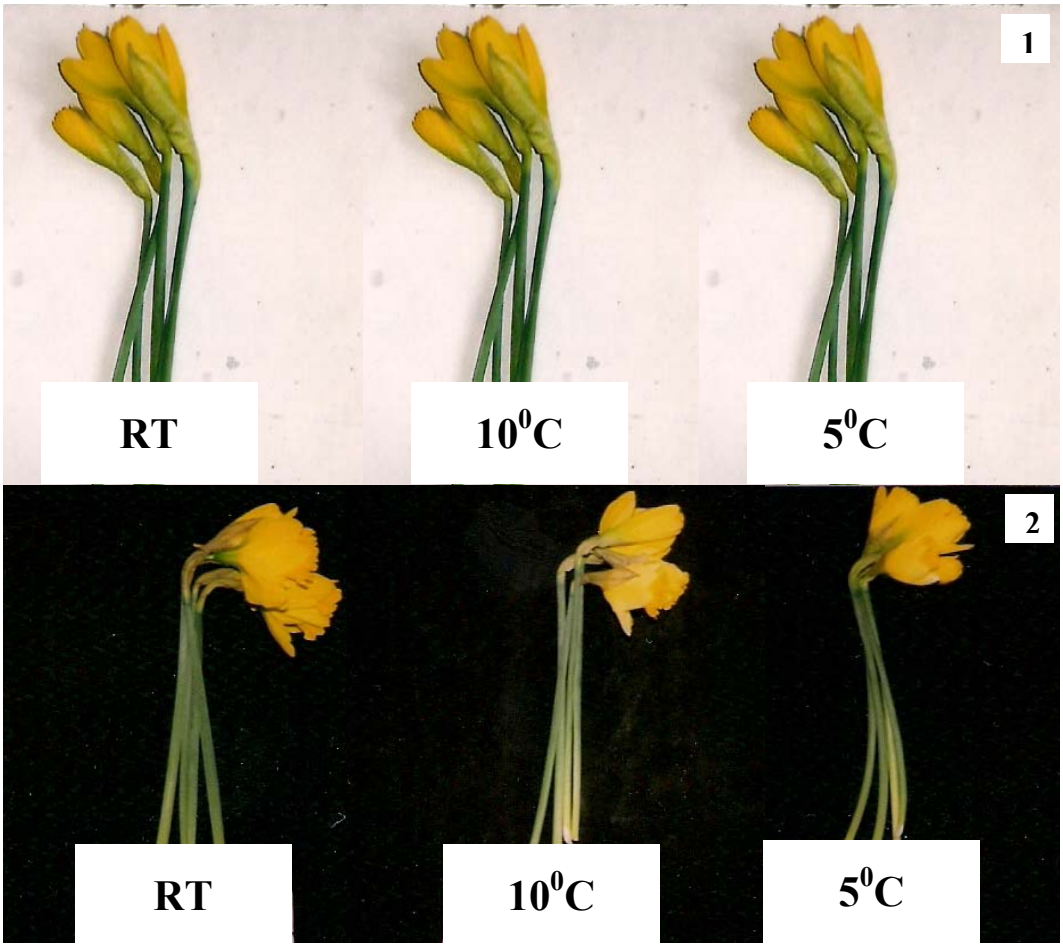


Plate. 2.3.1

Plate 2.3.2

Effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT) 10^0 and 5^0C, before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solution in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged flasks containing scapes stored at RT (15 ± 2^{o}C), 10^o and 5^{o}C.

Fig. 1 to 3 represent scapes dry stored at RT, 10 and 5^{o}C held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

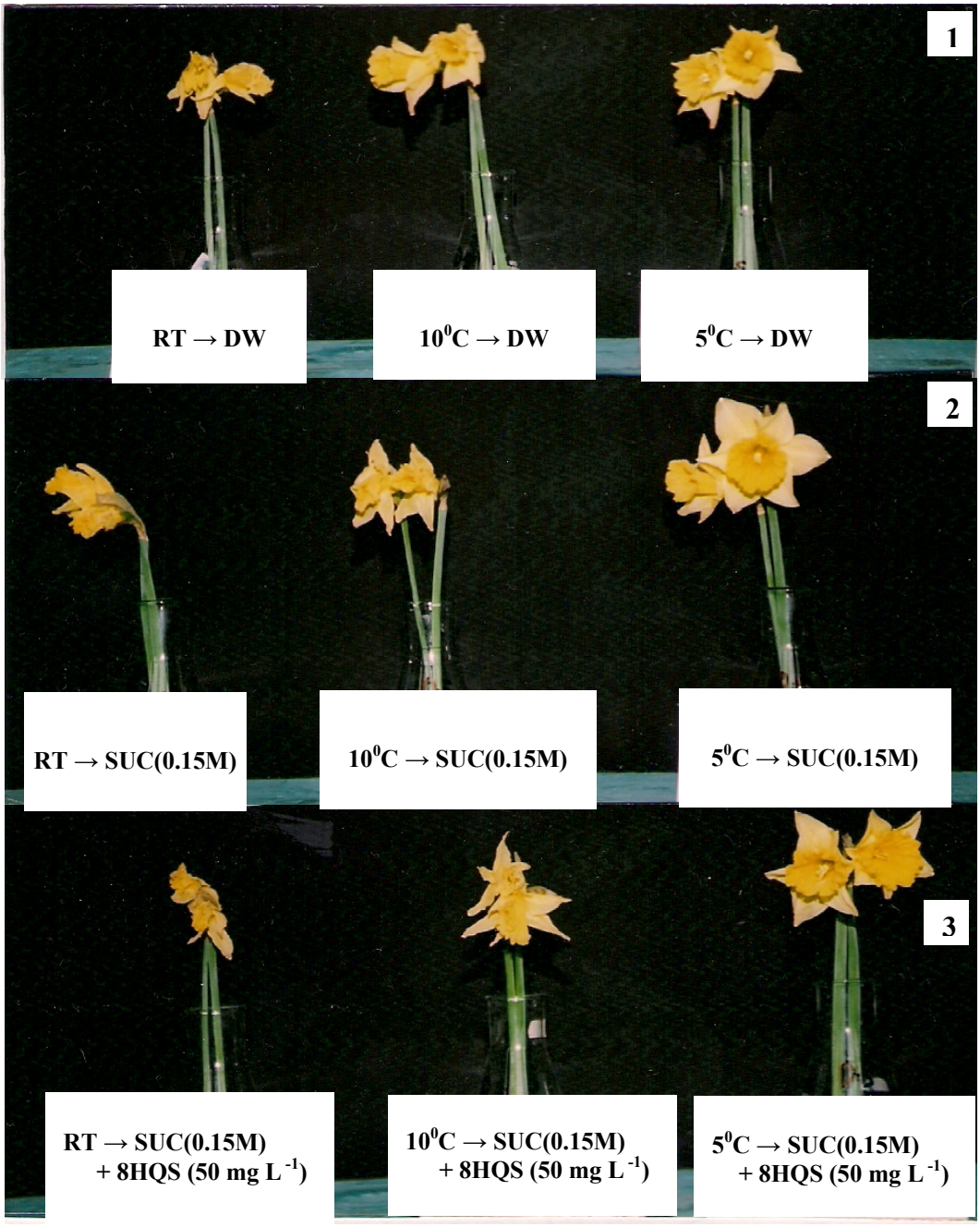

1
RT → DW
10⁰C → DW
5⁰C → DW
2
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC(0.15M)
3
RT → SUC(0.15M)
+ 8HQS (50 mg L -1)
10⁰C → SUC(0.15M)
+ 8HQS (50 mg L -1)
5⁰C → SUC(0.15M)
+ 8HQS (50 mg L -1)

Plate. 2.3.2

EXPERIMENT 2.4

Effect of pretreatment with varying grades of CHI (1h pulse) and subsequent transfer to distilled water (DW) set (A) and sucrose SUC (0.15M) set (B) on cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Experimental

Scapes of *N. pseudonarcissus* growing in the University Botanic garden were used for the study. The scapes were harvested at 08.00 h when the scapes were at goose neck stage. The scapes were brought to the laboratory and cut to a uniform scape length of 25 cm. The scapes were held in distilled water in 1000 ml borosil beakers for 1h containing CHI at 0.01, 0.05, 0.5 and 1.0 mM. After pulsing, the scapes were transferred to 250 ml conical flasks containing 200 ml of DW or SUC (0.15M) in triplicate. The unpulsed scapes transferred to DW represented the control. Pulsed scapes transferred to water (DW) represented set (A) and the scapes transferred to SUC (0.15M) represented set (B). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the scapes were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solution and was assessed to be terminated when the flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals. Volume of holding solution absorbed was recorded on day 2, 4 and 6 after the transfer. Electrical conductivity of leachates from tepal discs of flowers, fresh mass and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to DW or SUC. Changes in tissue constituents including sugar fractions, soluble proteins, α-amino acids and the concentration of total

phenols were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions, DW or SUC (0.15M) except in scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM). The scapes pretreated with CHI before transfer to DW (set A) or SUC (set B) showed bending on subsequent day of transfer to holding solutions but bending was more in flowers pretreated with 0.5 and 1.0 mM CHI (Plate. 2.4.1, Figs. 1-4). The flower senescence was delayed in the scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) by an increment of 5 to 6 days. Scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) failed to open and wilted quickly by day 2 of the treatment (Plate. 2.4.2, Figs. 1-4).

Vase life: The average vase life of flowers from scapes pretreated with 0.01 and 0.05 mM CHI before transfer to DW (set A) increased by an increment of 5 and 4 days respectively, whereas the average vase life of flower from scapes transferred to SUC (set B) was enhanced by an increment of about 6 to 5 days respectively as compared to the flowers from untreated scapes which exhibited vase life of about 6 days in DW and 8 days in SUC (0.15M). The vase life of flowers decreased with an increase in CHI concentration and the decrease was pronounced in flowers from scapes pretreated with 0.5 and 1.0 mM CHI before transfer to DW or SUC (Table 2.4.1, Text Fig. 2.4.1, A).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes to various holding solutions irrespective of the treatment however, the increase at each 2 , 4 and 6 days of transfer was higher in scapes pretreated with 0.01 and 0.05 mM CHI as also untreated scapes

before transfer to either DW or SUC. Pretreatment of scapes with higher grades of CHI (0.5 and 1.0 mM) before transfer to holding solution particularly SUC (set B) resulted in a decrease in the volume of holding solution absorbed as compared to the untreated scapes and scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) . At lower grades of CHI (0.01 and 0.05 mM) a marked increase was noticed in the solution uptake in both DW and SUC (Table 2.4.1, Text Fig. 2.4.1, B).

Conductivity of leachates (µS): The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer to either DW (set A) or SUC (set B). The concentration of ion leachates was found to be significantly higher in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) before transfer to either DW or SUC. At lower grades of CHI (0.01 and 0.05 mM) the concentration of ion leachates was found to decrease in the samples from pretreated scapes transferred to either DW or SUC (Table 2.4.2, Text Fig. 2.4.2,C).

Fresh mass and dry mass: Fresh and dry mass of flowers decreased with progression in time from day 4 to day 8 of transfer of untreated scapes as also scapes pretreated with higher grades of CHI (0.5and 1.0 mM) before transfer to either DW (set A) or SUC (set B). A higher fresh and dry mass was, however maintained in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) particularly in scapes transferred to SUC (Table 2.4.2, Text Fig. 2.4.2, D and Text Fig. 2.4.3, E).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however a higher reducing sugar content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The reducing sugar content registered a

significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls, both DW or SUC (Table 2.4.3, Text Fig. 2.4.3, F). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 2.4.3 & 2.4.4). The highest content of reducing sugar was maintained in samples from scapes pretreated with 0.05 mM CHI before transfer to either DW or SUC.

Non-reducing sugars: The non-reducing sugar content registered a decrease with progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), the decrease was however, pronounced in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) (Table 2.4.3, Text Fig. 2.4.4, G). When the data was expressed on per flower and on dry mass bases the differences were much sharp and apparent (Tables 2.4.3 & 2.4.4). The highest non-reducing sugar content was registered in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however a higher total sugar content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The total sugar content registered a sharp decrease in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both DW or SUC (Table 2.4.3, Text Fig. 2.4.4, H). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 2.4.3 & 2.4.4). The highest total sugar content was registered in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however a higher soluble protein content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The soluble protein content registered a significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both DW or SUC (Table 2.4.5, Text Fig. 2.4.5, I). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases but the differences were sharp and apparent (Table 2.4.5 & 2.4.6). The highest soluble protein content was marked in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

α- amino acids: The amino acid content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the amino acid content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The amino acid content registered a sharp increase in samples from scapes pretreated with higher concentrations of CHI (0.5 and 1.0 mM) as compared to untreated controls both in DW or SUC (Table 2.4.5, Text Fig. 2.4.5, J). When data was expressed on per flower basis and on dry mass bases the differences were sharp and apparent (Tables 2.4.5 & 2.4.6). A lower content of amino acids was registered in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B), as compared to untreated samples.

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however a higher phenolic content was more or less maintained over a period of time in samples from scapes pretreated with

varying grades of CHI. (Table 2.4.5, Text Fig. 2.4.6, K). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass basis (Tables 2.4.5 & 2.4.6). The highest content of total phenols was registered in samples from scapes pretreated with higher grades of CHI (0.5 and 1.0 mM) as compared to untreated samples.

Table 2.4.1: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on vase life and solution uptake in the cut scape of *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Vase life (days)	Volume of solution absorbed per scape (ml)		
		Days after treatment		
		2	4	6
A				
DW	6	0.28	1.02	1.77
CHI 0.01mM	8	1.02	2.03	3.03
CHI 0.05mM	10	1.77	2.56	4.02
CHI 0.5mM	3	1.00	1.28	2.28
CHI 1.0mM	2	0.56	0.70	1.00
B				
SUC (0.15M)	8	0.77	1.77	2.28
CHI 0.01mM	12	1.52	2.52	3.51
CHI 0.05mM	11	1.30	2.27	3.59
CHI 0.5mM	3	0.52	1.20	2.00
CHI 1.0mM	2	0.51	0.57	1.02
LSD at $P_{=0.05}$	0.17	0.002	0.003	0.005

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Table 2.4.2: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	12.66	21.76	2.38	1.24	0.225	0.208
CHI 0.01mM	11.01	10.83	2.72	2.92	0.277	0.301
CHI 0.05mM	12.0	11.67	2.64	2.87	0.269	0.283
CHI 0.5mM	14.34	22.67	1.64	1.18	0.172	0.125
CHI 1.0mM	16.14	26.14	1.46	1.04	0.135	0.11
B						
SUC (0.15M)	12.43	19.50	2.60	1.44	0.238	0.227
CHI 0.01mM	10.93	9.26	2.79	3.21	0.292	0.334
CHI 0.05mM	12.21	11.73	2.73	3.00	0.287	0.315
CHI 0.5mM	13.35	23.59	1.91	1.28	0.192	0.208
CHI 1.0mM	15.30	24.56	1.89	1.10	0.188	0.119
LSD at $P_{=0.05}$	0.25	0.37	0.06	0.04	0.004	0.007

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Table 2.4.3: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on sugar fractions expressed on fresh mass basis (mg g^{-1}FM) in tepal tissues on day 4 and 8 of transfer of cut scapes in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Reducing sugars		Non-reducing sugars		Total soluble sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	23.20 (55.45)	16.00 (19.84)	8.81 (20.96)	11.20 (13.90)	32.11 (76.42)	27.21 (33.74)
CHI 0.01mM	21.46 (58.37)	19.34 (56.47)	16.74 (45.53)	11.32 (33.97)	38.20 (103.90)	31.66 (92.44)
CHI 0.05mM	24.86 (62.99)	20.13 (57.77)	12.27 (32.39)	8.01 (22.98)	37.13 (95.38)	28.14 (80.76)
CHI 0.5mM	19.16 (31.42)	15.16 (17.88)	9.37 (15.36)	3.43 (4.04)	28.53 (46.78)	18.59 (21.93)
CHI 1.0mM	15.73 (22.97)	13.86 (14.41)	10.72 (15.65)	2.12 (2.20)	26.45 (38.61)	15.98 (16.61)
B						
SUC (0.15M)	25.60 (66.56)	22.20 (31.98)	9.86 (25.63)	8.46 (12.18)	35.46 (92.19)	30.67 (44.16)
CHI 0.01mM	26.00 (72.54)	22.89 (75.91)	20.13 (56.16)	22.11 (70.97)	46.13 (128.70)	45.00 (146.88)
CHI 0.05mM	27.06 (73.87)	25.67 (77.01)	16.67 (45.50)	14.45 (43.35)	43.73 (119.38)	40.12 (120.36)
CHI 0.5mM	20.40 (38.96)	17.16 (21.96)	10.23 (19.53)	9.36 (11.98)	30.66 (58.50)	26.52 (33.94)
CHI 1.0mM	18.93 (35.77)	11.46 (12.60)	9.55 (18.04)	4.25 (4.67)	28.48 (53.82)	15.71 (17.28)
LSD at $P_{=0.05}$	0.89	0.72	0.84	0.78	1.09	0.98

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.4.4: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) and subsequent transfer to DW (A) or SUC (B) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	246.46	95.38	93.19	66.82	339.65	162.21
CHI 0.01mM	210.72	187.61	164.37	119.51	375.10	307.13
CHI 0.05mM	234.16	204.14	120.41	81.23	354.58	285.37
CHI 0.5mM	182.68	143.11	89.34	32.37	272.03	175.48
CHI 1.0mM	170.11	131.04	115.93	20.04	286.05	151.08
B						
SUC (0.15M)	279.66	140.89	107.71	53.66	387.37	194.55
CHI 0.01mM	248.42	227.29	192.33	212.49	440.76	439.78
CHI 0.05mM	257.40	244.47	158.56	137.61	415.96	382.09
CHI 0.5mM	202.93	105.60	101.76	57.60	304.70	163.20
CHI 1.0mM	190.30	105.93	96.00	39.28	286.31	145.21
LSD at $P_{=0.05}$	2.34	1.72	3.00	2.13	1.87	2.11

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Table 2.4.5: Effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	2.33 (5.54)	1.41 (1.74)	0.49 (1.16)	0.55 (0.68)	5.06 (12.04)	6.80 (8.43)
CHI 0.01mM	5.23 (14.22)	5.01 (14.62)	0.17 (0.46)	0.18 (0.52)	4.53 (12.32)	5.32 (15.53)
CHI 0.05mM	4.02 (10.61)	3.08 (8.83)	0.26 (0.68)	0.27 (0.77)	5.86 (15.47)	6.81 (19.54)
CHI 0.5mM	3.01 (4.93)	2.66 (3.13)	0.30 (0.49)	0.34 (0.40)	6.53 (10.70)	7.13 (8.41)
CHI 1.0mM	2.14 (3.12)	1.18 (1.22)	0.52 (0.75)	0.56 (0.58)	8.80 (12.84)	9.62 (10.00)
B						
SUC (0.15M)	2.04 (5.30)	1.66 (2.39)	0.57 (1.48)	0.50 (0.72)	6.46 (16.79)	7.41 (10.67)
CHI 0.01mM	5.55 (15.48)	5.22 (16.75)	0.15 (0.41)	0.16 (0.51)	4.26 (11.88)	5.10 (16.37)
CHI 0.05mM	4.23 (11.54)	3.98 (11.94)	0.20 (0.54)	0.22 (0.66)	5.2 (14.19)	6.20 (18.60)
CHI 0.5mM	3.12 (5.95)	2.42 (3.09)	0.31 (0.59)	0.39 (0.49)	5.46 (10.42)	6.65 (8.51)
CHI 1.0mM	2.66 (5.02)	1.07 (1.17)	0.45 (0.85)	0.63 (0.69)	7.46 (14.09)	8.10 (8.91)
LSD at $P_{=0.05}$	0.18	0.22	0.018	0.026	0.54	0.85

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.4.6: Effect of pre treatment with varying grades of cycloheximide (CHI, 1 h pulse) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	24.64	8.40	5.18	3.27	53.52	40.53
CHI 0.01mM	51.35	48.60	1.66	1.74	44.48	51.60
CHI 0.05mM	39.45	31.23	2.55	2.73	57.51	69.06
CHI 0.5mM	28.70	25.11	2.84	3.20	62.26	67.30
CHI 1.0mM	23.14	11.15	5.62	5.29	95.17	90.95
B						
SUC (0.15M)	22.28	10.53	6.22	3.17	70.57	47.00
CHI 0.01mM	53.02	50.16	1.43	1.53	40.70	49.01
CHI 0.05mM	40.23	37.90	1.88	2.09	49.46	59.04
CHI 0.5mM	31.03	14.89	3.08	2.40	54.31	40.92
CHI 1.0mM	26.74	9.890	4.52	5.82	74.99	74.87
LSD at $P_{=0.05}$	3.18	2.67	0.99	0.66	3.25	2.88

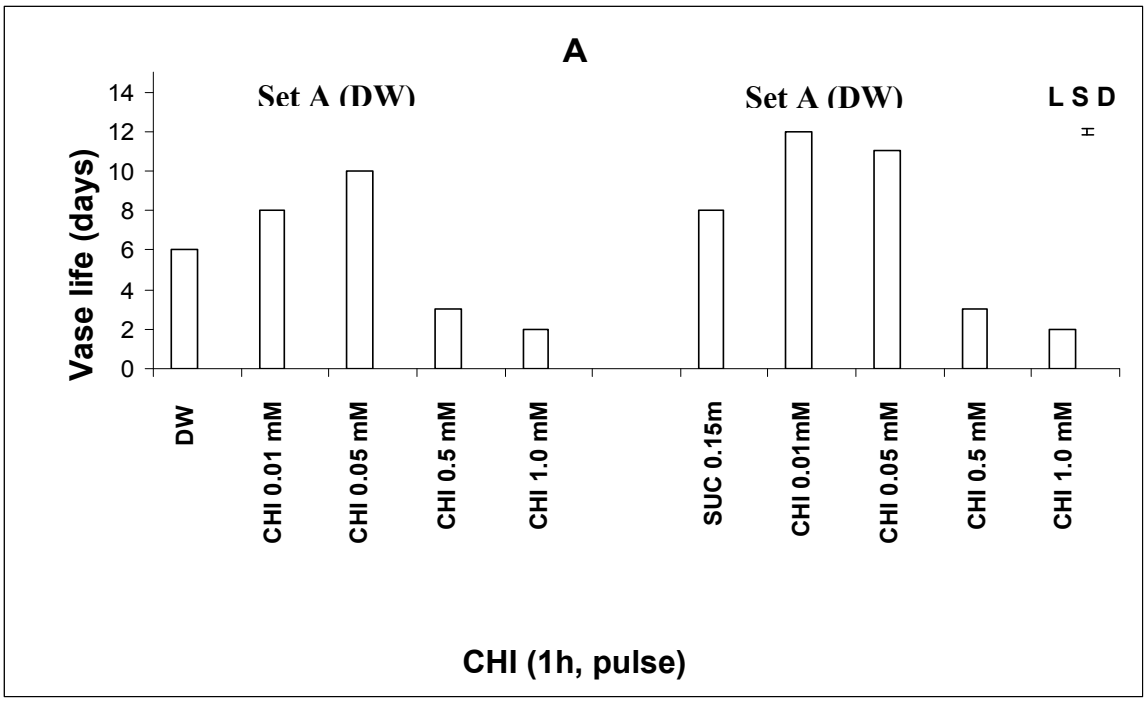
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Fig. 2.4.1

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) before transfer to DW (A) or SUC (B) on vase life (A) and volume of holding solutions absorbed per scape ml (B), on day 2, 4 and 6 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{=0.05}$.


A
Set A (DW)
Set A (DW)
L S D
Vase life (days)
14
12
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

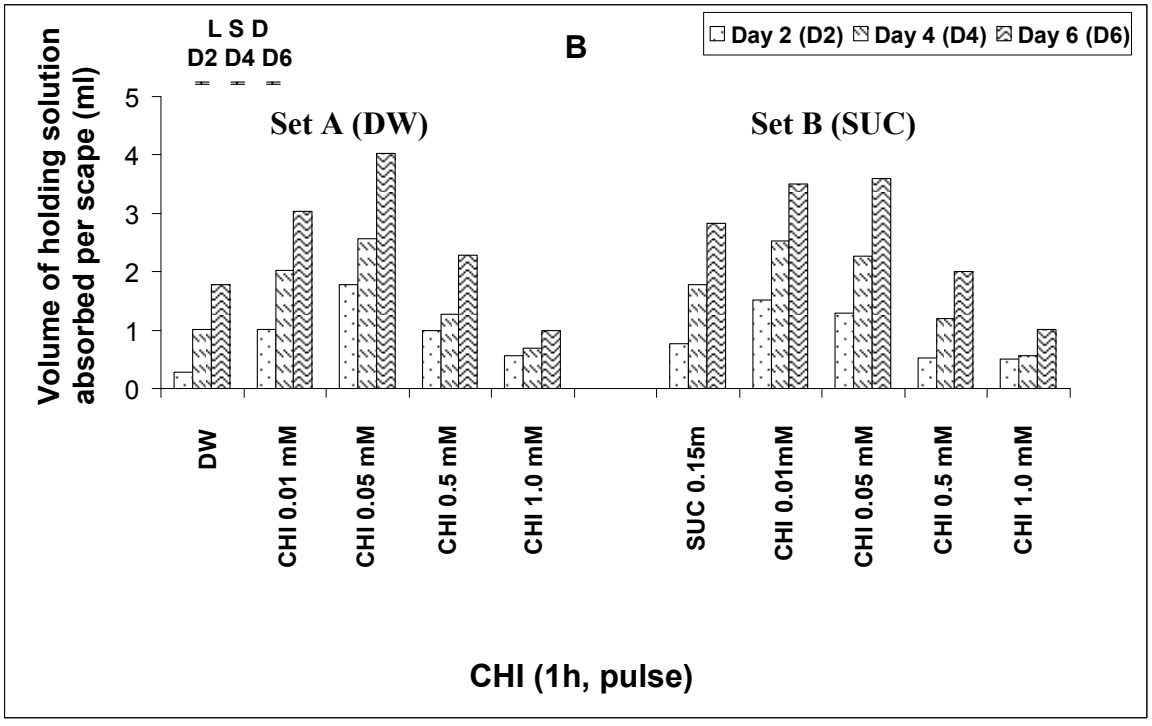
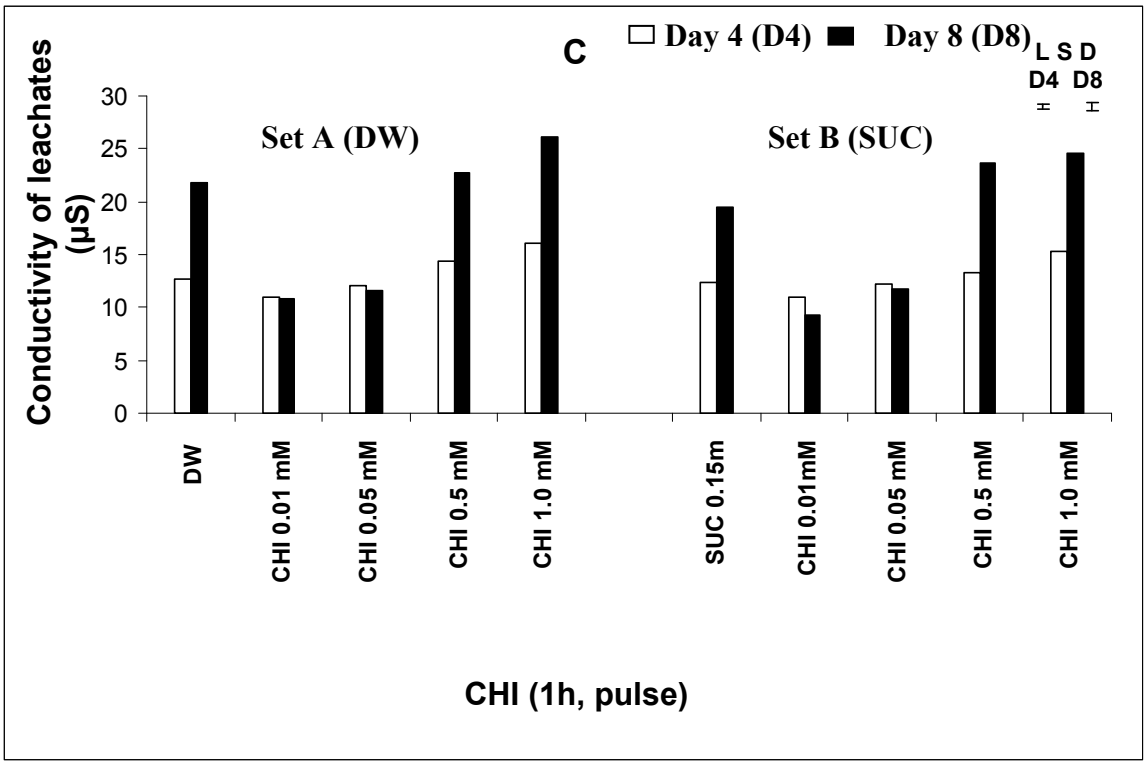

L S D
D2 D4 D6
B
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
5
4
3
2
1
0
Set A (DW)
Set B (SUC)
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.1

Fig. 2.4.2

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) conductivity of leachates (C) in tepal tissues and fresh mass (D) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{=0.05}$.


C
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
Set A (DW)
Set B (SUC)
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

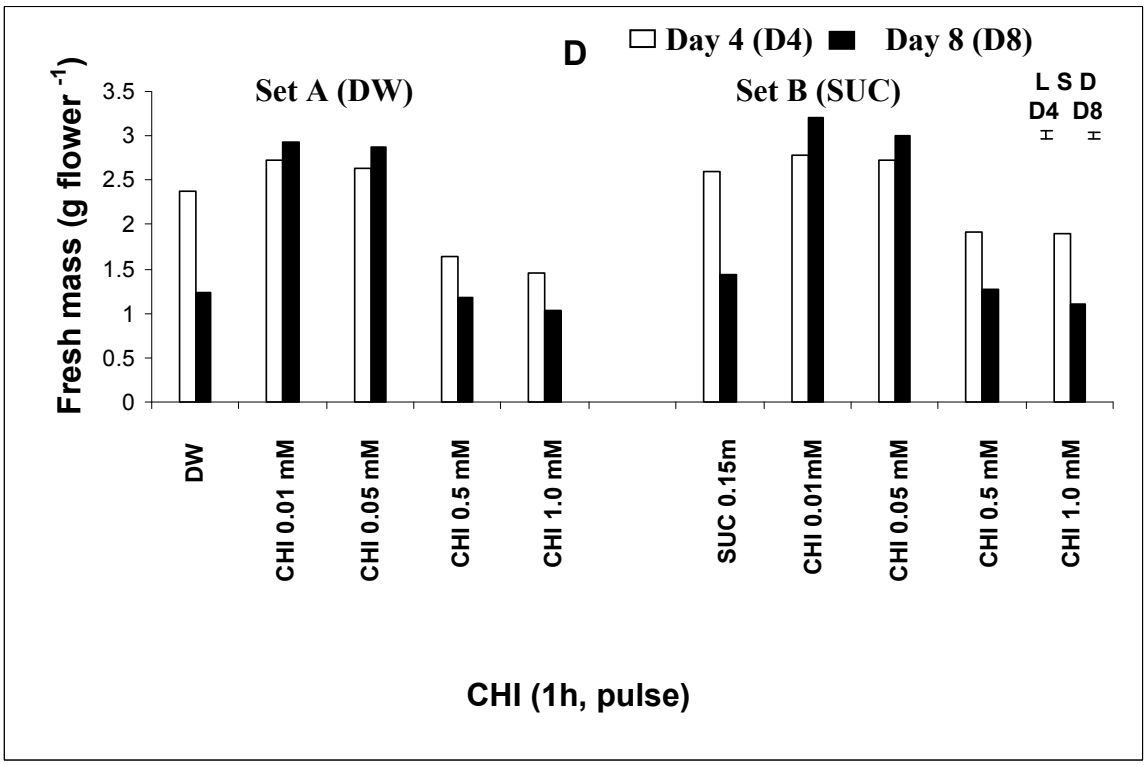
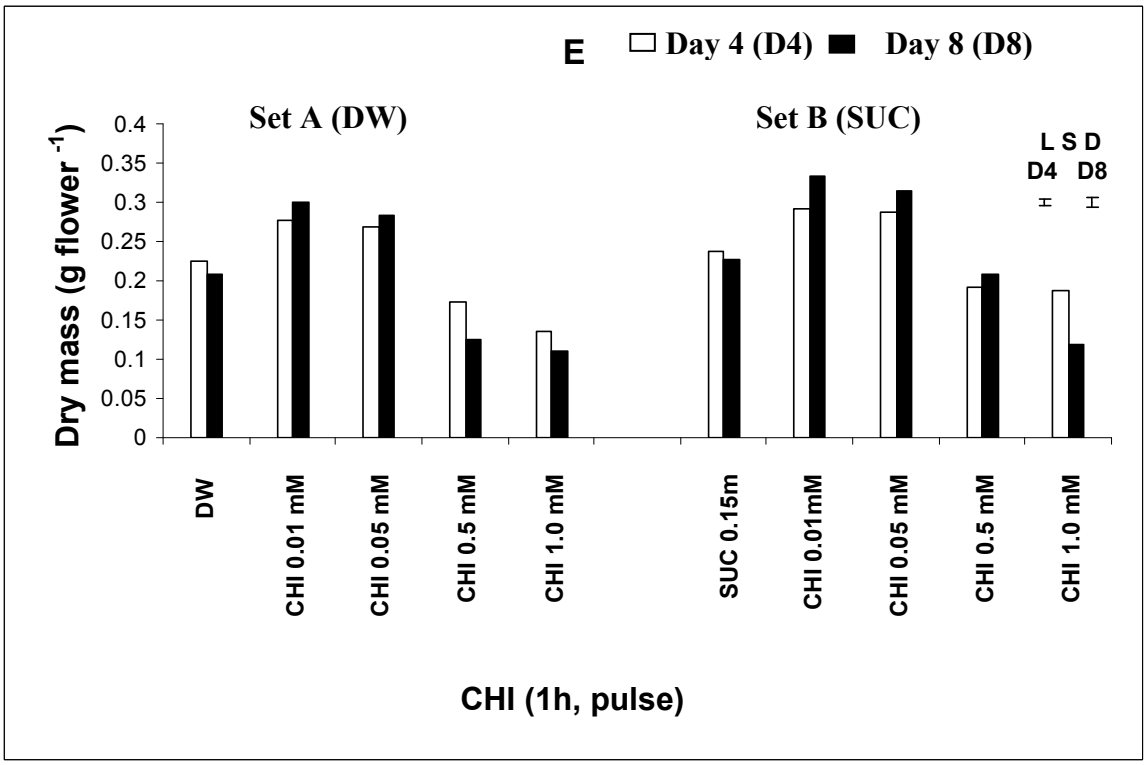

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Fresh mass (g flower -1)
Set A (DW)
Set B (SUC)
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.2

Fig. 2.4.3

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on dry mass (E) of flowers and reducing sugars (F) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{=0.05}$.


E
Day 4 (D4)
Day 8 (D8)
Set A (DW)
Set B (SUC)
L S D
D4 D8
Dry mass (g flower -1)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

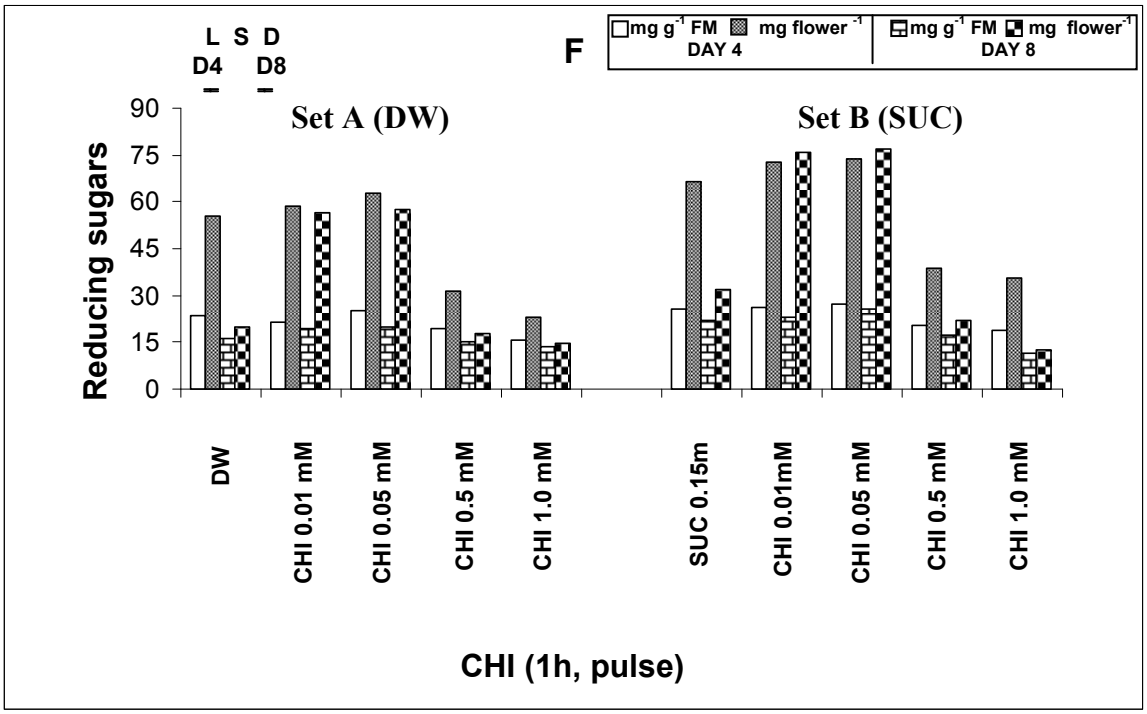
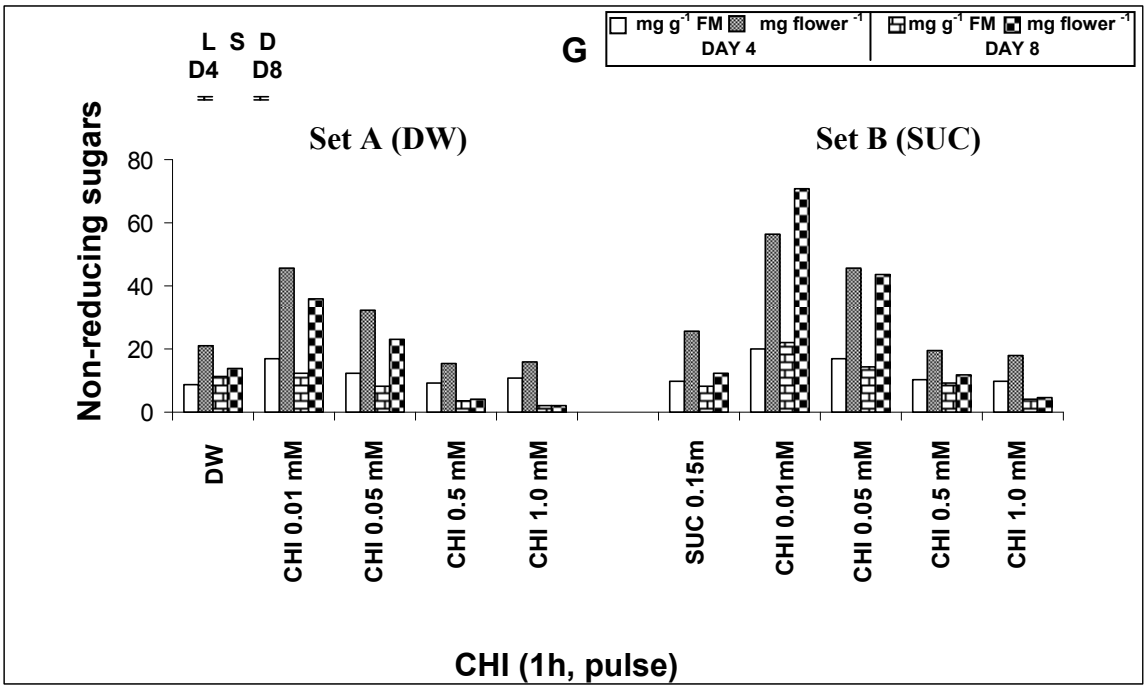

F
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower-1
DAY 8
L S D
D4 D8
Set A (DW)
Set B (SUC)
Reducing sugars
90
75
60
45
30
15
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.3

Fig. 2.4.4

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) non-reducing sugars (G) and total sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{=0.05}$.


G
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
L S D
D4 D8
Set A (DW)
Set B (SUC)
Non-reducing sugars
0
20
40
60
80
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

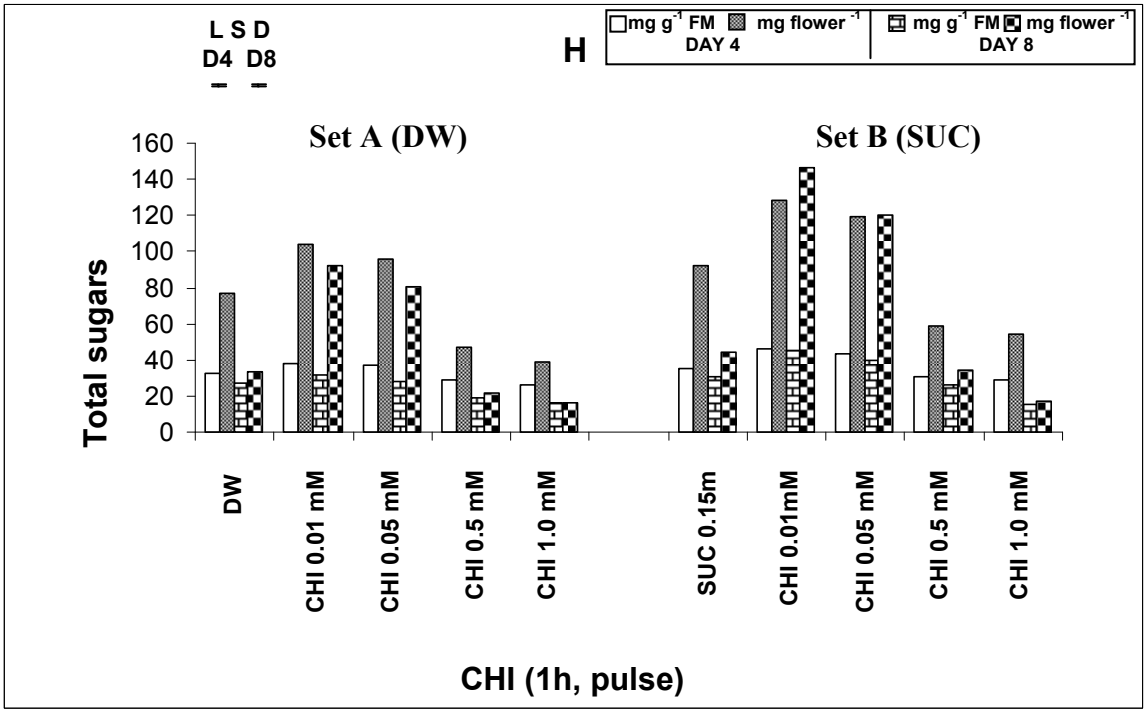
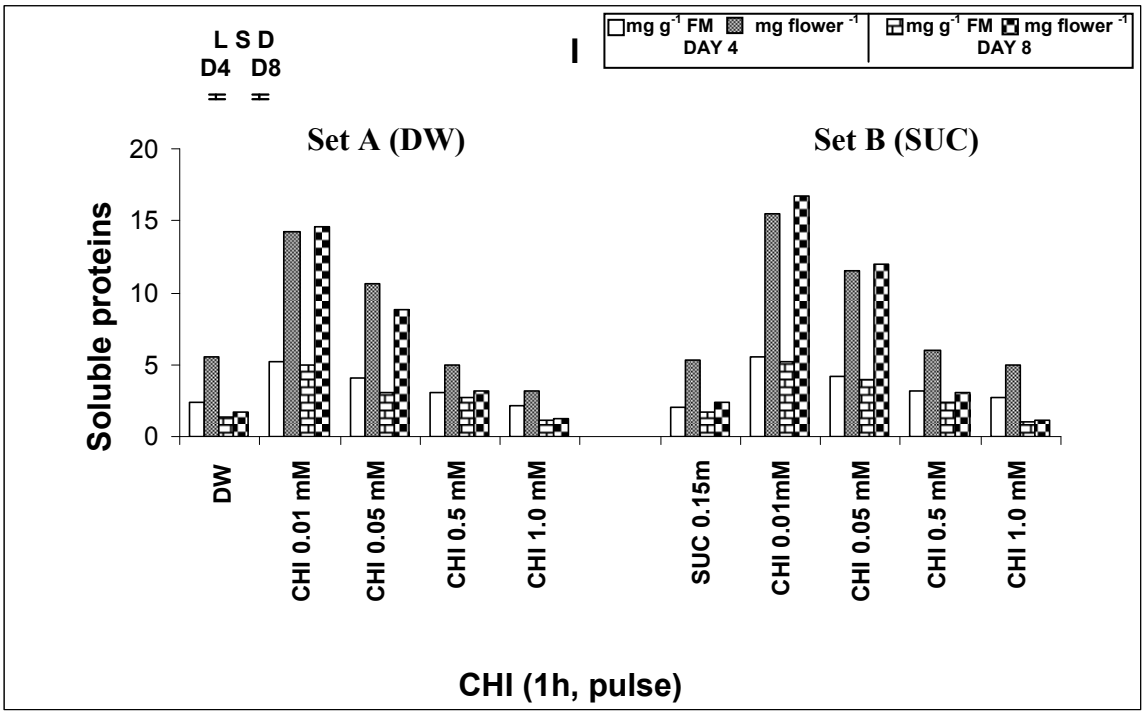

H
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
L S D
D4 D8
Set A (DW)
Set B (SUC)
Total sugars
0
20
40
60
80
100
120
140
160
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.4

Fig. 2.4.5

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) soluble proteins (I) and α-amino acids (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{=0.05}$.


I
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4
D8
Set A (DW)
Set B (SUC)
Soluble proteins
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

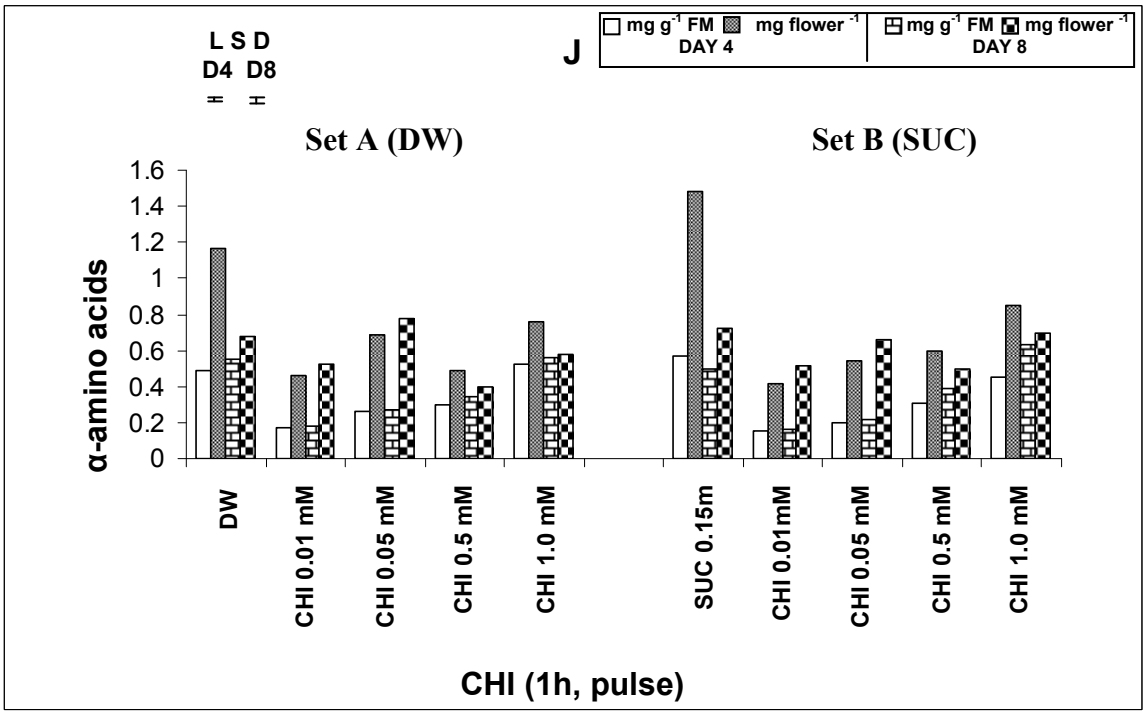

J
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4
D8
Set A (DW)
Set B (SUC)
α-amino acids
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.5

Fig. 2.4.6

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) total phenols (K) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$

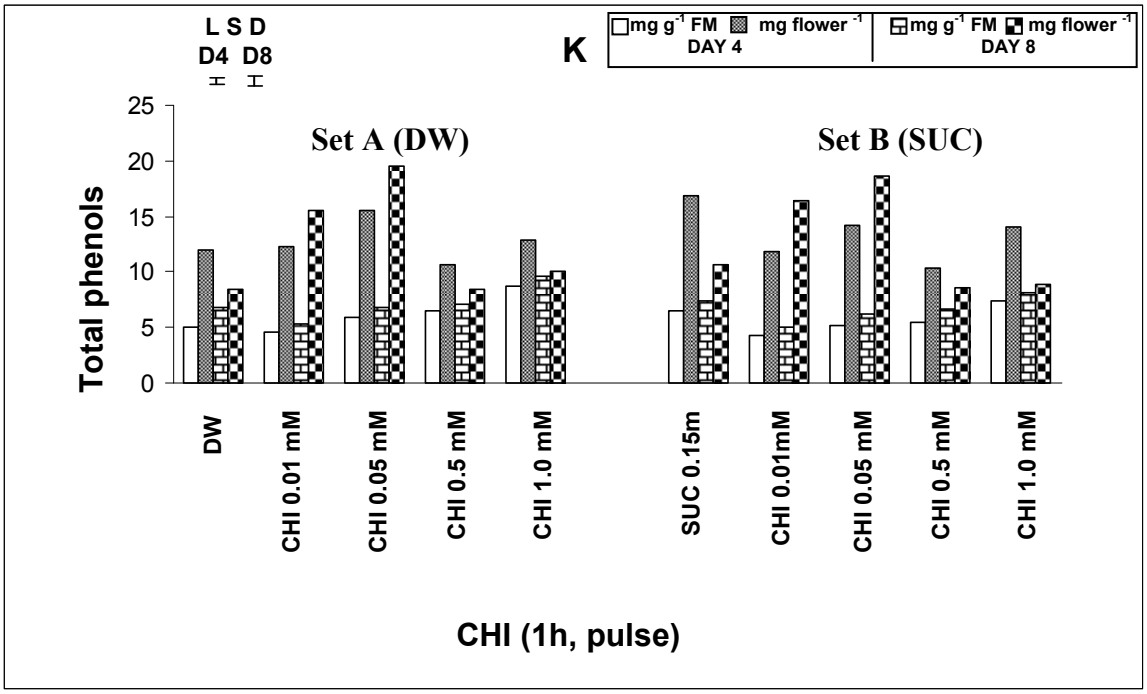

L S D
D4 D8
K
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Total phenols
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.5 mM
CHI 1.0 mM
CHI (1h, pulse)

Fig. 2.4.6

Plate. 2.4.1

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 4 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15 M), CHI (0.01 mM) → DW and CHI (0.01 mM) → SUC (0.15 M).

Fig.2: DW, SUC (0.15 M), CHI (0.05 mM) → DW and CHI (0.05 mM) → SUC (0.15 M).

Fig.3: DW, SUC (0.15 M), CHI (0.5 mM) → DW and CHI (0.5 mM) → SUC (0.15 M).

Fig.4: DW, SUC (0.15 M), CHI (1.0 mM) → DW and CHI (1.0 mM) → SUC (0.15 M).

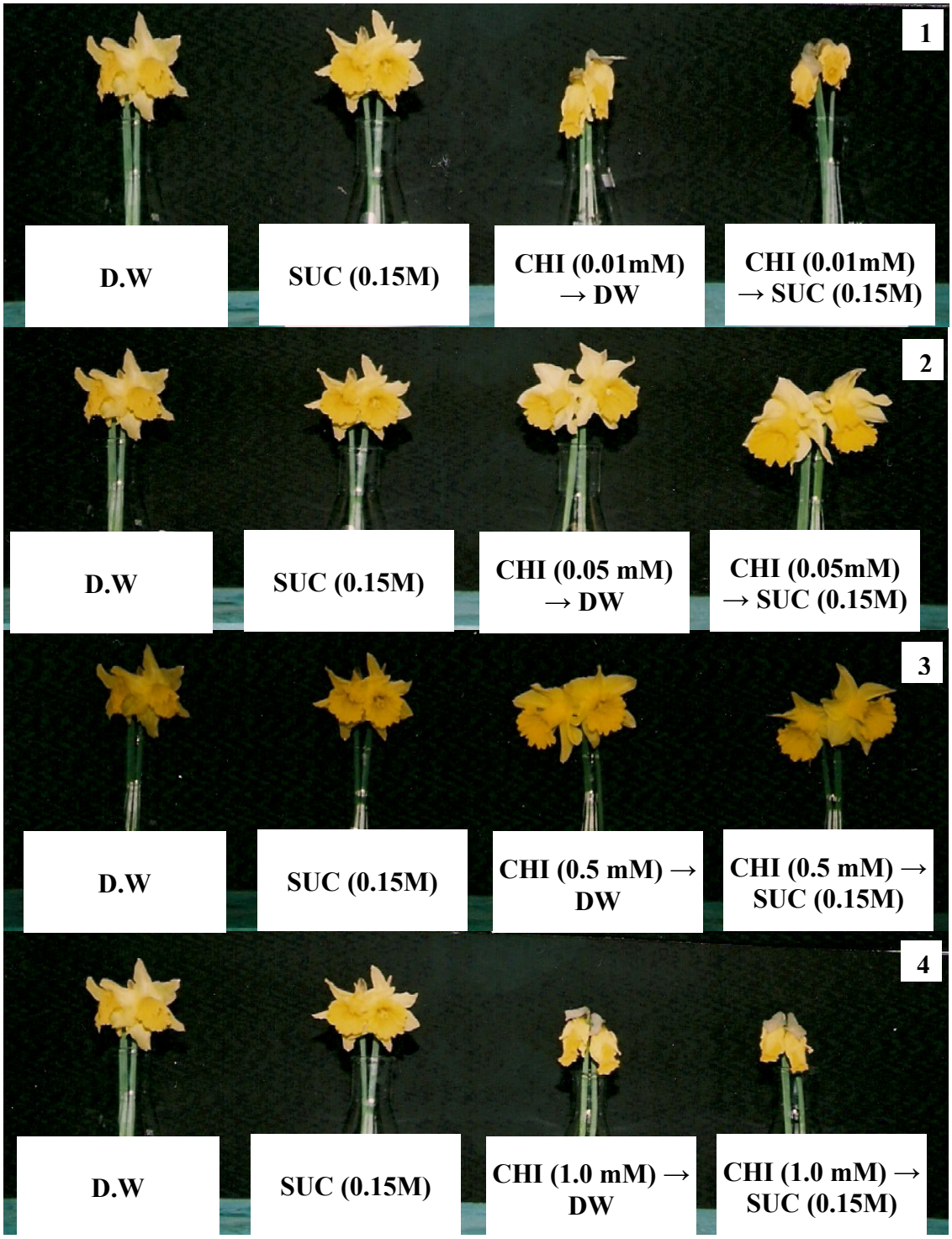

1
D.W
SUC (0.15M)
CHI (0.01mM) → DW
CHI (0.01mM) → SUC (0.15M)
2
D.W
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05mM) → SUC (0.15M)
3
D.W
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)
4
D.W
SUC (0.15M)
CHI (1.0 mM) → DW
CHI (1.0 mM) → SUC (0.15M)

Plate. 2.4.1

Plate. 2.4.2

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15 M), CHI (0.01 mM) → DW and CHI (0.01 mM) → SUC (0.15 M).

Fig.2: DW, SUC (0.15 M), CHI (0.05 mM) → DW and CHI (0.05 mM) → SUC (0.15 M).

Fig.3: DW, SUC (0.15 M), CHI (0.5 mM) → DW and CHI (0.5 mM) → SUC (0.15 M).

Fig.4: DW, SUC (0.15 M), CHI (1.0 mM) → DW and CHI (1.0 mM) → SUC (0.15 M).

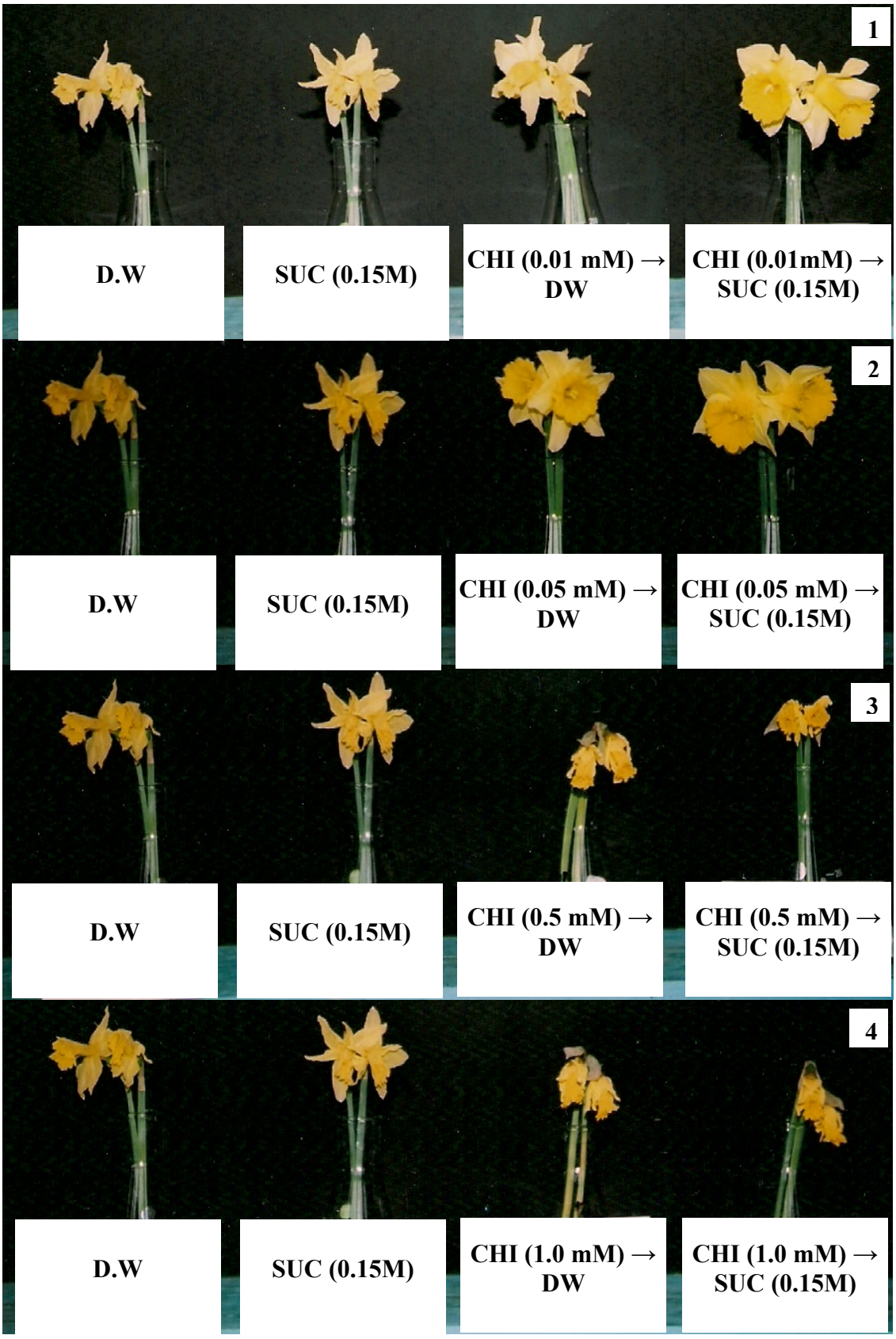

1
D.W
SUC (0.15M)
CHI (0.01 mM) → DW
CHI (0.01mM) → SUC (0.15M)
2
D.W
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05 mM) → SUC (0.15M)
3
D.W
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)
4
D.W
SUC (0.15M)
CHI (1.0 mM) → DW
CHI (1.0 mM) → SUC (0.15M)

Plate. 2.4.2

EXPERIMENT 2.5

Effect of pulse treatment with silver thiosulphate (STS, 0.5 mM, 1 h) before transfer to distilled water (DW); Sucrose, SUC (0.15M); Sucrose, SUC (0.15M) + 8- Hydroxyqunioline sulpate, 8-HQS (50 mg L^{-1}); Sucrose, SUC (0.15M) + 8- Hydroxyqunioline sulpate, 8-HQS (50 mg L^{-1}) + Kinetin, Kin (25 mg L^{-1}) on cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Experimental

Scapes of *N. pseudonarcissus* growing in the University Botanic garden were used for the study. The scapes were harvested at 08.00h when the scapes were at goose neck stage. The scapes were brought to the laboratory and cut to a uniform scape length of 25 cm, held in 1000 ml borosil beakers containing distilled water for 1h for the slime to drain off. The scapes were divided into two sets. One set of scapes was pulsed with STS (0.5 mM) for 1 h . Both the pulsed and unpulsed sets of scapes were separately transferred to 250 ml conical flasks containing 200 ml of DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC (0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) in triplicate. The unpulsed scapes transferred to DW represented the control. For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the scapes were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to holding solution and was assessed to be terminated when of the flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals. Volume of solution absorbed was recorded on day 2, 4 and 6 after the transfer. Electrical conductivity of leachates from tepal discs of flowers,

fresh mass and dry mass of flowers were recorded on day 4 and 8 of transfer to various holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and the concentration of total phenols were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to various holding solutions. The flower senescence was effectively delayed in the STS pulsed scapes, particularly in the scapes held in SUC + 8-HQS +KIN as compared to the corresponding unpulsed scapes (Plate 2.5.1,Figs. 1-2).

Vase life: The average vase life of flowers from STS pulsed scapes and transferred to SUC + 8-HQS and SUC + 8-HQS + Kin was enhanced by an increment of 8 and 6 days, while as the average vase life of unpulsed scapes transferred to SUC + 8-HQS and SUC + 8-HQS + Kin was enhanced by an increment of about 4 and 3 days respectively, as compared to the unpulsed scapes held in DW. However, an enhanced vase life by 3 to 5 days was registered in the pulsed scapes held in DW or SUC as compared to the unpulsed scapes held in DW or SUC which exhibited a vase life of 6 and 8 days respectively (Table 2.5.1, Text Fig. 2.5.1, A).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes to various holding solutions irrespective of the treatment. Generally a higher volume of solution uptake was recorded in STS pulsed scapes transferred to various holding solutions as compared to the corresponding unpulsed scapes. A higher solution uptake was however recorded in the unpulsed scapes transferred to SUC + HQS at day 6 after the

treatment as compared to the pulsed scapes transferred to the particular solution (Table 2.5.1, Text Fig. 2.5.1,B).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 in the unpulsed scapes as compared to the corresponding STS pulsed scapes transferred to various holding solutions. Lower concentration of leachates was maintained with progression in time in samples from pulsed scapes as compared to the corresponding unpulsed scapes The concentration of leachates remained lower in samples from the pulsed scapes transferred to SUC +8-HQS and SUC +8-HQS + Kin as compared to the samples from unpulsed scapes (Table 2.5.2, Text Fig. 2.5.2, C).

Fresh mass and dry mass: Fresh and dry mass of samples from scapes decreased with progression in time from day 4 to day 8 of transfer in all the samples from unpulsed scapes as also in the samples from pulsed scapes transferred to DW. A higher fresh and dry mass was recorded in samples from the pulsed scapes as compared to the corresponding samples from unpulsed scapes transferred to various holding solutions over a period of time. A higher fresh and dry mass was, however maintained with progression in time, in samples from scapes pulsed with STS and transferred to SUC, SUC + 8-HQS, or SUC + 8-HQS+ Kin (Table 2.5.2, Text Fig. 2.5.2 D and Text Fig. 2.5.3, E).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to various holding solutions, however the reducing sugar content was generally maintained over a period of time in samples from pulsed scapes transferred particularly to SUC or SUC+ 8-HQS. Higher content of reducing sugars was registered in the samples form pulsed scapes as compared to the samples from corresponding unpulsed scapes (Table 2.5.3, Text Fig. 2.5.3,F). Almost

similar trends were obtained when the data was expressed on per flower basis and on dry mass basis (Tables 2.5.3 & 2.5.4).

Non-reducing sugars: The non-reducing sugar content generally registered an increase with progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. A lower non-reducing sugar content was recorded in the samples form pulsed scapes as compared to the samples from corresponding unpulsed scapes. A higher content of non-reducing sugars was maintained in the samples from scapes transferred to SUC + 8-HQS or SUC+HQS+KIN on day 8 after the transfer of scapes to various holding solutions (Table 2.5.3, Text Fig. 2.5.4,G). Almost similar trends were observed in all the treatments when the data was expressed on per flower basis (Table 2.5.3). When the data was expressed on dry mass basis the differences were prominent although the trends were more or less similar (Table 2.5.4).

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. Higher content of total sugars was registered in the samples form pulsed scapes as compared to the samples from corresponding unpulsed scapes. The total sugar content was more or less maintained in the pulsed scapes transferred to SUC, SUC + 8-HQS or SUC+8-HQS + Kin (Table 2.5.3, Text Fig.2.5.4 H). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 2.5.3 & 2.5.4).

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of the unpulsed scapes to various holding solutions. However, the protein content showed an increase in samples from pulsed scapes transferred particularly to SUC or SUC +8-HQS over the period of time. A higher protein content was maintained in the

samples from the pulsed scapes as compared to the samples form corresponding unpulsed scapes (Table 2.5.5, Text Fig.2.5.5,I). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass basis but the differences were sharp and apparent (Table 2.5.6). Generally higher content of soluble protein was registered in samples from pulsed scapes transferred to SUC + 8-HQS.

α- amino acids: The α-amino acid content registered an increase with the progression in time from day 4 to day 8 of the transfer of unpulsed scapes to various holding solutions. However the α-amino acid content decreased with the progression in time in samples from pulsed scapes particularly transferred SUC + 8-HQS. A lower α-amino acid content was maintained in the samples from the pulsed scapes as compared to the samples form unpulsed scapes irrespective of the transfer to various holding solutions. (Table 2.5.5, Text Fig.2.5.5, J). Almost similar trends were obtained when the data was expressed on per flower basis (Table 2.5.5). On dry mass basis α-amino acid content registered a decrease with the progression in time irrespective of the transfer to various holding solutions but the decrease was generally sharp in samples from unpulsed scapes as compared to the samples from corresponding pulsed scapes (Table 2.5.6).

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer irrespective of the transfer of scapes to various holding solutions. Higher phenolic content was registered in the samples from pulsed scapes as compared to the samples from the corresponding unpulsed scapes transferred to various holding solutions (Table 2.5.5 Text Fig. 2.5.6, K). When the data was expressed on per flower basis and on dry mass basis the total phenolic content registered a decrease with the progression in time in the samples from unpulsed scapes and an increase in the samples from pulsed scapes transferred to various holding solutions (Tables 2.5.5 & 2.5.6).

Table 2.5.1: Effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on vase life and solution uptake in cut scapes of *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Vase life (days)	Volume of holding solution absorbed per scape (ml)		
		Days after treatment		
		2	4	6
DW	6	1.25	1.77	2.35
SUC (0.15M)	8	1.77	2.66	3.01
SUC (0.15M) + 8-HQS (50 mg L^{-1})	10	1.33	3.02	4.27
SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	9	1.01	2.02	3.52
STS → DW	9	1.51	2.27	2.93
STS → SUC (0.15M)	11	1.26	1.55	4.14
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1})	14	1.60	3.18	3.87
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	12	1.65	2.62	3.77
LSD at $P_{=0.05}$	0.15	0.04	0.007	0.09

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2^0C).

Table 2.5.2: Effect of pulse treatment with STS (0.5 mM, 1h) before transfer to DW, SUC (0.15M), SUC(0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on conductivity of leachates, fresh mass and dry mass in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Days after treatment					
	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	4	8	4	8	4	8
DW	13.46	21.76	2.38	1.24	0.225	0.208
SUC (0.15M)	12.43	19.50	2.60	1.44	0.267	0.227
SUC (0.15M) + 8-HQS (50 mg L $^{-1}$)	12.6	18.13	2.76	1.65	0.285	0.259
SUC (0.15M) + 8-HQS (50 mg L $^{-1}$) + KIN (25 mg L $^{-1}$)	12.96	16.36	2.58	1.49	0.241	0.238
STS → DW	12.86	13.46	3.24	2.45	0.309	0.290
STS → SUC (0.15M)	12.00	12.23	3.28	3.57	0.312	0.337
STS → SUC (0.15M) + 8-HQS (50 mg L $^{-1}$)	11.86	11.73	3.34	3.68	0.321	0.349
STS → SUC (0.15M) + 8-HQS (50 mg L $^{-1}$) + KIN (25 mg L $^{-1}$)	12.50	11.01	3.01	3.15	0.310	0.319
LSD at $P_{=0.05}$	0.23	0.30	0.07	0.11	0.008	0.004

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15±2^{o}C).

Table 2.5.3: Effect of pulse treatment with STS (0.5 mM, 1h) before transfer to DW, SUC (0.15M), SUC(0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on sugar fractions, expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Days after treatment					
	Reducing sugars		Non-reducing sugars		Total sugars	
	4	8	4	8	4	8
DW	24.26 (57.73)	17.00 (21.08)	7.73 (18.39)	9.63 (11.94)	32.00 (76.16)	27.20 (33.72)
SUC (0.15M)	26.66 (69.31)	23.20 (33.55)	8.80 (22.88)	7.46 (10.74)	35.46 (92.19)	30.66 (42.15)
SUC (0.15M) + 8-HQS (50 mg L^{-1})	30.93 (85.36)	21.33 (35.19)	6.40 (17.66)	10.66 (17.58)	37.33 (103.03)	32.00 (52.80)
SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	29.33 (75.67)	19.46 (28.99)	4.80 (12.38)	9.86 (14.69)	34.11 (88.0)	29.33 (43.70)
STS → DW	37.86 (122.66)	26.13 (64.01)	4.53 (14.67)	7.20 (17.64)	42.40 (137.37)	33.33 (81.65)
STS → SUC (0.15M)	40.80 (133.82)	37.06 (132.30)	3.73 (12.23)	5.06 (18.06)	44.53 (146.05)	42.10 (150.29)
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1})	42.93 (143.38)	40.13 (147.67)	3.63 (12.12)	4.26 (15.67)	46.66 (155.84)	47.21 (173.69)
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	45.33 (136.44)	28.53 (89.86)	2.40 (7.22)	12.00 (37.80)	47.73 (143.66)	40.51 (127.57)
LSD at $P_{=0.05}$	1.02	1.62	0.52	0.37	0.86	0.71

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.5.4: Effect of pulse treatment with STS (0.5 mM, 1h) before transfer to DW, SUC (0.15M), SUC(0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on sugar fractions, expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Days after treatment					
	Reducing sugars		Non-reducing sugars		Total soluble sugars	
	4	8	4	8	4	8
DW	256.61	101.34	81.76	57.40	338.38	158.75
SUC (0.15M)	259.61	147.17	85.69	47.32	345.30	194.49
SUC (0.15M) + 8-HQS (50 mg L^{-1})	299.53	135.88	61.97	67.91	361.51	203.79
SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	313.98	121.82	51.38	61.72	365.37	183.55
STS → DW	396.97	220.75	47.49	60.82	444.47	281.58
STS → SUC (0.15M)	428.92	392.59	39.21	53.60	468.13	446.19
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1})	446.6	423.14	37.77	44.91	484.45	468.06
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	440.13	281.72	23.30	118.49	463.44	400.21
LSD at $P_{=0.05}$	1.93	1.50	2.31	1.21	1.65	1.44

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2°C).

Table 2.5.5: Effect of pulse treatment with STS (0.5 mM, 1h) before transfer to DW, SUC (0.15M), SUC(0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Days after treatment					
	Soluble proteins		α-amino acids		Total phenols	
	4	8	4	8	4	8
DW	2.04 (5.77)	1.41 (1.74)	0.53 (1.49)	0.61 (0.75)	5.86 (13.94)	6.80 (8.43)
SUC (0.15M)	2.33 (6.05)	1.66 (2.93)	0.49 (1.27)	0.55 (0.79)	6.46 (16.79)	7.41 (10.65)
SUC (0.15M) + 8-HQS (50 mg L^{-1})	2.41 (6.65)	2.33 (3.84)	0.46 (1.26)	0.49 (0.80)	6.86 (18.93)	8.00 (13.20)
SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	2.58 (6.65)	2.40 (3.57)	0.41 (1.05)	0.44 (0.65)	7.33 (18.91)	8.53 (12.70)
STS → DW	2.70 (8.74)	2.77 (6.78)	0.30 (0.97)	0.27 (0.66)	6.60 (21.38)	12.60 (30.87)
STS → SUC (0.15M)	2.75 (9.02)	2.80 (9.99)	0.28 (0.91)	0.25 (0.89)	6.93 (22.73)	11.80 (42.12)
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1})	2.86 (8.60)	2.93 (9.22)	0.23 (0.76)	0.19 (0.69)	7.13 (23.81)	9.61 (35.32)
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	2.83 (9.45)	2.85 (10.48)	0.26 (0.78)	0.21 (0.66)	7.60 (22.87)	11.06 (34.83)
LSD at $P_{=0.05}$	0.02	0.06	0.05	0.07	0.21	0.28

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 2.5.6: Effect of pulse treatment with STS (0.5 mM, 1h) before transfer to DW, SUC (0.15M), SUC(0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Treatment	Days after treatment					
	Soluble proteins		α-amino acids		Total phenols	
	4	8	4	8	4	8
DW	25.65	8.40	6.666	3.636	61.98	40.53
SUC (0.15M)	22.68	10.53	4.771	3.488	62.90	46.94
SUC (0.15M) + 8-HQS (50 mg L^{-1})	23.33	14.84	4.454	3.121	66.43	50.96
SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	27.61	15.02	4.389	2.754	78.47	53.40
STS → DW	28.31	23.40	3.145	2.281	69.20	106.44
STS → SUC (0.15M)	28.91	29.66	2.943	2.648	72.85	125.00
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1})	27.76	28.93	2.390	2.000	74.18	101.22
STS → SUC (0.15M) + 8-HQS (50 mg L^{-1}) + KIN (25 mg L^{-1})	29.44	30.05	2.520	2.070	73.79	109.21
LSD at $P_{=0.05}$	1.61	1.72	0.55	0.62	1.33	1.91

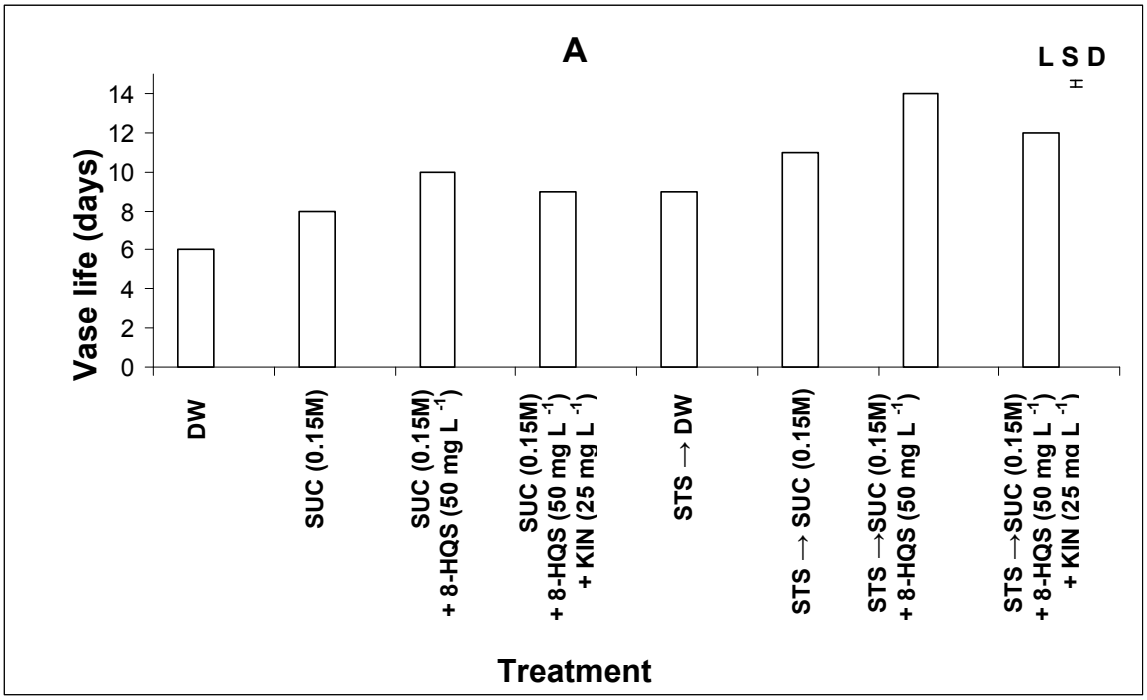
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (15 ± 2°C).

Fig. 2.5.1

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on vase life (A) and volume of holding solutions absorbed per scape ml (B), on day 2, 4 and 6 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at P = 0.05.


A
L S D
Vase life (days)
0
2
4
6
8
10
12
14
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
Treatment

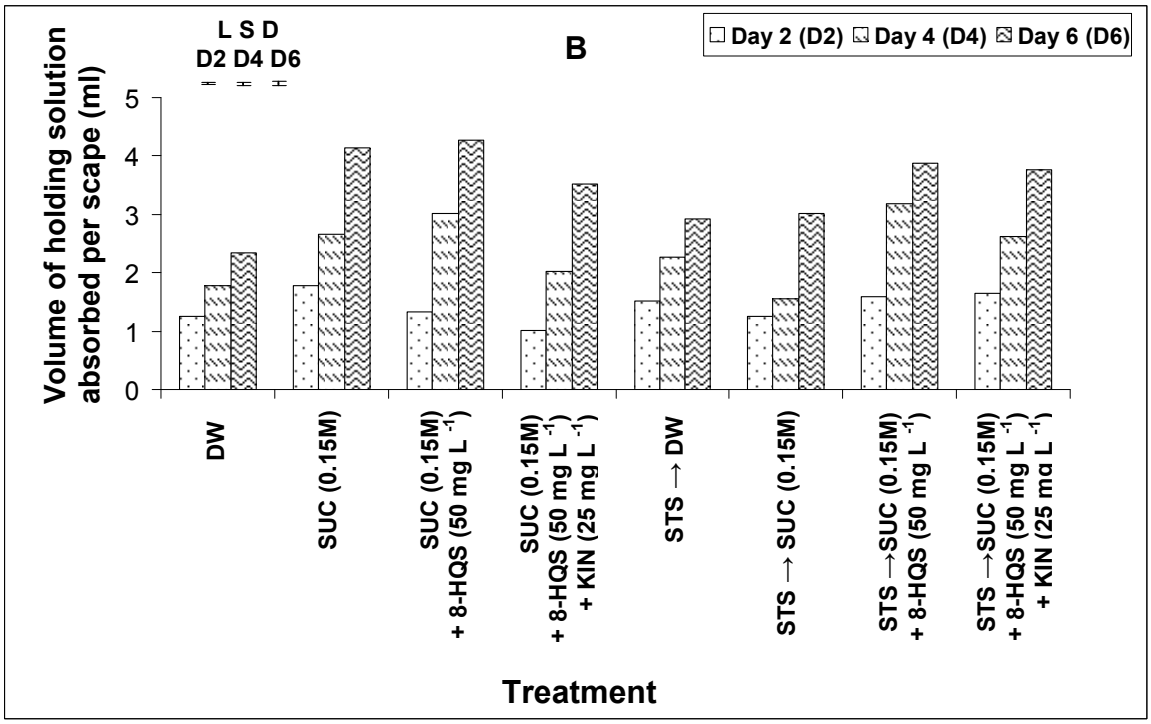
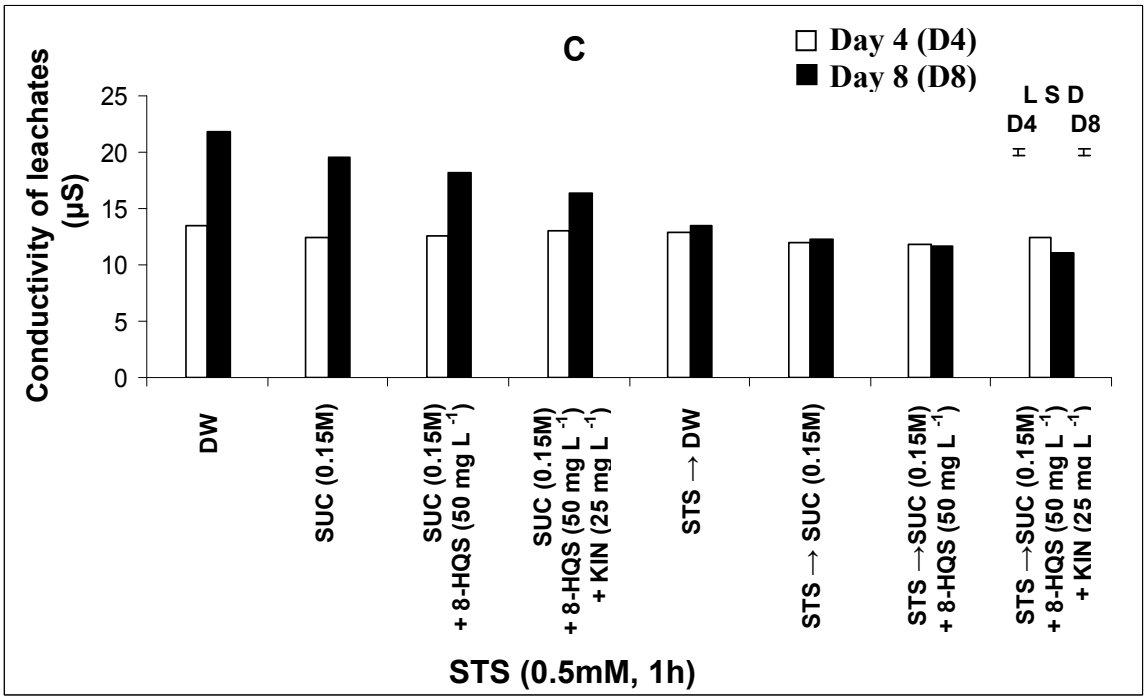

B
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
Treatment

Fig. 2.5.1

Fig. 2.5.2

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on conductivity of leachates (C) in tepal tissues and fresh mass of flowers (D) on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


C
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Conductivity of leachates (µS)
25
20
15
10
5
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

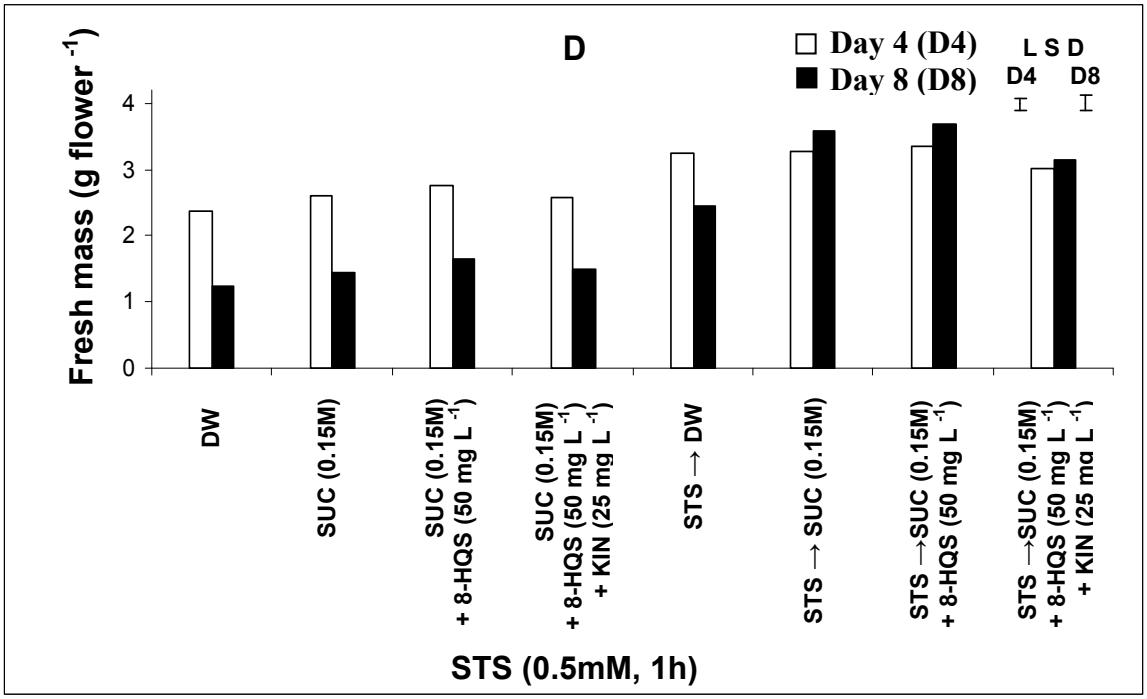
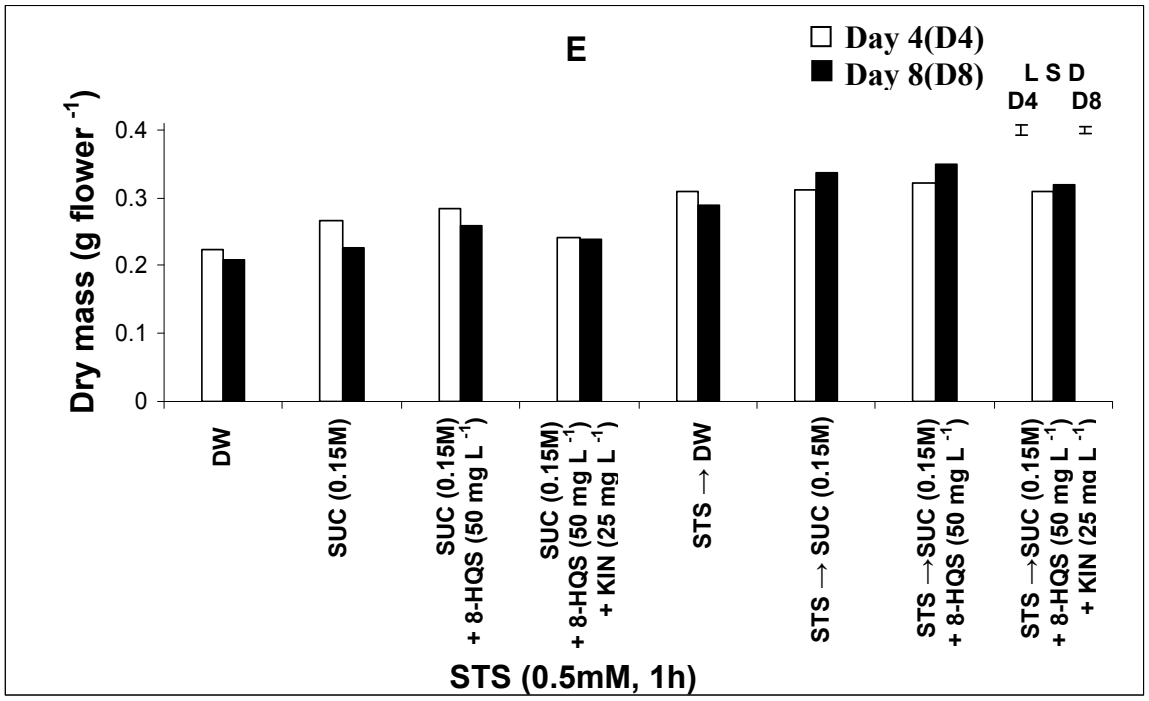

D
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Fresh mass (g flower -1)
4
3
2
1
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

Fig. 2.5.2

Fig. 2.5.3

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on dry mass of flowers (E) and reducing sugars (F) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Day 4(D4)
Day 8(D8)
L S D
D4 D8
Dry mass (g flower -1)
0.4
0.3
0.2
0.1
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

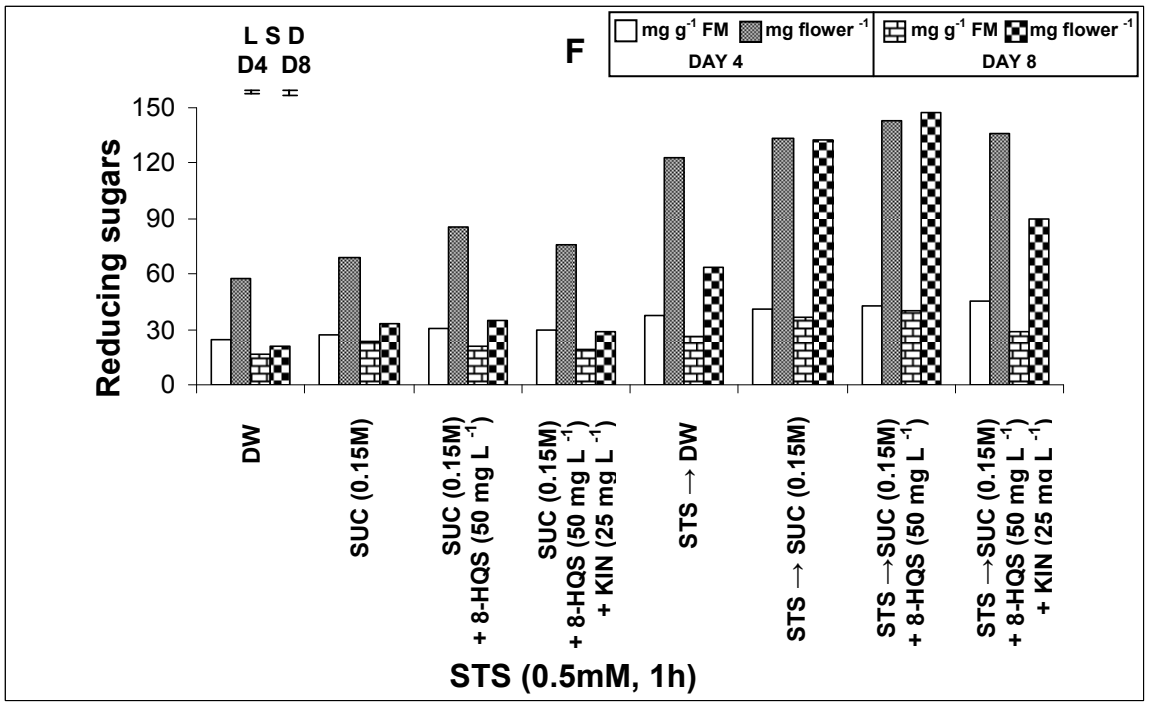
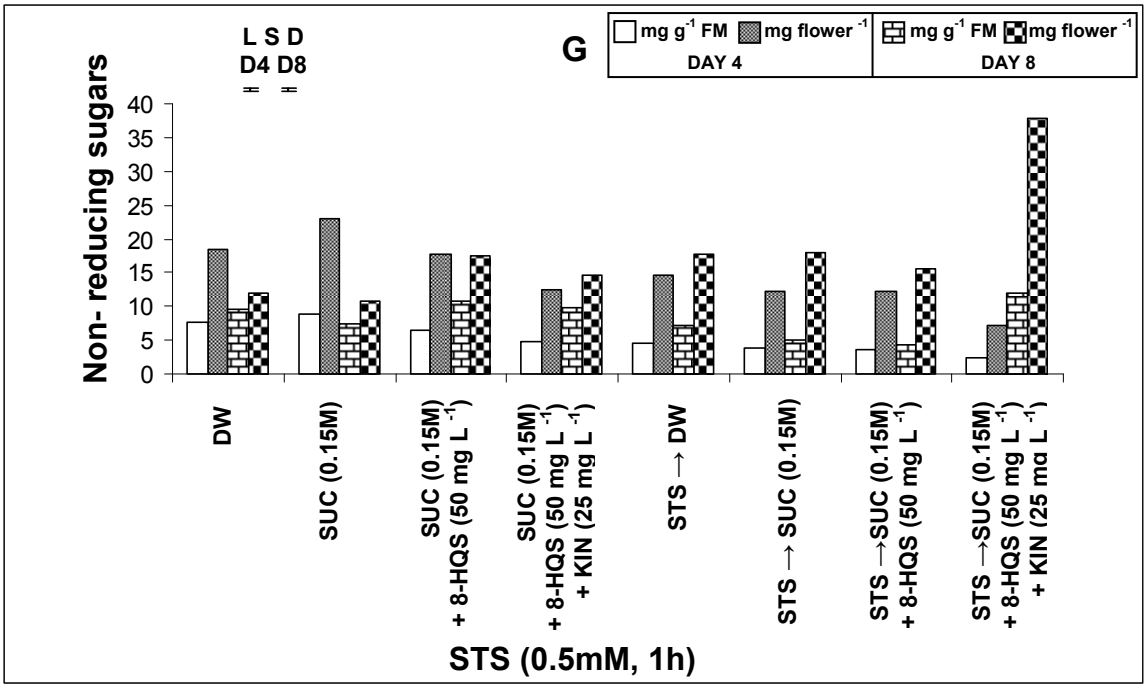

F
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Reducing sugars
150
120
90
60
30
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

Fig. 2.5.3

Fig. 2.5.4

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on non-reducing sugars (G) and total sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


G
L S D
D4 D8
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Non- reducing sugars
40
35
30
25
20
15
10
5
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

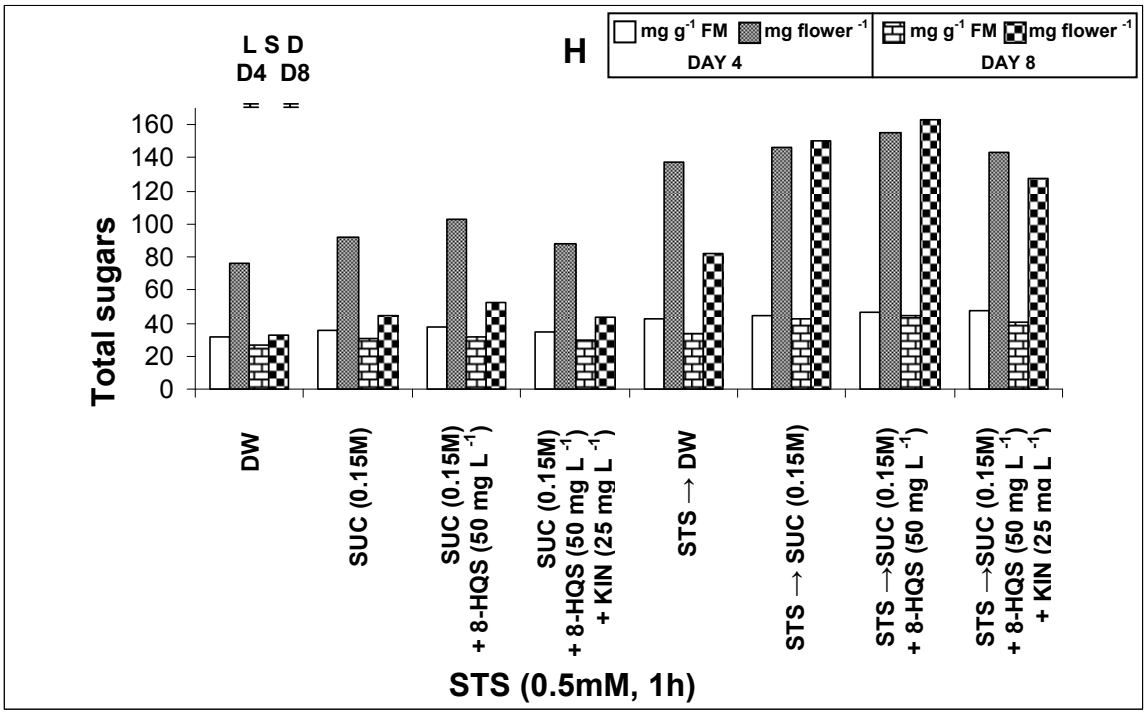
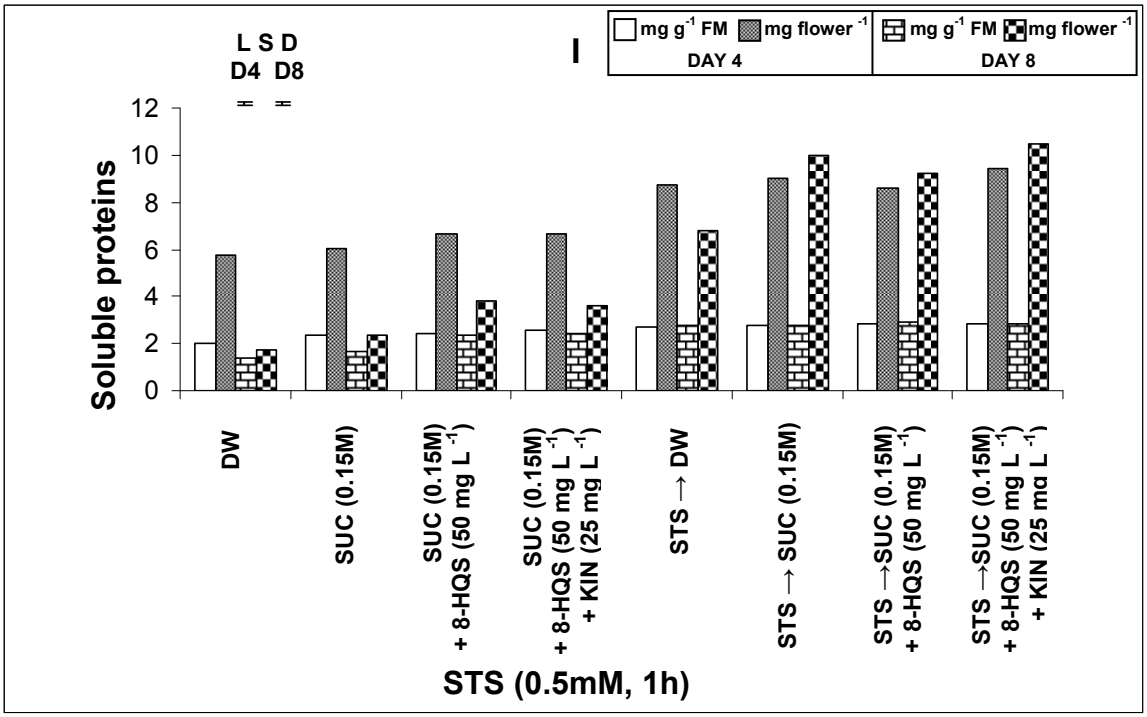

H
L S D
D4 D8
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total sugars
160
140
120
100
80
60
40
20
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

Fig. 2.5.4

Fig. 2.5.5

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on soluble proteins (I) and α-amino acids (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at $P_{= 0.05.}$


I
L S D
D4 D8
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Soluble proteins
12
10
8
6
4
2
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L-1)
SUC (0.15M) + 8-HQS (50 mg L-1) + KIN (25 mg L-1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L-1)
STS →SUC (0.15M) + 8-HQS (50 mg L-1) + KIN (25 mg L-1)
STS (0.5mM, 1h)

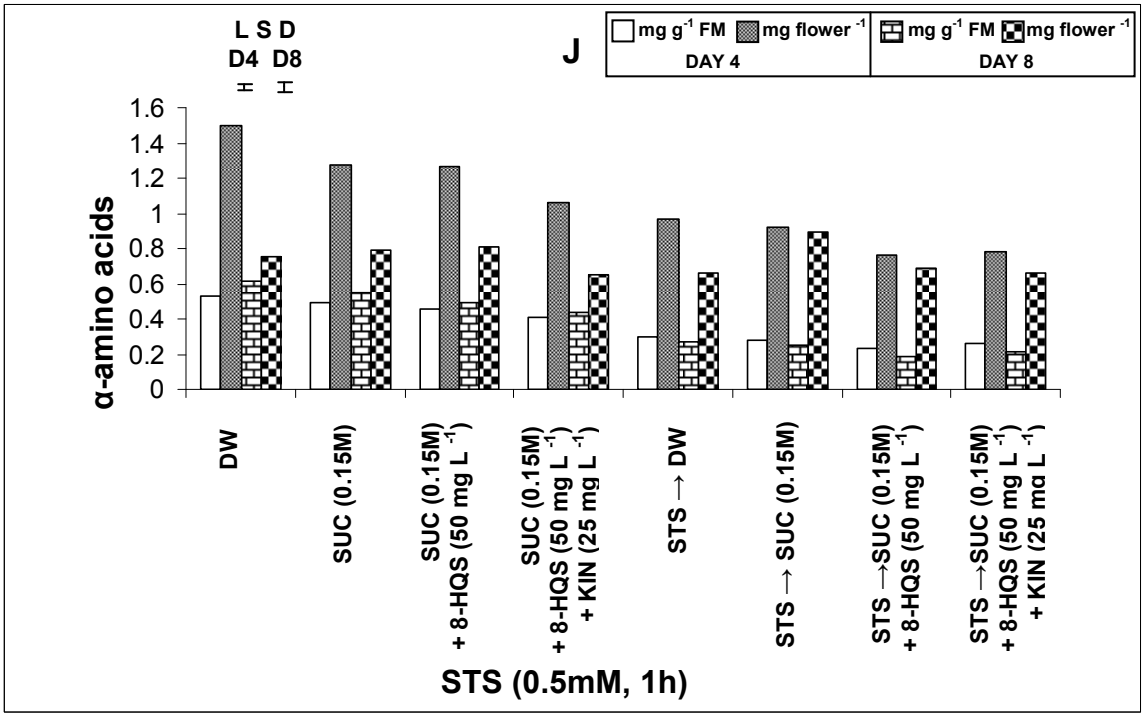

J
L S D
D4 D8
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
α-amino acids
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L-1)
SUC (0.15M) + 8-HQS (50 mg L-1) + KIN (25 mg L-1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L-1)
STS →SUC (0.15M) + 8-HQS (50 mg L-1) + KIN (25 mg L-1)
STS (0.5mM, 1h)

Fig. 2.5.5

Fig. 2.5.6

Histograms showing effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) total phenols (K) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

Vertical bars represent LSD at P = 0.05.

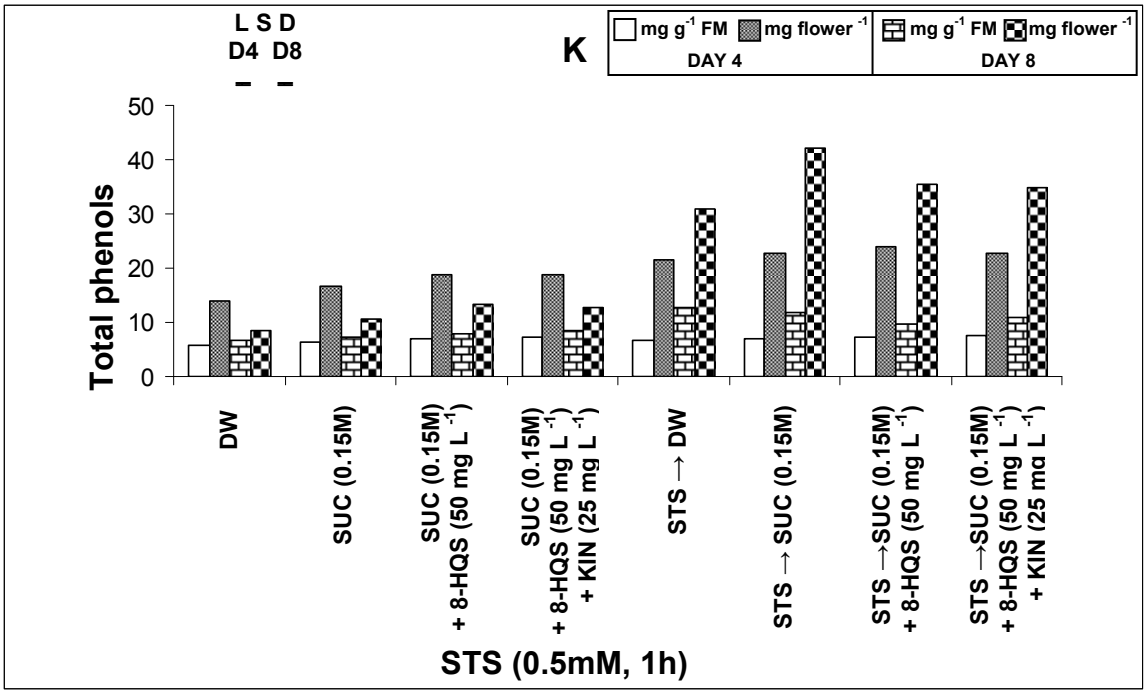

L S D
D4 D8
K
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Total phenols
50
40
30
20
10
0
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS (0.5mM, 1h)

Fig. 2.5.6

Plate. 2.5.1

Effect of pulse treatment with STS (0.5 mM, 1 h) before transfer to DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}) on vase life and senescence on day 4 and 8 of transfer of scapes to holding solutions in *Narcissus pseudonarcissus* cv. Emperor.

From left to right are arranged scapes held in DW, SUC (0.15M), SUC (0.15M) + 8-HQS (50 mg L^{-1}), SUC (0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1}), STS (0.5 mM, 1 h) → DW, STS (0.5 mM, 1 h) → SUC (0.15M), STS (0.5 mM, 1 h) → SUC (0.15M) + 8-HQS (50 mg L^{-1}), STS (0.5 mM, 1 h) → SUC(0.15M) + 8-HQS (50 mg L^{-1}) + Kin (25 mg L^{-1})

Fig. 1-2 represent photographs taken on day 4 and 8 after transfer of scapes to holding solutions.

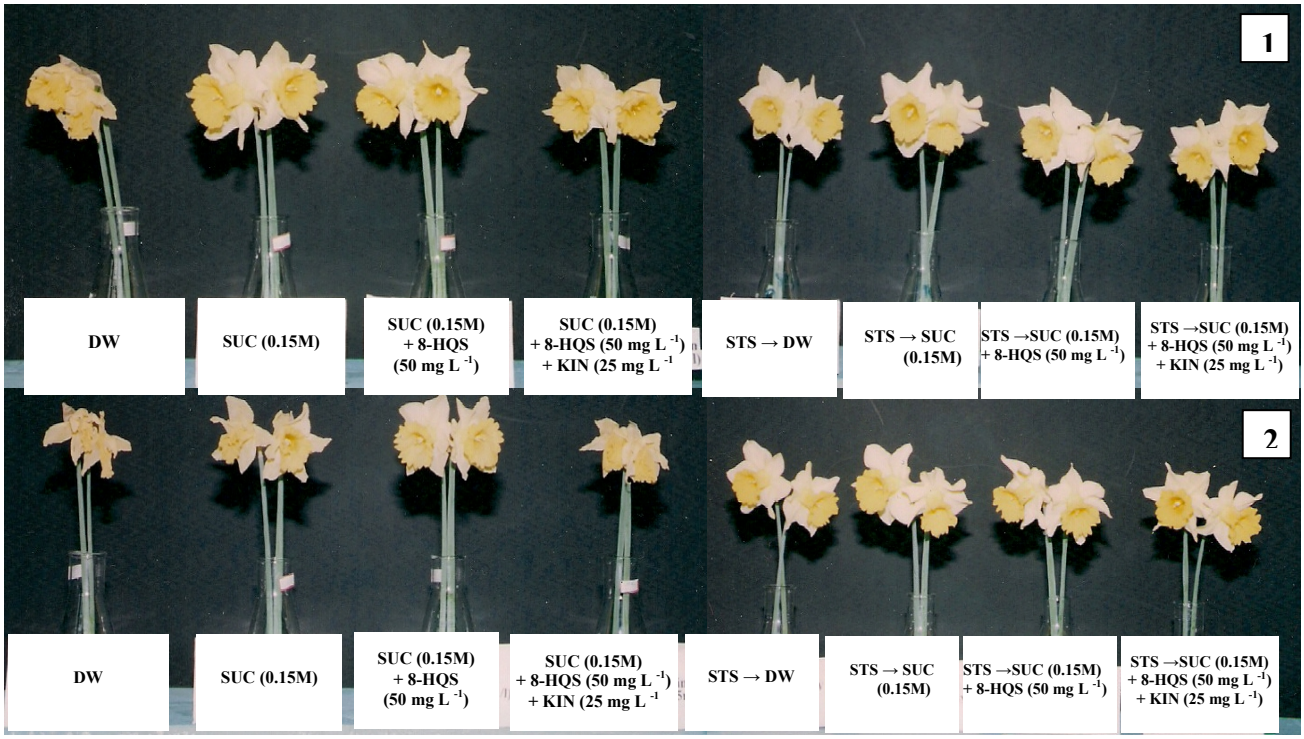

1
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
2
DW
SUC (0.15M)
SUC (0.15M) + 8-HQS (50 mg L -1)
SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)
STS → DW
STS → SUC (0.15M)
STS →SUC (0.15M) + 8-HQS (50 mg L -1)
STS →SUC (0.15M) + 8-HQS (50 mg L -1) + KIN (25 mg L -1)

Plate. 2.5.1

CHAPTER 3

Flower Senescence in *Narcissus poeticus* cv. Pheasant's Eye.

Narcissus poeticus is also known as Poet's Daffodil, Pheasant's Eye, Findern Flower and Pinkster Lily. It was one of the first daffodils to be cultivated and is frequently referred to as the *Narcissus* of the ancient times. The earliest mention of Poet's Daffodil is in the botanical writings of Theophrastus who wrote about a spring-blooming *Narcissus* that was later on identified as *Narcissus poeticus*. Poeticus is fragrant, with a ring of pure white tepals and a short corona of light yellow with a distinct reddish edge. It is the last to flower of all the charming species from the genus *Narcissus* and its snowy blooms announce the arrival of approaching summer. Poet's Daffodil is native to north Meditteranean and has been found extensively from Spain to Greece. It has also been widely naturalized in North America and Europe. In Kashmir, Poet's Daffodil is found growing wild on hills and is being cultivated in homes also.

Druing the present study an attempt was made to understand the mechanism involved in flower development and senescence in *Narcissus poeticus* cv. Pheasant's Eye. Investigations on storage and enhancement of vase life were envisaged keeping in with the general plan of thesis but due to the paucity of plant material this objective could not be accomplished.

EXPERIMENT 3.1

Physiological and biochemical changes associated with the flower development and senescence in *Narcissus poeticus* cv. Pheasant's Eye.

Experimental

Flowers of *N. poeticus* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were designated as tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI) (Plate. 3.1.1). Visible changes were recorded throughout flower development and senescence at periodical intervals. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the conductivity of leachates (μS) in tepal discs (5mm in diameter) punched from outer regions of perianth of five different flowers and incubated in 15ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents 1g chopped material of tepal tissues, was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times at 1000 rpm. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α- amino acids and total phenols as described in materials and methods. Non-reducing sugars were calculated as the difference between total and reducing sugars. Soluble proteins were extracted from 1 g of the tepal tissue drawn separately from five different flowers at each of the six stages and suitable aliquots were used for the estimation as described in material and methods. Electrophoretic profiles were studied at various stages of flower development and senescence, 80 μL of the SDS- denatured protein extract was loaded into each lane. Each value

represented in the tables corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: The greenish buds of *N.poeticus* open into bright white flowers with a small yellow cup shaped corona at the centre surrounded by tepals and the flower senescence is marked by the turgor loss in the perianth followed by complete wilting. The average life span of an individual flower after it opens fully is about 4 days (Plate. 3.1.1).

Floral diameter: Flower diameter increased as the flower development progressed up to stage V and declined thereafter as the floral development progressed to senescence up to stage VI (Table 3.1.1, Text Fig.3.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage IV and registered a decline thereafter as the senescence progressed through stages V and VI . The water content at various stages of floral development and senescence was more or less same when the data was expressed on percent fresh mass basis (Table 3.1.1, Text Fig.3.1.1, B,C and D).

Membrane permeability: Membrane permeability estimated as electrical conductivity of leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages, however almost steady increase in the ion leachates was registered up to stage IV after which the leachates increased considerably during senescence phase (stages V and VI) (Table 3.1.1, Text Fig.3.1.1, E).

Reducing sugars: The tissue content of reducing sugars increased during flower development from stage I to stage V and declined thereafter during senescence stage VI (Table 3.1.2, Text Fig.3.1.2,F). When expressed on per flower basis the reducing sugar content generally increased progressively

from stage I to stage V after which a marked decline was noticed in the reducing sugar content as the senescence progressed through final stags from V to VI (Table 3.1.2). On dry mass basis three phases however were noticed in the reducing sugar content i.e. a decrease up to stage III followed by an increase up to stage V and then a sharp decline from stage V to VI (Table 3.1.3.).

Non-reducing sugars: The tissue content of non-reducing sugars was by and large maintained up to stage III followed by a decrease up to stage V after which a sharp increase was noticed in the non-reducing sugar content (Table 3.1.2, Text Fig.3.1.2, G). When the data was expressed on per flower basis the non-reducing sugar content increased up to stage IV followed by a sharp decline up to stage VI (Table 3.1.2). On dry mass basis the non-reducing sugar content showed a slight increase up to stage II followed by a consistent decrease up to stage V, thereafter a sharp increase was observed from stage V to VI (Table 3.1.3.).

Total sugars: The total soluble sugars decreased slightly during stage I to II and thereafter increased steadily up to stage V, a sharp decline was noticed thereafter during senescence at stage VI (Table 3.1.2, Text Fig.3.1.2,H). On per flower basis the total soluble sugar content generally increased progressively from stage I to stage V and declined markedly thereafter during senescence (Table 3.1.2). On dry mass basis the total sugar content decreased during stage I to II and was maintained thereafter up to stage V followed by a sharp decline during final stages of senescence at stage VI (Table 3.1.3.).

Soluble proteins: The concentration of soluble proteins decreased as the flower development and senescence progressed from stage I to stage VI (Table 3.1.2, Text Fig.3.1.3, I). On per flower basis the soluble protein content was generally maintained up to stage IV followed by a slight

decrease at stage V, after which a sharp decline was noticed in the soluble protein content (Table 3.1.2). On dry mass basis the soluble protein content showed a consistent decrease throughout flower development and senescence (Table 3.1.3).

α- amino acids: The α-amino acid content registered an initial decrease during flower development from stage I to stage III after which a consistent increase was registered in the amino acid content as the flower development and senescence progressed from stage III to VI (Table 3.1.2, Text Fig.3.1.3, J). The amino acid content was by and large maintained during flower development and senescence when the data was expressed on per flower basis (Table 3.1.2). On dry mass basis amino acid content showed a decrease up to stage III, followed by an increase up to stage VI (Table 3.1.3).

Phenols: The concentration of total phenols decreased as the flower development progressed from stage I to stage III and increased thereafter up to stage V followed by a sharp decline at stage VI (Table 3.1.2, Text Fig.3.1.3, K).When expressed on per flower basis the concentration of phenols generally increased progressively up to stage V and declined markedly thereafter (Table 3.1.2). On dry mass basis the concentration of total phenols showed a declining trend during flower development and senescence, however the decrease was sharp as the flower senescence progressed from stage V to stage VI (Table 3.1.3).

Electrophoretic profile: The SDS-PAGE of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent from stage V and they almost disappeared at the last stage (stage VI) particularly polypeptides of molecular Weights of 83.1, 60.2 and 31.6 kDa (Plate. 3.1.2).

Table 3.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Narcissus poeticus* cv. Pheasant's Eye (Each value is a mean of 10 independent replicates, figures in parentheses represents values on percent basis).

Stages of flower development	Floral diameter (cm)	Fresh mass flower^{-1} (g)	Dry mass flower^{-1} (g)	Water content flower^{-1} (g)	Conductivity of leachates (µs)
I (tight bud stage)	0.66 ± 0.05	0.749 ± 0.01	0.062 ± 0.002	0.686 ± 0.01 (91.67)	8.40 ± 0.62
II (loose bud stage)	1.03 ± 0.15	0.868 ± 0.001	0.078 ± 0.0005	0.790 ± 0.002 (90.98)	10.90 ± 0.36
III (half open stage)	3.83 ± 0.15	0.910 ± 0.01	0.098 ± 0.001	0.812 ± 0.009 (89.23)	14.33 ± 0.81
IV (fully open stage)	5.83 ± 0.15	1.049 ± 0.05	0.112 ± 0.003	0.937 ± 0.053 (89.28)	21.83 ± 1.04
V (partially senescent stage)	6.16 ± 0.23	0.947 ± 0.007	0.104 ± 0.001	0.842 ± 0.009 (89.95)	30.83 ± 1.66
VI (senescent stage)	4.90 ± 0.10	0.563 ± 0.014	0.051 ± 0.001	0.512 ± 0.015 (90.88)	35.26 ± 1.25

Table 3.1.2: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} fresh mass) during development and senescence in flowers of *Narcissus poeticus* cv. Pheasant's Eye (Each value is a mean of 5 independent replicates, figures in parentheses represents values on mg flower $^{-1}$ basis).

Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α-amino acids	Total phenols
I	24.16 ± 0.28 (18.10)	3.83 ± 0.28 (2.87)	28.0 ± 0.5 (20.97)	7.79 ± 0.07 (5.83)	0.26 ± 0.004 (0.198)	6.0 ± 0.12 (4.49)
II	22.50 ± 0.50 (19.53)	4.33 ± 0.28 (3.76)	26.83 ± 0.28 (23.29)	7.25 ± 0.12 (6.29)	0.24 ± 0.004 (0.213)	5.29 ± 0.19 (4.59)
III	24.33 ± 0.76 (22.14)	3.83 ± 0.50 (3.48)	28.16 ± 0.28 (25.63)	6.41 ± 0.19 (5.83)	0.18 ± 0.01 (0.169)	4.50 ± 0.125 (4.09)
IV	27.0 ± 1.32 (28.32)	2.83 ± 1.15 (3.48)	29.83 ± 0.28 (31.29)	5.37 ± 0.21 (5.63)	0.23 ± 0.01 (0.261)	4.91 ± 0.19 (5.15)
V	28.83 ± 0.76 (27.30)	1.83 ± 0.57 (1.73)	30.60 ± 0.28 (29.04)	4.58 ± 0.14 (4.22)	0.27 ± 0.008 (0.261)	5.62 ± 0.12 (5.32)
VI	13.33 ± 0.76 (7.50)	3.16 ± 0.76 (1.78)	16.50 ± 1.50 (9.28)	2.91 ± 0.26 (1.64)	0.32 ± 0.008 (0.182)	2.70 ± 0.26 (1.52)

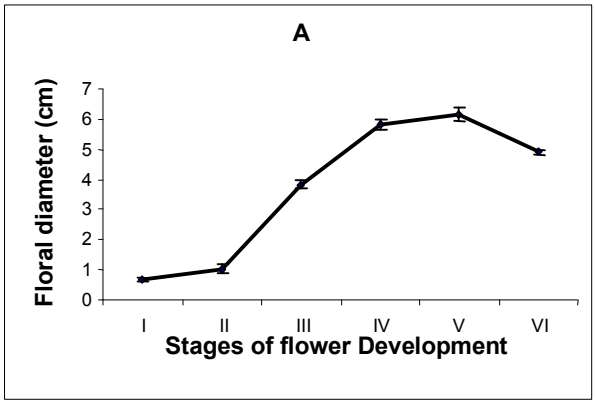
Table 3.1.3: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} dry mass) during development and senescence in flowers of *Narcissus poeticus* cv. Pheasant's Eye (Each value is a mean of 5 independent replicates).

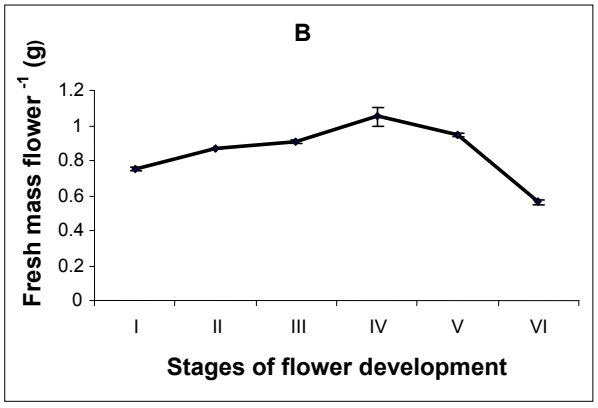
Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	291.94 ± 3.48	46.30 ± 3.48	323.64 ± 6.04	94.12 ± 0.87	3.20 ± 0.05	72.48 ± 1.15
II	250.38 ± 5.56	48.22 ± 3.21	298.60 ± 3.21	80.67 ± 1.39	2.74 ± 0.05	58.88 ± 2.12
III	225.95 ± 7.09	35.59 ± 5.36	261.54 ± 2.68	59.58 ± 1.77	1.73 ± 0.15	41.78 ± 1.16
IV	252.88 ± 12.39	26.53 ± 10.81	279.42 ± 2.70	50.34 ± 2.02	2.15 ± 0.11	46.04 ± 1.78
V	262.54 ± 6.95	16.69 ± 5.25	279.24 ± 2.62	40.59 ± 1.31	2.51 ± 0.07	51.21 ± 1.13
VI	147.18 ± 8.43	34.95 ± 8.43	182.14 ± 16.55	32.19 ± 2.87	3.58 ± 0.08	29.89 ± 2.87

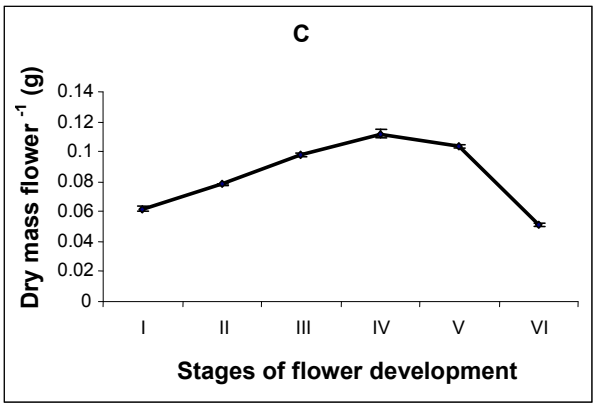
Fig.3.1.1

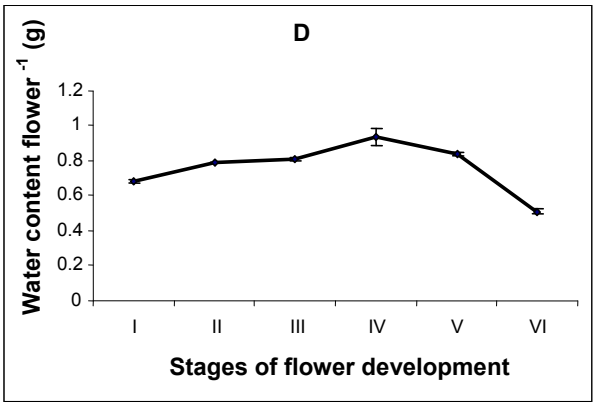
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in tepal tissues in flowers of *Narcissus poeticus* cv. Pheasant's Eye at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
0
1
2
3
4
5
6
7
I
II
III
IV
V
VI
Stages of flower Development


B
Fresh mass flower -1 (g)
0
0.2
0.4
0.6
0.8
1
1.2
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower -1 (g)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
0
0.2
0.4
0.6
0.8
1
1.2
I
II
III
IV
V
VI
Stages of flower development

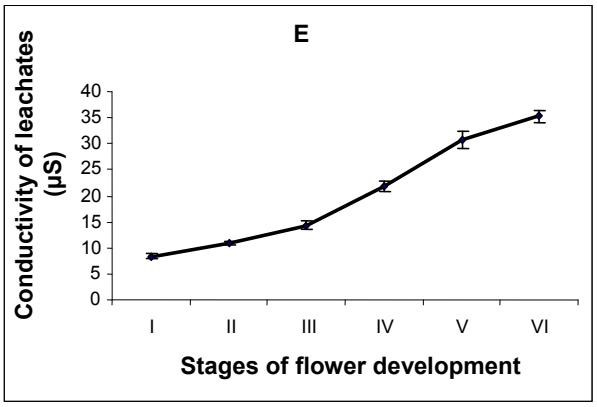

E
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
40
I
II
III
IV
V
VI
Stages of flower development

Fig. 3.1.1

Fig. 3.1.2

Changes in reducing sugars (F), non – reducing sugars (G) and total sugars (H), in tepal tissues in flowers of *Narcissus poeticus* cv. Pheasant's Eye at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

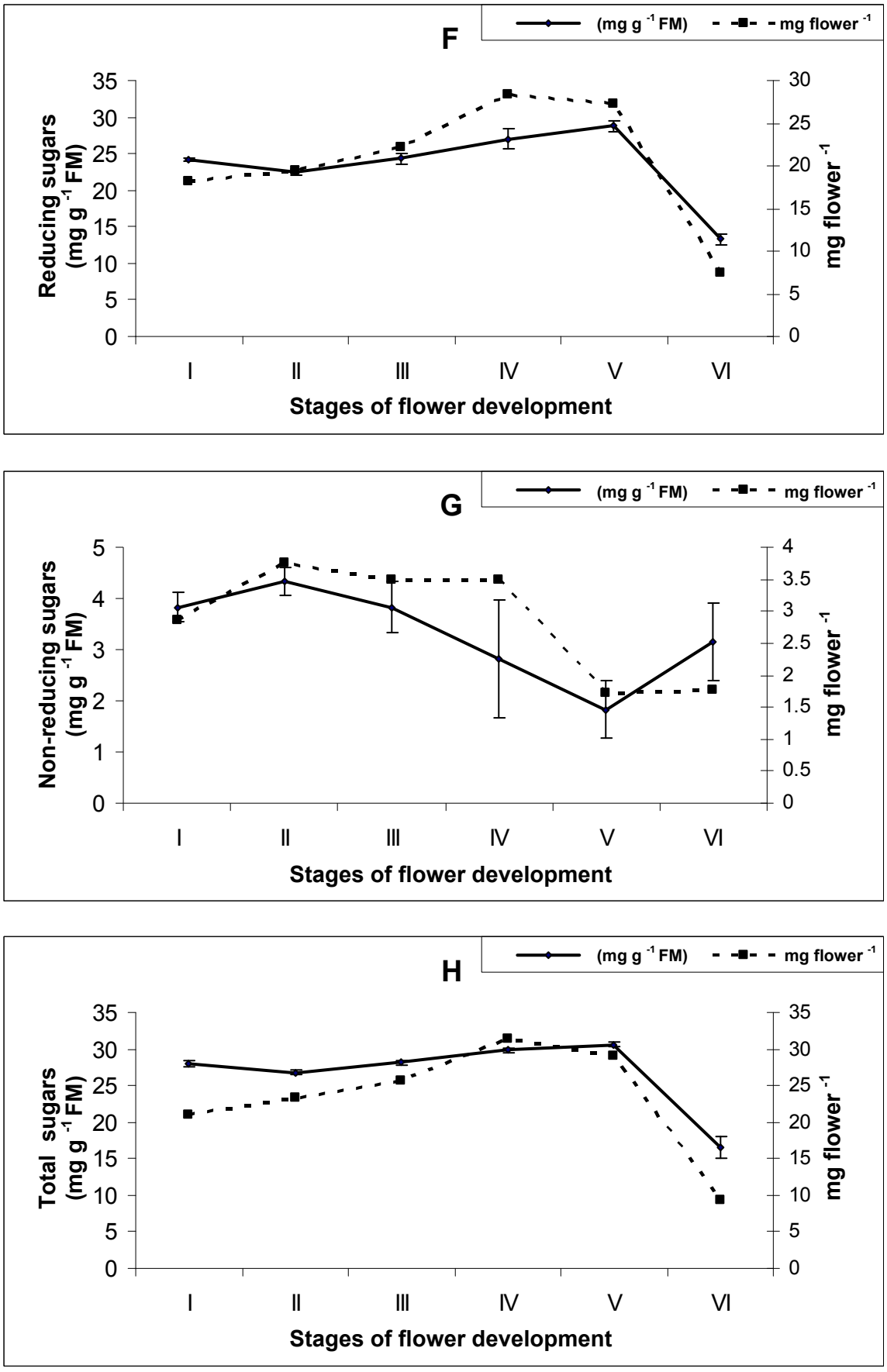
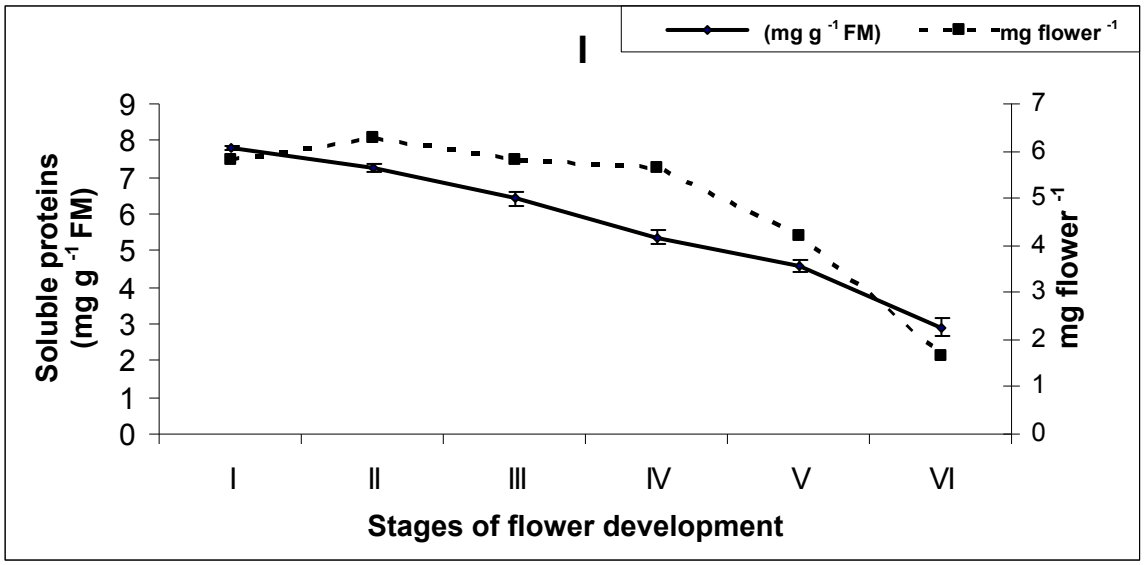

F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
Stages of flower development
H
(mg g -1 FM)
mg flower -1
Total sugars (mg g -1 FM)
mg flower -1
Stages of flower development
I
II
III
IV
V
VI

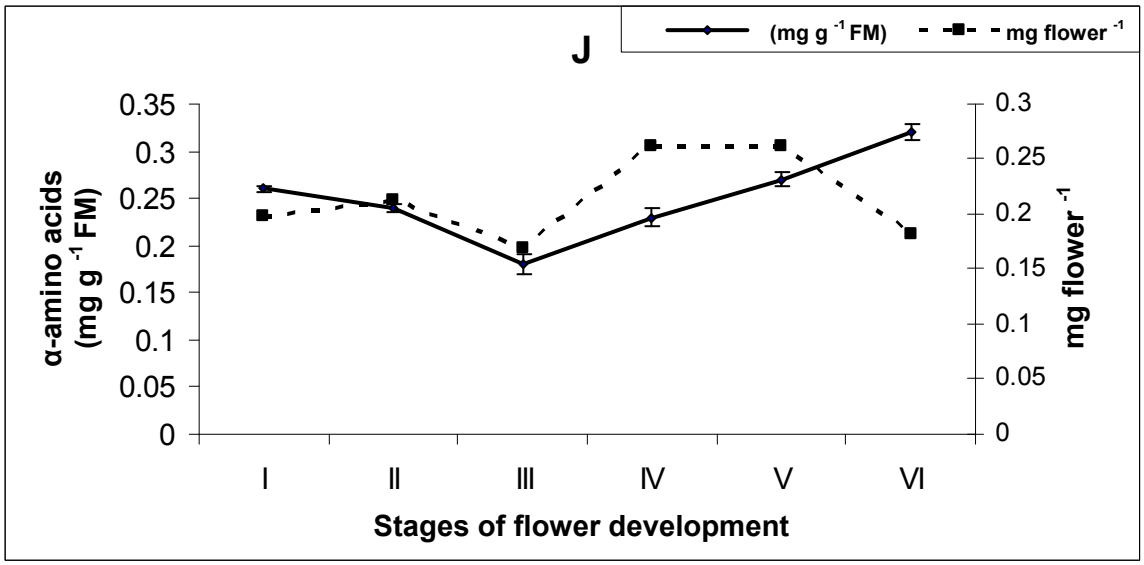
Fig. 3.1.2

Fig. 3.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in tepal tissues in flowers of *Narcissus poeticus* cv. Pheasant's Eye at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
6
7
8
9
I
II
III
IV
V
VI
Stages of flower development


J
(mg g -1 FM)
mg flower -1
α-amino acids (mg g -1 FM)
mg flower -1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
I
II
III
IV
V
VI
Stages of flower development

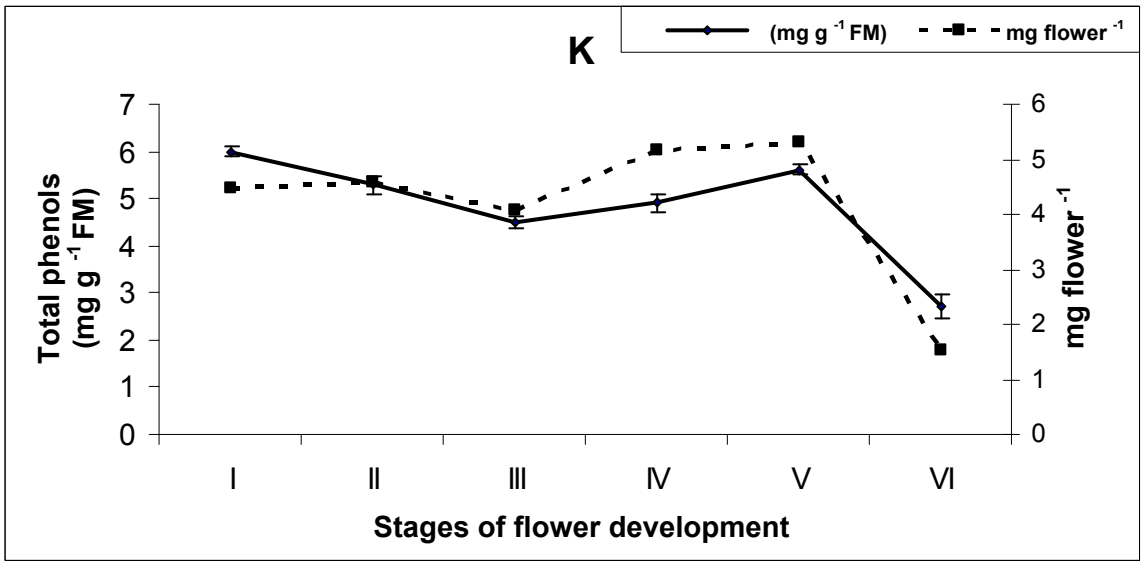

K
(mg g -1 FM)
mg flower -1
Total phenols (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
6
7
I
II
III
IV
V
VI
Stages of flower development

Fig. 3.1.3

Plate 3.1.1

Fig.1: Stages of flower development and senescence in *Narcissus poeticus* cv. Pheasant's Eye.

From left to right are arranged flowers at successive stages of development and senescence. Stages I to VI in the figure represent flowers at tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI).

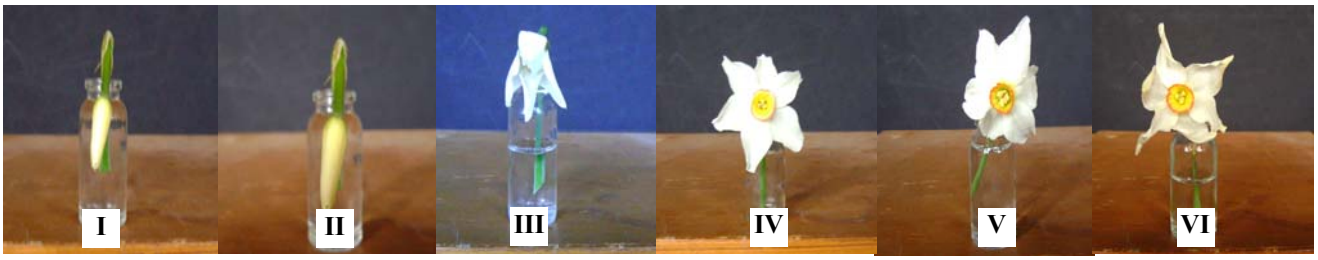


Plate. 3.1.1

Plate 3.1.2

Fig.: 12% SDS – PAGE, equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Narcissus poeticus* cv. Pheasant's Eye. The gel was stained with coomassie blue. Number above the lanes corresponds to developmental stages. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

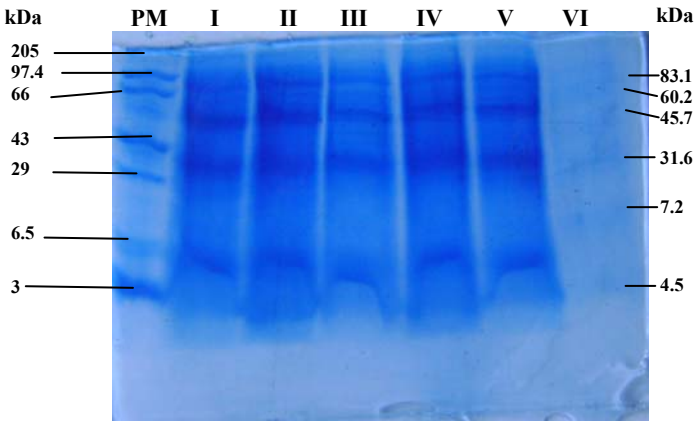

kDa
PM
I
II
III
IV
V
VI
kDa
205
97.4
66
43
29
6.5
3
83.1
60.2
45.7
31.6
7.2
4.5

Plate. 3.1.2

CHAPTER 4

Flower Senescence in *Hippeastrum aulicum* cv. Platifolium.

Hippeastrum is a genus of about 80 bulbous species in the family Amaryllidaceae (Perry, 2000), native to tropical and subtropical regions of America ranging from Argentina to Mexico and the Caribbean. The word *"Hippeastrum"* is actually a Greek word for "horseman's star" (also known today as "knight's star"). It was chosen in 1837 by the Honorable Reverend IWilliam Herbert, Dean of Manchester due to the plant's striking resemblance to the "morning star" type of a medieval weapon used by horsemen.

A certain amount of confusion exists about *'Hippeastrum',* the plant's scientific name, and '*Amaryllis'*, its common name which is also the name of the type genus of family Amaryllidaceae however the two are adequately different. *Hippeastrum* which originated in South America, has 4 to 6 large flowers on a hollow stem of 40-60 cm while as *Amaryllis* is native plant from South Africa, but this plant has 6 to 8 smaller flowers on a solid flower stem of 60-65 cm. The genus, *Hippeastrum* comprises of several species, while *Amaryllis belladonna* is the only species in the genus *Amaryllis*. For reasons difficult to fathom but certainly confusing, the *Hippeastrum* is known almost the world-over as *'Amaryllis*'. *Hippeastrum* needs a frost free winter and can be planted in early spring just below the soil surface with warm sunlight available through out the day.

The first commercial breeders of *Hippeastrum* were Dutch growers who imported several species from Mexico and South America and began developing cultivars or hybrids from them in the 18th century. In 1946 some Dutch growers moved to the Union of South Africa and began cultivation there. Although most of the *Hippeastrum* bulbs come from the Dutch and South African sources; they are now being developed in the United States,

Japan, Israel, India, Brazil and Australia. The double flowers from Japan are particularly beautiful ornamentals. Some species are grown for their large showy flowers. *Hippeastrum* is able to maintain bloom for a longer time as the second flower always develops later than the first one. The flowers of ordinary varieties measure 25 cm in diameter, while the miniature varieties display flowers measuring 12.5 cm across. The flowers are very similar to those of lilies and both of these genera are distantly related to one another. The bigger the bulb, the more chance that it possesses to produce several flowers on a stem.

Hippeastrums undoubtly have wonderful flowers with a sustained glorious cluster of blooms. They offer an obvious choice for being pronounced as potential cut flowers, besides they also make excellent winter house plants and potted plants.

During the present work an attempt was made to understand themechanism involved in flower development andsenescence in *Hippeastrum aulicum* cv. Platifolium. Investigations on storage and enhancement of vase life were envisaged in keeping with the general plan of thesis but due to the paucity of material this objective could not be accomplished.

Experiment 4.1

Physiological and biochemical changes associated with the flower development and senescence in *Hippeastrum aulicum* cv. Platifolium.

Experimental

Flowers of *H . aulicum* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were designated as tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI). Visible changes were recorded throughout flower development and senescence at periodic intervals. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the electrical conductivity of leachates (μS) in tepal discs (5mm in diameter) punched from the outer regions of tepals of five different flowers and incubated in 15ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents 1g chopped material of tepal tissue was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times at 1000 rpm. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α-amino acids and total phenols as described in materials and methods. Non-reducing sugars were calculated as the difference between total and reducing sugars. Soluble proteins were extracted from 1g tepal tissue drawn separately from five different flowers at each of the six stages and suitable aliquots were used for the estimation as described in material and methods. Electrophoretic profiles were studied at various stages of flower development and senescence, 80 μL of the SDS-denatured protein extract was loaded into each lane. Each value represented

in the tables corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: The reddish buds open into bright red flowers and the flower senescence in *H . aulicum* is marked by the turgor loss in the perianth followed by complete wilting. The average life span of an individual flower after it opens fully is about 4 days (Plate 4.1.1).

Floral diameter: Flower diameter increased as the flower development progressed up to stage V and declined thereafter as the floral development progressed towards final phase of senescence up to stage VI (Table 4.1.1; Text Fig.4.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage IV and registered a decline thereafter as the senescence progressed through stages V and VI . The water content at various stages of flower development and senescence was more or less same when the data was expressed on percent fresh mass basis (Table 4.1.1; Text Fig.4.1.1, B,C and D).

Membrane permeability: Membrane permeability estimated as electrical conductivity of leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages. However, almost steady increase in the ion leachates was registered up to stage III after which the leachates increased considerably during flower opening and senescence (stages IV and VI) (Table 4.1.1; Text Fig. 4.1.1, E).

Reducing sugars: The tissue content of reducing sugars increased during flower development from stage I to stage IV and declined thereafter during senescence (Table 4.1.2; Text Fig. 4.1.2, F). When expressed on per flower basis the reducing sugar content increased progressively from stage I to stage IV after which a sharp decline was noticed in the reducing sugar content as

the senescence progressed from stage IV to stage VI (Table 4.1.2). On dry mass basis the reducing sugar content increased up to stage IV, followed by decrease during senescence stage (V –VI) (Table 4.1.3).

Non-reducing sugars: The tissue content of non-reducing sugars decreased steadily up to stage IV, followed by slight increase at stage V to VI (Table 4.1.2; Text Fig.4.1.2, G). However, when the data was expressed on per flower basis the non-reducing sugars decreased up to stage III followed by an increase up to stage V and a decline thereafter at stage VI (Table 4.1.2). On dry mass basis the non-reducing sugar content decreased consistently up to stage IV and was generally maintained thereafter through up to stage VI (Table 4.1.3).

Total sugars: The total soluble sugars decreased slightly during stage I to II and increased thereafter up to stage III, a steady decline was noticed thereafter during senescence up to stage VI (Table 4.1.2; Text Fig.4.1.2, H). On per flower basis the total soluble sugar content increased progressively from stage I to stage IV and declined thereafter during senescence (Table 4.1.2). On dry mass basis the total sugar content increased up to stage IV and declined thereafter up to stage VI (Table. 4.1.3).

Soluble proteins: The concentration of soluble proteins decreased as the flower development and senescence progressed from stage I to stage VI (Table 4.1.2; Text Fig.4.1.3, I). On per flower basis the soluble protein content increased steadily up to stage IV and declined thereafter during senescent stages (Table 4.1.2). On dry mass basis the soluble protein content showed an increase during flower development form stage I to II and a steady decline thereafter up to stage VI; however, a sharp decline was registered in the protein content as the senescence progressed from stage V- VI (Table 4.1.3).

α- amino acids: The amino acid content increased steadily during flower development and senescence (Table 4.1.2; Text Fig.4.1.3, J). Similar trends were obtained in the amino acid content through various stages of flower development and senescence when the data was expressed on per flower basis but the increase was pronounced (Table 4.1.2). On dry mass basis amino acid content showed a consistent increase up to stage VI (Table 4.1.3).

Phenols: Total phenolic content showed a declining trend initially up to stage III, followed by an increase up to stage V and a decline thereafter (Table 4.1.2; Text Fig.4.1.3, K).When expressed on per flower basis the concentration of phenols generally increased progressively up to stage V and declined thereafter during the final phases of senescence (Table 4.1.2). On dry mass basis three phases were noticed in the total phenolic content i.e. an increase up to stage II, followed by decrease at stage III and then a sharp increase from stage IV to VI (Table. 4.1.3)

Electrophoretic profile: The SDS-PAGE of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent from stage V and they almost disappeared at the last stage (stage VI). The polypeptides which showed up on gels consistently up to stage V particularly included those having the molecular mass of 63, 19.9 and 6.6 kDa. Some new polypeptides emerged as bands at stage V these include polypeptides having molecular mass of 10.2 and 7.9 kDa respectively (Plate. 4.1.2).

Table 4.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Hippeastrum aulicum* cv. Platifolium (Each value is a mean of 10 independent replicates, figures in parentheses represent values on percent basis).

Stages of flower development	Flower diameter (cm)	Fresh mass flower^{-1} (g)	Dry mass flower^{-1} (g)	Water content flower^{-1} (g)	Conductivity of leachates (µS)
I (tight bud stage)	2.66±0.28	3.78±0.26	0.545±0.002	3.23±0.26 (85.41)	7.30±0.47
II (loose bud stage)	5.56±0.37	8.47±0.36	0.681±0.009	7.78±0.35 (91.88)	7.87±0.88
III (half open stage)	11.93±0.81	9.46±0.47	0.760±0.01	8.69±0.47 (91.91)	9.23±0.22
IV (fully open stage)	15.76±0.37	13.48±0.49	0.982±0.04	12.48±0.45 (92.65)	17.0±0.7
V (partially senescent stage)	19.06±0.40	10.91±0.42	0.863±0.07	10.04±0.37 (92.05)	21.16±1.36
VI (senescent stage)	11.70±0.26	9.15±0.50	0.662±0.005	8.48±0.50 (92.73)	25.8±2.80

Table 4.1.2: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} fresh mass) during development and senescence in flowers of *Hippeastrum aulicum* cv. Platifolium (Each value is a mean of 5 independent replicates, figures in parentheses represent values on mg flower $^{-1}$ basis).

Stages of flower development	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α - amino acids	Total phenols
I	11.83±0.28 (44.73)	14.33±0.28 (54.18)	26.16±0.28 (98.91)	3.24±0.12 (12.26)	0.06±0.005 (0.25)	3.28±0.13 (12.39)
II	14.33±0.76 (121.40)	6.33±0.28 (53.64)	20.66±0.76 (175.04)	2.70±0.18 (22.92)	0.08±0.005 (0.70)	3.01±0.12 (25.52)
III	20.83±1.60 (197.08)	3.33±1.04 (31.53)	24.16±0.76 (228.61)	2.24±0.18 (21.25)	0.09±0.003 (0.91)	2.48±0.08 (23.46)
IV	19.33±0.76 (260.61)	2.66±0.57 (35.94)	22.0±0.50 (296.56)	1.95±0.07 (26.43)	0.12±0.005 (1.65)	2.90±0.04 (39.18)
V	16.50±0.50 (180.01)	3.66±0.50 (40.00)	20.16±0.57 (220.01)	1.91±0.18 (20.87)	0.16±0.01 (1.76)	4.0±0.08 (43.64)
VI	14.83±0.28 (135.72)	3.50±0.50 (32.02)	18.33±0.76 (167.74)	0.79±0.06 (7.22)	0.22±0.01 (2.04)	3.68±0.13 (33.67)

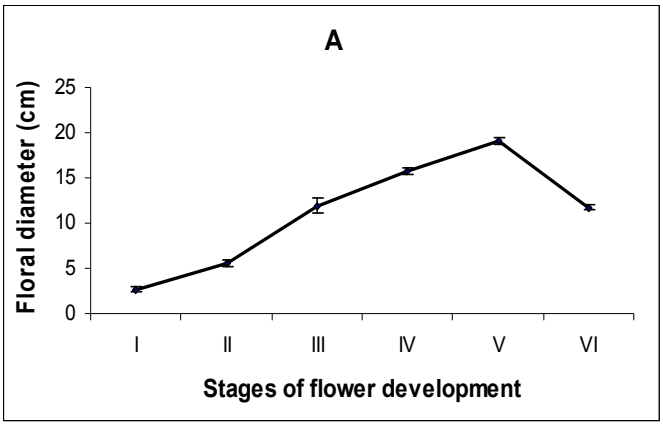
Table 4.1.3: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} dry mass) during development and senescence in flowers of *Hippeastrum aulicum* cv. Platifolium (Each value is a mean of 5 independent replicates).

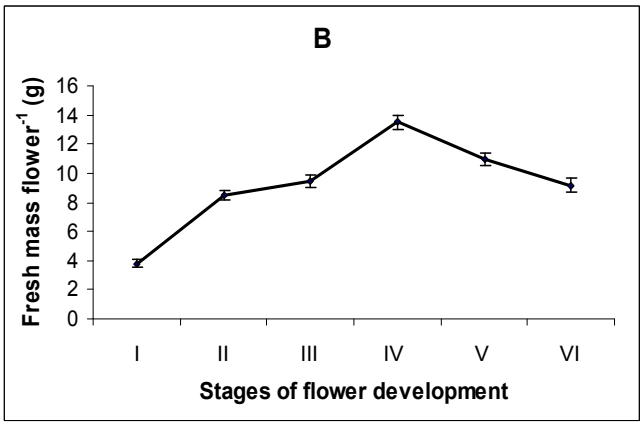
Stages of flower development	Reducing sugars	Non - reducing sugars	Total sugars	Soluble proteins	α -amino acids	Total phenols
I	82.06±1.99	99.41±1.99	181.48±1.99	22.50±0.81	0.46±0.03	22.74±0.96
II	178.26±9.5	78.77±3.58	257.04±9.49	33.65±2.34	1.03±0.06	37.47±1.51
III	259.31±20.03	41.49±12.59	300.8±9.50	27.94±1.56	1.20±0.04	30.86±0.99
IV	265.38±10.48	36.60±3.96	301.99±6.86	26.81±0.99	1.68±0.08	39.90±0.63
V	208.59±6.32	46.34±3.64	254.9±7.29	24.18±2.38	2.04±0.14	50.56±1.01
VI	205.01±3.98	48.38±6.91	253.39±10.5	10.91±0.95	3.08±0.14	50.86±1.91

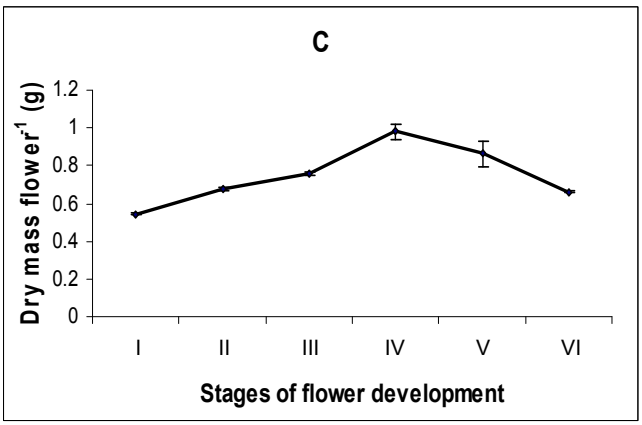
Fig.4.1.1

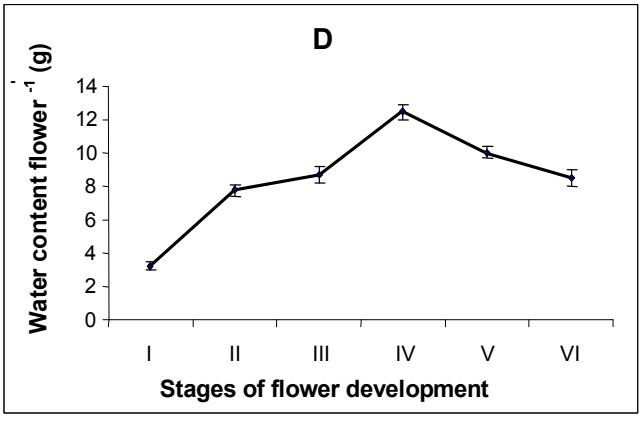
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in flowers of *Hippeastrum aulicum* cv. Platifolium at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
25
20
15
10
5
0
I
II
III
IV
V
VI
Stages of flower development


B
Fresh mass flower-1 (g)
16
14
12
10
8
6
4
2
0
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower-1 (g)
1.2
1
0.8
0.6
0.4
0.2
0
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
14
12
10
8
6
4
2
0
I
II
III
IV
V
VI
Stages of flower development

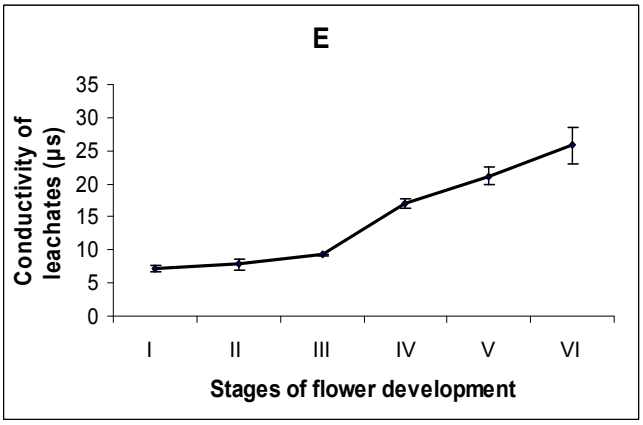

E
Conductivity of leachates (µs)
35
30
25
20
15
10
5
0
I
II
III
IV
V
VI
Stages of flower development

Fig. 4.1.1

Fig. 4.1.2

Changes in reducing sugars (F), non – reducing sugars (G) and total sugars (H), in tepal tissues in flowers of *Hippeastrum aulicum* cv. Platifolium at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.

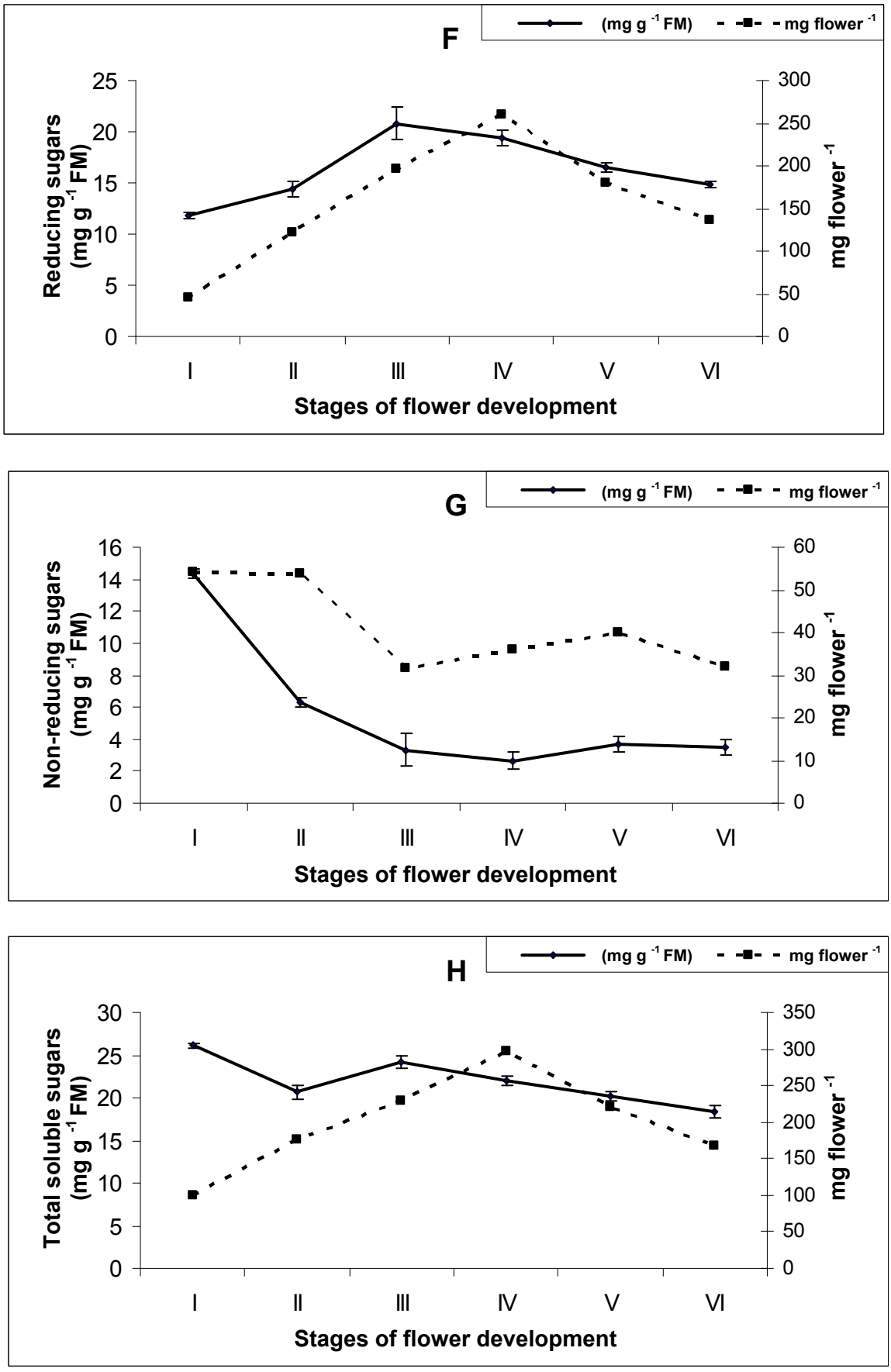
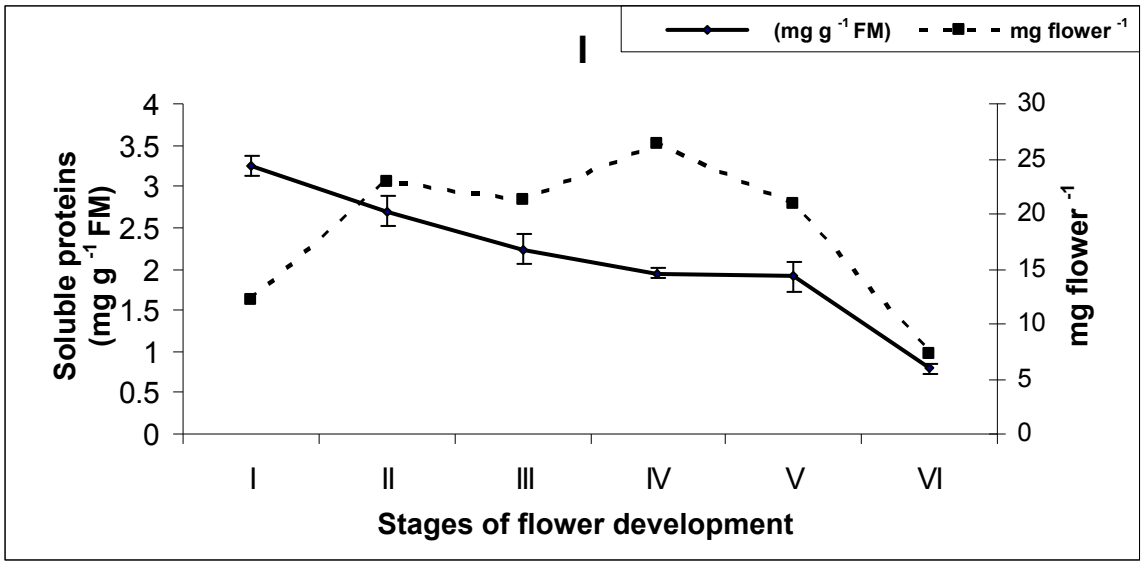

F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
0
50
100
150
200
250
300
I
II
III
IV
V
VI
Stages of flower development
G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
I
II
III
IV
V
VI
Stages of flower development
H
(mg g -1 FM)
mg flower -1
Total soluble sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350
I
II
III
IV
V
VI
Stages of flower development

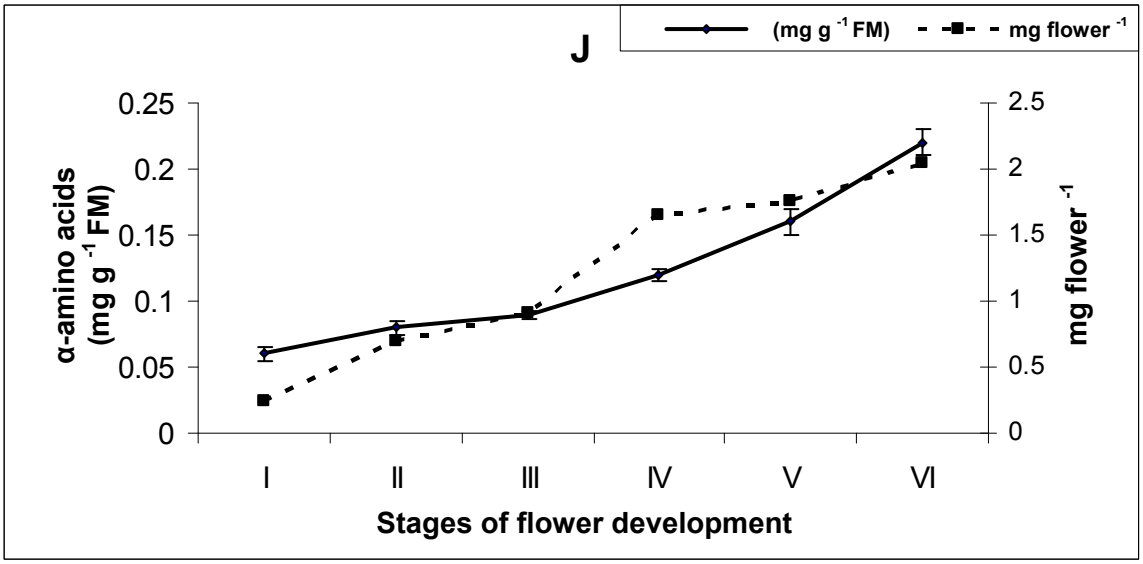
Fig. 4.1.2

Fig. 4.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in tepal tissues in flowers of *Hippeastrum aulicum* cv. Platifolium at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
30
I
II
III
IV
V
VI
Stages of flower development


J
(mg g -1 FM)
mg flower -1
α-amino acids (mg g -1 FM)
mg flower -1
0
0.05
0.1
0.15
0.2
0.25
0
0.5
1
1.5
2
2.5
I
II
III
IV
V
VI
Stages of flower development

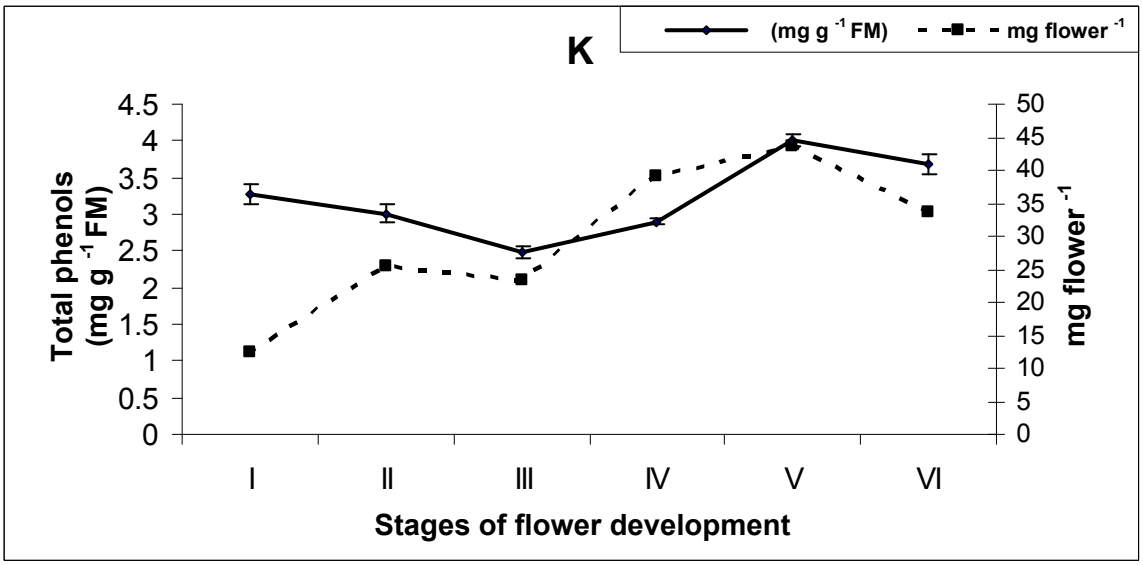

K
(mg g -1 FM)
mg flower -1
Total phenols (mg g -1 FM)
mg flower -1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
5
10
15
20
25
30
35
40
45
50
I
II
III
IV
V
VI
Stages of flower development

Fig. 4.1.3

Plate 4.1.1

Fig.1: Stages of flower development and senescence in *Hippeastrum aulicum* cv. Platifolium.

From left to right are arranged flowers at successive stages of development and senescence. Stages I to VI in the figure represent flowers at tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI).

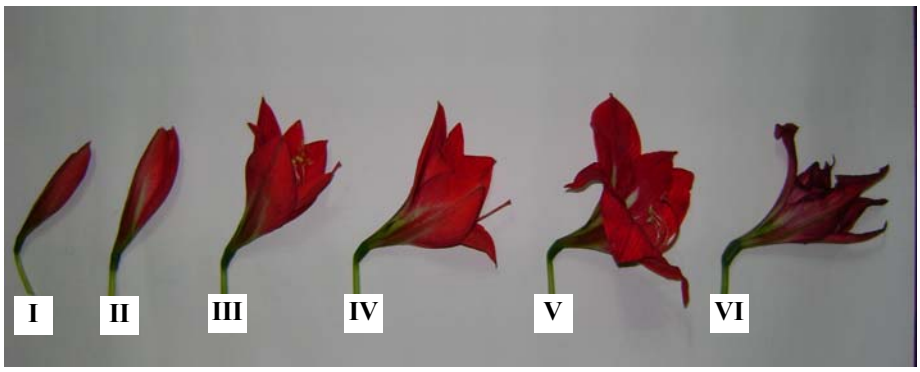


Plate. 4.1.1

Plate 4.1.2

Fig.: 12% SDS – PAGE, profile of equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Hippeastrum aulicum* cv. Platifolium. The gel was stained coomassie blue. Number above the lanes corresponds to developmental stages. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

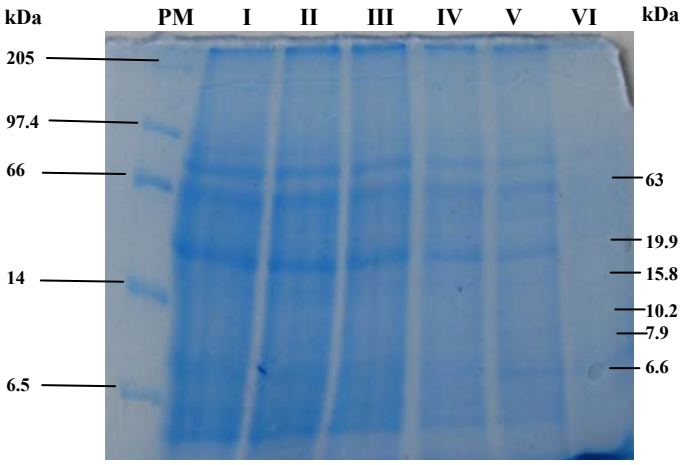


Plate. 4.1.2

CHAPTER 5

Flower Senescence and Regulation of Vase life in *Amaryllis belladonna* cv. Rosea.

Amaryllis is a Greek word meaning a shepherdess or a country girl. It is a monotypic genus containing the belladonna lily (*Amaryllis belladonna*), and is native to South Africa, where it was introduced into cultivation at the beginning of the 18th century. Reproduction takes place slowly either by bulb division or seeds. Bulbs can be planted in October to November with neck of the bulb just below the soil with full sunlight. *Amaryllis belladonna* produces leaves in spring which die down in early summer. The bulb is then dormant until late summer maintaining a dry resting period between leaf growth and flower scape production. From the dry ground in late summer each bulb produces one or two leafless scapes, bearing lily like funnel shaped flowers appearing as pink white, purple or white with crimson veins, comprising of 6 tepals (10-12 cm) with a diameter of 9-10 cm. The six stamens projecting out of the flower surround one carpel with a long style and simple stigma. The common name "naked lady" stems from the plant's pattern of flowering when the foliage has died down.

The plants bloom freely outdoors. The solid scape attains a maximum height of 60 - 65 cm and holds an average of 6 dark purple buds emerging from a common point. The buds are enclosed in a thin green spathe which splits and turns brown subsequently to expose the buds of various stages.

Most of the so-called Amaryllis sold as 'ready to bloom for the holidays' belong to the allied genus *Hippeastrum*, despite being labeled as *'Amaryllis'* by sellers and nurseries; however there are some subtle differences between the two. *Amaryllis* flowers are smaller and the stems are not hollow like *Hippeastrum* stems; *Amaryllis* originates from South Africa while *Hippeastrum* is native to South America; besides *Amaryllis* flowers appear after the foliage has died down. *Amaryllis* can be grown outside while *Hippeastrum* very often is used as an indoor plant. Bulbs of other species with a similar growth and flowering pattern sometimes are called 'naked ladies', even though those species have their own more widely used and

accepted common names, for example 'resurrection lily' for *Lycoris squamigera*. Since the plants of *Amaryllis belladonna* possess glorious cluster of blooms on each sturdy scape, they are an obvious choice for cut flower production. Besides plants of *Amaryllis belladonna* are also used in landscape development as a bedding plant and also as an indoor potted plant.

Being the type genus of family Amaryllidaceae, an initiative was undertaken to undestand the possible mechanism of flower development and senescence. Besides studies were conducted to determine the optimal harvest maturity stage by monitoring the effect of cool wet storage at varied temperature regimes for different time periods. Various formulations were tested with the ultimate objective of improving the vase life and postharvest performance.

EXPERIMENT 5.1

Physiological and biochemical changes associated with the flower development and senescence in *Amaryllis belladonna* cv. Rosea.

Experimental

Flowers of *A. belladonna* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were deciphered as small bud stage (I), tight bud stage (II), loose bud stage (III), open flower stage (IV), partially senescent stage (V) and senescent stage (VI) (Plate 5.1.1, Figs.1-2). Visible changes were recorded throughout flower development and senescence at periodic intervals. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the conductivity of leachates (μS) in tepal discs (5 mm in diameter) punched from outer regions of perianth of five different flowers and incubated in 15 ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents 1g chopped material of tepal tissue was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times at 1000 rpm. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α-amino acids and total phenols as described in materials and methods. Non-reducing sugars were calculated as the difference between total and reducing sugars. Soluble proteins were extracted from 1 g of the tepal tissue drawn separately from five different flowers at each of the six stages and suitable aliquots were used for the estimation as described in material and methods. Electrophoretic profiles were studied at various stages of flower development and senescence, 80 μL of the SDS- denatured protein extract was loaded into each lane. Each value represented in the tables

corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: The purple buds open into bright pink flowers and the flower senescence in *A. belladonna* is marked by turgor loss in the perianth followed by complete wilting. The average life span of an individual flower after it opens fully is about 2.5 days (Plate 5.1.1, Figs.1-2).

Floral diameter: Flower diameter increased as the flower development progressed up to stage V sharply declined thereafter as the floral development progressed to senescence at stage VI (Table 5.1.1, Text Fig. 5.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage V and registered a decline thereafter as the senescence progressed to stage VI. The water content at various stages of floral development and senescence was more or less same when the data was expressed on percent fresh mass basis (Table 5.1.1, Text Fig. 5.1.1, B,C and D).

Membrane permeability: Membrane permeability estimated as electrical conductivity of leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages. However almost steady increase in the ion leachates was registered up to stage V after which the leachates increased markedly during senescence at stage VI (Table 5.1.1, Text Fig. 5.1.1, E).

Reducing sugars: The tissue content of reducing sugars increased during flower development from stage I to stage III and declined thereafter up to stage VI, however a sharp decline was noticed during senescence from stage V to VI (Table 5.1.2, Text Fig. 5.1.2, F). When expressed on per flower basis the reducing sugar content increased progressively from stage I to

stage II after which a steady decline was noticed in the reducing sugar content as the senescence progressed from stage III to stage VI (Table 5.1.2). On dry mass basis three phases were noticed in the reducing sugar content i.e. a decrease up to stage II, followed by increase up to stage IV and then a sharp decline from stage V to VI (Table 5.1.3).

Non-reducing sugars: The non-reducing sugar content decreased steadily as the flowers progressed through various stages of development and senescence, stage I-VI (Table 5.1.2, Text Fig. 5.1.2, G). When the data was expressed on per flower basis the non-reducing sugars showed a declining trend throughout flower development and senescence (Table 5.1.2). On dry mass basis the non-reducing sugar content showed a steady decrease up to stages IV to V followed by a sharp decrease observed at stage VI (Table 5.1.3).

Total sugars: The total soluble sugars increased during flower development from stage I to III and thereafter decreased consistently up to stage V. A sharp decline was noticed thereafter during senescence at stage VI (Table 5.1.2, Text Fig. 5.1.2, H). On per flower basis the total soluble sugar content increased progressively from stage I to stage III and declined thereafter during senescence (Table 5.1.2). On dry mass basis the total sugar content increased progressively from stage I to V and a sharp decline was noticed thereafter at stage VI (Table 5.1.3).

Soluble proteins: The concentration of soluble proteins decreased as the flower development and senescence progressed from stage I to stage VI (Table 5.1.2, Text Fig. 5.1.3, I). On per flower basis the soluble protein content showed a declining trend up to stage V, a slight increase was noticed thereafter at stage VI (Table 5.1.2). On dry mass basis the soluble protein content showed a consistent decrease up to stage IV, a consistent decrease was noticed thereafter up to stage VI (Table 5.1.3).

α-amino acids: The α-amino acid content registered an initial decrease during flower development from stage I to stage II after which a consistent increase was registered in the α-amino acid content as the flower development and senescence progressed up to VI (Table 5.2, Text Fig. 5.1.3, J). The α-amino acid content steadily decreased up to stage IV, thereafter the α-amino acid content increased progressively thereafter up to stage VI. When data was expressed on per flower basis (Table 5.1.2). On dry mass basis, α-amino acid content showed an initial decrease from stage (I- II), followed by a steady increase up to stage VI (Table 5.1.3).

Phenols: The concentration of total phenols decreased as the flower development progressed from stage I to stage IV and increased thereafter up to stage VI (Table 5.1.2, Text Fig. 5.1.3, K). When expressed on per flower basis the concentration of phenols generally decreased progressively up to stage V and increased thereafter (Table 5.1.2). On dry mass basis the concentration of total phenols showed an increasing trend during flower development and senescence from stage I to VI. (Table 5.1.3).

***Electrophoretic profile*:** The SDS-PAGE of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent from stage V and they almost disappeared at the last stage (stage VI) particularly polypeptides having the molecular mass of 61.6 and 50.1 kDa. A polypeptide of molecular mass 15.8 showed up on gels consistently up to stage VI. A new polypeptide having the molecular mass of 15.1 kDa showed up as a bright band at stage VI (Plate 5.1.2).

Table 5.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Amaryllis belladonna* cv. Rosea (Each value is a mean of 10 independent replicates, figures in parentheses represents values on percent basis).

Stages of flower development	Floral diameter (cm)	Fresh mass flower^{-1} (g)	Dry mass flower^{-1} (g)	Water content flower^{-1} (g)	Conductivity of leachates (µs)
I (small bud stage)	0.43 ± 0.04	0.51 ± 0.02	0.08 ± 0.001	0.43 ± 0.04 (84.01)	9.13 ± 0.32
II (tight bud stage)	0.63 ± 0.04	0.73 ± 0.03	0.10 ± 0.001	0.63 ± 0.06 (85.46)	11.06 ± 1.0
III (loose bud stage)	1.30 ± 0.07	1.52 ± 0.07	0.150 ± 0.002	1.36 ± 0.12 (89.52)	13.20 ± 1.21
IV (open flower stage)	5.73 ± 0.17	2.70 ± 0.08	0.215 ± 0.001	2.48 ± 0.16 (92.00)	15.30 ± 1.47
V (partially senescent stage)	9.23 ± 0.17	2.95 ± 0.21	0.217 ± 0.001	2.73 ± 0.42 (92.48)	18.16 ± 0.76
VI (senescent stage)	3.0 ± 0.76	1.54 ± 0.09	0.15 ± 0.001	1.38 ± 0.18 (90.01)	32.70 ± 0.62

Table 5.1.2: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} fresh mass) during development and senescence in tepal tissue from flowers of *Amaryllis belladonna* cv. Rosea (Each value is a mean of 5 independent replicates, figures in parentheses represents values on mg flower $^{-1}$).

Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	1.77 ± 0.61 (3.46)	18.93 ± 2.13 (37.05)	20.70 ± 1.62 (40.51)	4.24 ± 0.24 (8.30)	0.08 ± 0.01 (0.04)	2.66 ± 0.24 (5.21)
II	12.66 ± 0.53 (16.41)	11.24 ± 1.71 (15.21)	23.37 ± 1.34 (31.62)	3.74 ± 0.25 (5.06)	0.11 ± 0.001 (0.08)	2.54 ± 0.25 (3.44)
III	22.04 ± 0.80 (14.40)	4.39 ± 1.40 (2.89)	26.44 ± 0.60 (17.39)	1.99 ± 0.32 (1.31)	0.12 ± 0.001 (0.07)	2.20 ± 0.20 (1.44)
IV	18.87 ± 0.81 (6.98)	2.09 ± 1.30 (0.77)	20.96 ± 1.66 (7.75)	1.66 ± 0.14 (0.61)	0.13 ± 0.001 (0.04)	1.90 ± 0.08 (0.70)
V	17.28 ± 0.81 (5.85)	2.13 ± 1.07 (0.72)	19.14 ± 1.10 (6.58)	1.33 ± 0.07 (0.45)	0.15 ± 0.001 (0.05)	1.92 ± 0.27 (0.64)
VI	6.91 ± 1.10 (4.48)	1.36 ± 0.88 (0.87)	8.26 ± 1.08 (5.36)	1.04 ± 0.07 (0.67)	0.18 ± 0.001 (0.11)	3.32 ± 0.19 (2.15)

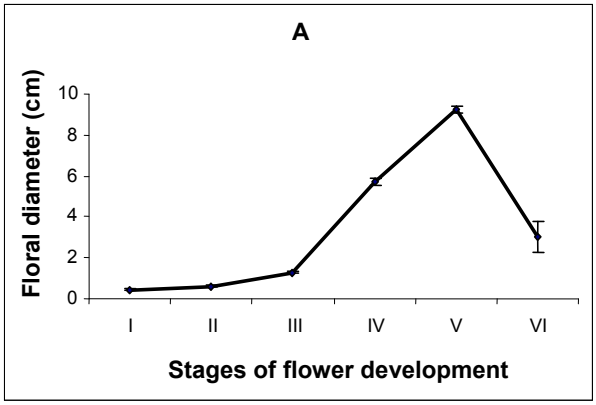
Table 5.1.3: Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} dry mass) during development and senescence in tepal tissue from flowers of *Amaryllis belladonna* cv. Rosea (Each value is a mean of 5 independent replicates).

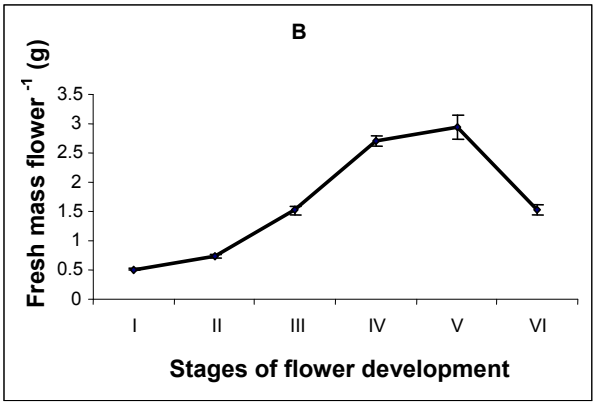
Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	11.16 ± 3.89	119.28 ± 13.45	130.44 ± 0.26	26.74 ± 1.56	0.51 ± 0.01	16.79 ± 1.53
II	83.69 ± 3.65	77.60 ± 11.81	161.07 ± 9.59	25.85 ± 1.72	0.75 ± 0.02	17.56 ± 1.77
III	210.73 ± 7.67	42.03 ± 13.42	252.76 ± 5.74	19.11 ± 3.15	1.12 ± 0.03	21.09 ± 1.98
IV	236.73 ± 10.17	26.18 ± 12.80	262.91 ± 20.86	20.91 ± 1.81	1.69 ± 0.02	23.84 ± 1.00
V	234.92 ± 11.06	28.94 ± 14.54	263.86 ± 15.06	17.55 ± 1.96	2.11 ± 0.05	26.08 ± 3.67
VI	69.51 ± 11.07	13.61 ± 9.10	83.12 ± 10.95	10.47 ± 0.72	1.77 ± 0.05	33.39 ± 1.92

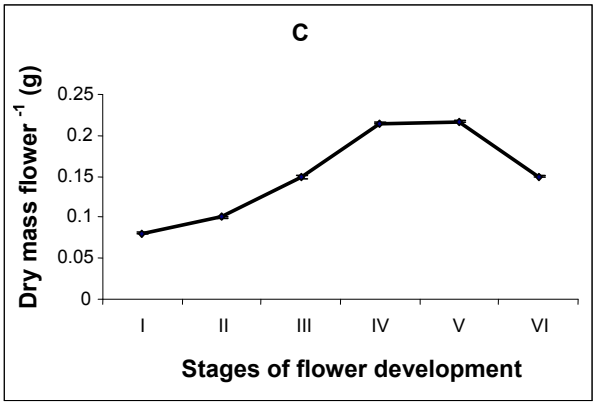
Fig. 5.1.1

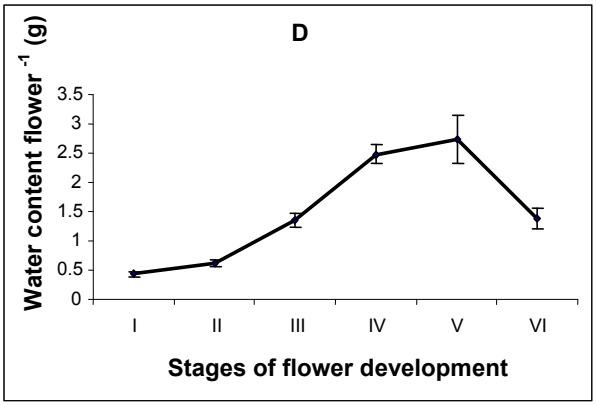
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in flowers of *Amaryllis belladonna* cv. Rosea at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
0
2
4
6
8
10
I
II
III
IV
V
VI
Stages of flower development


B
Fresh mass flower -1 (g)
0
0.5
1
1.5
2
2.5
3
3.5
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower -1 (g)
0
0.05
0.1
0.15
0.2
0.25
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
0
0.5
1
1.5
2
2.5
3
3.5
I
II
III
IV
V
VI
Stages of flower development

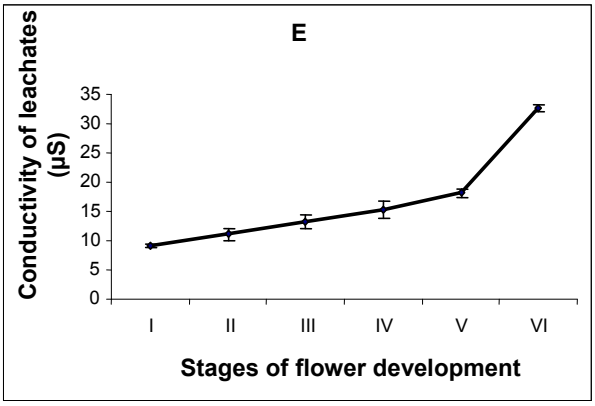
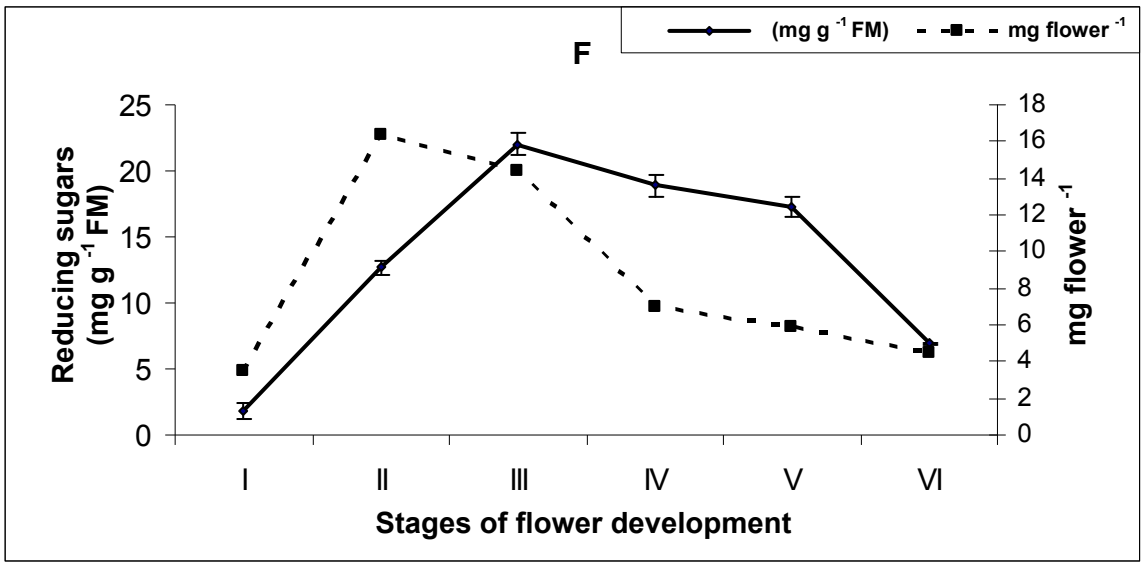

E
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
I
II
III
IV
V
VI
Stages of flower development

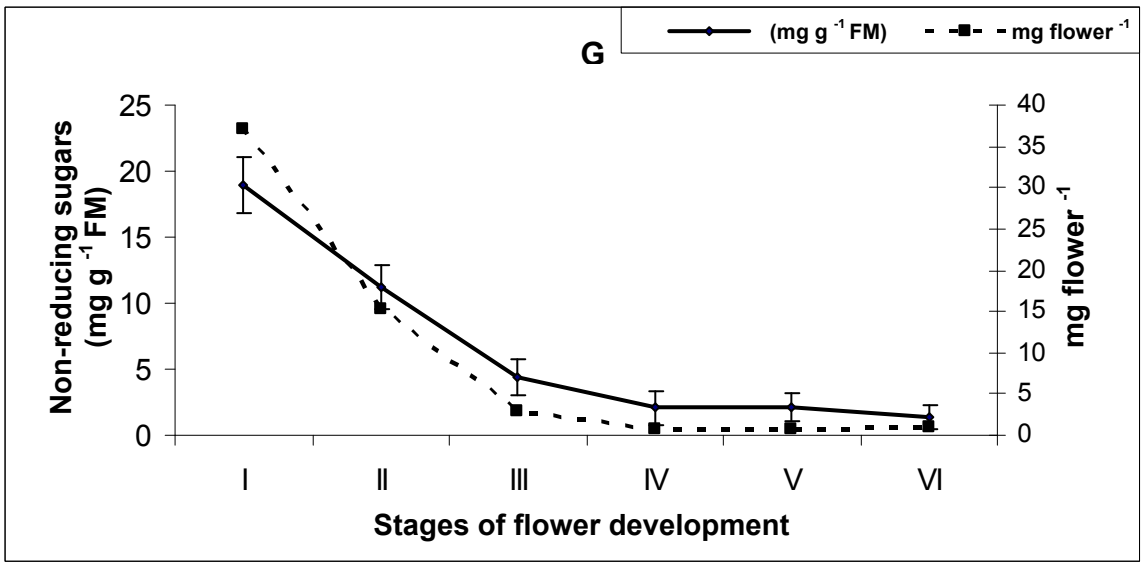
Fig. 5.1.1

Fig. 5.1.2

Changes in reducing sugars (F), non – reducing sugars (G), and total sugars (H) in tepal tissues in flowers of *Amaryllis belladonna* cv. Rosea at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
0
2
4
6
8
10
12
14
16
18
I
II
III
IV
V
VI
Stages of flower development


G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40
I
II
III
IV
V
VI
Stages of flower development

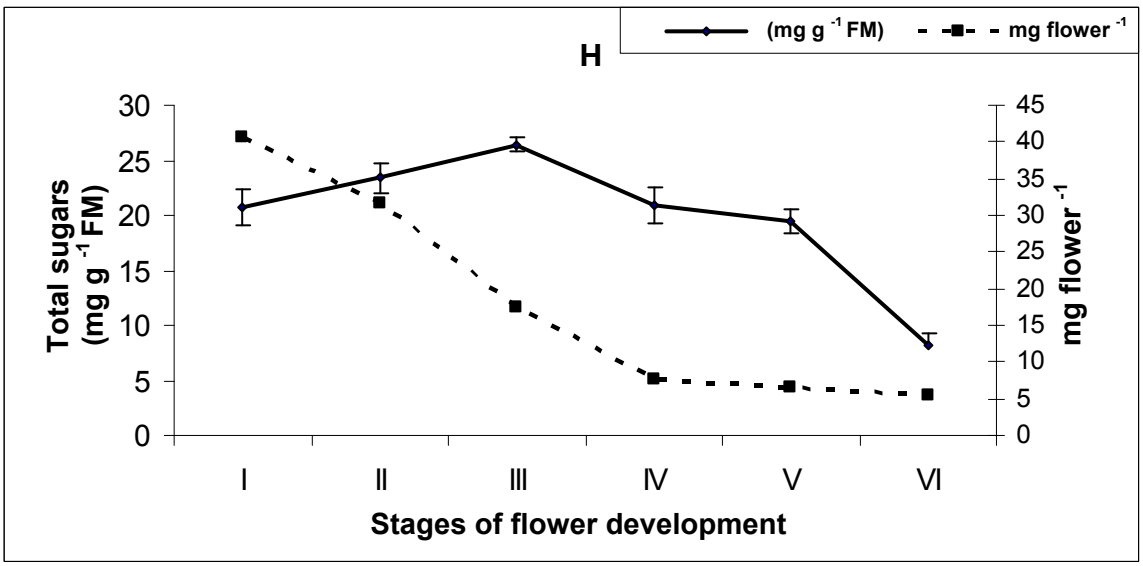
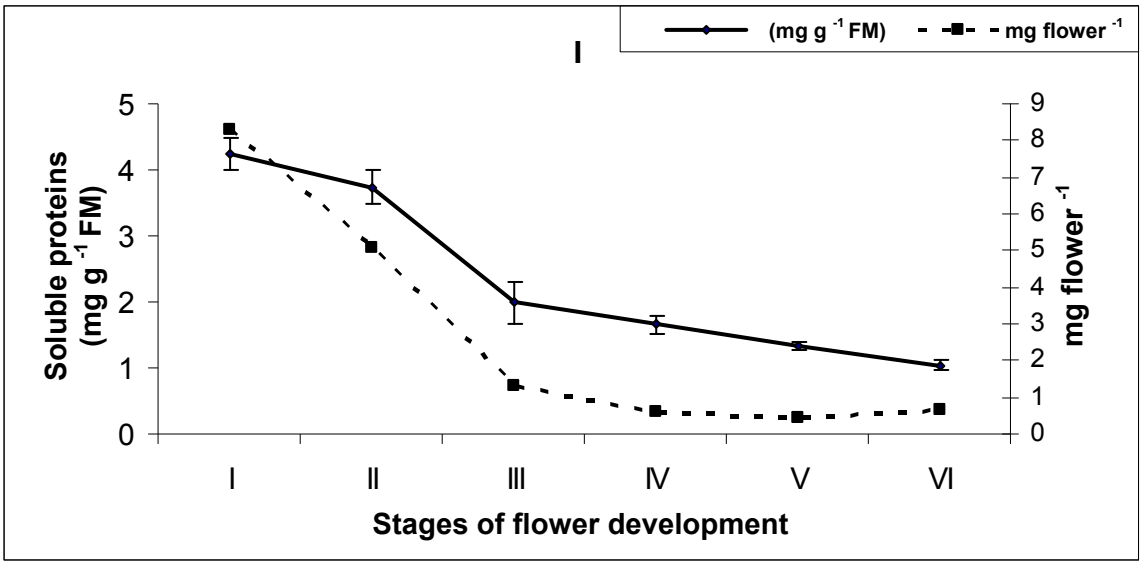

H
(mg g -1 FM)
mg flower -1
Total sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
30
0
5
10
15
20
25
30
35
40
45
I
II
III
IV
V
VI
Stages of flower development

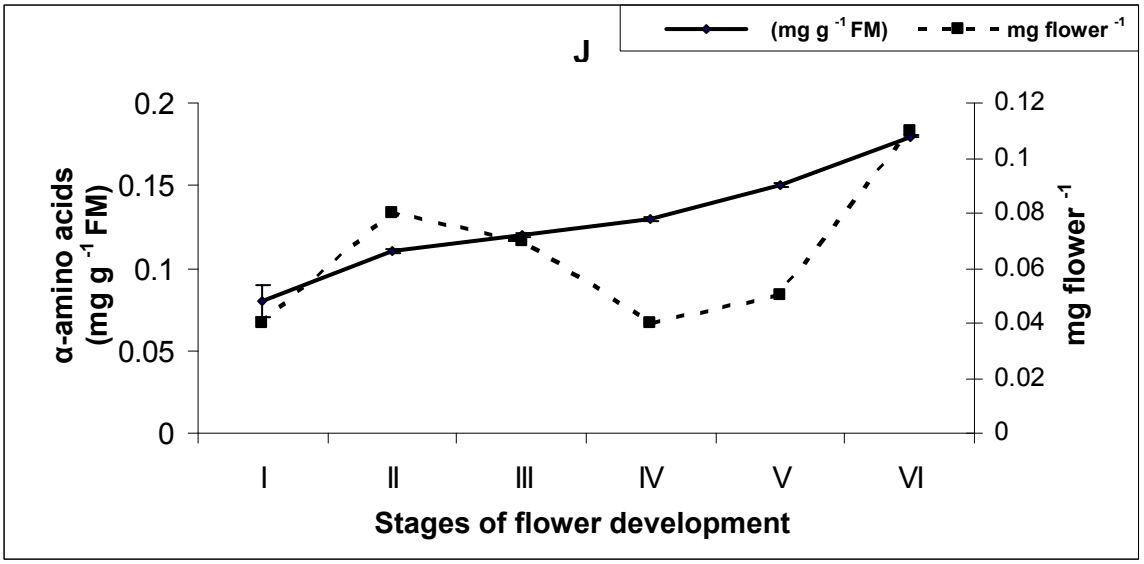
Fig. 5.1.2

Fig. 5.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in tepal tissues in flowers of *Amaryllis belladonna* cv. Rosea at successive stages of development and senescence.

The vertical bars represent the standard deviations (SD) of mean values.


I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
0
1
2
3
4
5
6
7
8
9
I
II
III
IV
V
VI
Stages of flower development


J
(mg g -1 FM)
mg flower -1
α-amino acids (mg g -1 FM)
mg flower -1
0
0.05
0.1
0.15
0.2
0
0.02
0.04
0.06
0.08
0.1
0.12
I
II
III
IV
V
VI
Stages of flower development

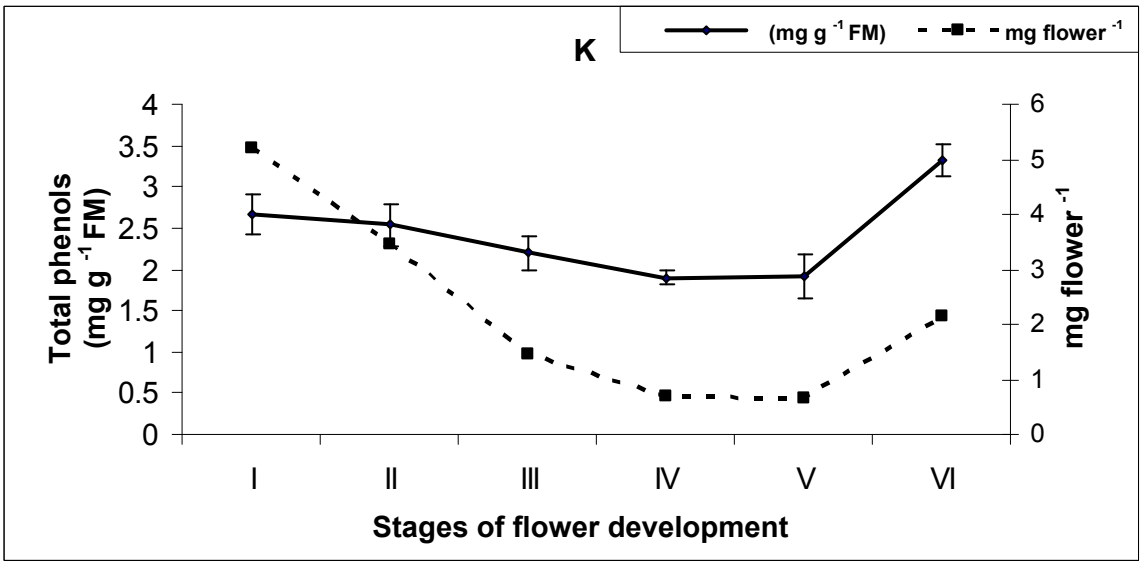

K
(mg g -1 FM)
mg flower -1
Total phenols (mg g -1 FM)
mg flower -1
0
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
5
6
I
II
III
IV
V
VI
Stages of flower development

Fig. 5.1.3

Plate 5.1.1

Fig.1: Stages of scape development in *Amaryllis belladonna* cv. Rosea.

Fig.2: Stages of flower development and senescence in *Amaryllis belladonna* cv. Rosea.

From left to right are arranged scapes or flowers at successive stages of development and senescence. Stages I to VI in the figure represent, small bud stage (I), tight bud stage (II), loose bud stage (III), open flower stage (IV), partially senescent stage (V) and senescent stage (VI).

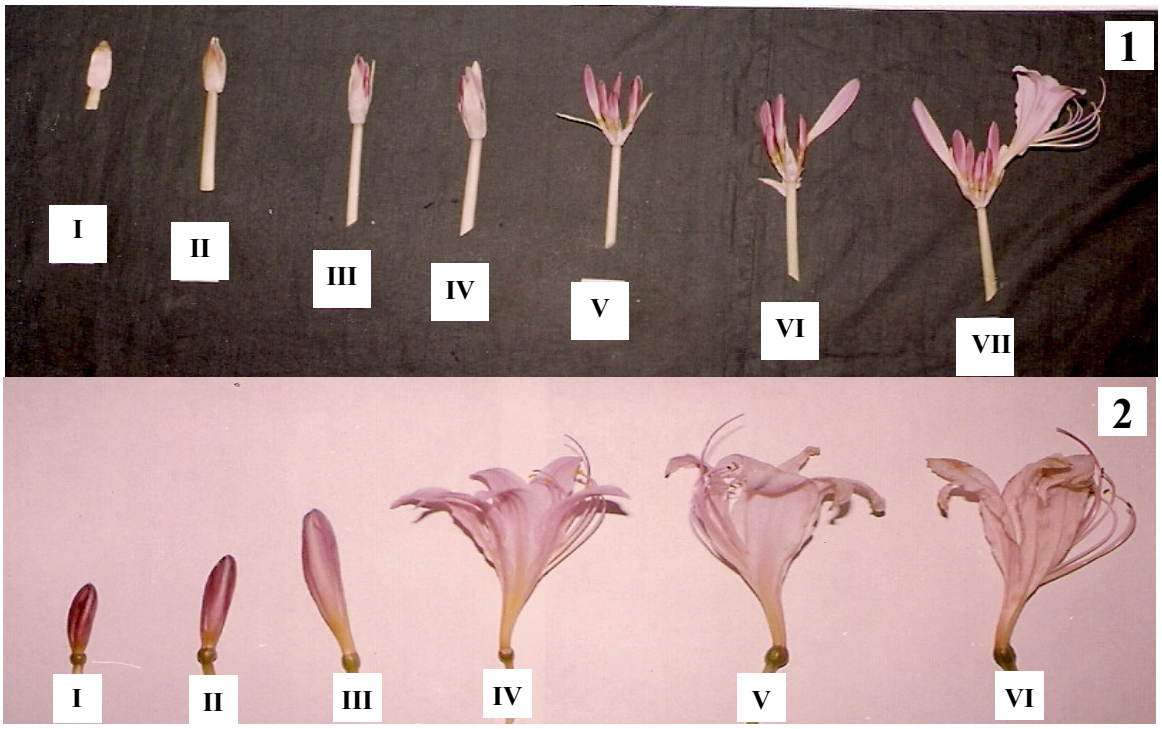


Plate. 5.1.1

Plate 5.1.2

Fig. : 12 % SDS –PAGE, equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Amaryllis belladonna* cv. Rosea. The gel was stained with coomassie blue. Number above the lanes corresponds to developmental stages. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

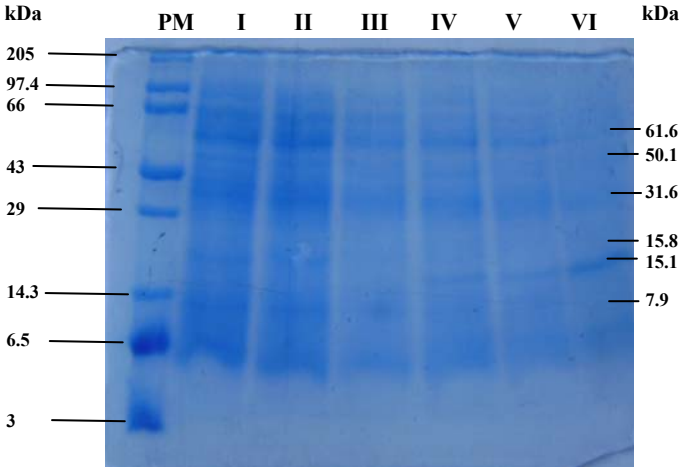

kDa
PM
I
II
III
IV
V
VI
kDa
205
97.4
66
43
29
14.3
6.5
3
61.6
50.1
31.6
15.8
15.1
7.9

Plate. 5.1.2

EXPERIMENT 5. 2

Effect of postharvest wet storage (PHWS) at different temperature regimes; 5, 10 and room temperature (RT = 25 ± 2°C) for 72 h before transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Experimental

Scapes of *A. belladonna* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in distilled water (DW) in separate buckets and kept at 5 and 10°C. A separate set of scapes was kept at room temperature (RT=25±2°C). After 72 h the scapes were recut to a length of 27 cm. After storage for 72 h all the scapes were kept at room temperature and transferred to 250 ml conical flasks containing 200 ml of distilled water (DW), (SUC 0.15M) sucrose (SUC 0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to a particular holding solution and was assessed to be terminated when 70 % flowers had senesced which was characterized by loss of turgor followed by wilting of tepals. Number of blooms per scape was recorded up to day 5 of the transfer. Volume of solution absorbed was recorded on day 2, 4 and 6 after the transfer of scapes to holding solutions. Electrical conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions.

Changes in tissue constituents comprising sugar fractions, soluble proteins, α- amino acids and phenolics were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes wet stored for 72 h at RT had already bloomed during the storage and senesced by day 4 of the transfer (Plate. 5.2.1). Blooming during storage was least in the scapes previously wet stored at 5 and 10 ^{o}C before transfer to holding solutions and showed symptoms of tepal senescence on the day 8 and 5 of transfer to a particular holding solution (Plate 5.2.2, Figs. 1-3) Senescence was assessed when 70 % of flowers had lost their display value which was characterized by turgor loss followed by wilting of tepals (Plate 5.2.3, Figs. 1-3).

Vase life: The average vase life of scapes previously wet stored at various temperature regimes i.e, RT, 10 and 5^{o}C for 72 h before transfer to DW was 3, 4 and 5 days respectively; whereas the vase life of the corresponding scapes wet stored at RT, 10 and 5^{o}C before transfer to SUC was 4, 6 and 7 days respectively. The maximum vase life was recorded in scapes stored at of RT,10 and 5^{o}C before transfer to SUC+8-HQS which was 5, 6 and 8 days respectively (Table 5.2.1; Text Fig.5.2.1, A).

Number of blooms per scape: The number of blooms per scape as also the percent blooming increased in all treatments with the progression in time irrespective of transfer to various holding solutions. The scapes previously wet stored at RT for 72 h exhibited 100 percent blooming by day 2 of the transfer of scapes to various holding solutions.The scapes previously wet stored at 10 ^{o}C for 72 h generally exhibited maximum blooming up to day 4 of transfer to various holding solution.Maximum and sustained blooming up

to day 5 was recorded in scapes wet stored at 5^{o}C particularly in SUC+8-HQS (Table 5.2.1; Text Fig. 5.2.1 B).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression from day 2 to 6 days of the transfer of scapes to various holding solutions irrespective of the particular temperature regime and holding solution. The solution uptake was found to be higher in scapes previously wet stored for 72 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of the holding solution. A higher solution uptake was recorded in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment, however maximum solution uptake was noticed in scapes previously wet stored at 5°C for 72 h and transferred to (SUC + 8-HQS) (Table 5.2.1; Text Fig. 5.2.2, C).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. The concentration of leachates significantly increased in samples from scapes previously wet stored at RT and 10°C, however the least conductivity of leachates was maintained in samples from scapes wet stored at 5 °C irrespective of the transfer to various holding solutions. At each temperature regime the leachates were found to be less in samples from scapes held in SUC + 8 - HQS followed by scapes held in SUC as compared to samples from corresponding scapes held in DW (Table 5.2.2; Text Fig. 5.2.2, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously wet stored for 72 h at 5 and 10 °C registered an increase with progression in time from day 4 to day 8, whereas the samples from scapes wet stored at RT registered a decrease over the period of time from day 4 to day 8. At each of the temperature regimes both fresh and dry mass

was found to be the highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW, however maximum value for fresh and dry mass was recorded in samples from scapes previously wet stored at 5°C for 72 h and transferred to SUC + 8-HQS (Table 5.2.2; Text Fig. 5.2.3, E & F).

Reducing sugars: The reducing sugar content of the samples from scapes previously wet stored for 72 h before transfer to SUC + 8-HQS and SUC registered an increase with progression in time from day 4 to 8, whereas the reducing sugar content of samples from the corresponding scapes held in DW decreased over the period of time irrespective of the temperature treatment. The reducing sugar content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.2.3; Text Fig. 5.2.4, G). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass basis but the differences showed up clearly on these particular reference bases (Table 5.2.4). Maximum reducing sugar content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Non-reducing sugars: The non-reducing sugar content of samples from scapes previously wet stored for 72 h in SUC + 8-HQS and DW registered an increase with progression in time from day 4 to 8, whereas the non-reducing sugar content of samples from the scapes held in SUC decreased over the period of time irrespective of the temperature treatment. The non-reducing sugar content of samples from scapes previously wet stored at RT and held in DW or SUC+ 8-HQS registered an increase as compared to the samples from corresponding scapes held in SUC over the period of time. The

non-reducing sugar content of samples from scapes previously stored at 10^0C and transferred to SUC or SUC +8-HQS registered an increase, whereas the corresponding samples held in DW decreased over the period of time. The non-reducing sugar content of samples from scapes previously wet stored at 5^0C for 72 h registered an increase irrespective of transfer to various holding solutions. However, at each of the temperature regimes, the non-reducing sugar content was generally found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 5.2.3; Text Fig. 5.2.4, H).When expressed on per flower or on dry mass bases the non-reducing sugar content registered a decrease in samples from scapes held at various temperature regimes and transferred to DW or SUC as compared to the corresponding samples from scapes held in SUC + 8-HQS over the period of time (Tables 5.2.3 & 5.2.4).

Total sugars: The total sugar content of samples form scapes previously wet stored for 72 h in SUC + 8-HQS and SUC registered a marked increase with progression in time from day 4 to 8 of transfer of scapes irrespective of the previous temperature treatment. However, the total sugar content decreased in the samples from corresponding scapes held in DW over a period of time. The total sugar content of samples from scapes previously wet stored for 72h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the total sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.2.3; Text Fig. 5.2.5, K).Almost similar trends were obtained when the data was expressed on per flower basis and dry mass basis but the differences showed up clearly on these particular reference bases (Tables 5.2.3 & 5.2.4). Maximum total sugar content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Soluble proteins: The soluble protein content of samples from scapes previously wet stored for 72 h at 10 and 5°C in SUC + 8-HQS and SUC registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the corresponding scapes held at RT in DW over a period of time. The soluble protein content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the soluble protein content was found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.2.5; Text Fig. 5.2.5,J). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases but the differences showed up clearly on these particular reference bases (Table 5.2.6). Maximum soluble protein content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC +8-HQS.

α- amino acids: The amino acid content of samples from scapes previously wet stored for 72 h at RT and 10°C before transfer to DW and SUC generally registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the corresponding scapes held at 10 and 5°C in SUC + 8-HQS which registered a decrease. The amino acid content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered a decrease as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the amino acid content was found to be highest in samples from scapes held in DW followed by SUC as compared to the samples from corresponding scapes held in SUC+8 -HQS (Table 5.2.5; Text Fig. 5.2.6, K). On per flower and dry mass basis the amino acid content generally decreased with the progression in time; however the highest amino

acid content was recorded in samples from scapes transferred to distilled water followed by samples from corresponding scapes held in SUC and SUC +8-HQS respectively (Tables 5.2.5 & 5.2.6). Lowest content of amino acids was noticed in samples from scapes stored wet at 5^{o}C for 72 h and transferred to SUC+8-HQS.

Total phenols: Generally the content of total phenols from scapes previously wet stored at RT and 10^{o}C before transfer to various holding solutions registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the samples from corresponding scapes held at 5°C. A lower content of phenols was registered in samples from scapes previously wet stored at 5 and 10°C for 72 h as compared to the samples from scapes held at RT. (Table 5.2.5; Text Fig. 5.2.6, L). On per flower and dry mass bases the phenolic content generally decreased in samples from corresponding scapes transferred to either SUC or SUC +8-HQS irrespective of the temperature treatment (Tables 5.2.5 & 5.2.6).

Table 5.2.1: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Amaryllis belladonna* cv. Rosea.

Temperature treatment (72h)	Vase life (days)	No. of blooms per scape						Volume of holding solution absorbed per scape (ml)		
		Days after treatment								
		0	1	2	3	4	5	2	4	6
RT→DW	3	4.30 (75)	5.17 (90)	5.75 (100)	-	-	-	2.25	3.25	5.25
10 °C→DW	4	1.28 (20)	2.22 (35)	3.48 (55)	5.02 (80)	6.25 (100)	-	3.00	5.50	6.50
5 °C →DW	5	0.71 (11)	1.26 (20)	2.20 (35)	3.75 (60)	5.68 (90)	6.25 (100)	3.25	6.75	8.50
RT→SUC(0.15M)	6	4.14 (75)	5.09 (92)	5.50 (100)	-	-	-	5.00	6.50	7.25
10°C→SUC(0.15M)	7	2.90 (62)	4.10 (80)	4.92 (99)	-	-	-	5.75	7.25	8.25
5°C→SUC(0.15M)	5	0.71 (11)	1.26 (20)	2.66 (42)	4.07 (65)	5.99 (95)	6.25 (100)	6.00	8.25	9.50
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	5	4.90 (75)	6.22 (95)	6.50 (100)	-	-	-	5.50	7.50	10.50
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	6	1.28 (20)	3.13 (50)	4.07 (65)	5.76 (92)	6.25 (100)	-	6.50	7.50	11.00
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	8	0.71 (11)	1.85 (29)	2.86 (45)	4.41 (70)	6.13 (98)	6.52 (100)	6.25	8.50	13.20
LSD at $P_{=0.05}$	0.22	0.04	0.06	0.06	0.08	0.01	-	0.04	0.08	0.02

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Figures in parentheses represent percent blooms.

Table: 5.2.2: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment (72h)	Conductivity of leachates (µS)		Fresh mass (g flower^{-1})		Dry mass (g flower^{-1})	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	29.97	43.27	1.41	0.47	0.087	0.060
10 °C→DW	19.90	38.80	1.60	0.51	0.091	0.063
5 °C →DW	17.10	18.53	1.68	0.59	0.100	0.071
RT→SUC(0.15M)	24.03	42.37	1.54	1.81	0.110	0.122
10°C→SUC(0.15M)	17.67	30.23	1.78	2.00	0.122	0.151
5°C→SUC(0.15M)	16.00	15.23	1.81	2.05	0.128	0.214
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	23.07	36.50	1.57	1.92	0.116	0.130
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	16.60	23.57	2.00	2.24	0.157	0.168
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	13.66	12.33	2.11	2.31	0.163	0.223
LSD at $P_{=0.05}$	0.70	0.44	0.04	0.07	0.004	0.007

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Table 5.2.3: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fraction, expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	4.53 (6.38)	2.93 (1.37)	3.80 (5.35)	4.53 (2.12)	8.33 (11.74)	7.46 (3.50)
10 °C→DW	6.00 (9.60)	5.86 (2.98)	5.93 (9.48)	3.47 (1.76)	11.93 (19.08)	9.33 (4.75)
5 °C →DW	13.50 (27.00)	6.40 (3.77)	1.43 (2.86)	4.93 (2.90)	12.07 (24.14)	11.33 (6.68)
RT→SUC(0.15M)	10.67 (16.43)	12.67 (22.93)	2.40 (3.69)	1.80 (3.25)	13.07 (20.12)	14.47 (26.19)
10°C→SUC(0.15M)	11.93 (21.23)	13.80 (27.60)	1.73 (3.07)	2.50 (5.00)	13.66 (24.31)	16.30 (32.60)
5°C→SUC(0.15M)	12.27 (22.20)	17.60 (36.08)	4.60 (8.32)	2.53 (5.18)	16.87 (30.53)	20.13 (41.26)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	13.00 (20.41)	15.60 (29.95)	3.60 (5.65)	6.00 (11.52)	16.60 (26.06)	21.60 (41.72)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	18.53 (37.06)	20.21 (45.27)	2.00 (4.00)	3.33 (7.45)	20.53 (41.06)	23.54 (52.72
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	23.00 (48.50)	25.61 (59.15)	4.07 (8.58)	4.41 (10.18)	27.07 (57.11)	30.02 (69.34)
LSD at $P_{=0.05}$	0.92	1.03	0.67	0.77	0.90	0.96

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Figures in parentheses represent value on mg $flower^{-1}$ basis.

Table 5.2.4: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Reducing Sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	73.41	22.95	61.59	35.49	135.00	58.44
10 °C→DW	105.49	47.43	104.30	28.09	209.80	75.53
5 °C →DW	270.00	53.18	28.60	40.97	241.40	94.15
RT→SUC(0.15M)	149.38	187.97	33.60	26.70	183.00	214.70
10°C→SUC(0.15M)	174.06	182.78	25.24	16.55	199.30	215.89
5°C→SUC(0.15M)	173.51	168.60	65.05	24.24	238.60	192.80
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	175.95	230.40	48.72	88.62	224.70	319.00
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	236.05	269.47	25.48	44.40	261.50	313.90
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	297.73	265.29	52.69	45.68	350.40	311.00
LSD at $P_{=0.05}$	0.65	0.29	0.81	0.53	0.64	0.44

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25±2^{o}C).

Table 5.2.5: Effect of postharvest wet storage (PHWS) for 72h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g $^{-1}$ FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment (72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	2.91 (4.10)	1.91 (0.89)	0.94 (1.32)	1.27 (0.59)	1.98 (2.79)	2.90 (1.36)
10 °C→DW	3.50 (5.60)	1.50 (0.76)	0.65 (1.04)	0.90 (0.45)	1.85 (2.96)	2.36 (1.20)
5 °C →DW	3.83 (7.66)	1.59 (0.93)	0.60 (1.20)	0.84 (0.49)	1.51 (3.02)	1.31 (0.77)
RT→SUC(0.15M)	3.05 (4.69)	1.77 (3.20)	0.56 (0.86)	0.70 (1.26)	1.91 (2.94)	2.80 (5.06)
10°C→SUC(0.15M)	3.15 (5.60)	3.90 (7.80)	0.48 (0.85)	0.36 (0.72)	1.78 (3.16)	2.23 (4.46)
5°C→SUC(0.15M)	3.50 (6.33)	4.00 (8.20)	0.39 (0.70)	0.32 (0.65)	1.31 (2.37)	1.21 (2.48)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	3.91 (6.13)	2.31 (4.43)	0.35 (0.54)	0.53 (1.01)	2.86 (4.49)	2.50 (4.80)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	4.01 (8.02)	4.20 (9.40)	0.31 (0.62)	0.21 (0.47)	1.38 (2.76)	2.06 (4.61)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	4.14 (8.73)	5.25 (12.12)	0.26 (0.54)	0.19 (0.43)	1.11 (2.34)	1.01 (2.33)
LSD at $P_{=0.05}$	0.15	0.21	0.04	0.02	0.13	0.16

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25±2^{o}C).

Figures in parentheses represent value on mg flower^{-1} basis.

Table 5.2.6: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	47.16	14.96	15.23	9.94	32.09	22.72
10 °C→DW	61.54	12.14	11.42	7.28	32.53	19.10
5 °C →DW	76.60	13.21	12.01	6.98	30.20	10.89
RT→SUC(0.15M)	42.71	26.26	7.84	10.38	26.74	41.54
10°C→SUC(0.15M)	45.96	51.66	7.00	4.76	25.97	29.54
5°C→SUC(0.15M)	49.49	38.32	5.51	3.06	18.52	11.59
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	52.92	34.12	4.73	7.82	38.71	36.92
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	51.08	56.00	3.94	2.80	17.58	27.47
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	53.59	54.38	3.36	1.96	14.37	10.46
LSD at $P_{=0.05}$	0.44	0.36	0.89	0.67	0.91	0.25

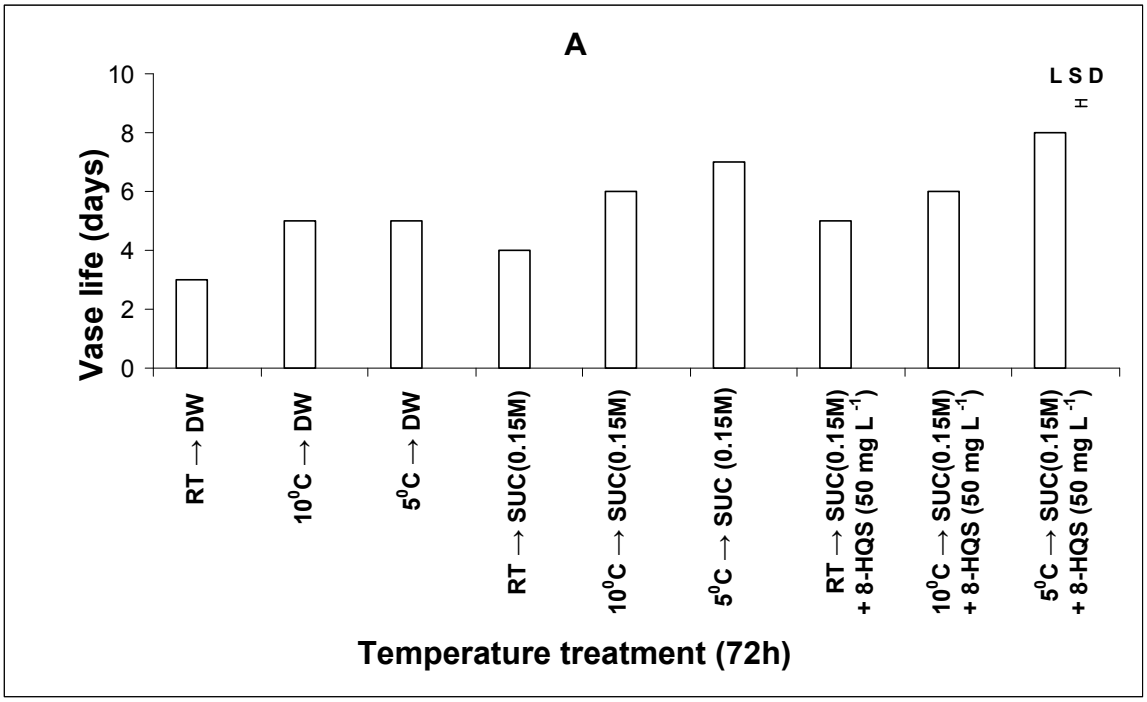
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Fig. 5.2.1

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$


A
Vase life (days)
10
8
6
4
2
0
L S D
H
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

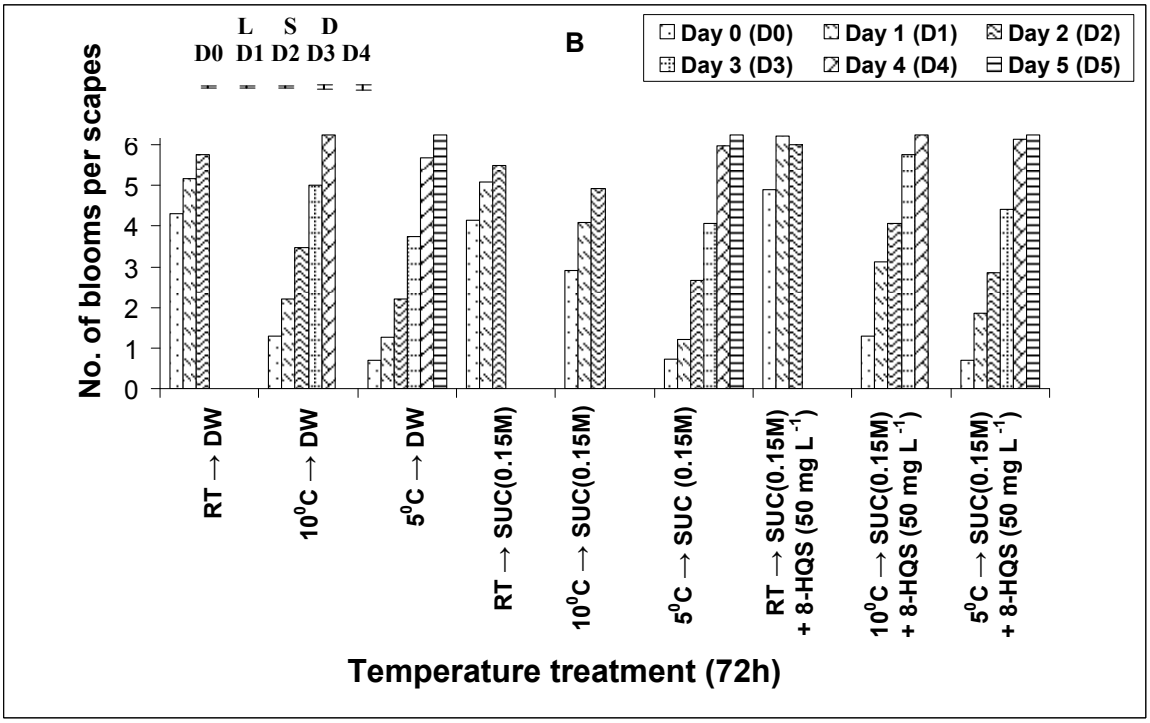
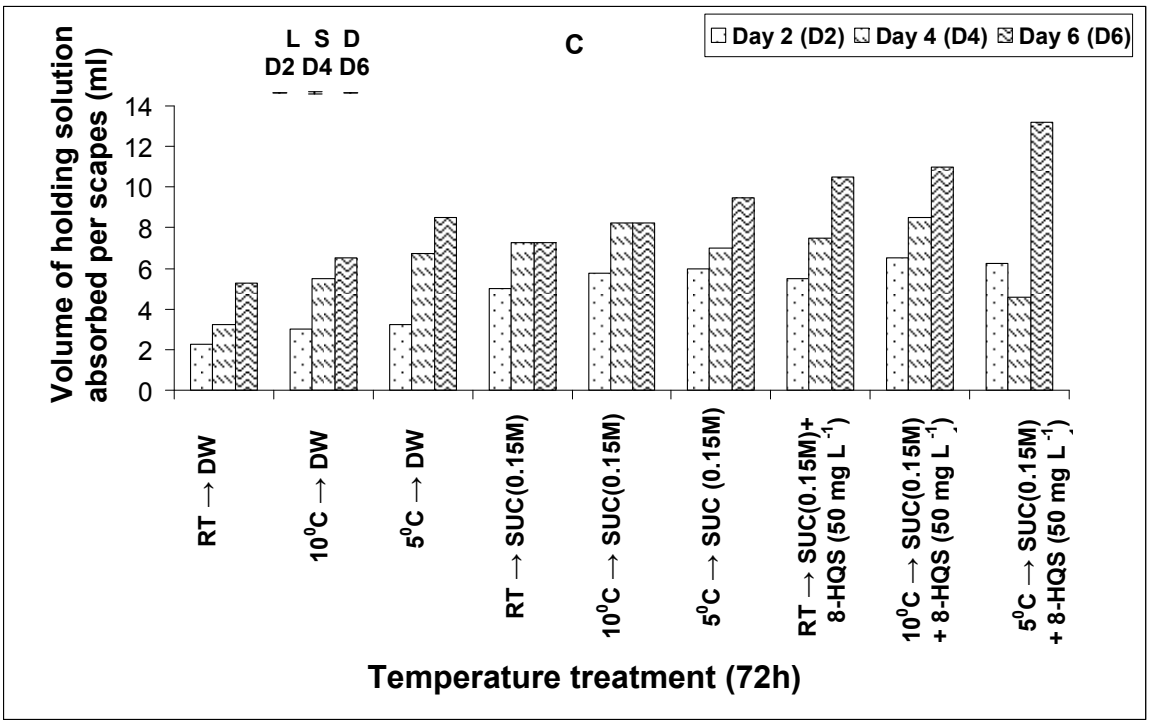

B
L S D
D0 D1 D2 D3 D4
H
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
Day 5 (D5)
No. of blooms per scapes
6
5
4
3
2
1
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC(0.15M)
10⁰C → SUC(0.15M)
5⁰C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC(0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

Fig. 5.2.1

Fig. 5.2.2

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$


C
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scapes (ml)
0
2
4
6
8
10
12
14
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M)+ 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

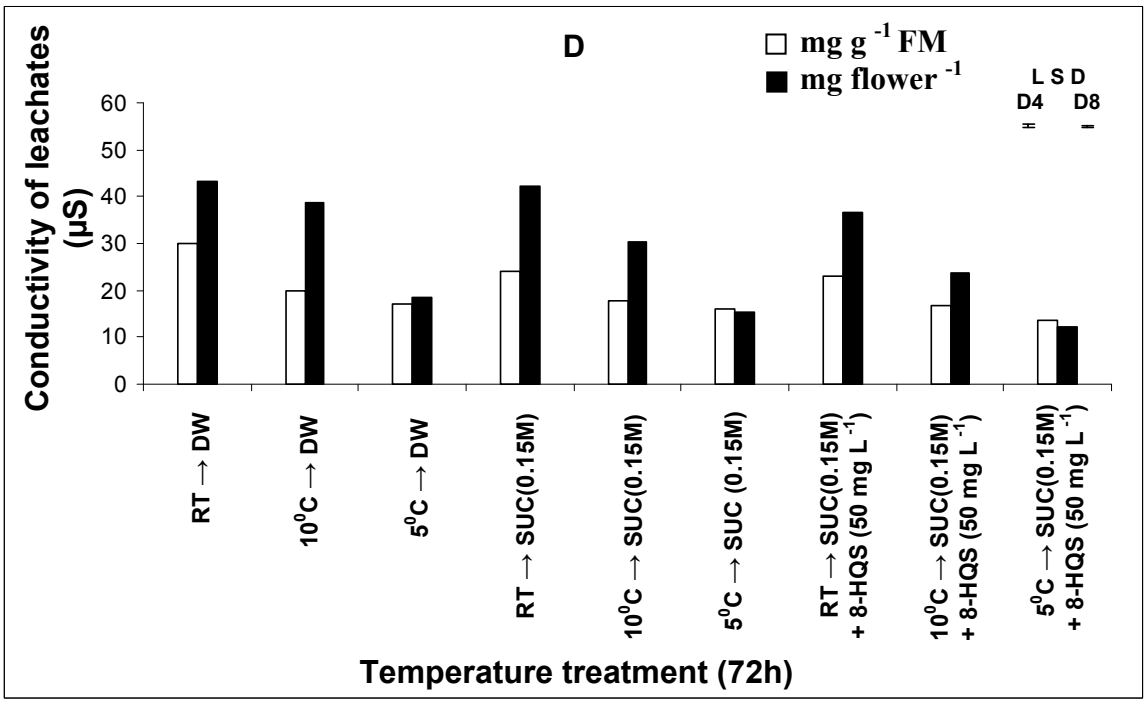
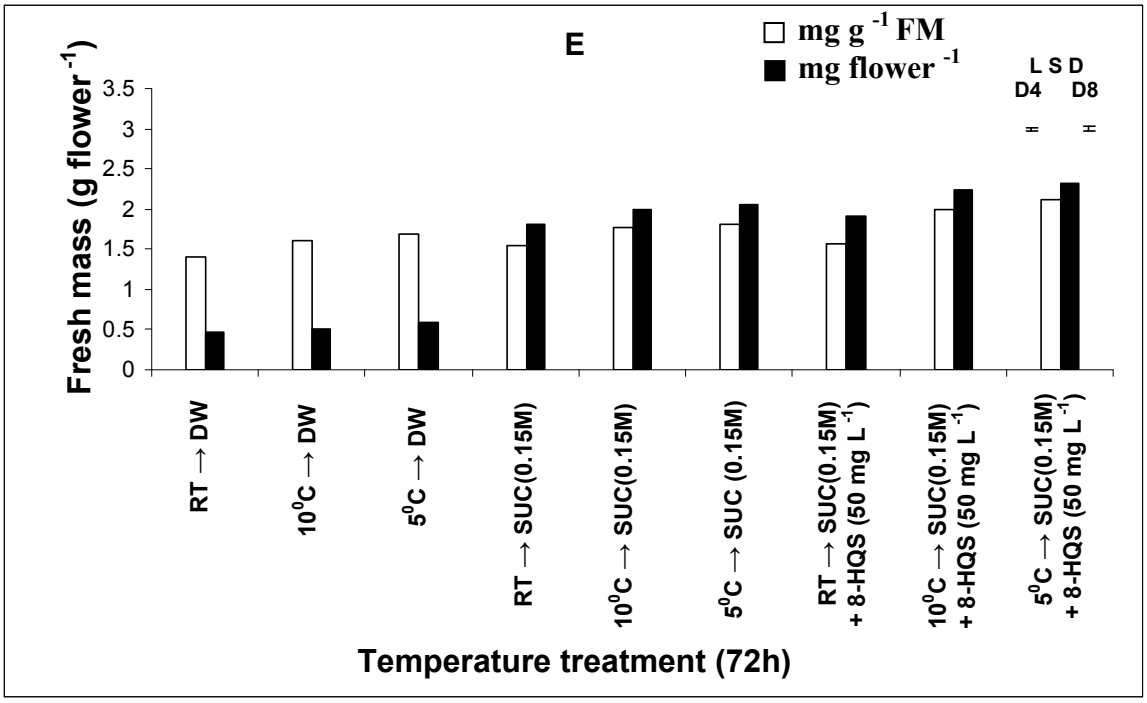

D
mg g -1 FM
mg flower -1
L S D
D4 D8
Conductivity of leachates (µS)
0
10
20
30
40
50
60
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 5.2.2

Fig.5.2.3

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05.}$


E
mg g -1 FM
mg flower -1
L S D
D4 D8
Fresh mass (g flower -1)
3.5
3
2.5
2
1.5
1
0.5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

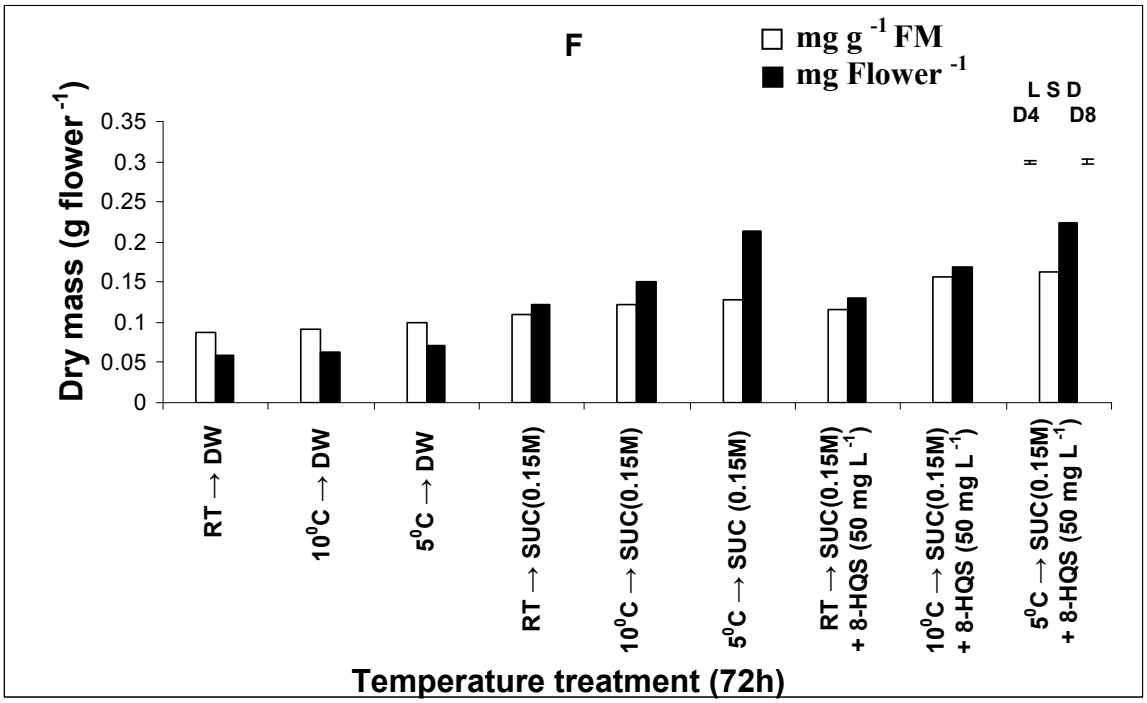
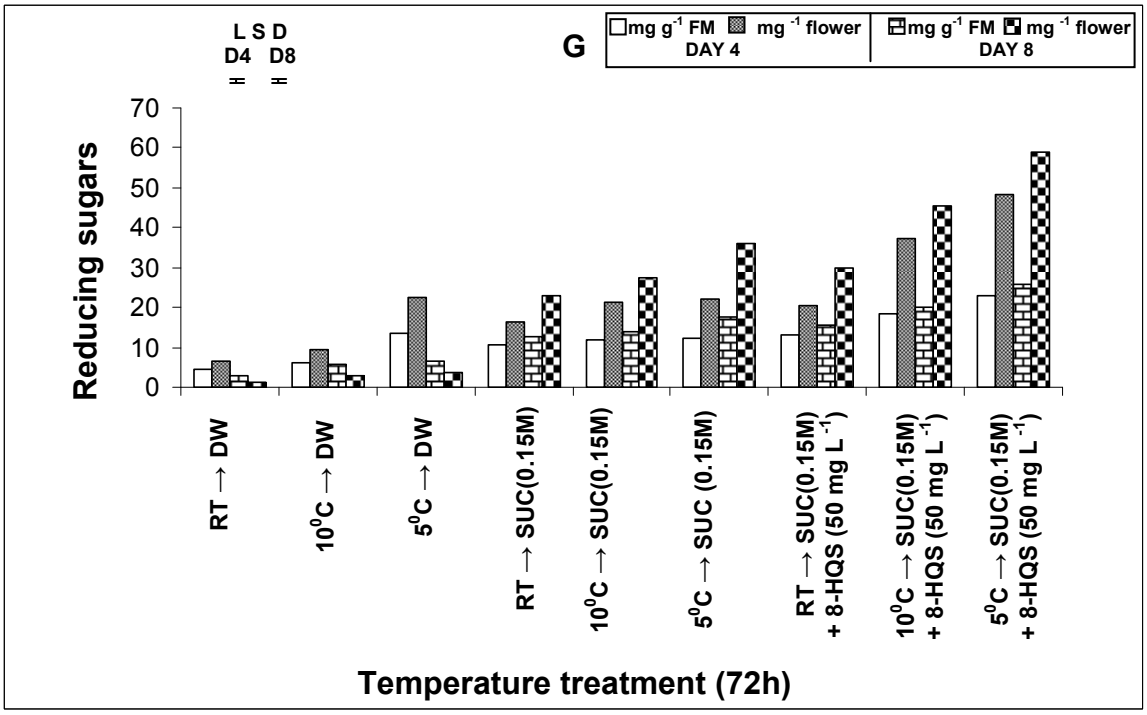

F
mg g -1 FM
mg Flower -1
L S D
D4 D8
Dry mass (g flower -1)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L -1)
10°C → SUC(0.15M) + 8-HQS (50 mg L -1)
5°C → SUC(0.15M) + 8-HQS (50 mg L -1)
Temperature treatment (72h)

Fig. 5.2.3

Fig. 5.2.4

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$.


G
L S D
D4 D8
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
Reducing sugars
70
60
50
40
30
20
10
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

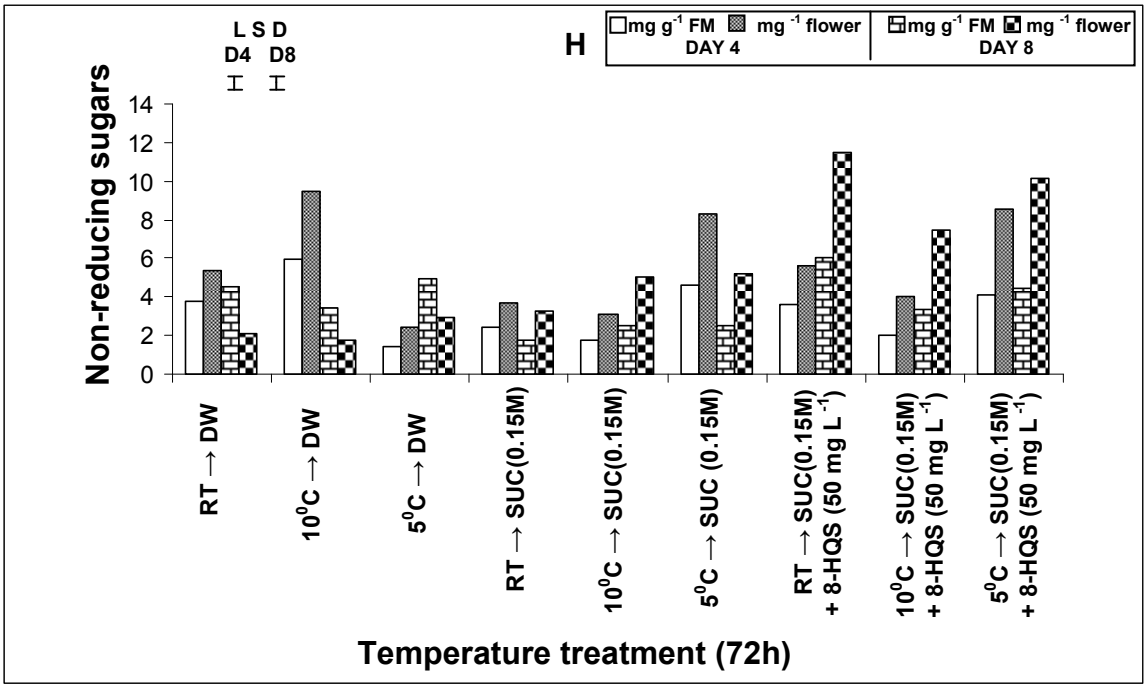
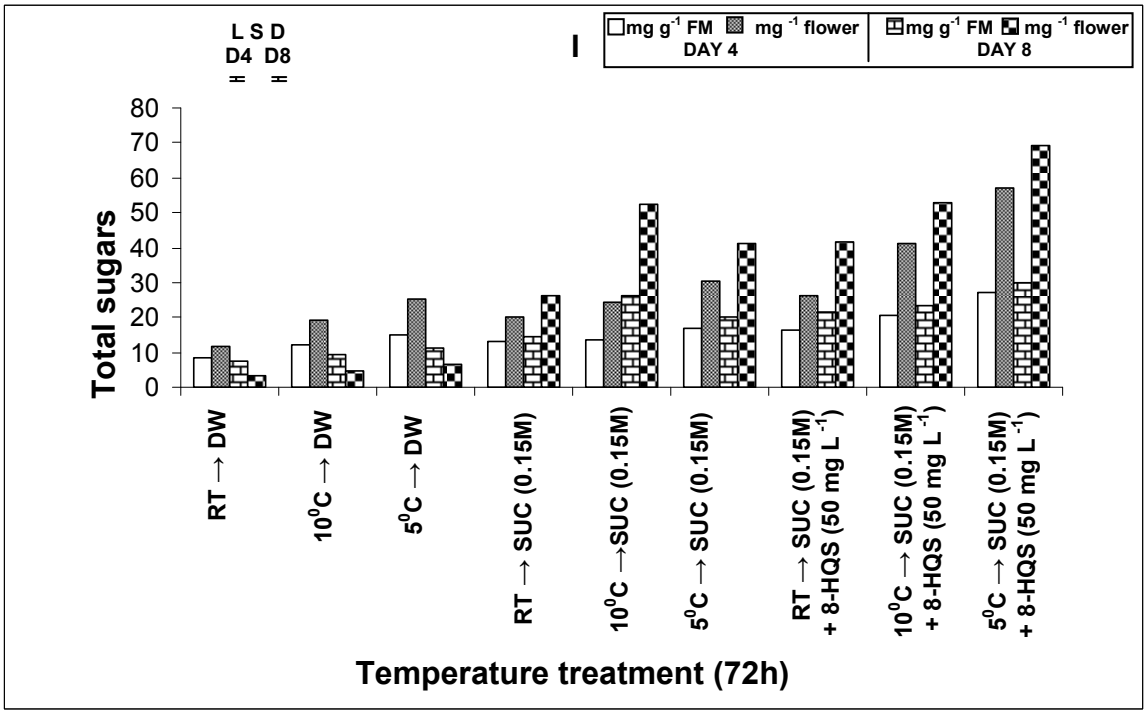

H
L S D
D4 D8
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
Non-reducing sugars
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 5.2.4

Fig. 5.2.5

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05.}$


L S D
D4 D8
I
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
Total sugars
80
70
60
50
40
30
20
10
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C →SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

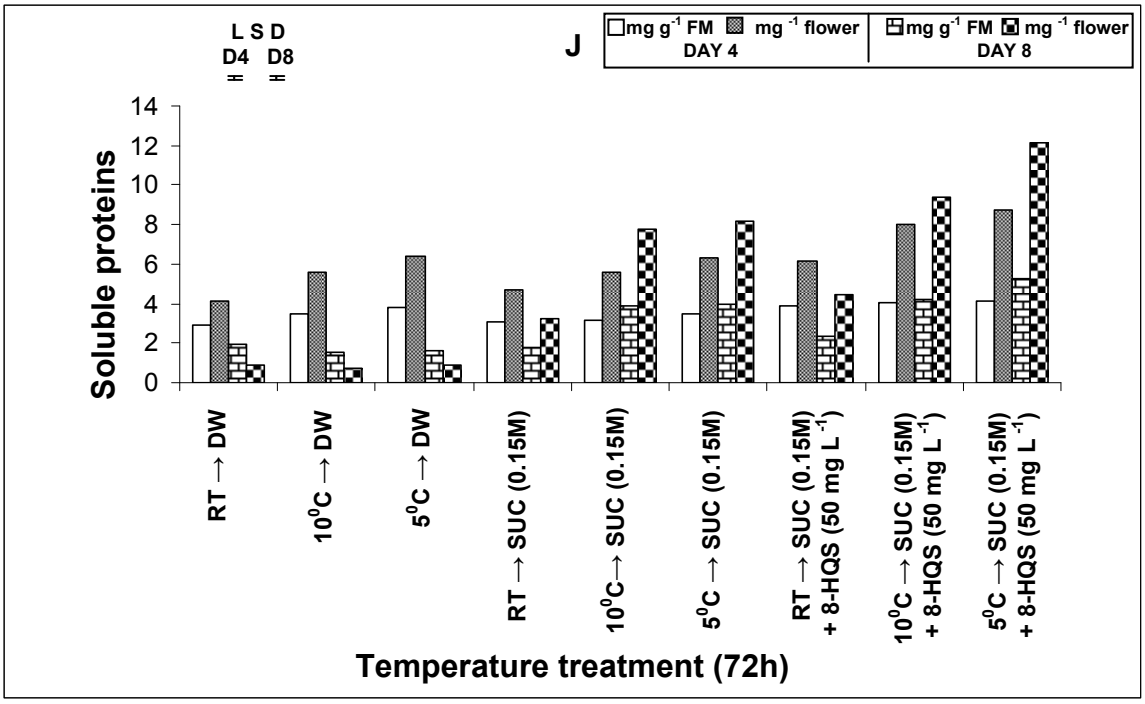
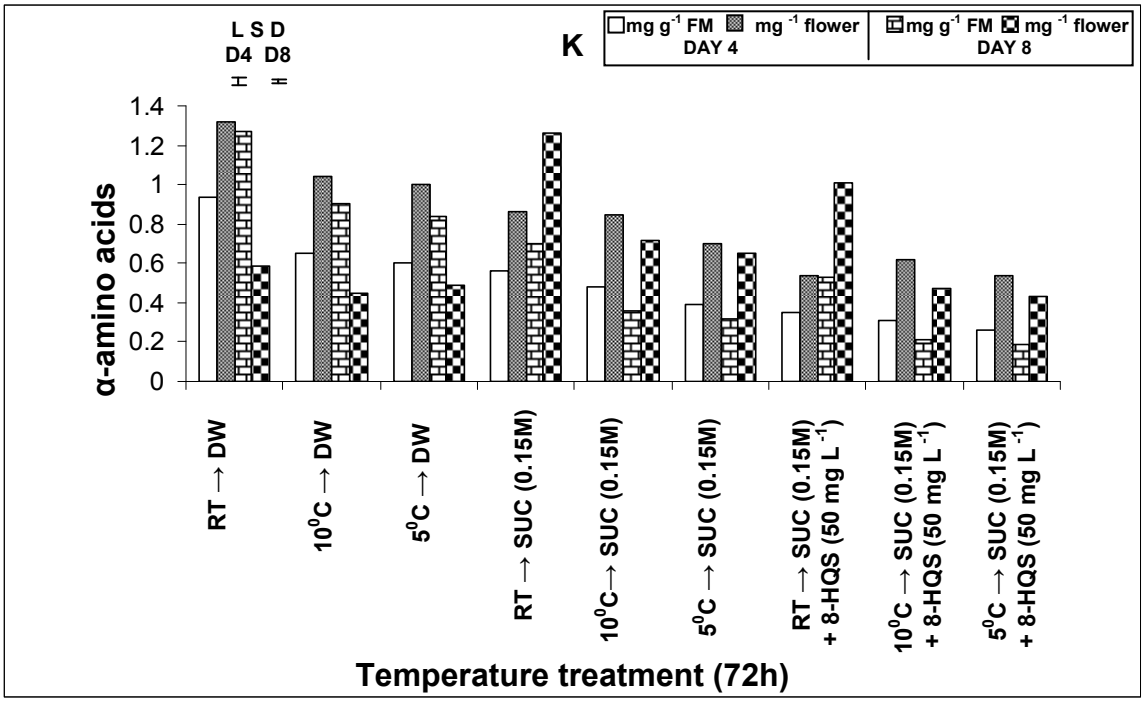

L S D
D4 D8
J
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
Soluble proteins
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 5.2.5

Fig. 5.2.6

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea

Vertical bars represent LSD at $P_{= 0.05.}$


K
L S D
D4 D8
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
α-amino acids
1.4
1.2
1
0.8
0.6
0.4
0.2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

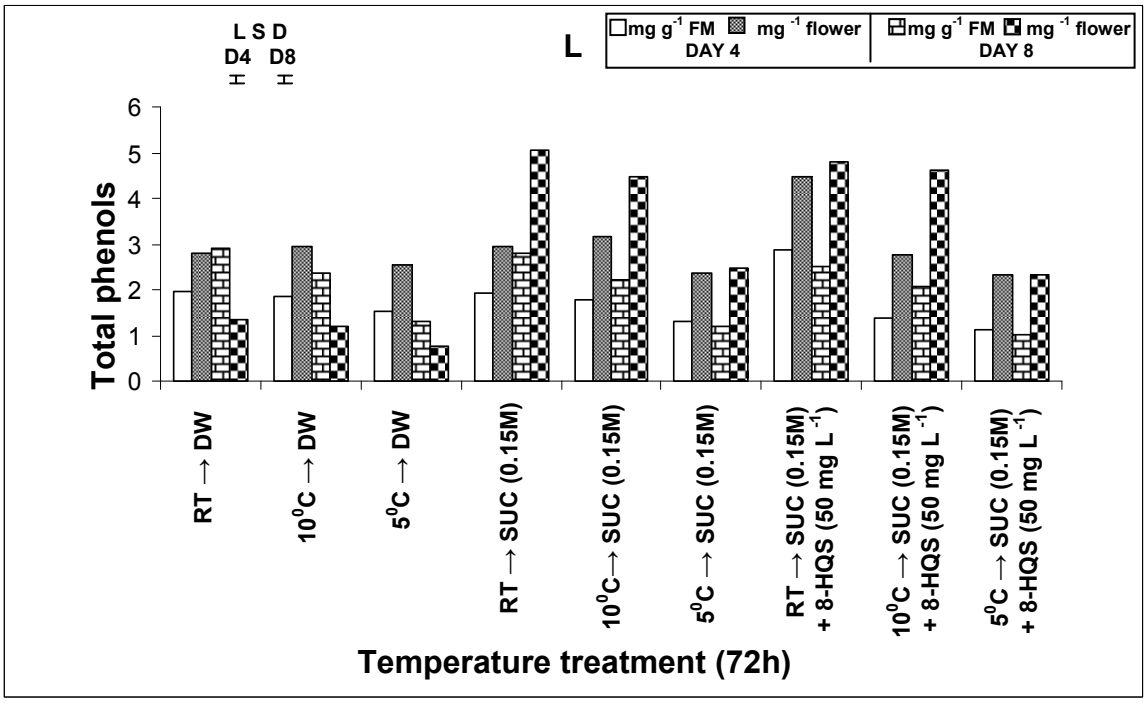

L
L S D
D4 D8
mg g-1 FM mg -1 flower
DAY 4
mg g-1 FM mg -1 flower
DAY 8
Total phenols
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 5.2.6

Plate 5.2.1

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Fig.: From left to right are arranged scapes after wet storage for 72 h held at, RT, 10^oC and 5^oC.

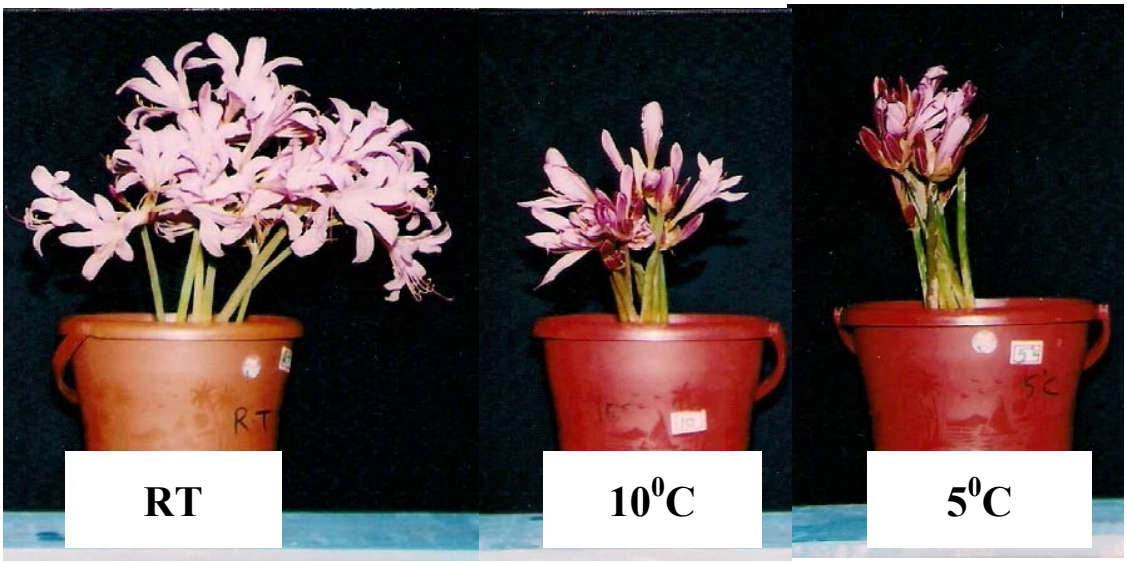


Plate. 5.2.1

Plate. 5.2.2

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (25 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

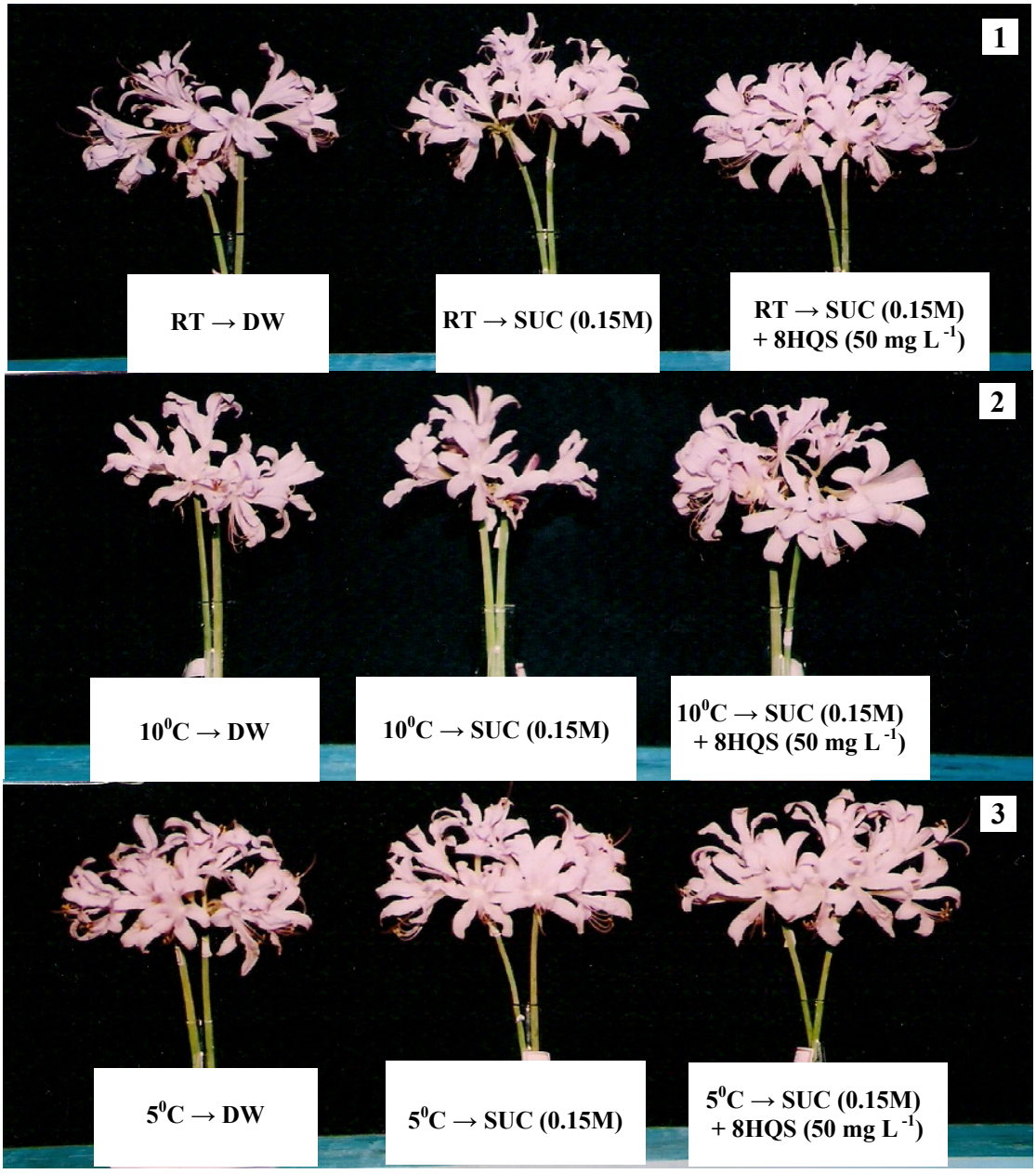

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M) + 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 5.2.2

Plate. 5.2.3

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (25 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

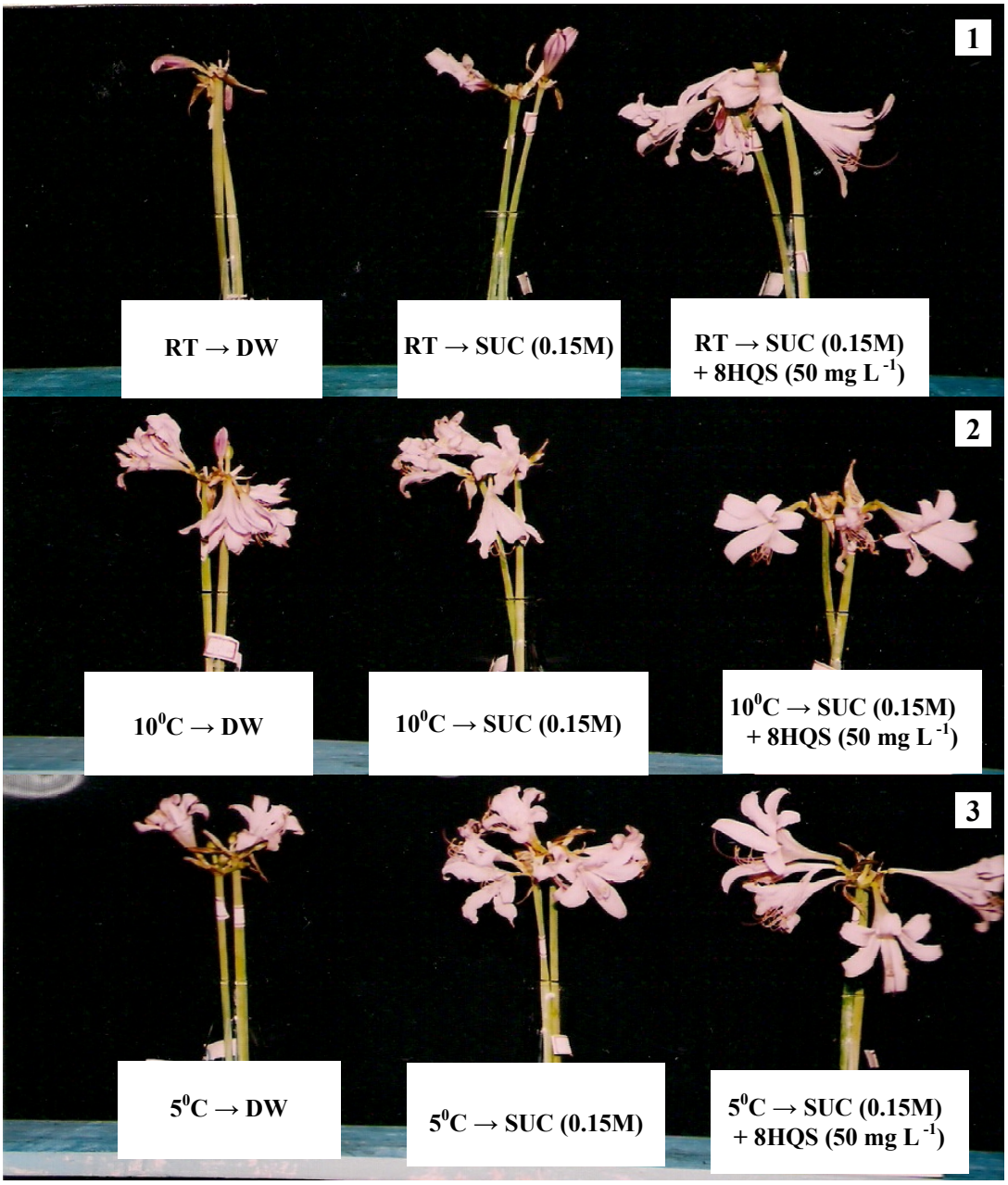

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M)
+ 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M)
+ 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
+ 8HQS (50 mg L -1)

Plate. 5.2.3

EXPERIMENT 5. 3

Effect of postharvest wet storage (PHWS) at different temperature regimes; 5, 10 and room temperature (RT=25 ± 2°C) for 24 h before transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on cut scapes of *Amaryllis belladonna* cv. Rosea.

Experimental

Scapes of *A. belladonna* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in distilled water (DW) in separate buckets and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (RT =25 ± 2^{o}C). After 24 h the scapes were recut to a scape length of 27 cm. After storage for 24 h all the scapes were kept at room temperature after transferring them to 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC (0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to a particular holding solution and was assessed to be terminated when 70 % flowers had senesced which was characterized by loss of turgor followed by wilting of tepals. Number of blooms per scape was recorded up to day 4 of the transfer. Volume of holding solutions absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Electrical conductivity of leachates form tepal discs, fresh and dry mass of flowers were recorded on day 4 and day 8 of transfer

of scapes to holding solutions. Changes in tissue constituents comprising sugar fractions, soluble proteins, α- amino acids and phenolics were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes wet stored for 24 h at RT had already bloomed during the storage and senesced by day 3 of the transfer (Plate. 5.3.1). Blooming during storage was least in the scapes previously wet stored at 5 and 10 ^{o}C before transfer to holding solutions and showed tepal senescence on the day 8 and 5 of transfer to a particular holding solution (Plate. 5.3.2, Figs.1-3). Senescence was assessed when 70% of flower had lost their display value which was characterized by turgor loss followed by wilting of tepals (Plate.5.3.3, Figs 1-3).

Vase life: The average vase life of scapes previously wet stored at various temperature regimes i.e. RT, 10 and 5^{o}C for 24 h before transfer to DW was 3, 4 and 4 days respectively; whereas the vase life of the corresponding scapes wet stored at RT, 10 and 5^{o}C before transfer to SUC was 4, 4 and 5 days respectively. The maximum vase life was recorded in scapes stored at of RT, 10 and 5^{o}C before transfer to SUC+8-HQS was 4, 5 and 6 days respectively (Table 5.3.1; Text Fig.5.3.1, A).

Number of blooms per scape: The number of blooms per scape as also the percent blooming increased in all treatments with the progression in time irrespective of transfer to various holding solutions. The scapes previously wet stored at RT for 24 h exhibited 100 percent blooming by day 2 of the transfer of scapes in SUC or SUC+8-HQS and by day 3 of transfer in DW. The scapes previously wet stored at 10^{o}C for 24 h generally exhibited maximum blooming up to day 3 of transfer to DW or SUC +8-HQS and by day 4 of transfer in SUC. Maximum and sustained blooming up to day 4 was

particularly recorded in scapes wet stored at 5^{o}C particularly in SUC+8-HQS (Table 5.3.1; Text Fig. 5.3.1, B).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression from day 2 to 6 of transfer of scapes to various holding solutions irrespective of the particular temperature regime and holding solution. The solution uptake was found to be higher in scapes previously wet stored for 24 h at 5 and 10 °C as compared to the corresponding scapes held at RT irrespective of the holding solution. A higher solution uptake was recorded in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment however maximum solution uptake was noticed in scapes previously wet stored at 5°C for 24 h and transferred to (SUC + 8-HQS) (Table 5.3.1; Text Fig. 5.3.2, C).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. The concentration of leachates significantly increased in samples from scapes previously wet stored at RT and 10°C, however the least conductivity of leachates was maintained in samples from scapes wet stored for 24 h at 5 °C irrespective of the transfer to various holding solutions. At each temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8 - HQS followed by scapes held in SUC as compared to samples from corresponding scapes held in DW (Table 5.3.2; Text Fig. 5.3.4, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously wet stored for 24 h at 5 and 10 °C registered an increase with progression in time from day 4 to day 8, whereas the samples from scapes wet stored at RT registered a decrease over the period of time from day 4 to day 8. At each of the temperature regimes both fresh and dry mass

was found to be the highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW, however maximum value for fresh and dry mass was recorded in samples from scapes previously wet stored at 5°C for 24 h and transferred to SUC + 8-HQS (Table 5.3.2; Text Fig. 5.3.3, E & F).

Reducing sugars: The reducing sugar content of the samples form scapes previously wet stored for 24 h before transfer to SUC + 8-HQS and SUC registered an increase with progression in time from day 4 to 8, whereas the reducing sugar content of samples from the corresponding scapes held in DW decreased over the period of time irrespective of the temperature treatment. The reducing sugar content of samples from scapes previously wet stored for 24h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.3.3; Text Fig. 5.3.4, G). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass basis but the differences showed up clearly on these particular reference bases (Tables 5.3.4 & 5.3.4). Maximum reducing sugar content was noticed in samples from scapes wet stored at 5 °C for 24 h and transferred to SUC +8-HQS.

Non-reducing sugars: The non-reducing sugar content of samples form scapes previously wet stored for 24 h in SUC + 8-HQS and SUC registered an increase with progression in time from day 4 to 8, whereas the non-reducing sugar content of samples from the scapes held in DW decreased, over the period of time. The non-reducing sugar content of samples from scapes previously wet stored at RT and held in DW and SUC registered a decrease as compared to the samples from corresponding scapes held in SUC + 8-HQS over the period of time. The non-reducing sugar content of scapes

from the samples of scapes wet stored at 10 and 5°C registered an increase when held in SUC and SUC + 8-HQS, whereas the non-reducing sugar content of the corresponding scapes held in DW decreased. However, at each of the temperature regimes, the non-reducing sugar content was generally found to be the highest in samples form scapes held in SUC+8-HQS followed by SUC as compared to corresponding scapes held in DW (Table 5.3.3; Text Fig. 5.3.4, H). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis but the differences were sharp and apparent (Tables 5.3.3 & 5.3.4). Maximum non-reducing sugar content was noticed in samples from scapes wet stored at 5°C for 24 h and transferred to SUC +8-HQS.

Total sugars: The total sugar content of samples form scapes previously wet stored for 24 h in SUC + 8-HQS and SUC registered a marked increase with progression in time from day 4 to 8 of transfer of scapes irrespective of the previous temperature temperature. However, the total sugar content decreased in the samples from corresponding scapes held in DW over a period of time. The total sugar content of samples from scapes previously wet stored at RT and held in DW and SUC registered a decrease as compared to the samples from corresponding scapes held in SUC + 8-HQS over the period of time. The total sugar content of the samples from the scapes wet stored at 10 and 5°C registered an increase when held in SUC and SUC + HQS, whereas the total sugar content of the corresponding scapes held in DW decreased. The total sugar content of samples from scapes previously wet stored for 24 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the total sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.2.3; Text Fig. 5.3.5, I). Almost similar trends were obtained when the data was expressed on per

flower basis and dry mass basis but the differences showed up clearly on these particular reference bases (Table 5.3.4). Maximum total sugar content was noticed in samples from scapes wet stored at 5°C for 24 h and transferred to SUC +8-HQS.

Soluble proteins: The soluble protein content of samples form scapes previously wet stored for 24 h at 10 and 5°C held in SUC + 8-HQS and SUC registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the corresponding scapes held at RT in DW over a period of time. The soluble protein content of samples from scapes previously wet stored for 24 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the soluble protein content was found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 5.3.5; Text Fig. 5.3.5, J). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases but the differences showed up clearly on these particular reference bases (Tables 5.3.5 & 5.3.6). Maximum soluble protein content was noticed in samples from scapes wet stored at 5°C for 24 h and transferred to SUC +8-HQS.

α- amino acids: The amino acid content of samples form scapes previously wet stored for 24 h at RT and 10°C before transfer to DW and SUC generally registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the corresponding scapes held at 10 and 5°C in SUC+ 8-HQS which registered a decrease. The amino acid content of samples from scapes previously wet stored for 24 h at 5 and 10°C registered a decrease as compared to the samples from corresponding scapes held at RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the amino acid content was found to be highest in

samples from scapes held in DW followed by SUC as compared to the corresponding scapes held in SUC+8-HQS (Table 5.3.5; Text Fig. 5.3.6, K). Similar trends were obtained when the data was expressed on per flower basis but the differences showed up clearly on these particular reference bases (Table 5.3.6). On dry mass basis the amino acid content was more or less maintained in the samples from scapes stored at various temperature regimes before transfer to SUC +8-HQS; in samples from scapes transferred to SUC the amino acid content registered a decrease over the period of time whereas, as in the samples form scapes held in DW amino acid content increased in progression with time from day 4 to day 8 of the transfer of scapes to various holding solutions (Table 5.3.6). Lowest content of amino acids was noticed in samples from scapes stored wet at 5^{o}C for 24 h and transferred to SUC + 8-HQS.

Total phenols: The content of total phenols from scapes previously wet stored at RT and 10^{o}C held in DW and SUC registered an increase with progression in time from day 4 to 8 of transfer of scapes as compared to the corresponding scapes held at 10 and 5°C in SUC + 8-HQS over a period of time. A lower content of phenols was registered in samples from scapes previously wet stored at 5 and 10°C for 24 h as compared to the samples from scapes held at RT. (Table 5.3.5; Text Fig. 5.3.6, L). Almost similar trends were obtained when the data was expressed on per flower and on dry mass basis but the differenced showed up clearly on these particular reference bases (Table 5.3.6).

Table 5.3.1: Effect of postharvest wet storage (PHWS) for 24 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Amaryllis belladonna* cv. Rosea.

Temperature treatment (72h)	Vase life (days)	No. of blooms per scape					Volume of holding solution absorbed per scape (ml)		
		Days after treatment							
		0	1	2	3	4	2	4	6
RT→DW	3	0.75 (12)	1.50 (25)	2.50 (41)	4.50 (75)	6.00 (100)	1.75	3.00	4.00
10 °C→DW	4	-	1.50 (20)	4.08 (59)	5.25 (80)	6.75 (100)	3.25	5.75	7.00
5 °C →DW	4	-	0.75 (7.00)	4.00 (46)	5.75 (82)	6.75 (100)	3.50	6.25	7.50
RT→SUC(0.15M)	4	0.75 (12)	2.00 (33)	3.75 (62)	6.00 (100)	-	2.00	3.00	4.50
10°C→SUC(0.15M)	4	-	1.25 (25)	3.25 (63)	5.25 (84)	6.25 (100)	3.00	4.75	5.75
5°C→SUC(0.15M)	5	-	0.50 (11)	3.25 (57)	5.25 (87)	7.00 (100)	3.25	5.50	7.25
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	4	0.75 (12)	1.25 (36)	1.75 (65)	3.00 (93)	5.75 (100)	2.75	4.25	5.50
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	5	-	1.00 (29)	4.00 (72)	6.00 (96)	6.25 (100)	3.75	5.75	6.25
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	6	-	0.25 (15)	3.75 (60)	6.25 (92)	6.50 (100)	4.50	7.25	8.25
LSD at $P_{=0.05}$	0.27	-	0.07	0.08	0.05	-	0.12	0.56	0.89

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Figures in parentheses represent percent blooms.

Table: 5.3.2: Effect of postharvest wet storage (PHWS) for 24 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(24h)	Conductivity of leachates (µS)		Fresh mass (g flower^{-1})		Dry mass (g flower^{-1})	
	Days after treatment					
	4	8	4	8	4	8
RT→DW	19.62	21.35	1.54	0.540	0.120	0.046
10 °C→DW	10.66	12.16	1.68	1.32	0.126	0.070
5 °C →DW	8.46	8.52	1.73	1.42	0.139	0.105
RT→SUC(0.15M)	14.73	19.03	1.70	1.91	0.133	0.157
10°C→SUC(0.15M)	9.72	10.66	1.92	2.11	0.160	0.195
5°C→SUC(0.15M)	7.76	6.52	2.13	2.39	0.167	0.216
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	12.93	17.46	1.85	2.19	0.149	0.187
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	8.12	9.81	2.03	2.32	0.165	0.205
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	6.76	5.91	2.29	2.72	0.173	0.237
LSD at $P_{=0.05}$	0.23	0.59	0.13	0.66	0.009	0.11

Each value is a mean of 5 independent replicates.

Room temperature (RT)= (25±2^{o}C).

Table 5.3.3: Effect of postharvest wet storage (PHWS) for 24 h at different temperature regimes on sugar fractions, expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Reducing Sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	8.00 (12.32)	6.93 (3.74)	4.41 (6.79)	2.71 (1.45)	12.41 (19.12)	9.63 (5.20)
10 °C→DW	9.91 (16.64)	7.73 (10.20)	7.16 (12.02)	3.59 (4.73)	17.07 (28.67)	11.32 (14.94)
5 °C →DW	11.51 (19.91)	10.07 (14.29)	7.01 (13.02)	6.46 (9.17)	18.52 (32.03)	16.53 (23.47)
RT→SUC(0.15M)	10.23 (17.39)	15.53 (29.66)	9.42 (15.98)	7.14 (13.63)	19.63 (33.37)	22.67 (43.29)
10°C→SUC(0.15M)	14.32 (27.49)	18.67 (39.39)	8.80 (16.89)	12.56 (26.50)	23.12 (44.39)	31.23 (65.89)
5°C→SUC(0.15M)	19.33 (41.17)	21.23 (50.73)	8.19 (17.44)	10.84 (25.90)	27.52 (58.61)	32.07 (76.64)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	22.27 (42.03)	26.32 (57.64)	3.81 (7.04)	5.31 (11.62)	26.08 (48.24)	31.63 (69.26)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	24.37 (49.47)	28.32 (65.70)	4.94 (10.02)	8.61 (19.97)	29.31 (59.44)	36.93 (85.67)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	26.67 (61.07)	30.43 (82.76)	8.66 (19.83)	12.24 (33.29)	35.33 (80.90)	42.67 (116.06)
LSD at $P_{=0.05}$	1.24	0.66	0.52	0.37	1.14	1.36

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25±2°C).

Figures in parentheses represent value on mg $flower^{-1}$ basis.

Table 5.3.4: Effect of postharvest wet storage (PHWS) for 24 h at different temperature regimes on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv.Rosea.

Temperature treatment(72h)	Reducing sugars		Non-reducing sugars		Total Sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	102.73	81.35	56.63	31.71	159.40	113.11
10 °C→DW	132.13	145.76	95.47	67.70	227.64	213.50
5 °C →DW	143.25	136.18	87.25	87.36	230.56	223.55
RT→SUC(0.15M)	130.75	188.93	120.23	86.86	250.90	275.88
10°C→SUC(0.15M)	171.84	202.01	105.64	135.91	277.40	337.92
5°C→SUC(0.15M)	246.54	234.90	104.50	119.90	351.23	354.84
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	276.50	308.23	47.31	62.19	323.85	370.43
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	299.82	320.49	60.78	97.44	360.68	417.90
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	353.03	349.23	114.67	140.51	467.70	489.71
LSD at $P_{=0.05}$	0.65	0.29	0.81	0.53	0.64	0.44

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Table 5.3.5: Effect of postharvest wet storage (PHWS) for 24 h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g $^{-1}$ FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	2.33 (3.59)	2.16 (1.16)	0.81 (1.24)	0.92 (0.49)	3.13 (4.82)	4.53 (2.44)
10 °C→DW	2.91 (4.88)	2.66 (3.51)	0.60 (1.00)	0.86 (1.13)	2.63 (4.41)	4.07 (5.37)
5 °C →DW	3.16 (5.46)	3.02 (4.28)	0.55 (0.95)	0.60 (0.85)	1.97 (3.40)	3.83 (5.43)
RT→SUC(0.15M)	2.83 (4.81)	2.75 (5.25)	0.66 (1.12)	0.74 (1.41)	3.32 (5.64)	3.35 (6.39)
10°C→SUC(0.15M)	3.00 (5.76)	3.66 (7.72)	0.53 (1.01)	0.45 (0.94)	2.77 (5.31)	2.53 (5.33)
5°C→SUC(0.15M)	3.25 (6.92)	4.25 (10.15)	0.44 (0.93)	0.33 (0.78)	2.37 (5.04)	2.12 (5.06)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	3.33 (6.16)	3.08 (6.74)	0.41 (0.75)	0.44 (0.96)	3.71 (6.86)	3.33 (7.29)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	3.41 (6.92)	4.41 (10.23)	0.38 (0.77)	0.35 (0.81)	2.87 (5.82)	1.97 (4.57)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	3.58 (8.19)	5.16 (14.03)	0.30 (0.68)	0.27 (0.73)	2.53 (5.79)	1.43 (3.88)
LSD at $P_{=0.05}$	0.14	0.18	0.03	0.04	0.15	0.12

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^{o}C).

Figures in parenthesis represent value on mg flower^{-1} basis.

Table 5.3.6: Effect of post harvest wet storage (PHWS) for 24 h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g $^{-1}$ DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Temperature treatment(72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	29.92	25.36	10.41	10.80	40.19	53.18
10 °C→DW	38.80	50.16	8.23	16.22	35.07	76.75
5 °C →DW	39.33	40.84	6.84	8.11	24.52	51.80
RT→SUC(0.15M)	36.17	33.46	8.43	8.98	42.44	40.75
10°C→SUC(0.15M)	36.13	39.60	6.36	4.86	33.24	27.38
5°C→SUC(0.15M)	41.45	47.03	5.61	3.65	30.23	23.46
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	41.35	36.07	5.03	5.13	46.06	39.23
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	41.95	49.91	4.66	4,68	35.31	22.29
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	47.39	59.22	3.93	3.08	33.49	16.41
LSD at $P_{=0.05}$	0.44	0.36	0.89	0.67	0.91	0.25

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25±2 °C).

Fig. 5.3.1

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$

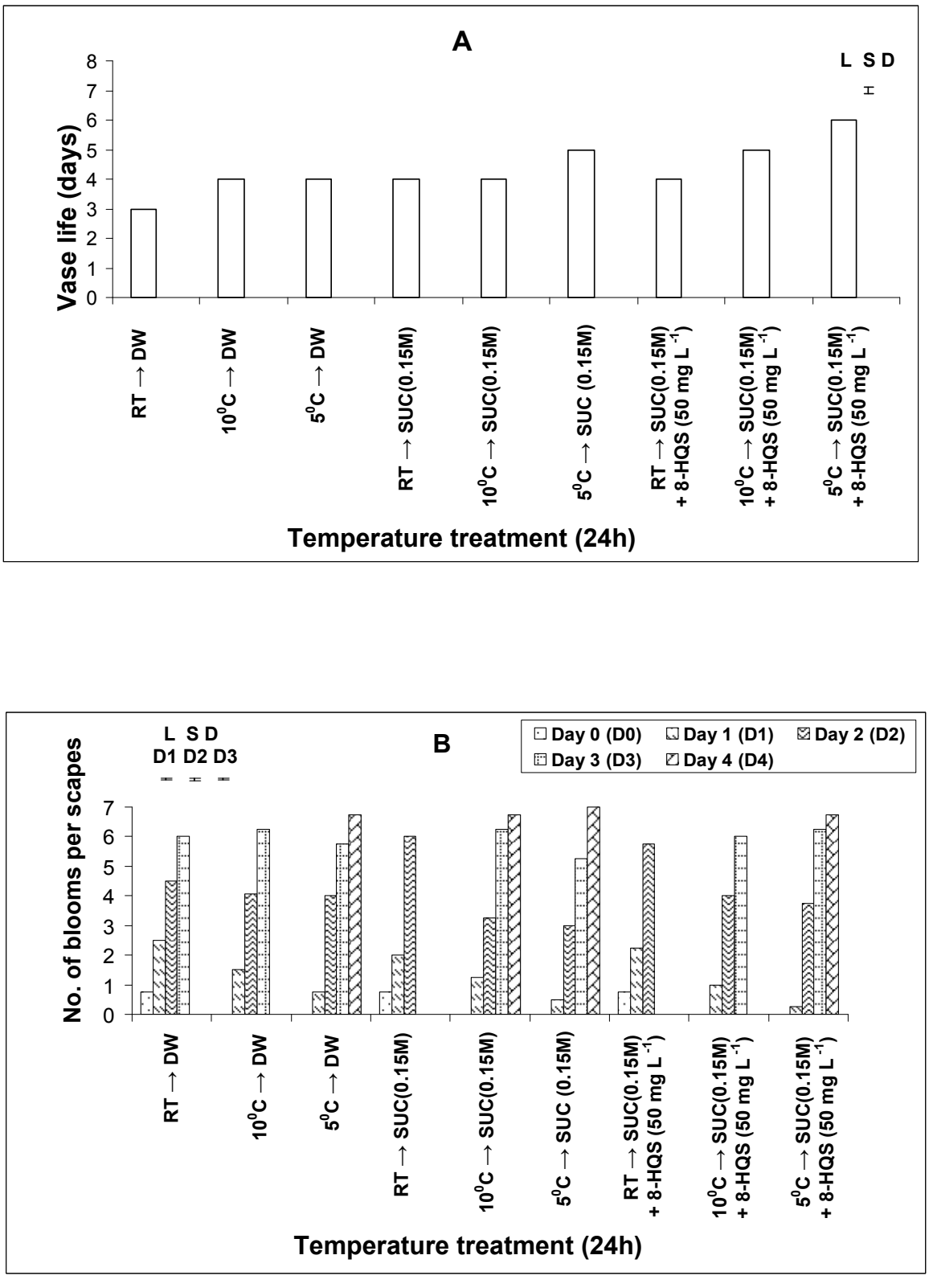
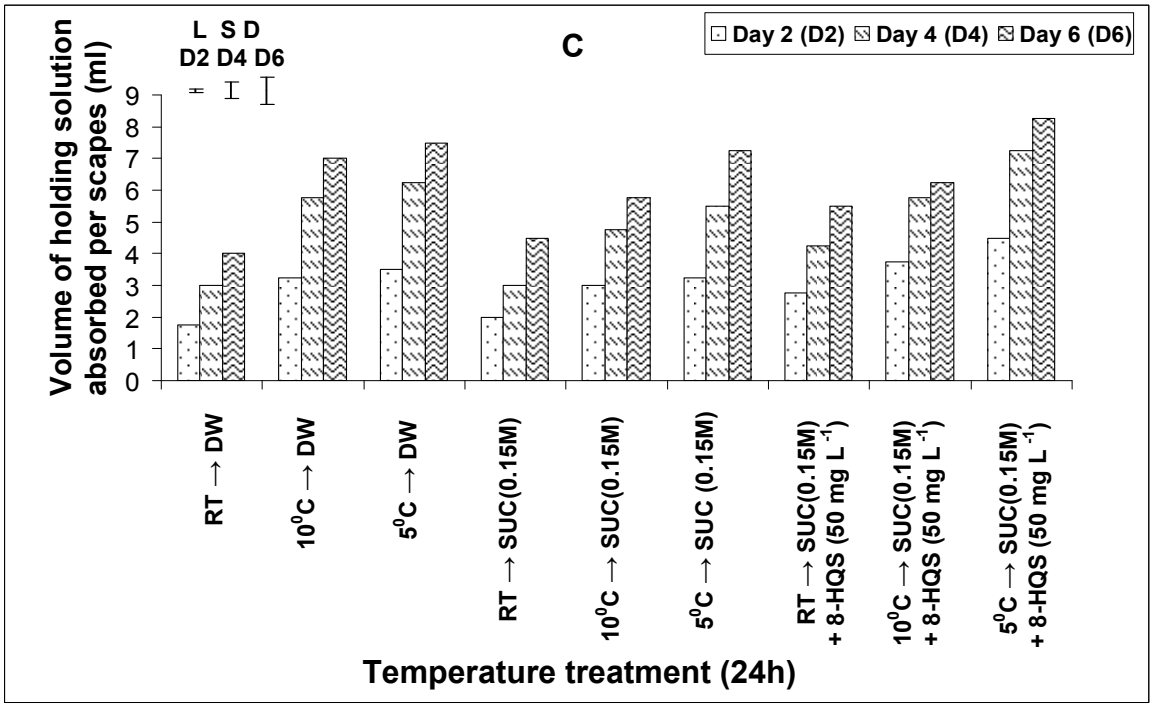

A
L S D
Vase life (days)
0
1
2
3
4
5
6
7
8
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)
B
L S D
D1 D2 D3
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
No. of blooms per scapes
0
1
2
3
4
5
6
7
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.1

Fig. 5.3.2

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scapes (ml)
0
1
2
3
4
5
6
7
8
9
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

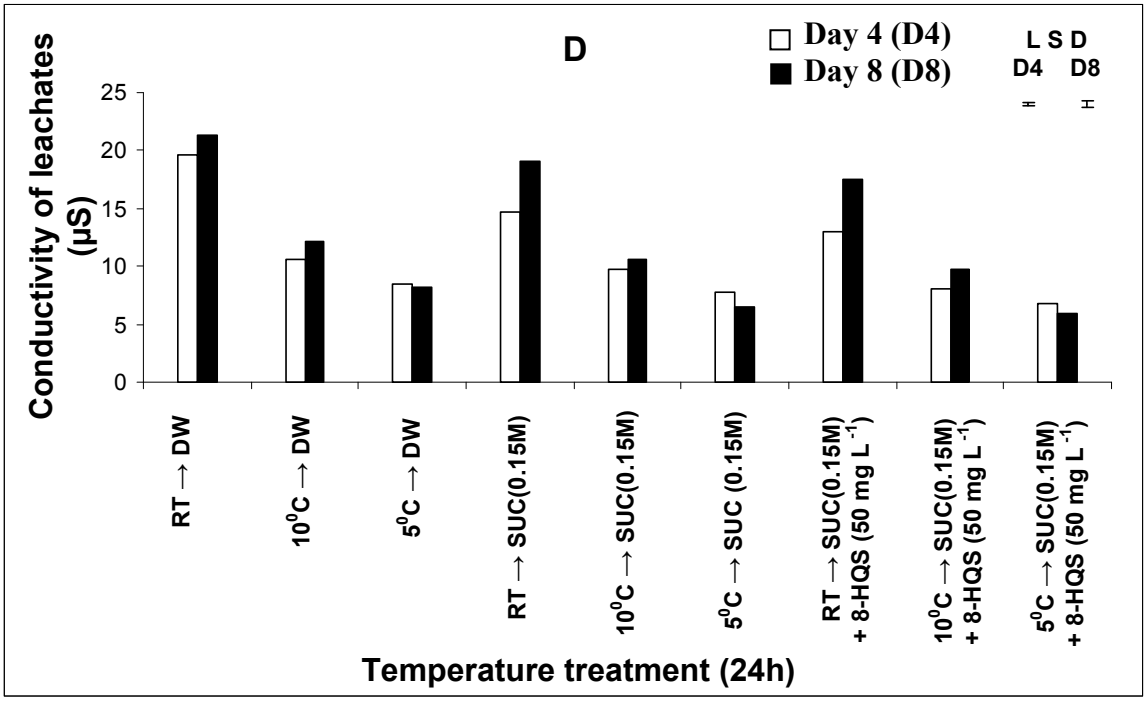
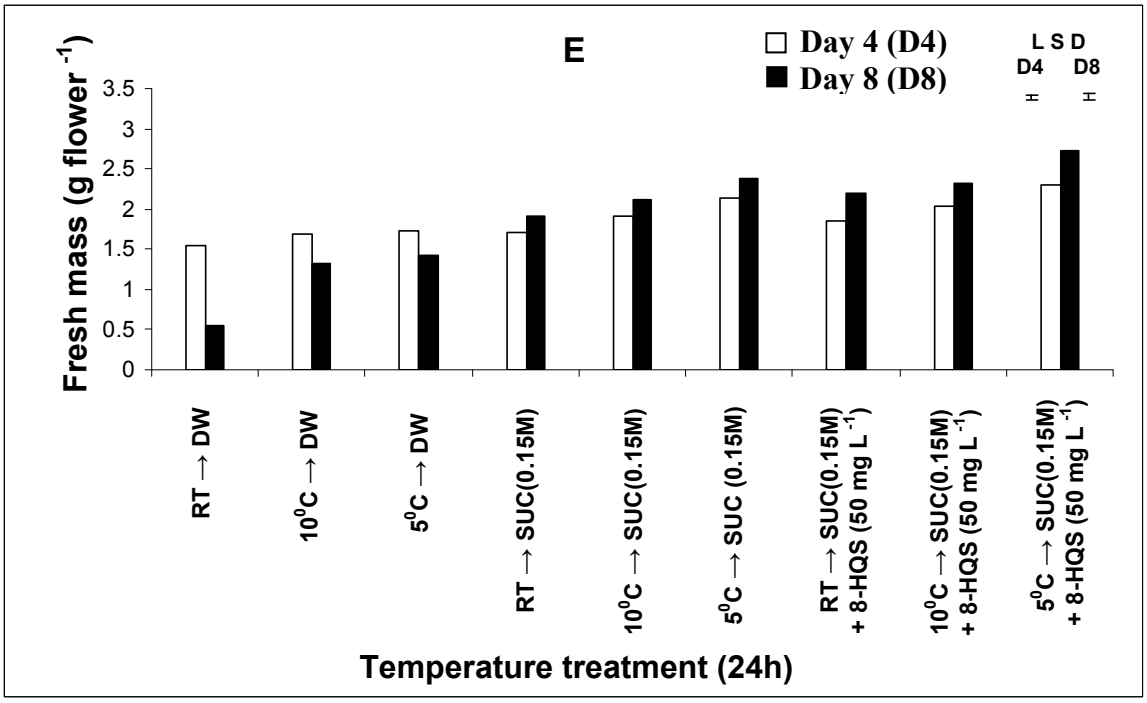

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.2

Fig.5.3.3

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Fresh mass (g flower -1)
3.5
3
2.5
2
1.5
1
0.5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

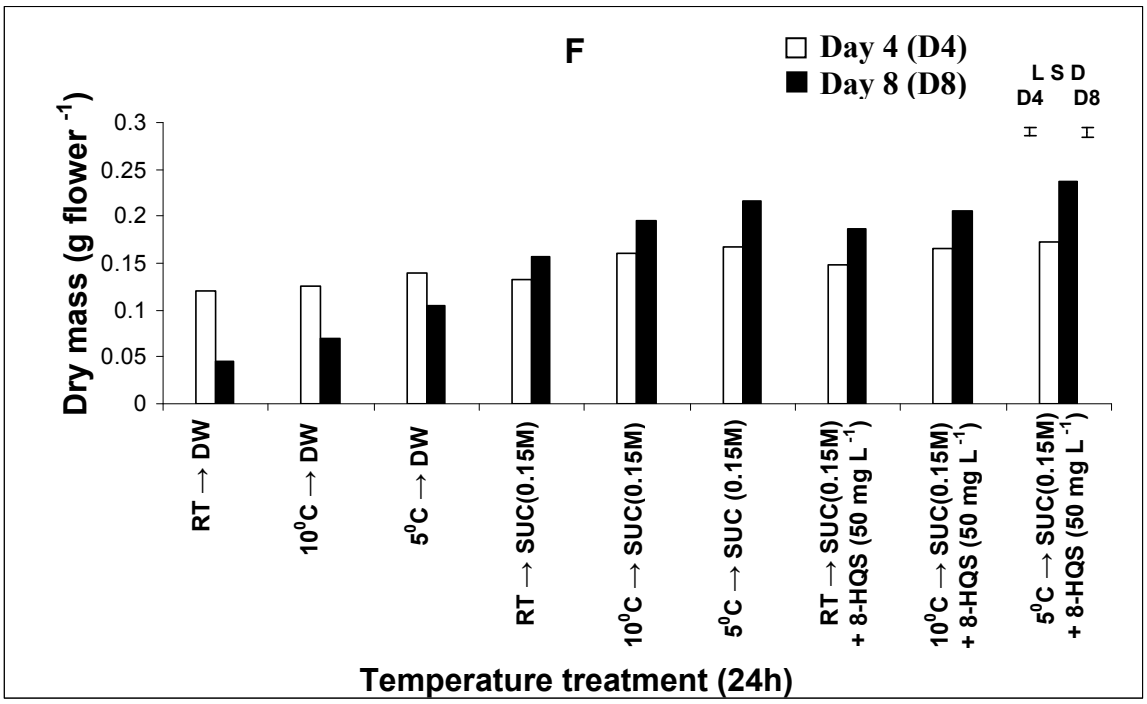
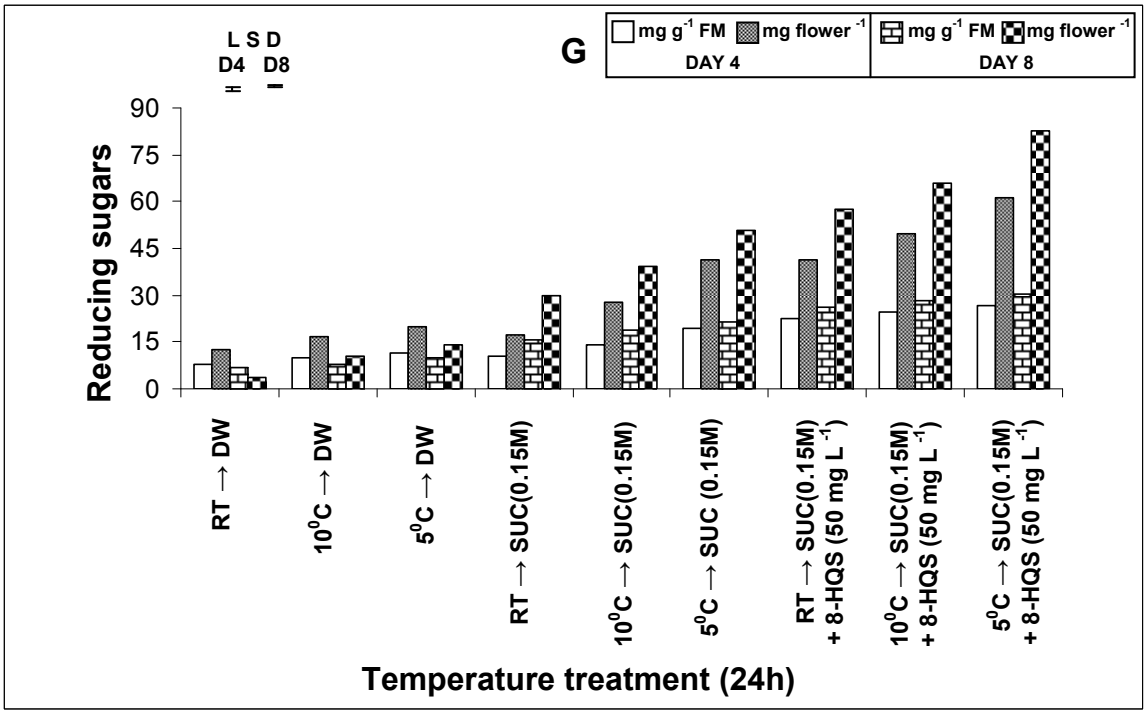

F
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Dry mass (g flower -1)
0.3
0.25
0.2
0.15
0.1
0.05
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.3

Fig. 5.3.4

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$.


G
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Reducing sugars
90
75
60
45
30
15
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

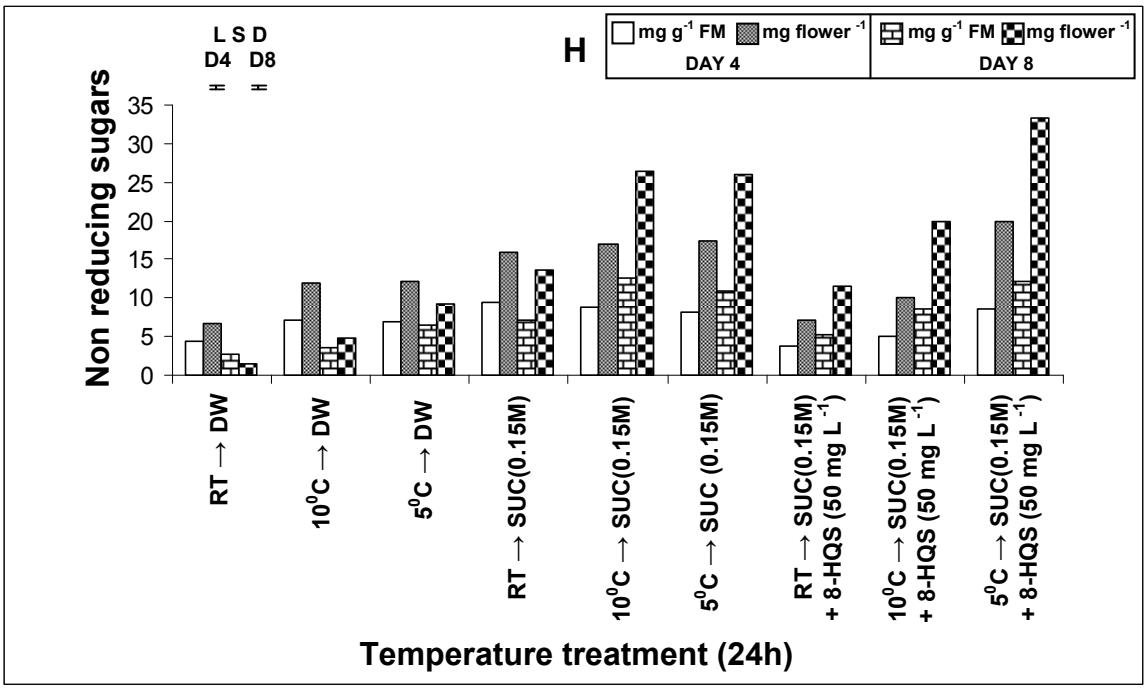
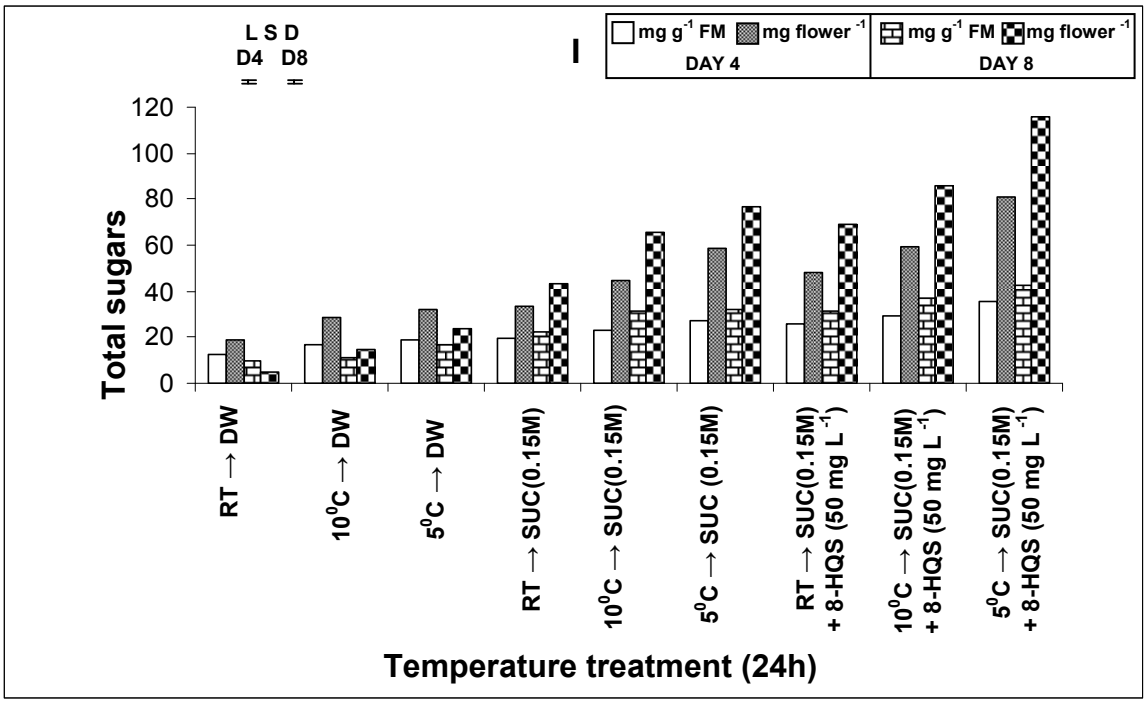

H
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Non reducing sugars
35
30
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.4

Fig. 5.3.5

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea

Vertical bars represent LSD at $P_{= 0.05.}$


I
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total sugars
120
100
80
60
40
20
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

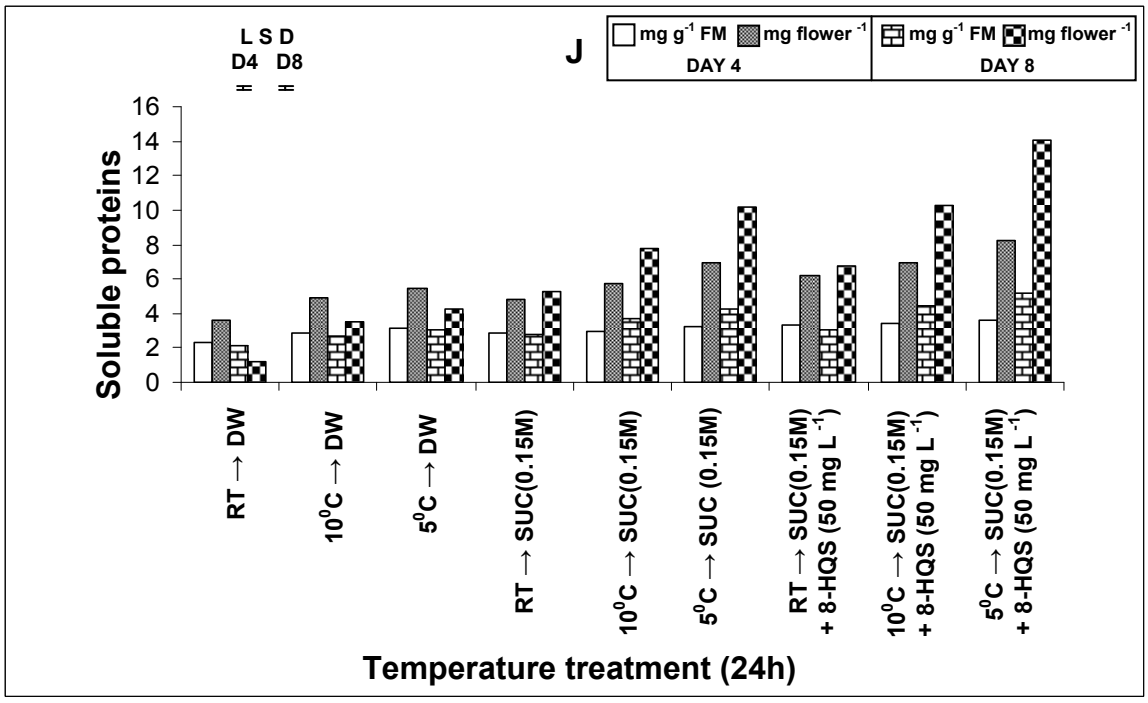
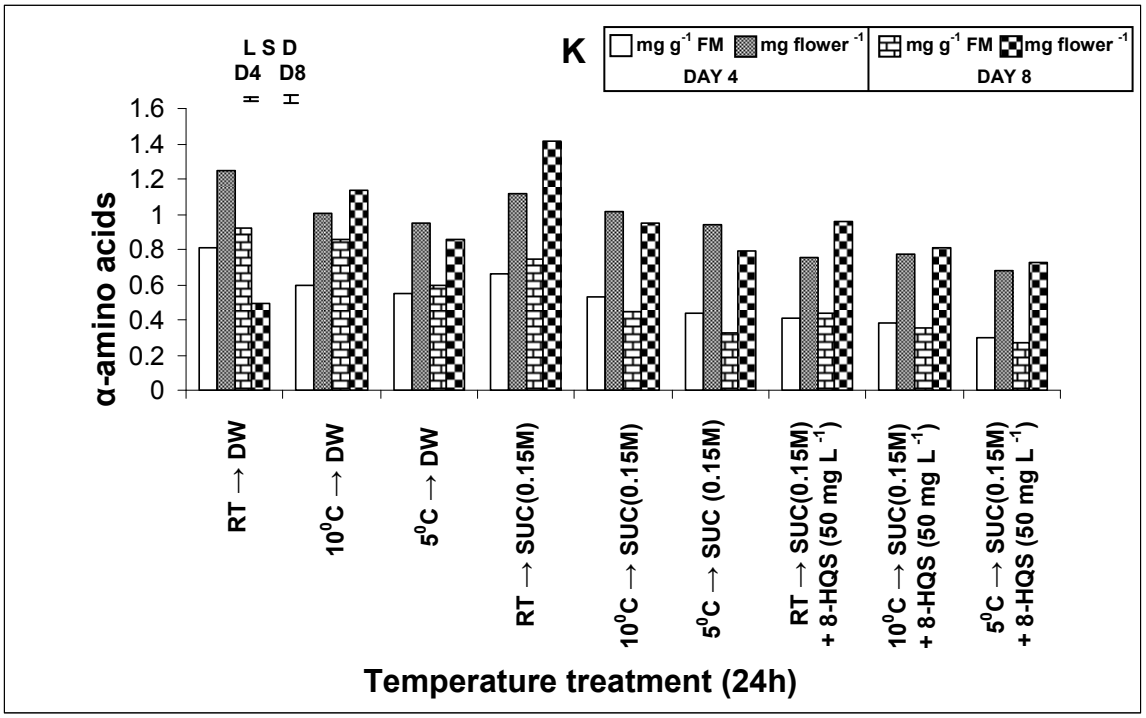

J
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Soluble proteins
16
14
12
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.5

Fig. 5.3.6

Histograms showing effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at P $_{= 0.05.}$


K
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
α-amino acids
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

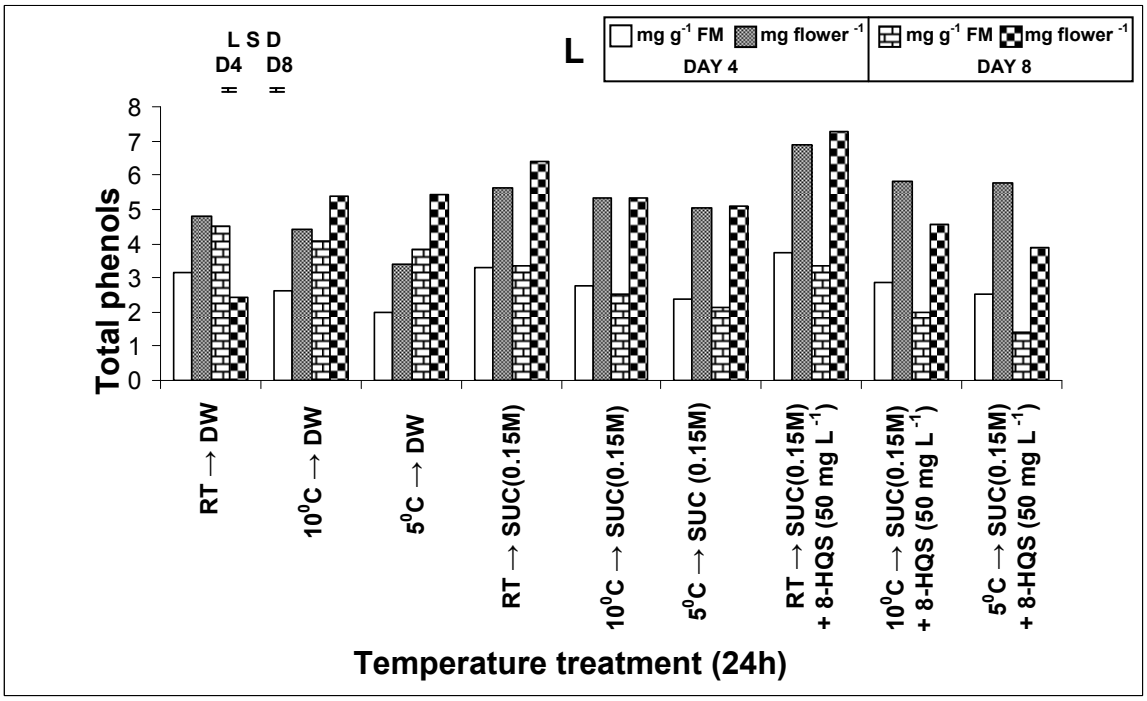

L
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total phenols
8
7
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (24h)

Fig. 5.3.6

Plate 5.3.1

Effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT) 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Fig.: From left to right are arranged scapes after wet storage for 24 h held at RT, 10^oC and 5^oC.

Plate. 5.3.1

Plate. 5.3.2

Effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (25 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

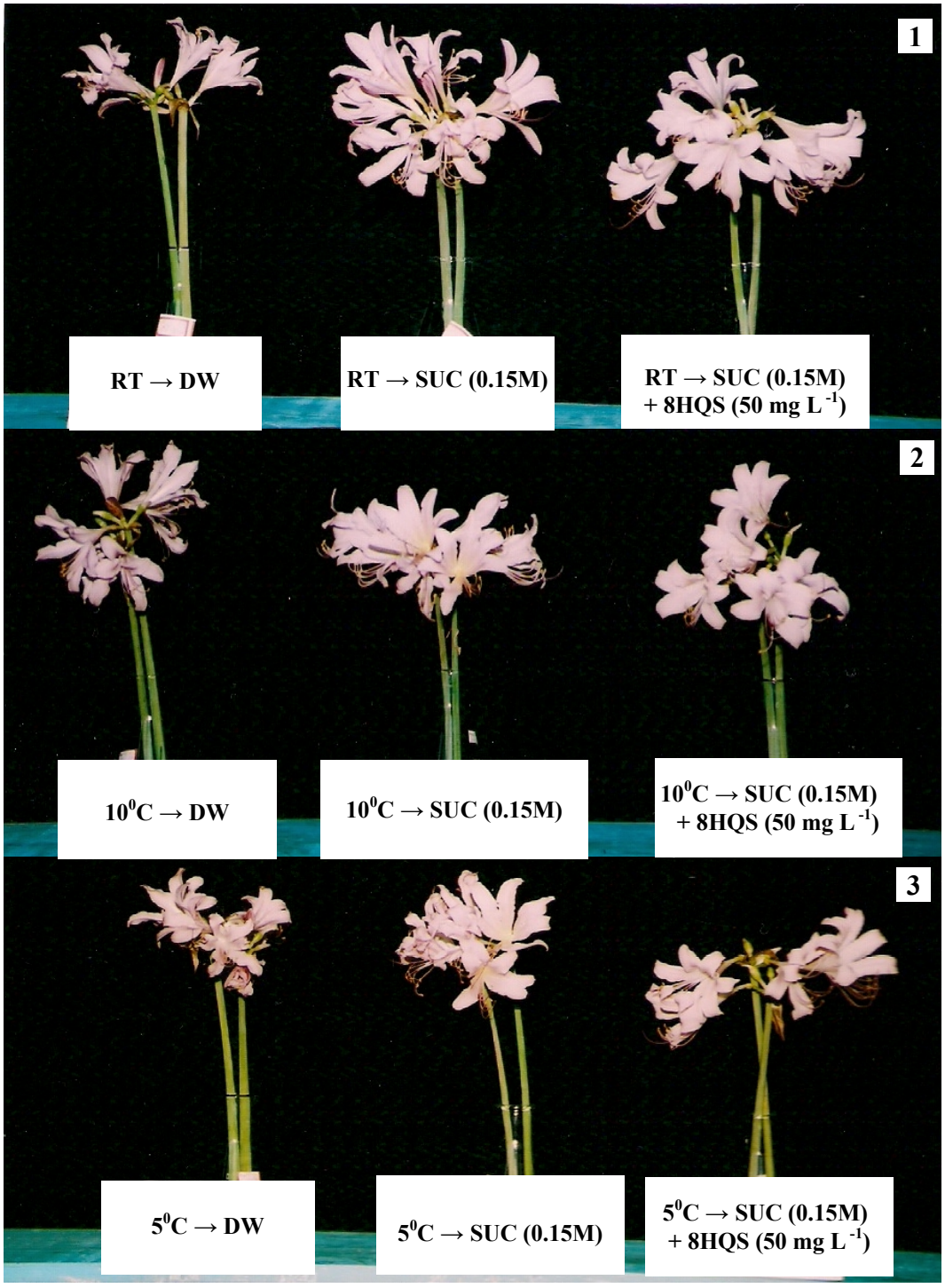

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M) + 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

Plate. 5.3.2

Plate. 5.3.3

Effect of postharvest wet storage (PHWS) for 24 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (25 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C and held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

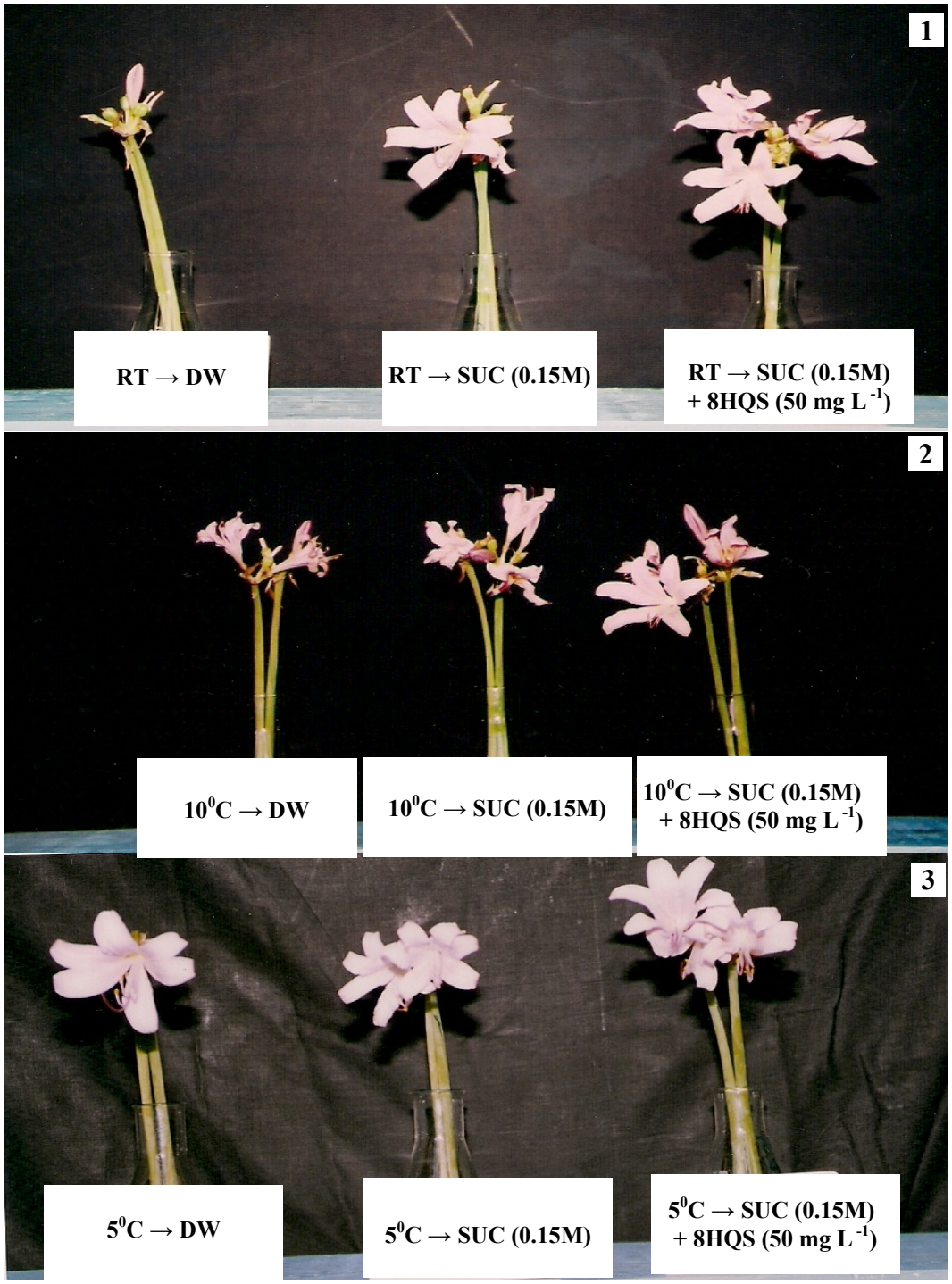

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M)
+ 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M)
+ 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M)
+ 8HQS (50 mg L -1)

Plate. 5.3.3

EXPERIMENT 5.4

Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on cut scapes of *Amaryllis belladonna* cv. Rosea.

Experimental

Scapes of *A. belladonna* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08.00 h immediately brought to the laboratory and cut to a uniform length of 27 cm. The scapes were held in 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solution and was assessed to be terminated when 70 % flowers had senesced which was characterized by loss of turgor followed by wilting of tepals. Number of blooms per scapes was recorded up to day 3 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and total phenols were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions. The scapes held in distilled water (DW) exhibited scape end splitting; as a result of which the scapes held in DW deformed and therefore decreased in length as compared to the corresponding

scapes held in SUC or SUC + $CoCl_2$ (Plate 5.4.1). Flower senescence was delayed in the scapes held in SUC + $CoCl_2$ by 2 days and in SUC by about 1 day as compared to the scapes held in DW which exhibited a vase life of about 4 days (Plate 5.4.2; Figs. 1-2).

Vase life: The average vase life of scapes held in SUC + $CoCl_2$ was enhanced by an increment of 2 days while as the vase life of scapes held in SUC was enhanced by about 1 day as compared to the corresponding scapes held in DW which exhibited vase life of about 3 days (Table 5.4.1, Text Fig. 5.4.1, A).

Number of blooms per scape: Number of blooms increased in all treatments irrespective of the transfer to various holding solution. Comparatively number of blooms per scape were relatively more in scapes held in SUC + $CoCl_2$ as also in SUC as compared to the corresponding scapes held in DW (Table 5.4.1; Text Fig. 5.4.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of the transfer of scapes irrespective of the transfer to various holding solutions. With the progression in time the solution uptake was more in scapes held in SUC + $CoCl_2$ followed by SUC as compared to the corresponding scapes held in DW (Table 5.4.1, Text Fig.5.4.2, C).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer of scapes irrespective of the holding solutions. The concentration of ion leachates was found to be minimum in the samples from the scapes held in SUC + $CoCl_2$ followed by SUC as compared to the corresponding samples from scapes held in DW (Table 5.4.2, Text Fig. 5.4.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers decreased with progression in time from day 4 to day 8 of transfer of scapes irrespective of the holding solution transferred to. A higher fresh and dry mass was observed

in the samples form SUC + $CoCl_2$ followed by SUC as compared to the samples from the scapes held in DW (Table 5.4.2, Text Fig. 5.4.3 E & F).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. Higher reducing sugar content was registered in the samples from scapes held in SUC + $CoCl_2$ followed by SUC as compared to the samples from scapes held in DW (Table 5.4.3; Text Fig. 5.4.4, G). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.4.4). The highest content of reducing sugar was observed in samples from scapes held in SUC + $CoCl_2$.

Non reducing sugars: The non-reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solution. A higher non-reducing sugar content was maintained in the samples from scapes held in SUC + $CoCl_2$ followed by SUC as compared to the samples from scapes held in DW (Table 5.4.3, Text Fig. 5.4.4, H). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.4.4). The highest content of non-reducing sugar was registered in samples from scapes held in SUC + $CoCl_2$.

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. Higher content of total sugars was registered in the samples from scapes held in SUC + $CoCl_2$ followed by the samples from the scapes held in SUC as compared to the samples from corresponding scapes held in DW (Table 5.4.3; Text Fig. 5.4.5, I). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.4.4). The highest content of total sugars was observed in samples from scapes held in SUC + $CoCl_2$.

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solution. Higher soluble protein content was registered in the samples from scapes held in SUC + $CoCl_2$ followed by the samples from the scapes held in SUC as compared to the samples from corresponding scapes held in DW (Table 5.4.5;Text Fig. 5.4.5, J). When the data was expressed on per flower and on dry mass bases the differences were sharp and apparent (Table 5.4.6). The highest soluble protein content was registered in the samples from scapes held in SUC + $CoCl_2$.

α- amino acids: The amino acid content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solution. Lower amino acid content was registered in the samples from scapes held in SUC + $CoCl_2$ followed by SUC as compared to the samples from corresponding scapes held in DW (Table 5.4.5;Text Fig. 5.4.6, K). When the data was expressed on per flower and on dry mass basis, the amino acid content decreased with the progression in time irrespective of the transfer to various holding solutions (Table 5.4.6). Generally lower amino acid content was maintained in the samples from scapes held in SUC + $CoCl_2$.

Total phenols: The content of total phenols registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. Higher phenols were recorded in the samples from scapes held in SUC + $CoCl_2$ followed by SUC as compared to the samples from corresponding scapes held in DW (Table 5.4.5; Text Fig. 5.4.6, L). When the data was expressed on per flower and on dry mass basis the total phenolic content generally decreases with the progression in time (Table 5.4.6). The highest contents of phenols was observed in the samples from scapes held in SUC + $CoCl_2$.

Table 5.4.1: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on vase life, blooming and solution uptake in cut scapes of *Amaryllis belladonna* cv. Rosea.

Treatment	Vase life (days)	No of blooms per scape			Volume of holding solution absorbed per scape (ml)		
		Days after treatment					
		1	2	3	2	4	6
DW	3	5.00 (89)	5.20 (95)	5.60 (100)	1.75	2.50	3.00
SUC (0.15M)	4	5.40 (90)	5.60 (96)	6.00 (100)	2.25	3.50	3.50
$CoCl_2$ (0.15mM) + SUC (0.15M)	5	5.50 (92)	5.60 (97)	6.00 (100)	2.50	4.00	5.00
LSD at $P_{=0.05}$	0.30	0.06	0.10	-	0.15	0.23	0.32

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 5.4.2: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on conductivity of leachates (µS), fresh mass and dry mass in flowers on day 4 and 8 of transfer of on cut scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
DW	25.76	43.40	2.72	1.13	0.165	0.111
SUC (0.15M)	19.40	37.08	3.08	1.45	0.220	0.135
$Cocl_2$ (0.15mM) + SUC (0.15M)	13.40	32.40	3.42	1.60	0.254	0.145
LSD at $P_{=0.05}$	0.70	1.04	0.08	0.06	0.006	0.008

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Table 5.4.3: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on concentration of sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to various holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	11.00 (29.92)	4.88 (5.51)	2.33 (6.33)	1.34 (1.51)	13.33 (36.25)	6.22 (7.02)
SUC (0.15M)	12.40 (38.19)	6.21 (9.00)	3.44 (10.59)	3.00 (4.35)	15.84 (48.78)	9.21 (13.35)
CoC_2 (0.15mM) + SUC (0.15M)	15.14 (51.77)	7.56 (12.08)	4.55 (15.56)	4.10 (6.56)	19.69 (67.33)	11.66 (18.65)
LSD at $P_{=0.05}$	0.66	0.76	0.45	0.88	1.09	0.64

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 5.4.4: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on concentration of sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to various holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	181.33	49.67	38.40	13.64	219.74	63.32
SUC (0.15M)	173.60	66.70	48.16	32.22	221.76	98.92
$Cocl_2$ (0.15mM) + SUC (0.15M)	203.85	83.42	61.26	45.24	265.11	128.66
LSD at $P_{=0.05}$	0.73	0.99	0.51	0.46	0.86	0.95

Each value is a mean of 5 independent replicates.

Room temperature (RT)= (25 ± 2°C).

Table 5.4.5: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on concentration of soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to various holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	2.58 (7.01)	1.91 (2.16)	0.38 (1.03)	0.45 (0.50)	2.63 (7.15)	3.38 (3.81)
SUC (0.15M)	3.25 (10.01)	3.00 (4.35)	0.24 (0.73)	0.29 (0.42)	2.97 (9.14)	3.77 (5.46)
$CoCl_2$ (0.15mM) + SUC (0.15M)	4.75 (16.24)	3.50 (5.60)	0.22 (0.75)	0.33 (0.52)	4.83 (16.51)	6.33 (10.12)
LSD at $P_{=0.05}$	0.54	0.42	0.48	0.72	0.74	0.97

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 5.4.6: Effect of sucrose SUC (0.15M) and sucrose + cobalt chloride SUC (0.15M) + $CoCl_2$ (0.15 mM) on concentration of soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to various holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	42.53	19.44	6.26	4.58	43.35	34.40
SUC (0.15M)	45.50	32.22	3.36	3.11	41.58	40.49
$Cocl_2$ (0.15mM) + SUC (0.15M)	63.95	38.62	2.96	3.64	65.03	69.84
LSD at $P_{=0.05}$	0.88	0.92	0.87	0.33	0.57	0.80

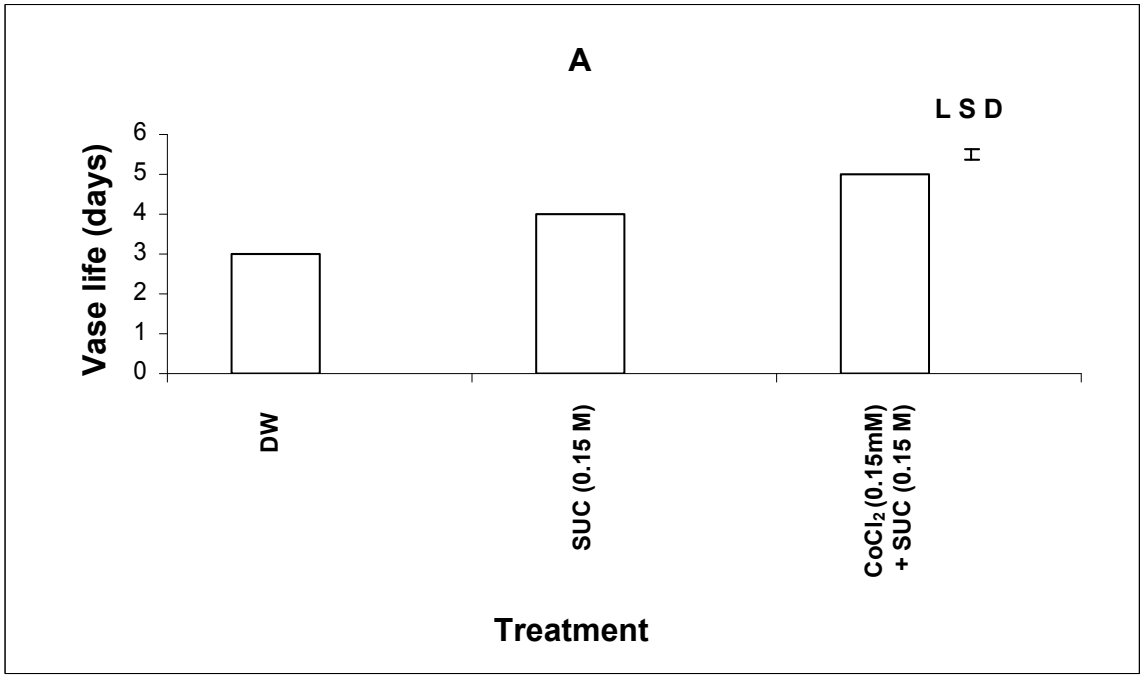
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2°C).

Fig. 5.4.1

Effect of SUC (0.15M) and Sucrose + SUC (0.15M) + $CoCl_2$ (0.15 mM) on vase life (A) and number of blooms per scape (B) in cut scapes of Amaryllis *belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$.


A
L S D
Vase life (days)
6
5
4
3
2
1
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

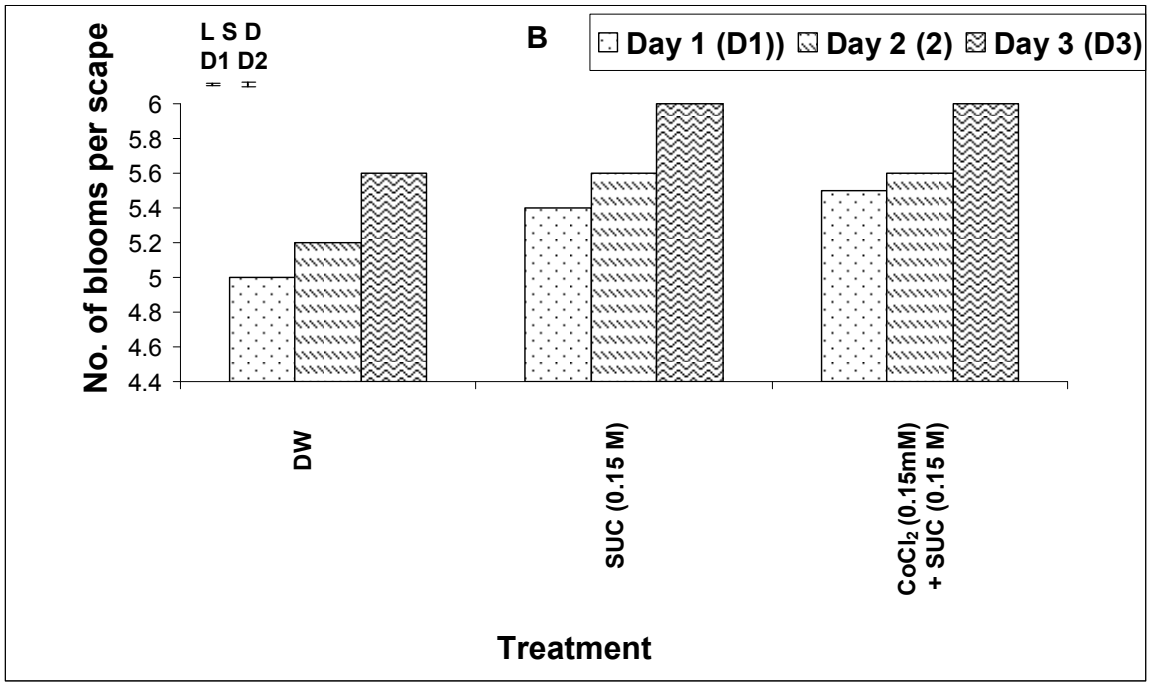
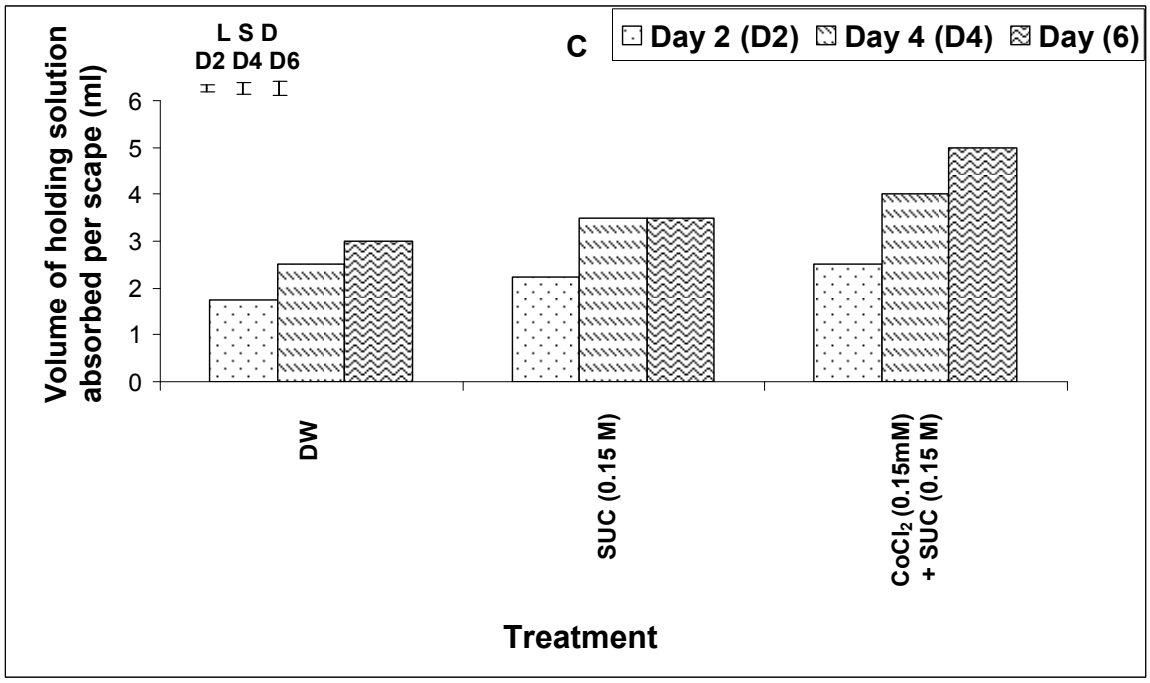

B
Day 1 (D1)) Day 2 (2) Day 3 (D3)
L S D
D1 D2
No. of blooms per scape
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.1

Fig. 5.4.2

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on volume of holding solutions absorbed per scape (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


C
Day 2 (D2)
Day 4 (D4)
Day (6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
6
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

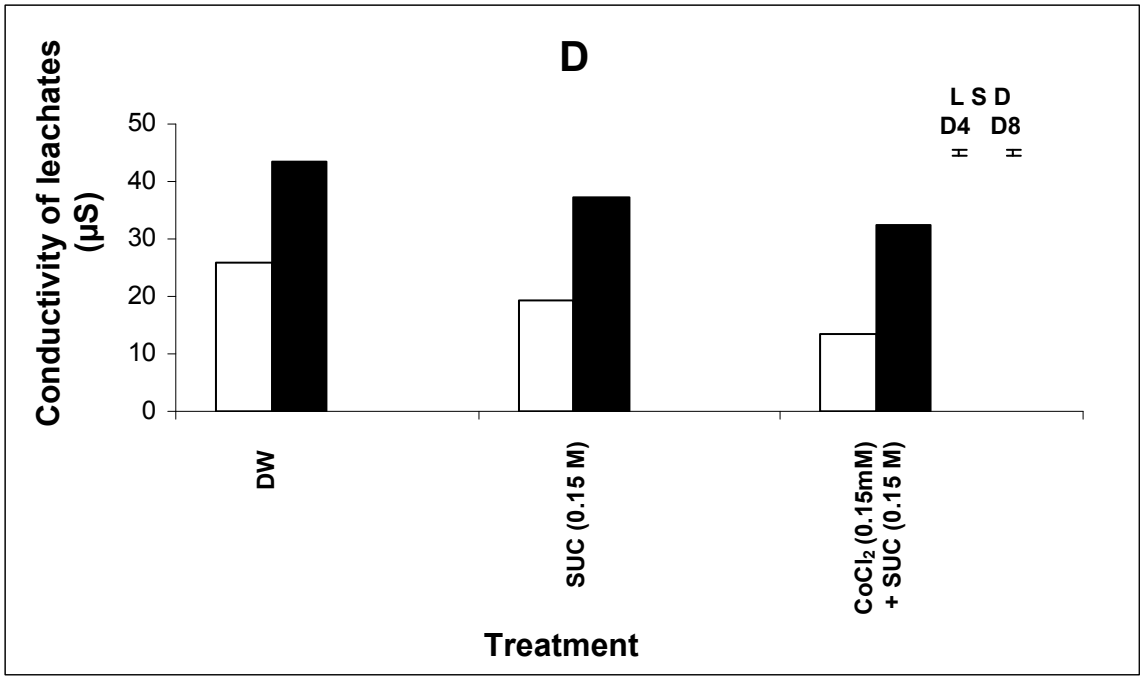
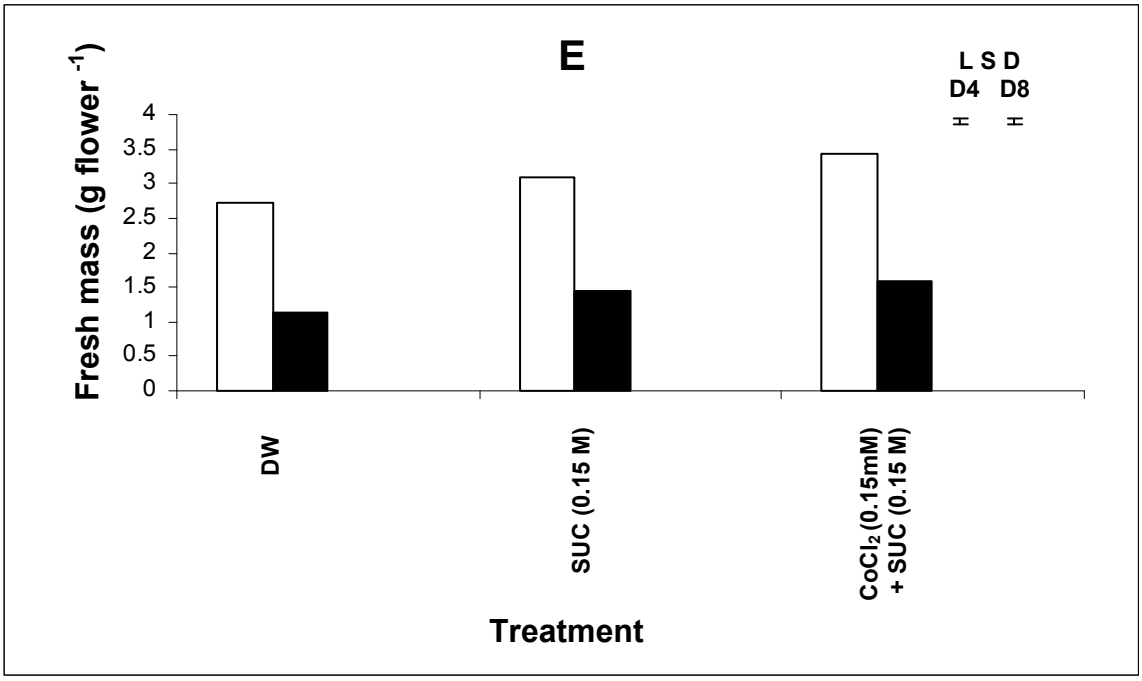

D
L S D
D4 D8
Conductivity of leachates (µS)
0
10
20
30
40
50
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.2

Fig. 5.4.3

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


E
L S D
D4 D8
H H
Fresh mass (g flower -1)
4
3.5
3
2.5
2
1.5
1
0.5
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

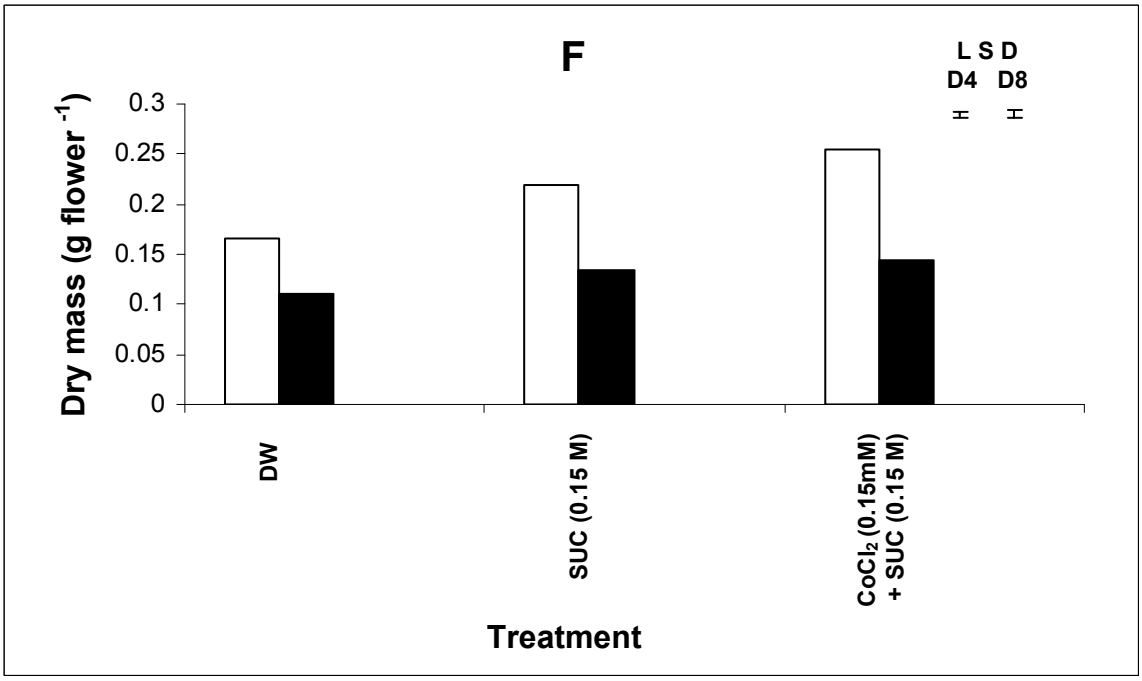
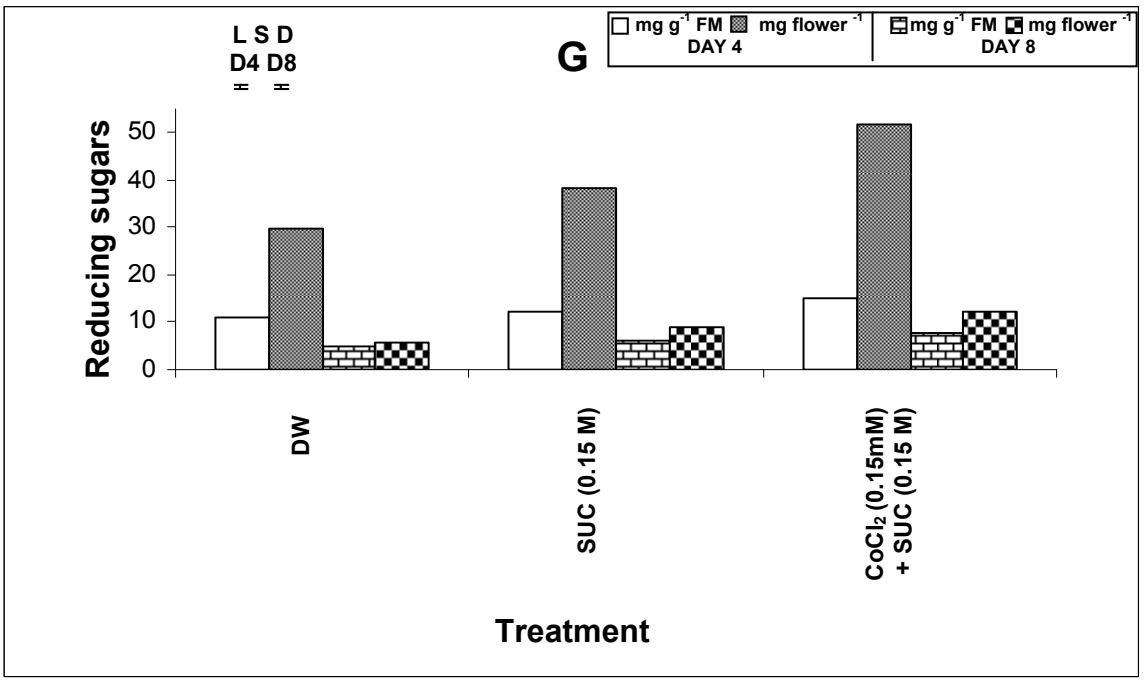

F
L S D
D4 D8
H H
Dry mass (g flower -1)
0.3
0.25
0.2
0.15
0.1
0.05
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.3

Fig. 5.4.4

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


G
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Reducing sugars
50
40
30
20
10
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

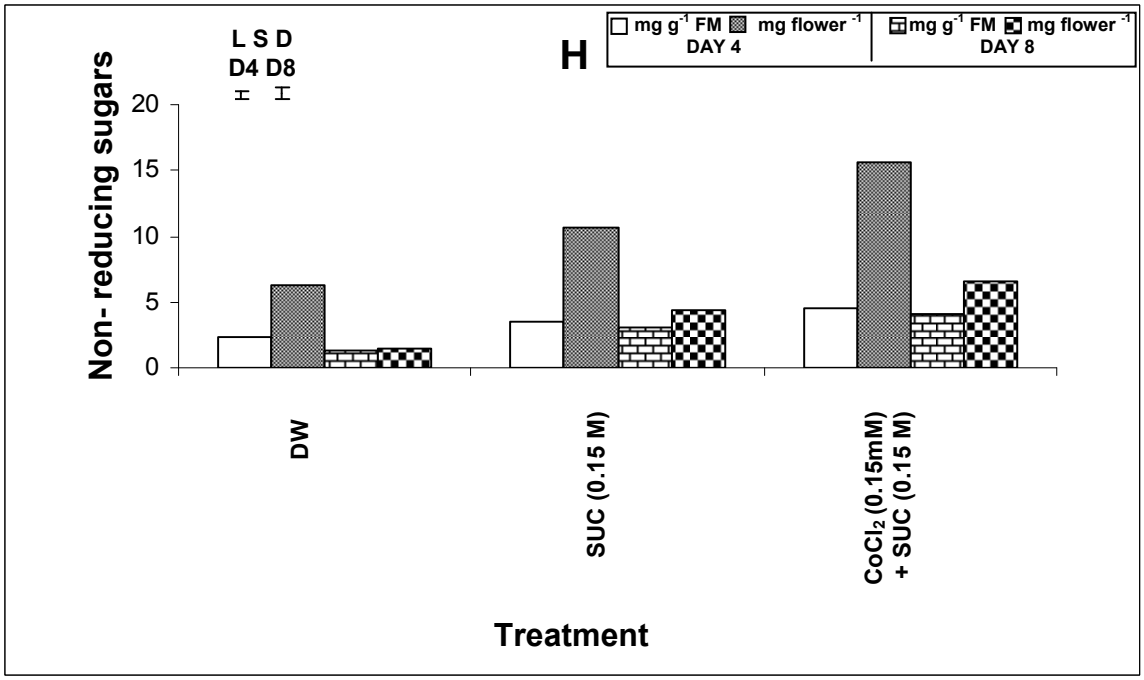
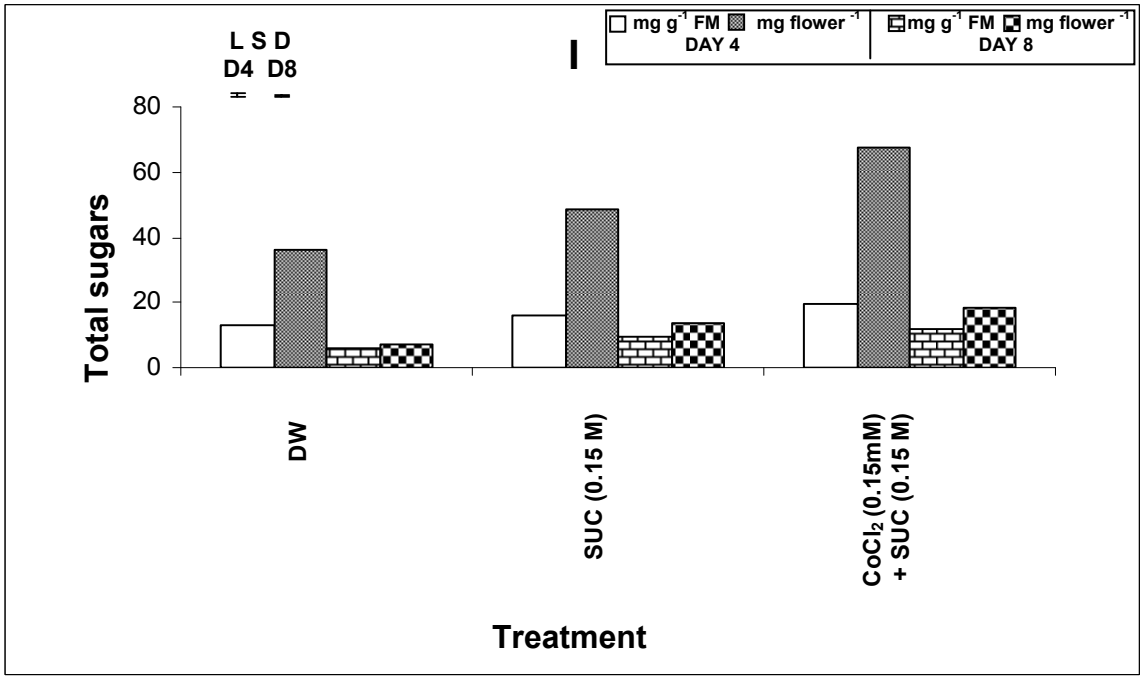

H
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Non- reducing sugars
20
15
10
5
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.4

Fig. 5.4.5

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


I
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Total sugars
80
60
40
20
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

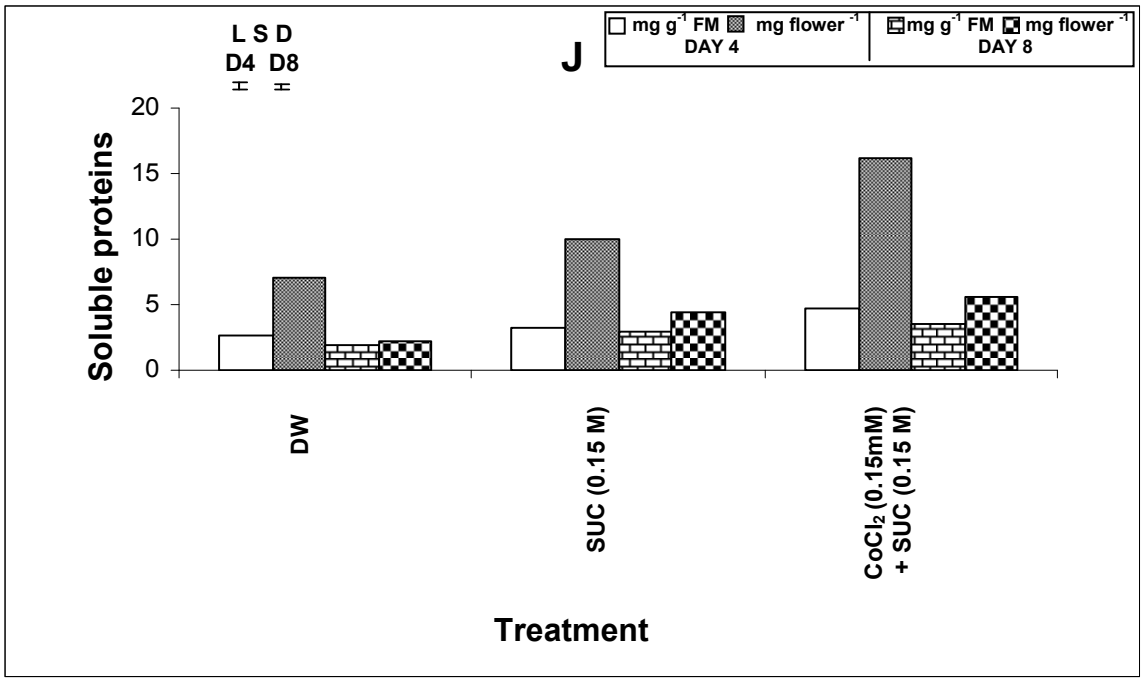
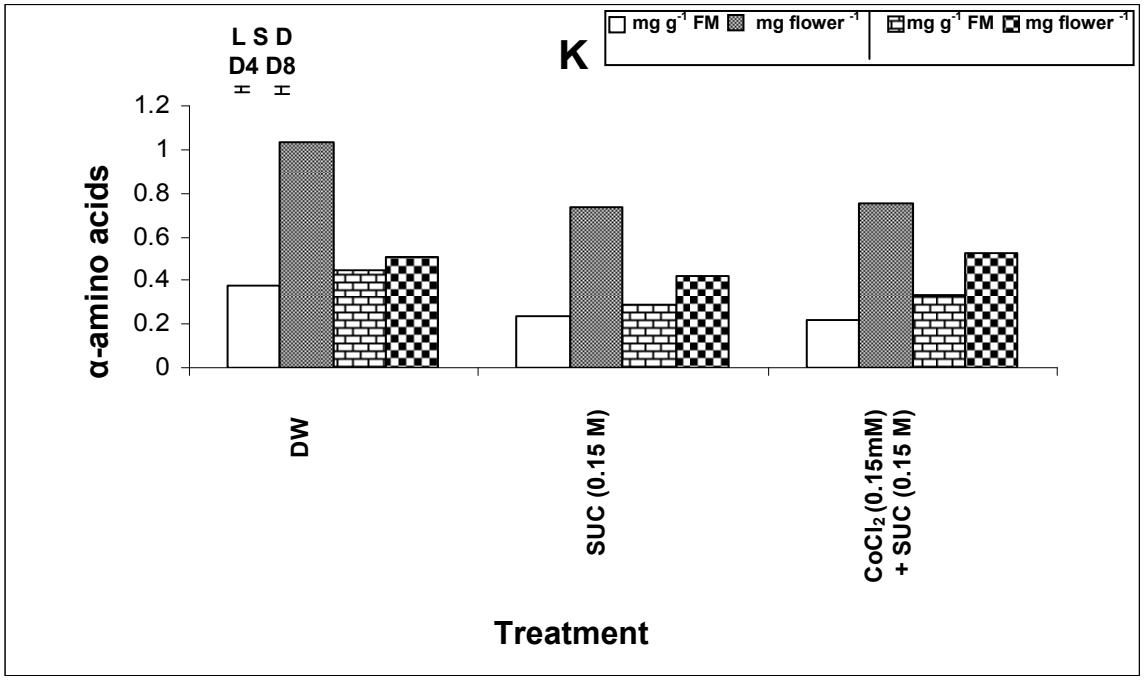

J
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Soluble proteins
20
15
10
5
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.5

Fig. 5.4.6

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


K
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
L S D
D4 D8
H H
α-amino acids
1.2
1
0.8
0.6
0.4
0.2
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

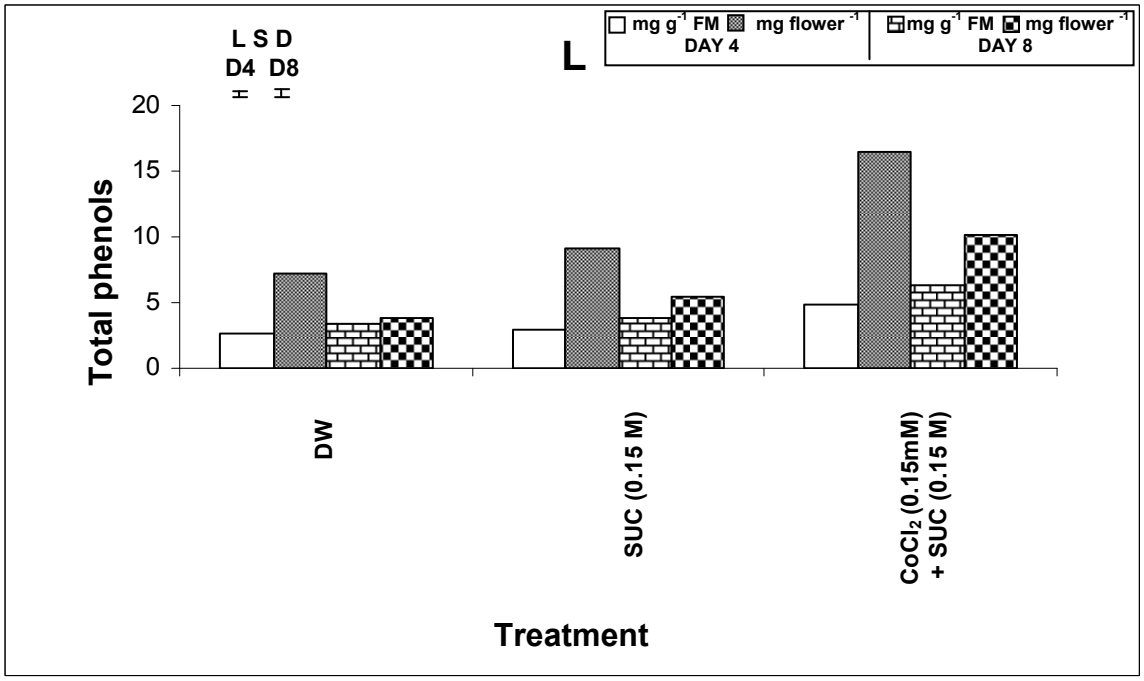

L
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
H H
Total phenols
20
15
10
5
0
DW
SUC (0.15 M)
CoCl2 (0.15mM) + SUC (0.15 M)
Treatment

Fig. 5.4.6

Plate. 5.4.1

Scapes of *Amaryllis belladonna* cv. Rosea showing distortion due to scape end splitting on day 1 of transfer to

(a) Distilled water (DW).

(b) SUC (0.15 M, 3h pulse) → DW.

(c) SUC (0.15 M).

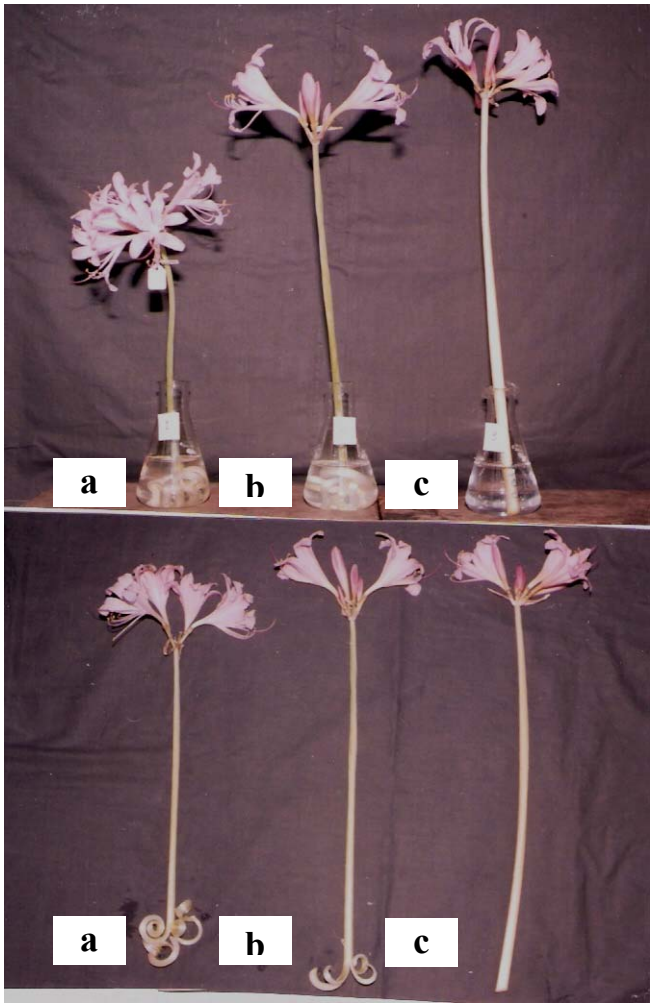


Plate. 5.4.1

Plate. 5.4.2

Effect of SUC (0.15M) and SUC (0.15M) + $CoCl_2$ (0.15 mM) on cut scapes of *Amaryllis belladonna* cv. Rosea.

From left to right are arranged scapes held in DW, SUC (0.15M) and SUC + $CoCl_2$ (0.15mM)

Figs. 1-2 represent photographs taken on day 4 and day 8 after the transfer of scapes to the particular holding solutions.

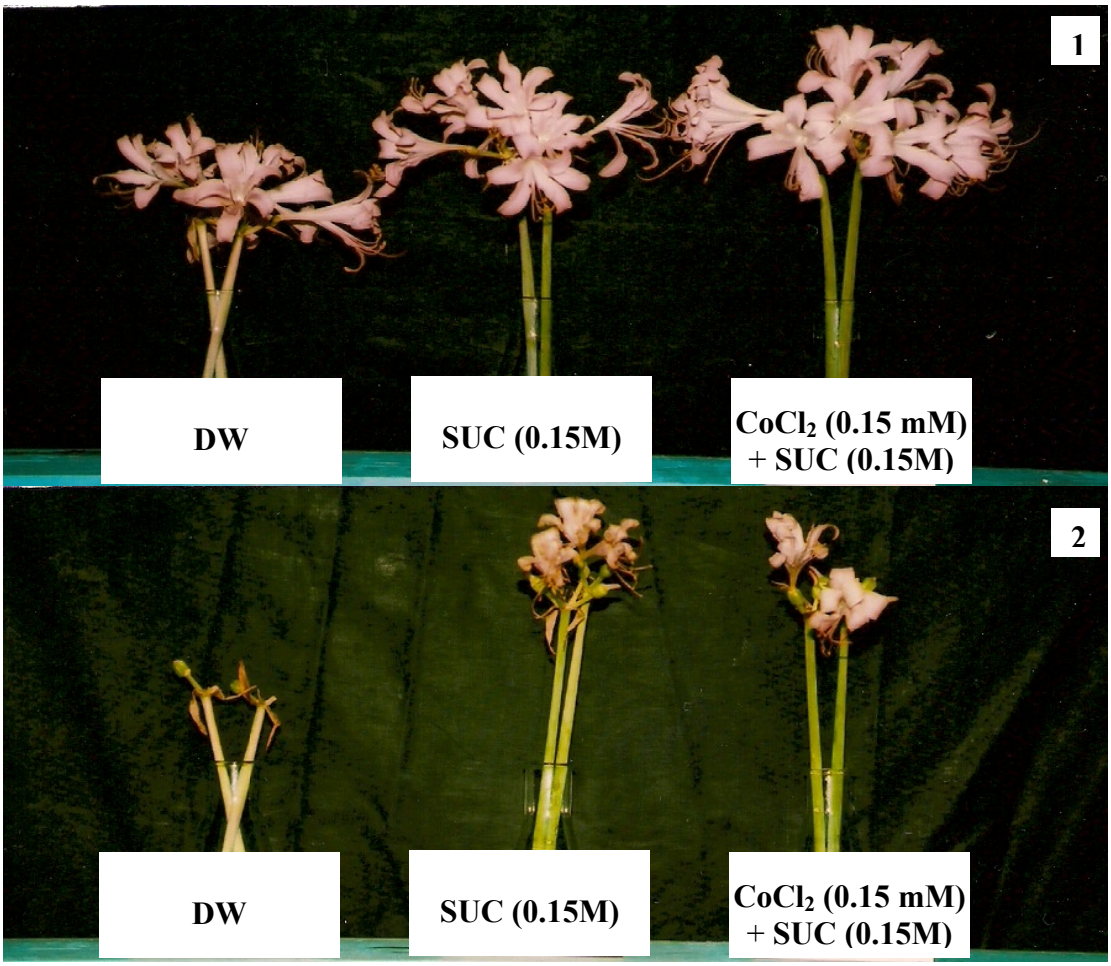

1
DW
SUC (0.15M)
CoCl2 (0.15 mM) + SUC (0.15M)
2
DW
SUC (0.15M)
CoCl2 (0.15 mM) + SUC (0.15M)

Plate. 5.4.2

EXPERIMENT 5.5

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at 50, 100 and 150 mg L^{-1} on cut scapes of *Amaryllis belladonna* cv Rosea.

Experimental

Scapes of *A. belladonna* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 27 cm. The scapes were held in 250 ml conical flasks containing 200 ml of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15 M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solutions and was assessed to be terminated when 70% flowers had senesced which was characterized by loss of turgor followed by wilting of tepals. Number of blooms per scape was recorded up to day 3 of the transfer. Volume of holding solutions absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and total phenols were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions. Flower senescence was delayed in the

scapes held in varying grades of aluminum sulphate $Al_2(SO_4)_3$ particularly at (100 mg L^{-1}) and (50 mg L^{-1}). When SUC was given in combination with $Al_2(SO_4)_3$, the vase life was enhanced by an increment of about 3 days (Plate 5.5.2 Fig 1-2).

Vase life: The average vase life of scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) was enhanced by an increment of 3 days while as the vase life of scapes held in $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M) was enhanced by about 1 day . Scapes held in SUC or $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) exhibited a vase life of about 4 days (Table 5.5.1, Text Fig. 5.5.1, A).

Number of blooms per scape : Number of blooms increased in all the treatments irrespective of the transfer to various holding solutions. Higher number of blooms per scape were marked in scapes held in SUC. Scapes held in varying grades of $Al_2(SO_4)_3$ + SUC exhibited lower number of blooms on day 1 and the blooming was over by day 3 of the transfer (Table 5.5.1; Text Fig. 5.5.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes irrespective of the transfer to various holding solutions. Higher solution uptake was recorded in the scapes held in the varying grades of $Al_2(SO_4)_3$ + SUC as compared to SUC alone (Table 5.5.1, Text Fig. 5.5.2,C). Maximum solution uptake was noticed in the scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with the progression in time from day 4 to day 8 of transfer irrespective of the transfer to various holding solutions. The concentration of ion leachates was found to be lower in the samples from in the scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as compared to SUC only. A lower conductivity of leachates was maintained in samples

from scapes held in $Al_2(SO_4)_3$ + SUC at (100 mg L^{-1}) followed by samples from scapes held in $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M) (Table 5.5.2, Text Fig. 5.5.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers decreased with progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. Higher fresh and dry mass was observed in the samples from scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as compared to SUC only. Highest fresh and dry mass was observed samples from scapes held in $Al_2(SO_4)_3$ 100 mg L^{-1} + SUC 0.15M (Table 5.5.2, Text Fig. 5.5.3, E & F).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solution. Higher reducing sugar content was registered in the samples from scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as compared to SUC only. Highest content of reducing sugars was marked in the sample from scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) (Table 5.5.3; Text Fig. 5.5.4, G). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.5.4).

Non-reducing sugars: The non-reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. The content of non-reducing sugars increased with increasing grades of $Al_2(SO_4)_3$ + SUC as compared to SUC only. Highest content of non-reducing sugars was marked in the sample from scapes held in $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) (Table 5.5.3, Text Fig. 5.5.4, H). Almost similar trends were obtained when the data was expressed on mg per flower and on dry mass bases (Table 5.5.4).

Total sugars: The content of total sugars registered a decrease with progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The content of total sugars increased with increasing grades of $Al_2(SO_4)_3$ + SUC as compared to SUC only. Highest content of total sugars was registered in the sample from scapes held in $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0,15M) (Table 5.5.3, Text Fig. 5.5.5,I). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.5.4).

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. Protein content was more or less maintained in the samples from scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as also in SUC only. Highest content of soluble protein was marked in the sample from scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M), (Table 5.5.5; Text Fig. 5.5.5, G). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.5.6).

α-amino acids: The amino acid content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The amino acid content was more or less maintained in the samples from scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as also in SUC only. Lowest content of amino acids was recorded in the sample from scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M), Table 5.5.5; Text Fig. 5.5.6, K). Similar trends was obtained when the data was expressed on dry mass basis (Table 5.5.6). However when the data was expressed on per flower basis the amino acid content decreased irrespective of the transfer to various holding solutions (Table 5.5.5). The concentration of amino acids was observed to be lowest in the samples from scapes held in $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M).

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The phenolic content was more or less maintained in the samples from scapes held in varying grades of $Al_2(SO_4)_3$ + SUC as also in SUC. The content of total phenols decreased with increasing grades of $Al_2(SO_4)_3$ + SUC (0.15M). Lowest content of phenolics was observed in the sample from scapes held in $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC 0.15M (Table 5.5.5; Text Fig. 5.5.6, L). Similar trends were obtained when the data was expressed on per flower and on dry mass bases (Table 5.5.6).

Table 5.5.1: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on vase life, blooming and solution uptake in cut scapes of *Amaryllis belladonna* cv. Rosea.

Treatment	Vase life (days)	No of blooms per scape			Volume of holding solution absorbed per scape (ml)		
		Days after treatment					
		1	2	3	2	4	6
SUC (0.15M)	4	5.40 (89)	5.60 (9.00	6.00 (100)	1.75	2.50	3.25
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	5	2.25 (40.90)	4.50 (81.81)	6.00 (100)	4.50	5.50	6.25
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	7	2.66 (33)	5.00 (75.75)	6.00 (100)	5.00	7.10	9.60
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	3	1.80 (42.10)	4.16 (78.94)	6.00 (100)	4.00	5.70	7.80
LSD at $P_{=0.05}$	0.31	0.26	0.11	-	0.33	0.17	0.27

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 5.5.2: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of the transfer of scapes to holding solutions in *Amaryllis belladonna.* cv. Rosea.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
SUC (0.15M)	19.40	37.08	3.08	1.25	0.165	0.111
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	18.77	22.30	2.99	1.62	0.224	0.119
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	17.26	16.80	3.25	1.82	0.232	0.148
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	26.73	35.96	2.41	0.98	0.185	0.068
LSD at $P_{=0.05}$	0.29	0.36	0.06	0.03	0.009	0.011

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Table 5.5.3: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of scapes to holding solutions in *Amaryllis belladonna* cv.Rosea.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
SUC (0.15M)	12.40 (38.19)	6.21 (7.76)	3.44 (10.59)	2.00 (2.50)	15.84 (48.78)	8.21 (10.26)
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	10.86 (32.47)	9.89 (16.02)	4.45 (13.30)	2.12 (3.43)	15.31 (45.77)	12.01 (19.45)
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	12.66 (41.14)	10.33 (18.80)	5.67 (18.42)	3.60 (6.55)	18.33 (59.57)	13.93 (25.35)
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	13.33 (32.12)	8.88 (8.70)	6.13 (14.77)	4.32 (4.23)	19.46 (46.89)	13.20 (12.93)
LSD at $P_{=0.05}$	0.66	0.71	0.30	0.41	0.92	0.67

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 5.5.4: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of scapes to holding solutions in *Amaryllis belladonna* cv.Rosea.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
SUC (0.15M)	231.46	69.93	64.21	22.52	295.68	92.45
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	144.96	134.63	59.39	28.86	204.36	163.49
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	177.34	127.03	79.42	44.27	256.77	171.30
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	173.65	127.97	79.85	62.25	253.50	190.23
LSD at $P_{=0.05}$	0.81	0.54	0.91	0.44	0.67	0.60

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Table 5.5.5: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of scapes to holding solutions in *Amaryllis belladonna* cv.Rosea.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
SUC (0.15M)	5.33 (16.41)	2.00 (2.50)	0.21 (0.64)	0.45 (0.56)	2.63 (8.10)	3.38 (4.22)
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	5.00 (14.95)	3.24 (5.24)	0.25 (0.74)	0.34 (0.55)	2.87 (8.58)	3.20 (5.18)
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	5.67 (18.42)	4.21 (7.66)	0.18 (0.58)	0.29 (0.52)	2.38 (7.73)	2.83 (5.15)
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	4.56 (10.98)	2.45 (2.40)	0.30 (0.72)	0.40 (0.39)	2.17 (5.22)	2.52 (2.46)
LSD at $P_{=0.05}$	0.51	0.83	0.46	0.31	0.88	0.73

Each value is a mean of 5 independent replicates.

Room temperature RT = (25 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 5.5.6: Effect of SUC (0.15M), $Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M), $Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M) and $Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
SUC (0.15M)	99.49	22.52	3.92	5.06	49.09	38.06
$Al_2(SO_4)_3$ (50 mg L^{-1}) + SUC (0.15M)	66.74	44.10	3.33	4.62	38.30	43.56
$Al_2(SO_4)_3$ (100 mg L^{-1}) + SUC (0.15M)	79.42	51.77	2.52	3.56	33.34	34.80
$Al_2(SO_4)_3$ (150 mg L^{-1}) + SUC (0.15M)	59.40	35.30	3.90	5.76	28.26	36.31
LSD at $P_{=0.05}$	0.75	0.52	0.23	0.68	0.88	0.55

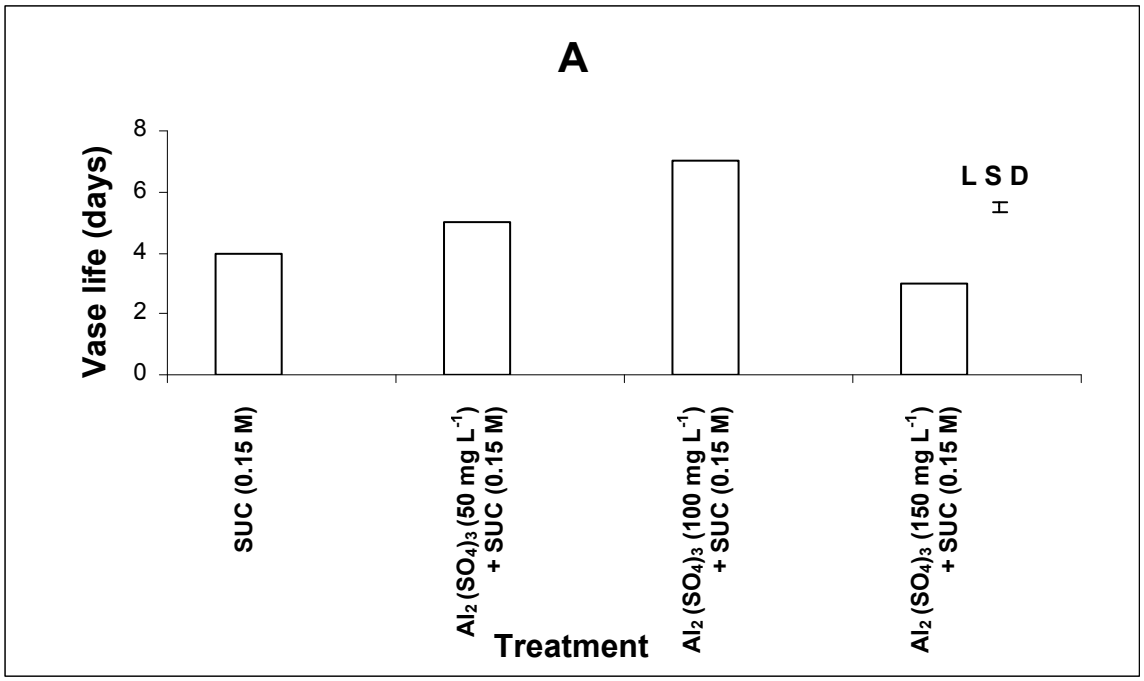
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (25 ± 2^0C).

Fig. 5.5.1

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on vase life (A) and number of blooms per scape (B) in cut scapes of *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


A
Vase life (days)
8
6
4
2
0
L S D
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

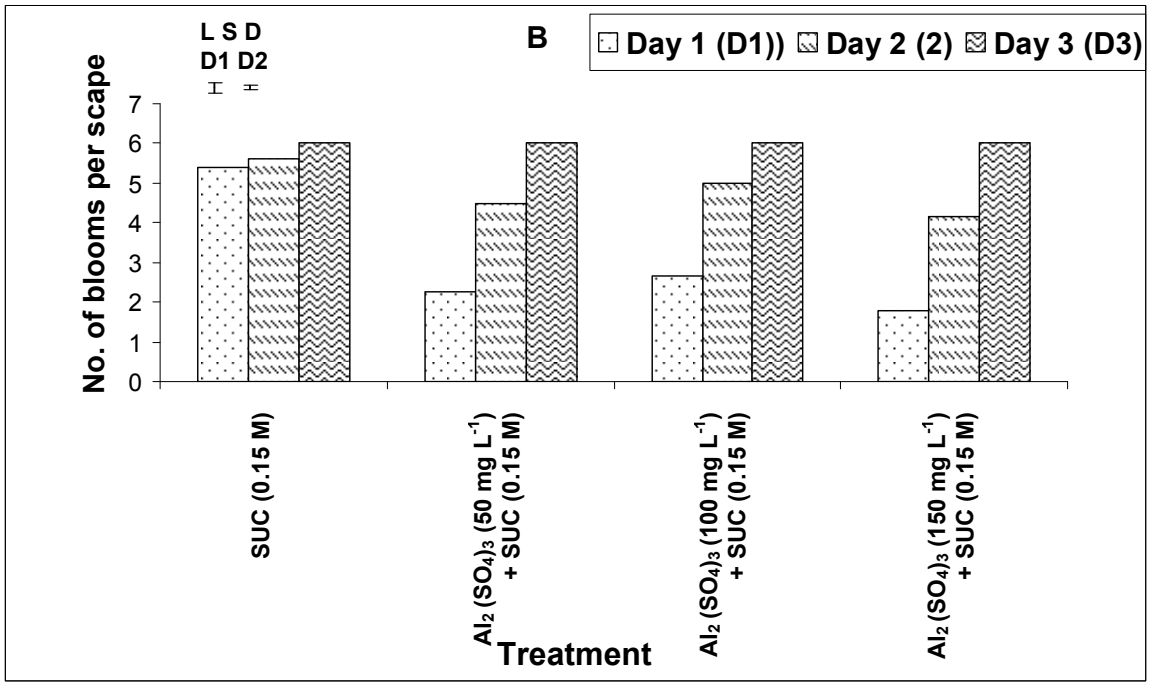
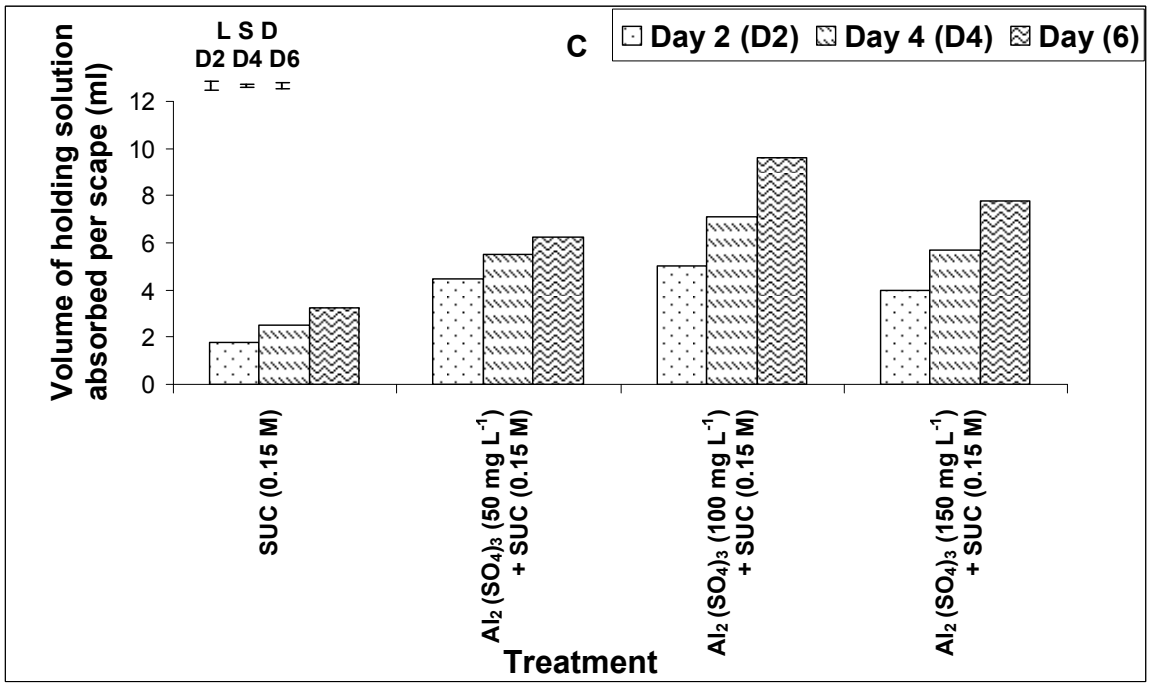

B
L S D
D1 D2
Day 1 (D1)) Day 2 (2) Day 3 (D3)
No. of blooms per scape
7
6
5
4
3
2
1
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.1

Fig. 5.5.2

Effect of SUC (0.15M) separately and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on volume of holding solution absorbed (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


C
Day 2 (D2)
Day 4 (D4)
Day (6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
2
4
6
8
10
12
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

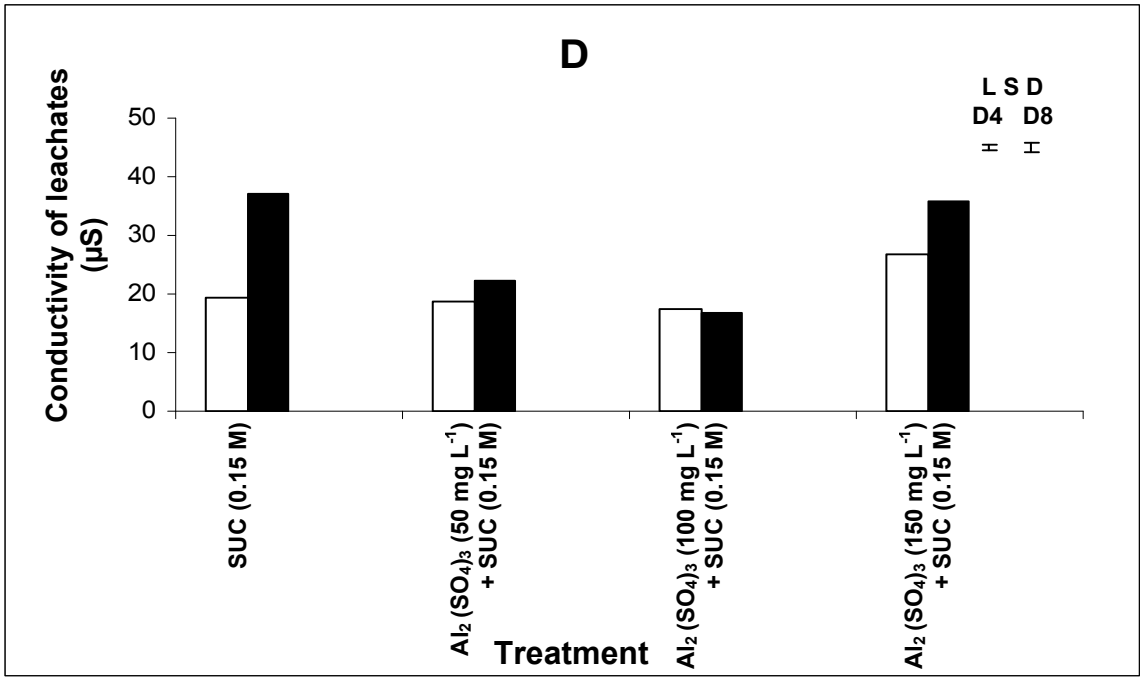
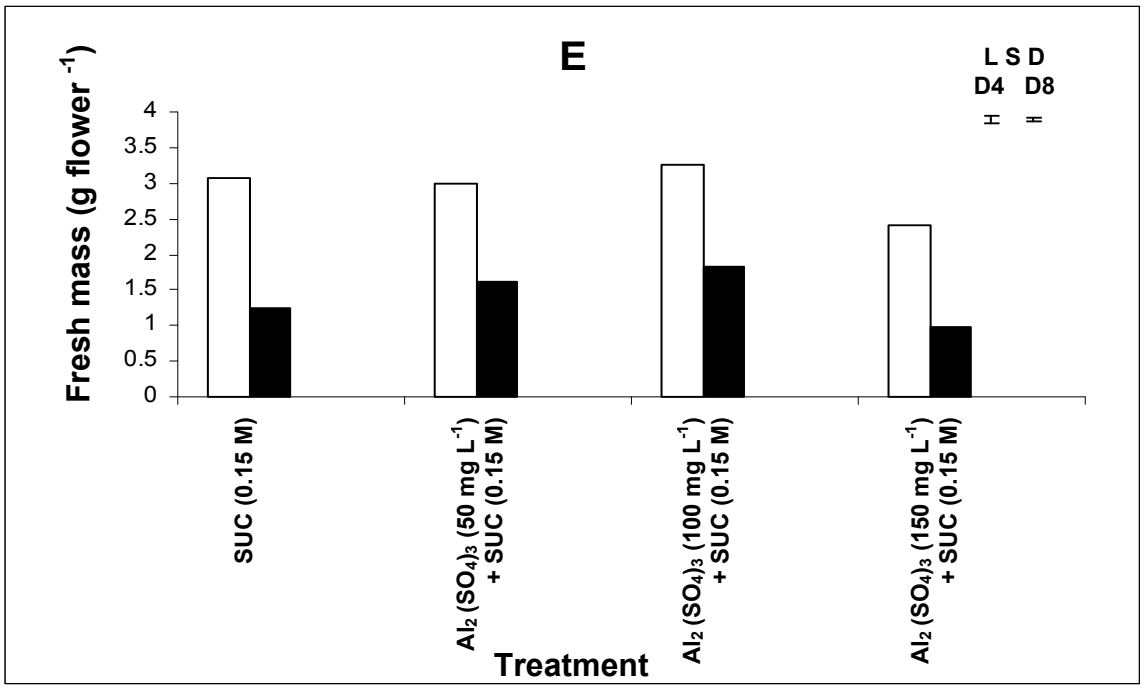

D
L S D
D4 D8
Conductivity of leachates (µS)
0
10
20
30
40
50
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.2

Fig. 5.5.3

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


E
L S D
D4 D8
Fresh mass (g flower -1)
4
3.5
3
2.5
2
1.5
1
0.5
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

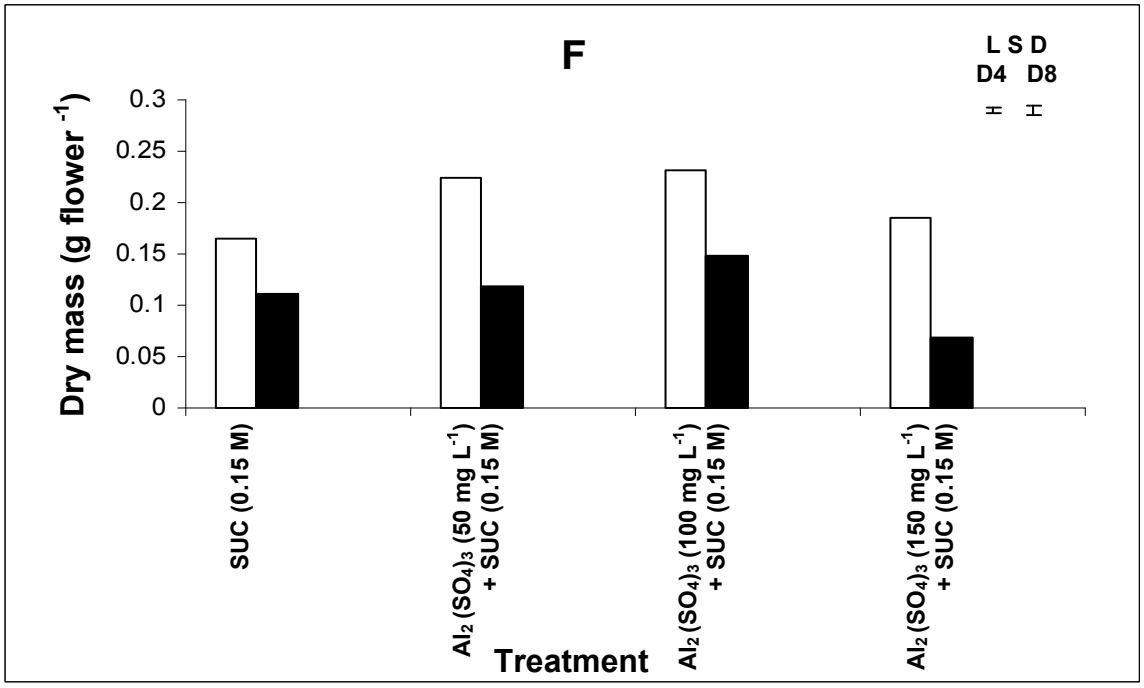
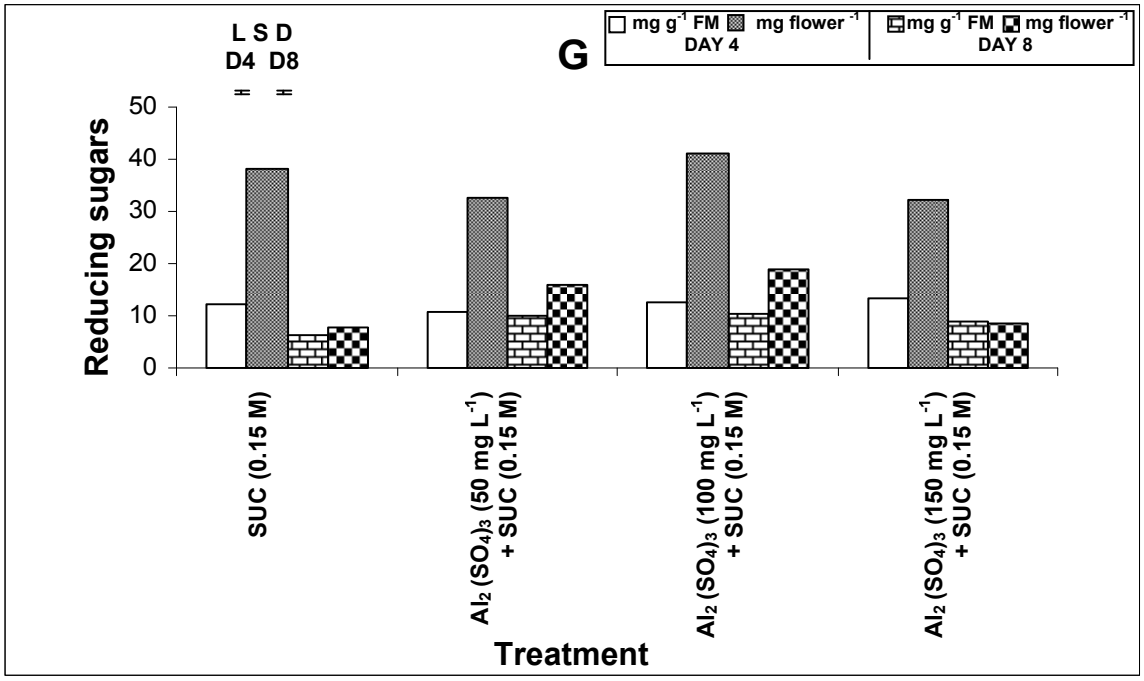

F
L S D
D4 D8
Dry mass (g flower -1)
0.3
0.25
0.2
0.15
0.1
0.05
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.3

Fig. 5.5.4

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on reducing sugars (G) and non reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


G
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Reducing sugars
50
40
30
20
10
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

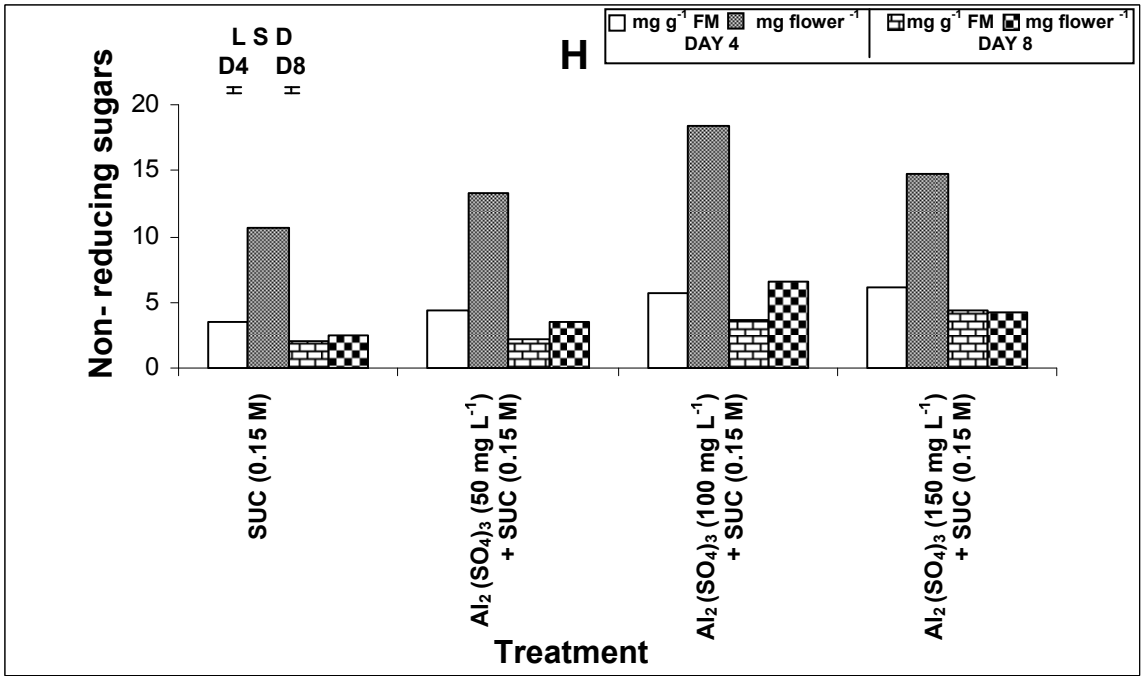
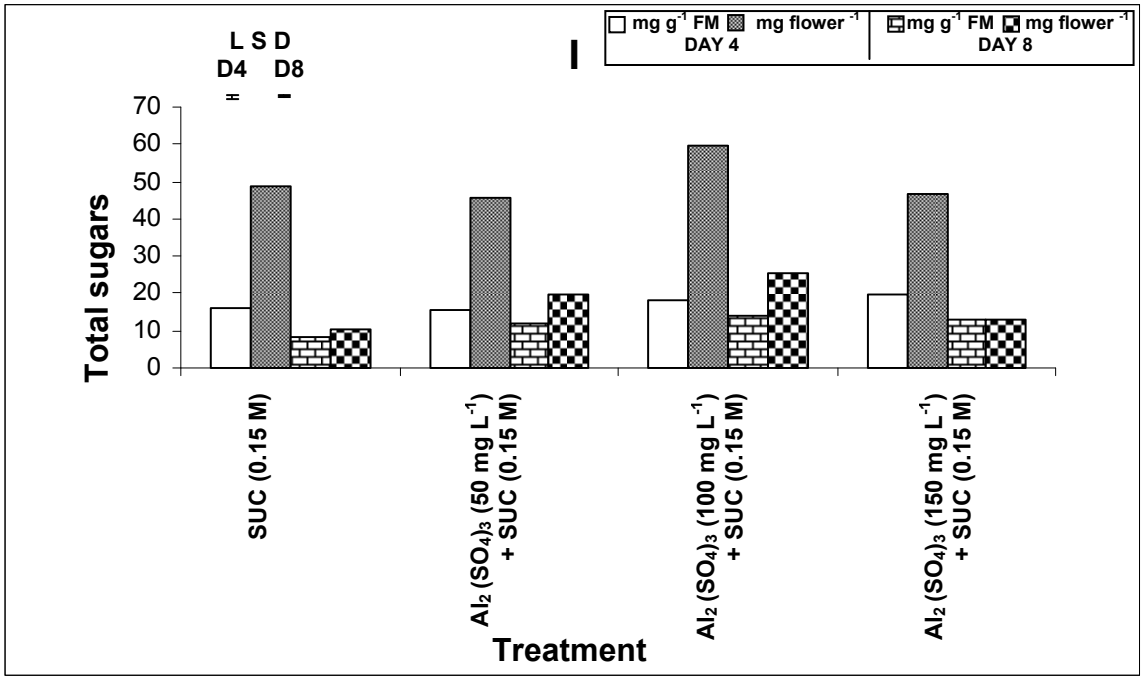

H
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Non- reducing sugars
20
15
10
5
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.4

Fig. 5.5.5

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on total sugars (I) and soluble protein (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


I
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4
D8
Total sugars
70
60
50
40
30
20
10
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

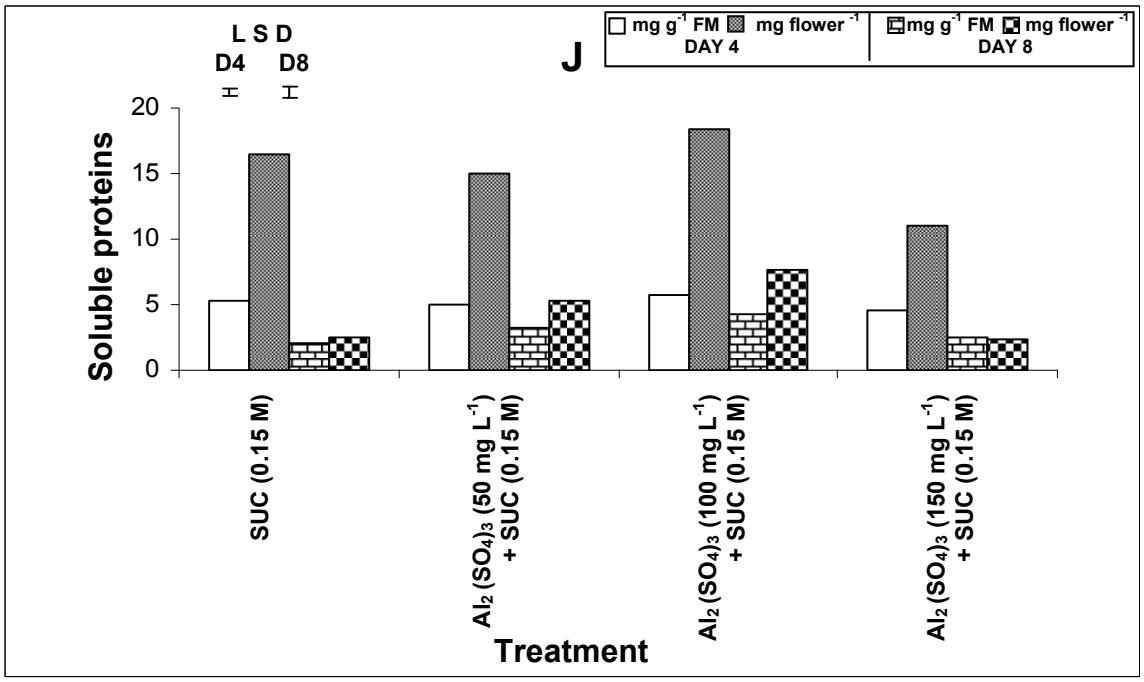
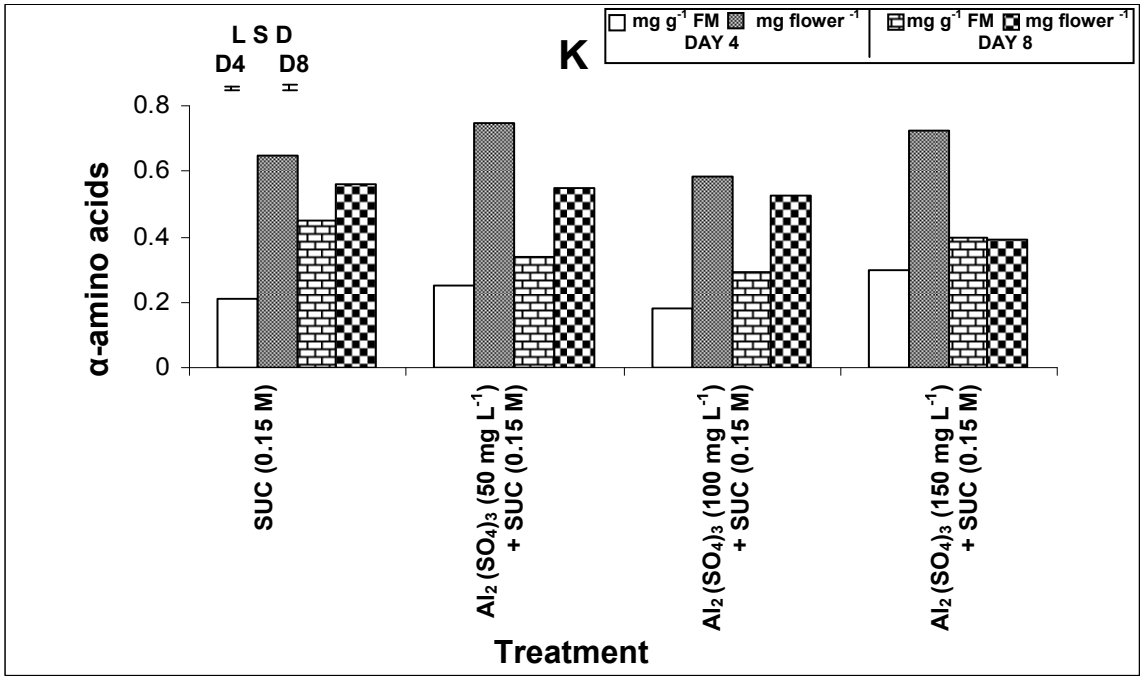

J
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4
D8
Soluble proteins
20
15
10
5
0
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.5

Fig. 5.5.6

Effect of SUC (0.15M) alone and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.

Vertical bars represent LSD at $P_{= 0.05}$


K
L S D
D4
D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
α-amino acids
0
0.2
0.4
0.6
0.8
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

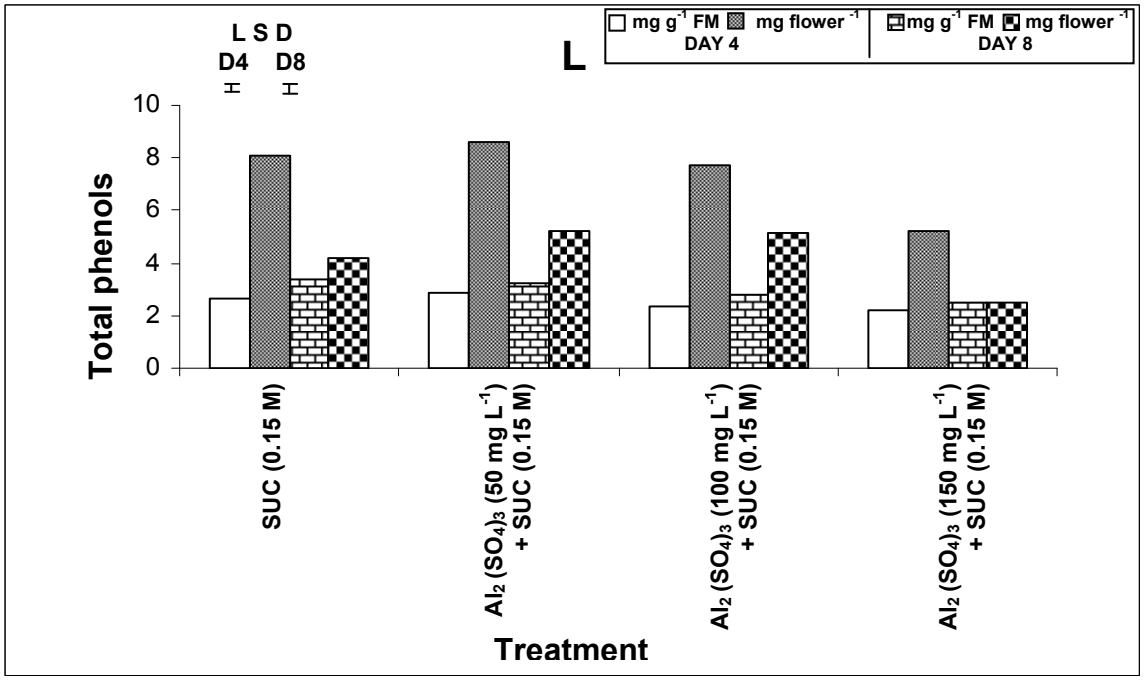

L
L S D
D4
D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Total phenols
0
2
4
6
8
10
SUC (0.15 M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15 M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15 M)
Treatment

Fig. 5.5.6

Plate. 5.5

Effect of SUC (0.15M) separately and in combination with $Al_2 (SO_4)_3$ at (50 mg L^{-1}), (100 mg L^{-1}) and (150 mg L^{-1}) on day 4 and 8 of transfer of scapes to holding solutions in *Amaryllis belladonna* cv. Rosea.


1
SUC (0.15M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15M)
2
SUC (0.15M)
Al2 (SO4)3 (50 mg L-1) + SUC (0.15M)
Al2 (SO4)3 (100 mg L-1) + SUC (0.15M)
Al2 (SO4)3 (150 mg L-1) + SUC (0.15M)

Plate. 5.5

CHAPTER 6

Flower Senescence and Regulation of Vase life in *Nerine sarniensis* cv. Red.

Nerine derives its name from "Neried", the Greek water-nymph. *Nerines* are native to South Africa and were first described as *Narcissus japonicus rutilo flore* in 1635 by J. Cornut. Later in 1735 Linnaeus included this species under the name *Amaryllis sarniensis* and in 1820 the genus *Nerine* was established by Herbert (Zonneveld and Duncan, 2006). Today about 30 bulbous perennial species found on mountain sides, rocky and dry areas are included in this genus of family Amaryllidaceae (Perry, 2000). Nerines have been widely cultivated and much hybridized and are now spread world wide. *Nerine* bulbs can be planted in November with neck just above the soil with full sun and sheltered location. After flowering plant produces leaves which die down by late spring and the bulb is then dormant until late summer. In fall each bulb produces a single naked stem about 35 cm tall which bears a cluster of 2 to 6 funnel shaped white, orange, pink or red coloured flowers at their top. Each flower is about 4 cm in diameter. Much of the display value to flower is added by the stamens projecting brilliantly out of the tepals.

Great clusters of *Nerine* trumpets add colour to the autumn gardens giving a passable impression of spring. The flowers have a delicacy often missing at autumn time when the gardens are preparing for winter. The flowers of *Nerine sarniensis* are used for borders containers and are an excellent choice as cut flowers. Realizing the tremendous potential of Nerines as cut flowers, studies pertaining to the mechanism of flower development and senescence were made, besides effective postharvest handling techniques were attempted to determine the optimal harvest maturity stage and possible mode of effective, wet or dry cool storage. The vase life and postharvest modulations using protein synthesis inhibitors (CHI), ethylene sensitivity with STS or AOA were studied. Responses to growth regulators like KIN, BAP and GA_3 were also attempted.

EXPERIMENT 6.1

Physiological and biochemical changes associated with the flower development and senescence in *Nerine sarniensis* cv. Red.

Experimental

Flowers of *N. sarniensis* growing in the University Botanic Garden were used for the study. Flower development and senescence was divided into six stages. These stages were designated as tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI) (Plate 6.1.1, Figs.1-2). Visible changes were recorded throughout flower development and senescence at periodic intervals. Floral diameter, fresh and dry mass were determined at each stage. Changes in membrane permeability were estimated by measuring the conductivity of leachates (μS) in tepal discs (5 mm in diameter) punched from outer regions of perianth of five different flowers and incubated in 15 ml glass distilled water for 15 h at 20^{o}C.

For the estimation of tissue constituents 1g chopped material of tepal tissue was fixed in hot 80% ethanol at each stage of flower development and senescence. The material was macerated and centrifuged three times at 1000 rpm. The supernatants were pooled, made to volume and suitable aliquots were used for the estimation of reducing sugars, non-reducing sugars, total sugars, α-amino acids and total phenols as described in materials and methods. Non-reducing sugars were calculated as the difference between total and reducing sugars. Soluble proteins were extracted from 1 g tepal tissue drawn separately from five different flowers at each of the six stages and suitable aliquots were used for the estimation as described in material and methods. Electrophoretic profiles were studied at various stages of flower development and senescence, 80 μL of the SDS-denatured protein extract was loaded into each lane. Each value represented

in the tables corresponds to the mean of five to ten independent replicates. The data have been analyzed statistically by computing standard deviation.

Results

Visible changes: The buds open into red flowers and the flower senescence in *N. sarniensis* is characterised by the curling and turgor loss starting at the margins of tepals followed by complete wilting. The average life span of an individual flower after it opens fully is about 3 days while as the average life span on scape is about 6 days (Plate 6.1.1, Figs.1-2).

Floral diameter: Flower diameter increased as the flower development progressed up to stage IV to V and declined thereafter as the floral development progressed to senescence from V to stage VI (Table 6.1.1, Text Fig. 6.1.1, A).

Fresh mass, dry mass and water content of flowers: Fresh mass, dry mass and water content of flowers increased with flower development up to stage V and registered a sharp decline thereafter as the senescence progressed from stage V to stage VI. The water content at various stages of floral development and senescence was more or less constant when the data was expressed on percent fresh mass basis (Table 6.1.1, Text Fig. 6.1.1, B,C and D).

Membrane permeability: Membrane permeability estimated as electrical conductivity of leachates (μS) from tepal discs increased as the flower development and senescence progressed through various stages. Lower values of electrical conductivity were maintained up to stage II followed by an appreciable increase in the electrical conductivity of ion leachates (Table 6.1.1, Text Fig. 6.1.1, E).

Reducing sugars: The tissue content of reducing sugars increased consistently during flower development up to stage IV and declined thereafter as the flower development progressed through senescence (Table

6.1.2, Text Fig. 6.1.2, F). When expressed on per flower basis the reducing sugar content increased progressively from stage I to stage V followed by a decline therafter during the senescent stage (Table 6.1.2). On dry mass basis a progressive increase in the reducing sugar content was noticed up to stage IV followed by decline therafter during the final stages of senescence (Table 6.1.3).

Non-reducing sugars: The tissue concentration of non-reducing sugars declined during early stages of flower development, from stage I to II followed by a marked increase up to stage III and a considerable decline thereafter during flower senescence up to stage VI (Table 6.1.2, Text Fig. 6.1.2, G). Almost similar trends were observed when the data was expressed on per flower and on dry mass basis (Tables 6.1.2 & 6.1.3).

Total sugars: The total sugars increased during flower development from stage I to IV and declined thereafter during senescence up to stage VI (Table 6.2, Text Fig. 6.1.2, H). On per flower basis the total sugar content increased progressively from stage I to stage VI and declined thereafter during the final stages of senescence (Table 6.1.2). On dry mass basis the total sugar content increased progressively from stage I to III and declined thereafter as the senescence progressed from stage III to V followed by a slight increase towards final stages of senescence (Table 6.1.3).

Soluble proteins: The concentration of soluble proteins registered a consistent decline during flower development and senescence from stage I to stage VI both on fresh mass and dry mass basis (Tables 6.1.2, 6.1.3 Text Fig. 6.1.3, I). On per flower basis the soluble protein content showed a decrease during flower development up to stage II followed by an increase up to stage IV and a decline thereafter during the final stages of senescence up to stage VI (Table 6.1.2).

α- amino acids: The amino acid content increased consistently during flower development and senescence from stage I to stage VI (Table 6.1.2, Text Fig. 6.1.3, J). On per flower basis the amino acid content increased consistently up to stage V followed by a decline during final stage of senescence at stage VI (Table 6.1.2) On dry mass basis amino acid content showed a progressive and apparent increase during flower development and senescence (Table 6.1.3).

Phenols: The concentration of total phenols decreased initially at stage II and then remained more or less constant up to stage V followed by a sharp increase during final stages of senescence (Table 6.1.2, Text Fig. 6.1.3,K). When expressed on per flower basis the concentration of phenols was maintained up to stage II followed by an increase thereafter up to stage VI (Table 6.1.2). On dry mass basis the concentration of total phenols was more or less maintained up to stage V followed by a sharp increase thereafter during senescence at stage VI (Table 6.1.3).

***Electrophoretic profile*:** The SDS-PAGE profile of tepal proteins at various stages of flower development and senescence showed that most of the polypeptides were consistent throughout the various stages of flower development and senescence particularly polypeptides having the molecular mass of 79.4, 43.6 and 21.8 kDa. A new polypeptide having the molecular mass of 7.9 kDa showed up during the final phase of senescence at stage VI (Plate 6.1.2).

Table 6.1.1: Flower diameter, fresh mass, dry mass, water content and conductivity of leachates during development and senescence in flowers of *Nerine sarniensis* cv. Red (Each value is a mean of 10 independent replicates, figures in parentheses represents values on percent basis).

Stages of flower development	Floral diameter (cm)	Fresh mass flower^{-1} (g)	Dry mass flower^{-1} (g)	Water content flower^{-1} (g)	Conductivity of leachates (µs)
I (tight bud stage)	0.58 ±0.07	0.258 ± 0.01	0.031 ± 0.007	0.227 ± 0.03 (87.80)	8.46 ± 0.56
II (loose bud stage)	1.25 ± 0.01	0.296 ± 0.01	0.032 ± 0.001	0.264 ± 0.02 (89.41)	8.16 ± 0.56
III (half open stage)	3.50 ± 0.35	0.449 ± 0.01	0.046 ± 0.002	0.403 ± 0.01 (89.70)	11.13 ± 0.65
IV (fully open stage)	5.08 ± 0.27	0.569 ± 0.01	0.058 ± 0.002	0.511 ± 0.03 (89.77)	11.86 ± 0.77
V (partially senescent stage)	6.33 ± 0.20	0.658 ± 0.02	0.073 ± 0.001	0.585 ± 0.04 (88.73)	13.86 ± 1.41
VI (senescent stage)	5.75 ± 0.17	0.482 ± 0.08	0.045 ± 0.001	0.437 ± 0.03 (90.60)	16.50 ± 0.50

Table 6.1.2 : Sugars, proteins, α-amino acids and phenols (expressed as mg g^{-1} fresh mass) during development and senescence in flowers of *Nerine sarniensis* cv. Red (Each value is a mean of 5 independent replicates, figures in parentheses represents values on mg $flower^{-1}$ basis).

Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	11.10 ± 0.40 (2.86)	6.73 ± 0.45 (1.74)	17.86 ± 0.45 (4.60)	5.80 ± 0.02 (1.49)	0.26 ± 0.01 (0.06)	3.25 ± 0.10 (0.83)
II	16.26 ± 0.35 (4.81)	3.13 ± 0.40 (0.92)	19.40 ± 0.40 (5.74)	4.06 ± 0.11 (1.20)	0.27 ± 0.005 (0.070	2.75 ± 0.20 (0.81)
III	17.46 ± 0.40 (7.83)	6.76 ± 0.50 (3.03)	24.23 ± 0.45 (10.87)	3.06 ± 0.11 (1.37)	0.31 ± 0.01 (0.13)	2.27 ± 0.10 (1.01)
IV	20.23 ± 0.80 (11.51)	2.23 ± 0.59 (1.26)	22.46 ± 0.46 (12.77)	2.66 ± 0.11 (1.51)	0.33 ± 0.01 (0.18)	2.56 ± 0.10 (1.45)
V	19.00 ± 0.40 (12.50)	2.06 ± 0.11 (1.35)	21.00 ± 0.40 (13.81)	1.80 ± 0.20 (1.18)	0.44 ± 0.01 (0.28)	2.69 ± 0.15 (1.77)
VI	17.03 ± 0.40 (8.20)	2.80 ± 0.10 (1.34)	19.83 ± 0.45 (9.55)	1.60 ± 0.40 (0.77)	0.46 ± 0.005 (0.22)	4.28 ± 0.14 (2.06)

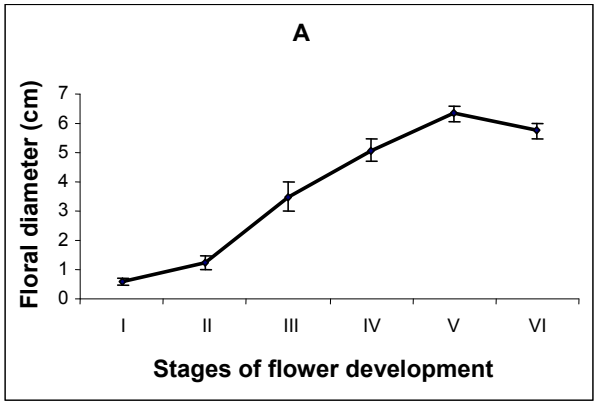
Table 6.1.3 : Sugars, proteins, α-amino acids and phenols expressed on dry mass basis (mg g^{-1} DM) during development and senescence in flowers of *Nerine sarniensis* cv. Red (Each value is a mean of 5 independent replicates).

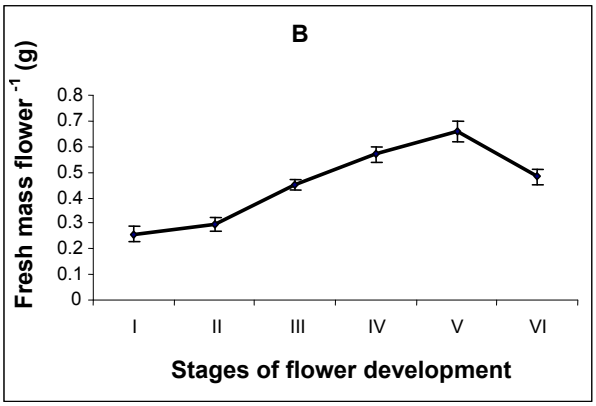
Stages of flower development	Reducing sugars	Non-reducing sugars	Total sugars	Soluble proteins	α- amino acids	Total phenols
I	55.15 ± 1.77	85.69 ± 0.89	140.85 ± 1.60	24.09 ± 1.06	0.88 ± 0.06	51.66 ± 1.06
II	82.05 ± 6.06	78.20 ± 4.09	160.26 ± 3.58	24.03 ± 0.77	1.24 ± 0.07	53.76 ± 1.95
III	106.25 ± 5.17	70.47 ± 3.39	176.72 ± 5.56	22.22 ± 0.92	1.62 ± 0.02	38.02 ± 1.67
IV	131.40 ± 1.34	79.98 ± 2.56	211.39 ± 3.64	23.08 ± 0.52	1.94 ± 0.05	41.0 ± 0.91
V	124.60 ± 1.34	71.30 ± 1.84	195.91 ± 2.10	28.59 ± 0.52	1.63 ± 0.03	36.20 ± 1.05
VI	92.97 ± 2.25	67.53 ± 2.05	160.50 ± 1.75	17.77 ± 0.43	1.86 ± 0.09	36.57 ± 2.01

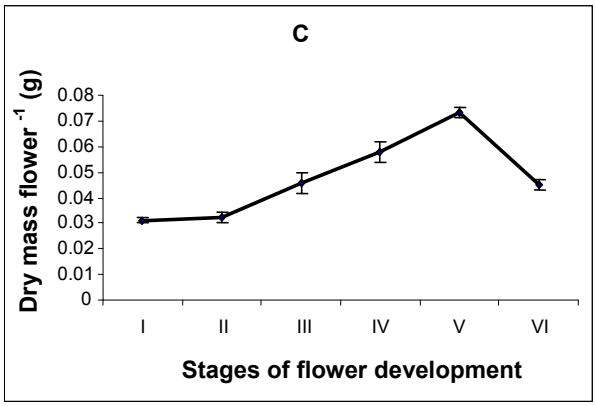
Fig. 6.1.1

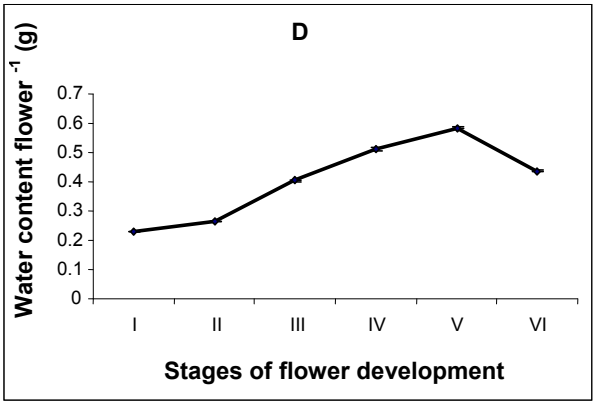
Changes in floral diameter (A), fresh mass (B), dry mass (C), water content (D) and conductivity of leachates (E) in flowers of *Nerine sarniensis* cv. Red at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


A
Floral diameter (cm)
0
1
2
3
4
5
6
7
I
II
III
IV
V
VI
Stages of flower development


B
Fresh mass flower -1 (g)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
I
II
III
IV
V
VI
Stages of flower development


C
Dry mass flower -1 (g)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
I
II
III
IV
V
VI
Stages of flower development


D
Water content flower -1 (g)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
I
II
III
IV
V
VI
Stages of flower development

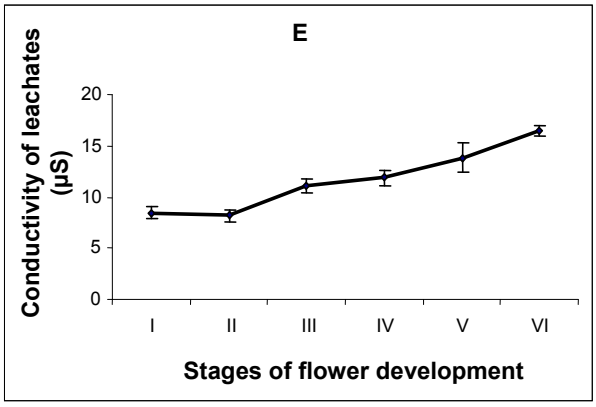
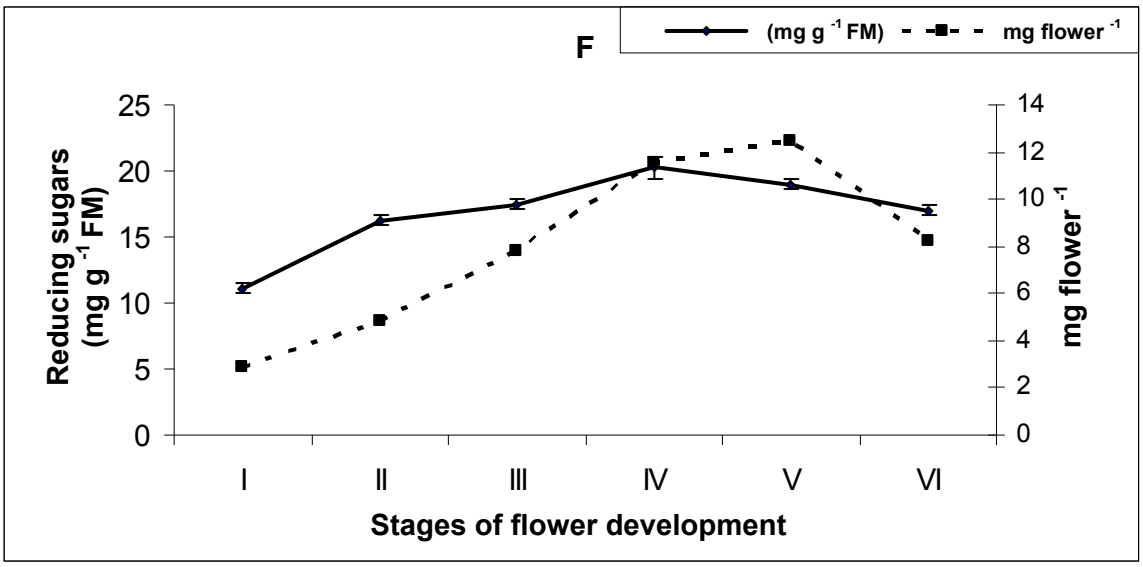

E
Conductivity of leachates (µS)
0
5
10
15
20
I
II
III
IV
V
VI
Stages of flower development

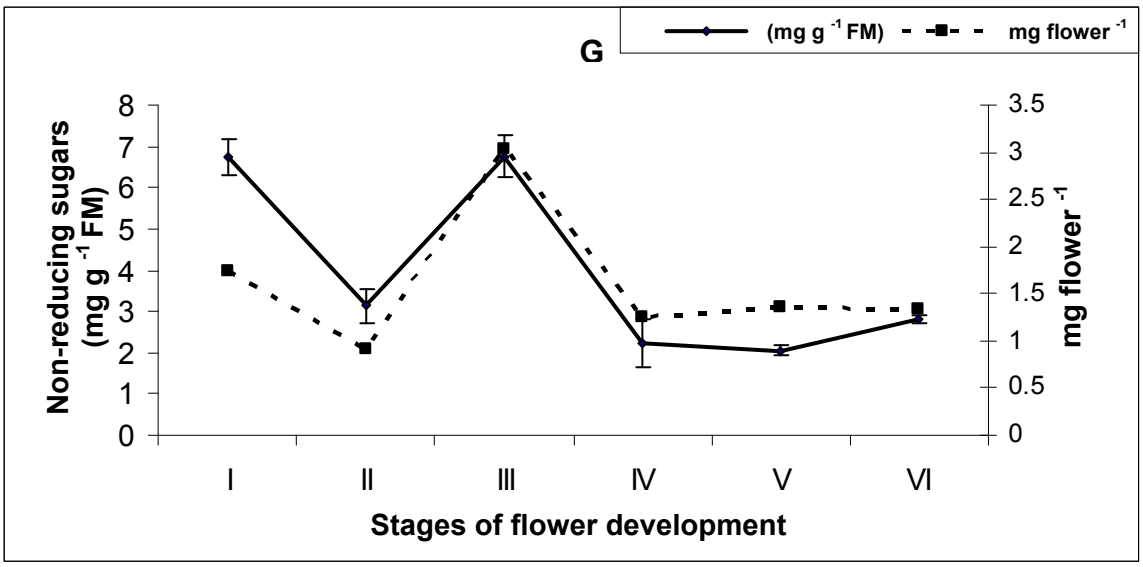
Fig. 6.1.1

Fig. 6.1.2

Changes in reducing sugars (F), non – reducing sugars (G), and total sugars (H) in flowers of *Nerine sarniensis* cv. Red at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


F
(mg g -1 FM)
mg flower -1
Reducing sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
0
2
4
6
8
10
12
14
I
II
III
IV
V
VI
Stages of flower development


G
(mg g -1 FM)
mg flower -1
Non-reducing sugars (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
6
7
8
0
0.5
1
1.5
2
2.5
3
3.5
I
II
III
IV
V
VI
Stages of flower development

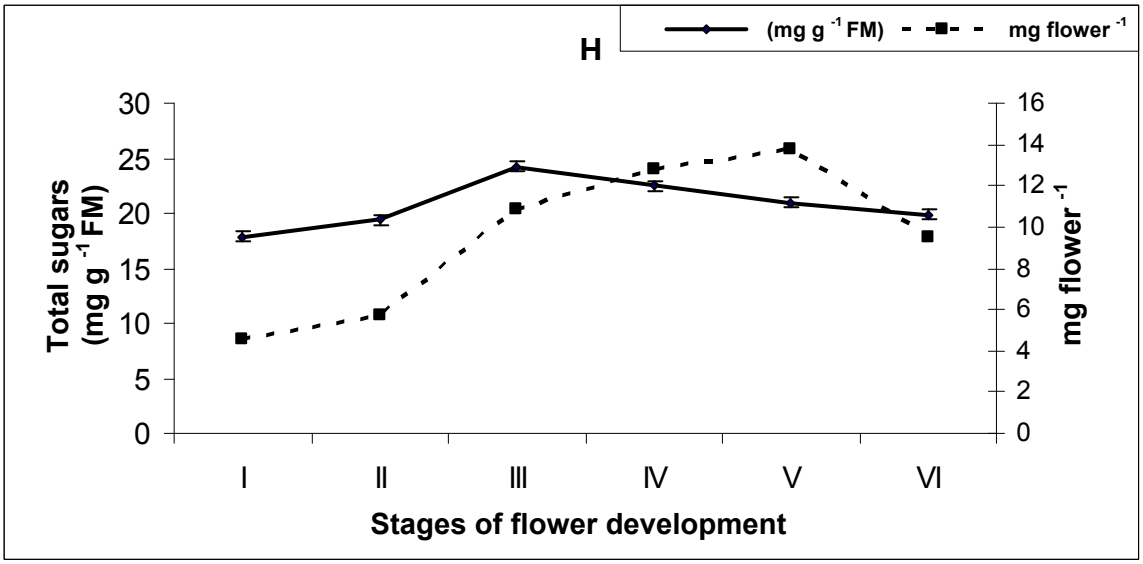
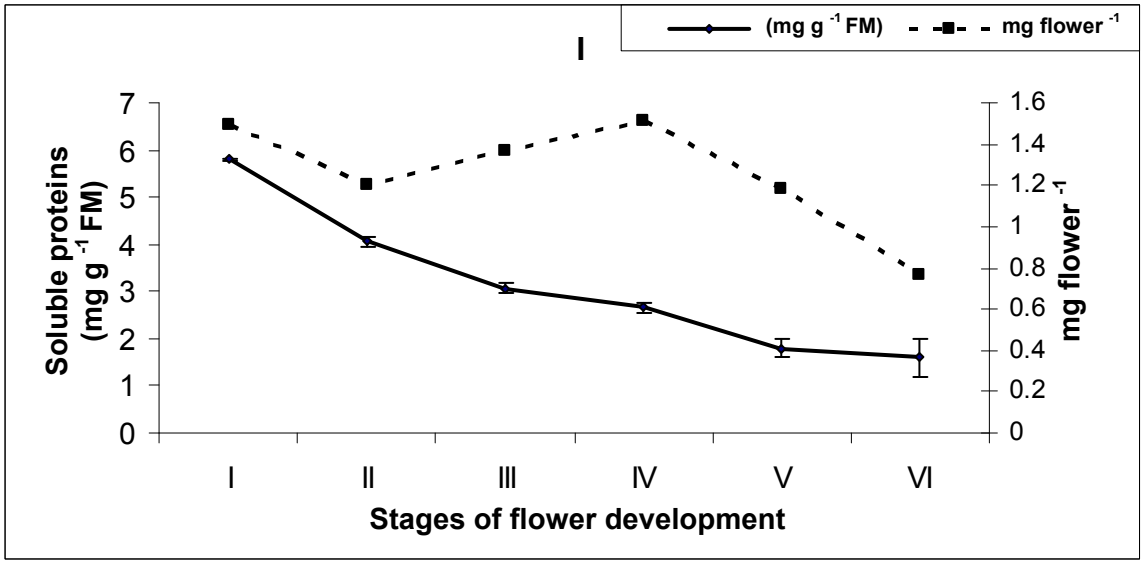

H
(mg g -1 FM)
mg flower -1
Total sugars (mg g -1 FM)
mg flower -1
0
5
10
15
20
25
30
0
2
4
6
8
10
12
14
16
I
II
III
IV
V
VI
Stages of flower development

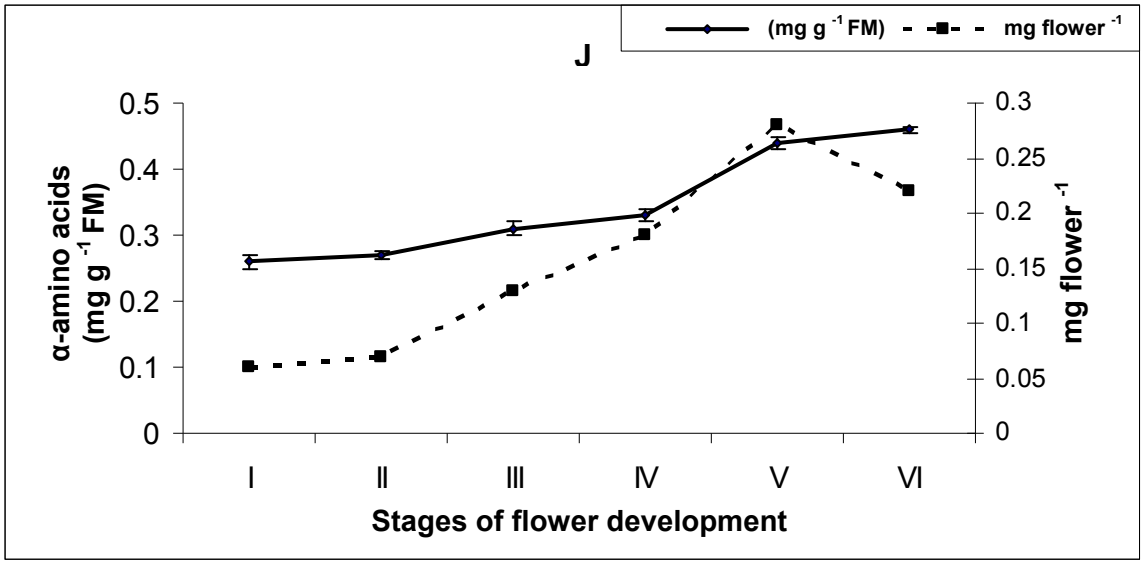
Fig. 6.1.2

Fig. 6.1.3

Changes in soluble proteins (I), α- amino acids (J) and total phenols (K) in flowers of *Nerine sarniensis* cv. Red at successive stages of development and senescence.

The vertical bars represent the standard deviation (SD) of mean values.


I
(mg g -1 FM)
mg flower -1
Soluble proteins (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
I
II
III
IV
V
VI
Stages of flower development


J
(mg g -1 FM)
mg flower -1
α-amino acids (mg g -1 FM)
mg flower -1
0
0.1
0.2
0.3
0.4
0.5
0
0.05
0.1
0.15
0.2
0.25
0.3
I
II
III
IV
V
VI
Stages of flower development

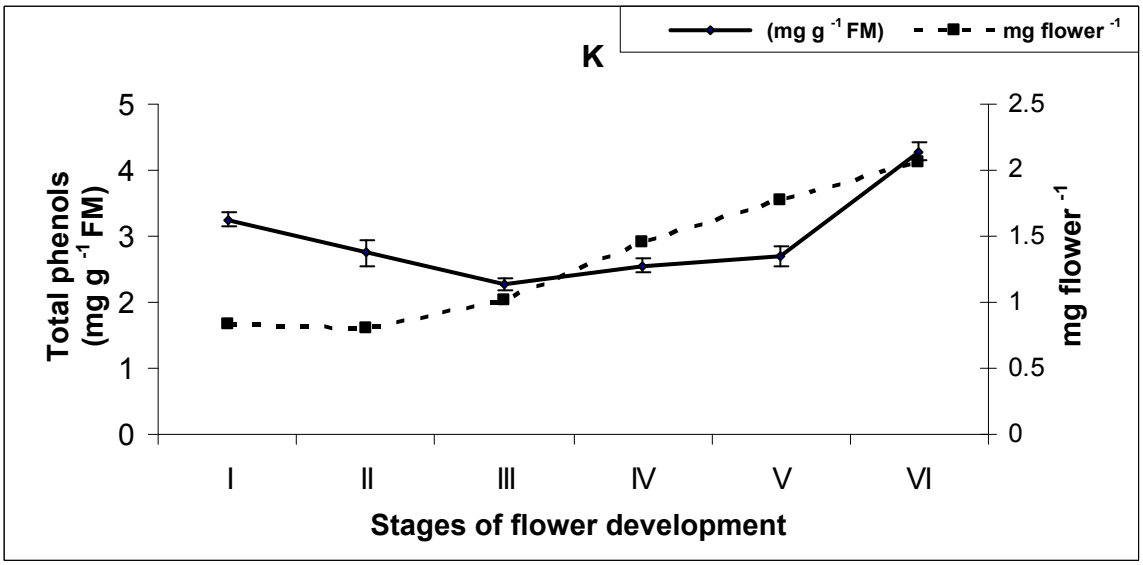

K
(mg g -1 FM)
mg flower -1
Total phenols (mg g -1 FM)
mg flower -1
0
1
2
3
4
5
0
0.5
1
1.5
2
2.5
I
II
III
IV
V
VI
Stages of flower development

Fig. 6.1.3

Plate 6.1.1

Fig.1: Stages of scapes development in *Nerine sarniensis* cv. Red.

Fig.2: Stages of flower development and senescence in *Nerine sarniensis* cv. Red.

From left to right are arranged scapes or flowers at successive stages of development and senescence. Stages I to VI in the figure represent, tight bud stage (I), loose bud stage (II), half open stage (III), fully open stage (IV), partially senescent stage (V) and senescent stage (VI).

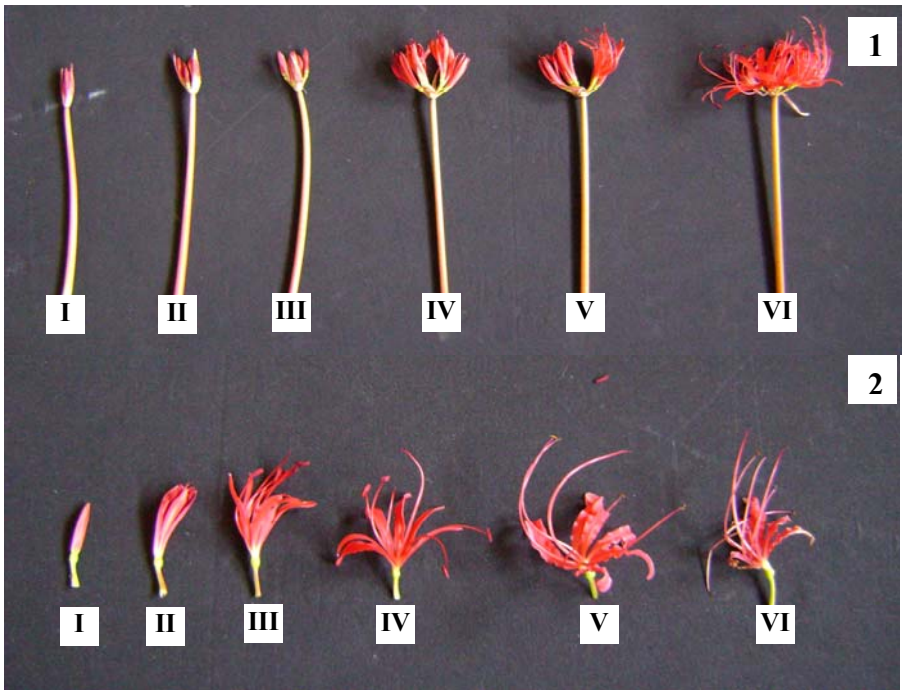


Plate. 6.1.1

Plate 6.1.2

Fig. : 12 % SDS –PAGE, equal amounts of extractable protein at various stages (I-VI) of flower development and senescence from tepal tissues of *Nerine sarniensis* cv. Red number above the lanes corresponds to developmental stages. The gel was stained with coomassie blue. Molecular weight standards are indicated on the left (kDa) and approximate molecular weights of major polypeptides to the right of the gel (kDa).

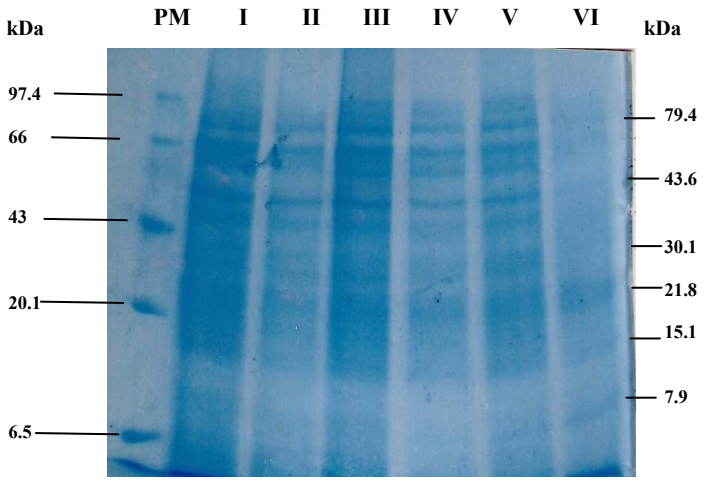


Plate. 6.1.2

EXPERIMENT 6. 2

Effect of postharvest wet storage (PHWS) at different temperatures regimes 5, 10 and room temperature (RT=21 ± 2°C) for 72 h before transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in distilled water (DW) in separate buckets and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (21±2^{o}C). After storage for 72 h all the scapes were kept at room temperature and transferred to 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC (0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to holding solution and was assessed to be terminated when of the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 3 of the transfer. Volume of solutions absorbed per scape was recorded on day 2 to 6 after the transfer of scapes to holding solutions. Electrical conductivity of leachates, form tepal discs; fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to various

holding solutions. Changes in tissue constituents comprising sugar fractions, soluble proteins, α- amino acids and phenolics were also estimated on day 4 and 8 after the transfer of scapes to various holding solutions. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes wet stored for 72 h at RT had already bloomed during the storage and senesced by day 7 of the transfer of scapes to SUC +8-HQS (Plate. 6.2.1, Figs. 1-2). Blooming during storage was least in the scapes previously wet stored at 5 and 10 ^{o}C before transfer to holding solutions and showed symptoms of tepal senescence by day 9 and 11 of transfer to SUC+8-HQS (Plate. 6.2.2; Figs. 1-3). Senescence was assessed when the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) (Plate. 6.2.3; Figs. 1-3).

Vase life: The average vase life of scapes previously wet stored at 5 and 10^{o}C before transfer to DW was about 5 days each while as the corresponding scapes stored at RT before transfer to DW exhibited a vase life of 4 days. The average vase life of scapes previously wet stored at 5^{o}C, 10^{o}C and RT before transfer to SUC was 7, 7 and 6 days respectively. The average vase life of scapes stored at different temperature regimes (5^{0}C, 10^{0}C and RT) before transfer to SUC+8-HQS was 11, 9 and 7 days respectively (Table 6.2.1; Text Fig.6.2.1, A).

Number of blooms per scape: Number of blooms per scape as also the percent blooming increased in all treatments with progression in time irrespective of the transfer to various holding solutions. The scapes previously wet stored at RT for 72 h exhibited 100 percent blooming by day 1 of transfer irrespective of the transfer to various holding solutions. The scapes previously wet stored at 10^{0}C for 72 h generally exhibited maximum blooming up to day

2 of transfer to various holding solutions. Maximum and sustained blooming up to day 3 was particularly recorded in scapes wet stored at 5 ^{o}C especially in SUC+8-HQS (Table 6.2.1; Text Fig. 6.2.2, B).

Volume of holding solution absorbed per scape (ml): The volume of holding solutions absorbed increased with progression from day 2 to 6 of transfer of scapes to various holding solutions irrespective of the particular temperature regime and holding solution. The solution uptake was found to be higher in scapes previously wet stored for 72 h at 5 and 10°C as compared to the corresponding scapes held at RT irrespective of the holding solution. A higher solution uptake was recorded in (SUC + 8- HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment however, maximum solution uptake was noticed in scapes previously wet stored at 5°C for 72 h transferred to (SUC + 8- HQS) (Table 6.2.1; Text Fig. 6.2.2, C).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. The concentration of leachates significantly increased in samples from scapes previously wet stored at RT, however the conductivity of leachates from samples wet stored at 10 and 5°C was maintained irrespective of the transfer to various holding solutions. At each temperature regime the leachates were found to be less in samples from scapes held in SUC + 8 - HQS followed by scapes held in SUC as compared to samples from corresponding scapes held in DW (Table 6.2.2; Text Fig. 6.2.2, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously wet stored at various temperature regimes registered an decrease with progression in time from day 4 to day 8 irrespective of the transfer to various holding solutions. However, the samples from scapes wet stored at 5 and 10 C ^{0} and transferred to SUC + 8-HQS registered an increase

over the period of time. At each of the temperature regimes both fresh and dry mass was found to be the highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the samples from corresponding scapes held in DW, however maximum value for fresh and dry mass was recorded in samples from scapes previously wet stored at 5°C for 72 h and transferred to SUC +8- HQS (Table 6.2.2; Text Fig. 6.2.3, E & F).

Reducing sugars: The reducing sugar content of the samples form scapes previously wet stored for 72 h before transfer to SUC + 8-HQS registered an increase with progression in time from day 4 to 8, whereas the reducing sugar content of samples from the corresponding scapes held in SUC or DW decreased over the period of time irrespective of the temperature treatment. The reducing sugar content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.2.3; Text Fig. 6.2.4, G).Almost similar trends were obtained when the data was expressed on per flower and on dry mass basis but the differences showed up clearly on these particular reference bases (Tables 6.2.3 & 6.2.4). Generally higher reducing sugar content was noticed in samples from scapes wet stored at 5 °C for 72 h and transferred to SUC + 8-HQS.

Non-reducing sugars: The non-reducing sugar content of samples form scapes previously wet stored for 72 h at various temperatures registered an increase with progression in time from day 4 to 8 irrespective of the transfer to various holding solutions. At each of the temperature regimes the non-reducing sugar content was found to be highest in samples form scapes held in SUC+8-HQS or SUC as compared to corresponding scapes held in DW (Table 6.2.3; Text Fig. 6.2.4, H). Almost similar trends were obtained when the data was expressed on per flower basis as also on dry mass basis but the differences

were sharp and apparent (Table 6.2.3 & 6.2.4). Generally higher non-reducing sugar content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Total sugars: The total sugar content of samples form scapes previously wet stored for 72 h in SUC + 8-HQS registered an increase with progression in time from day 4 to 8 of transfer of scapes, whereas the total sugar content of samples from the corresponding scapes held in SUC or DW decreased over the period of time irrespective of the storage temperature. The total sugar content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the total sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.2.3; Text Fig. 6.2.4, I). Almost Similar trends were obtained when the data was expressed on per flower and on dry mass basis but the differences showed up clearly on these particular reference bases (Tables 6.2.3 & 6.2.4). Generally higher total sugar content was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Soluble proteins: The soluble protein content of samples form scapes previously wet stored for 72 h in SUC + 8-HQS registered an increase with progression in time from day 4 to 8 of transfer of scapes whereas the protein content of samples from the corresponding scapes held in SUC or DW decreased over the period of time irrespective of the storage temperature. The protein content of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the protein content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.2.3; Text Fig. 6.2.5, J). Almost similar trends were obtained when the data was

expressed on per flower and on dry mass basis but the differences showed up clearly on these particular reference bases (Table 6.2.3 & 6.2.4). Generally higher protein content was noticed in samples from scapes wet stored at 5 °C for 72 h and transferred to SUC + 8-HQS.

α- amino acids: The α-amino acid content of samples form scapes previously wet stored for 72 h in SUC + 8-HQS registered a decrease with progression in time from day 4 to 8 of scapes, whereas the amino acid content of samples from the corresponding scapes held in SUC or DW increased over the period of time irrespective of the storage temperature. The content of amino acids of samples from scapes previously wet stored for 72 h at 5 and 10°C registered an increase as compared to the samples from corresponding scapes held at RT. At each of the temperature regimes the amino acid content was found to be lowest in samples from scapes held in SUC+8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.2.3; Text Fig. 6.2.6, K). Almost similar trends were obtained when the data was expressed on per flower and on dry mass basis but the differences showed up clearly on these particular reference bases (Tables 6.2.3 & 6.2.4). Generally a lower content of amino acids was noticed in samples from scapes wet stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Total phenols: Generally the content of total phenols registered an increase with progression in time from day 4 to 8 of transfer of scapes irrespective of the transfer to various holding solutions. A lower content of phenols was registered in samples from scapes previously wet stored at 5 and 10 °C for 72 h as compared to the samples from scapes held at RT. At each temperature regime, a higher content of phenols was maintained in the samples form scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.2.5; Text Fig. 6.2.6, L). When the data was expressed on per flower or dry mass basis, similar trends were observed but the differences became sharp and apparent (Tables 6.2.5 & 6.2.6).

Table 6.2.1: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Temperature treatment (72h)	Vase life (days)	No. of blooms per scape				Volume of holding solution absorbed per scape (ml)		
		Days after treatment						
		0	1	2	3	2	4	6
RT→DW	4	5.10 (90)	5.66 (100)	-	-	3.00	5.50	6.76
10 °C→DW	5	2.32 (41)	4.58 (80)	5.66 (100)	-	3.25	6.70	7.00
5 °C →DW	5	1.13 (20)	3.40 (60)	5.21 (100)	5.66 (100)	4.50	7.00	8.50
RT→SUC(0.15M)	6	5.10 (90)	5.66 (100)	-	-	3.50	6.50	7.00
10°C→SUC(0.15M)	7	2.32 (41)	5.10 (90)	5.66 (100)	-	5.00	7.50	9.00
5°C→SUC(0.15M)	7	1.13 (20)	3.96 (70)	5.44 (96)	5.66 (100)	6.00	8.00	10.00
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	9	5.10 (90)	5.66 (100)	-	-	4.00	3.60	10.00
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	9	2.32 (41)	5.25 (95)	5.66 (100)	-	8.00	10.30	12.60
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	11	1.12 (20)	5.40 (96)	5.66 (100)	-	9.60	13.50	15.00
LSD at $P_{=0.05}$	0.33	0.50	0.57	0.63	-	0.90	1.50	1.60

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent percent blooms.

Table: 6.2.2: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment (72h)	Conductivity of leachates (µS)		Fresh mass (g flower^{-1})		Dry mass (g flower^{-1})	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	14.00	26.89	0.301	0.232	0.042	0.030
10 °C→DW	12.31	15.86	0.363	0.260	0.051	0.036
5 °C →DW	10.09	9.96	0.411	0.391	0.064	0.058
RT→SUC(0.15M)	13.03	21.66	0.333	0.258	0.048	0.033
10°C→SUC(0.15M)	11.03	10.90	0.396	0.288	0.060	0.041
5°C→SUC(0.15M)	10.00	9.66	0.433	0.401	0.071	0.061
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	9.53	9.00	0.359	0.302	0.050	0.044
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	9.80	7.50	0.428	0.430	0.069	0.070
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	6.96	6.00	0.502	0.562	0.079	0.083
LSD at $P_{=0.05}$	0.44	0.67	0.12	0.34	0.04	0.08

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Table 6.2.3: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72h)	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	11.32 (3.40)	7.33 (1.70)	0.68 (0.20)	2.00 (0.46)	12.00 (3.61)	9.33 (2.16)
10 °C→DW	12.31 (4.46)	9.31 (2.42)	2.00 (0.72)	2.80 (0.72)	14.31 (5.19)	12.11 (3.14)
5 °C →DW	15.98 (6.56)	11.62 (4.54)	3.91 (1.60)	3.60 (1.40)	19.89 (8.17)	15.22 (5.95)
RT→SUC(0.15M)	13.00 (4.32)	8.81 (2.27)	2.61 (0.86)	2.97 (0.76)	15.61 (5.19)	11.78 (3.03)
10°C→SUC(0.15M)	16.00 (6.33)	11.99 (3.45)	3.33 (1.31)	1.24 (0.35)	19.33 (7.65)	13.23 (3.81)
5°C→SUC(0.15M)	17.83 (7.72)	16.09 (6.45)	3.50 (1.51)	3.60 (1.44)	21.33 (9.23)	19.69 (7.89)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	16.77 (6.02)	17.32 (5.23)	3.86 (1.38)	3.90 (1.17)	20.63 (7.40)	21.22 (6.40)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	19.88 (8.50)	20.11 (8.64)	5.11 (2.18)	8.88 (3.81)	24.99 (10.69)	28.99 (12.46)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	23.92 (12.01)	25.67 (14.42)	4.71 (2.36)	7.95 (4.46)	28.63 (14.37)	33.62 (18.89)
LSD at $P_{=0.05}$	1.13	1.68	0.98	0.67	1.45	2.03

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent value on mg $flower^{-1}$ basis.

Table 6.2.4: Effect of postharvest wet storage (PHWS) for 72 h at different temperature regimes on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72h)	Reducing Sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	81.12	56.68	4.87	15.46	86.00	72.15
10 °C→DW	87.61	67.23	14.23	20.22	101.85	87.46
5 °C →DW	102.62	78.33	25.10	24.26	127.73	102.60
RT→SUC(0.15M)	90.18	68.87	18.10	23.22	108.29	92.098
10°C→SUC(0.15M)	105.60	84.22	21.97	8.71	127.57	92.932
5°C→SUC(0.15M)	108.73	105.77	21.34	23.66	130.08	129.43
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	120.40	118.87	27.71	26.76	148.12	145.64
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	123.31	123.53	31.69	54.54	155.01	178.08
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	151.99	173.81	29.92	53.83	181.92	227.64
LSD at $P_{=0.05}$	5.66	8.67	2.65	3.55	9.73	13.43

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21±2°C).

Table 6.2.5: Effect of postharvest wet storage (PHWS) for 72 h on at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g $^{-1}$ FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment (72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	4.65 (1.39)	3.21 (0.74)	0.60 (0.18)	0.72 (0.16)	5.00 (1.50)	5.03 (1.16)
10 °C→DW	5.51 (2.00)	4.00 (1.04)	0.52 (0.18)	0.63 (0.16)	4.23 (1.53)	4.21 (1.09)
5 °C →DW	6.00 (2.46)	4.09 (1.59)	0.48 (0.19)	0.60 (0.23)	4.00 (1.64)	3.82 (1.49)
RT→SUC(0.15M)	5.00 (1.66)	3.50 (0.90)	0.51 (0.16)	0.68 (0.17)	6.33 (2.10)	6.65 (1.71)
10°C→SUC(0.15M)	6.23 (2.46)	4.21 (1.21)	0.44 (0.17)	0.50 (0.14)	5.52 (2.18)	6.00 (1.72)
5°C→SUC(0.15M)	7.33 (3.17)	6.33 (2.53)	0.30 (0.12)	0.40 (0.16)	4.62 (2.00)	4.99 (2.00)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	8.83 (3.16)	8.80 (2.65)	0.26 (0.09)	0.21 (0.06)	6.60 (2.36)	7.33 (2.21)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	10.33 (4.42)	11.32 (4.86)	0.14 (0.05)	0.17 (0.07)	6.00 (2.56)	6.99 (3.00)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	12.33 (6.18)	12.51 (7.03)	0.11 (0.05)	0.09 (0.05)	5.00 (2.51)	5.21 (2.92)
LSD at $P_{=0.05}$	0.62	0.85	0.23	0.04	0.64	0.82

.Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Figures in parentheses represent value on mg flower^{-1} basis.

Table 6.2.6: Effect of postharvest wet storage (PHWS) for 72 h on at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	33.32	24.82	4.30	5.56	35.83	38.89
10 °C→DW	39.21	28.88	3.70	4.55	30.10	30.40
5 °C →DW	38.53	27.57	3.08	4.04	25.68	25.75
RT→SUC(0.15M)	34.68	27.36	3.53	5.31	43.91	51.99
10°C→SUC(0.15M)	41.11	29.57	2.90	3.51	36.43	42.14
5°C→SUC(0.15M)	44.70	41.61	1.82	2.62	28.17	32.80
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	63.39	60.40	1.86	1.44	47.38	50.31
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	64.07	69.53	0.86	1.04	37.21	42.93
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	78.35	84.70	0.69	0.60	31.77	35.27
LSD at $P_{=0.05}$	1.57	1.05	0.21	0.17	1.66	0.89

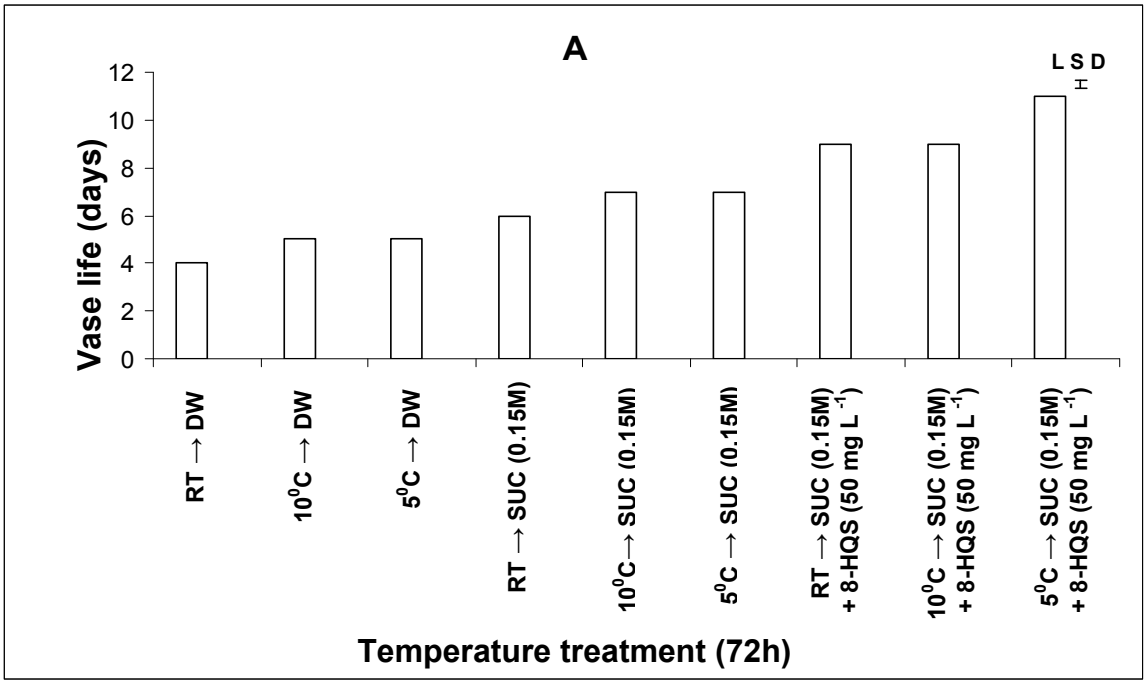
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Fig. 6.2.1

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


A
L S D
Vase life (days)
0
2
4
6
8
10
12
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C→ SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

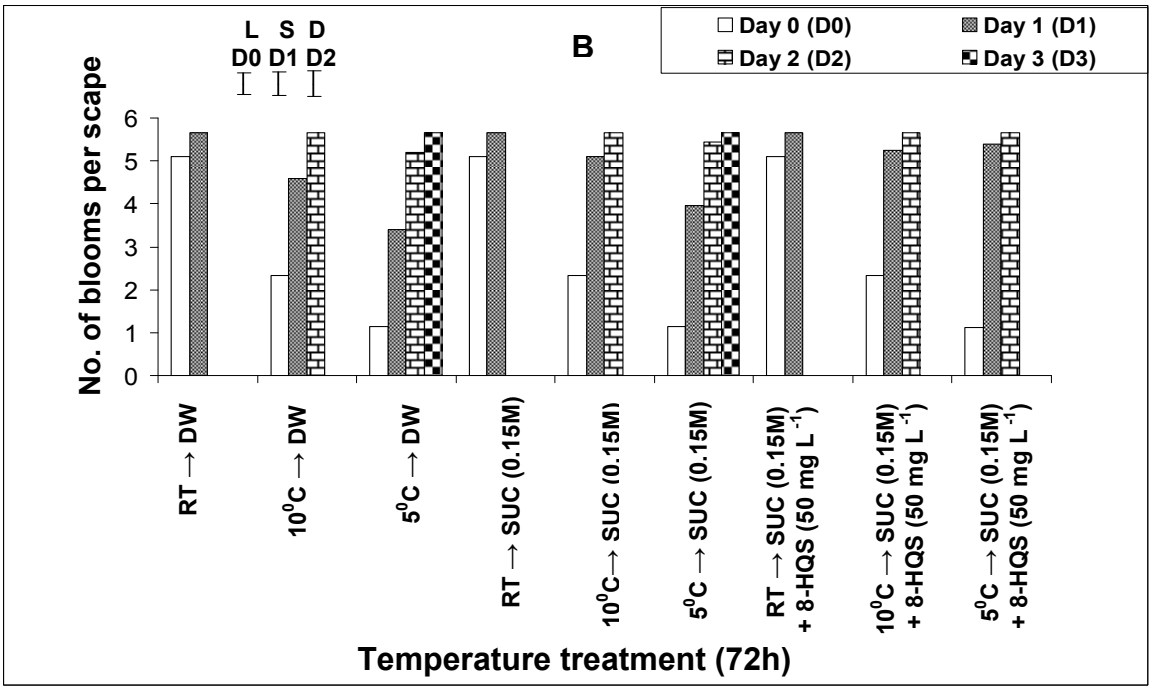
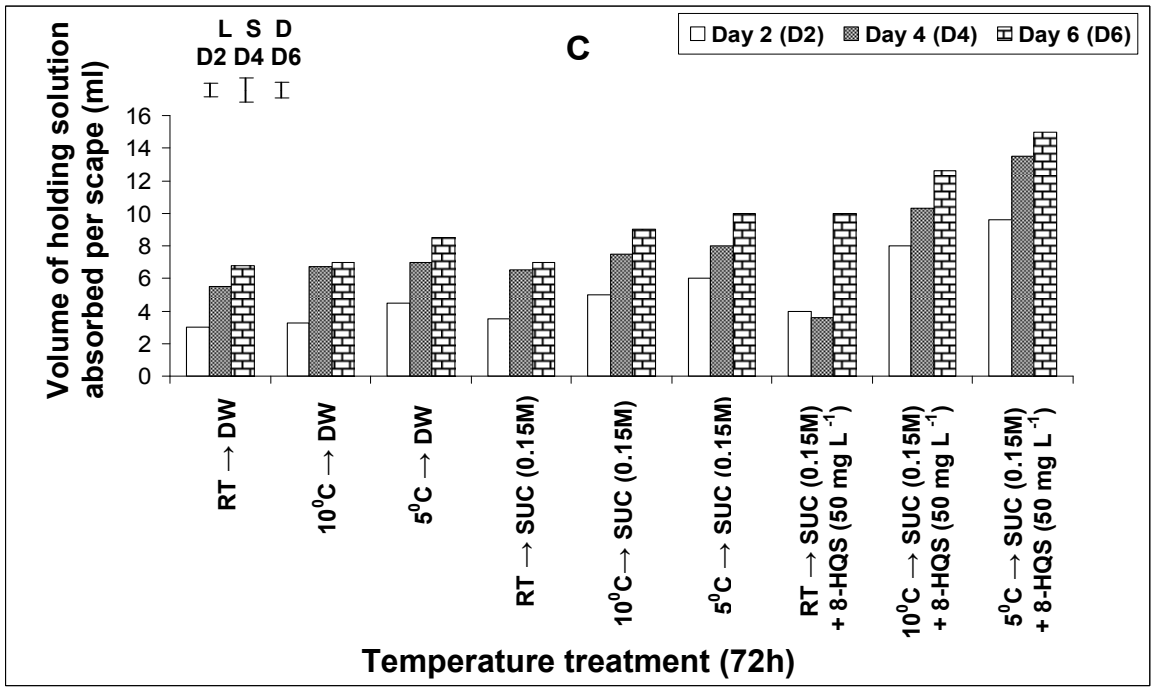

B
L S D
D0 D1 D2
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
No. of blooms per scape
0
1
2
3
4
5
6
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C→ SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L⁻¹)
Temperature treatment (72h)

Fig. 6.2.1

Fig. 6.2.2

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4 and 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at P $_{= 0.05.}$


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
0
2
4
6
8
10
12
14
16
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

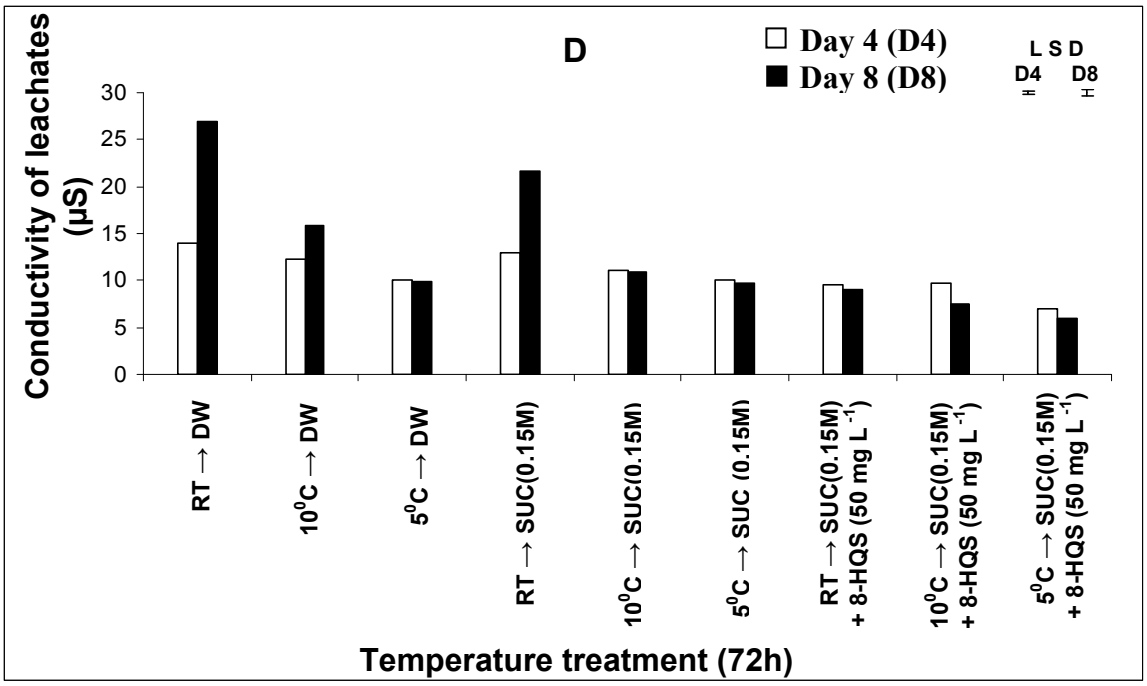
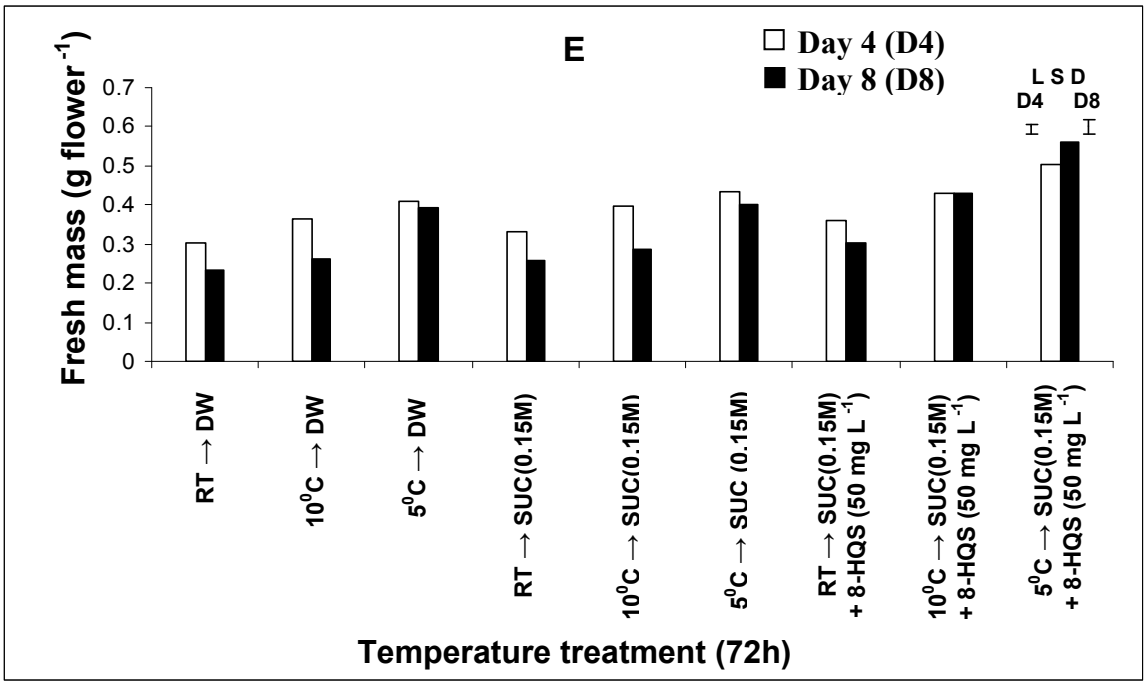

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.2.2

Fig.6.2.3

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Fresh mass (g flower-1)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

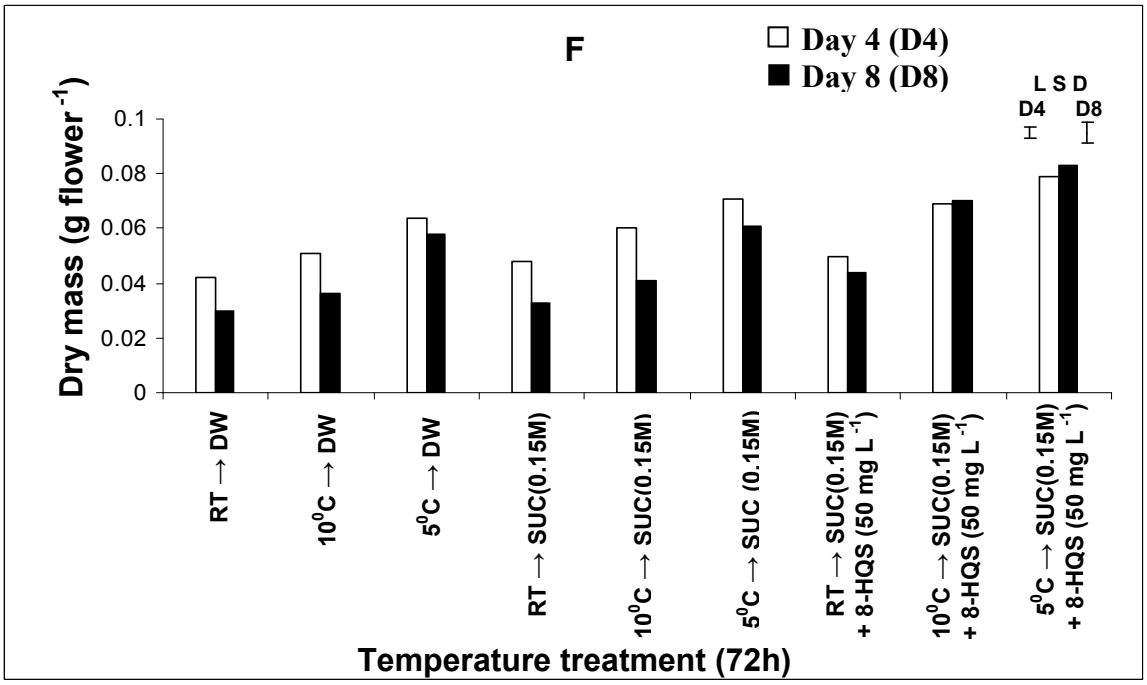
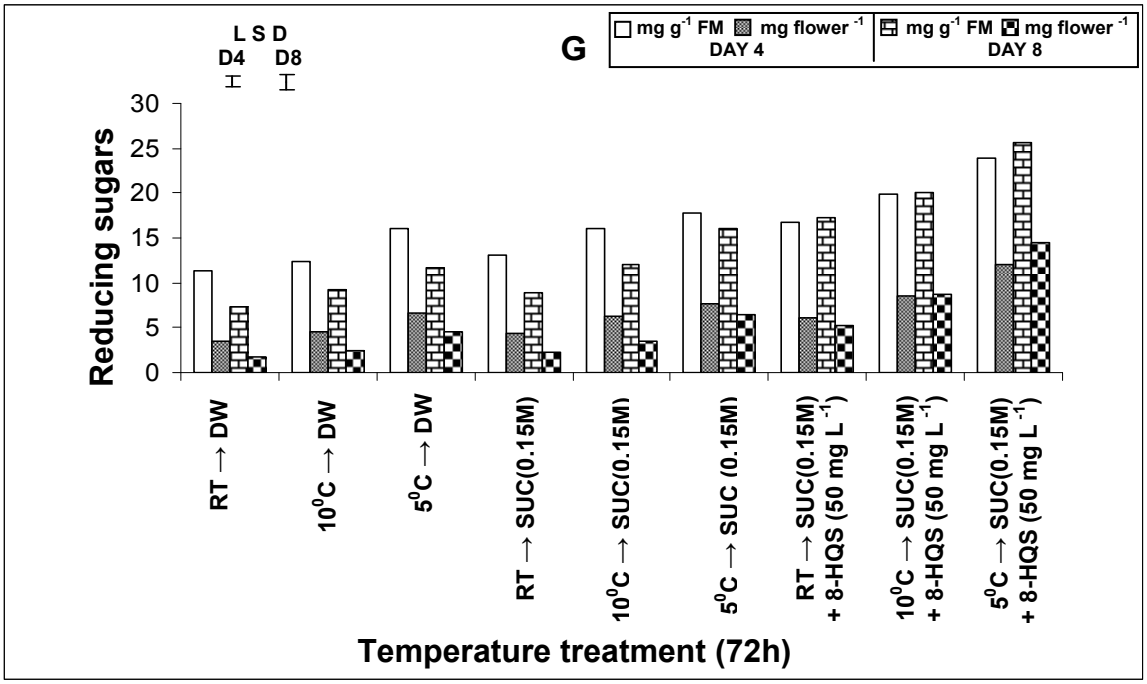

F
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Dry mass (g flower-1)
0.1
0.08
0.06
0.04
0.02
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.2.3

Fig. 6.2.4

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$.


G
L S D
D4
D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Reducing sugars
30
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

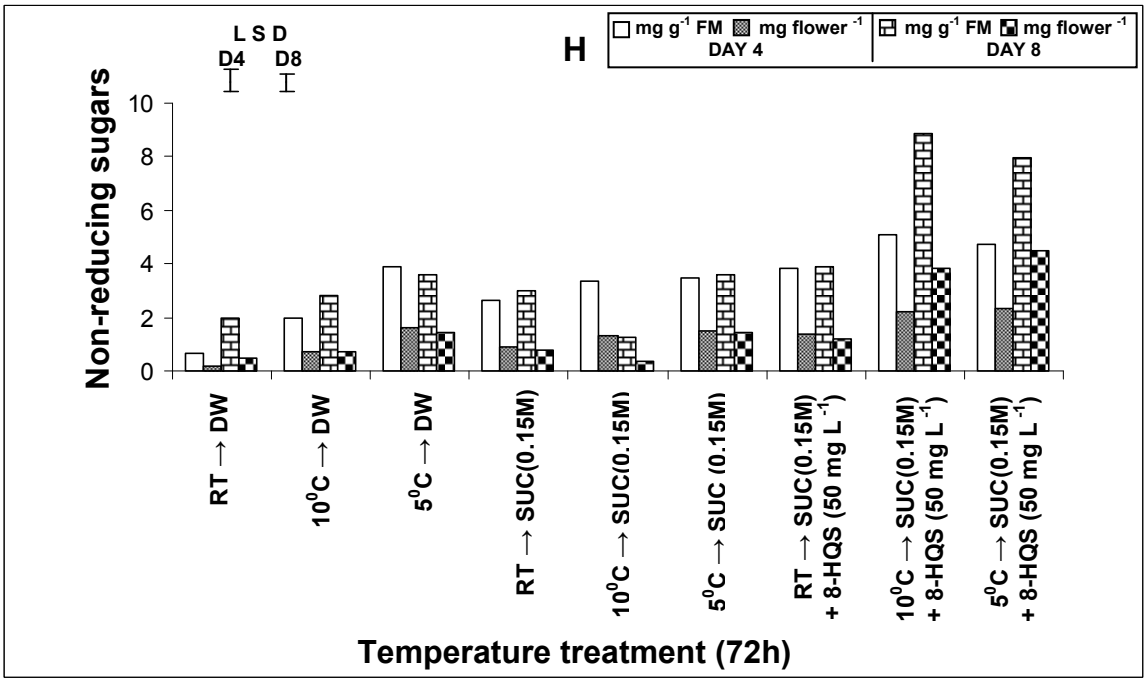
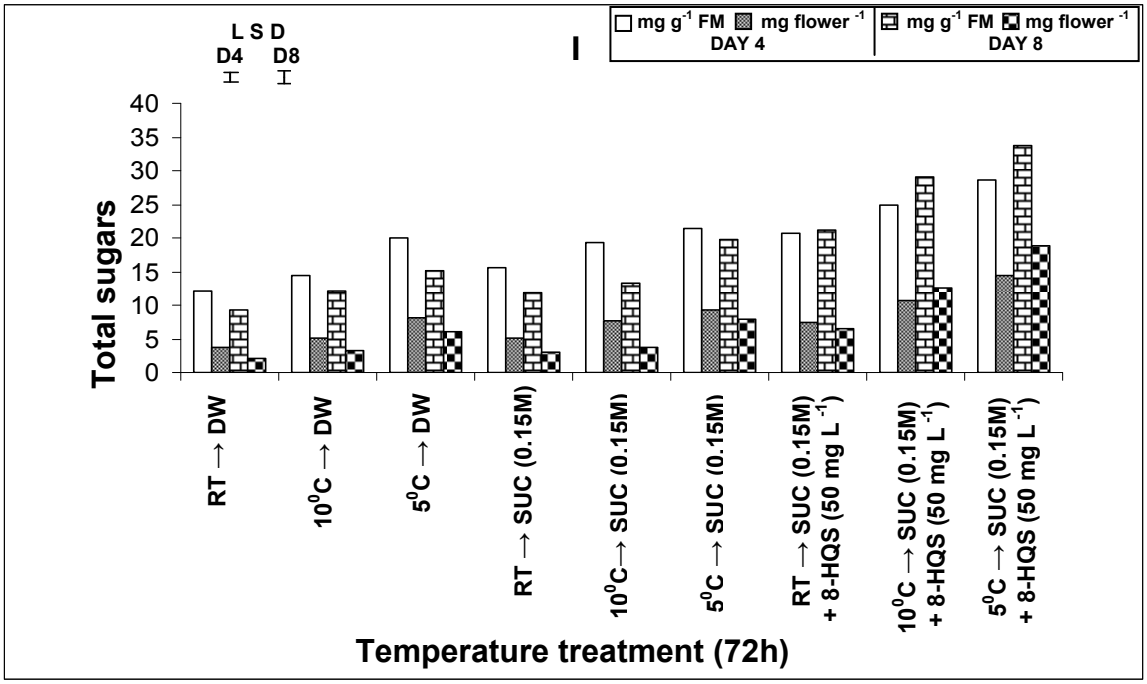

H
L S D
D4
D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Non-reducing sugars
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.2.4

Fig. 6.2.5

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


I
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Total sugars
40
35
30
25
20
15
10
5
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C→ SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

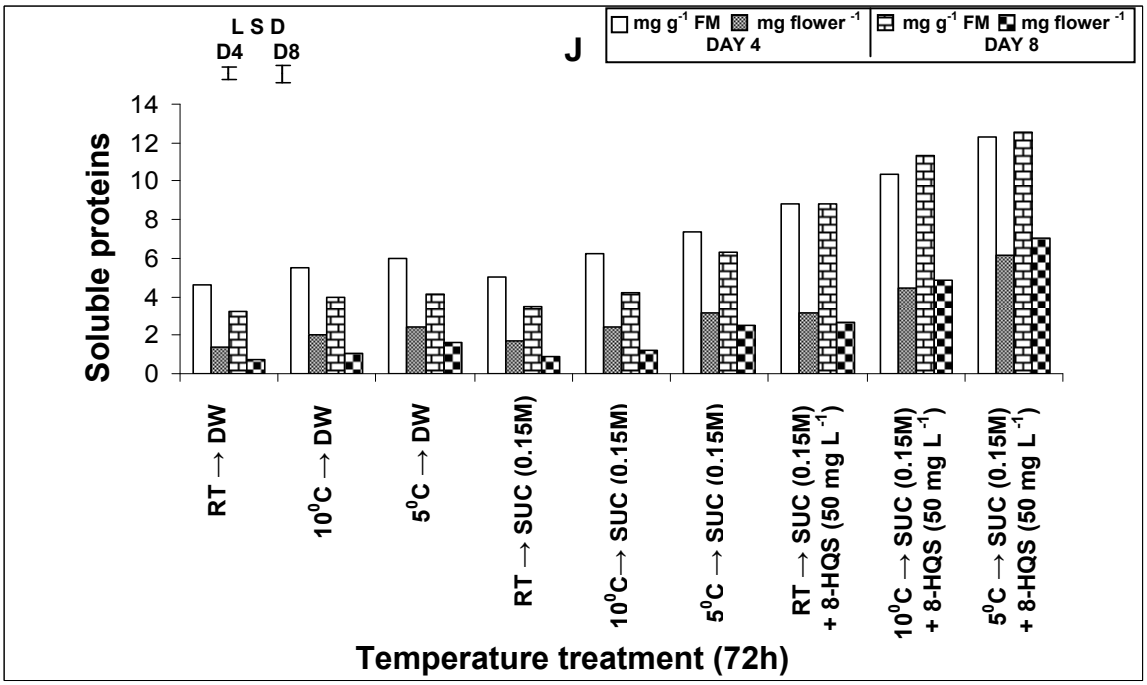
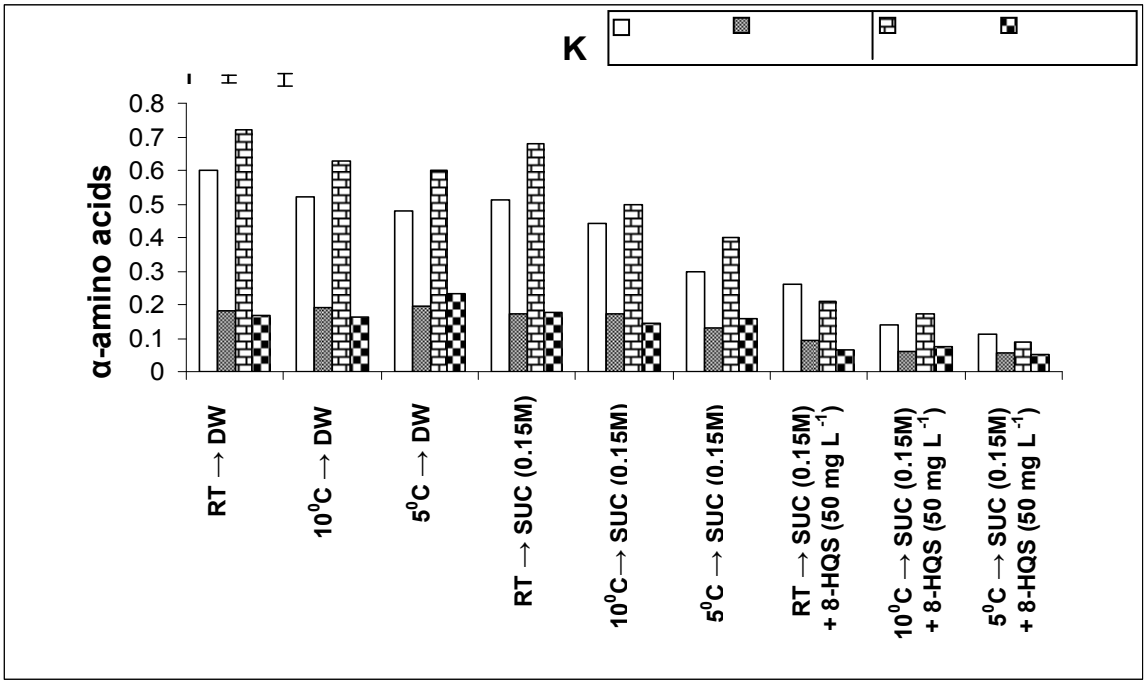

J
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Soluble proteins
14
12
10
8
6
4
2
0
RT → DW
10⁰C → DW
5⁰C → DW
RT → SUC (0.15M)
10⁰C→ SUC (0.15M)
5⁰C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
5⁰C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.2.5

Fig. 6.2.6

Histograms showing effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


K
α-amino acids
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)

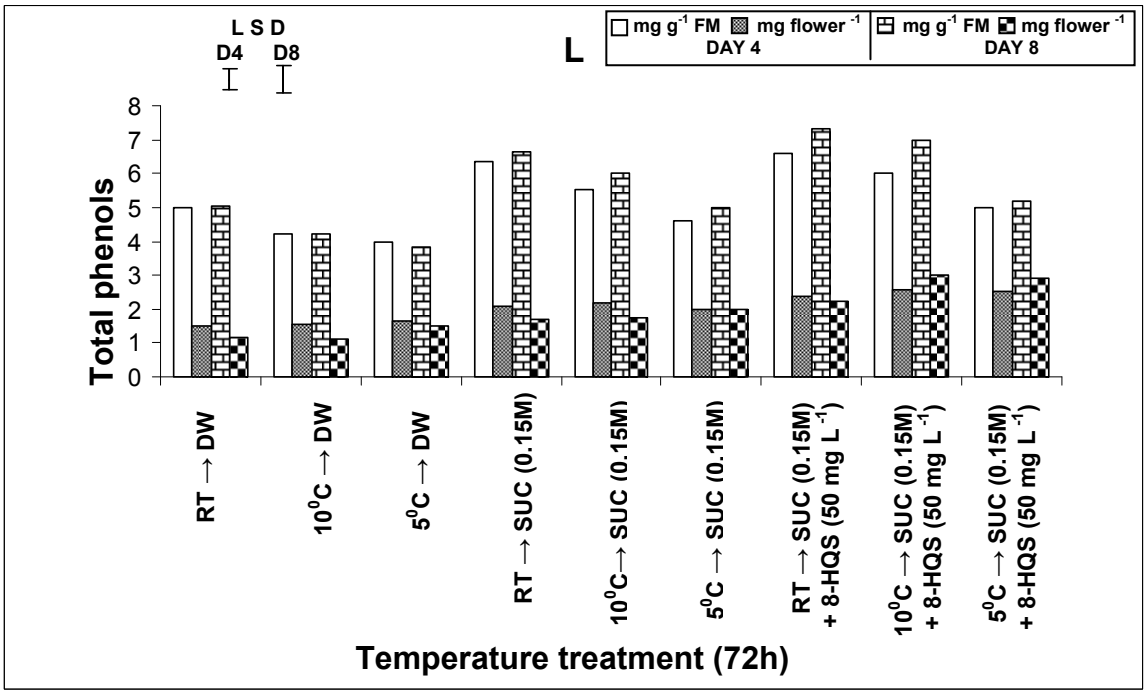

L S D
D4
D8
L
mg g-1 FM
mg flower-1
DAY 4
mg g-1 FM
mg flower-1
DAY 8
Total phenols
8
7
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.2.6

Plate 6.2.1

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT) 10^0 and 5^0C, before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Nerine sarniensis* cv. Red.

Fig 1: From left to right are arranged scapes before wet storage for 72 h held at RT, 10^oC and 5^oC.

Fig 2: From left to right are arranged scapes after wet storage for 72 h held at RT, 10^oC and 5^oC.

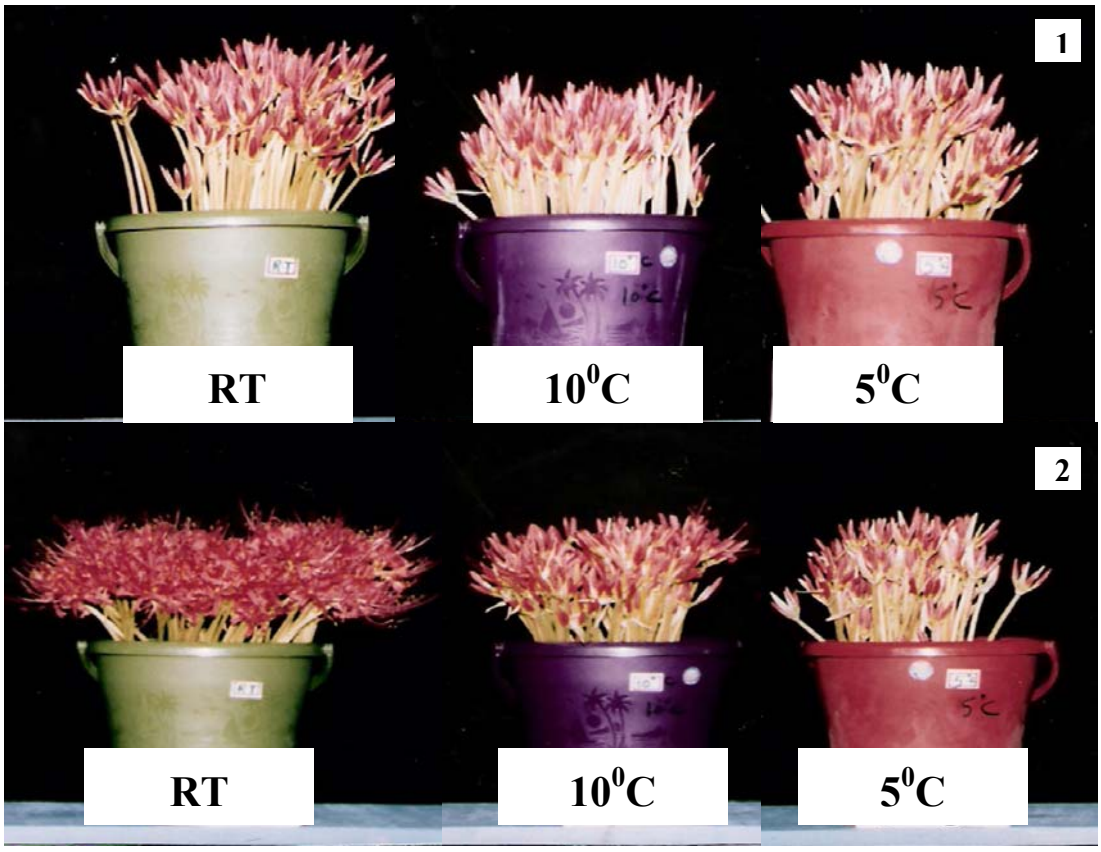


Plate. 6.2.1

Plate. 6.2.2

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 4 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (21 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.

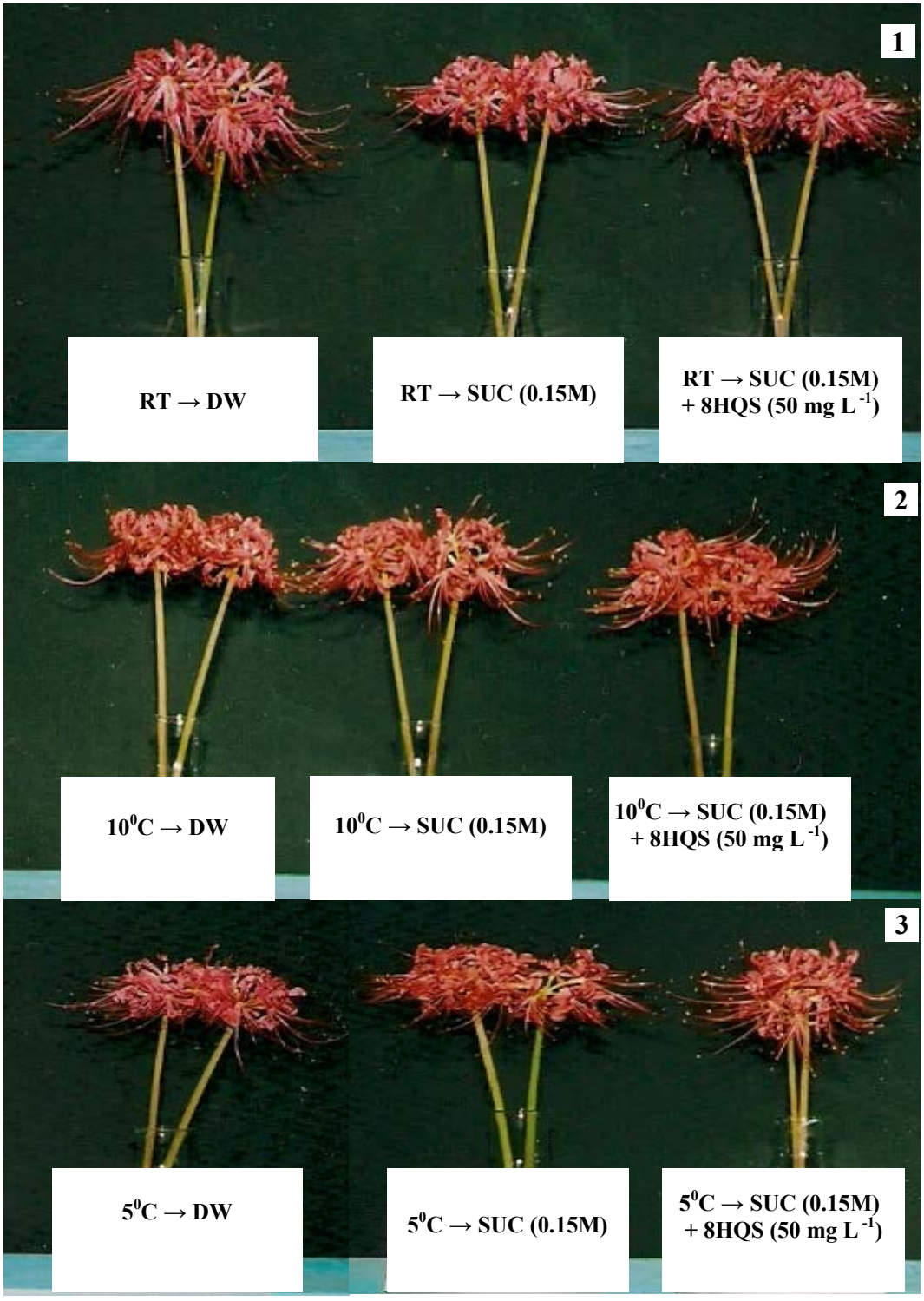

1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M) + 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

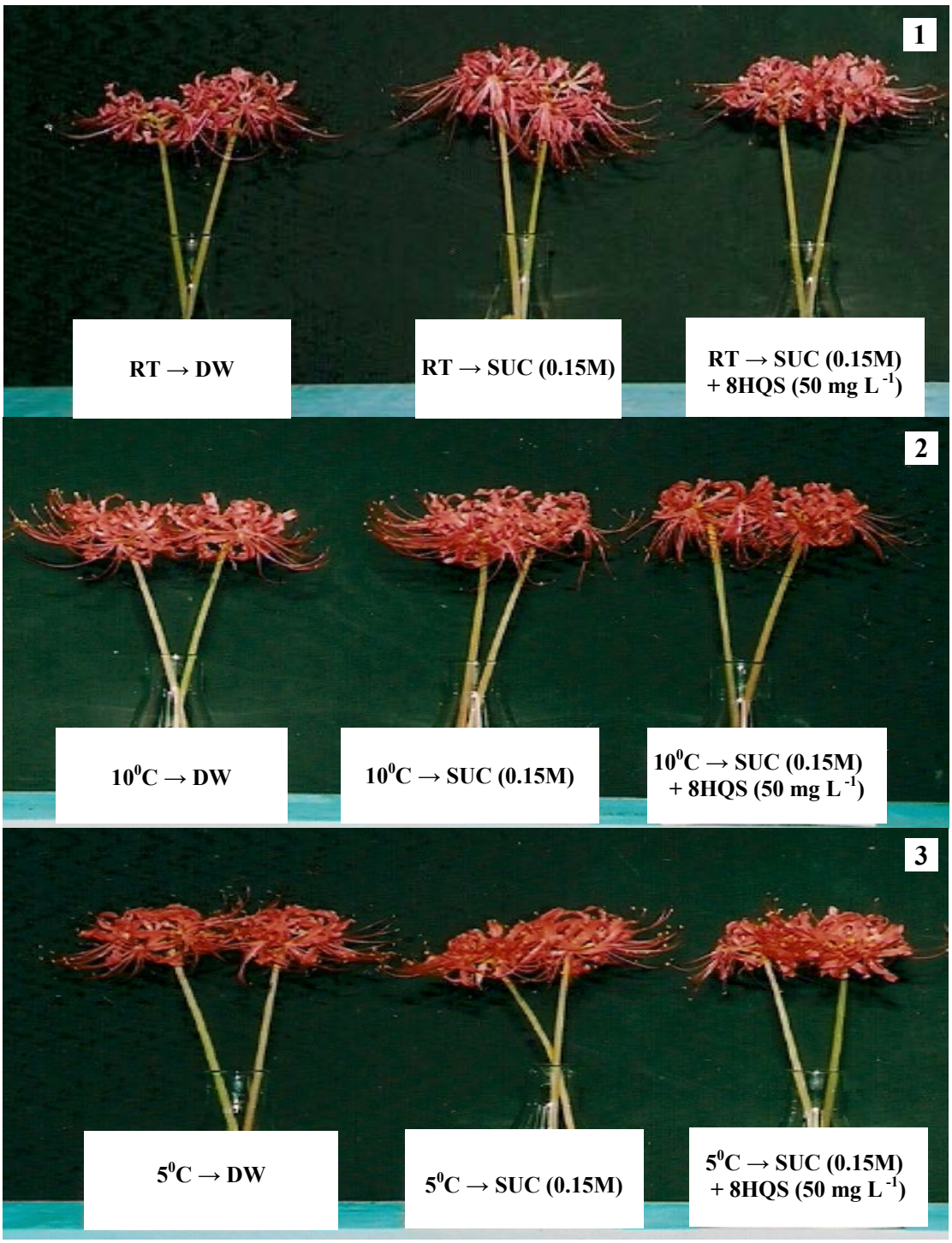
Plate. 6.2.2

Plate. 6.2.3

Effect of postharvest wet storage (PHWS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on day 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged flasks containing scapes held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) stored at RT (21 ± 2^0C), 10^0 and 5^0C.

Figs. 1 to 3 represent scapes wet stored at RT, 10 and 5^0C held in DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) respectively.


1
RT → DW
RT → SUC (0.15M)
RT → SUC (0.15M) + 8HQS (50 mg L -1)
2
10⁰C → DW
10⁰C → SUC (0.15M)
10⁰C → SUC (0.15M) + 8HQS (50 mg L -1)
3
5⁰C → DW
5⁰C → SUC (0.15M)
5⁰C → SUC (0.15M) + 8HQS (50 mg L -1)

EXPERIMENT 6.3

Effect of postharvest dry storage (PHDS) at different temperatures regimes; 5, 10 and room temperature (RT = 21 ± 2°C) for 72 h before transfer to distilled water (DW), sucrose SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) in cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at tight bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were completely wrapped in moistened filter papers and kept at 5 and 10^{o}C. A separate set of scapes was kept at room temperature (RT = 21 ± 2^{o}C). After 72 h all the scapes were kept at room temperature and transfered to 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M) and SUC(0.15M) + 8-HQS (50mg L^{-1}). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorestent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity RH of 60 ± 10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer to particular holding solution and was assessed to be terminated when the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 3 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2 to 6 after the transfer of scapes to holding solutions. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer

of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α-amino acids and total phenols were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{0.05}$.

Results

Visible effects: The scapes dry stored for 72 h at RT had already bloomed during the storage and senesced by day 5 of the transfer (Plate. 6.3.1, Figs. 1-2). Blooming was least in the scapes previously dry stored at 5 and 10^{o}C before transfer to holding solutions and showed tepal senescence on the day 8 and 6 of transfer to holding solutions (Plate. 6.3.2; Figs.1-3). Scapes were designated as senescent when the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) (Plate. 6.3.3; Figs.1-3).

Vase life: The average vase life of scapes previously dry stored at various temperature regimes before transfer to DW was about 2-3 days, whereas the vase life of scapes transfered to SUC was about 4-5 days. The maximum vase life of 7 days was recorded in scapes stored at 10 or 5^{o}C before transfer to SUC + 8-HQS, the corresponding scapes of the particular set stored at RT registered a vase life of 5 days (Table 6.3.1; Text Fig.6.3.1, A).

Number of blooms per scape: The number of blooms per scape as also the percent blooming increased in all the treatments with the progression in time irrespective of the transfer to various holding solutions. Scapes previously dry stored at RT and 10^{o}C for 72 h exhibited 100 percent blooming by day 2 of transfer to various holding solutions, whereas the scapes stored particularly at 5^{o}C exhibited 100 percent blooming by day 3 of transfer to DW, SUC or SUC ± 8-HQS (Table 6.3.1; Text Fig. 6.3.1, B).

Volume of holding solution absorbed per scape (ml): The volume of holding solution absorbed increased with progression from day 2 to 6 of

transfer of scapes to various holding solutions irrespective of the particular temperature regime. The solution uptake was found to be higher in scapes previously dry stored for 72 h at 5 and 10°C as compared to the corresponding scapes held at RT irrespective of the holding solution. A higher solution uptake was recorded in scapes held in (SUC + 8-HQS) followed by SUC as compared to DW irrespective of the particular temperature treatment, however the maximum solution uptake was registered in scapes previously dry stored at 5°C for 72 h before transfer to SUC + 8- HQS (Table 6.3.1; Text Fig. 6.3.2, C).

Conductivity of leachates: The electrical conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer of scapes to various holding solutions. A lower concentration of leachates was maintained in the samples from scapes previously dry stored at 5 and 10°C, however the conductivity of leachates of samples from the scapes dry stored at RT increased significantly irrespective of the transfer to various holding solutions. At each of the temperature regimes the leachates were found to be less in samples from scapes held in SUC + 8 - HQS followed by scapes held in SUC as compared to samples from corresponding scapes held in DW (Table 6.3.2; Text Fig. 6.3.2, D).

Fresh mass and dry mass: The fresh and dry mass of the samples from scapes previously dry stored for 72 h registered a decrease with progression in time from day 4 to day 8 irrespective of the transfer to various holding solutions. Higher fresh and dry mass was registered in the samples from scapes dry stored at 5^0C over the period of time. At each of the temperature regimes both fresh and dry mass was generally found to be higher in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the samples from corresponding scapes held in DW, however maximum value for fresh and dry mass was recorded in samples from scapes previously dry

stored at 5°C for 72 h and transferred to SUC + 8-HQS (Table 6.3.2; Text Fig. 6.3.3, E & F).

Reducing sugars: The reducing sugar content of the samples form scapes previously dry stored for 72 h at 5, 10°C and RT registered a decrease irrespective of the transfer to various holding solutions. However, the reducing sugar content of samples from scapes previously dry stored for 72 h at 5°C and transferred to SUC + 8-HQS or SUC registered an increase over a period of time. At each of the temperature regimes the reducing sugar content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.3; Text Fig. 6.3.4, G). Almost similar trends were obtained when the data was expressed on per flower and dry mass basis but the differences showed up clearly on these particular reference bases (Table 6.3.3 & 6.3.4). The highest reducing sugar content was recorded in samples from scapes dry stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Non-reducing sugars: The non-reducing sugar content of the samples from scapes previously dry stored for 72 h at 5 °C registered an increase as compared to the samples from scapes previously dry stored at 10°C and RT irrespective of the transfer to various holding solutions. At each of the temperature regimes the non-reducing sugar content was found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.3; Text Fig. 6.3.4, H). Almost similar trends were obtained when the data was expressed on per flower basis and dry mass bases but the differences showed up clearly on these particular reference bases (Table 6.3.3 & 6.3.4). The highest non-reducing sugar content was noticed in samples from scapes dry stored at 5°C for 72 h and transferred to SUC +8-HQS.

Total sugars: The total sugar content of samples from scapes previously dry stored for 72 h at 5, 10 °C and RT registered a decrease irrespective of the transfer to various holding solutions. However, an increase was registered in the content of total sugars in the samples from scapes previously dry stored for 72 h at 5°C and transferred to SUC + 8-HQS or SUC with the progression in time. At each of the temperature regimes the total sugar content was found to be highest in samples from scapes held in SUC + 8-HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.3; Text Fig. 6.3.5, I). Almost similar trends were obtained when the data was expressed on per flower basis and dry mass basis but the differences showed up clearly on these particular reference bases (Table 6.3.3 & 6.3.4). Generally higher total sugar content was recorded in samples from scapes dry stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Soluble proteins: The soluble protein content of samples form scapes previously dry stored for 72 h at 5, 10 °C and RT registered a decrease with progression in time from day 4 to day 8 irrespective of the transfer to various holding solutions. However, the protein content of samples from scapes previously dry stored for 72 h at 5°C and transferred to SUC + 8-HQS registered an increase over the period of time. At each of the temperature regimes the protein content was found to be highest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.5; Text Fig. 6.3.5, J). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.3.5). When the data was expressed on dry mass basis, a higher protein content was maintained in the samples from scapes stored at 5 and 10^0 C particularly in 8-HQS + SUC (Table 6.3.6). Generally higher protein content was recorded in samples from scapes dry stored at 5°C for 72 h and transferred to SUC + 8-HQS.

α- amino acids: The α-amino acid content of samples form scapes previously dry stored for 72 h at 5, 10°C and RT registered an increase with the progression in time from day 4 to day 8 irrespective of the transfer to various holding solutions. However, the α-amino acid content of samples from scapes previously dry stored for 72 h at 5°C and transferred to SUC + 8-HQS registered a decrease over the period of time. At each of the temperature regimes the α-amino acid content was found to be lowest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.5; Text Fig. 6.3.6, K). Almost similar trends were obtained when the data was expressed on dry mass basis (Table 6.3.6). When the data was expressed on per flower basis the α-amino acid content generally decreased in all the treatments irrespective of the transfer to various holding solutions. (Table 6.3.5). The lowest α-amino acids content was maintained in samples from scapes dry stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Total phenols: The content of total phenols registered a decrease in the samples from scapes previously dry stored for 72 h at 5°C however, an increase was registered in the samples from scapes previously dry stored at 10°C and RT with progression in time from day 4 to day 8 irrespective of the transfer to various holding solutions. At each of the temperature regimes the phenolic content was found to be lowest in samples from scapes held in SUC + 8- HQS followed by SUC as compared to the corresponding scapes held in DW (Table 6.3.5; Text Fig. 6.3.6, L). Almost similar trends were obtained when the data was expressed on dry mass basis (Table 6.3.6). When the data was expressed on per flower basis the phenolic content was maintained in the samples from scapes previously dry stored at 5^{o}C particularly in SUC + 8-HQS (Table 6.3.6). Generally lower concentration of phenols was recorded in samples from scapes dry stored at 5°C for 72 h and transferred to SUC + 8-HQS.

Table 6.3.1: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes before transfer to various holding solutions on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Temperature treatment (72h)	Vase life (days)	No. of blooms per scape				Volume of holding solution absorbed per scape (ml)		
		Days after treatment						
		0	1	2	3	2	4	6
RT→DW	2	3.96 (70)	5.44 (96)	5.66 (100)	-	2.00	3.50	5.00
10 °C→DW	3	1.75 (31)	4.13 (73)	5.66 (100)	-	3.30	4.60	5.50
5 °C →DW	3	1.13 (20)	2.83 (50)	4.87 (86)	5.66 (100)	4.21	5.53	7.10
RT→SUC(0.15M)	4	3.96 (71)	5.55 (98)	5.66 (100)	-	3.00	4.87	6.00
10°C→SUC(0.15M)	4	1.75 (31)	4.25 (75)	5.66 (100)	-	4.00	5.50	7.50
5°C→SUC(0.15M)	5	1.13 (20)	3.51 (62)	5.27 (93)	5.66 (100)	5.00	5.75	7.85
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	5	3.96 (70)	5.66 (100)	-	-	4.00	5.00	6.00
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	7	1.75 (30)	4.53 (80)	5.66 (100)	-	5.00	7.00	8.00
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	7	1.13 (20)	3.96 (70)	5.44 (96)	5.66 (100)	5.00	7.50	9.21
LSD at $P_{=0.05}$	0.48	0.06	0.06	0.08		0.28	0.36	0.42

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent percent blooms.

Table: 6.3.2: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on conductivity of leachates (µS), fresh mass and dry mass of flowers on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment (72 h)	Conductivity of leachates (µS)		Fresh mass (g flower^{-1})		Dry mass (g flower^{-1})	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	15.33	29.86	0.275	0.210	0.035	0.025
10 °C→DW	10.36	16.33	0.354	0.247	0.044	0.030
5 °C →DW	9.98	12.33	0.397	0.354	0.056	0.040
RT→SUC(0.15M)	15.00	27.65	0.314	0.206	0.038	0.024
10°C→SUC(0.15M)	10.01	14.35	0.381	0.261	0.051	0.033
5°C→SUC(0.15M)	9.10	12.02	0.405	0.383	0.057	0.050
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	14.88	26.66	0.350	0.278	0.042	0.035
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	8.85	8.00	0.393	0.325	0.055	0.038
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	7.65	7.01	0.423	0.478	0.062	0.066
LSD at $P_{=0.05}$	1.22	1.46	0.015	0.004	0.020	0.040

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Table 6.3.3: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72h)	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	10.51 (2.89)	5.65 (1.18)	1.38 (0.38)	3.23 (0.67)	11.89 (3.27)	8.88 (1.86)
10 °C→DW	10.90 (3.86)	9.63 (2.31)	6.86 (2.43)	5.31 (1.38)	17.77 (6.29)	14.94 (3.69)
5 °C →DW	16.96 (6.73)	12.52 (4.44)	4.44 (1.76)	6.46 (2.29)	21.41 (8.50)	18.98 (6.73)
RT→SUC(0.15M)	12.92 (4.05)	9.69 (2.00)	5.25 (1.64)	2.01 (0.41)	18.18 (5.70)	10.50 (2.16)
10°C→SUC(0.15M)	16.56 (6.31)	11.71 (3.05)	6.86 (2.61)	7.27 (1.89)	23.43 (8.93)	18.98 (4.95)
5°C→SUC(0.15M)	19.39 (7.86)	22.22 (8.51)	9.29 (3.76)	18.58 (7.12)	28.68 (11.62)	40.80 (15.64)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	14.94 (5.23)	11.71 (3.25)	5.25 (1.84)	2.02 (0.56)	20.20 (7.07)	13.73 (3.81)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	18.18 (7.15)	15.35 (4.98)	6.86 (2.70)	6.86 (2.23)	25.05 (9.85)	22.22 (7.22)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	23.43 (9.92)	29.09 (13.90)	14.54 (6.15)	14.94 (7.14)	37.97 (16.07)	44.03 (21.05)
LSD at $P_{=0.05}$	0.88	0.64	0.56	0.64	1.24	1.44

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent value on mg $flower^{-1}$ basis.

Table 6.3.4: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72 h)	Reducing Sugars		Non-reducing sugars		Total sugars	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	82.57	47.51	10.87	27.15	93.45	74.66
10 °C→DW	87.85	77.00	55.31	46.00	143.16	123.08
5 °C →DW	120.30	111.05	31.50	57.31	151.83	168.37
RT→SUC(0.15M)	106.83	83.36	43.40	17.35	150.23	90.31
10°C→SUC(0.15M)	123.86	92.67	51.35	57.51	175.21	150.19
5°C→SUC(0.15M)	137.91	170.36	66.08	142.48	203.99	312.85
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	124.70	93.06	43.81	16.04	168.50	109.11
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	130.03	131.31	49.12	58.74	179.14	190.05
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	160.01	210.68	99.31	108.26	259.31	318.95
LSD at $P_{=0.05}$	7.66	8.67	5.65	3.55	9.73	13.43

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21±2°C).

Table 6.3.5: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g $^{-1}$ FM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment (72 h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	4.33 (1.19)	2.91 (0.61)	0.61 (0.16)	0.69 (0.14)	3.33 (0.91)	4.24 (0.89)
10 °C→DW	5.41 (1.91)	3.58 (0.88)	0.49 (0.17)	0.56 (0.13)	3.73 (1.32)	4.64 (1.14)
5 °C →DW	5.91 (2.34)	4.58 (1.62)	0.38 (0.15)	0.45 (0.16)	3.53 (1.40)	3.43 (1.21)
RT→SUC(0.15M)	4.83 (1.51)	3.33 (0.68)	0.49 (0.15)	0.60 (0.12)	4.64 (1.45)	4.34 (0.89)
10°C→SUC(0.15M)	6.33 (2.41)	5.16 (1.34)	0.41 (0.15)	0.49 (0.12)	4.54 (1.73)	5.05 (1.31)
5°C→SUC(0.15M)	6.83 (2.76)	6.41 (2.45)	0.34 (0.14)	0.37 (0.14)	4.14 (1.67)	3.73 (1.43)
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	5.66 (1.98)	4.66 (1.29)	0.37 (0.13)	0.43 (0.11)	4.04 (1.41)	3.83 (1.06)
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	6.58 (2.58)	6.33 (2.05)	0.32 (0.12)	0.39 (0.12)	3.83 (1.50)	4.74 (1.54)
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	7.41 (3.13)	7.91 (3.78)	0.26 (0.11)	0.22 (0.10)	3.83 (1.62)	3.63 (1.73)
LSD at $P_{=0.05}$	0.22	0.36	0.21	0.17	0.18	0.16

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21±2^{o}C).

Figures in parentheses represent value on mg flower^{-1} basis.

Table 6.3.6: Effect of postharvest dry storage (PHDS) for 72 h at different temperature regimes on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of the transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Temperature treatment(72 h)	Soluble proteins		α-amino acids		Total phenols	
	Days after transfer					
	4	8	4	8	4	8
RT→DW	34.04	24.50	4.82	5.81	26.18	35.63
10 °C→DW	43.62	29.50	3.99	4.62	30.09	38.25
5 °C →DW	41.94	40.63	2.73	4.05	25.06	30.44
RT→SUC(0.15M)	39.93	28.65	4.10	5.16	38.39	37.33
10°C→SUC(0.15M)	47.35	40.86	3.07	3.87	33.98	39.94
5°C→SUC(0.15M)	48.59	49.19	2.46	2.90	29.44	28.65
RT→SUC(0.15M) +8-HQS(50 mg L^{-1})	47.26	37.06	3.16	3.42	33.69	30.48
10°C→SUC(0.15M) +8-HQS(50 mg L^{-1})	47.08	54.16	2.28	3.40	27.44	40.59
5°C→SUC(0.15M +8-HQS(50 mg L^{-1})	50.64	57.33	1.78	1.65	26.20	26.33
LSD at $P_{=0.05}$	1.57	1.05	0.21	0.17	1.66	0.89

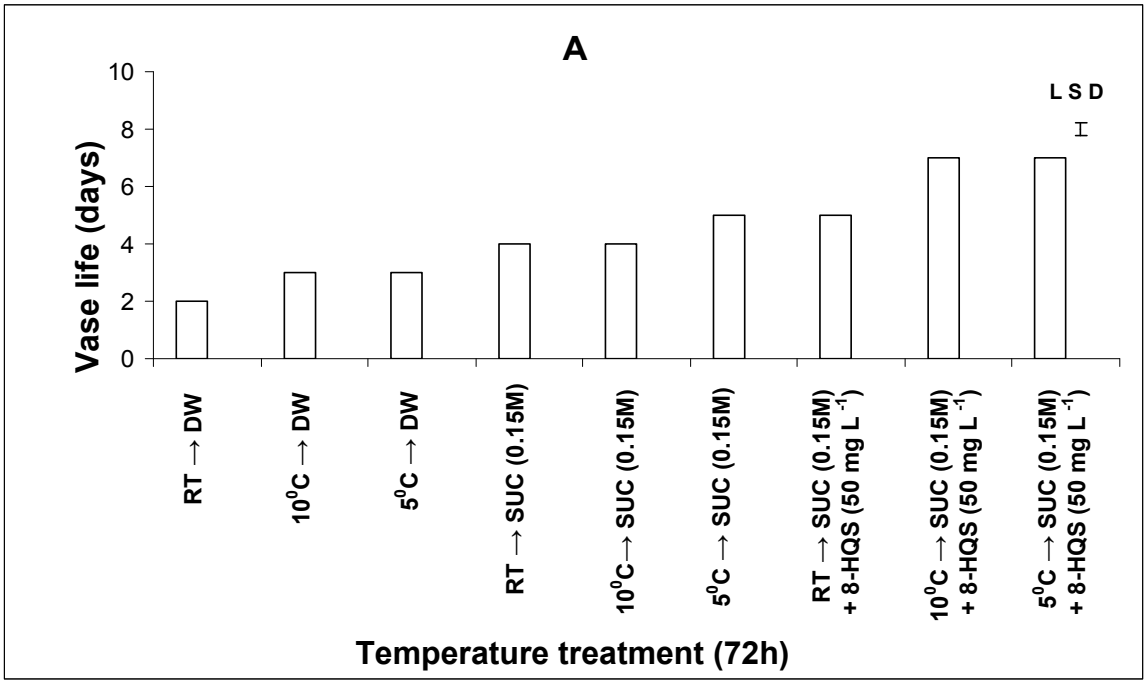
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Fig. 6.3.1

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on vase life (A) and number blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


A
Vase life (days)
10
8
6
4
2
0
L S D
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

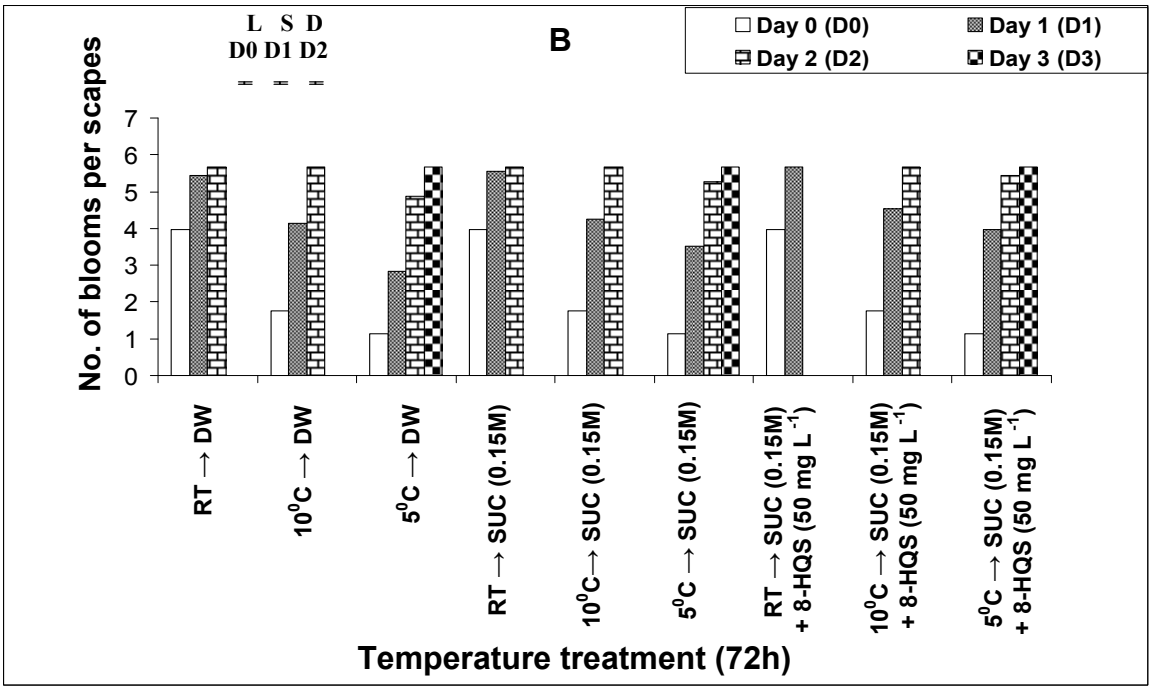
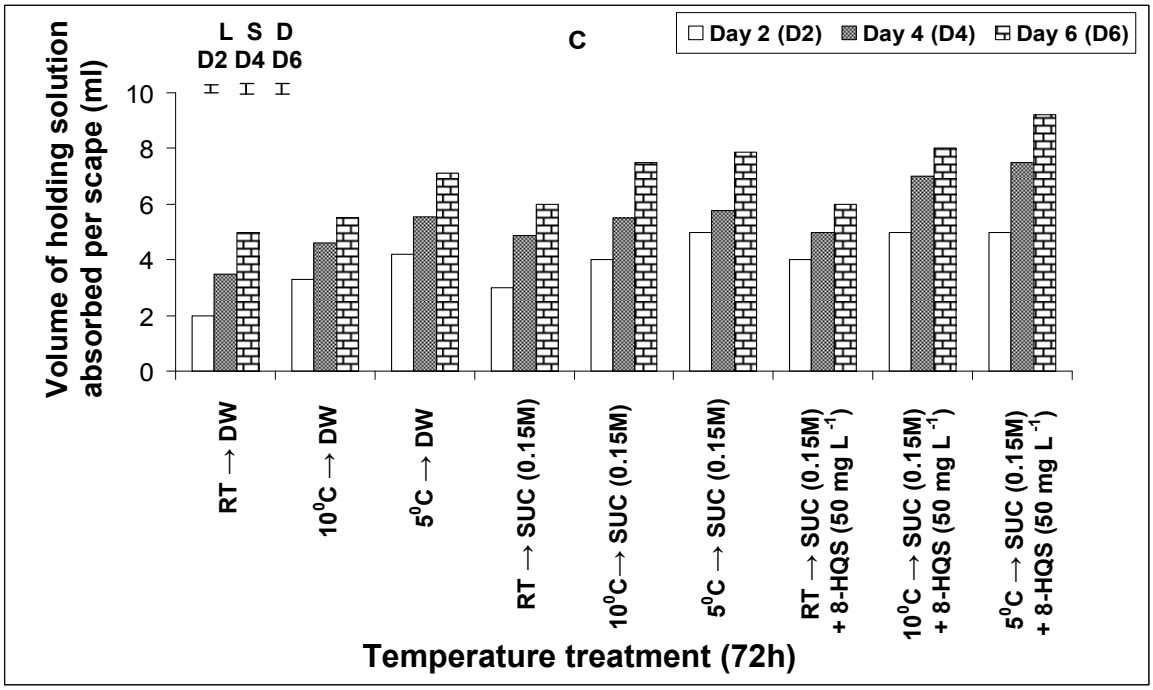

B
L S D
D0 D1 D2
Day 0 (D0)
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
No. of blooms per scapes
7
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.1

Fig. 6.3.2

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at P $_{= 0.05.}$


C
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
2
4
6
8
10
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

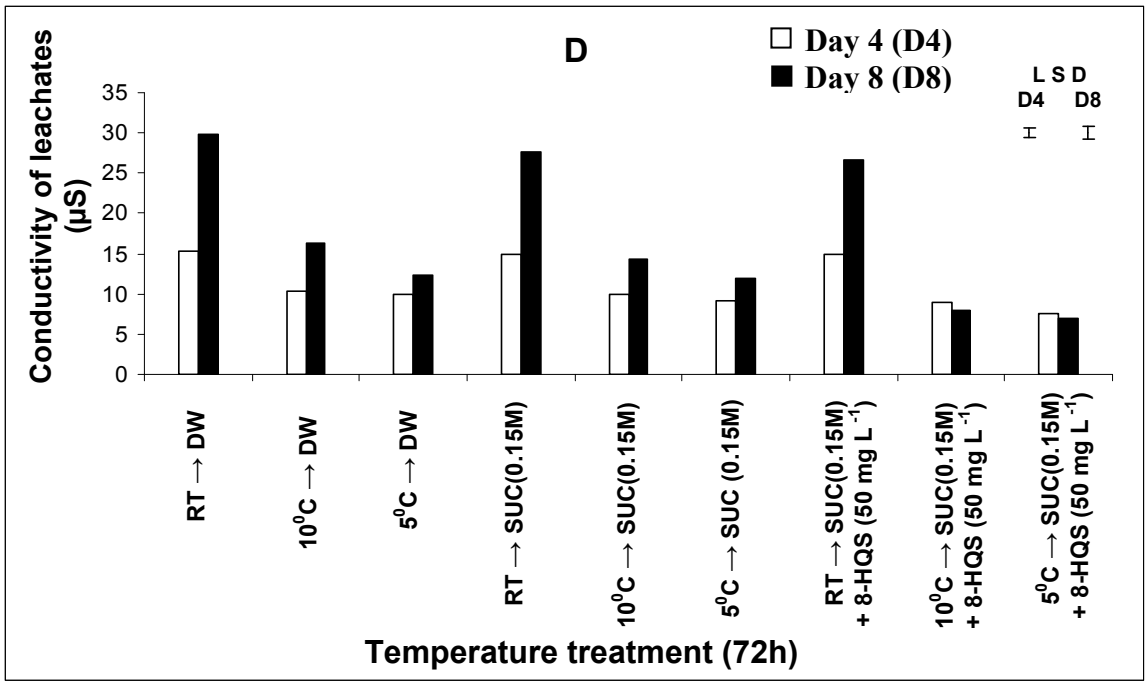
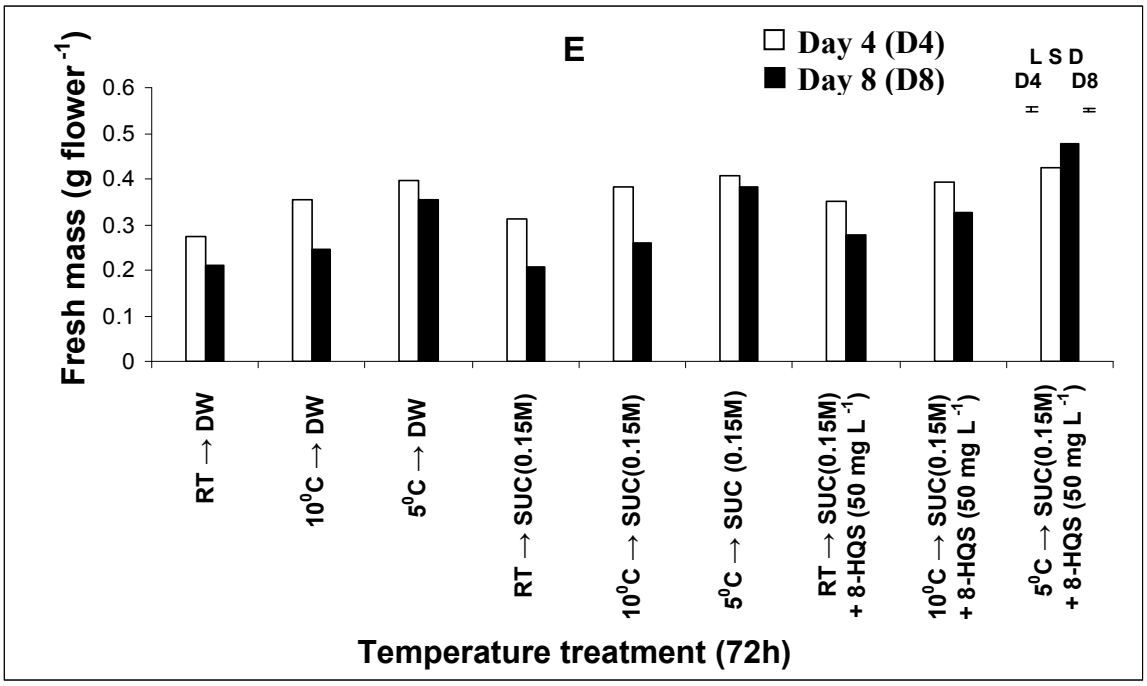

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.2

Fig.6.3.3

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at P $_{= 0.05.}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Fresh mass (g flower-1)
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

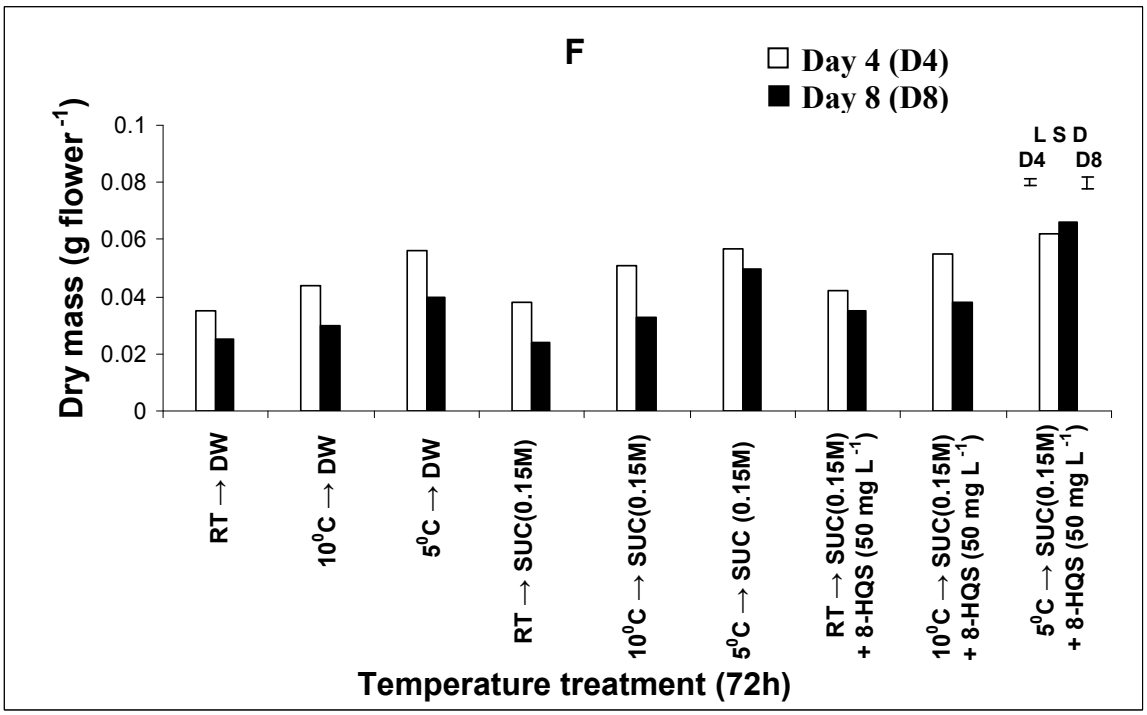
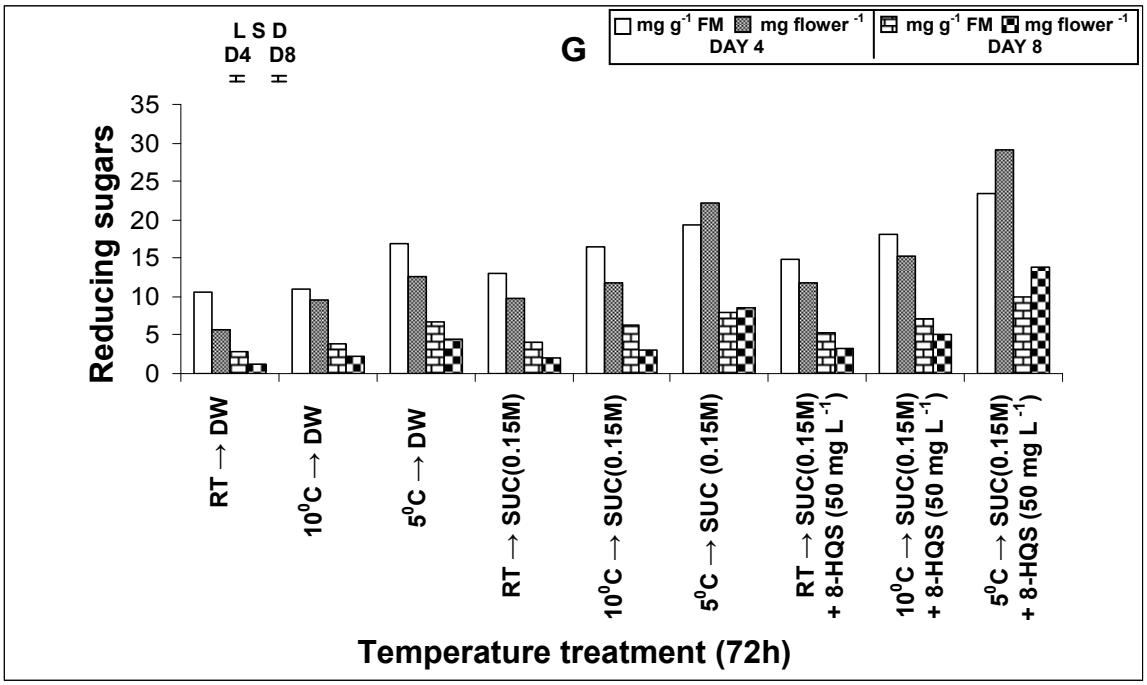

F
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Dry mass (g flower-1)
0.1
0.08
0.06
0.04
0.02
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.3

Fig. 6.3.4

Histograms showing effect of postharvest dry storage (PHDS) for 72 h at room temperature (RT), 10^0 and 5^0C before transfer to DW, SUC (0.15M) and SUC (0.15M) + 8-HQS (50 mg L^{-1}) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$.


G
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Reducing sugars
35
30
25
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

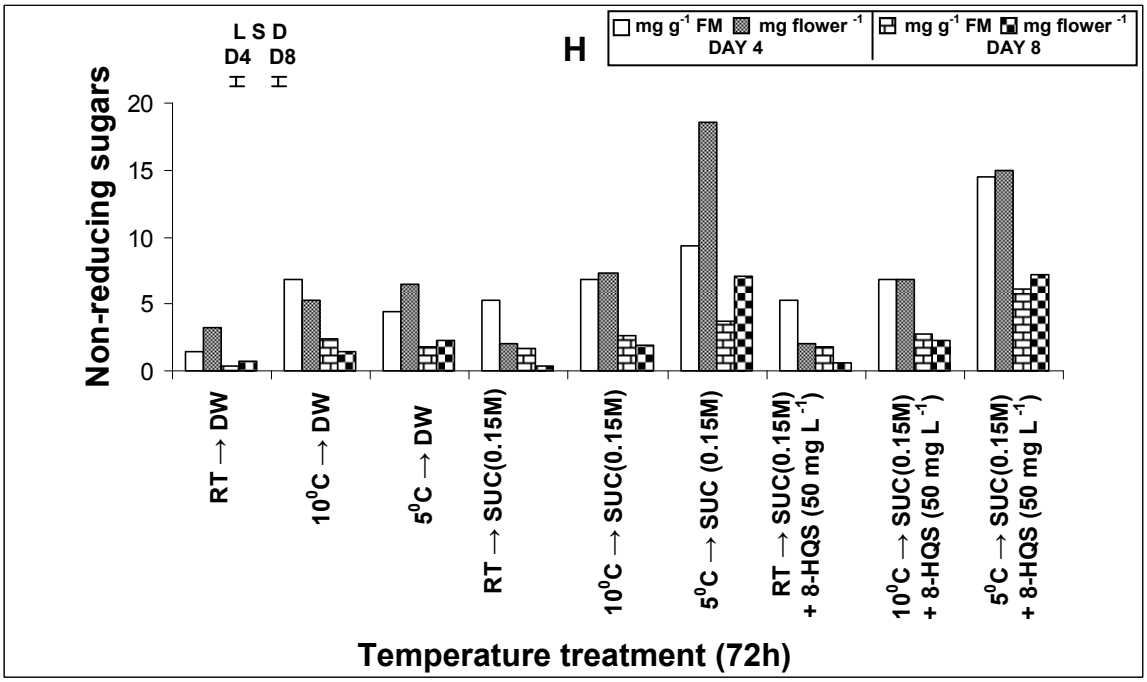
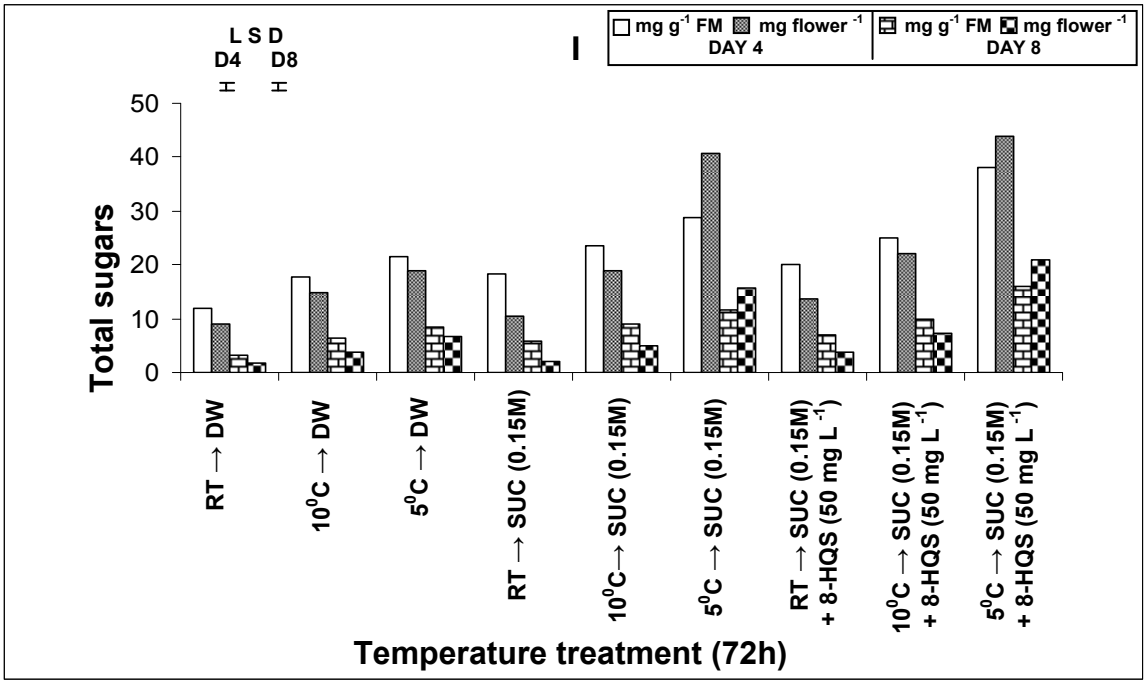

H
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Non-reducing sugars
20
15
10
5
0
RT → DW
10°C → DW
5°C → DW
RT → SUC(0.15M)
10°C → SUC(0.15M)
5°C → SUC (0.15M)
RT → SUC(0.15M) + 8-HQS (50 mg L-1)
10°C → SUC(0.15M) + 8-HQS (50 mg L-1)
5°C → SUC(0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.4


I
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Total sugars
50
40
30
20
10
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

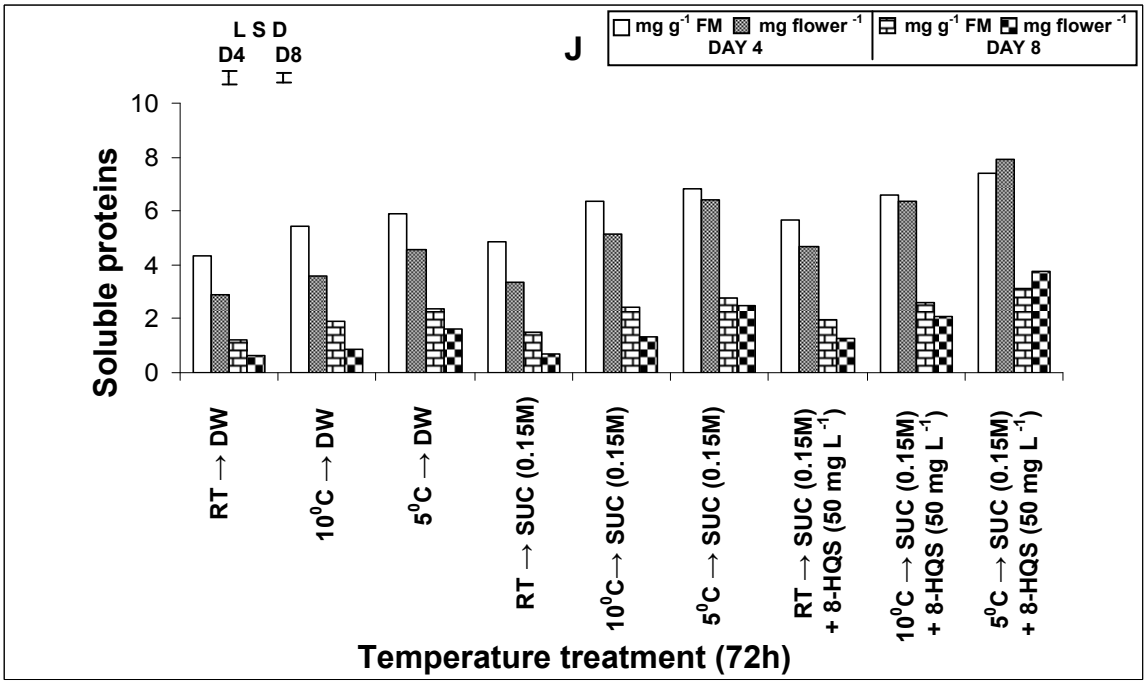
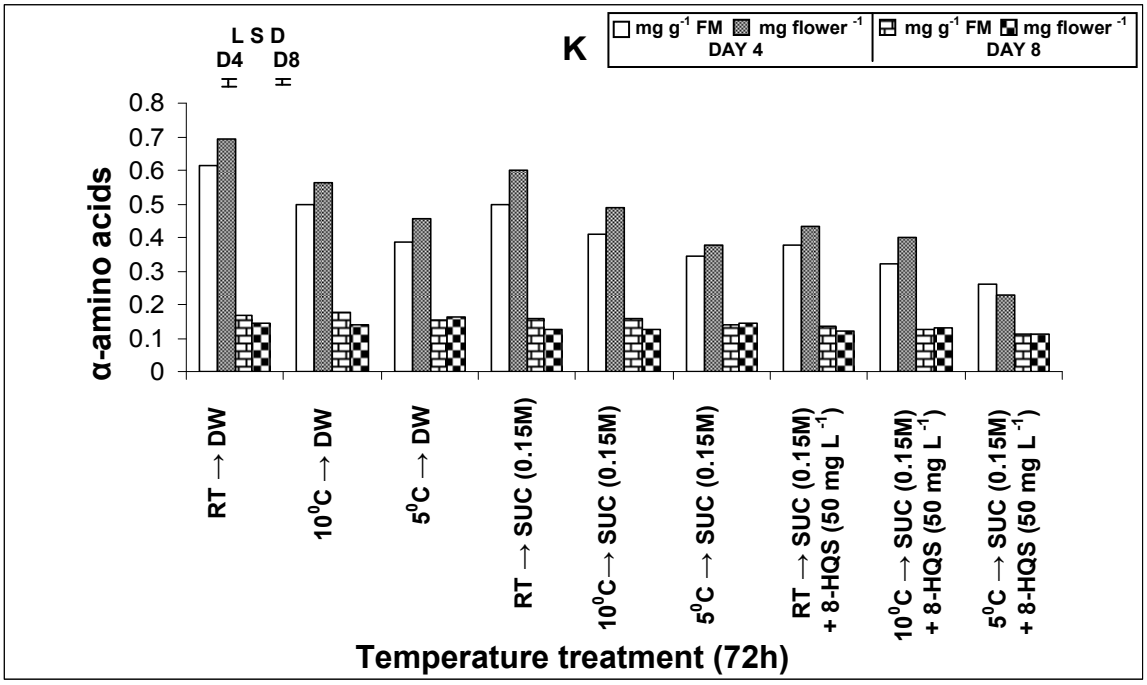

J
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Soluble proteins
10
8
6
4
2
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C→ SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.5


K
L S D
D4 H
D8 H
mg g-1 FM
mg flower -1
DAY 4
DAY 8
α-amino acids
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

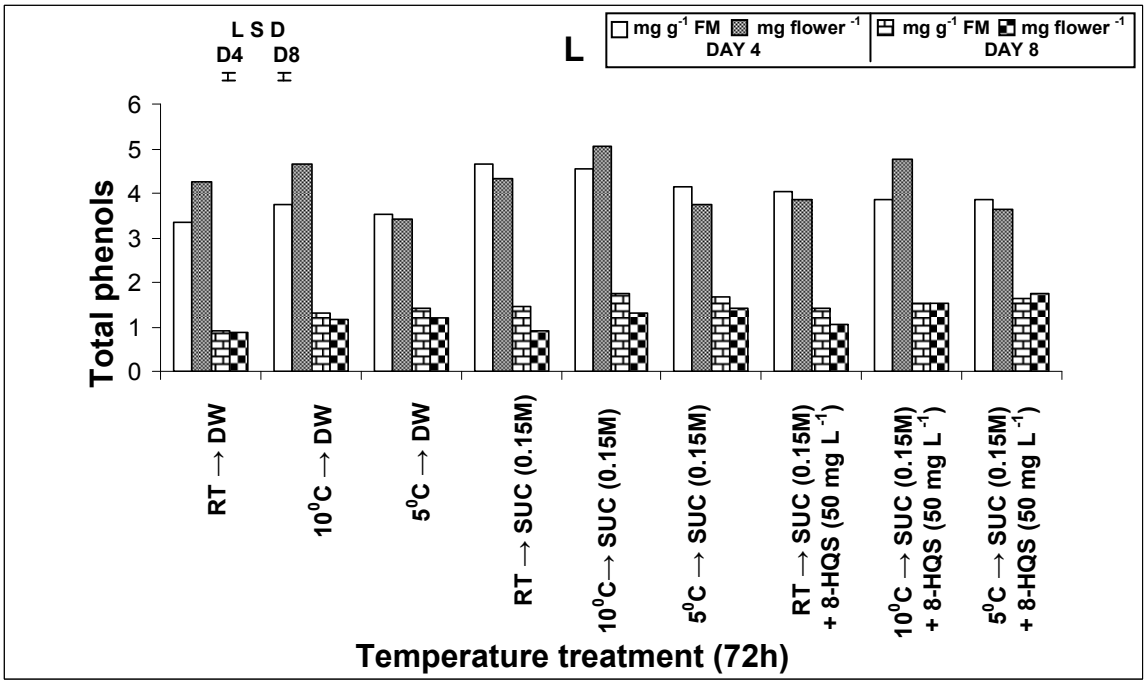

L
L S D
D4 H
D8 H
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total phenols
6
5
4
3
2
1
0
RT → DW
10°C → DW
5°C → DW
RT → SUC (0.15M)
10°C → SUC (0.15M)
5°C → SUC (0.15M)
RT → SUC (0.15M) + 8-HQS (50 mg L-1)
10°C → SUC (0.15M) + 8-HQS (50 mg L-1)
5°C → SUC (0.15M) + 8-HQS (50 mg L-1)
Temperature treatment (72h)

Fig. 6.3.6

Experiment 6.4

Effect of pretreatment with varying grades of CHI (1h pulse) and subsequent transfer to distilled water (DW) set (A) and sucrose SUC (0.15M) set (B) in cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at 08.00h when the scapes were at loose bud stage the scapes and brought to the laboratory and cut to a uniform scape length of 30 cm. The scapes were held in distilled 1000 ml Borosil beakers for 1h containing CHI at 0.01, 0.05, 0.1 and 0.5 mM. After pulsing the scapes were transferred to 250 ml conical flasks containing 200 ml of DW and SUC (0.15M) in triplicate. The unpulsed scapes transferred to DW represented the control. Pulsed scapes transferred to water (DW) represented set (A) and the scapes transferred to SUC (0.15M) represented set (B). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the scapes were recorded. The average vase life of flowers was counted from the day of transfer to holding solution and was assessed to be terminated when of the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms produced per scape were recorded up to day 6 after the transfer. Volume of holding solution absorbed was recorded on day 2 to 6 of transfer of scapes to various holding solutions. Conductivity of leachates from tepal discs of flowers, fresh mass and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes

to DW or SUC. Changes in tissue constituents including sugar the concentration of total phenols were also estimated on day 4 and 8 after transfer of scapes to holding solutions. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions, DW or SUC (0.15M) except in case of scapes pretreated with higher concentrations of CHI (0.1 and 0.5 mM). The flower senescence was delayed in the scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) by an increment of 6 days each in scapes transferred to DW (set A) and by 6 and 5 days in scapes transferred to SUC set B respectively (Plate. 6.4.1, Figs. 1-4). Scapes pretreated in with higher concentrations of CHI (0.1 and 0.5 mM) failed to open and wilted quickly by day 4 and 3 of the treatment (Plate 6.4.2, Figs. 1-4).

Vase life: The average vase life of flowers from scapes pretreated with 0.01 and 0.05 mM CHI before transfer to DW (set A) increased by an increment of 6 days, whereas the average vase life of flower from scapes transferred to SUC (set B) was enhanced by an increment of about 6 to 5 days as compared to the flowers from untreated scapes which exhibited vase life of about 4 days in DW and 5 days in SUC (0.15M). The vase life of flowers decreased with an increase in CHI concentration particularly in scapes pretreated with higher grades of CHI (0.1 and 0.5 mM) before transfer to DW or SUC (Table 6.4.1, Text Fig. 6.4.1, A).

Number of blooms per scape: The number of blooms per scape increased with progression in time. Progressive blooming was noticed in the unpulsed scapes and scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) which achieved complete blooming by day 4 to day 6 of the transfer. However blooming was prevented in scapes pretreated with higher grades of

CHI (0.1 and 0.5 mM) and the closed buds wilted as such on the scapes (Table 6.4.1, Text Fig. 6.4.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes to various holding solutions irrespective of the treatment however, the increase at each 2, 4 and 6 days of transfer was higher in scapes pretreated with 0.01 and 0.05 mM CHI as also untreated scapes before transfer to either DW or SUC. Pretreatment of scapes with higher grades of CHI (0.1 and 0.5 mM) before transfer to holding solution particularly SUC (set B) resulted in a decrease in the volume of holding solution absorbed as compared to the untreated scapes and scapes pretreated with lower grades of CHI (0.01 and 0.05 mM). At lower grades of CHI (0.01 and 0.05 mM) a marked increase was noticed in the solution uptake in both DW and SUC (Table 6.4.1, Text Fig. 6.4.2, C).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer to either DW (set A) or SUC (set B). The concentration of ion leachates was found to be significantly higher in samples from scapes pretreated with higher grades of CHI (0.1 and 0.5 mM) before transfer to either DW or SUC. At lower grades of CHI (0.01 and 0.05 mM) the concentration of ion leachates was maintained in the samples from pretreated scapes transferred to either DW or SUC (Table 6.4.2, Text Fig. 6.4.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers decreased with progression in time from day 4 to day 8 of transfer of untreated scapes as also scapes pretreated with higher grades of CHI (0.1and 0.5 mM) before transfer to either DW (set A) or SUC (set B). A higher fresh and dry mass was, however maintained in samples from scapes pretreated with lower

grades of CHI, (0.01 and 0.05 mM) particularly in scapes transferred to SUC (Table 6.4.2, Text Fig. 6.4.3, E & F).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the reducing sugar content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The reducing sugar content registered a significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.1 and 0.5 mM) as compared to untreated controls both in DW or SUC (Table 6.4.3, Text Fig. 6.4.4, G). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Table 6.4.4). The highest content of reducing sugar was maintained in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) before transfer to either DW or SUC.

Non-reducing sugars: The non-reducing sugar content registered a decrease with progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), the decrease was however pronounced in samples from scapes pretreated with higher grades of CHI (0.1 and 0.5 mM) (Table 6.4.3, Text Fig. 6.4.4, H). When the data was expressed on per flower and on dry mass bases the differences were much sharp and apparent (Table 6.4.4). The highest non-reducing sugar content was registered in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B) as compared to untreated samples.

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to DW (set A), however an increase in the content of total sugars was noticed in samples from scapes transferred SUC (set B) over the period of time. The total sugar content was generally maintained over a period of time in samples from

scapes pretreated with 0.01 and 0.05 mM of CHI in scapes transferred to DW (set A) and increased significantly in scapes transferred to SUC (set B) (Table 6.4.3, Text Fig. 6.4.5, I). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Table 6.4.4). The highest total sugar content was registered in samples from scapes pretreated with higher grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B) as compared to untreated samples.

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the soluble protein content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The soluble protein content registered a significant decrease in samples from scapes pretreated with higher concentrations of CHI (0.1 and 0.5 mM) as compared to untreated controls both DW or SUC (Table 6.4.5, Text Fig. 6.4.5, J). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases but the differences were sharp and apparent (Table 6.4.6). The highest soluble protein content was marked in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B) as compared to untreated samples.

α- amino acids: The amino acids content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the amino acids content was generally maintained over a period of time in samples from scapes pretreated with 0.01 and 0.05 mM CHI. The amino acid content registered a sharp increase in samples from scapes pretreated with higher concentrations of CHI (0.1 and 0.5 mM) as compared to untreated controls both in DW or SUC (Table 6.4.5, Text Fig. 6.4.6, K). When the data was expressed on per flower basis and on dry mass bases the differences were sharp and apparent (Table 6.4.6). The

lowest amino acids content was marked in samples from scapes pretreated with lower grades of CHI (0.01 and 0.05 mM) and transferred particularly to SUC (set B) as compared to untreated samples.

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to either DW (set A) or SUC (set B), however the phenolic content was more or less maintained over a period of time in samples from scapes pretreated with varying grades of CHI. (Table 6.4.5, Text Fig. 6.4.6, L). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass basis (Table 6.4.6). The highest content of total phenols was registered in samples from scapes pretreated with higher grades of CHI (0.1 and 0.5 mM) as compared to untreated samples.

Table 6.4.1: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) and subsequent transfer to DW (A) or SUC (B) on vase life, blooming and volume of solution uptake (ml) in the scapes of *Nerine sarniensis* cv. Red.

Treatment	Vase life (days)	No. of blooms per scape						Volume of holding solution absorbed per scape (ml)		
		Days after treatment								
A		1	2	3	4	5	6	2	4	6
DW	4	5.30 (96)	5.60 (100)	-	-	-	-	2.60	6.60	8.00
CHI 0.01 mM	10	1.50 (30)	3.80 (75)	4.60 (85)	5.50 (100)	-	-	1.30	3.60	7.00
CHI 0.05 mM	10	1.60 (28)	3.30 (57)	4.10 (71)	4.50 (77)	5.00 (85)	5.80 (100)	0.60	2.60	4.30
CHI 0.1 mM	4	0.10 (2)	0.50 (8)	0.80 (14)	2.10 (38)	3.00 (52)	3.00 (52)	0.60	1.60	3.50
CHI 0.5 mM	3	0.00 (0)	0.80 (13)	1.00 (15)	1.00 (15)	1.30 (21)	1.30 (21)	0.40	1.60	3.30
B										
SUC (0.15M)	5	5.60 (98)	5.80 (100)	-	-	-	-	1.80	4.00	6.80
CHI 0.01 mM	11	2.00 (35)	4.10 (75)	5.00 (90)	5.30 (99)	5.50 (100)	-	0.50	1.50	2.80
CHI 0.05 mM	10	1.80 (20)	4.10 (73)	5.00 (88)	5.30 (94)	5.30 (98)	5.60 (100)	0.60	1.30	2.00
CHI 0.1 mM	4	0.30 (6)	0.60 (12)	1.00 (18)	2.00 (37)	2.30 (43)	3.00 (56)	0.50	1.00	1.40
CHI 0.5 mM	3	0.00 (0)	0.80 (15)	0.80 (15)	0.80 (15)	1.50 (27)	1.50 (27)	0.10	1.00	1.00
LSD at $P_{=0.05}$	0.58	0.80	0.60	0.70	0.70	0.80	0.80	0.30	0.50	0.50

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Figures in parentheses represent percent blooms.

Table 6.4.2: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer, of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	11.73	27.30	0.607	0.445	0.043	0.022
CHI 0.01 mM	4.80	6.93	0.633	0.698	0.072	0.077
CHI 0.05 mM	4.33	9.63	0.506	0.573	0.048	0.056
CHI 0.1 mM	6.23	16.50	0.416	0.507	0.049	0.050
CHI 0.5 mM	13.60	22.93	0.440	0.246	0.041	0.038
B						
SUC (0.15 M)	7.90	12.96	0.691	0.481	0.061	0.056
CHI 0.01 mM	6.33	7.46	0.478	0.505	0.063	0.069
CHI 0.05 mM	4.70	10.16	0.390	0.462	0.043	0.054
CHI 0.1 mM	10.03	21.63	0.506	0.407	0.053	0.047
CHI 0.5 mM	19.50	24.60	0.320	0.307	0.037	0.033
LSD at $P_{=0.05}$	1.29	1.89	0.04	0.04	0.006	0.005

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Table 6.4.3: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on sugar fractions expressed on fresh mass basis (mg g^{-1}FM) in tepal tissues on day 4 and 8 after transfer, of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	15.84 (9.61)	13.76 (6.12)	4.72 (2.86)	2.40 (1.07)	20.53 (12.46)	16.16 (7.19)
CHI 0.01 mM	15.04 (9.52)	17.76 (12.39)	2.88 (1.82)	2.16 (1.51)	17.92 (11.34)	19.92 (13.90)
CHI 0.05 mM	20.08 (10.16)	11.44 (6.55)	3.28 (1.66)	2.96 (1.69)	23.36 (11.82)	14.40 (8.25)
CHI 0.1 mM	14.96 (6.22)	3.84 (1.95)	4.56 (1.89)	2.56 (1.29)	19.52 (8.12)	6.40 (3.24)
CHI 0.5 mM	5.44 (2.39)	3.20 (0.79)	6.32 (2.78)	5.04 (1.24)	11.76 (5.17)	8.24 (2.03)
B						
SUC (0.15 M)	23.76 (16.42)	18.40 (8.85)	4.16 (2.87)	2.48 (1.19)	27.92 (19.92)	20.88 (10.04)
CHI 0.01 mM	19.28 (9.21)	18.56 (9.37)	8.96 (4.28)	9.40 (4.74)	28.24 (13.49)	27.96 (14.12)
CHI 0.05 mM	24.08 (9.39)	22.16 (10.24)	8.64 (3.37)	7.04 (3.25)	32.72 (12.76)	29.20 (13.49)
CHI 0.1 mM	12.64 (6.39)	8.56 (3.48)	9.20 (4.65)	6.16 (2.51)	21.84 (11.05)	14.72 (5.99)
CHI 0.5 mM	11.20 (3.58)	8.24 (2.53)	7.52 (2.41)	5.28 (1.62)	18.72 (5.99)	13.36 (4.10)
LSD at $P_{=0.05}$	2.73	1.90	1.94	1.00	2.81	1.74

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.4.4: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
A						
DW	226.19	280.70	67.40	48.96	293.59	329.66
CHI 0.01 mM	132.35	164.34	25.35	16.73	157.69	181.07
CHI 0.05 mM	213.44	117.83	34.87	30.49	248.31	148.32
CHI 0.1 mM	127.75	39.16	45.09	26.11	166.70	65.28
CHI 0.5 mM	58.48	20.77	67.96	32.71	126.44	53.47
B						
SUC (0.15 M)	269.90	158.24	47.26	21.33	317.17	179.56
CHI 0.01 mM	147.10	136.41	68.39	68.80	215.46	205.21
CHI 0.05 mM	218.88	191.01	78.53	60.69	297.42	251.70
CHI 0.1 mM	121.47	74.38	88.41	53.53	209.88	127.91
CHI 0.5 mM	91.05	76.95	61.14	47.82	152.19	124.78
LSD at $P_{=0.05}$	27.70	23.69	19.46	14.15	29.07	16.66

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Table 6.4.5: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on soluble proteins α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 after transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	4.25 (2.57)	3.33 (1.48)	0.33 (0.20)	0.39 (0.17)	4.30 (2.61)	4.36 (1.94)
CHI 0.01 mM	5.50 (3.48)	4.31 (3.00)	0.23 (0.14)	0.26 (0.18)	4.66 (2.95)	4.82 (3.36)
CHI 0.05 mM	5.58 (2.82)	5.25 (3.00)	0.28 (0.14)	0.32 (0.18)	5.14 (2.60)	4.40 (2.52)
CHI 0.1 mM	3.91 (1.62)	2.66 (1.34)	0.45 (0.18)	0.56 (0.28)	5.90 (2.45)	7.25 (3.67)
CHI 0.5 mM	1.58 (0.69)	0.91 (0.22)	0.52 (0.22)	0.62 (0.15)	6.17 (2.71)	7.09 (1.74)
B						
SUC (0.15 M)	5.55 (3.83)	3.83 (1.84)	0.3 (0.20)	0.35 (0.16)	3.84 (2.65)	5.18 (2.49)
CHI 0.01 mM	4.73 (2.26)	4.16 (2.10)	0.21 (0.10)	0.24 (0.12)	4.66 (2.23)	6.22 (3.14)
CHI 0.05 mM	5.75 (2.24)	5.16 (2.38)	0.26 (0.10)	0.29 (0.13)	5.36 (2.09)	5.58 (2.58)
CHI 0.1 mM	5.16 (2.61)	5.08 (2.06)	0.38 (0.19)	0.51 (0.20)	5.85 (2.96)	8.69 (3.54)
CHI 0.5 mM	5.08 (1.62)	3.66 (1.12)	0.49 (0.15)	0.59 (0.18)	6.90 (2.21)	8.00 (2.45)
LSD at $P_{=0.05}$	0.46	0.56	0.03	0.02	0.32	0.40

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.4.6: Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on soluble proteins α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
A	**4**	**8**	**4**	**8**	**4**	**8**
DW	60.69	67.86	4.65	7.88	61.49	88.94
CHI 0.01 mM	47.52	39.23	2.02	2.35	41.06	43.86
CHI 0.05 mM	59.34	59.22	2.95	3.27	54.70	45.76
CHI 0.1 mM	33.44	26.35	3.82	5.67	50.43	73.98
CHI 0.5 mM	17.01	5.95	5.58	4.01	66.36	46.02
B						
SUC (0.15 M)	62.48	32.96	3.39	3.00	43.61	44.60
CHI 0.01 mM	36.11	30.62	1.59	1.75	35.60	45.76
CHI 0.05 mM	52.26	44.53	2.35	2.48	48.71	48.15
CHI 0.1 mM	49.65	44.17	3.62	4.41	56.24	75.54
CHI 0.5 mM	41.32	34.24	4.23	5.48	56.14	74.71
LSD at $P_{=0.05}$	5.32	7.84	0.96	0.84	3.37	3.66

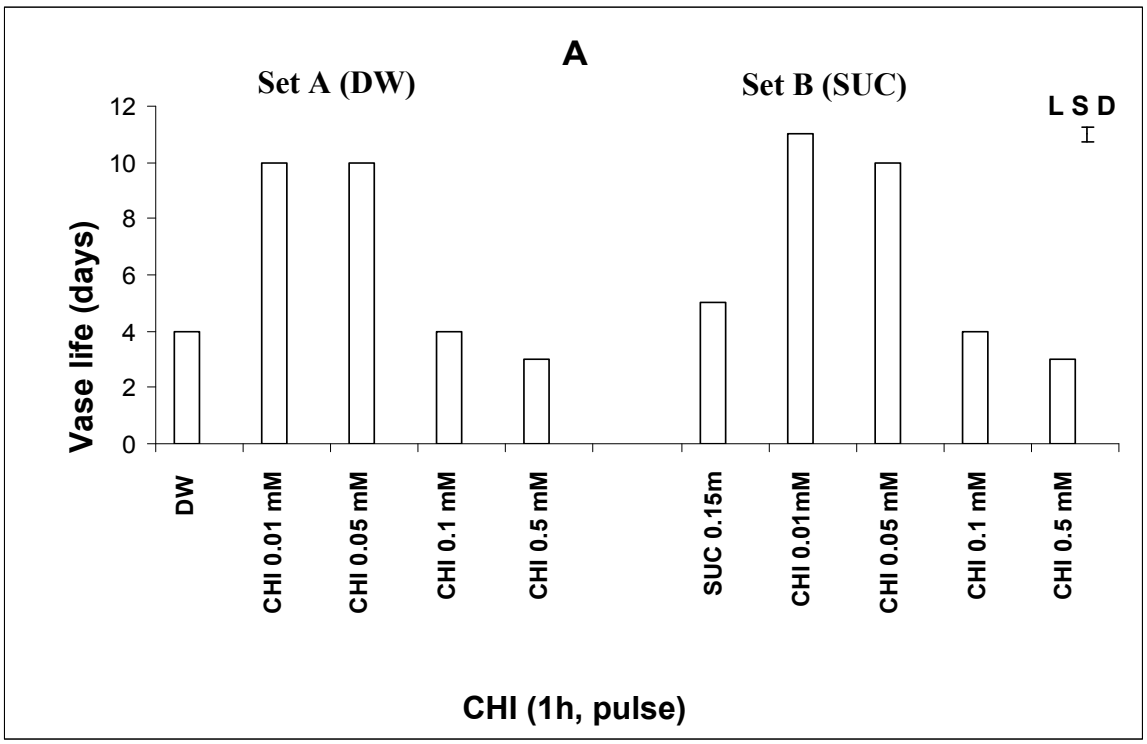
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Fig. 6.4.1

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1 h pulse) before transfer to DW (A) or SUC (B) on vase life (A) and number of blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


A
Set A (DW)
Set B (SUC)
L S D
Vase life (days)
12
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

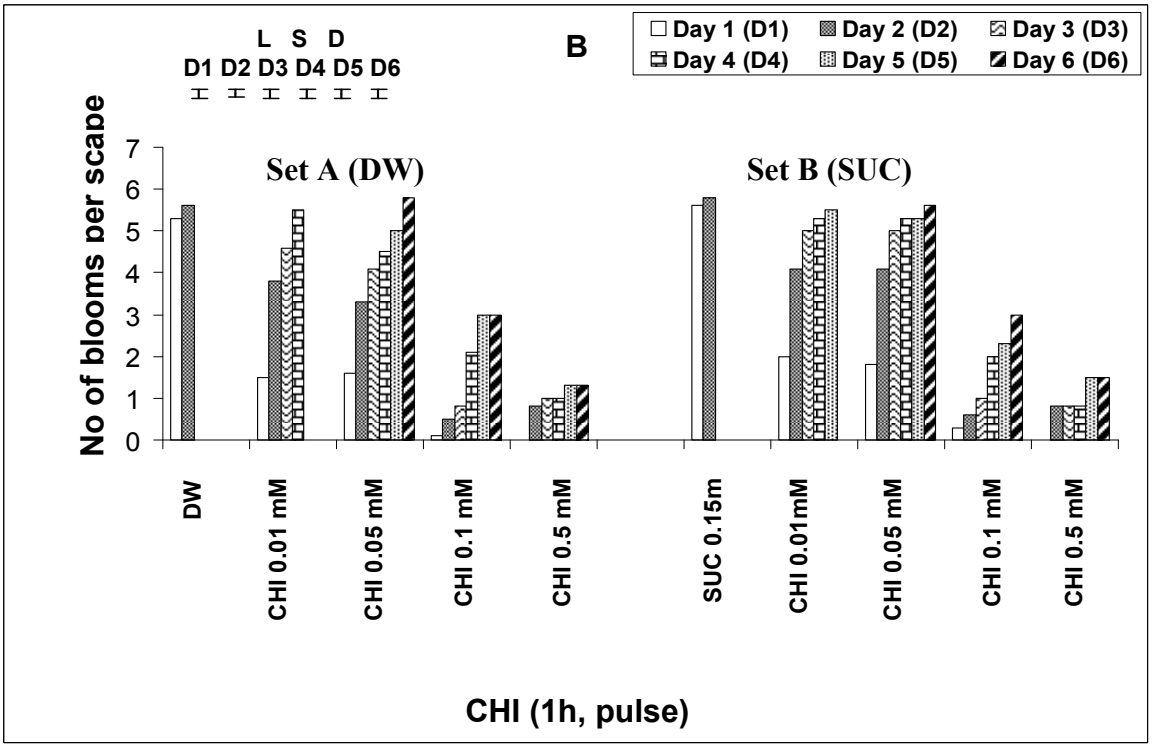
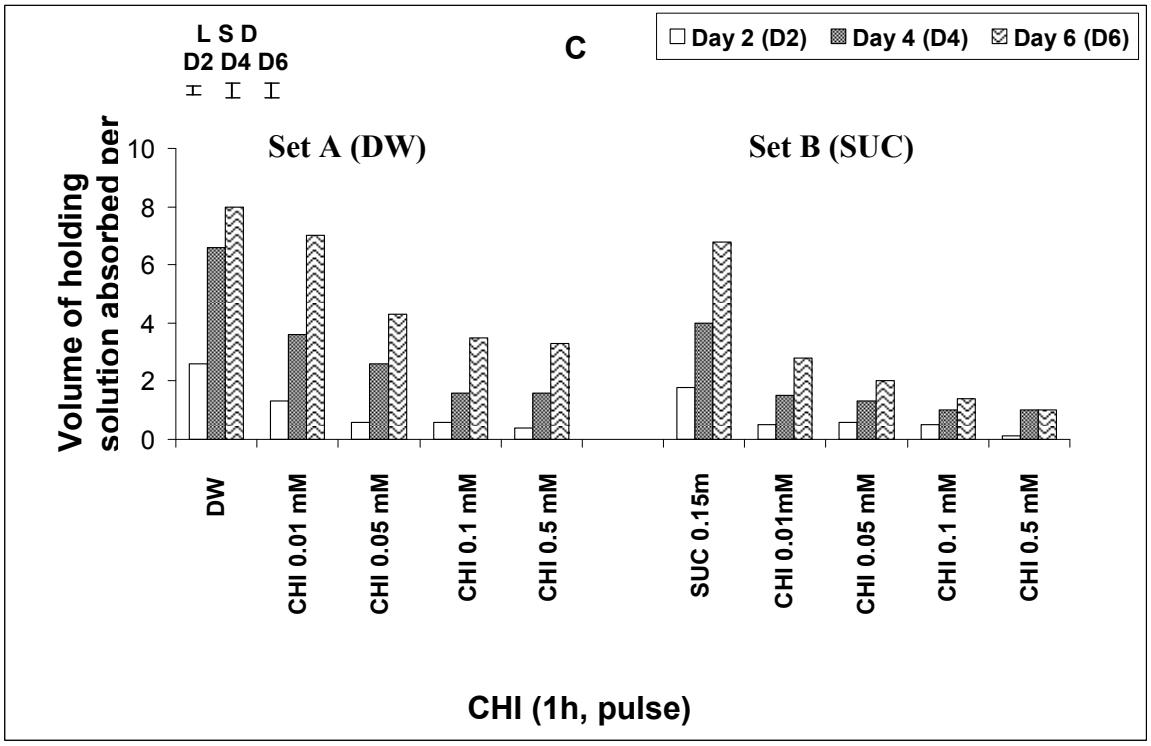

B
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
Day 4 (D4)
Day 5 (D5)
Day 6 (D6)
L S D
D1 D2 D3 D4 D5 D6
No of blooms per scape
Set A (DW)
Set B (SUC)
7
6
5
4
3
2
1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.1

Fig. 6.4.2

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on volume of holding solution absorbed per scape ml (C) and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Set A (DW)
Set B (SUC)
Volume of holding solution absorbed per
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

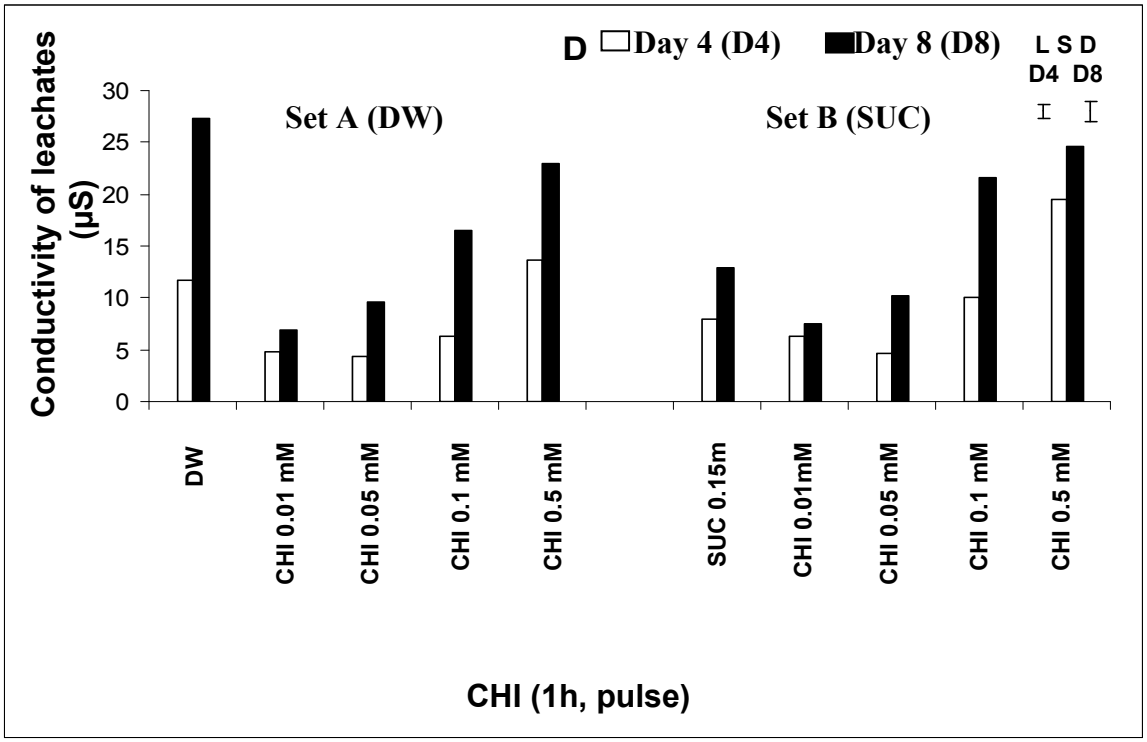
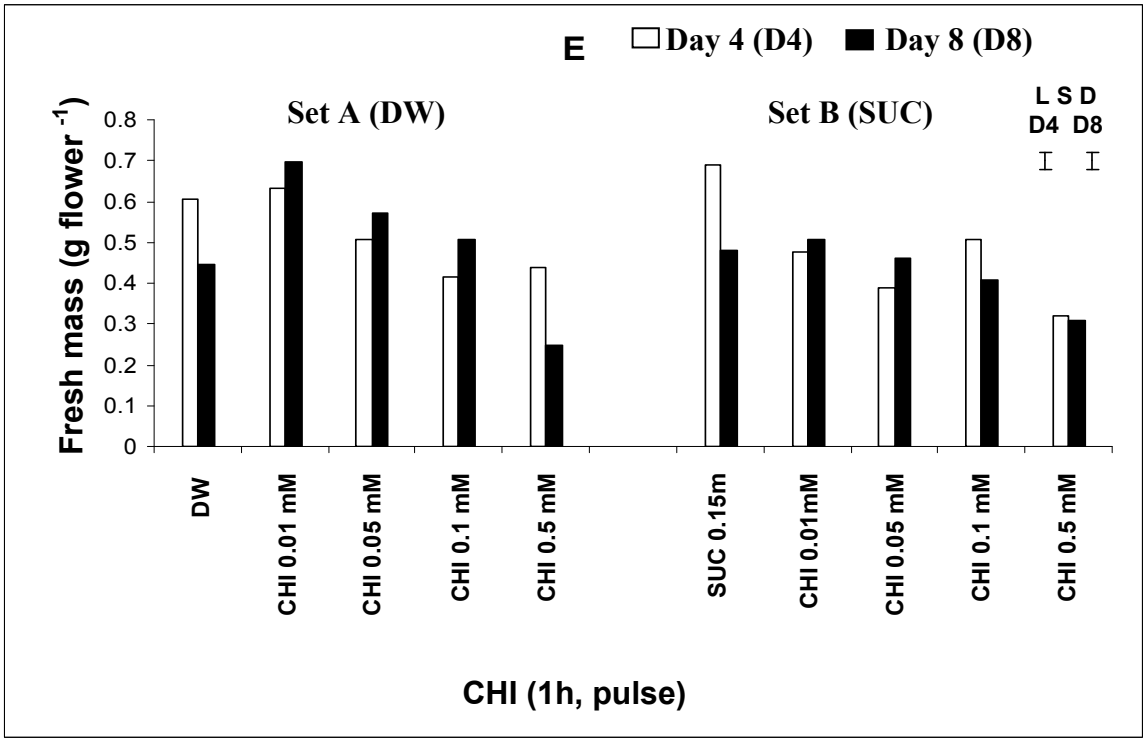

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Set A (DW)
Set B (SUC)
Conductivity of leachates (µS)
30
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.2

Fig. 6.4.3

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Day 4 (D4)
Day 8 (D8)
Set A (DW)
Set B (SUC)
L S D
D4 D8
Fresh mass (g flower -1)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

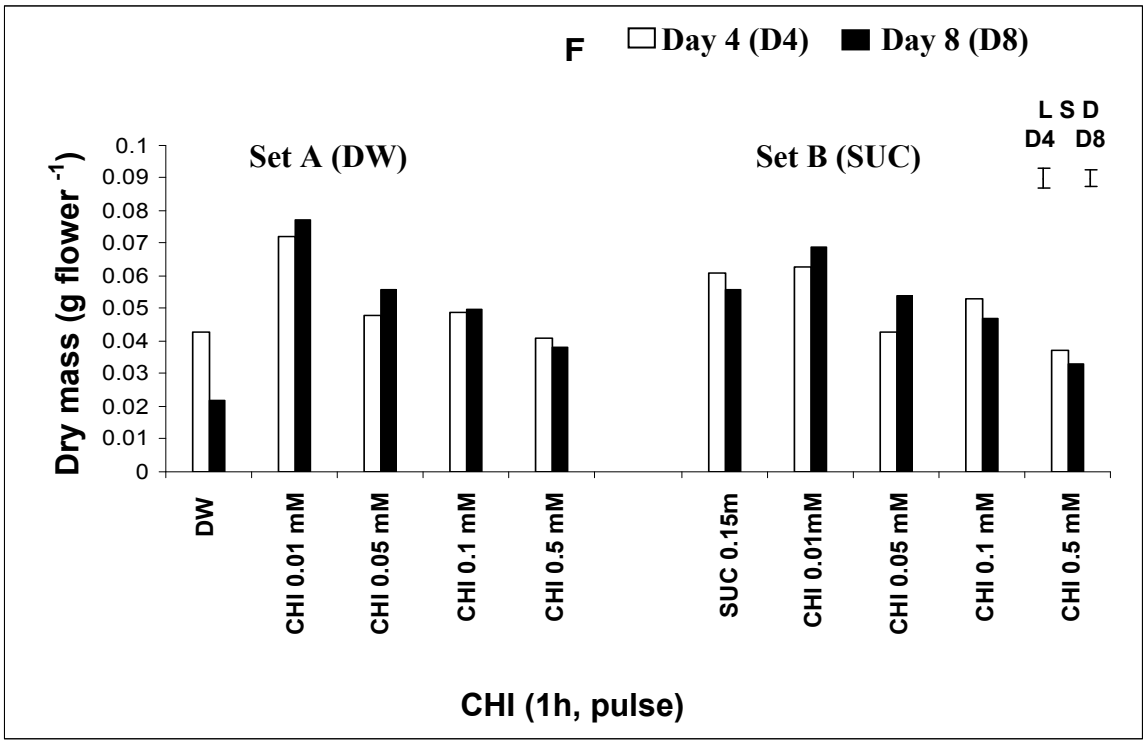
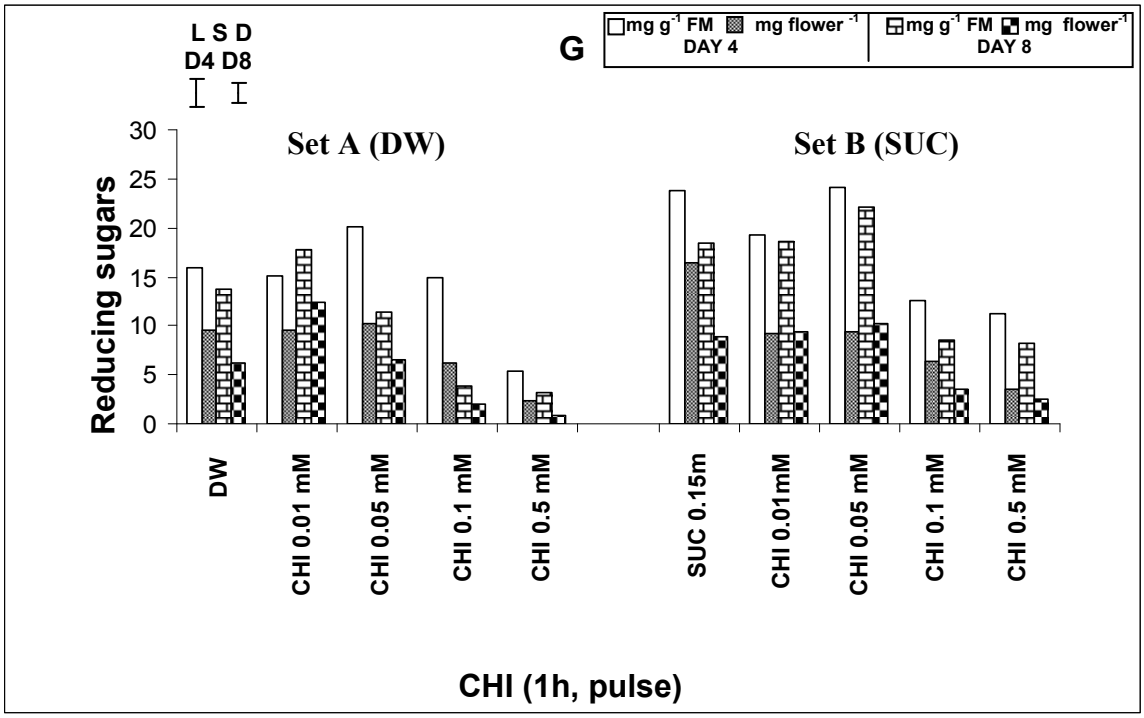

F
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Set A (DW)
Set B (SUC)
Dry mass (g flower -1)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.3

Fig. 6.4.4

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on reducing sugars (G) and non reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


G
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower-1
DAY 8
Set A (DW)
Set B (SUC)
Reducing sugars
30
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

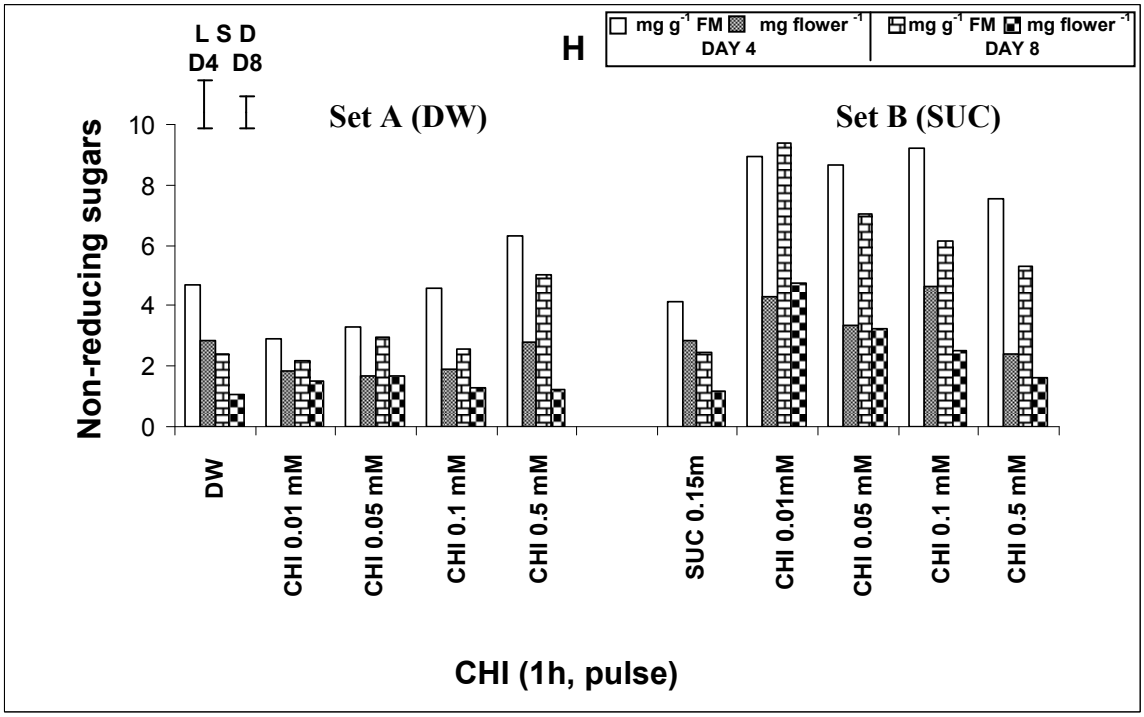
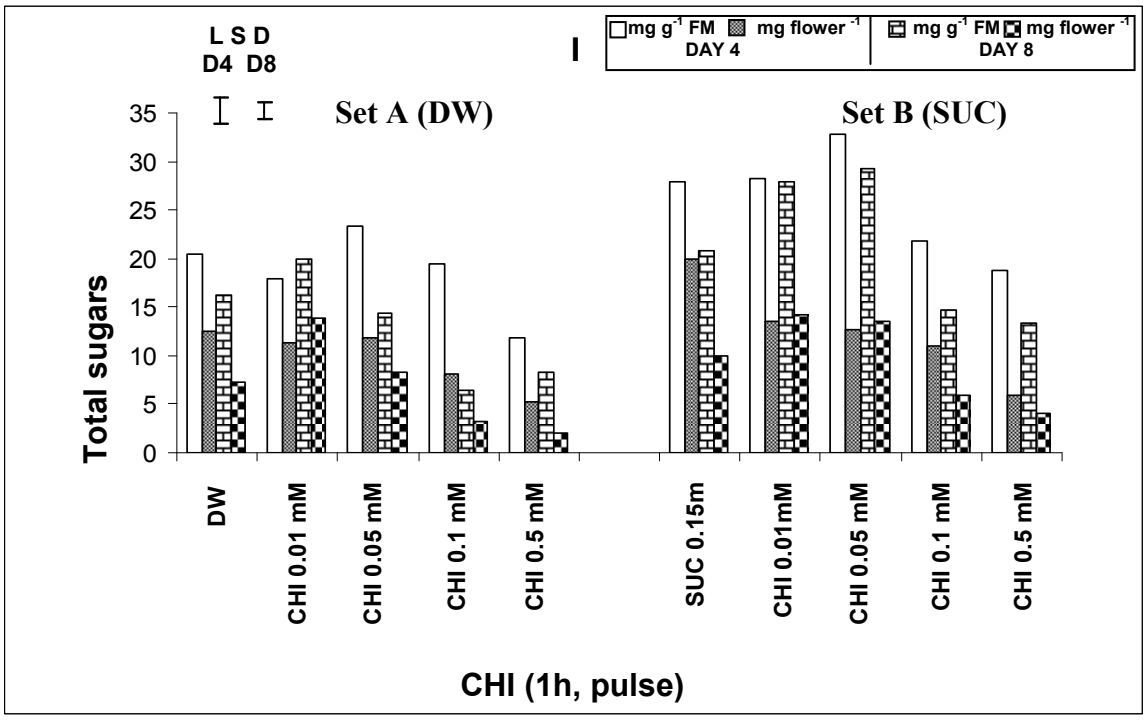

H
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Non-reducing sugars
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.4

Fig. 6.4.5

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


I
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Set A (DW)
Set B (SUC)
Total sugars
35
30
25
20
15
10
5
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

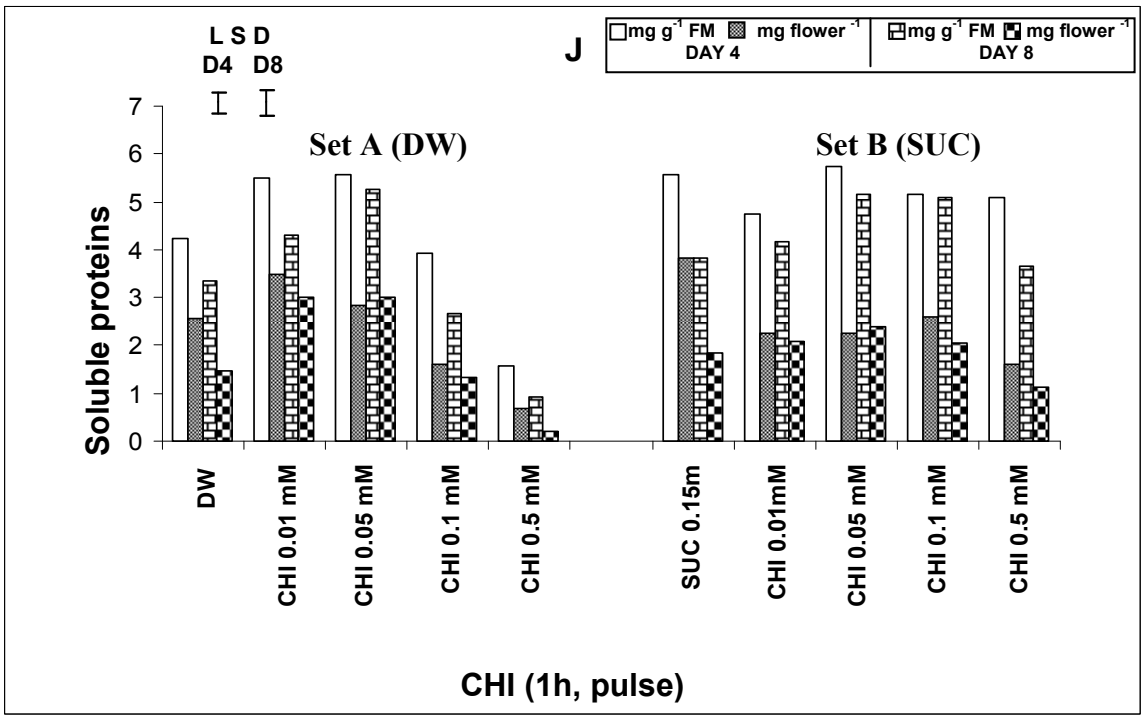
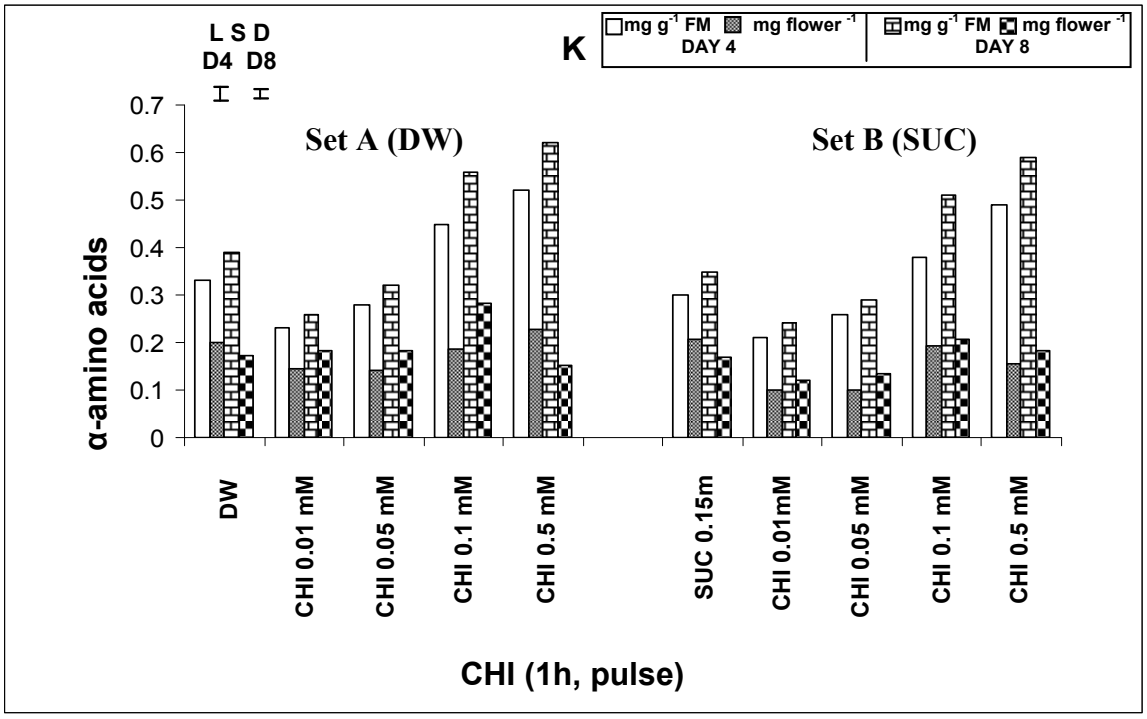

J
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Set A (DW)
Set B (SUC)
Soluble proteins
7
6
5
4
3
2
1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.5

Fig. 6.4.6

Histograms showing effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on α- amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


K
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
α-amino acids
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

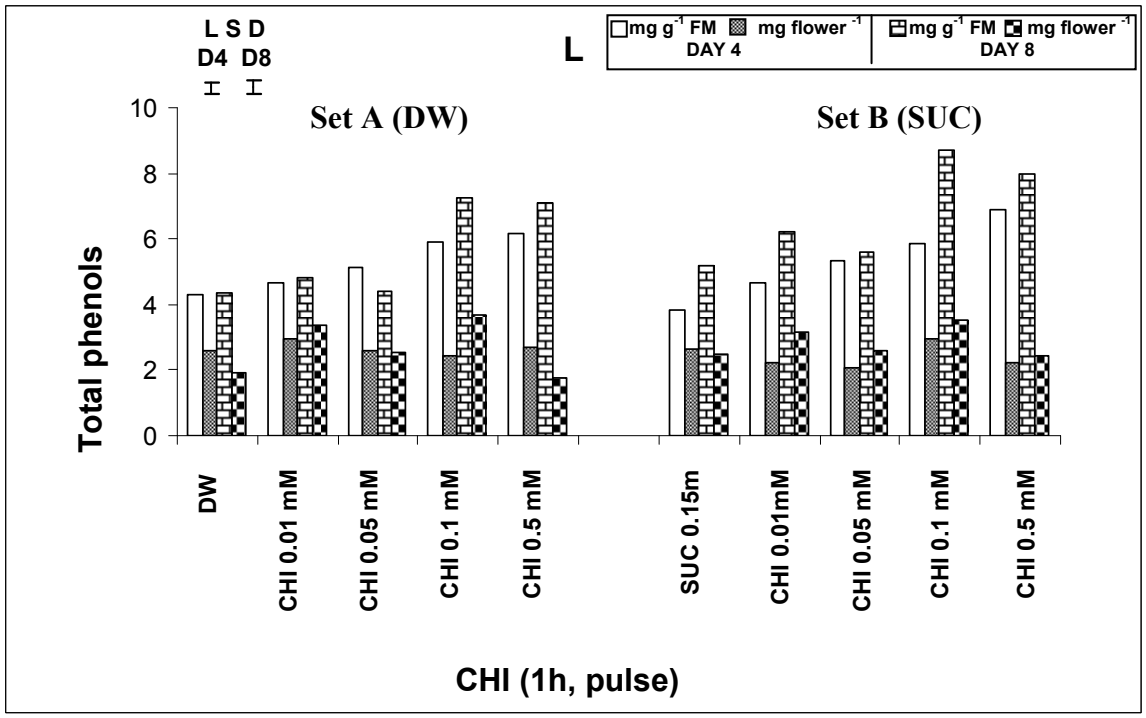

L
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
Set A (DW)
Set B (SUC)
Total phenols
10
8
6
4
2
0
DW
CHI 0.01 mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
SUC 0.15m
CHI 0.01mM
CHI 0.05 mM
CHI 0.1 mM
CHI 0.5 mM
CHI (1h, pulse)

Fig. 6.4.6

Plate. 6.4.1

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 6 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15M), CHI (0.01mM) → DW and CHI (0.01mM) → SUC (0.15M).

Fig.2: DW, SUC (0.15M), CHI (0.05mM) → DW and CHI (0.05mM) → SUC (0.15M).

Fig.3: DW, SUC (0.15M), CHI (0.5mM) → DW and CHI (0.5mM) → SUC (0.15M).

Fig.4: DW, SUC (0.15M), CHI (1.0mM) → DW and CHI (1.0 mM) → SUC (0.15M).

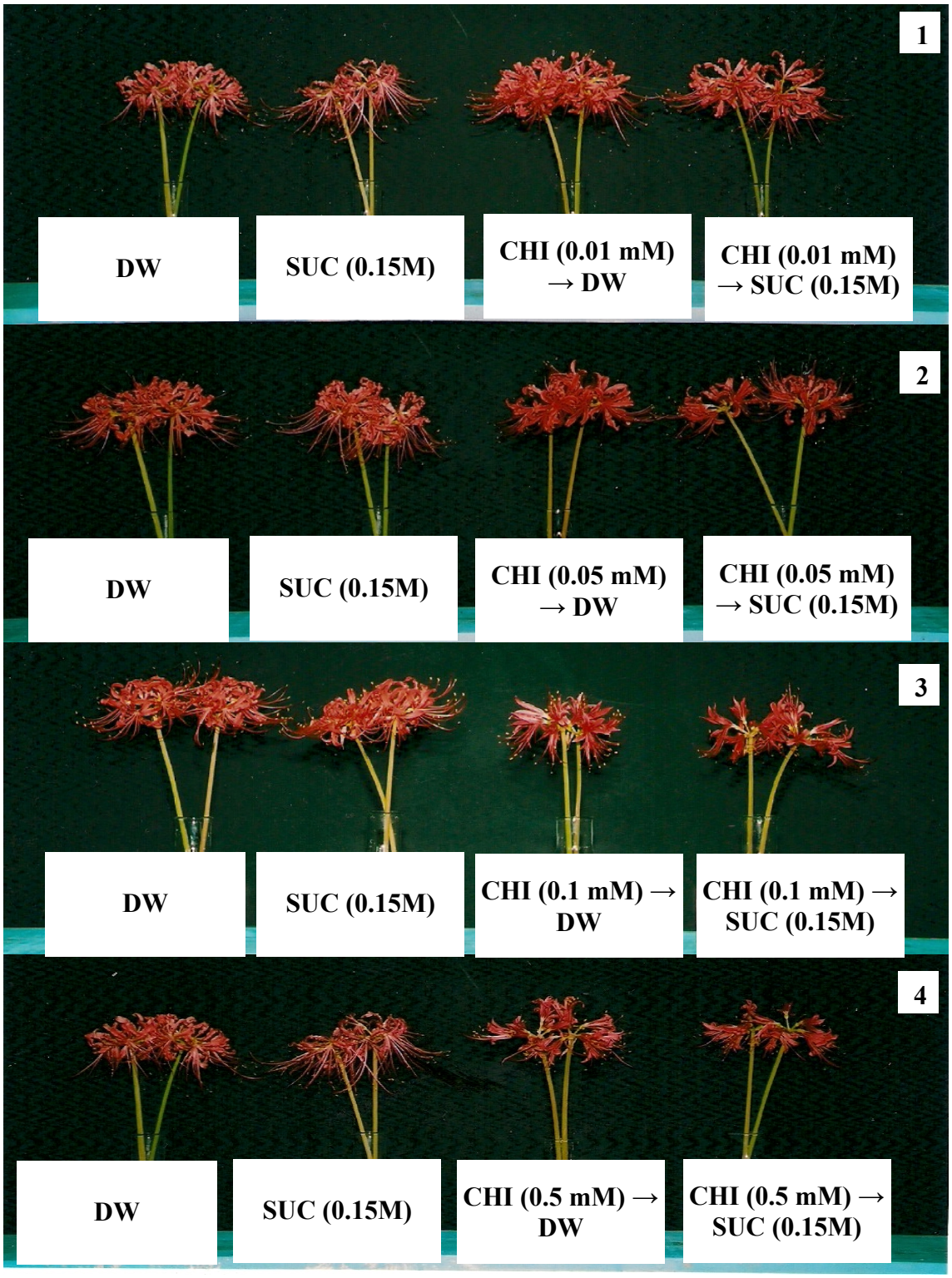

1
DW
SUC (0.15M)
CHI (0.01 mM) → DW
CHI (0.01 mM) → SUC (0.15M)
2
DW
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05 mM) → SUC (0.15M)
3
DW
SUC (0.15M)
CHI (0.1 mM) → DW
CHI (0.1 mM) → SUC (0.15M)
4
DW
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)

Plate. 6.4.1

Plate. 6.4.2

Effect of pretreatment with varying grades of cycloheximide (CHI, 1h pulse) before transfer to DW (A) or SUC (B) on vase life and senescence on day 12 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged scapes held in

Fig.1: DW, SUC (0.15M), CHI (0.01mM) → DW and CHI (0.01mM) → SUC (0.15M).

Fig.2: DW, SUC (0.15M), CHI (0.05mM) → DW and CHI (0.05mM) → SUC (0.15M).

Fig.3: DW, SUC (0.15M), CHI (0.5mM) → DW and CHI (0.5mM) → SUC (0.15M).

Fig.4: DW, SUC (0.15M), CHI (1.0mM) → DW and CHI (1.0 mM) → SUC (0.15M).

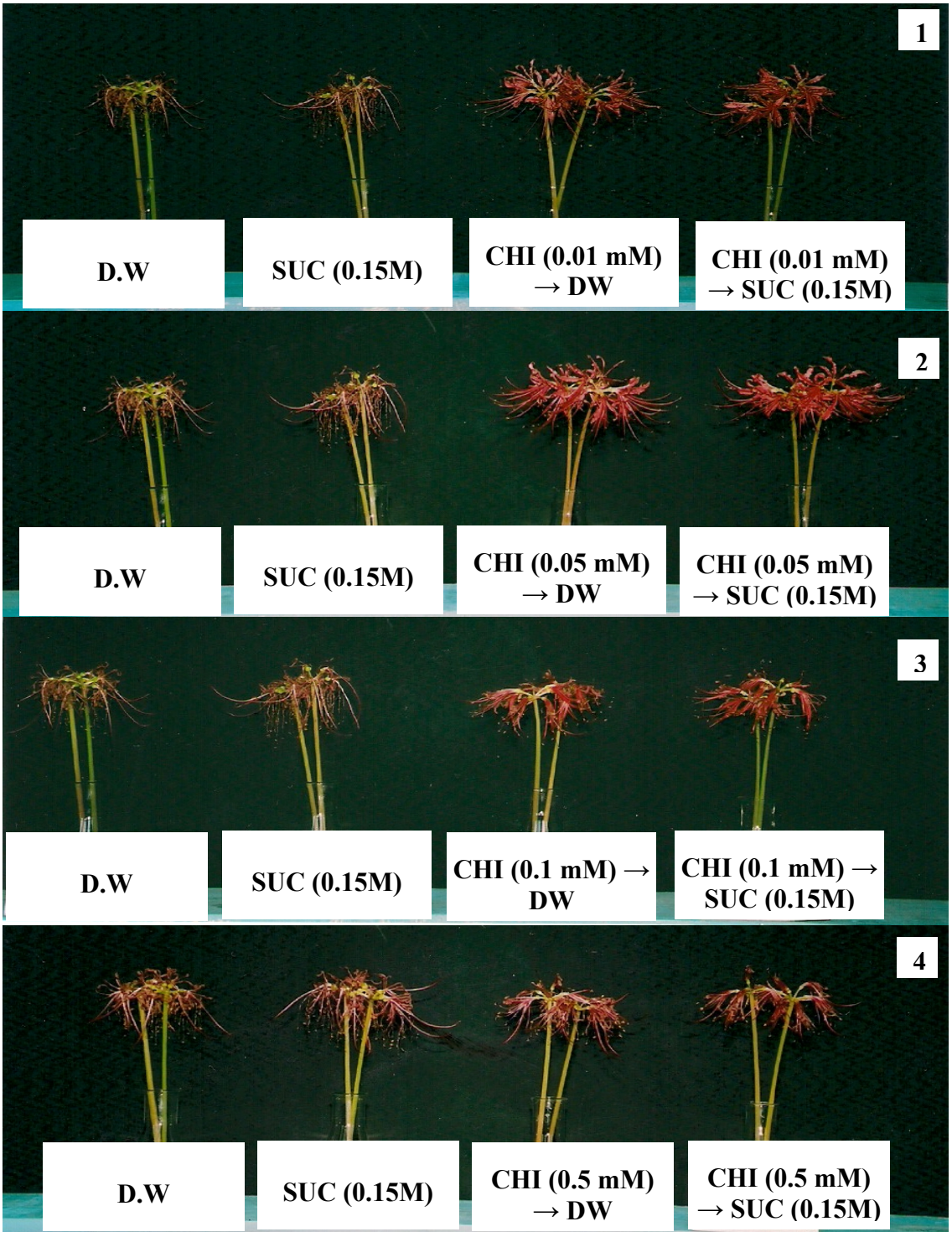

1
D.W
SUC (0.15M)
CHI (0.01 mM) → DW
CHI (0.01 mM) → SUC (0.15M)
2
D.W
SUC (0.15M)
CHI (0.05 mM) → DW
CHI (0.05 mM) → SUC (0.15M)
3
D.W
SUC (0.15M)
CHI (0.1 mM) → DW
CHI (0.1 mM) → SUC (0.15M)
4
D.W
SUC (0.15M)
CHI (0.5 mM) → DW
CHI (0.5 mM) → SUC (0.15M)

Plate. 6.4.2

EXPERIMENT 6.5

Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1 h) and aminooxyacetate AOA (0.5 mM, 1 h) before transfer to distilled water DW and sucrose SUC (0.15M) in cut scapes of *Nerine sarniensis* cv.Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. Scapes were pulsed with STS (0.5 mM, 1 h) and AOA (0.5mM, 1.h). After pulsing the scapes were transferred to 250 ml conical flasks containing 200 ml of DW or SUC (0.15M) in triplicate. The unpulsed scapes transferred to DW represented the control. A separate set of unpulsed scapes was transferred to SUC (0.15M). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of the scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solutions and was assessed to be terminated when the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 3 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of the scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and total phenols

were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{=0.05}$

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions. Both STS and AOA were effective in delaying senescence in the scapes (Plate. 6.5, Figs. 1-4). Vase life of scapes pulsed either with STS or AOA was enhanced by an increment of 4 to 7 days as compared to the unpulsed scapes held in DW or SUC which exhibited a vase life of about 4 and 5 days respectively. Scapes pulsed with STS or AOA showed slow blooming as compared to the corresponding scapes held in DW or SUC.

Vase life: The average vase life of the unpulsed scape held either in DW or SUC was 4 and 5 days respectively while as the average vase life of scapes pulsed either with STS or AOA before transfer to DW was enhanced by an increment of about 2 and 5 days and the vase life of the pulsed scapes transferred to SUC was enhanced by an increment of about 4 and 7 days respectively (Table 6.5.1, Text Fig. 6.5.1, A).

Number of blooms per scape: Number of blooms increased in all treatments irrespective of the transfer to various holding solutions Scapes held in SUC registered slightly more blooms as compared to the scapes held in DW irrespective of the treatment. Scapes pulsed with AOA showed sustained blooming up to day 3 of transfer to either DW or SUC as compared to the scapes pulsed with STS (Table 6.5.1; Text Fig. 6.5.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 4 and 6 days of the transfer of scapes irrespective of the transfer of various holding solution. Higher solution uptake was registered in scapes pulsed with AOA as compared to the corresponding scapes pulsed with STS, transferred to

either DW or SUC (Table 6.5.1, Text Fig. 6.5.2, C). Maximum solution uptake was noticed by the scapes pulsed with AOA transferred to DW or SUC.

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs decreased with progression in time from day 4 to day 8 of transfer of scapes (pulsed with STS or AOA) to DW or SUC as compared to the corresponding unpulsed scapes transferred to DW or SUC. A slightly lower concentration of ion leachates was maintained in the samples from scapes pulsed with STS as compared to the samples from scapes pulsed with AOA. (Table 6.5.2, Text Fig. 6.5.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers increased with progression in time from day 4 to day 8 of transfer of pulsed scapes to DW or SUC as compared to the flowers from unpulsed scapes transferred to DW or SUC. Higher fresh and dry mass was noticed in flower from scapes pulsed with AOA as compared to the flowers from scapes pulsed with STS. (Table 6.5.2, Text Fig. 6.5.3 E & F). Highest fresh and dry mass was maintained in the samples from scapes pulsed with AOA.

Reducing sugars: The reducing sugar content was either maintained or registered an increase with the progression in time from day 4 to day 8 of transfer of scapes (pulsed with STS or AOA) to DW or SUC; while as reducing sugars content decreased in the samples from corresponding unpulsed scapes transferred to DW or SUC over the period of time. Higher content of reducing sugars was registered in the samples from scapes pulsed with AOA as compared to the samples from scapes pulsed with STS (Table 6.5.3; Text Fig. 6.5.4, G). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.5.3). On dry mass basis, however the content of reducing sugars generally decreased irrespective of the transfer to various holding solutions transferred to however the reducing

sugars increased in the samples from unpulsed scapes held in DW as also in samples from scapes pulsed with AOA and transferred to SUC (Table 6.5.4).

Non-reducing sugars: The non-reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer irrespective of pulse treatment with STS or AOA. However, a higher content of non-reducing sugar was maintained in the samples from scapes pulsed with STS and AOA and transferred to SUC and DW respectively. Higher content of non-reducing sugars was registered in the samples from scapes pulsed with AOA as compared to the samples from scapes pulsed with STS (Table 6.5.3; Text Fig. 6.5.4, H). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.5.3 & 6.5.4).

Total sugars: The total sugar content was generally maintained with the progression in time from day 4 to day 8 of transfer of scapes pulsed with STS or AOA transferred to DW or SUC while as content of total sugars decreased in the samples from corresponding unpulsed scapes transferred to DW or SUC over the period of time. Higher content of total sugars was registered in the samples from scapes pulsed with AOA as compared to the samples from scapes pulsed with STS (Table 6.5.3; Text Fig. 6.5.5, I). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.5.3). On dry mass basis the content of reducing sugars decreased irrespective of the transfer to various holding solutions however, the total sugars content increased with the progression of time in the samples from unpulsed scapes held in DW and to some extent in samples from scapes pulsed with AOA transferred to SUC (Table 6.5.4).

Soluble proteins: The soluble protein content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes pulsed with STS or AOA before transfer to DW or SUC, while as content of proteins decreased in the samples from corresponding unpulsed scapes transferred to

DW or SUC over the period of time. A higher soluble protein content was maintained in the samples from scapes pulsed with AOA as compared to the samples from scapes pulsed with STS (Table 6.5.5; Text Fig. 6.5.5, J). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.5.5). On dry mass basis the content of soluble proteins was generally maintained irrespective of the transfer to various holding solutions, however soluble content protein increased in the samples from unpulsed scapes particularly held in SUC (Table 6.5.6).

α- amino acids: The α- amino acids content generally decreased with the progression in time from day 4 to day 8 of transfer of pulsed scapes to either DW or SUC, while as an increase was noticed in the α- amino acid content in the samples from corresponding unpulsed scapes transferred to DW or SUC over the period of time. A lower amino acids content was maintained in the samples from scapes pulsed with AOA as compared to the samples from scapes pulsed with STS (Table 6.5.5;Text Fig. 6.5.6, K). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.5.5). On dry mass basis the content of α-amino acids generally decreased irrespective of the transfer to various holding solutions however, α- amino acids increased in the samples from unpulsed scapes held in DW (Table 6.5.6)

Total phenols: The content of total phenols generally registered an increase with the progression in time from day 4 to day 8 of transfer of scapes pulsed with STS as also the unpulsed scapes transferred to either to DW or SUC. The phenolic content of samples from scapes pulsed with AOA before transfer to DW registered a decrease while as an increase in the phenolic content was observed in the AOA pulsed scapes transferred to SUC (Table 6.5.3; Tect Fig. 6.5.6, L). Approximately similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 6.5.5 & 6.5.6).

Table 6.5.1: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water DW and sucrose SUC (0.15 M) on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Treatment	Vase life (days)	No. of blooms per scape			Volume of holding solution absorbed per scape (ml)		
		Days after treatment					
		1	2	3	2	4	6
DW	4	5.16 (96)	5.66 (100)	-	2.60	6.66	8.00
SUC (0.15M)	5	5.66 (98)	5.66 (100)	-	2.10	4.00	6.83
STS (0.5 mM, 1h) → DW	6	4.50 (61)	5.66 (100)	-	4.30	6.00	7.66
STS (0.5 mM, 1h) → SUC (0.15M)	8	4.16 (73)	6.00 (100)	-	2.30	4.66	7.50
AOA (0.5 mM, 1h) → DW	9	3.00 (40)	4.33 (56)	5.66 (100)	2.60	7.66	9.66
AOA (0.5 mM, 1h) → SUC (0.15M)	11	3.33 (38)	5.50 (91)	5.66 (100)	2.00	7.33	9.16
LSD at $P_{=0.05}$	0.58	1.27	0.63	-	0.33	0.17	0.27

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 6.5.2: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water DW and sucrose SUC (0.15 M) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer of cut scape to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
DW	11.73	32.00	0.607	0.441	0.043	0.022
SUC (0.15M)	7.90	12.96	0.651	0.481	0.061	0.05
STS (0.5 mM, 1h) → DW	12.03	9.70	0.534	0.571	0.034	0.052
STS (0.5 mM, 1h) → SUC (0.15M)	10.13	7.36	0.567	0.596	0.048	0.059
AOA (0.5 mM, 1h) → DW	13.81	9.93	0.547	0.659	0.040	0.050
AOA (0.5 mM, 1h) → SUC (0.15M)	12.33	9.19	0.572	0.576	0.049	0.057
LSD at $P_{=0.05}$	1.27	0.63	0.045	0.041	0.006	0.004

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Table 6.5.3: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water DW and sucrose SUC (0.15 M) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	15.84 (9.61)	13.76 (6.12)	4.72 (2.86)	2.40 (1.06)	20.56 (12.47)	16.16 (7.18)
SUC (0.15M)	23.76 (16.41)	18.40 (8.85)	4.16 (1.86)	2.48 (1.19)	27.92 (19.28)	20.88 (10.04)
STS (0.5 mM, 1h) → DW	9.06 (4.83)	9.56 (5.46)	1.30 (0.69)	1.31 (0.73)	10.36 (5.52)	10.87 (6.19)
STS (0.5 mM, 1h) → SUC (0.15M)	11.93 (6.76)	10.41 (6.19)	1.06 (0.60)	3.23 (1.92)	12.99 (7.36)	13.64 (8.11)
AOA (0.5 mM, 1h) → DW	13.8 (7.54)	12.03 (7.92)	2.43 (1.33)	4.00 (2.63)	16.23 (8.87)	16.03 (10.55)
AOA (0.5 mM, 1h) → SUC (0.15M)	7.23 (4.13)	15.03 (8.65)	5.33 (3.04)	1.76 (1.01)	12.56 (7.17)	16.79 (9.66)
LSD at $P_{=0.05}$	1.38	1.90	0.52	0.64	1.58	1.28

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.5.4: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water (DW) and sucrose SUC (0.15 M) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

.Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	226.19	280.70	67.40	48.96	293.59	329.14
SUC (0.15M)	269.90	158.24	30.62	21.33	317.17	179.56
STS (0.5 mM, 1h) → DW	142.39	105.04	20.41	14.27	162.81	119.32
STS (0.5 mM, 1h) → SUC (0.15M)	140.95	68.97	12.60	32.68	153.55	137.71
AOA (0.5 mM, 1h) → DW	188.71	158.59	33.27	52.72	221.98	211.31
AOA (0.5 mM, 1h) → SUC (0.15M)	84.43	151.90	62.25	17.85	146.69	169.76
LSD at $P_{=0.05}$	39.94	17.07	13.65	18.28	28.12	13.92

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Table 6.5.5: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water (DW) and sucrose SUC (0.15 M) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	4.25 (2.57)	3.33 (1.48)	0.35 (0.21)	0.53 (0.23)	4.30 (2.61)	4.36 (1.94)
SUC (0.15M)	5.50 (3.80)	3.83 (1.84)	0.18 (0.12)	0.21 (0.10)	3.84 (2.65)	5.18 (2.49)
STS (0.5 mM, 1h) → DW	2.75 (1.46)	3.66 (2.09)	0.23 (0.11)	0.21 (0.11)	1.51 (0.80)	2.03 (1.15)
STS (0.5 mM, 1h) → SUC (0.15M)	4.08 (2.30)	4.58 (2.73)	0.27 (0.14)	0.22 (0.12)	2.28 (1.29)	2.73 (1.62)
AOA (0.5 mM, 1h) → DW	5.33 (2.91)	5.83 (3.84)	0.17 (0.09)	0.11 (0.07)	2.01 (0.10)	1.65 (1.08)
AOA (0.5 mM, 1h) → SUC (0.15M)	5.58 (3.19)	6.16 (3.54)	0.13 (0.06)	0.09 (0.05)	1.11 (0.63)	1.71 (0.98)
LSD at $P_{=0.05}$	0.69	0.65	0.02	0.02	0.41	0.45

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.5.6: Effect of pulse treatment with silver thiosulphate STS (0.5 mM, 1h) and aminoxyacetate AOA (0.5 mM, 1h) before transfer to distilled water (DW) and sucrose SUC (0.15 M) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	59.76	67.27	5.09	10.80	61.49	88.94
SUC (0.15M)	62.29	36.80	2.07	1.85	43.61	44.60
STS (0.5 mM, 1h) → DW	43.27	40.25	3.65	2.30	23.79	22.32
STS (0.5 mM, 1h) → SUC (0.15M)	48.23	46.29	3.18	2.22	26.97	27.90
AOA (0.5 mM, 1h) → DW	72.88	76.83	2.25	1.44	27.57	21.74
AOA (0.5 mM, 1h) → SUC (0.15M)	65.13	62.24	0.36	0.90	13.03	17.34
LSD at $P_{=0.05}$	9.28	10.59	0.36	0.35	5.66	4.21

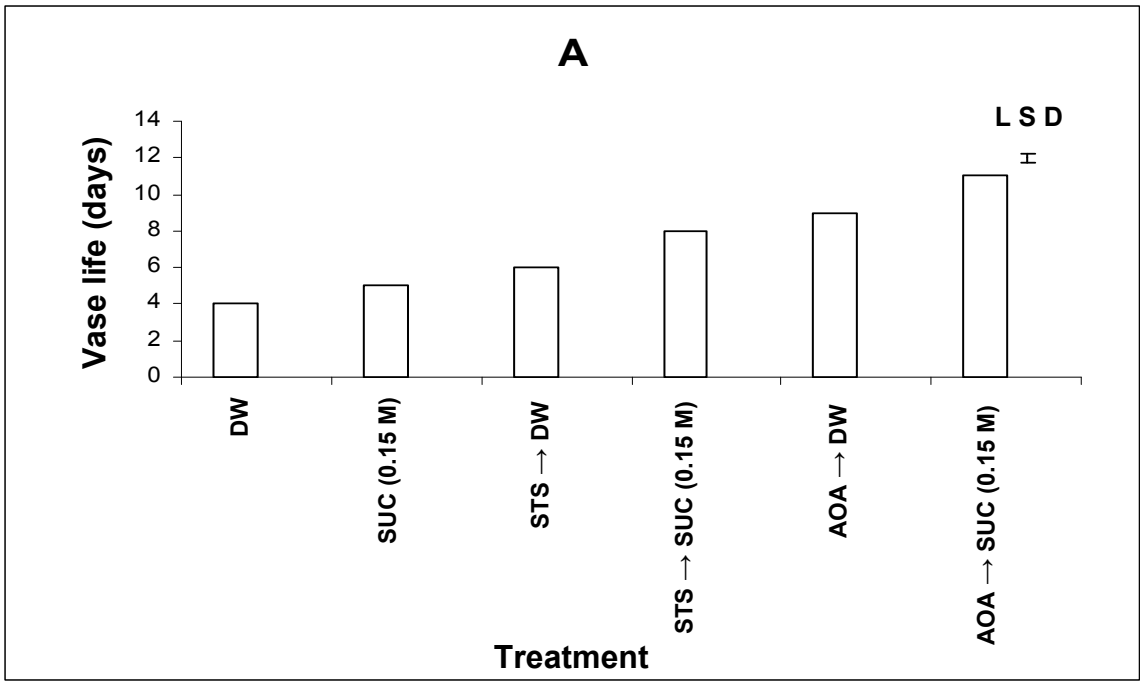
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Fig. 6.5.1

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on vase life (A) and number of blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


A
Vase life (days)
14
12
10
8
6
4
2
0
L S D
H
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

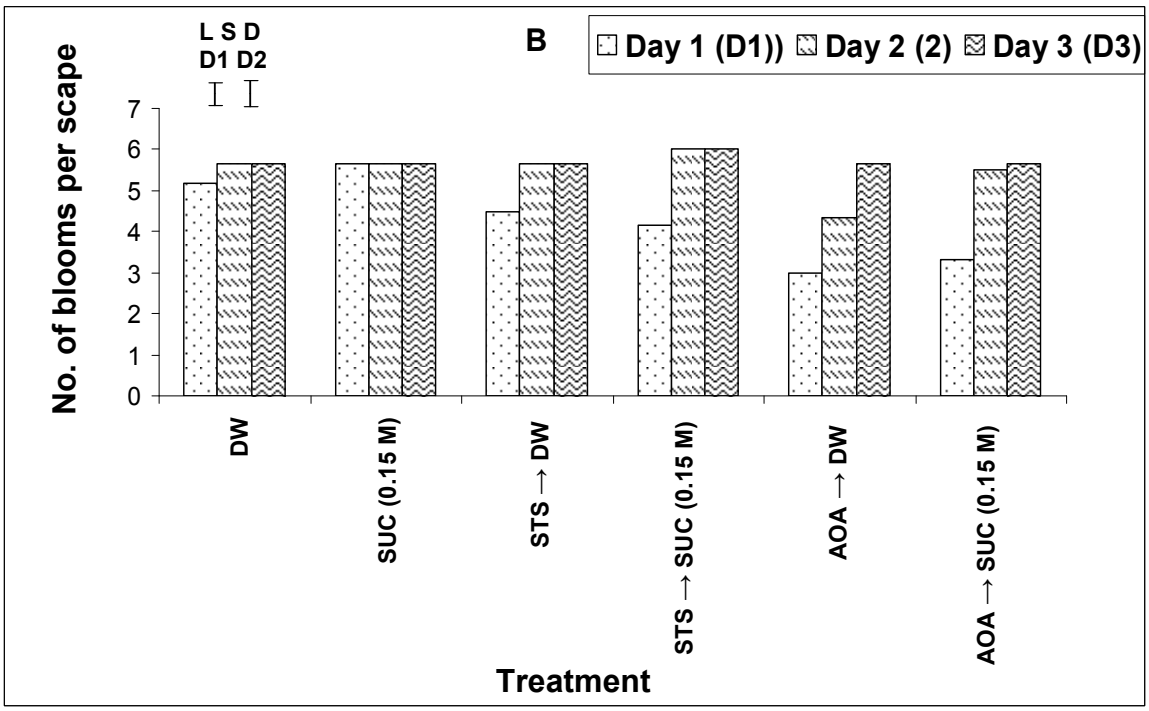
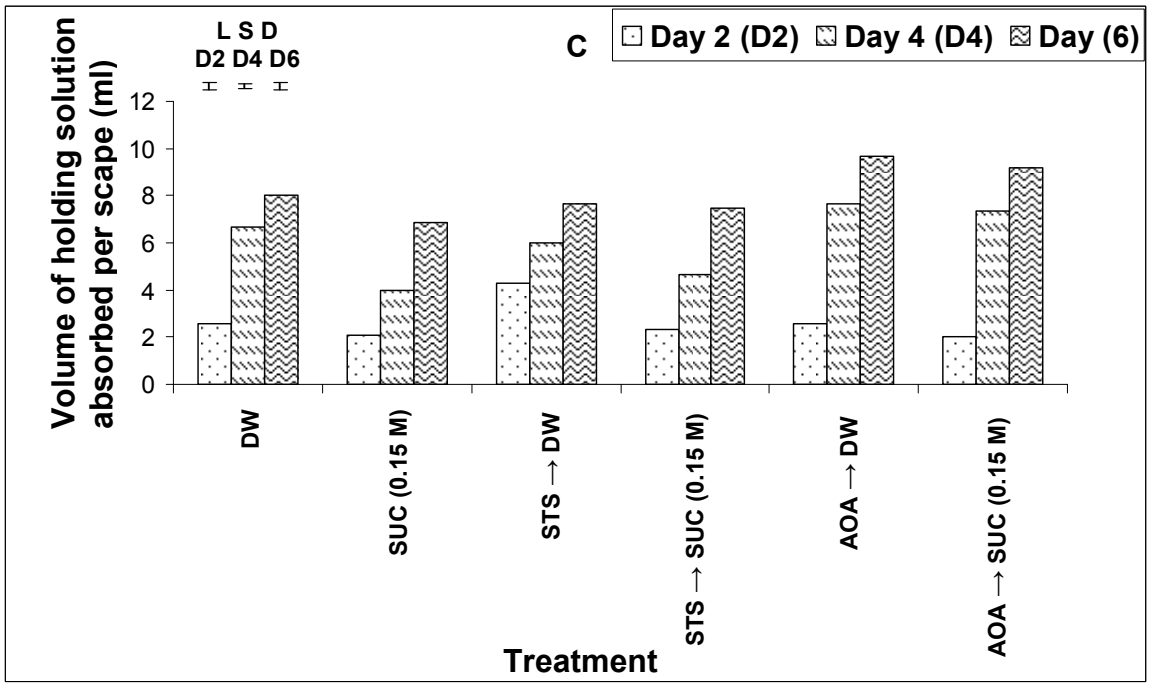

B
Day 1 (D1))
Day 2 (2)
Day 3 (D3)
L S D
D1 D2
No. of blooms per scape
7
6
5
4
3
2
1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.1

Fig. 6.5.2

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on volume of holding solution absorbed per scape ml (C) and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$.


C
Day 2 (D2)
Day 4 (D4)
Day (6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
2
4
6
8
10
12
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

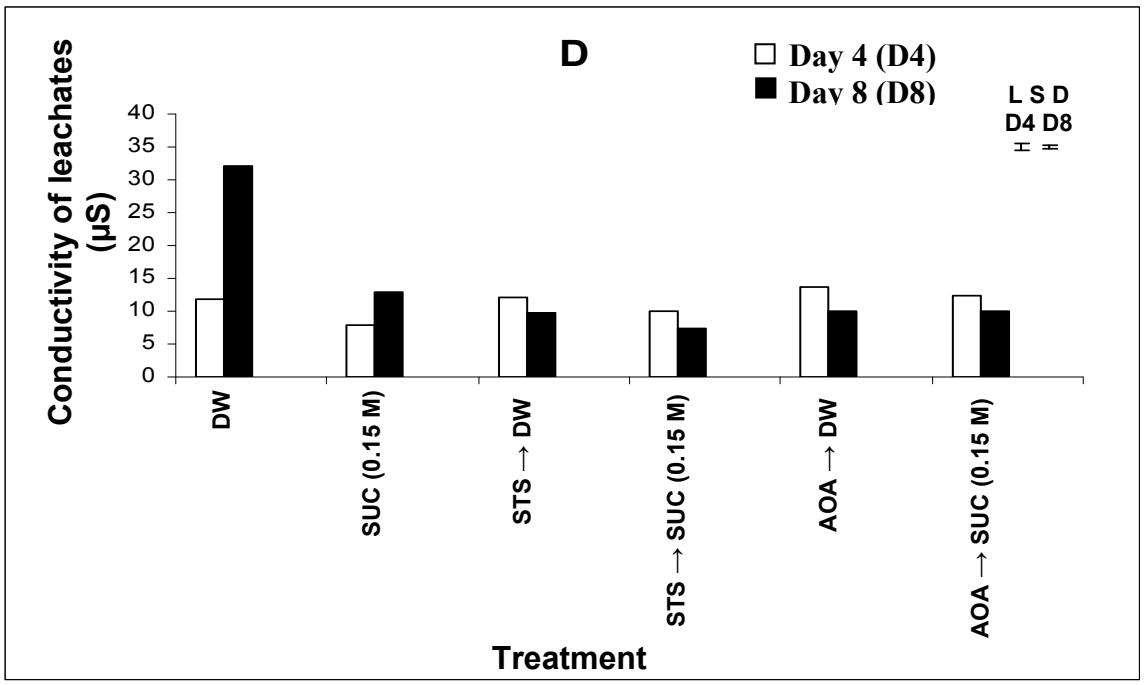
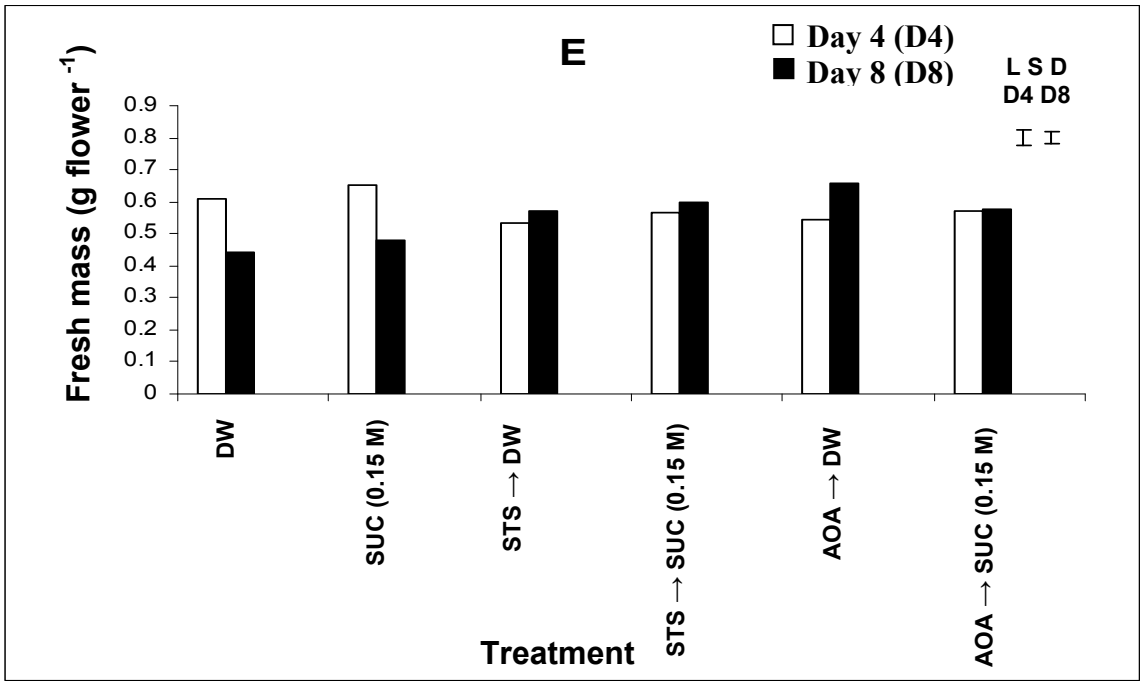

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
40
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.2

Fig. 6.5.3

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


E
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Fresh mass (g flower -1)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

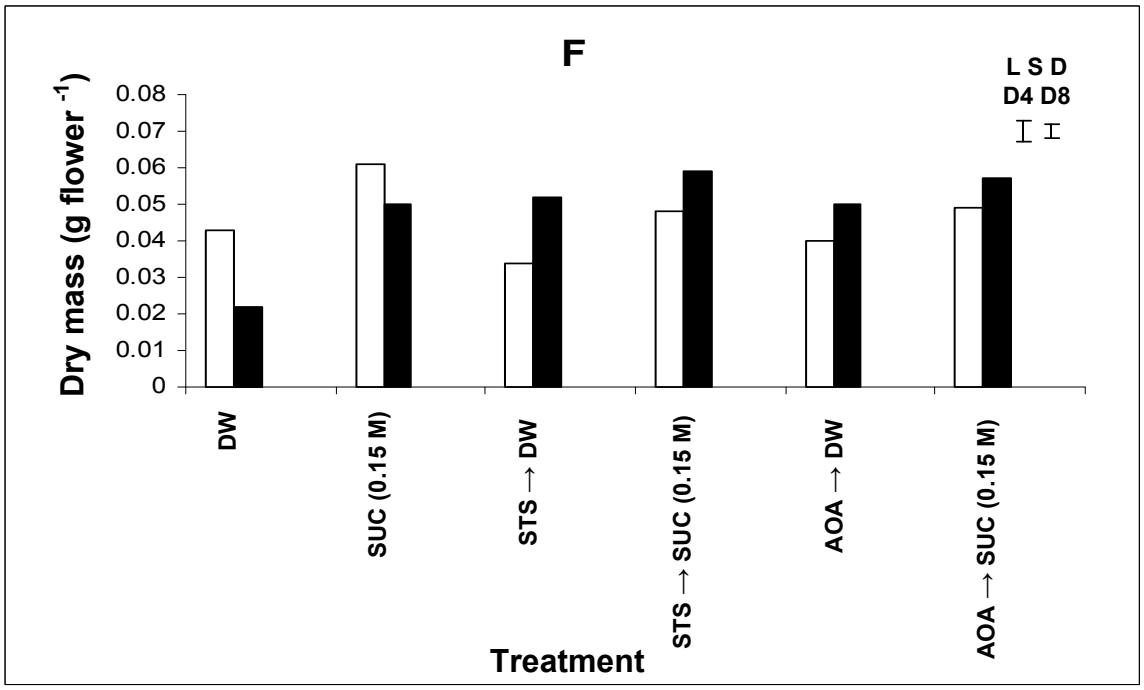
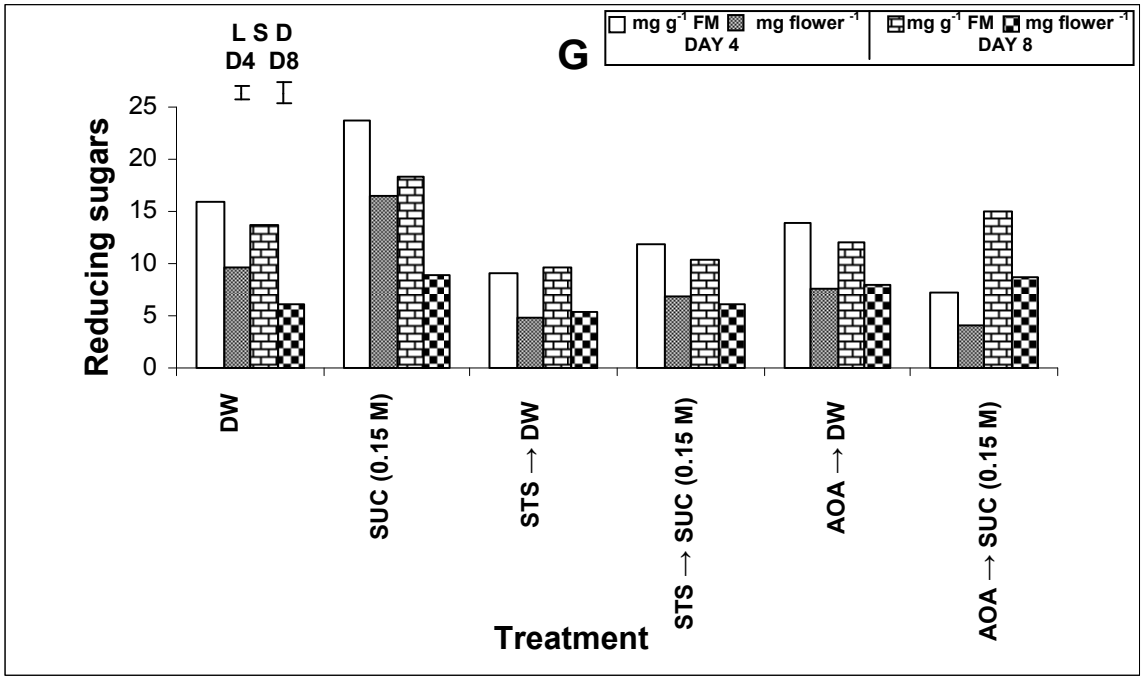

F
L S D
D4 D8
Dry mass (g flower -1)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.3

Fig. 6.5.4

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on reducing sugars (G) and non reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


G
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Reducing sugars
25
20
15
10
5
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

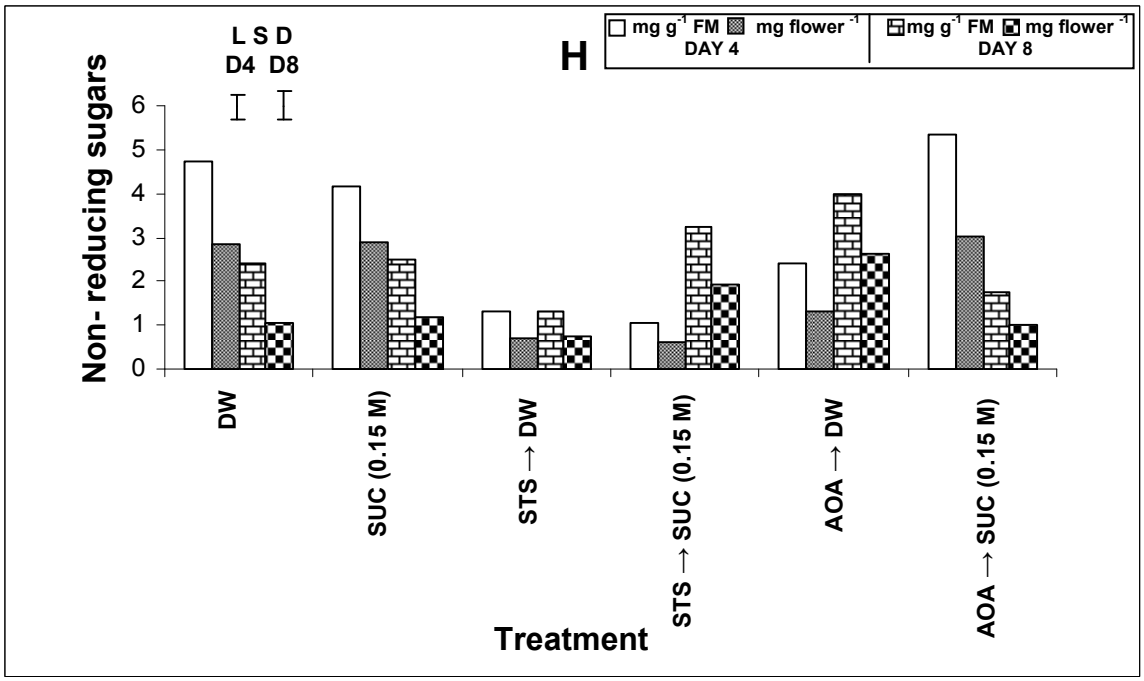
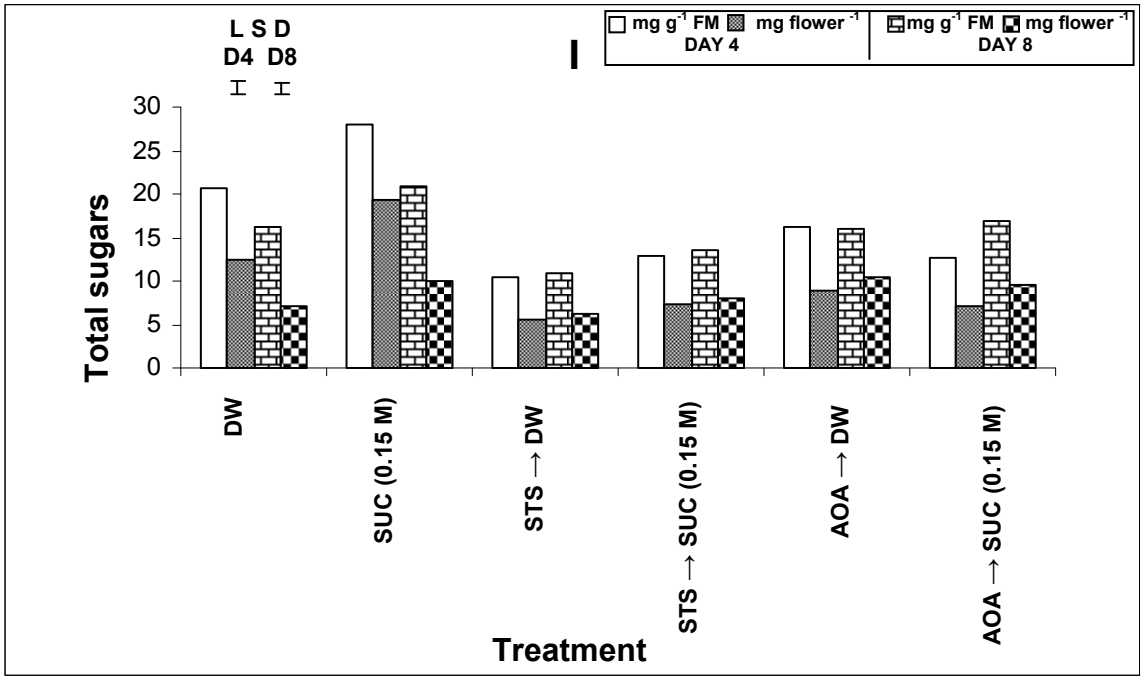

H
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Non- reducing sugars
6
5
4
3
2
1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.4

Fig. 6.5.5

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


L S D
D4 D8
I
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Total sugars
30
25
20
15
10
5
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

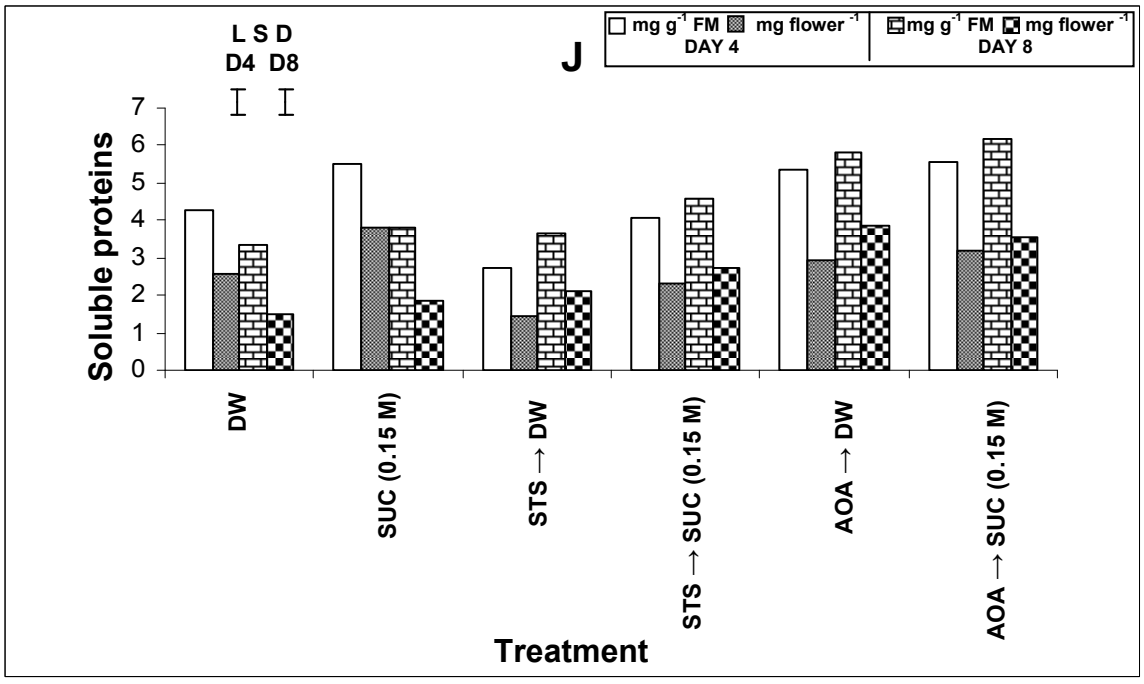
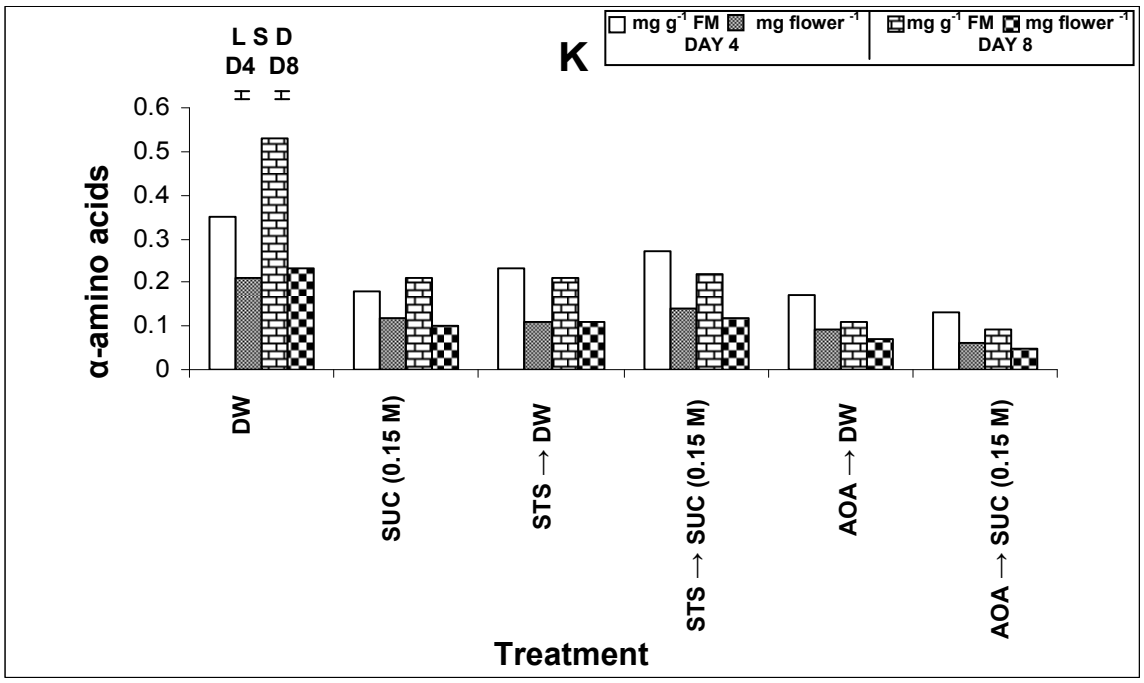

L S D
D4 D8
J
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Soluble proteins
7
6
5
4
3
2
1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.5

Fig. 6.5.6

Histograms showing effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on α- amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{=0.05}$.


K
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
α-amino acids
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

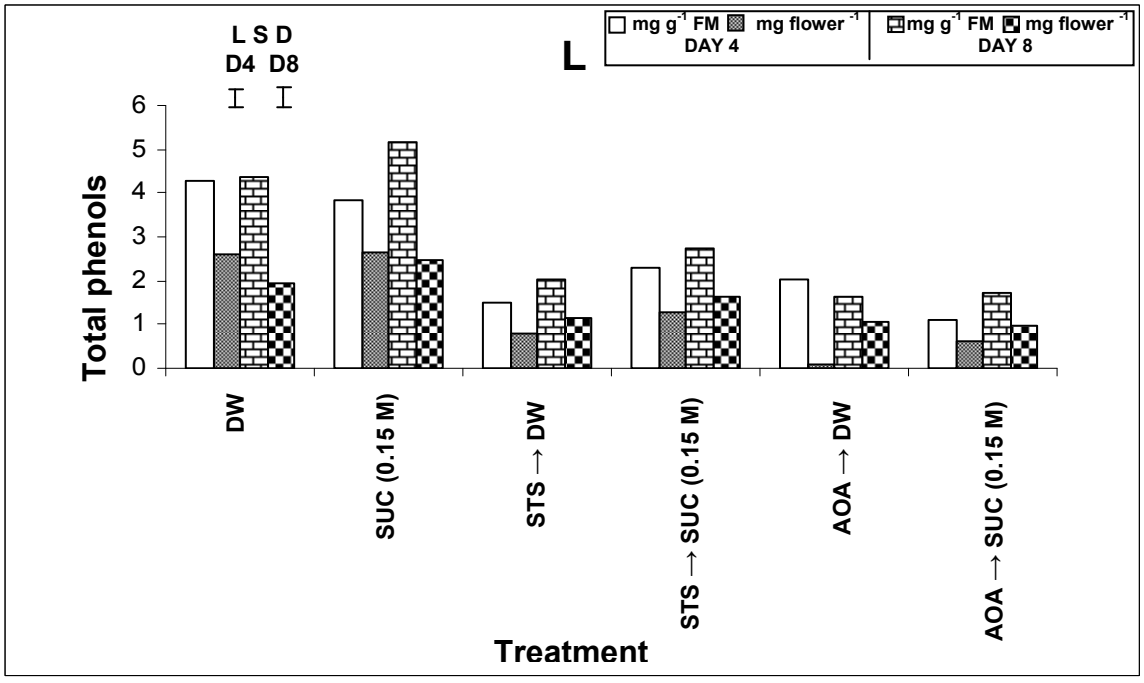

L
mg g-1 FM
mg flower -1
DAY 4
mg g-1 FM
mg flower -1
DAY 8
L S D
D4 D8
Total phenols
6
5
4
3
2
1
0
DW
SUC (0.15 M)
STS → DW
STS → SUC (0.15 M)
AOA → DW
AOA → SUC (0.15 M)
Treatment

Fig. 6.5.6

Plate. 6.5

Effect of pulse treatment with STS (0.5 mM, 1h) and AOA (0.5 mM, 1h) before transfer to DW and SUC (0.15M) on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged scapes held in

DW, SUC (0.15M), STS (0.5 mM, 1h) → DW, STS (0.5 mM, 1h) → SUC (0.15M).

DW, SUC (0.15M), AOA (0.5 mM, 1h) → DW, AOA (0.5 mM, 1h) → SUC (0.15M).

Figs.1 - 2 represents photographs taken on day 4 of transfer.

Fig.3 - 4 represents photographs taken on day 8 of the transfer.

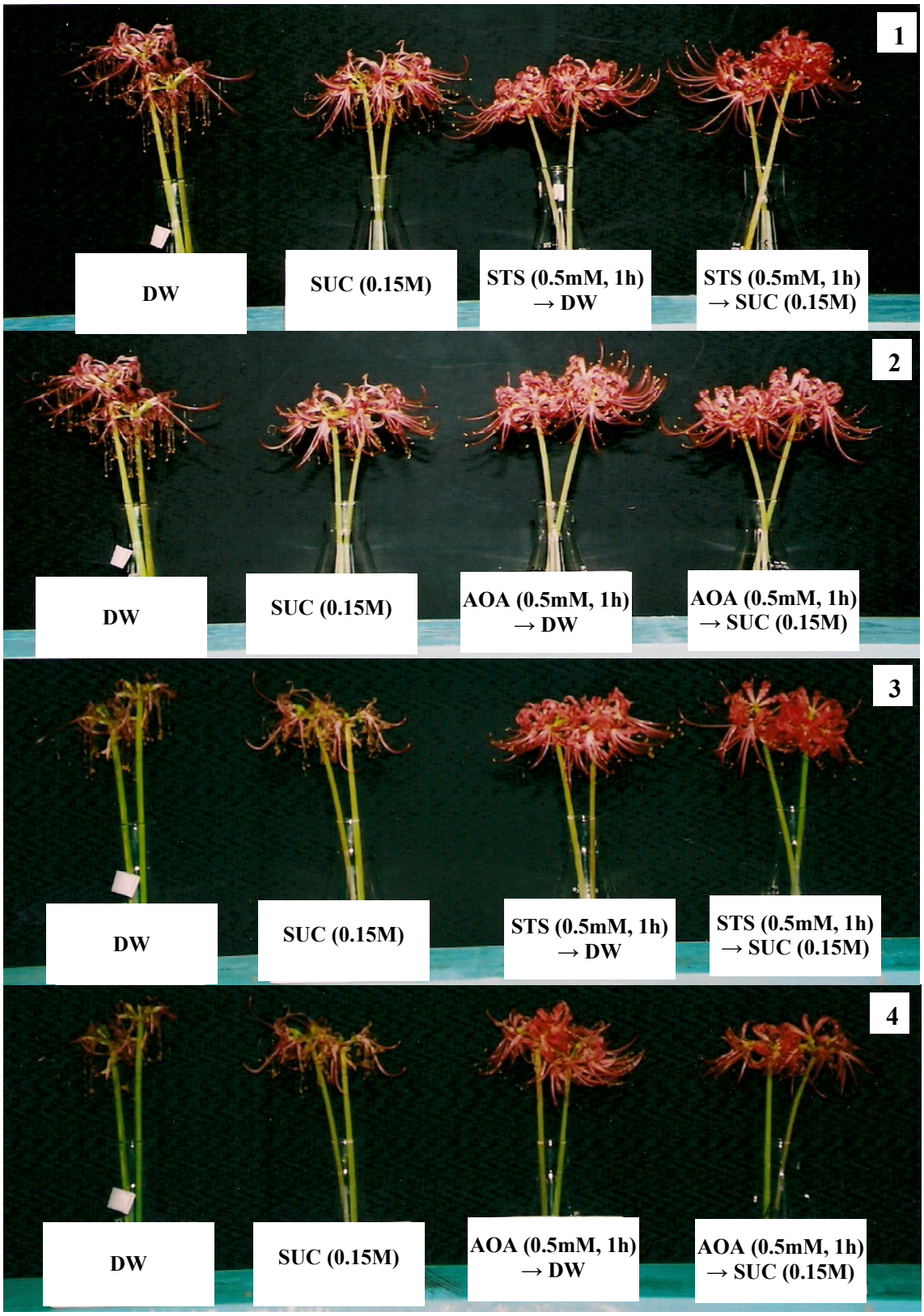

1
DW
SUC (0.15M)
STS (0.5mM, 1h) → DW
STS (0.5mM, 1h) → SUC (0.15M)
2
DW
SUC (0.15M)
AOA (0.5mM, 1h) → DW
AOA (0.5mM, 1h) → SUC (0.15M)
3
DW
SUC (0.15M)
STS (0.5mM, 1h) → DW
STS (0.5mM, 1h) → SUC (0.15M)
4
DW
SUC (0.15M)
AOA (0.5mM, 1h) → DW
AOA (0.5mM, 1h) → SUC (0.15M)

Plate. 6.5

EXPERIMENT 6.6

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}), (50 mg L^{-1}) alone and in combination with sucrose SUC (0.15M) on cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M), KIN (10 mg L^{-1}), KIN (25 mg L^{-1}), KIN (50 mg L^{-1}); KIN (10 mg L^{-1}) + SUC (0.15M), KIN (25 mg L^{-1}) + SUC (0.15M) and KIN (50 mg L^{-1}) + SUC (0.15M). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solutions and was assessed to be terminated when of the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 3 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α-amino acids and total phenols were estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer of scapes to various holding solutions. Kinetin (KIN) in combination with SUC was effective in delaying the senescence as compared to KIN alone. Flower senescence was delayed in the scapes held in (KIN +SUC) particularly at (50 mg L^{-1}) by 4 days as compared to the scapes held in DW which exhibited a vase life of about 4 days (Plate 6.6, Figs. 1-4).

Vase life: The average vase life of scapes held in KIN + SUC was enhanced by an increment of 3 to 4 days, while as the vase life of scapes held separately in KIN or SUC was enhanced by 2 to 1 days, as compared to the corresponding scapes held in DW, which exhibited vase life of about 4 days (Table 6.6.1, Text Fig. 6.6.1, A).

Number of blooms per scape: Number of blooms as also the percentage blooming increased in all the treatments irrespective of the transfer to various holding solutions. Blooming increased with the increasing the grades of KIN. Blooming was more in the scapes held in KIN + SUC as compared to the scapes held in KIN alone. Blooming was extended to day 3 of the transfer of scapes to various grades of KIN (Table 6.6.1; Text Fig. 6.6.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with the progression in time from 2 to 6 days of transfer of scapes irrespective of the transfer of scapes to various holding solution. Higher solution uptake was noticed in scapes held in varying grades of KIN + SUC as compared to the scapes held in KIN alone, but in all the cases the solution uptake was less as compared to the corresponding scapes held in DW or SUC. (Table 6.6.1, Text Fig. 6.6.2,C).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with progression in time from day 4 to day 8 of transfer irrespective of the transfer to various holding solutions. The

concentration of ion leachates was found to be minimum in the samples from the scapes held in varying grades of KIN + SUC as compared to the samples of tepal discs from scapes held in KIN alone as also from DW or SUC. Lower concentrations of ion leachates were observed in the samples from scapes held in KIN + SUC particularly at (50 mg L^{-1}) (Table 6.6.2, Text Fig. 6.6.2, D). The concentration of leachates was maximum in samples from scapes on day 8 of transfer of scapes to DW alone.

Fresh mass and dry mass: Fresh and dry mass of flowers increased with progression in time from day 4 to day 8 of transfer of scapes held in varying grades of KIN +SUC or KIN alone. However, a decrease in fresh and dry mass was noticed in flowers from scapes held in SUC or DW over the period of time. Fresh and dry mass increased with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Higher fresh and dry mass was generally maintained in the samples from scapes held in KIN + SUC as compared to the samples from scapes held in KIN, DW or SUC (Table 6.6.2, Text Fig. 6.6.3 E & F). Highest fresh and dry mass was maintained in the samples from scapes held in KIN (50 mg L^{-1})+ SUC at (0.15M).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of KIN as also in the case of DW or SUC. However, the content of reducing sugar increased in the samples from scapes held in KIN +SUC over the period of time. The reducing sugar content increased with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Higher content of reducing sugars was registered in the samples from scapes held in KIN + SUC as compared to the samples from scapes held in KIN, DW or SUC (Table 6.6.3; Text Fig. 6.6.4, G). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.6.3). On dry mass basis the content of reducing sugars generally increased irrespective of the transfer of scapes to holding solutions, however the reducing sugars decreased in the samples from

scapes held in KIN (Table 6.6.4). The highest content of reducing sugar was observed in samples from scapes held in KIN (50 mg L^{-1}) + SUC (0.15 M).

Non-reducing sugars: The non-reducing sugar content generally registered a decrease with progression in time from day 4 to day 8 of transfer of scapes; however, the content of non-reducing sugar increased in the samples from scapes held in KIN (50 mg L^{-1}) and KIN (25 mg L^{-1}) + SUC (0.15 M) over a period of time. (Table 6.6.3, Text Fig. 6.6.4, H). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.6.3 & 6.6.4).

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of KIN as also in case of DW or SUC. However, the content of total sugars increased in the samples from scapes held in KIN +SUC over a period of time. The total sugar content increased with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Higher content of total sugars was registered in the samples from scapes held in KIN + SUC as compared to the samples from scapes held in KIN alone (Table 6.6.3; Text Fig. 6.6.5, I). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.6.3). On dry mass basis the content of total sugars increased in the samples from scapes held in KIN + SUC as also in DW or SUC, however the total sugars decreased in the samples from scapes held in KIN alone (Table 6.6.4). The highest content of total sugar was observed in samples from scapes held in KIN (50 mg L^{-1}) +SUC (0.15 M).

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of KIN as also in case of DW or SUC. However, the content of soluble proteins increased in the samples from scapes held in KIN +SUC over a period of time particularly at (25 and 50 mg L^{-1}). The soluble protein content increased

with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Higher content of soluble proteins was registered in the samples from scapes held in KIN + SUC as compared to the samples from scapes held in KIN, DW or SUC (Table 6.6.5; Text Fig. 6.6.5, J). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 6.6.5 & 6.6.6). The highest content of soluble proteins was observed in samples from scapes held in KIN (50 mg L^{-1}) + SUC (0.15 M).

α- amino acids: The α- amino acid content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of KIN as also in DW or SUC. However, the content of α- amino acids decreased in the samples from scapes held in KIN +SUC over the period of time particularly at (25 and 50 mg L^{-1}). The α- amino acid content decreased with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Lower content of α- amino acid was registered in the samples from scapes held in KIN + SUC as compared to the samples from scapes held in KIN, DW or SUC (Table 6.6.5; Text Fig. 6.6.6, K). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.6.5 & 6.6.6). The lowest content of α-amino acid was observed in samples from scapes held in KIN (50 mg L^{-1}) + SUC (0.15 M).

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The phenolic content decreased with increasing grades of KIN as also of KIN + SUC particularly at (50 mg L^{-1}). Higher content of phenols was registered in the samples from scapes held in KIN + SUC as compared to the samples from KIN only (Table 6.6.5; Text Fig. 6.6.6 L). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.6.5 & 6.6.6). The lowest content of total phenols was observed in samples from scapes held in KIN (50 mg L^{-1}) + SUC (0.15 M).

Table 6.6.1: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Treatment	Vase life (days)	No. of blooms per scape			Volume of holding solution absorbed per scape (ml)		
		Days after treatment					
		1	2	3	2	4	6
DW	4	5.16 (96)	5.66 (100)		2.60	6.60	8.00
SUC (0.15M)	5	5.60 (100)	-		2.10	4.00	6.83
KIN (10 mg L^{-1})	5	4.08 (72)	5.55 (98)	5.66 (100)	1.21	2.60	3.00
KIN (25 mg L^{-1})	6	4.53 (80)	5.44 (96)	5.66 (100)	1.50	3.00	3.50
KIN (50 mg L^{-1})	6	5.44 (96)	5.66 (100)		2.00	2.50	3.22
KIN (10 mg L^{-1}) + SUC (0.15M)	7	5.32 (94)	5.66 (100)		2.23	2.75	3.75
KIN (25 mg L^{-1}) + SUC (0.15M)	7	5.44 (96)	5.66 (100)		3.00	3.25	4.00
KIN (50 mg L^{-1}) + SUC (0.15M)	8	5.53 (98)	5.66 (100)		3.50	4.00	4.50
LSD at $P_{=0.05}$	0.58	0.30	0.36	-	0.24	0.12	0.22

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21± 2^0C).

Figures in parentheses represent percent blooms.

Table 6.6.2: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on conductivity of leachates, fresh mass and dry mass in of flowers on day 4 and 8 of transfer of cut scape to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
DW	11.73	32.00	0.607	0.441	0.043	0.022
SUC (0.15M)	7.90	12.96	0.651	0.481	0.048	0.026
KIN (10 mg L $^{-1}$)	14.36	15.66	0.515	0.500	0.030	0.029
KIN (25 mg L $^{-1}$)	13.33	20.92	0.531	0.541	0.032	0.039
KIN (50 mg L $^{-1}$)	11.73	13.93	0.552	0.591	0.038	0.062
KIN (10 mg L $^{-1}$) + SUC (0.15M)	9.93	12.33	0.588	0.613	0.053	0.060
KIN (25 mg L $^{-1}$) + SUC (0.15M)	9.79	10.08	0.621	0.650	0.062	0.069
KIN (50 mg L $^{-1}$) + SUC (0.15M)	9.00	8.80	0.626	0.671	0.066	0.072
LSD at $P_{=0.05}$	1.22	1.67	0.23	0.56	0.002	0.005

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Table 6.6.3: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	15.84 (9.61)	13.76 (6.06)	4.72 (2.86)	2.40 (1.05)	20.53 (12.46)	16.16 (7.12)
SUC (0.15M)	20.76 (13.51)	18.40 (8.85)	4.16 (2.70)	2.48 (1.19)	27.92 (18.17)	20.88 (10.04)
KIN (10 mg L^{-1})	8.88 (4.57)	8.17 (4.08)	3.37 (1.73)	1.77 (0.88)	12.26 (6.31)	9.95 (4.97)
KIN (25 mg L^{-1})	11.19 (5.94)	9.77 (5.28)	2.48 (1.32)	1.59 (0.86)	13.68 (7.26)	11.37 (6.15)
KIN (50 mg L^{-1})	15.46 (8.53)	11.02 (6.51)	1.95 (1.07)	3.19 (1.89)	17.42 (9.61)	14.22 (8.40)
KIN (10 mg L^{-1}) + SUC (0.15M)	12.08 (7.10)	15.82 (9.69)	2.66 (1.56)	1.42 (0.87)	14.75 (8.67)	17.24 (10.57)
KIN (25 mg L^{-1}) + SUC (0.15M)	16.88 (10.48)	17.95 (11.67)	1.06 (0.66)	1.59 (1.03)	17.95 (11.14)	19.55 (12.71)
KIN (50 mg L^{-1}) + SUC (0.15M)	17.24 (10.79)	19.02 (12.76)	2.13 (1.33)	1.95 (1.31)	19.37 (12.12)	20.97 (14.07)
LSD at $P_{=0.05}$	1.02	1.62	0.52	0.37	0.86	0.71

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.6.4: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	223.60	275.82	66.62	48.10	289.80	323.93
SUC (0.15M)	281.55	340.40	56.42	45.88	378.66	386.28
KIN (10 mg L^{-1})	152.58	140.98	57.98	30.64	210.56	171.63
KIN (25 mg L^{-1})	185.83	135.62	41.29	22.19	227.13	157.82
KIN (50 mg L^{-1})	224.65	105.06	28.40	30.50	253.06	135.56
KIN (10 mg L^{-1}) + SUC (0.15M)	134.10	161.64	29.58	14.52	163.69	176.16
KIN (25 mg L^{-1}) + SUC (0.15M)	169.15	169.13	10.68	15.07	179.83	184.20
KIN (50 mg L^{-1}) + SUC (0.15M)	163.55	177.26	20.23	18.22	183.78	195.48
LSD at $P_{=0.05}$	11.66	18.83	9.89	11.21	13.87	15.10

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21±2^{o}C).

Table 6.6.5: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	4.25 (2.57)	3.33 (1.46)	0.35 (0.21)	0.53 (0.23)	4.30 (2.61)	4.36 (1.92)
SUC (0.15M)	5.50 (3.58)	3.83 (1.84)	0.28 (0.18)	0.41 (0.19)	3.84 (2.49)	5.18 (2.49)
KIN (10 mg L^{-1})	3.08 (1.58)	2.16 (1.08)	0.37 (0.19)	0.43 (0.21)	2.35 (1.21)	3.15 (1.57)
KIN (25 mg L^{-1})	3.75 (1.99)	2.91 (1.57)	0.37 (0.20)	0.40 (0.21)	1.86 (0.99)	2.35 (1.27)
KIN (50 mg L^{-1})	4.33 (2.39)	3.41 (2.01)	0.33 (0.18)	0.38 (0.22)	1.55 (0.85)	2.17 (1.28)
KIN (10 mg L^{-1}) + SUC (0.15M)	5.50 (3.23)	4.66 (2.86)	0.30 (0.18)	0.34 (0.20)	3.02 (1.77)	3.55 (2.17)
KIN (25 mg L^{-1}) + SUC (0.15M)	6.41 (3.98)	6.66 (4.33)	0.29 (0.18)	0.24 (0.15)	2.75 (1.71)	3.37 (2.19)
KIN (50 mg L^{-1}) + SUC (0.15M)	7.41 (4.64)	8.16 (5.47)	0.26 (0.16)	0.21 (0.14)	2.62 (1.64)	2.97 (1.99)
LSD at $P_{=0.05.004}$	0.25	0.32	0.003	0.004	0.21	0.28

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.6.6: Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (KIN + SUC) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	59.99	66.75	4.94	10.62	60.70	87.39
SUC (0.15M)	74.59	70.85	3.79	7.58	52.08	95.83
KIN (10 mg L^{-1})	52.93	37.35	6.44	7.41	40.42	54.39
KIN (25 mg L^{-1})	62.22	40.45	6.27	5.60	30.96	32.66
KIN (50 mg L^{-1})	62.94	32.56	4.86	3.68	22.59	20.75
KIN (10 mg L^{-1}) + SUC (0.15M)	61.01	47.67	3.42	3.48	33.52	36.31
KIN (25 mg L^{-1}) + SUC (0.15M)	64.27	62.80	2.92	2.31	27.59	31.81
KIN (50 mg L^{-1}) + SUC (0.15M)	70.34	76.10	2.51	2.04	24.86	27.74
LSD at $P_{=0.05}$	2.31	6.79	0.43	0.29	2.01	2.75

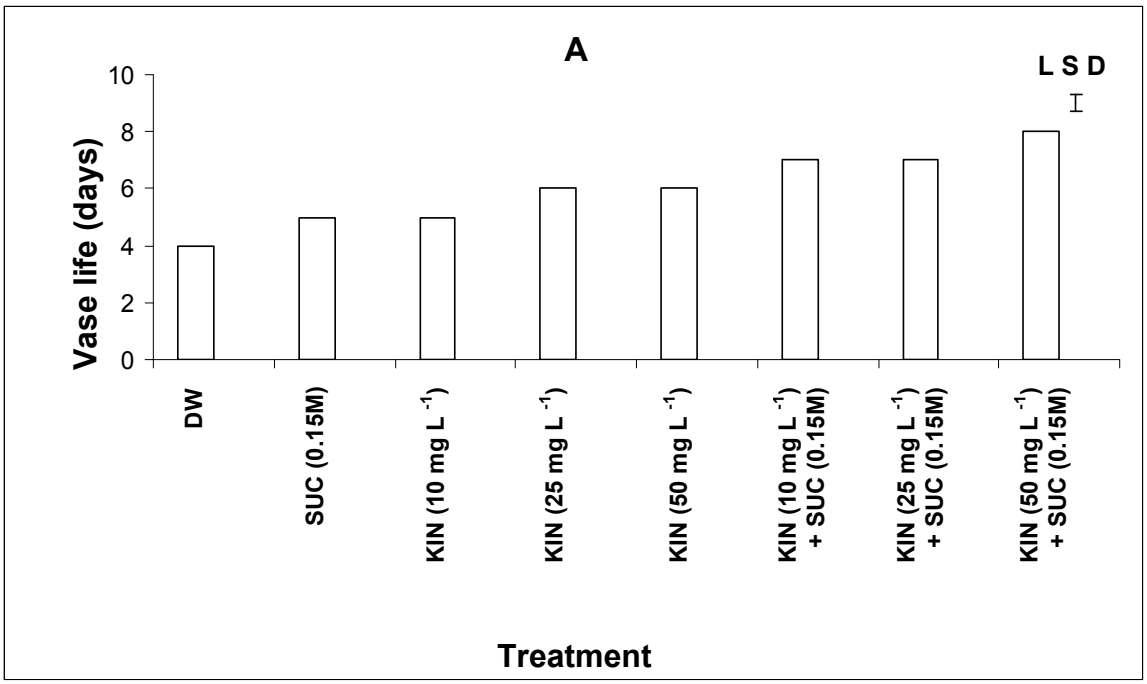
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Fig. 6.6.1

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on vase life (A) and number of blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


A
L S D
Vase life (days)
10
8
6
4
2
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

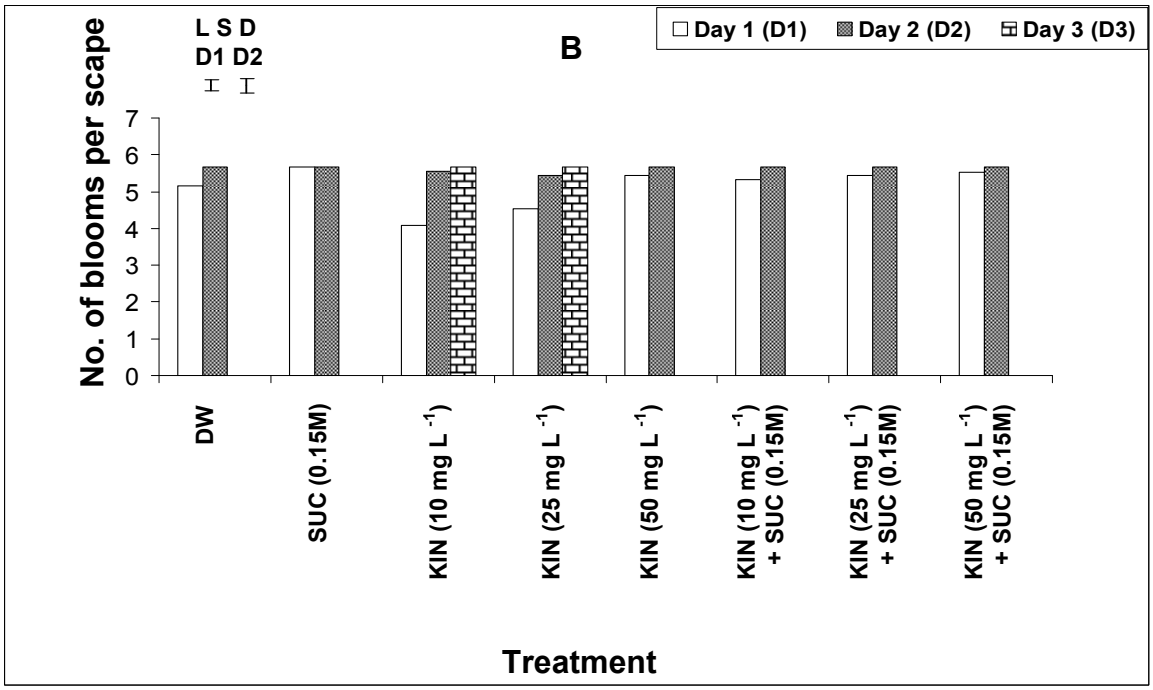
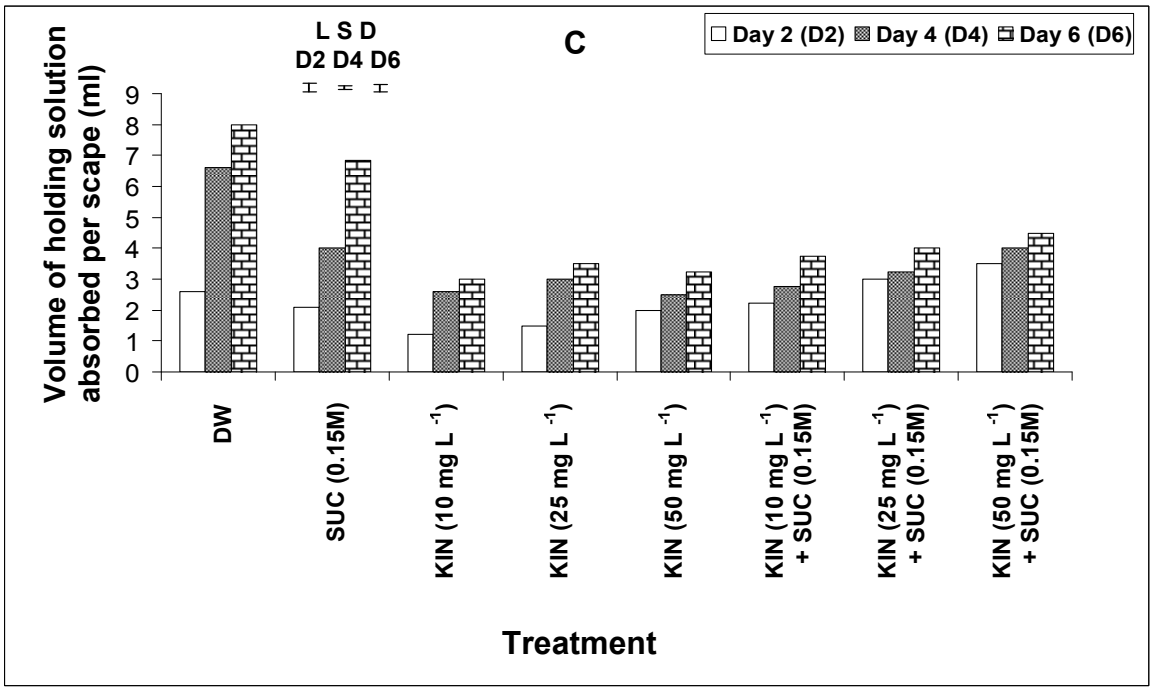

B
L S D
D1 D2
Day 1 (D1)
Day 2 (D2)
Day 3 (D3)
No. of blooms per scape
7
6
5
4
3
2
1
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.1

Fig. 6.6.2

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
6
7
8
9
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

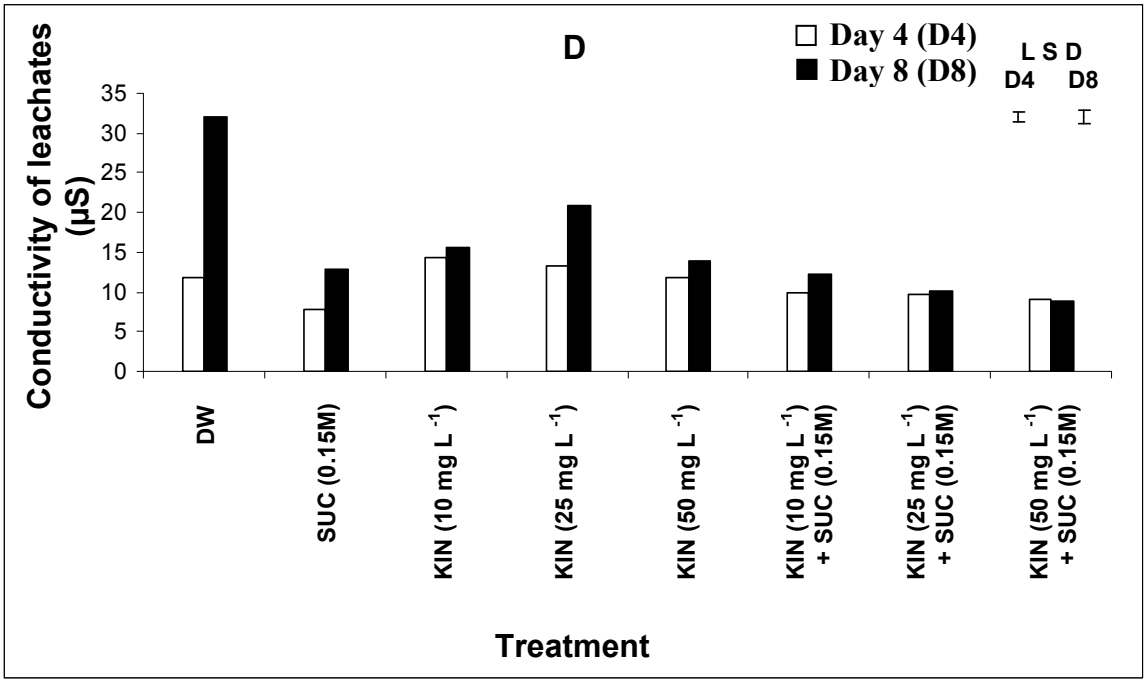
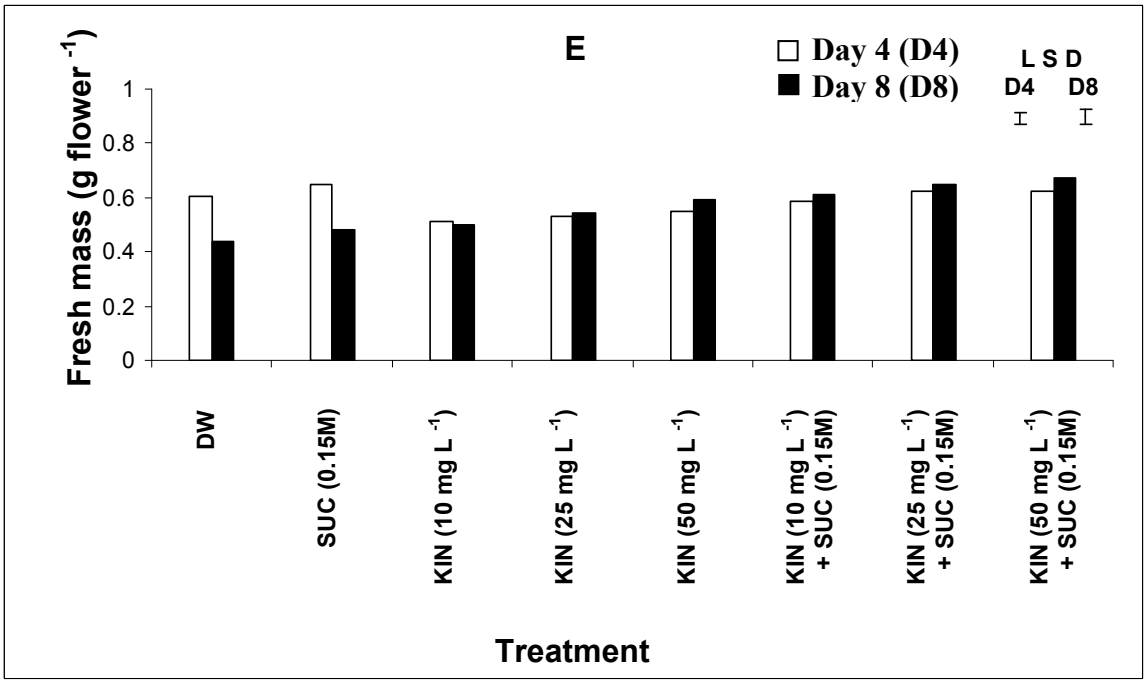

D
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.2

Fig. 6.6.3

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Fresh mass (g flower -1)
1
0.8
0.6
0.4
0.2
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

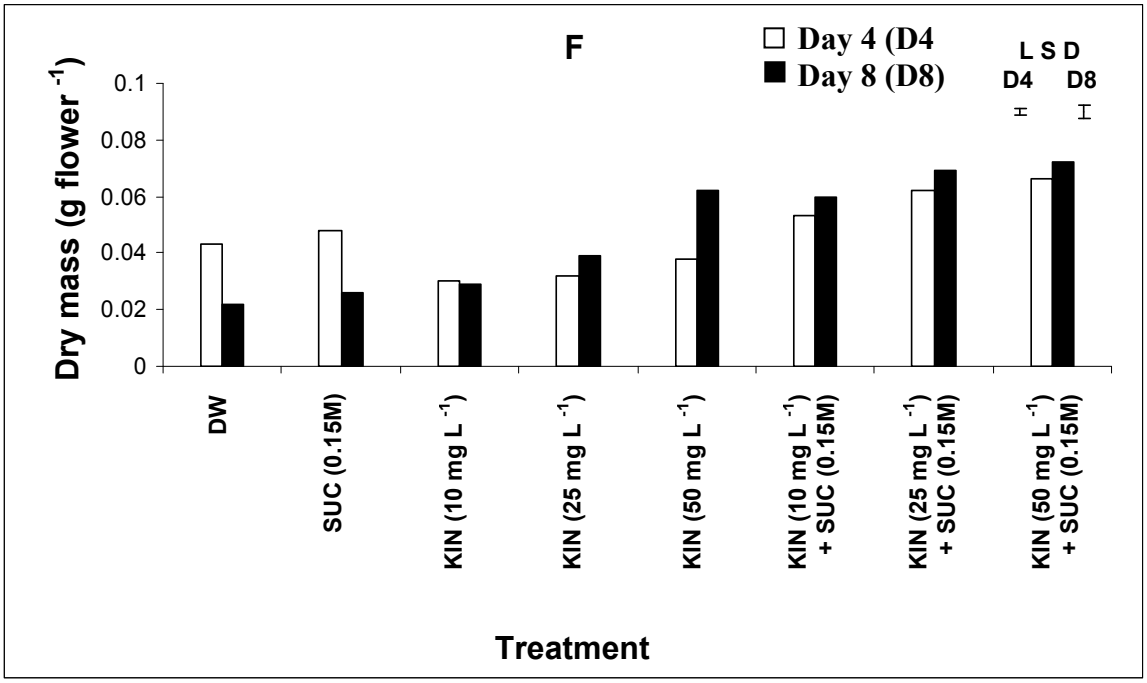
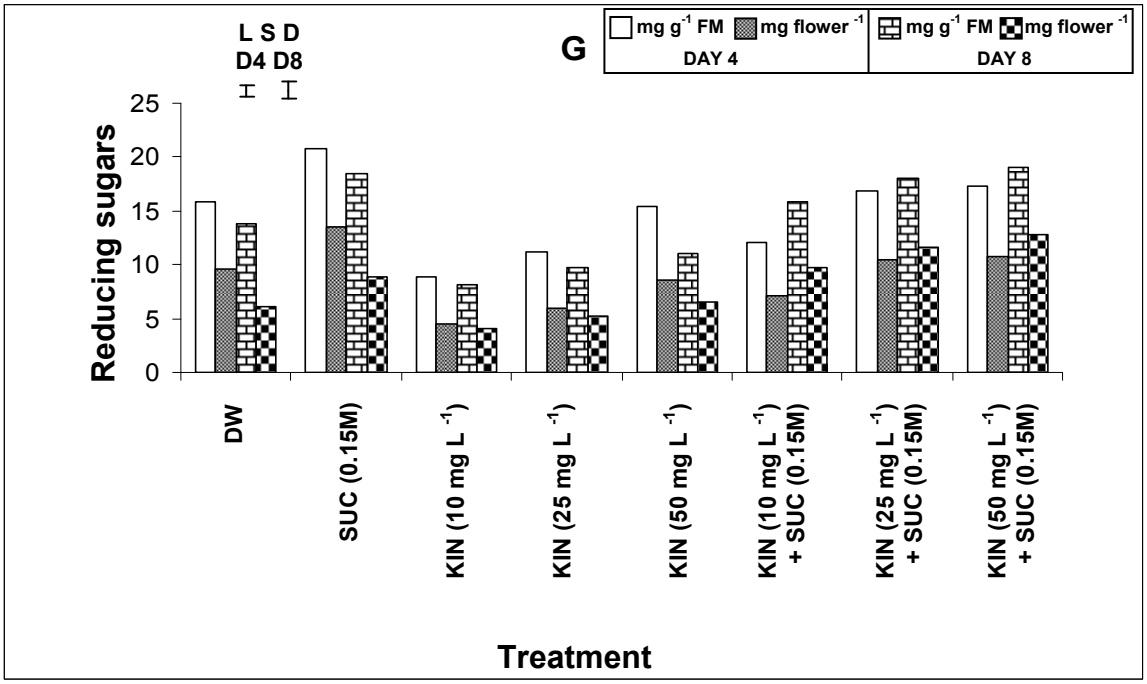

F
Day 4 (D4
Day 8 (D8)
L S D
D4
D8
Dry mass (g flower -1)
0.1
0.08
0.06
0.04
0.02
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.3

Fig. 6.6.4

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on reducing sugars (G) and non reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


G
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Reducing sugars
25
20
15
10
5
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

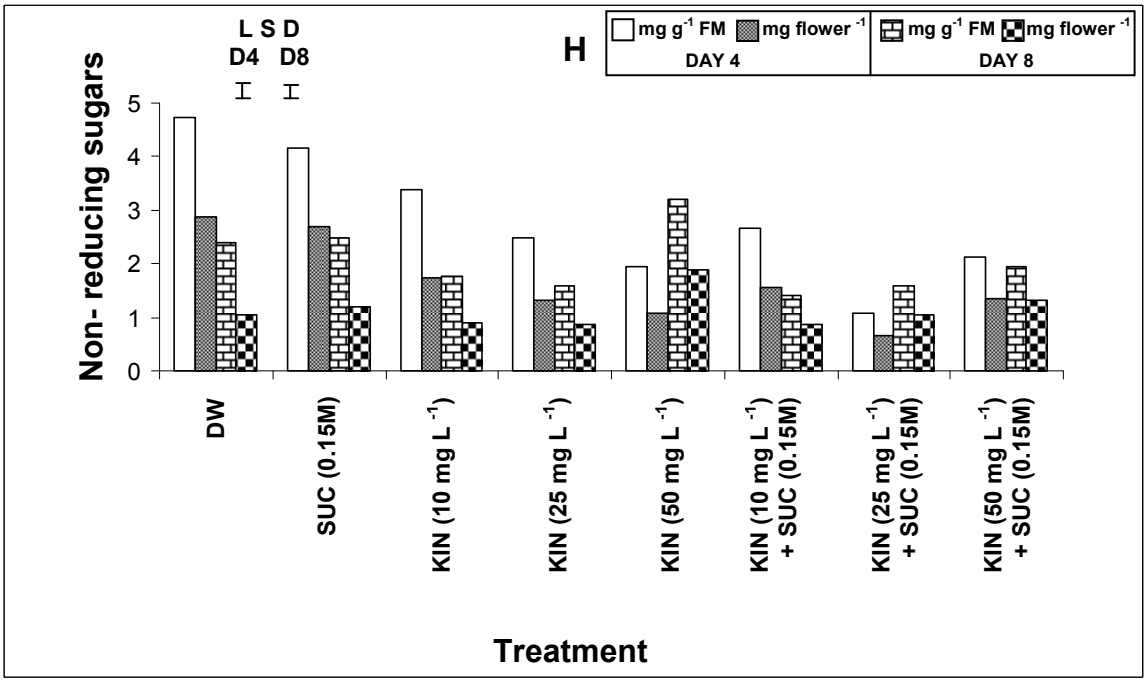
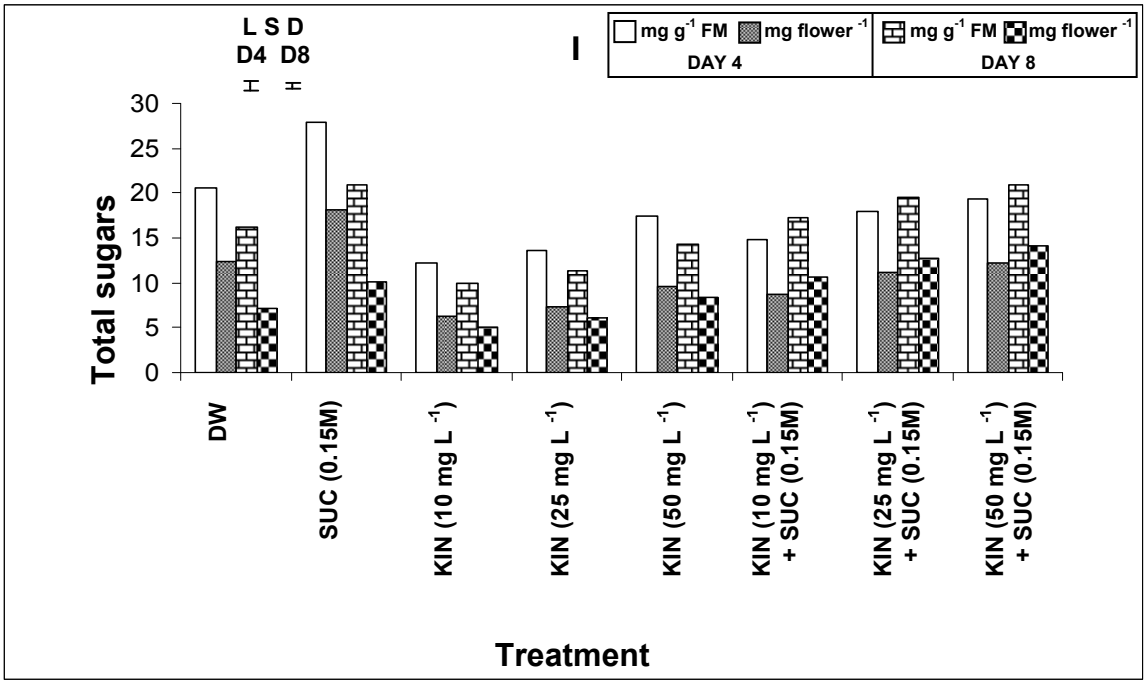

H
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Non- reducing sugars
5
4
3
2
1
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.4

Fig. 6.6.5

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


I
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total sugars
30
25
20
15
10
5
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

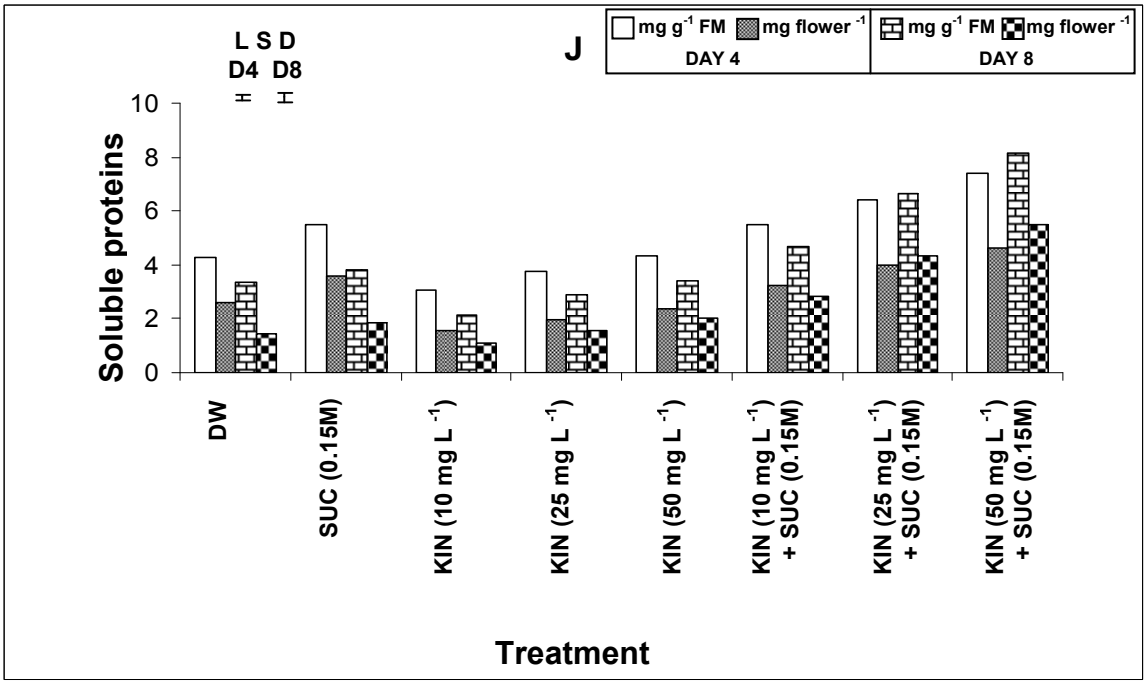
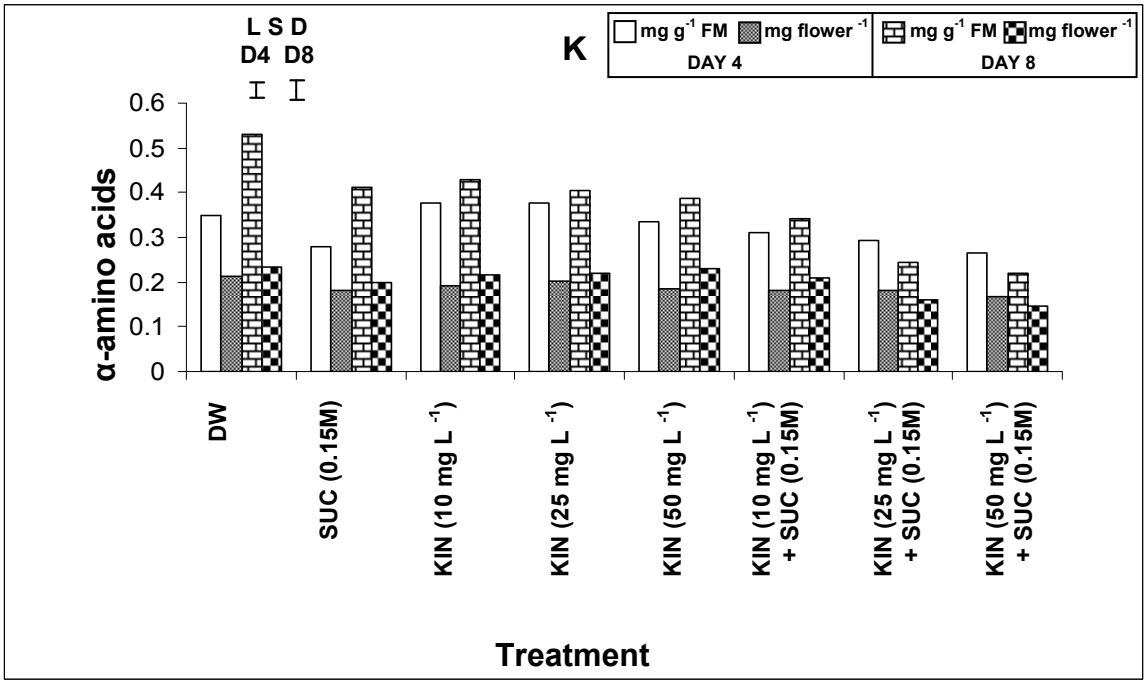

J
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Soluble proteins
10
8
6
4
2
0
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.5

Fig. 6.6.6

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on α- amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


L S D
D4 D8
K
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
α-amino acids
0
0.1
0.2
0.3
0.4
0.5
0.6
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

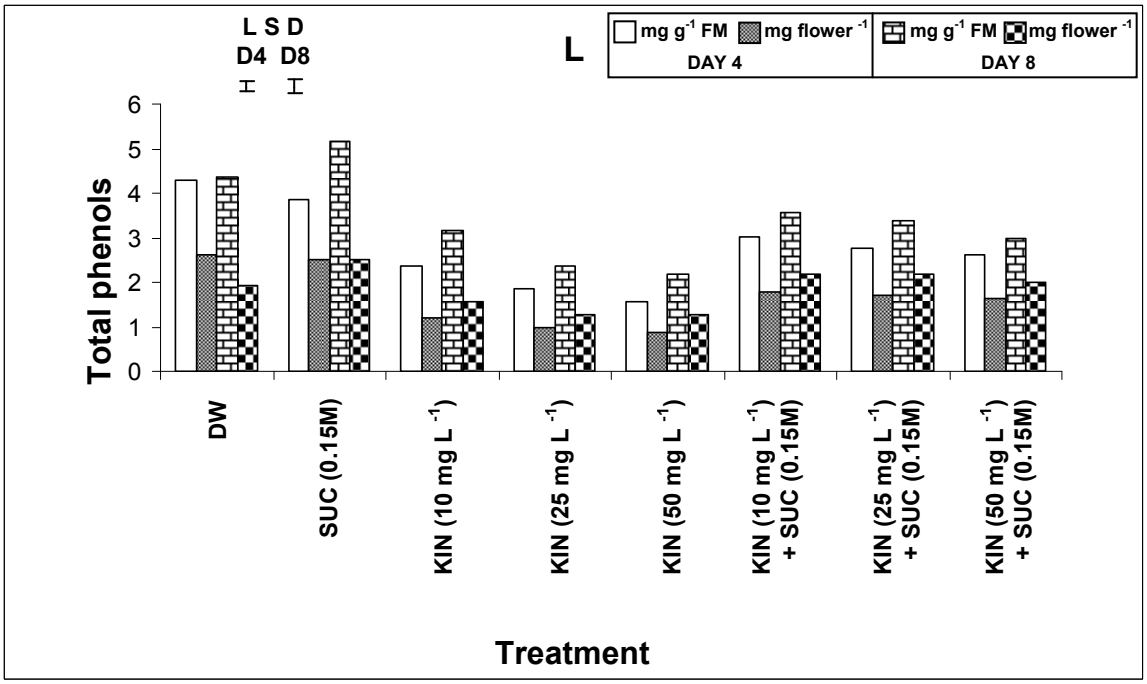

L S D
D4 D8
L
mg g-1 FM
mg flower -1
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total phenols
0
1
2
3
4
5
6
DW
SUC (0.15M)
KIN (10 mg L -1)
KIN (25 mg L -1)
KIN (50 mg L -1)
KIN (10 mg L -1) + SUC (0.15M)
KIN (25 mg L -1) + SUC (0.15M)
KIN (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.6.6

Plate. 6.6

Effect of kinetin (KIN) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (KIN + SUC) on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged flasks containing scapes held in

Fig. 1: DW, SUC, KIN (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) on day 4 of the transfer.

Fig. 2: DW, SUC, KIN (10 mg L^{-1}) + SUC (0.15M), KIN (25 mg L^{-1}) + SUC (0.15M) and KIN (50 mg L^{-1}) + SUC (0.15M) on day 4 of the transfer.

Fig.1-2: represent photographs taken on day 4 after the transfer of scapes to holding solutions.

Fig. 3-4: represent photographs taken on day 8 after the transfer of scapes to holding solutions.

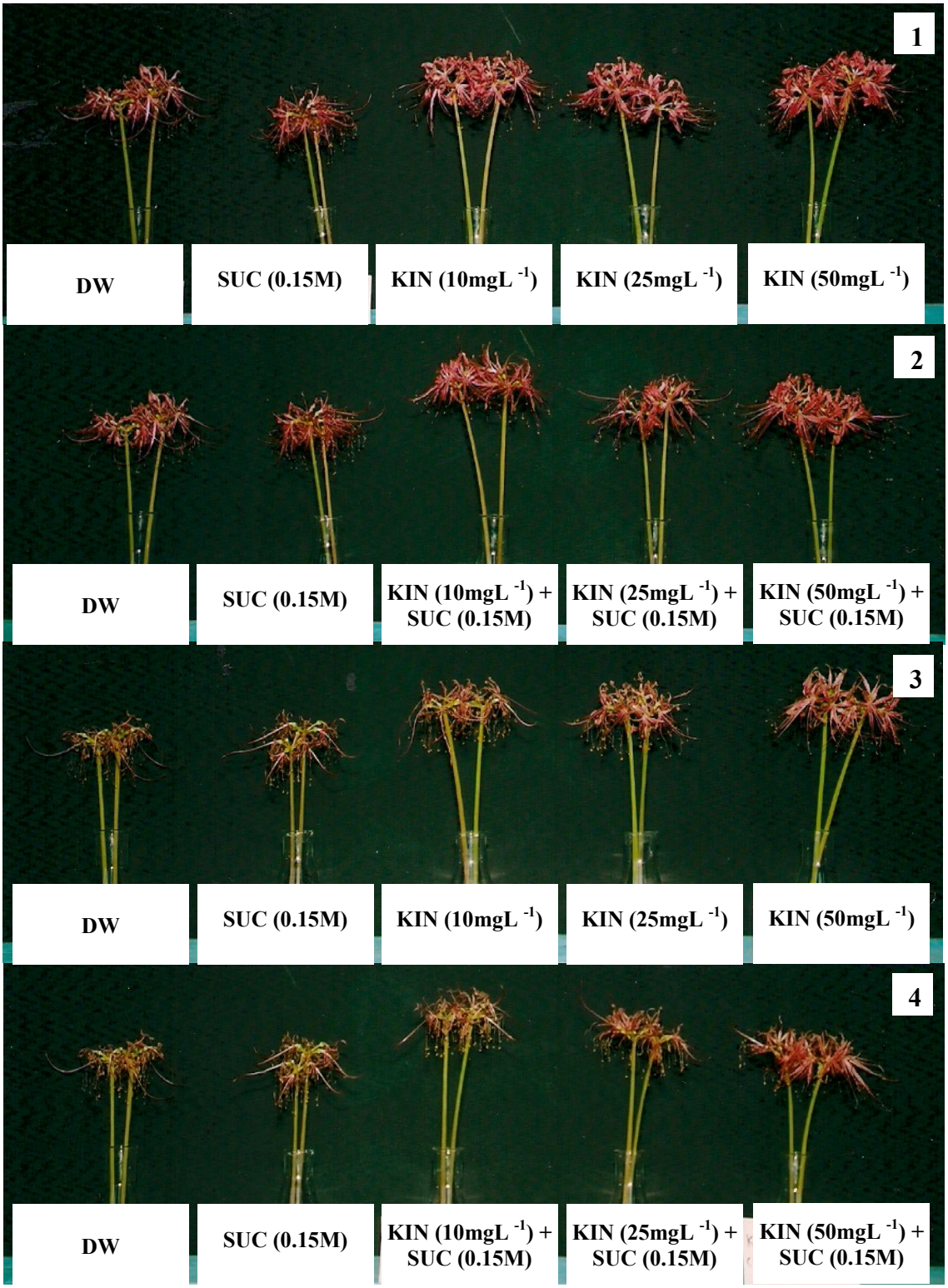

1
DW
SUC (0.15M)
KIN (10mgL -1)
KIN (25mgL -1)
KIN (50mgL -1)
2
DW
SUC (0.15M)
KIN (10mgL -1) + SUC (0.15M)
KIN (25mgL -1) + SUC (0.15M)
KIN (50mgL -1) + SUC (0.15M)
3
DW
SUC (0.15M)
KIN (10mgL -1)
KIN (25mgL -1)
KIN (50mgL -1)
4
DW
SUC (0.15M)
KIN (10mgL -1) + SUC (0.15M)
KIN (25mgL -1) + SUC (0.15M)
KIN (50mgL -1) + SUC (0.15M)

Plate. 6.6

EXPERIMENT 6.7

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}), (50 mg L^{-1}) alone and in combinations with sucrose, SUC (0.15M) on cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M), BAP (10 mg L^{-1}), BAP (25 mg L^{-1}), BAP (50 mg L^{-1}); BAP (10 mg L^{-1}) + SUC (0.15M), BAP (25 mg L^{-1}) + SUC (0.15M) and BAP (50 mg L^{-1}) + SUC (0.15M) . For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The samples were kept under cool white fluorescent light with a mix of diffused natural light (10 Wm^{-2}) 12 h a day and relative humidity (RH) of 60±10%. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solution and was assessed to be terminated when of the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 2 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates, from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α-amino acids and

total phenols were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer to holding solutions. BAP in combination with SUC, (BAP + SUC) was effective in delaying the senescence as compared to BAP alone. Flower senescence was delayed in the scapes held in (BAP +SUC) particularly at (50 mg L^{-1}) by 3 days as compared to the scapes held in DW which exhibited a vase life of about 4 days (Plate 6.7, Figs. 1-4).

Vase life: The average vase life of scapes held in BAP and BAP + SUC at (50 mg L^{-1}) was enhanced by an increment of 2 and 3 days respectively, whereas the vase life of scapes held in SUC and other grades of BAP (10 and 25 mg L^{-1}) as also in combinations of BAP +SUC (10 and 25 mg L^{-1}) was enhanced by about 1 day as compared to the corresponding scapes held in DW which exhibited a vase life of about 4 days (Table 6.7.1, Text Fig. 6.7.1, A).

Number of blooms per scape: Number of blooms increased in all treatments irrespective of the transfer to various holding solutions More or less same number of blooms were observed in all the treatments. Complete blooming was generally marked by day 2 of transfer of scapes to various holding solutions (Table 6.7.1; Text Fig. 6.7.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of transfer of scapes irrespective of the transfer to vaious holding solutions. Higher solution uptake was marked in scapes held in varying grades of BAP + SUC as compared to the scapes held in BAP, DW or SUC. (Table 6.7.1, Text Fig. 6.7.2, C). Maximum solution uptake was noticed in the scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs increased with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The concentration of ion leachates was found to be least in the samples from scapes held in varying grades of BAP + SUC as compared to the samples of tepal discs from scapes held in BAP, DW or SUC. A lower concentration of ion leachates was observed in the samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M) (Table 6.7.2, Text Fig. 6.7.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers increased with progression in time from day 4 to day 8 of transfer of scapes held in varying grades of BAP +SUC or BAP alone. However, a decrease in fresh and dry mass was noticed in flowers from scapes held in SUC or DW over a period of time. Fresh and dry mass increased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Higher fresh and dry mass was noticed in the samples from scapes held in BAP + SUC as compared to the samples from scapes held in BAP, DW or SUC (Table 6.7.2, Text Fig. 6.7.3 E & F). Highest fresh and dry mass was maintained it the samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Reducing sugars: The reducing sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions; however, the content of reducing sugar was maintained increased in the samples from scapes held in BAP + SUC over a period of time. The reducing sugar content increased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Higher content of reducing sugars was registered in the samples from scapes held in BAP + SUC as compared to the samples from scapes held in BAP, DW or SUC (Table 6.7.3; Text Fig. 6.7.4, G). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.7.3). On dry mass basis the content of reducing sugars decreased irrespective of the

transfer to various holding solutions however the reducing sugars increased in the samples from scapes held in DW or SUC (Table 6.7.4). The highest content of reducing sugar was observed in samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Non-reducing sugars: The non-reducing sugar content registered a decrease with progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions, however the content of non-reducing sugar was maintained in the samples from scapes held in BAP (50 mg L^{-1}) as also in BAP + SUC over a period of time. The non- reducing sugar content decreased with increasing grades of BAP as also of BAP + SUC (Table 6.7.3, Text Fig. 6.7.4, H). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.7.3 & 6.7.4).

Total sugars: The total sugar content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of BAP as also in case of DW or SUC. However, the content of total sugars was maintained in the samples from scapes held in BAP +SUC over a period of time. The total sugar content increased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Higher content of total sugars was registered in the samples from scapes held in BAP + SUC as compared to the samples from scapes held in BAP, DW or SUC (Table 6.7.3; Text Fig. 6.7.5, I). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.7.3). On dry mass basis the content of total sugars increased in the samples from BAP + SUC as also in DW or SUC, however the total sugars decreased in the samples from scapes held in BAP alone (Table 6.7.4). The highest content of total sugars was observed in samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Soluble proteins: The soluble protein content registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of BAP as also in case of DW or SUC, however the content of soluble

proteins was generally maintained in the samples from scapes held in BAP +SUC over a period of time. The soluble protein content increased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Higher content of soluble proteins was registered in the samples from scapes held in BAP + SUC as compared to the samples from scapes held in BAP, DW or SUC (Table 6.7.5; Text Fig. 6.7.5, J). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 6.7.5 & 6.7.6). The highest content of soluble proteins was observed in samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

α- amino acids: The α- amino acid content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes held in varying grades of BAP as also in case of DW or SUC, however the content of α-amino acid was maintained in the samples from scapes held in BAP +SUC over a period of time. The α- amino acid content decreased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Lower content of α- amino acid was registered in the samples from scapes held in BAP + SUC as compared to the samples from scapes held in BAP, DW or SUC (Table 6.7.5; Text Fig. 6.7.6, K). Almost similar trends were obtained when the data was expressed on per flower basis and on dry mass bases (Tables 6.7.5 & 6.7.6). The lowest content of α- amino acid was observed in samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes irrespective of the transfer to various holding solutions. The phenolic content decreased with increasing grades of BAP as also of BAP + SUC particularly at (50 mg L^{-1}). Higher content of phenols was registered in the samples from scapes held in BAP + SUC as compared to the samples from BAP only (Table 6.7.5; Text Fig. 6.7.6, L). Almost similar trends were obtained when

the data was expressed on per flower basis and on dry mass bases (Tables 6.7.5 & 6.7.6). The lowest content of total phenols was observed in samples from scapes held in BAP (50 mg L^{-1}) + SUC (0.15 M).

Table 6.7.1: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Treatment	Vase life (days)	No of blooms per scape		Volume of holding solution absorbed per scape (ml)		
		Days after treatment				
		1	2	2	4	6
DW	4	5.16 (96)	5.66 (100)	2.60	6.60	8.00
SUC (0.15M)	5	5.66 (100)	-	2.10	4.00	6.83
BAP (10 mg L^{-1})	5	5.55 (98)	5.66 (100)	1.50	2.00	3.30
BAP (25 mg L^{-1})	5	5.44 (96)	5.66 (100)	2.00	2.50	3.50
BAP (50 mg L^{-1})	6	5.44 (96)	5.66 (100)	2.00	3.00	3.50
BAP (10 mg L^{-1}) + SUC (0.15M)	5	5.32 (94)	5.66 (100)	3.00	4.00	4.50
BAP (25 mg L^{-1}) + SUC (0.15M)	5	5.44 (96)	5.66 (100)	3.00	3.66	4.25
BAP (50 mg L^{-1}) + SUC (0.15M)	7	5.53 (98)	5.66 (100)	3.50	4.50	5.00
LSD at $P_{=0.05}$	0.34	0.23	-	0.19	0.31	0.37

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 6.7.2: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer of cut scape to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
DW	11.73	32.00	0.607	0.441	0.603	0.442
SUC (0.15M)	7.90	12.96	0.651	0.481	0.658	0.486
BAP (10 mg L $^{-1}$)	17.88	21.22	0.500	0.488	0.509	0.487
BAP (25 mg L $^{-1}$)	14.36	15.88	0.522	0.540	0.522	0.540
BAP (50 mg L $^{-1}$)	13.28	12.51	0.545	0.564	0.542	0.569
BAP (10 mg L $^{-1}$) + SUC (0.15M)	11.25	12.71	0.598	0.610	0.599	0.610
BAP (25 mg L $^{-1}$) + SUC (0.15M)	10.98	10.02	0.611	0.628	0.612	0.629
BAP (50 mg L $^{-1}$) + SUC (0.15M)	9.98	8.99	0.621	0.635	0.626	0.632
LSD at $P_{=0.05}$	1.36	0.99	0.044	0.051	0.040	0.030

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^{o}C).

Table 6.7.3: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	15.84 (9.61)	13.76 (6.06)	4.69 (2.84)	2.40 (1.05)	20.53 (12.46)	16.16 (7.12)
SUC (0.15M)	23.76 (15.46)	18.40 (8.85)	4.16 (2.70)	2.48 (1.19)	27.92 (18.17)	20.88 (10.04)
BAP (10 mg L^{-1})	18.23 (9.11)	12.32 (6.01)	6.42 (3.21)	5.29 (2.58)	24.65 (12.32)	17.61 (8.59)
BAP (25 mg L^{-1})	21.22 (11.07)	17.85 (9.63)	4.14 (2.16)	2.45 (1.32)	25.36 (13.23)	20.30 (10.96)
BAP (50 mg L^{-1})	23.65 (12.88)	20.13 (11.35)	3.01 (1.64)	4.16 (2.34)	26.66 (14.52)	24.29 (13.69)
BAP (10 mg L^{-1}) + SUC (0.15M)	28.32 (16.93)	27.36 (16.68)	5.33 (3.18)	6.86 (4.18)	33.65 (20.12)	34.22 (20.87)
BAP (25 mg L^{-1}) + SUC (0.15M)	31.20 (19.06)	33.65 (21.13)	4.41 (2.69)	5.00 (3.14)	35.61 (21.75)	38.65 (24.27)
BAP (50 mg L^{-1}) + SUC (0.15M)	35.62 (22.12)	37.44 (23.77)	3.37 (2.09)	3.79 (2.40)	38.99 (24.21)	41.23 (26.18)
LSD at $P_{=0.05}$	1.32	1.22	0.46	0.52	1.01	1.33

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.7.4: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	223.60	275.82	66.20	48.10	289.80	323.93
SUC (0.15M)	322.24	340.40	56.42	45.88	378.66	386.28
BAP (10 mg L^{-1})	314.31	222.67	110.68	95.61	425.00	318.28
BAP (25 mg L^{-1})	346.15	240.97	67.53	33.07	413.68	274.05
BAP (50 mg L^{-1})	306.88	231.70	39.05	47.88	345.94	279.58
BAP (10 mg L^{-1}) + SUC (0.15M)	287.04	278.16	54.02	69.74	341.06	347.90
BAP (25 mg L^{-1}) + SUC (0.15M)	307.47	306.26	43.45	45.50	350.93	351.77
BAP (50 mg L^{-1}) + SUC (0.15M)	335.15	330.20	31.70	33.42	366.86	363.62
LSD at $P_{=0.05}$	1.93	1.50	2.31	1.21	1.65	1.44

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Table 6.7.5: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	4.25 (2.57)	3.33 (1.46)	0.35 (0.21)	0.53 (0.23)	4.40 (2.67)	4.99 (2.20)
SUC (0.15M)	5.50 (3.58)	3.83 (1.84)	0.28 (0.18)	0.41 (0.19)	5.67 (3.69)	4.12 (1.98)
BAP (10 mg L^{-1})	4.02 (2.01)	3.65 (1.78)	0.38 (0.19)	0.44 (0.21)	3.12 (1.56)	4.00 (1.95)
BAP (25 mg L^{-1})	4.85 (2.53)	3.99 (2.15)	0.30 (0.15)	0.38 (0.20)	2.23 (1.16)	3.01 (1.62)
BAP (50 mg L^{-1})	5.12 (2.79)	4.35 (2.45)	0.29 (0.16)	0.32 (0.18)	1.91 (1.04)	2.65 (1.49)
BAP (10 mg L^{-1}) + SUC (0.15M)	5.89 (3.52)	5.00 (3.05)	0.24 (0.14)	0.30 (0.18)	4.02 (2.40)	4.14 (2.52)
BAP (25 mg L^{-1}) + SUC (0.15M)	6.12 (3.73)	6.53 (4.10)	0.20 (0.12)	0.19 (0.11)	3.02 (1.84)	3.62 (2.27)
BAP (50 mg L^{-1}) + SUC (0.15M)	6.65 (4.12)	6.69 (4.24)	0.15 (0.09)	0.14 (0.08)	2.85 (1.76)	3.00 (1.90)
LSD at $P_{=0.05}$	0.35	0.27	0.015	0.022	0.33	0.27

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.7.6: Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with sucrose (0.15M), (BAP + SUC) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	59.99	66.75	4.94	10.62	62.11	100.02
SUC (0.15M)	74.59	70.85	3.79	7.58	76.89	76.22
BAP (10 mg L^{-1})	69.31	65.97	6.55	7.95	53.79	72.29
BAP (25 mg L^{-1})	79.11	53.86	4.89	5.13	36.37	40.63
BAP (50 mg L^{-1})	66.43	50.06	3.76	3.68	24.78	30.50
BAP (10 mg L^{-1}) + SUC (0.15M)	59.69	50.83	2.43	3.05	40.74	42.09
BAP (25 mg L^{-1}) + SUC (0.15M)	60.31	59.43	1.97	1.72	29.76	32.94
BAP (50 mg L^{-1}) + SUC (0.15M)	62.57	59.00	1.41	1.23	26.81	26.45
LSD at $P_{=0.05}$	1.61	1.72	0.55	0.62	1.33	1.91

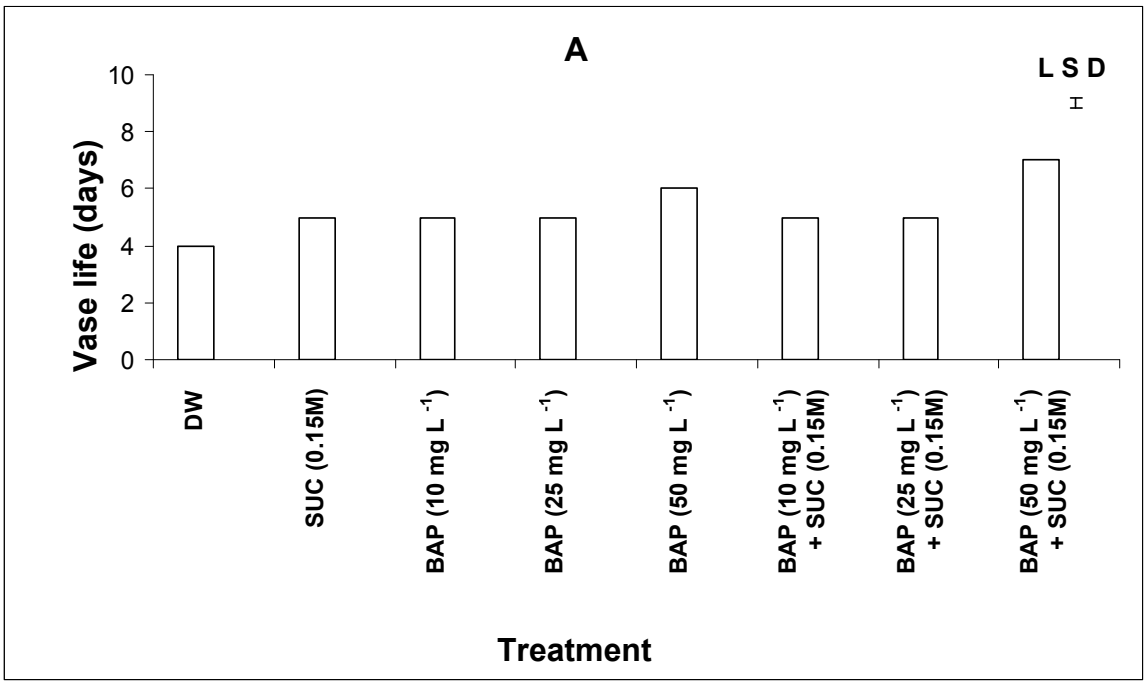
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2°C).

Fig. 6.7.1

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combinations with SUC (0.15M), (BAP + SUC) on vase life (A) and number of blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


A
L S D
Vase life (days)
10
8
6
4
2
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

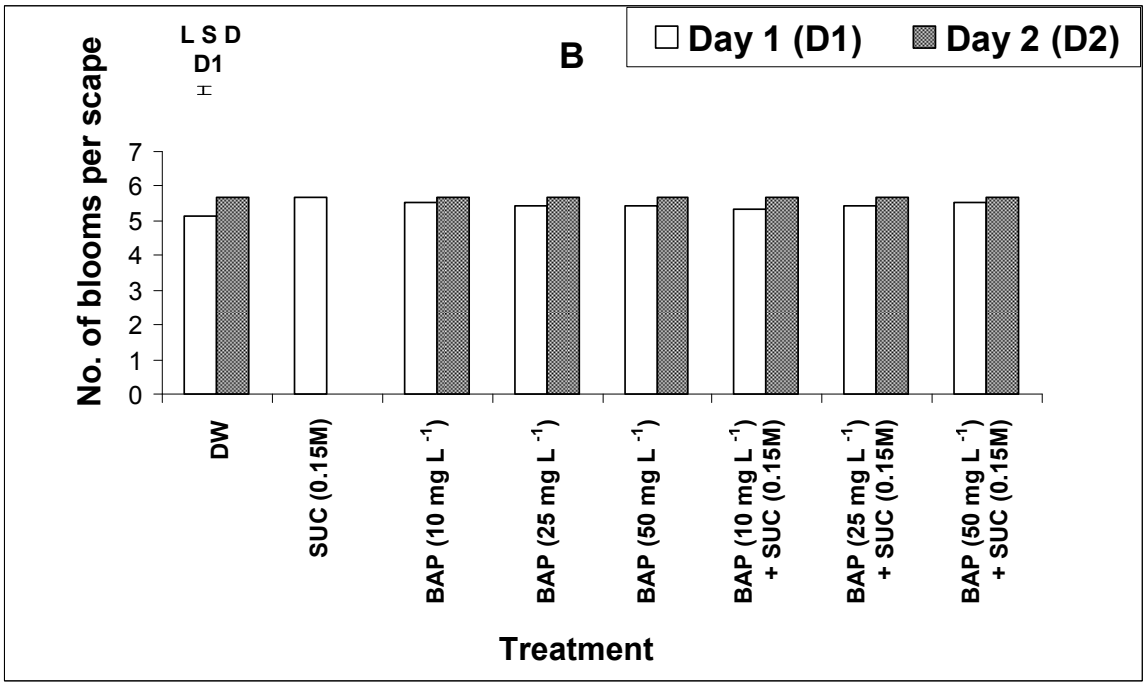
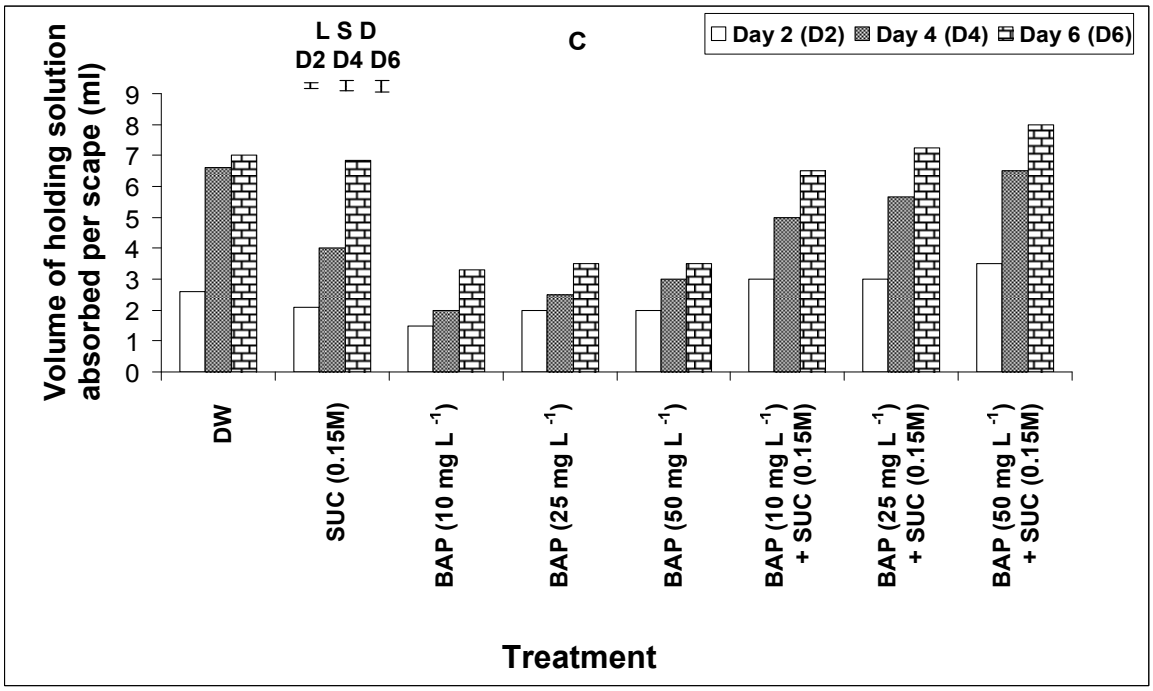

B
Day 1 (D1)
Day 2 (D2)
L S D D1
No. of blooms per scape
7
6
5
4
3
2
1
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.1

Fig. 6.7.2

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


C
L S D
D2 D4 D6
Day 2 (D2)
Day 4 (D4)
Day 6 (D6)
Volume of holding solution absorbed per scape (ml)
0
1
2
3
4
5
6
7
8
9
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

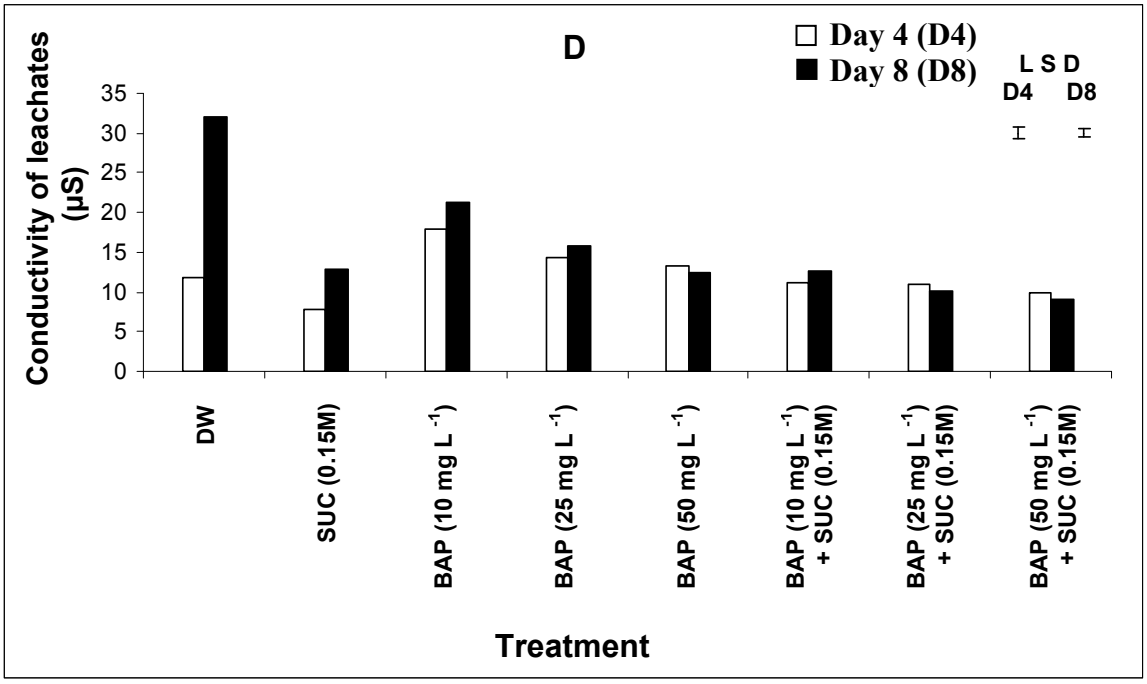
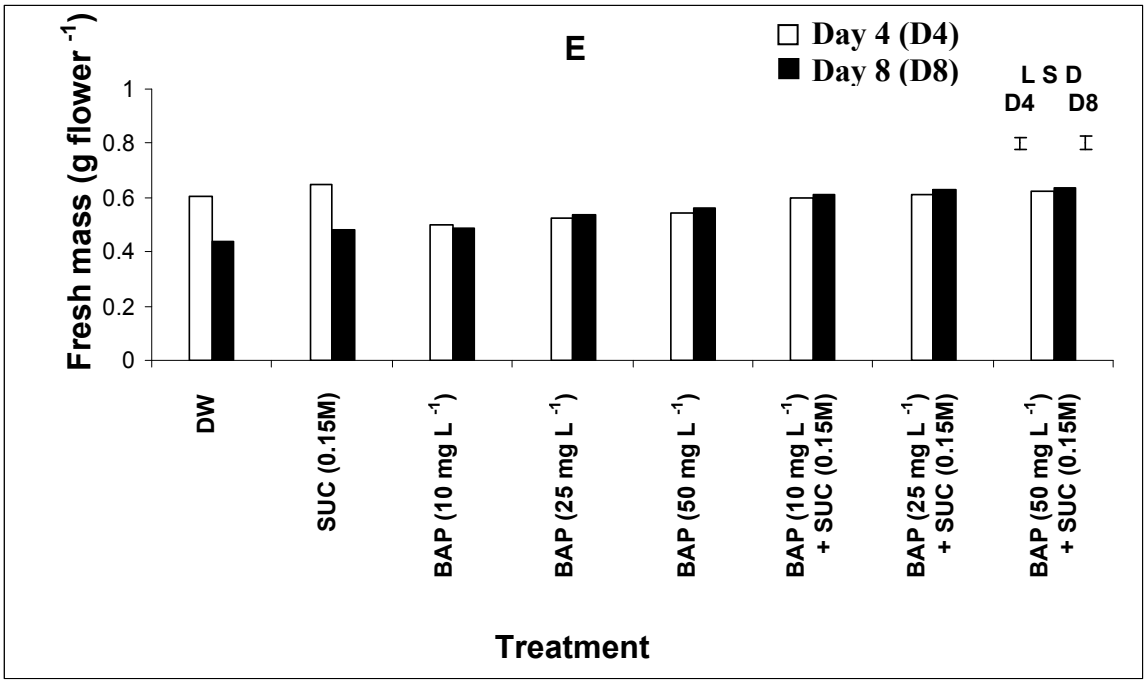

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.2

Fig. 6.7.3

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Fresh mass (g flower -1)
1
0.8
0.6
0.4
0.2
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

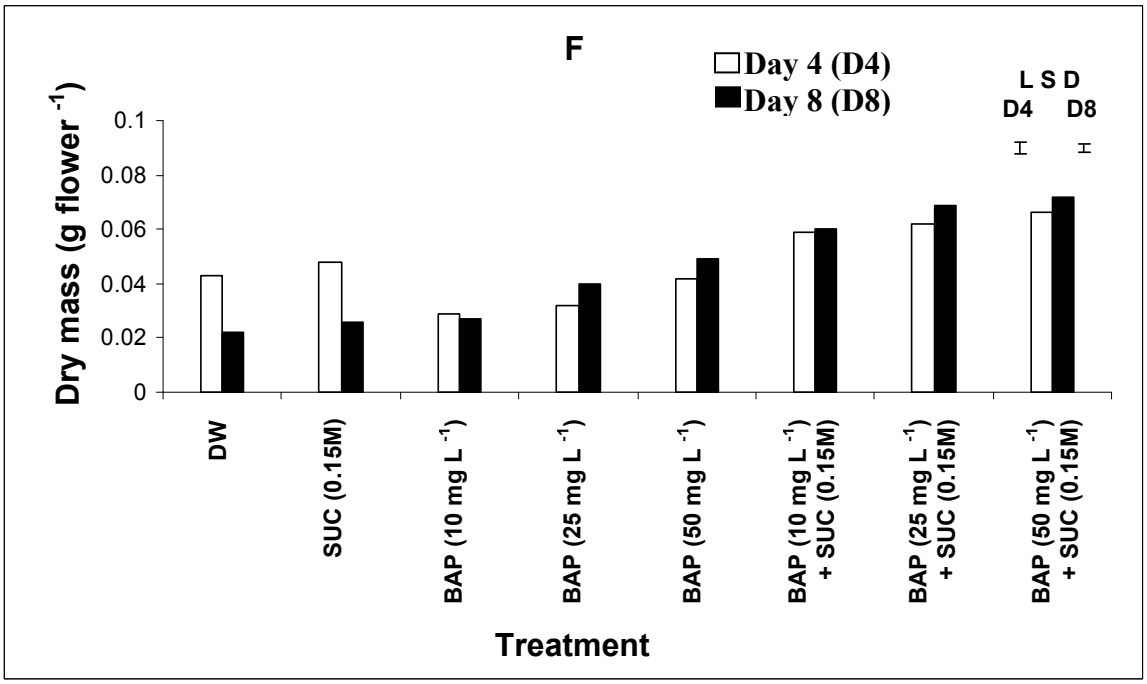
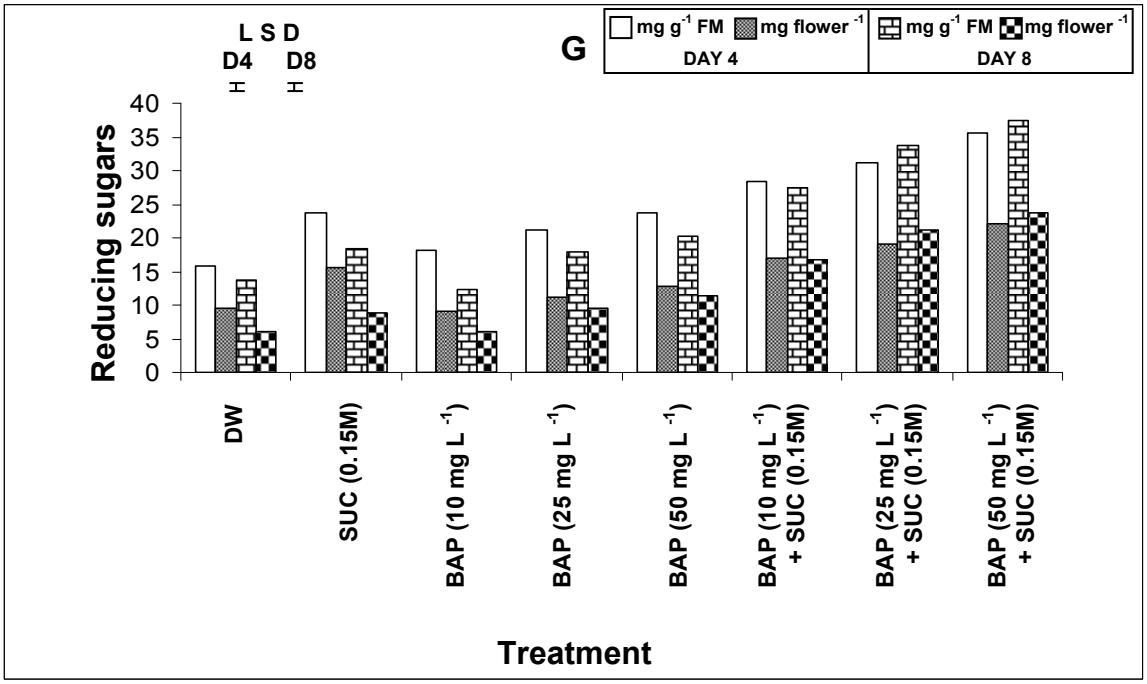

F
Day 4 (D4)
Day 8 (D8)
L S D
D4
D8
Dry mass (g flower -1)
0.1
0.08
0.06
0.04
0.02
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.3

Fig. 6.7.4

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on reducing sugars (G) and non-reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


G
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Reducing sugars
40
35
30
25
20
15
10
5
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

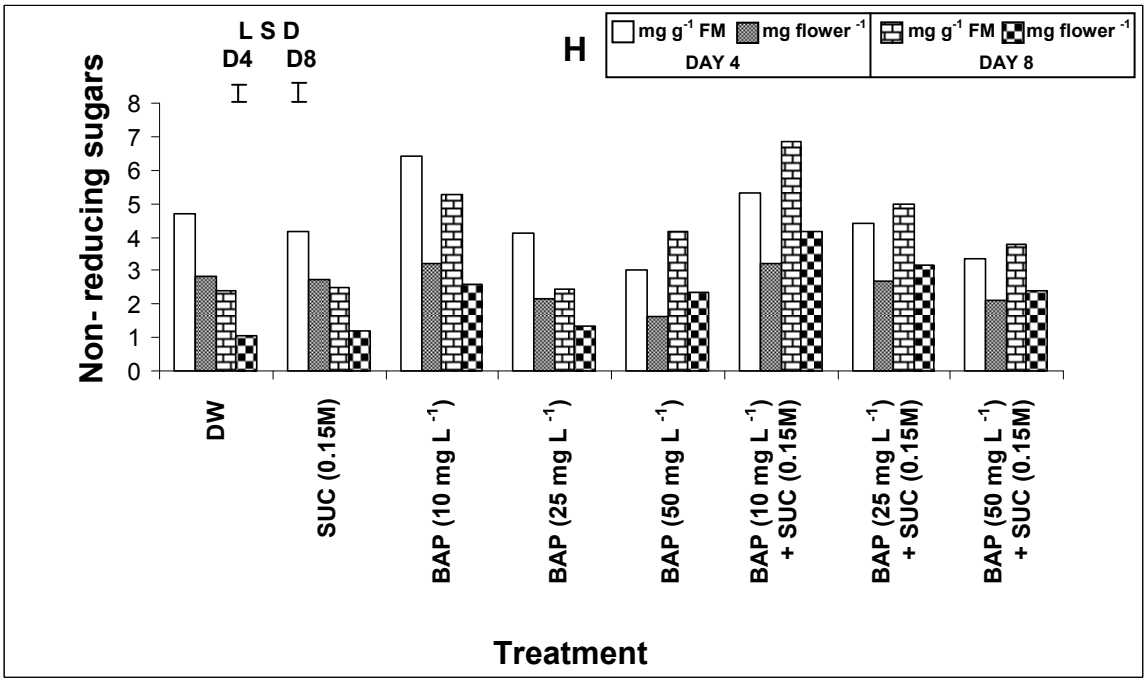
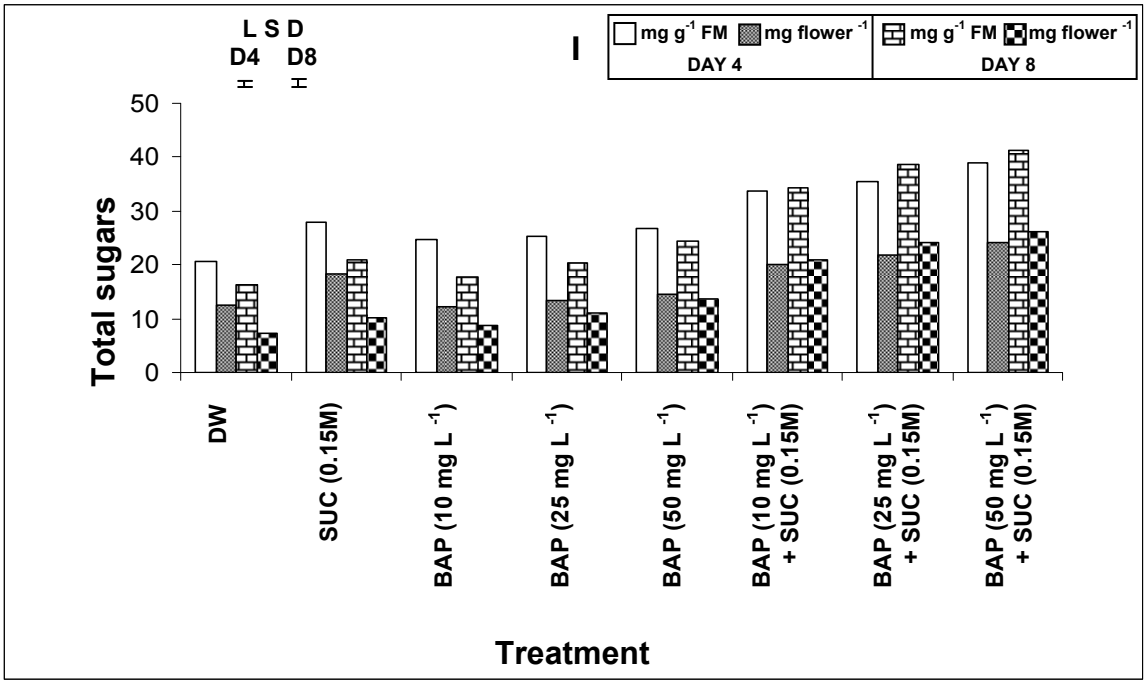

H
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Non- reducing sugars
8
7
6
5
4
3
2
1
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.4

Fig. 6.7.5

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


I
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total sugars
50
40
30
20
10
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

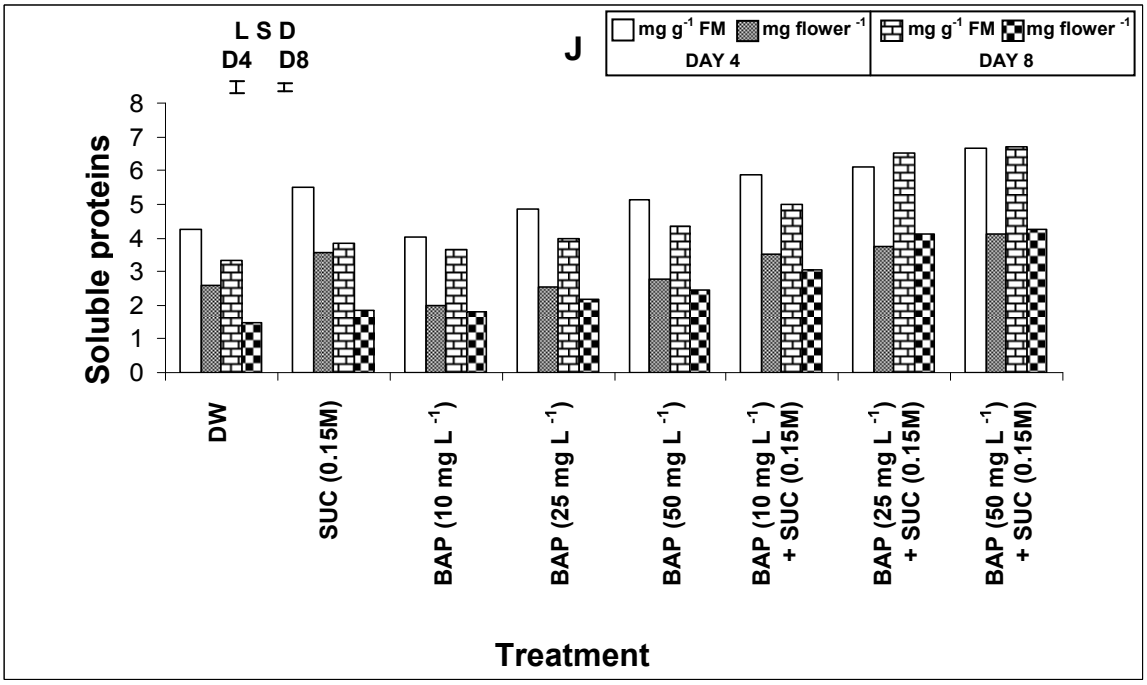
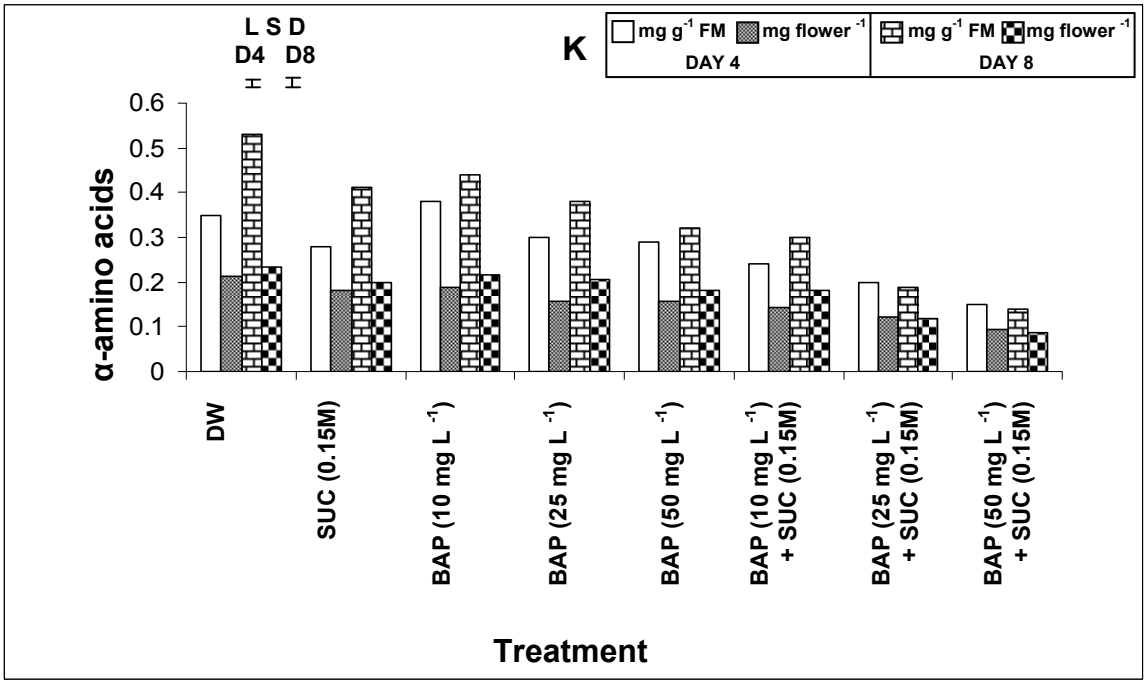

J
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Soluble proteins
8
7
6
5
4
3
2
1
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.5

Fig. 6.7.6

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on α- amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$


K
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
α-amino acids
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

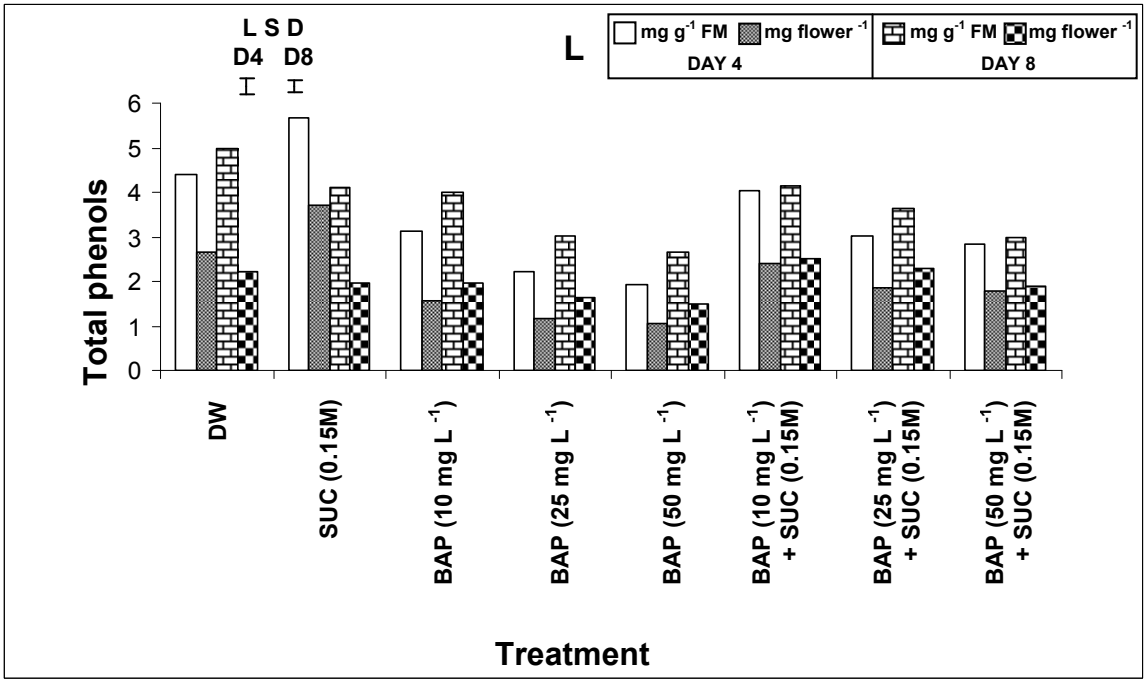

L
L S D
D4 D8
mg g-1 FM
mg flower -1
DAY 4
DAY 8
Total phenols
6
5
4
3
2
1
0
DW
SUC (0.15M)
BAP (10 mg L -1)
BAP (25 mg L -1)
BAP (50 mg L -1)
BAP (10 mg L -1) + SUC (0.15M)
BAP (25 mg L -1) + SUC (0.15M)
BAP (50 mg L -1) + SUC (0.15M)
Treatment

Fig. 6.7.6

Plate. 6.7

Effect of benzyl amino purine (BAP) at varying grades (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) and in combination with SUC (0.15M), (BAP + SUC) on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged flasks containing scapes held in

Fig. 1: DW, SUC, BAP (10 mg L^{-1}), (25 mg L^{-1}) and (50 mg L^{-1}) on day 4 of the transfer

Fig. 2: DW, SUC, BAP (10 mg L^{-1}) + SUC (0.15M), BAP (25 mg L^{-1}) + SUC (0.15M) and BAP (50 mg L^{-1}) + SUC (0.15M) on day 4 of the transfer.

Figs. 1-2 represent photographs taken on day 4 after the transfer of scapes to holding solutions.

Figs. 3-4 represent photographs taken on day 8 after the transfer of scapes to holding solutions

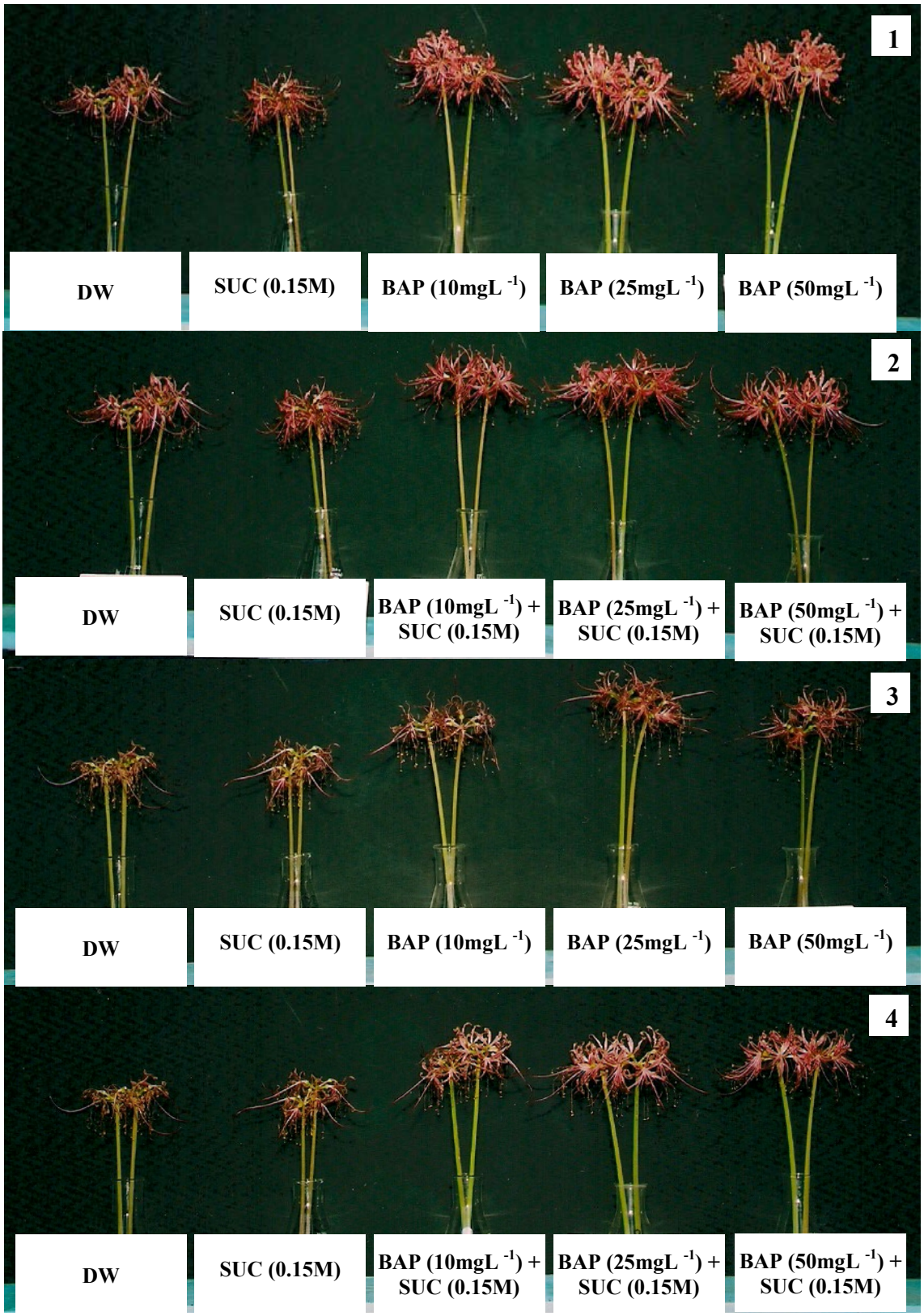

1
DW
SUC (0.15M)
BAP (10mgL -1)
BAP (25mgL -1)
BAP (50mgL -1)
2
DW
SUC (0.15M)
BAP (10mgL -1) + SUC (0.15M)
BAP (25mgL -1) + SUC (0.15M)
BAP (50mgL -1) + SUC (0.15M)
3
DW
SUC (0.15M)
BAP (10mgL -1)
BAP (25mgL -1)
BAP (50mgL -1)
4
DW
SUC (0.15M)
BAP (10mgL -1) + SUC (0.15M)
BAP (25mgL -1) + SUC (0.15M)
BAP (50mgL -1) + SUC (0.15M)

Plate. 6.7

EXPERIMENT 6.8

Effect of gibberellic acid GA_3 (25 mg L^{-1}) separately and in combination with sucrose GA_3 (25 mg L^{-1}) + SUC (0.15 M) and cobalt chloride, GA_3 (25 mg L^{-1}) + SUC (0.15 M) + $CoCl_2$ (0.15 mM) in cut scapes of *Nerine sarniensis* cv. Red.

Experimental

Scapes of *N. sarniensis* growing in the University Botanic garden were used for the study. The scapes were harvested at loose bud stage at 08:00 h, immediately brought to the laboratory and cut to a uniform length of 30 cm. The scapes were held in 250 ml conical flasks containing 200 ml of distilled water (DW), sucrose (SUC 0.15M), gibberellic acid, GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM). For each treatment there were 5 replicates represented by 5 flasks with each flask containing two scapes. The day of transfer of scapes to holding solutions was designated as day zero. Visible changes occurring in the flowers were recorded at periodic intervals. The average vase life of flowers was counted from the day of transfer of scapes to holding solutions and was assessed to be terminated when of the flowers had lost their display value which was characterized by curling of tepals, turgor loss followed by wilting of tepals (status 4) as described in materials and methods (Table 1). Number of blooms per scape was recorded up to day 2 of the transfer. Volume of holding solution absorbed per scape was recorded on day 2, 4 and 6 after the transfer. Conductivity of leachates, from tepal discs, fresh and dry mass of flowers were recorded on day 4 and 8 of transfer of scapes to holding solutions. Changes in tissue constituents including sugar fractions, soluble proteins, α- amino acids and total phenols were also estimated on day 4 and 8 after transfer. The data have been analyzed statistically and LSD computed at $P_{=0.05}$.

Results

Visible effects: In all the treatments the buds opened on the subsequent day of the transfer of scapes to holding solutions. Flower senescence was delayed in scapes held in GA_3, GA_3 + SUC or GA_3 + SUC + $CoCl_2$ by about 4 days (Plate 6.8.2, Figs. 1-2).

Vase life: The average vase life of scapes held in GA_3 + SUC + $CoCl_2$ and GA_3 + SUC was enhanced by an increment of 5 days, while as the vase life of scapes held in GA_3 or SUC was enhanced by increment of 3 and 1 days respectively as compared to the corresponding scapes held in DW which exhibited vase life of about 4 days (Table 6.8.1, Text Fig. 6.8.1, A).

Number of blooms per scape: Number of blooms increased in all the treatments irrespective of the transfer to various holding solutions. The number and percent blooming in all the scapes was almost same irrespective of the transfer to various holding solutions. However, complete blooming was observed by day 2 of the transfer of scapes in all the cases (Table 6.8.1; Text Fig. 6.8.1, B).

Volume of holding solution absorbed per scape (ml): Volume of holding solution absorbed increased with progression in time from 2 to 6 days of the transfer of scapes irrespective of the transfer to holding solutions. Higher solution uptake was observed in scapes held in GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC as compared to scapes held in GA_3 followed by DW or SUC (Table 6.8.1, Text Fig. 6.8.2,C). Maximum solution uptake was noticed in the scapes transfer to GA_3 + SUC + $CoCl_2$.

Conductivity of leachates (µS): The conductivity of leachates estimated as ion leakage of tepal discs decreased with progression in time from day 4 to day 8 of transfer of the scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC. The conductivity of leachates increased in the samples from scapes held in all other treatments (Table 6.8.2, Text Fig 6.8.2, D).

Fresh mass and dry mass: Fresh and dry mass of flowers increased with progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Maximum fresh and dry mass was registered in the samples from GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC (Table 6.8.2, Text Fig. 6.8.3, E & F).

Reducing sugars: The reducing sugar content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Higher reducing sugar content was registered in the samples from scapes held in GA_3 + SUC + $CoCl_2$ followed GA_3 + SUC as compared to the samples from scapes held in DW (Table 6.8.3; Text Fig. 6.8.4, G). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.8.3). When expressed on dry mass basis the content of reducing sugars increased irrespective of the transfer to various holding solutions transferred over a period of time (Table 6.8.4).

Non-reducing sugars: The non-reducing sugar content registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Higher non-reducing sugar contents was registered in the samples from scapes held in GA_3 + SUC + $CoCl_2$ or GA_3 + SUC as compared to the samples from scapes held in DW (Table 6.8.3; Text Fig. 6.8.4, H). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.8.3). When expressed on dry mass basis the content of non-reducing sugars decreased in the scapes from scapes held in DW or SUC and registered an increase in all the other treatments (Table 6.8.4).

Total sugars: The content of total sugars registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Higher content of total sugars was observed in the samples from scapes held in GA_3 + SUC + $CoCl_2$ or GA_3 + SUC as compared to the samples from scapes held in DW (Table 6.8.3; Text Fig. 6.8.5, I). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.8.3). When expressed on dry mass basis the content of total sugars decreased in the sample from scapes held in DW or SUC and registered an increase in other treatments (Table 6.8.4).

Soluble proteins: The content of soluble proteins registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Higher content of proteins was observed in the samples from scapes held in GA_3 + SUC + $CoCl_2$ or GA_3 + SUC as compared to the samples from scapes held in DW or SUC (Table 6.8.5; Text Fig. 6.8.5, J). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.8.5). When expressed on dry mass basis the content of soluble proteins decreased slightly in the samples from scapes held in SUC as also in GA_3 whereas it increased in rest of the treatment (Table 6.8.6).

α- amino acids: The content of α – amino acid registered a decrease with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Lower content of α – amino acids was observed in the samples from scapes held in GA_3 + SUC + $CoCl_2$ followed GA_3 + SUC as compared to the samples from scapes held in DW (Table 6.8.5; Text Fig. 6.8.6, K). Almost similar trends were obtained when the data was expressed on per flower and on dry mass bases (Tables 6.8.5 & 6.8.6).

Total phenols: The content of total phenols registered an increase with the progression in time from day 4 to day 8 of transfer of scapes to GA_3 + SUC + $CoCl_2$ followed by GA_3 + SUC and GA_3 as compared to the scapes held in DW or SUC. Higher content of phenolics was notice in the samples from scapes held in GA_3 + SUC + $CoCl_2$ or GA_3 + SUC as compared to the samples from scapes held in DW (Table 6.8.5; Text Fig. 6.8.6, L). Almost similar trends were obtained when the data was expressed on per flower basis (Table 6.8.5). When expressed on dry mass basis the content of total phenols increased with the progression in time in the samples from scapes held in DW, whereas in rest of the treatment it was generally maintained (Table 6.8.6).

Table 6.8.1: Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM) on vase life, blooming and solution uptake in cut scapes of *Nerine sarniensis* cv. Red.

Treatment	Vase life (days)	No. of blooms per scape		Volume of holding solution absorbed per scape (ml)		
		Days after treatment				
		1	2	2	4	6
DW	4	5.16 (96)	5.66 (100)	2.60	6.60	8.00
SUC (0.15M)	5	5.66 (100)	-	2.10	4.00	6.83
GA_3 (25 mg L^{-1})	7	5.53 (98)	5.66 (100)	2.00	3.35	4.00
GA_3 (25 mg L^{-1}) + SUC (0.15M)	9	5.53 (98)	5.66 (100)	2.50	4.50	6.50
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	9	5.44 (96)	5.66 (100)	3.00	5.00	8.50
LSD at $P_{=0.05}$	0.58	0.36	-	0.33	0.17	0.27

Each value is a mean of 5 independent replicates.

Room temperature (RT)= (21 ± 2^0C).

Figures in parentheses represent percent blooms.

Table 6.8.2: Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15 M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on conductivity of leachates, fresh mass and dry mass of flowers on day 4 and 8 of transfer of cut scape to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Conductivity of leachates (µS)		Fresh mass (g flower $^{-1}$)		Dry mass (g flower $^{-1}$)	
	Days after treatment					
	4	8	4	8	4	8
DW	11.73	32.00	0.607	0.441	0.043	0.022
SUC (0.15M)	7.90	12.96	0.651	0.481	0.048	0.026
GA_3 (25 mg L^{-1})	7.21	9.93	0.625	0.631	0.064	0.068
GA_3 (25 mg L^{-1}) + SUC (0.15M)	7.00	6.51	0.657	0.666	0.075	0.078
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	6.65	5.52	0.671	0.680	0.082	0.091
LSD at $P_{=0.05}$	1.16	0.63	0.045	0.041	0.006	0.004

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Table 6.8.3: Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on sugar fractions expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	15.84 (9.61)	13.76 (6.06)	4.69 (2.84)	2.40 (1.05)	20.53 (12.46)	16.16 (7.12)
SUC (0.15M)	20.76 (13.51)	18.40 (8.85)	4.16 (2.70)	2.48 (1.19)	27.92 (18.17)	20.88 (10.04)
GA_3 (25 mg L^{-1})	14.44 (9.02)	15.66 (9.86)	6.78 (4.23)	10.88 (6.85)	21.22 (13.26)	26.54 (16.72)
GA_3 (25 mg L^{-1}) + SUC (0.15M)	19.21 (12.62)	22.35 (14.88)	6.45 (4.23)	8.98 (5.98)	25.66 (16.85)	31.33 (20.86)
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	25.32 (16.98)	29.38 (19.97)	4.52 (3.03)	5.16 (3.50)	29.84 (20.02)	34.54 (23.48)
LSD at $P_{=0.05}$	1.38	1.92	0.98	1.19	1.58	1.28

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.8.4: Effect of gibberellic acid (GA_3) at (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15 M) + $CoCl_2$ (0.15 mM) on sugar fractions expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Reducing sugars		Non-reducing sugars		Total sugars	
	Days after treatment					
	4	8	4	8	4	8
DW	223.60	275.82	66.20	48.10	289.80	323.93
SUC (0.15M)	281.55	340.40	56.42	45.88	378.66	386.28
GA_3 (25 mg L^{-1})	141.01	145.08	66.21	100.80	207.22	245.88
GA_3 (25 mg L^{-1}) + SUC (0.15M)	168.27	190.83	56.50	76.67	224.78	267.51
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	207.19	219.54	36.98	38.55	244.17	258.10
LSD at $P_{=0.05}$	12.24	16.31	10.09	9.89	15.23	19.01

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Table 6.8.5: Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on soluble proteins, α-amino acids and total phenols expressed on fresh mass basis (mg g^{-1} FM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	4.25 (2.57)	3.33 (1.46)	0.35 (0.21)	0.53 (0.23)	4.40 (2.67)	4.99 (2.20)
SUC (0.15M)	5.50 (3.58)	3.83 (1.84)	0.28 (0.18)	0.41 (0.19)	5.67 (3.69)	4.12 (1.98)
GA_3 (25 mg L^{-1})	5.20 (3.25)	5.01 (3.15)	0.30 (0.18)	0.28 (0.17)	5.32 (3.32)	5.59 (3.52)
GA_3 (25 mg L^{-1}) + SUC (0.15M)	5.99 (3.93)	6.78 (4.51)	0.21 (0.13)	0.12 (0.07)	6.12 (4.02)	6.98 (4.64)
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	6.21 (4.16)	6.90 (4.69)	0.15 (0.10)	0.09 (0.06)	6.66 (4.46)	7.01 (4.76)
LSD at $P_{=0.05}$	0.69	0.65	0.02	0.02	0.41	0.45

Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21± 2^0C).

Figures in parentheses represent values on mg $flower^{-1}$ basis.

Table 6.8.6: Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3(25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}), + SUC (0.15M) + $CoCl_2$ (0.15mM) on soluble proteins, α-amino acids and total phenols expressed on dry mass basis (mg g^{-1} DM) in tepal tissues on day 4 and 8 of transfer of cut scapes to holding solutions in *Nerine sarniensis* cv. Red.

Treatment	Soluble proteins		α-amino acids		Total phenols	
	Days after treatment					
	4	8	4	8	4	8
DW	59.99	66.75	4.94	10.62	62.11	100.02
SUC (0.15M)	74.59	70.85	3.79	7.58	76.89	76.22
GA_3 (25 mg L^{-1})	50.78	46.41	2.92	2.59	51.95	51.78
GA_3 (25 mg L^{-1}) + SUC (0.15M)	52.47	57.89	1.83	1.02	53.61	59.59
GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15mM)	50.81	51.56	1.22	0.67	54.49	52.38
LSD at $P_{=0.05}$	5.66	4.89	0.48	0.23	3.21	2.55

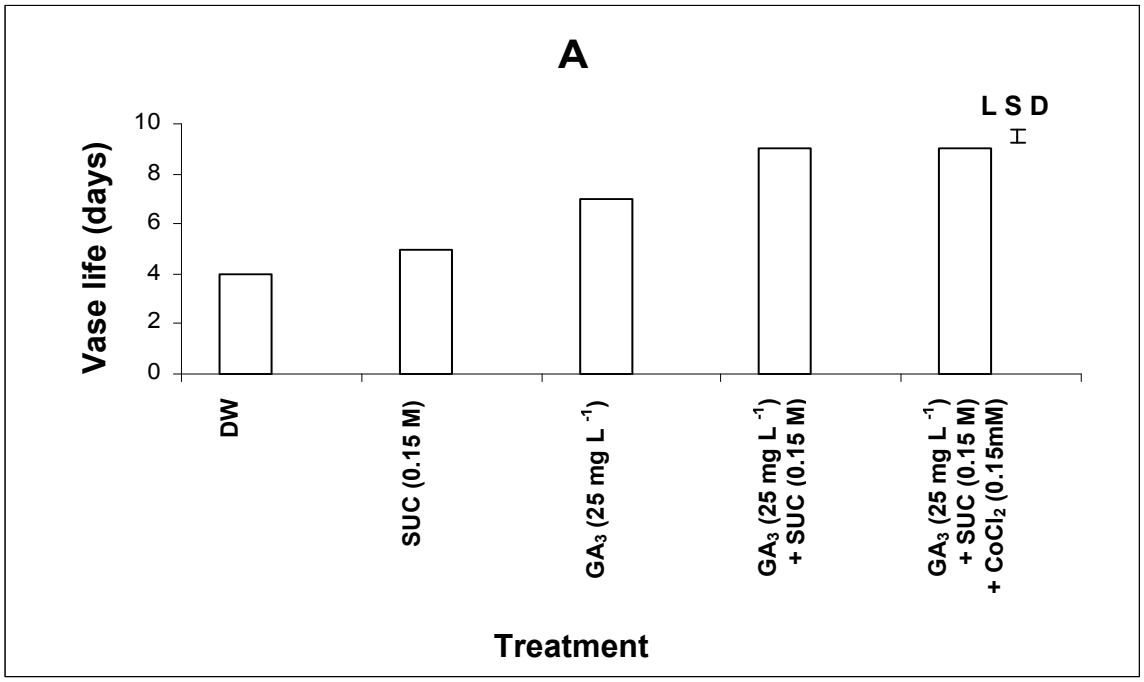
Each value is a mean of 5 independent replicates.

Room temperature (RT) = (21 ± 2^0C).

Fig. 6.8.1

Histograms showing effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on vase life (A) and number of blooms per scape (B) in cut scapes of *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


A
L S D
Vase life (days)
10
8
6
4
2
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) + CoCl2 (0.15mM)
Treatment

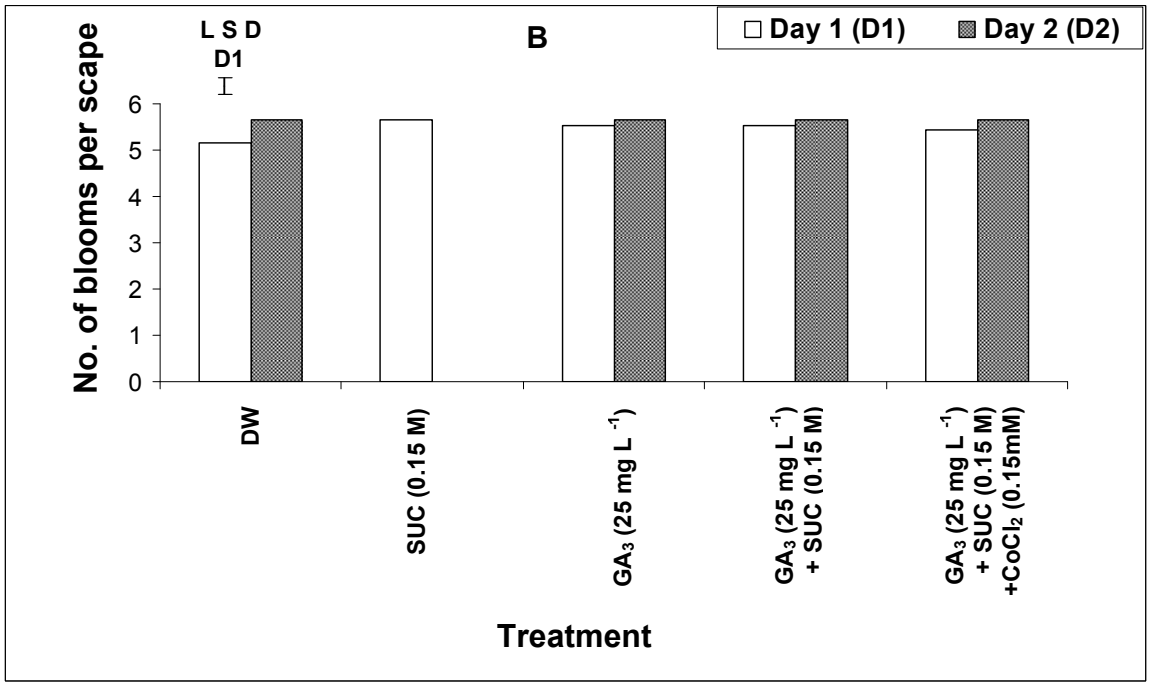
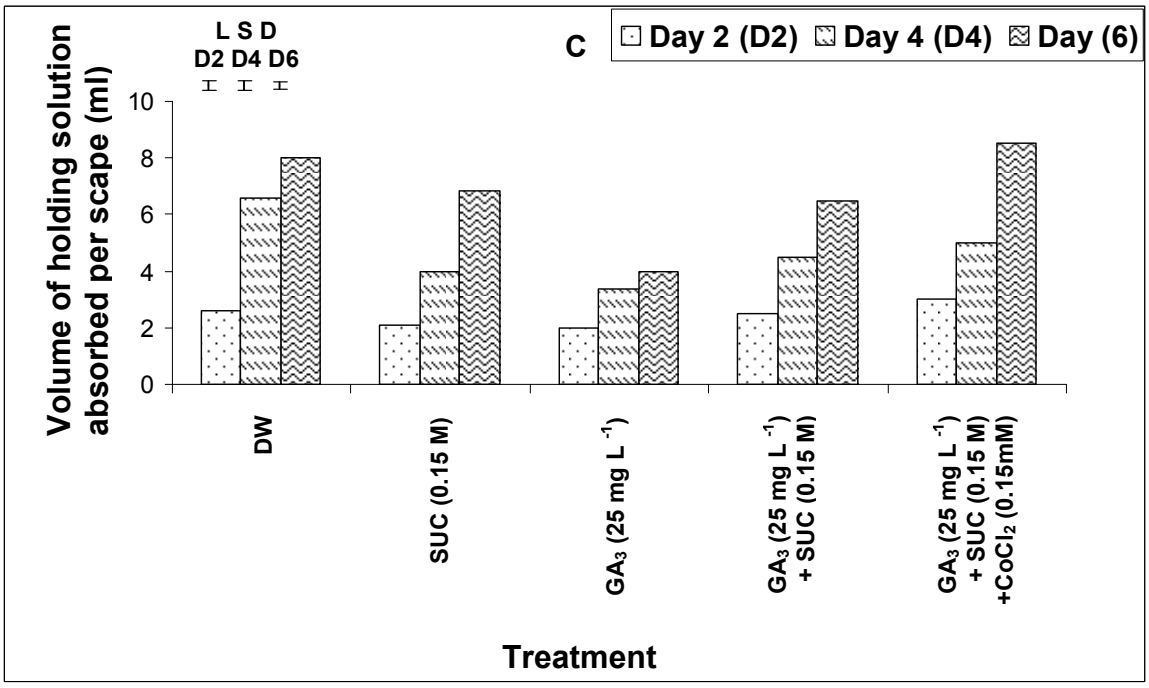

B
Day 1 (D1)
Day 2 (D2)
L S D
D1
No. of blooms per scape
6
5
4
3
2
1
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.1

Fig. 6.8.2

Histograms showing effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on volume of holding solution absorbed per scape ml (C) on day 2, 4, 6 and conductivity of leachates (D) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$.


C
Day 2 (D2)
Day 4 (D4)
Day (6)
L S D
D2 D4 D6
Volume of holding solution absorbed per scape (ml)
0
2
4
6
8
10
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

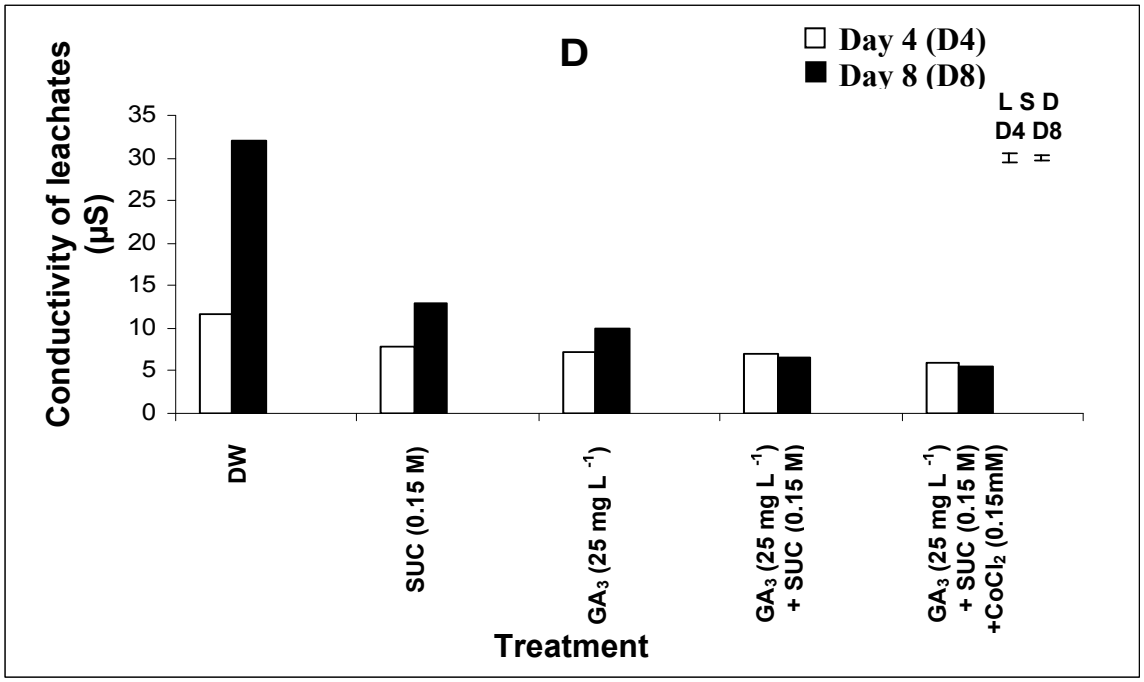
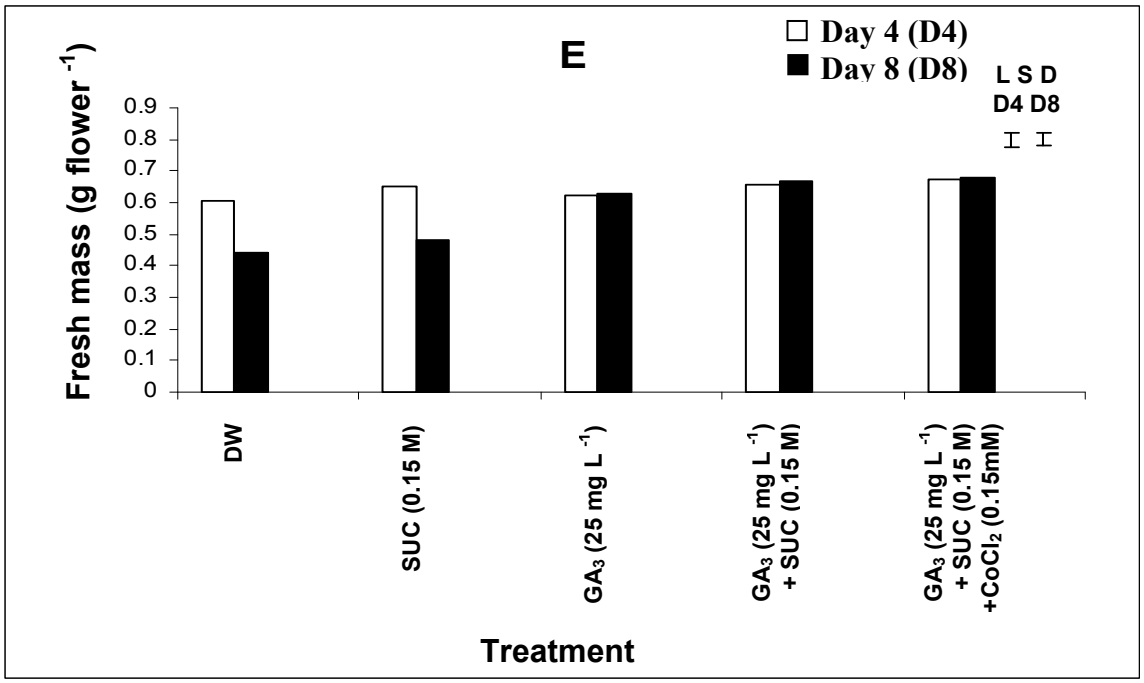

D
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Conductivity of leachates (µS)
0
5
10
15
20
25
30
35
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.2

Fig. 6.8.3

Histograms showing effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on fresh mass (E) and dry mass (F) of flowers on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


E
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Fresh mass (g flower -1)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

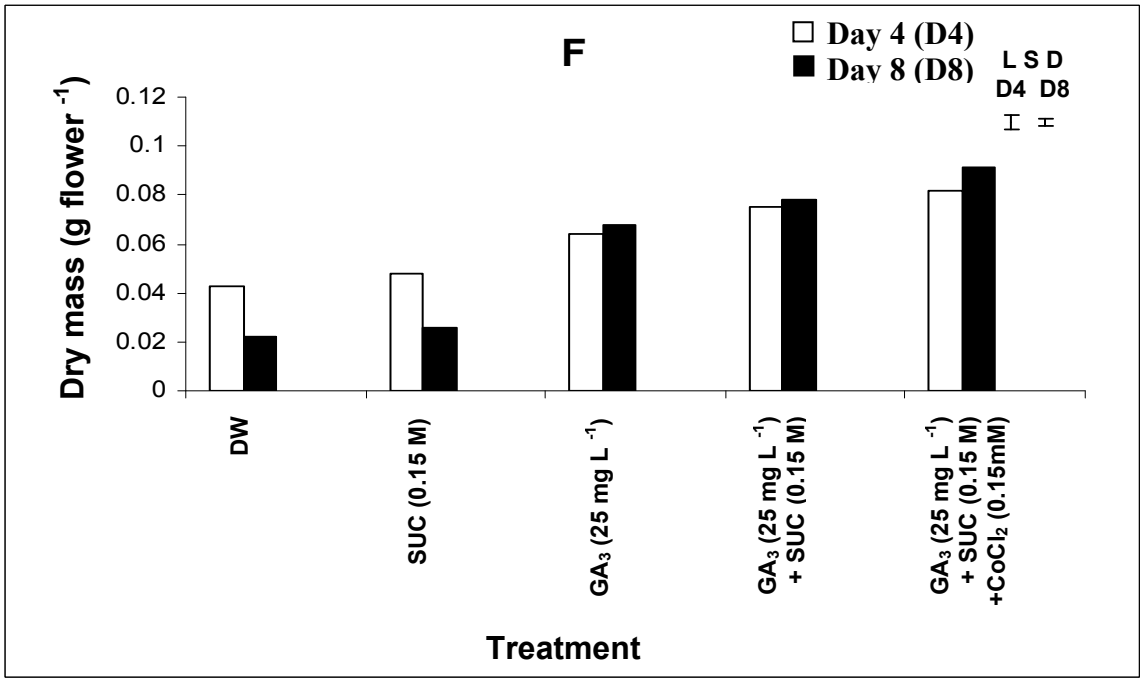
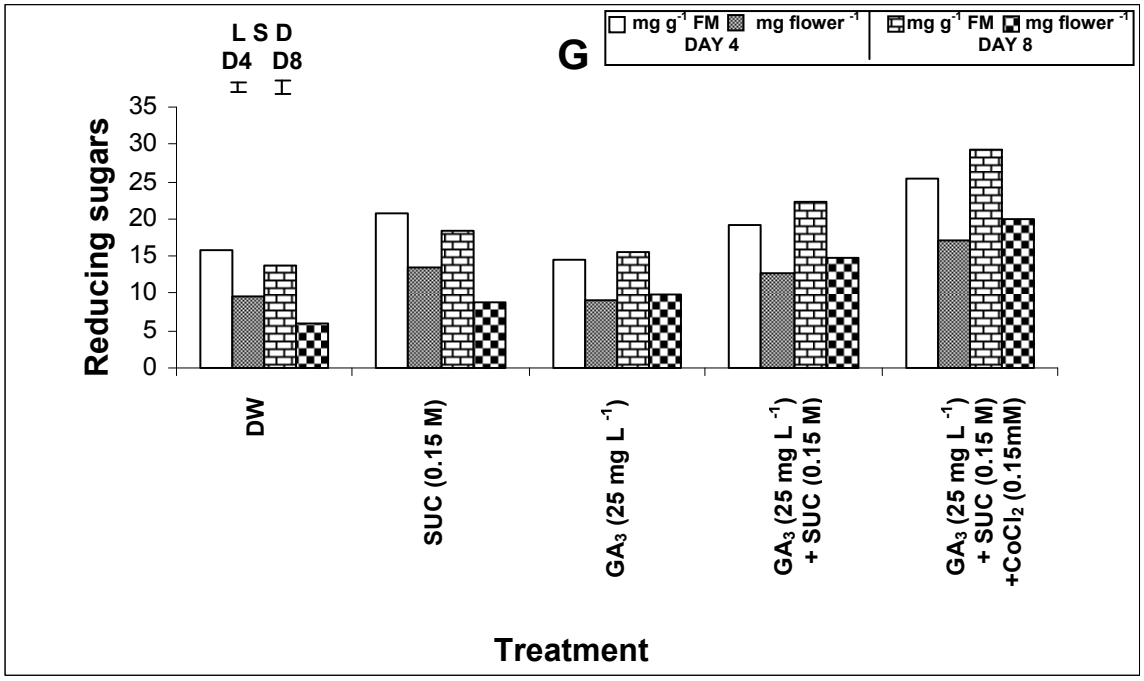

F
Day 4 (D4)
Day 8 (D8)
L S D
D4 D8
Dry mass (g flower -1)
0.12
0.1
0.08
0.06
0.04
0.02
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.3

Fig. 6.8.4

Histograms showing effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15 M) + $CoCl_2$ (0.15 mM) on reducing sugars (G) and non reducing sugars (H) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


G
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Reducing sugars
35
30
25
20
15
10
5
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

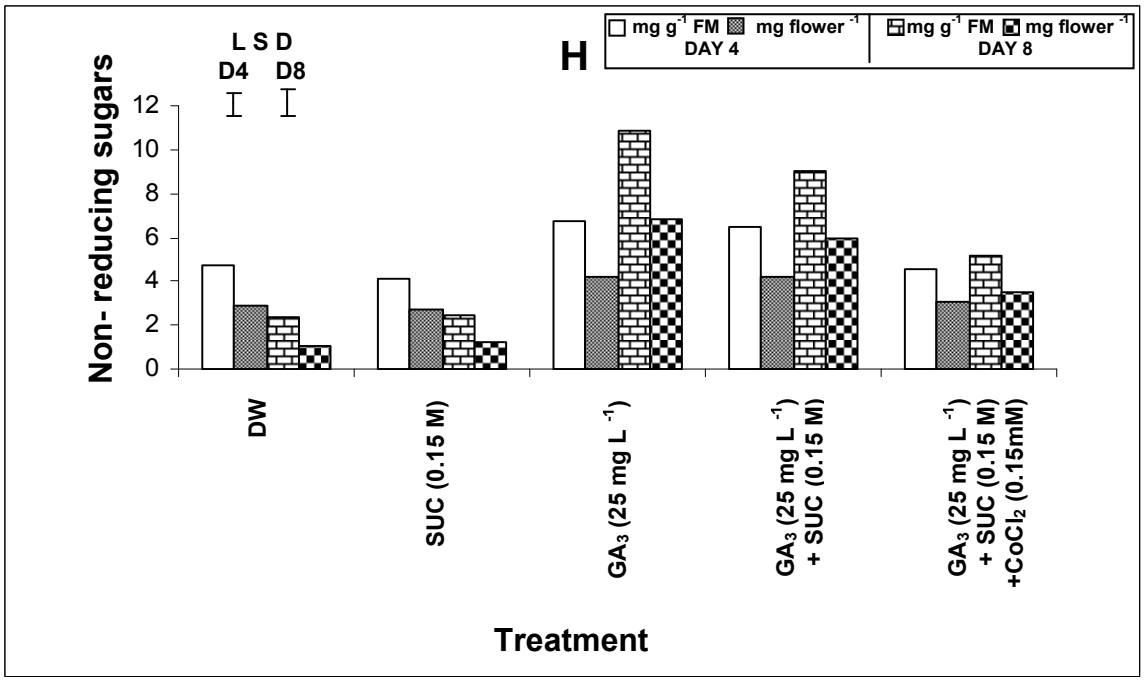
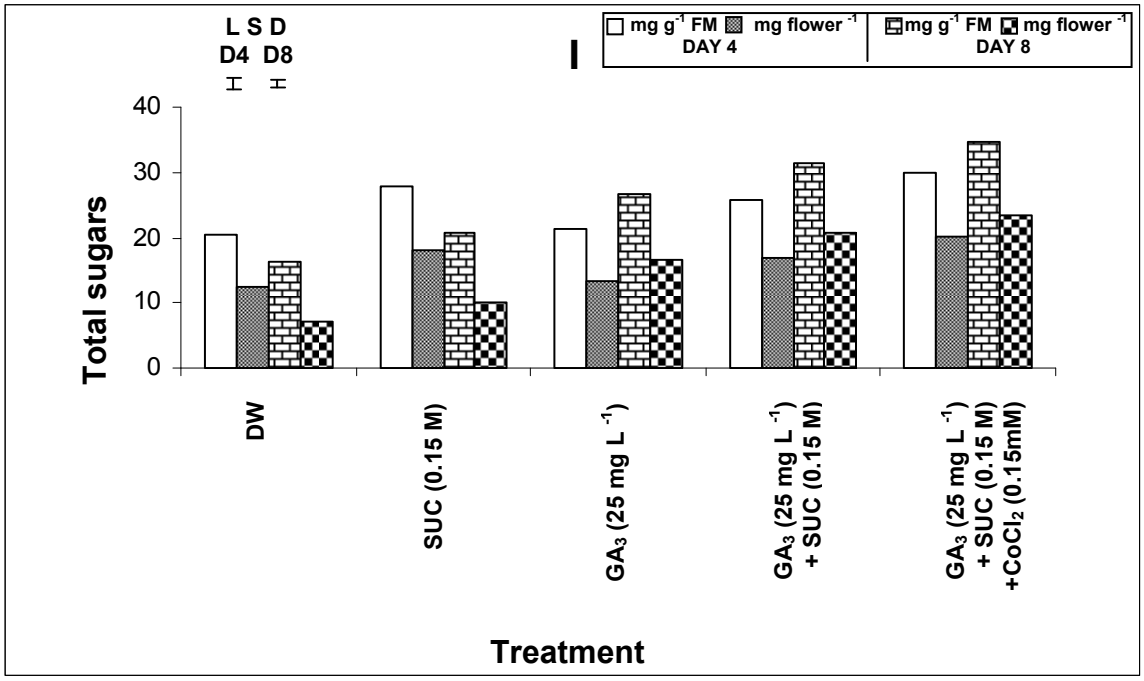

H
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Non- reducing sugars
12
10
8
6
4
2
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.4

Fig. 6.8.5

Histograms showing effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on total sugars (I) and soluble proteins (J) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05.}$


L S D
D4 D8
I
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Total sugars
40
30
20
10
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

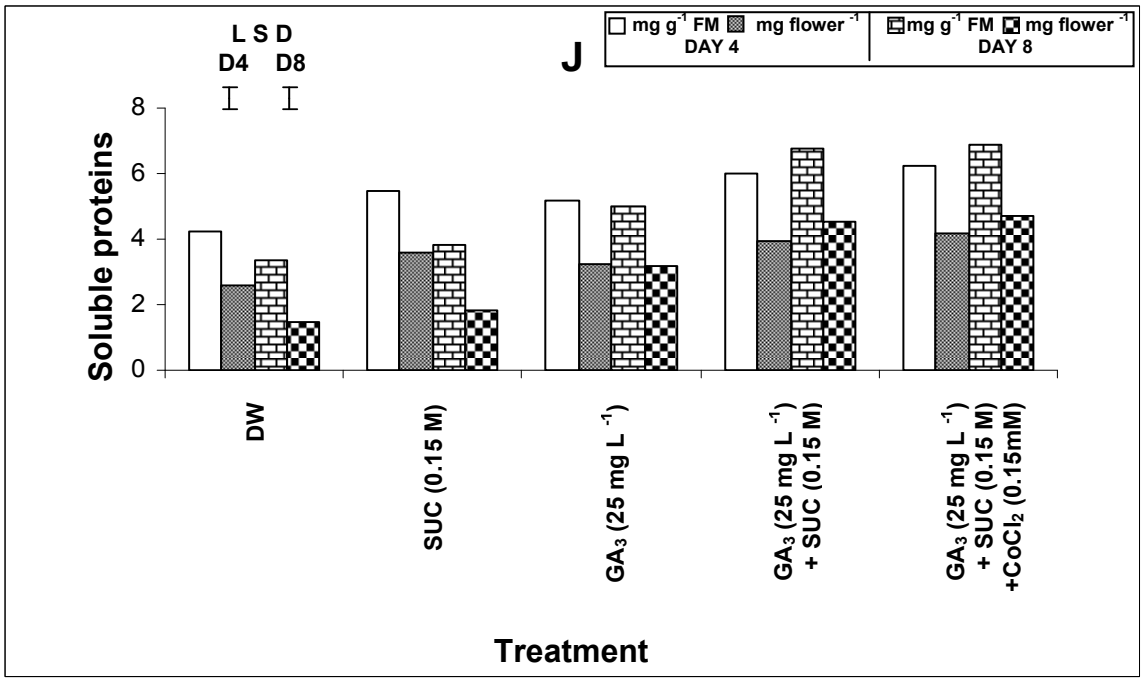
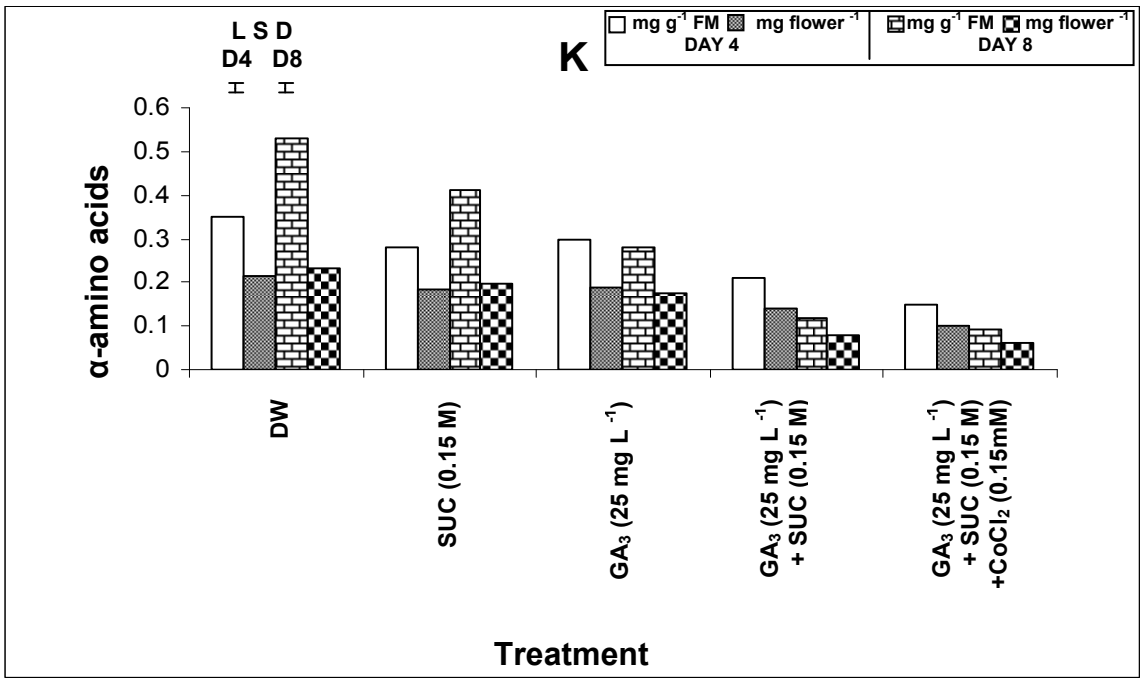

L S D
D4 D8
J
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Soluble proteins
8
6
4
2
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.5

Fig. 6.8.6

Histograms showing effect of gibberellic acid GA_3 at (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on α-amino acids (K) and total phenols (L) in tepal tissues on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

Vertical bars represent LSD at $P_{= 0.05}$.


K
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
α-amino acids
0.6
0.5
0.4
0.3
0.2
0.1
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

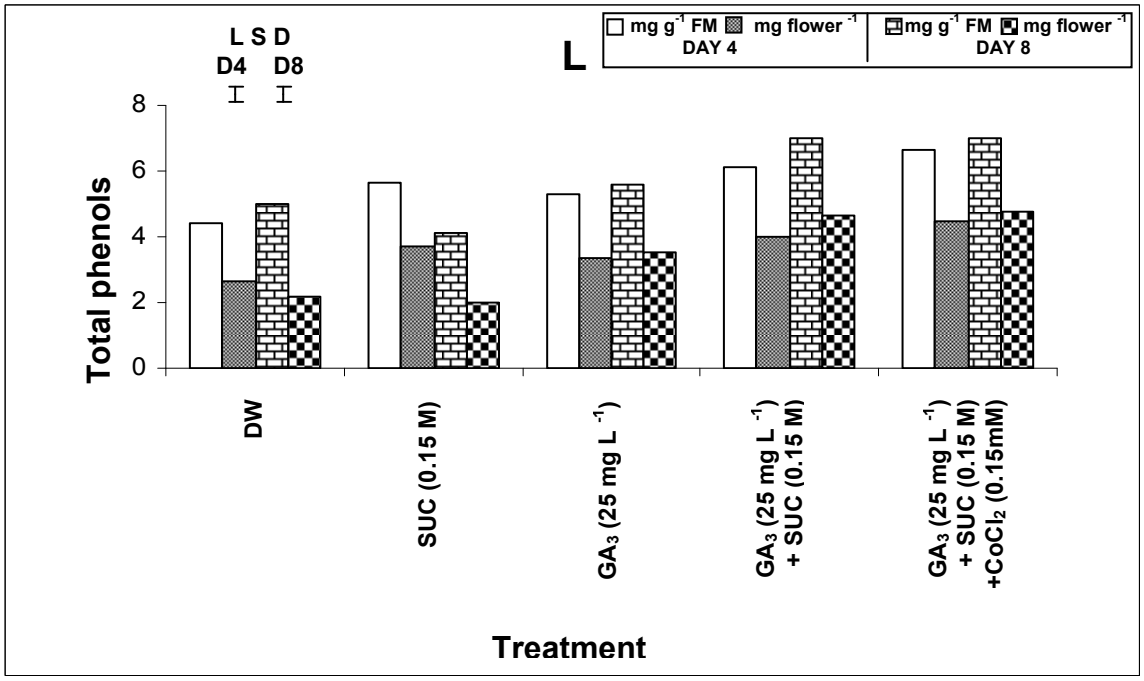

L
L S D
D4 D8
mg g-1 FM mg flower -1
DAY 4
mg g-1 FM mg flower -1
DAY 8
Total phenols
8
6
4
2
0
DW
SUC (0.15 M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15 M)
GA3 (25 mg L -1) + SUC (0.15 M) +CoCl2 (0.15mM)
Treatment

Fig. 6.8.6

Plate. 6.8.

Effect of gibberellic acid GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM) on day 4 and 8 of transfer of scapes to holding solutions in *Nerine sarniensis* cv. Red.

From left to right are arranged scapes held in DW, SUC (0.15M), GA_3 (25 mg L^{-1}), GA_3 (25 mg L^{-1}) + SUC (0.15M) and GA_3 (25 mg L^{-1}) + SUC (0.15M) + $CoCl_2$ (0.15 mM).

Figs. 1-2 represents photographs taken on day 4 and 8 of the treatment.

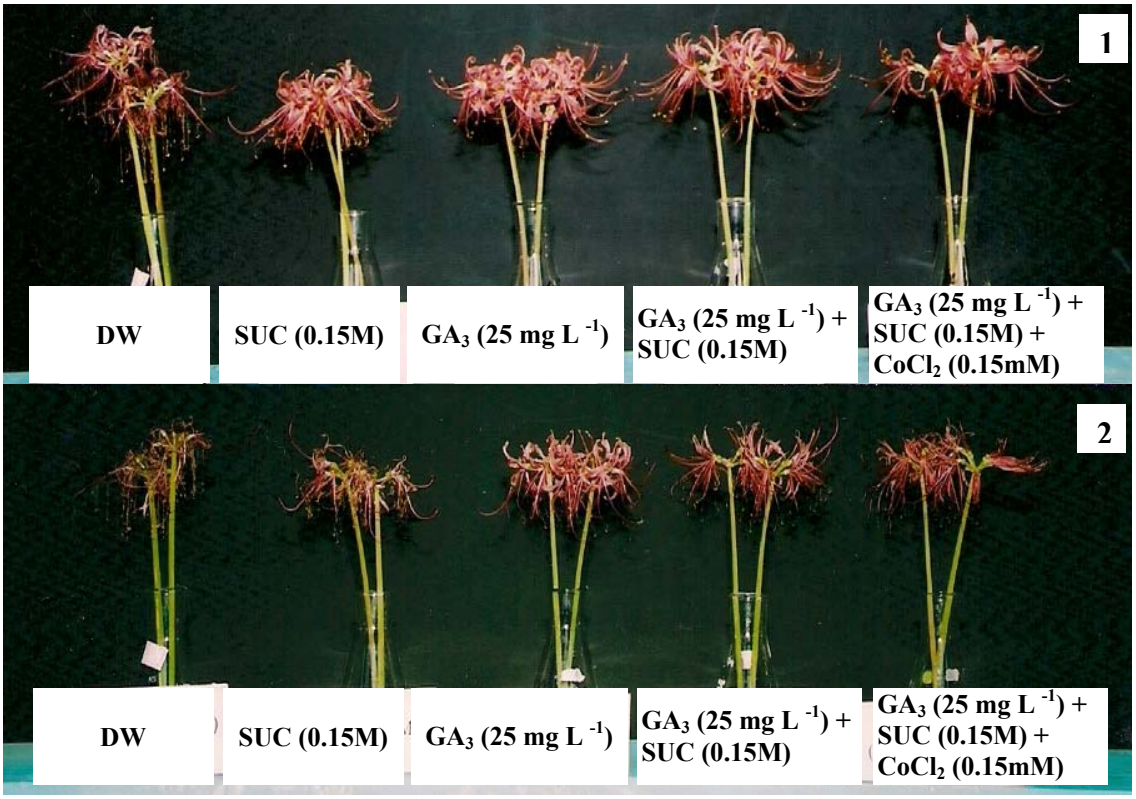

1
DW
SUC (0.15M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15M)
GA3 (25 mg L -1) + SUC (0.15M) + CoCl2 (0.15mM)
2
DW
SUC (0.15M)
GA3 (25 mg L -1)
GA3 (25 mg L -1) + SUC (0.15M)
GA3 (25 mg L -1) + SUC (0.15M) + CoCl2 (0.15mM)

Plate. 6.8

Discussion

A study was undertaken to understand the mechanism of senescence and develop proper postharvest handling as also storage techniques in order to improve the keeping quality of some important ornamental plants belonging to family Amaryllidaceae. The plants included in the present study belong to four genera of family Amaryllidaceae viz. *Narcissus tazetta,* cv. Kashmir Local; *Narcissus pseudonarcissus* cv. Emperor; *Narcissus poeticus* cv. Pheasant's Eye; *Hippeastrum aulicum* cv. Platifolium; *Amaryllis belladonna* cv. Rosea and *Nerine sarniensis* cv. Red. Studies were conducted to gain an insight into the mechanism of flower senescence with the ultimate aim to delay it in these plant species. However, due to the paucity of the material and difficulty in handling all the experiments, the studies related to postharvest improvement were restricted to *Narcissus tazetta, Narcissus pseudonarcissus, Amaryllis belladonna* and *Nerine sarniensis.* The postharvest experiments were planned depending upon the availability of the particular plant material and keeping in view the importance of the particular experiment; besides, the handling of the experiments within the particular harvesting period. The postharvest improvement through chemical regulation was mainly pursued by using biocides (8-Hydroxyquinoline sulphate 8-HQS), carbohydrates (Sucrose SUC), protein synthesis inhibitors (Cycloheximide CHI), ethylene antagonists (Silver thiosulphate STS; Aminooxyacetic acid AOA) and growth regulators (gibberellic acid $GA_{3;}$ kinetin KIN, benzyl amino purine BAP). These experiments were planned keeping in view of the availability of the plant material and preliminary trials on a particular plant species. The postharvest storage experiments wet or dry (PHWS or PHDS) were generally pursued after 72 h storage of scapes at 5^0 C, 10^0 C and room temperature RT. The postharvest performance was later on assessed in different vase solutions (DW, SUC and SUC +8-HQS).

The process of flower senescence in general and tepal or petal senescence in particular has been shown to be a genetically programmed event and a great deal of research in this area has led to review and reevaluate senescence and cell death in plant tissues (Rubinstein, 2000; Eason *et al*., 2002; Wagstaff *et al*., 2002; van Doorn, 2004; Hoeberichts *et al*., 2005; Zhou *et al*., 2005; Eason, 2006; Price *et al*., 2008; van Doorn and Woltering, 2008; Shibuya *et al*., 2009; Woltering and van Doorn, 2009). Flower tepals or petals are ideal tissues for cell death studies as they are short lived, the tissue is relatively homogenous and chemical manipulation can be applied without substantial wounding. Tepal or petal senescence is a part of a developmental continuum in the flower, preceded by tissue differentiation, growth and development of seeds and coordinated by plant hormones. The process of tepal or petal senescence has been found to be accompanied by decline in petal or tepal mass, proteins, soluble carbohydrates, nucleic acids and increase in the activity of catabolic enzymes, amino acid content, ion leakage, DNA degradation, nuclear fragmentation; besides the mobilization of nutrients from senescing petals to other parts of the same flower (e.g. the developing ovary) or to other flowers of the same branch has also been observed (Halevy and Mayak, 1979; Xu and Hanson, 2000; Yamada *et al*., 2001; van der Kop *et al*., 2003; Woltering *et al*., 2005; Zhou *et al*., 2005; van Doorn and Woltering, 2008).

The process of tepal or petal senescence is complex as in many flowers petals abscise well before the visible senescence and nutrient mobilization, besides ethylene has been shown to modulate senescence in a number of flowers (Woltering and van Doorn, 1988; Stead and van Doorn, 1994; van Doorn and Woltering, 2008). In flowering ornamentals the condition of the tepals or petals is the most important determinant of their freshness and understanding the physiology of tepal or petal senescence is essential in improving the postharvest quality of ornamentals. Keeping in

view the diversity of floral behaviour it is realized that detailed studies are required to fully understand the process in individual genera, species and perhaps even cultivars (Reid, 2005). It is in this perspective that the present investigation has been undertaken on so far unexplored ornamental members of Amaryllidaceae to understand the changes occurring during flower development and senescence with the ultimate aim to improve the postharvest performance of these beautiful flowers.

The petal or tepal senescence is visibly shown either by flower wilting or by shedding of flower parts termed as abscission or even wilting followed by abscission (Hunter and Reid, 2001; van Doorn and Woltering, 2008). Blossom fading prior to wilting or abscission is also considered to be an early visible symptom of senescence (Triparthi and Tuteja, 2007). During the present study it was revealed that flower senescence is pursued through tepal wilting in Narcissi, *Hippeastrum*, and *Amaryllis* and by blossom fading prior to wilting in *Nerine*. Flowers of *Narcissus tazetta* after opening had a field life of five days. During senescence the tepals lose turgor, become translucent with the dilation of corona followed by wilting and drying of tepals and subsequently corona. *Narcissus pseudonarcissus* after blooming had a field life of three days. Senescence in this species is characterized by the loss of turgor in tepals which become papery, finally wilt and dry on the protruded corona. The corona loses turgor and wilts subsequently. *Narcissus poeticus* after blooming possesses a field life of three days. During senescence the tepals lose turgor, become slightly translucent, papery with some expansion of corona followed by wilting and drying. Flowers of *Hippeastrum aulicum* after blooming had a field life of about four days. The senescence is characterized by the loss of turgor in tepals accompanied by the appearance of water soaked areas towards margins followed by wilting and drying. Flowers of *Amaryllis belladonna* after opening showed a field life of about 2.5 days. During senescence the tepals lose turgor, develop

bluish colouration toward the tips followed by wilting and finally drying. Flowers of *Nerine sarniensis* after blooming have a filed life of four days. The senescence is characterized by the fading of coloured blossoms. The tepals becomes curly, lose turgor along with stamens which turn brown. The tepals wilt and dry subsequently. It is pertinent to mention that in *Amaryllis belladonna* and *Nerine sarniensis* the bunch of leaves comes after the scape dislodges and these leaves persist till May to June following year. The present studies on the senescence patterns suggest that strategies of senescence differ even at family level within the genera. This corroborates the observation that the diversity of the floral senescence can differ within the genera, species and even cultivars (Reid, 2005).

During the present study on some ornamental members of Amaryllidaceae it was observed that the floral development is accompanied by an increase in floral diameter, fresh and dry mass of flowers, water content, total sugars, amino acids and phenols; whereas the content of soluble proteins generally decreased during floral development and senescence in the tepal tissues. During senescence phases; however, the fresh and dry mass of flowers, water content and respiratory pool of sugars registered a decrease. The content of non-reducing sugars invariably decreased in the tepal tissues from bud to bloom; however, in *Nerine sarniensis* the non-reducing sugars decreased during bud opening followed by increase during flower opening. The electrical conductivity of ion leachates registered a consistent increase throughout flower development and senescence. Generally the differences in tissue constituents showed up clearly when the data was expressed on per flower and dry mass bases suggesting that on per flower basis the effects got magnified due to dilution of the tissue constituents as the water content increased throughout floral development. On dry mass basis the tissue constituents got concentrated and the effects due to increase in water content did not show up resulting in clear

trends. However, the trends generally remained consistent on all these reference bases suggesting that the flower is a composite system and is under tight developmental control.

Flower represents the site for one of the most active growth periods during its transition from bud to bloom (Reid, 2005). As the flower opens up from tight buds, new cells are added to meet the demands for increased surface. The hydrolysis of carbohydrates is important for the expansion of sepals, petals or tepals. It has been shown that flower (sepals, petals or tepals) switch from being a sink to source during senescence and the changes such as decline of fresh mass, dry mass and soluble carbohydrates are often linked to PCD in ornamental plants (Zhou *et al*. 2005). The increase in fresh and dry mass of flowers during development as observed during the present study reflects the mobilization capabilities of tepal vasculature. A consistent feature of senescence is the loss of differential permeability of cell membranes leading to the loss of ionic gradients and pumps. Membrane permeability has been shown to increase with age in various flowers such as *Hemerocallis*, *Dianthus*, *Iris*, *Petunia*; besides it has been suggested that leakage may rather be an indicator of cell death and its increase a measure of dead cells (Borochov and Woodson, 1989; Stead and van Doorn, 1994; Celikel and van Doorn, 1995; van Doorn, 2004; Gulzar *et al.*, 2005; Eason, 2006; Triparthi and Tuteja, 2007; van Doorn and Woltering, 2008). Our studies showed that tepal wilting generally starts towards the margins indicating increasing plasmodesmata blockade to distal parts first rather than proximal parts, besides the tepal turgor loss is a hallmark of membrane damage which starts before the appearance of morphological symptoms. This is consistent with our observation on the increase in electrical conductivity of leachates throughout the flower development and senescence.

The process of flower development and senescence is accompanied by the changes in sugar levels of the tepals tissue in accordance with the ongoing morphological developments. Flower maturation and senescence has been found to be accompanied by a decline in total soluble carbohydrate content in various flowers such as carnations, day-lily, iris and rose (Nichols, 1976; Paulin and Jamain, 1982; Lukaszewski and Reid, 1989; Lay – Yee *et al.*, 1992; Bieleski, 1993; Sultan and Farooq, 1997; Mwangi *et al,.* 2003; Gulzar *et al.,* 2005; Reid, 2005; Yamada *et al.*, 2007). One implication of this decrease in sugar levels may be due to enhanced rate of respiration which is responsible for rapid utilization of the available sugars (Mwangi *et al.,* 2003). It has been suggested that sugar metabolism is active in senescing cells as many carbon skeletons that are remobilized from macromolecules are transported out of the tepals mainly as sucrose (van Doorn and Woltering, 2008). Almost consistent increase in reducing and total sugar content of tepal tissues from bud to bloom and even up to partially senescence stage in *Narcissus poeticus* as observed during the present study has also been shown in other flower systems such as carnations (Panavas *et al*., 1999).

Proteins have been shown to play a significant role during flower senescence and recent biochemical studies have shown the synthesis of new proteins during senescence (Woodson, 1987; Woodson and Lawton, 1988; Woltering and van Doorn, 2009). During the present study an overall decrease in the content of soluble proteins was observed as the flower development progressed towards senescence in all the six plant species of Amaryllidaceae. The increase in the protein content on per flower basis could be due to an increase in the hydration status during flower development. On dry mass basis the protein content decreased during flower development and senescence in *Narcissus tazetta*, *Narcissus poeticus, Amaryllis belladonna* and *Nerine sarniensis*; however, in *Narcissus*

pseudonarcissus and *Hippeastrum aulicum* the protein content increased from bud to bloom followed by a decrease during senescence. In *Narcissus tazetta* the protein content on dry mass basis increased slightly towards the commencement of initial phase of senescence. The protein degradation in tepal tissue during flower senescence has been shown to start before the onset of visible symptoms of senescence (van Doorn, 2004). The increase in protein content towards the commencement of senescence in such species such as *Narcissus tazetta* suggests the development of senescence related proteins. Recent studies indicate that factors controlling senescence related changes are indicated prior to the development of visual symptoms of senescence and involve new protein synthesis (Celikel and van Doorn, 1995; van Doorn *et al*., 1995; Panavas and Rubinstein, 1998). An overall decrease in cell proteins levels as reported both in ethylene sensitive and insensitive flower senescence has been attributed either to decrease in protein synthesis or to an increase in protein degradation, the latter appears to play a significant role in flower senescence as the expression of protease genes is one of the earliest senescence related changes (van Doorn and Stead, 1994; Eason *et al*., 2002; van Doorn and Woltering, 2008). It is pertinent to mention that cell death processes have recently been thought to be regulated by anti and pro death proteins which may be expressed throughout the life of the flower (Eason, 2006).

Studies on electrophoretic profiles of proteins form tepal tissue through SDS – PAGE revealed a decrease of high molecular weight proteins and an increase of the low molecular weight proteins in Narcissi, *Hippeastrum aulicum, Amaryllis belladonna* and *Nerine sarniensis*. However in *Narcissus pseudonarcissus, Narcissus poeticus, Hippeastrum aulicum* and *Nerine sarniensis*. SDA- PAGE revealed that some proteins showed differential expression during flower development and senescence. This corroborates the similar findings on flowers such as

Hibiscus and *Hemerocallis* (Woodson and Handa, 1987; Courtney *et al*., 1994). In *Narcissus tazetta* and *Amaryllis belladonna* the polypeptides having the approximate molecular weights of 7.5 and 15.1 kDA showed up during senescent stages but at this stages we do not know whether these polypeptides play a significant role in senescence of these flowers. These findings suggest that the regulation of flower senescence is linked to protein turnover and that these newly synthesized proteins are probably involved in proteolysis.

The α-amino acids content from tepal tissue generally increased as the flowers progressed towards senescence. It has been shown in some flowers e.g. *Hemerocallis* that after the flower opens it abruptly changes from sink to source for transporting breakdown products of proteins (Bieleski, 1995). An apparent decrease in the amino acid content during the final stages of senescence as observed during the present study may be due to the strong supply of the breakdown products of proteins to the developing pistil. The total phenolic content generally decreased from bud to bloom and increased as the flower development progressed towards senescence. The increase in the content of phenolics particularly during flower development could be attributed to drastic increase in the hydration status during various stages. The leakage of ions and phenols preceding the visible symptoms of senescence has also been observed in tepals of cut Iris flowers placed in water (Celikel and van Doorn, 1995). The present study suggests that the accumulation of phenols in flower tepals during senescence is indicative of cell death and may be a consequence of increased membrane permeability.

Rapid senescence of ornamental flowers is highly undesirable from a postharvest perspective. Flower senescence involves a complex interplay of environmental stimuli and internal genetic regulation (Triparthi and Tuteja, 2007; van Doorn and Woltering, 2008). From an ecological point of view senescence should be regarded as a functional process. In many flowers, the

petals rapidly senesce following pollination presumably to direct pollinators to other flowers on the plant and thereby to prevent wasting energy necessary to maintain the petals, besides to retrieve nutrients from the senescing tissue. In the absence of pollination such flowers have a relatively long life span (e.g., Carnation, Petunia, Orchids). In other types of flowers, petal senescence seems to be independent of external stimuli such as pollination. Such flowers have generally a relatively short life span often less than one day (e.g. *Ipomea, Hibiscus*) but several flowers with longer span also belong to this category (e.g. *Aster*, *Gerbera*). Increased ethylene production is the signal mediating the pollination induced senescence. Ethylene is also the signal in various ethylene sensitive flowers even if the flowers do not become pollinated. Chemical and molecular strategies have been developed to block ethylene production or perception to prolong life span of such flowers (Woltering, *et al* .,2003; Serek *et al*., 2006). Postharvest studies provide an insight into the mechanism of senescence under controlled conditions.

Postharvest studies on ornamentals occupy a pivotal role in the emerging floricultural business all over the world. Postharvest physiology deals with the functional processes in intact plants or plant parts after these have been harvested and kept in storage for marketing. Postharvest physiology spans over the time period from harvest or removal of plant from its normal growing environment to the time of utilization. Both preharvesting and harvesting factors are vital for postharvest utilization of cut flowers. Postharvest quality characteristics include flower longevity and changes during handling, transportation or marketing. In case of cut flowers flower size, number and arrangement of open flowers are regarded to be important attributes for the display value and hence acceptability by the ultimate consumer (Worley *et al*., 2000). Much of the harvested cut flower material is discarded because of deterioration either due to natural

senescence, stress conditions, pathogen activity or even due to lack of proper storage and transport facilities. Therefore the thermal or chemical regulation of senescence in enhancing vase life and improving postharvest performance assume considerable significance in ornamental horticulture (Halevy and Mayak, 1979, 1981; Salunkhe *et al*., 1990). For horticulturists and consumers flower bloom is a critical parameter determining the commercial potential (Reid, 2005).

During postharvest vase period the preservative solutions comprising carbohydrates, biocides, plant growth regulators, ethylene antagonists are effective in preventing many disorders apart from providing nutrients necessary for flower opening, sustaining normal development and preventing bacterial growth within the vase (van Doorn *et al*., 1991; Ichimura *et al*., 1999; Eason *et al*., 2002; Redman *et al*., 2002; Janowska and Jerzy, 2004). Flower opening in many species is accompanied by the mobilization of storage carbohydrates and import of sucrose; besides the young petals of many species have been shown to mobilize glucose and fructose shortly before opening (Hammond, 1982; Collier, 1997; Bieleski *et al*., 2000). The exogenous application of sucrose supplies the flower with much needed substrates for respiration and not only prolongs vase life but also enables cut flowers harvested at the bud stage to open (Pun and Ichimura, 2003). Recently sucrose has been reported to prevent up regulation of senescence associated genes, besides acting as a repressor of senescence at transcriptional levels (Hoeberichts *et al*., 2007). Sucrose alone or in combination with biocides or antioxidants, 8- Hydroxyquinoline sulphate (8-HQS) has been shown to improve the postharvest performance of many cut flowers such as Tuberose, *Phalaenopsis, Leptospermum, Amaryllis* (Huang *et al*., 1995; Reddy *et al*., 1995; Burge *et al*., 1996; Gul *et al*., 2007). Part of the beneficial effects of 8-HQS have been attributed due to its effect on stomatal closure and in part due its antibacterial or antifungal activity

(Halevy and Mayak, 1979, 1981; Reid and Kofranek, 1980; Ichimura *et al*., 1999).

During the present investigation it was observed that sucrose (0.15M) alone or in combination with 8-HQS (50 mg L^{-1}) was effective as vase solution in improving the postharvest performance of cut scapes of *Narcissus tazetta*, *Narcissus pseudonarcissus*, *Amaryllis belladonna* and *Nerine sarniensis*. Our observations showed that the scapes of *Amaryllis belladonna* particularly and to a slight extent *Nerine sarniensis* when held in distilled water were susceptible to scape end splitting resulting in distortion of the scape and loss of cut flower performance. Preliminary trials showed that these postharvest disorders were preventable. For instance, sucrose (0.15M) given as continuous supply or as pulse for 3 h considerably reduced the scape end splitting suggesting a need for maintaining an osmotic balance between the scape tissues and the vase solution to prevent excess water uptake by the cells (Eason *et al*., 2002; Gul *et al*, 2007). Stem end splitting has also been reported earlier in *Cytranthus* cut flowers (Eason *et al.,* 2002). Sucrose (0.15M) in combination with growth regulators (gibberellic acid, kinetin and benzyl amino purine) enhanced vase life and improved postharvest performance in *Narcissus pseudonarcissus* and *Nerine sarniensis*. In combination with cobalt chloride (0.15mM) sucrose delayed senescence in cut scapes of *Amaryllis belladonna* and *Nerine sarniensis*. Cobalt has been found to enhance water uptake, maintain water balance and fresh mass in flower such as *Hemerocallis* and *Iris* (Zhou *et al.,* 1994; Venkatesh – Reddy, 1988).

During the present study the treatment of scapes of *Narcissus tazetta*, *Narcissus pseudonarcissus* and *Nerine sarniensis* with cycloheximide (a protein synthesis inhibitor at the translational level) followed by transfer to vase solution containing either distilled water or sucrose (0.15M) has been studied on senescence and postharvest performance. The scapes were pulse

treated for 1h with different concentrations cycloheximide before transfer to solutions. The results of our experiments suggest that pretreatment of scapes with a particular threshold concentration of CHI (0.01 and 0.05mM) delays senescence, maintains a sustained rate of blooming; besides improving postharvest performance. However, at higher concentrations (> 0.05mM) CHI prevents bud or flower opening and promotes positive gravitropism and senescence. At 0.01 and 0.05mM concentrations CHI was found to maintain fresh and dry mass, membrane integrity, respiratory pool of sugars; besides slowing down the process of protein degradation as the flowers opened and then senesced. The results of our experiments suggest that pretreatment of scapes at 0.01 and 0.05mM CHI before transfer to distilled water or sucrose enhanced vase life by an increment of 3 to 7 days in *Narcissus tazetta*, 3 to 6 days in *Narcissus pseudonarcissus* and 5 to 6 days in *Nerine sarniensis*. Cycloheximide has been found to delay senescence in *Dianthus*, *Hemerocallis, Gladiolus* and *Iris* (Wulster *et al.,* 1982; Lukaszewski and Reid, 1989; Jones *et al*., 1994; van Doorn *et al.,* 1995; Gulzar *et al*., 2005). Cycloheximide has been shown to inhibit the flower opening and also delay senescence depending upon the stages at which it is included in the experiment (Celikel and van Doorn, 1995; Gulzar *et al*., 2005; Zhou *et al*., 2005). The effect of cycloheximide in delaying the senescence does not seem to be due to improvement of water balance as pretreatment of scapes with various concentrations of CHI resulted in corresponding decrease in the volume of holding solution absorbed. Cycloheximide has been shown to rapidly reduce the rate of transpiration and water uptake in *Iris* tepal which apparently was not suggested to be the reason for the delay in tepal wilting (van Doorn *et al*., 1995). The delay in leakiness of tepal by the application of cycloheximide as revealed during the present study has been shown to indicate that one or more proteins synthesized *de novo* are responsible for increase in leakiness; the protein that is rate limiting in the senescence

programme could either be a factor that regulates gene expression or an enzyme (Celikel and van Doorn, 1995). It is interesting to note that understanding the cause of membrane breakdown in senescing tissues has implications for signal transduction chains, as the components of these chains are often associated with the membranes; use of potent protein synthesis inhibitors like CHI in maintaining the membrane integrity could modulate such cascades. Such studies offer scope to identify the components of signal transduction chains leading to PCD. Maintenance of higher fresh and dry mass of flowers particularly at lower concentrations of CHI (0.01 and 0.05 mM) could be due to lower respiratory losses as CHI has been found to suppress respiration in certain plant tissues; besides in *Hemerocallis* it has been shown to abolish the peak in respiration at the start of senescence (Ellis and Macdonald, 1970; Bieleski and Reid, 1992).

The maintenance of total sugars in CHI treated samples during the current investigation suggests that delay in senescence is caused by the curtailment of respiratory climacteric otherwise in normal senescence process sugars are rapidly respired and utilized (Mwangi *et al*., 2003; Gulzar *et al*., 2005). Pretreatment of scapes with CHI (0.01 and 0.05 mM) concentrations resulted in an increase in the content of soluble proteins followed by a decrease with higher concentrations of CHI (0.1 and 0.5 mM). It has been suggested that CHI maintained a higher protein content presumably by inhibiting specific proteases responsible for protein degradation; however in order to establish a relationship between increase in cell leakiness and protein degradation, protein levels of tonoplast or plasma membrane need to be assessed. Cycloheximide has been shown to delay the decrease in protein levels and increase the time to visible senescence in day lily tepals; besides curtailing the decline of protein populations (Lay – Yee *et al*., 1992; Courtney *et al.,* 1994). The ability of cycloheximide to delay senescence of flowers has been attributed to the fact that senescence requires

active gene expression and *de novo* protein synthesis (Dilley and Carpenter, 1975; Wulster *et al*., 1982; Lukaszewski and Reid, 1989; Lay –Yee *et al*., 1992; van Doorn *et al*., 1995). The modification of proteolysis in the down regulation of senescence associated cysteine proteases offers a strategy to produce transgenic plants as has been achieved in *Brocolli* (Eason *et al*., 2005). Even the active compound in the mucilage of daffodil flowers (Narciclasine) which delayed tepal senescence in cut Iris flowers is known to inhibit protein synthesis (van Doorn *et al*., 2004).The present results suggest that the effects of cycloheximide indicate a programme at the cellular level. The fact that cycloheximide delays petal senescence demonstrates that the synthesis of particular suicide proteins orchestrate the cell death programme and that CHI exercises its regulatory effects in improving postharvest performance.

Amaryllidaceae *per se* is regarded to be an ethylene insensitive family (Woltering and van Doorn, 1988). However, during the present investigation flower senescence in *Narcissus pseudonarcissus* cv. Emperor and *Nerine sarniensis* cv. Red was found to be ethylene sensitive in that pulse treatment with inhibitors of ethylene action silver thiosulphate (STS) or synthesis aminooxyacetic acid (AOA) resulted in the delay of senescence and improvement in postharvest performance. Pulse treatment with STS or AOA followed by transfer to vase solutions containing either distilled water or sucrose 0.15M (alone or in combination with 8-HQS 50 mg L^{-1}) was found to increase longevity, enhance solution uptake; besides maintaining sustained rate of blooming, fresh or dry mass, membrane integrity and respiratory pool of sugars as also soluble proteins. Treatment of scapes in *Narcissus pseudonarcissus and Nerine sarniensis* with STS or AOA resulted in the enhancement of vase life by an increment of 6- 8 days in *Narcissus. pseudonarcissus* and 4-7 days in *Nerine sarniensis*. The flowers of families such as Geraniaceae, Lamiaceae, Ranunculaceae, Rosaceae and

Scrophulariaceae have been reported to show accelerated senescence of petals and flowers when exposed to 0.1 to 1.0 μL/L of ethylene (Woltering and van Doorn, 1998). Treatment with STS has been found to prolong the vase life of many cut flowers such as *Consolida*, *Petunia* and *Lathyrus* (Borochov *et al*., 1997; Ichimura and Hiraya, 1999; Finger *et al*., 2004). Similarly pretreatment with AOA has been shown to be effective in reducing respiration rate, ethylene production and enhancing vase life (Goh *et al*., 1985; Woltering, 1987; Bichara and van Staden, 1993; Porat *et al*., 1995 a, Uda *et al*., 1997). Our results pertaining to ethylene sensitivity of *Narcissus pseudonarcissus* and *Nerine sarniensis* corroborate with earlier findings (Harkema and Woltering, 1981; Lukaszewska, 1997; Hunter *et al*., 2001).

During the present investigation the effect of gibberellic acid (GA_3) and cytokinins (kinetin and benzyl amino purine) was evaluated on senescence and postharvest performance in *Nerine sarniensis*. The growth regulators when supplied alone or in combination with sucrose (0.15M) or cobalt chloride) delayed senescence and improved postharvest performance. Kinetin and benzyl amino purine (50 mg L^{-1}) enhanced flower longevity by an increment of 3 to 4 days, enhanced the solution uptake; besides maintaining higher fresh or dry mass, membrane integrity, sugars and protein content. Cytokinins have been shown to delay senescence and slow down ageing process in various flowers such as rose, carnation and petunia (Mayak and Halevy, 1972; van Stead and Dimmala, 1980; Borochov and Woodson, 1989; van Staden *et al*.,1990; Lara *et al*., 2004). Cytokinins have been suggested to maintain the integrity of tonoplast membranes preventing the leakage of proteases from the vacuoles into the cytoplasm which could otherwise hydrolyze soluble proteins (Thiman, 1987). Cytokinins slow down the process of senescence possibly by their ability to promote the transport, accumulation and retention of metabolites in tissues and organs; besides protecting membranes against degradation (Lesham, 1988; Beckman and

Ingram, 1994). Apart from their general effects on growth and metabolism, cytokinins have been shown to inhibit ethylene biosynthesis by influencing the activity of ACC- synthase and ACC – oxidase (Mor *et al*., 1984; Cook *et al*., 1985; Sacalis, 1986; Eason, 2006). Gibberellic acid GA_3 (25 mg L^{-1}) was found to enhance longevity by an increment of 3 to 5 days besides improving postharvest performance similar to that of cytokinins. The presence of gibberellic acid and sugars in the vase solutions or application of gibberellic acid have been found to enhance vase life and improve postharvest performance in various flowers such as *Narcissus*, *Dianthus*, *Nerine and Zantedeschia* (Goszezynska *et al*., 1989; Saks *et al*., 1993; Lukaszewska, 1997; Janowska and Jerzy, 2004). Our results showed that addition of cobalt chloride to a solution of sucrose and gibberellic acid could prove to be a better vase solution for *Nerine sarniensis* cut scapes. The detailed studies on the effects of growth regulators and their relationship with ethylene sensitivity need further investigation for future experimental work.

During the present course of investigation different sets of storage experiments were conducted on cut scapes of *Narcissus tazetta, Narcissus pseudonarcissus, Amaryllis belladonna* and *Nerine sarniensis*. The scapes were stored under dry or wet conditions at different temperature regimes (5^0C, 10^0C and room temperature RT) for 72 h and these scapes were assessed for their postharvest performance in vase solutions comprising of distilled water or sucrose (alone or in combination with 8-HQS). However, in case of *Amaryllis belladonna* an additional experiment where in wet storage was pursued for 24 h; was conducted in order to simulate the differences for postharvest performance as compared to 72 h storage. Generally the postharvest performance of scapes wet stored at 5^0C for 72 h was found to be much better as compared to the corresponding scapes held at 10^0C and RT. Our studies on dry storage in *Amaryllis belladonna* showed that the scapes exhibited deleterious effects which included chilling injury,

scape bending, bud abortion, tepal curling and colour change. So experiments pertaining to dry storage in *Amaryllis belladonna* could not be pursued during the present investigation. The optimal harvest maturity stage and postharvest temperature requirements of cut flowers are important for the maintenance of quality with respect to cut flower marketing. Scapes harvested at an immature stage may not open fully and tepals of flowers harvested at fully open stage are prone to damage and increased packaging cost. Harvest at an appropriate stage of flower development has been shown to influence the appearance, longevity and vase life of several cut flowers (Ahn and Park, 1996; Lee and Suh, 1996; Meulen-Muisers and Oeveren, 1997; Redman *et al*., 2002; Gul *et al*., 2007, 2009). Low temperature is recognized as the important factor in the successful storage of cut flowers by reducing both the plant metabolic processes and microbial growth rate (van Doorn and de Witte, 1991). Besides during postharvest vase period the preservative solutions comprising biocides, carbohydrates, plant growth regulators, ethylene antagonists are effective in preventing many disorders apart from providing nutrients necessary for flower opening, sustaining normal development and preventing bacterial growth within the vase solution (van Doorn *et al*., 1991; Ichimura *et al*., 1999; Eason *et al*., 2002; Redman *et al*., 2002; Janowska and Jerzy, 2004). The vase life of many cut flowers can be reduced by improper storage and variety performance can differ widely within a species; besides temperature can influence the respiration rate, response to ethylene, moisture loss and physical damage in various flowers (Cevallos and Reid, 2001; Leonard *et al*., 2001; Reid, 2001; Celikel and Reid, 2002).

During the present investigation scapes of *Narcissus tazetta, Narcissus pseudonarcissus, Amaryllis belladonna* and *Nerine sarniensis* were carefully selected after the determination of their optimal harvest maturity stage which has been designated as “tight bud stage”. The scapes cool and wet stored at 5^0C for 72 h showed enhanced vase life, sustained rate of blooming,

improved solution uptake, higher fresh or dry mass; besides maintaining membrane integrity by exhibiting significantly lower ion leakage from tepal tissues. This could be attributed to reduced metabolic processes at low temperatures. Low temperature storage has been reported to enhance the maximum fresh mass achieved in cut rose flowers; besides a higher storage temperature has been shown to decrease the initial increment in fresh mass of *Grevillea* 'Sylvia' inflorescences (Ichimura *et al*., 1999; Joyce *et al*., 2000). Our results corroborate with the earlier findings about maintenance of membrane integrity at low temperature of 3^0C in cut roses (Faragher *et al*., 1986). Maximum vase life was observed in scapes previously wet stored for 72 h at 5^0C and transferred to (SUC +8-HQS); the enhancement of vase life was achieved by an increment of 6 days in *Narcissus tazetta*, 2 days in *Narcissus pseudonarcissus*, 3 days in *Amaryllis belladonna* and 6 days in *Nerine sarniensis*.

Higher content of sugars was maintained in tepal tissues from flowers of scapes stored at 5^0C or 10^0C for 72 h before transfer to vase solutions particularly SUC +8-HQS as compared to the scapes kept at room temperature. The increase was particularly marked when the data was expressed on per flower and dry mass bases. The concentration of various carbohydrate fractions such as glucose, fructose and sucrose has been shown to increase at low temperature regimes in cut roses (Ichimura *et al*., 1999). The effects of low temperature can be attributed to the increase in carbohydrate concentration in tepals, thus enhancing the influx of water and osmolyte in the tepal cells. A significant increase the content of soluble protein as also phenols and a decrease in α-amino acids was recorded in samples from flowers of scapes stored at 5^0C for 72 h before transfer to a vase solution particularly SUC +8-HQS. Maintenance of higher protein content in the tepal tissues at low temperatures could be attributed to inhibition of specific proteases responsible for protein

degradation. Besides, a high content of total phenols has also been associated with longer vase life in cut rose petals (Mwangi *et al*., 2003).

The present results suggests that the scapes of *Narcissus tazetta, Narcissus pseudonarcissus, Amaryllis belladonna* and *Nerine sarniensis* harvested at the right stage (tight bud stage) can provide good models for market flexibility as export cut flower crops. The scapes may be cool stored at 5^0C for 72 h before transferring them into vase solutions without affecting their subsequent vase life. Wet handling in buckets may be easier and less labour intensive for domestic marketing.

From the present studies on some ornamental species of family Amaryllidaceae, it can be suggested that protein turnover (synthesis and degradation) plays a central role in both ethylene sensitive and insensitive flower systems and that tepal or petal senescence assumes lots of significance in the overall process. The loss of membrane integrity, decline in fresh or dry mass and reduction in the respiratory pool of sugars are the consequences of senescence. Besides, the growth regulators also have a significant role to play in this process. For ethylene insensitive flowers, no clear master switch that regulates the senescence has been identified as yet. Besides ethylene sensitivity can vary within particular family and even at species level. The observation that cycloheximide delays senescence in both ethylene dependent and ethylene independent flower systems is an indicator that it could be used to modulate senescence programme and can help in the study of the expression of senescence associated proteins or suicide proteins orchestrating the death programme; however it is necessary to show that these proteins and their products play a causal role. The expression of some low molecular weight proteins particularly in *Narcissus tazetta* and *Amaryllis belladonna* as revealed by preliminary electrophoretic studies can be pursued to ascertain the role of these so called "death proteins" during flower senescence. The present studies reveal that ornamental members of Amaryllidaceae have an immense potential

in the floricultural market and the storage protocols developed during present study offer lot of scope to improve the postharvest performance for efficient export and domestic marketing.

Future strategies for studies pertaining to pre and postharvest improvements:

1) Sowing the bulbs according to different size and weight classes and assess their effect on flowering performance.
2) Forcing the bulbs to flower under controlled conditions by various physical and chemical methods to ensure staggered flowering.
3) Using protein synthesis inhibitions as a strategy to modulate senescence programme.
4) Isolation of marker proteins related to flower senescence in various species and modulating them to delay senescence.
5) Comprehensive studies pertaining to effective storage protocols at the molecular levels in order to assess and evaluate role of proteins at low temperatures.
6) Assess the role of sugars more comprehensively in order to assess the following questions :

Do sugars provide only substrates for respiration, structural support, improvement of water balance or do they have a role to interfere with ethylene biosynthesis or action.

Do sugars prevent upregulation of senescence associated progremmes. Studies on sugars induced signal transduction or sugar senescing or sucrose sensitivity can provide a lot of information in this regard.

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