# PHYSIOLOGICAL INVESTIGATIONS OF THE RESPONSE OF WHEAT (Triticum aestivum L.) TO SOIL SALINITY



by

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# ABSTRACT

A series of greenhouse and control environment experiments were carried out to study the response of some wheat cultivars (*Triticum aestivum* L.) to soil salinity.

The rate and percentage of seed germination were reduced by increasing soil salinity. The cultivar Falchetto was more tolerant in terms of germination than the other cultivars under saline conditions.

Increasing salinity consistently reduced the growth and dry matter production of all wheat cultivars used. The most sensitive growth character to salinity was leaf area and tiller number while net assimilation rate was least sensitive and sometimes not affected by salinity. The retardation of growth under salt stress in this study may result from reduced leaf area for photosynthesis, but the cause of reduced leaf area is not clear.

In all cultivars tested, grain yield and its components were reduced by increasing soil salinity (0 - 0.6% salt) or irrigation with saline water (0 - 4000 ppm salt). The most sensitive yield characters to salinity were spike number and grain number per spike while spike length and spikelet number per spike were less sensitive as compared with the other components. Falchetto and Shakha 62 were less sensitive than the other cultivars used in this study.

Leaf proline content increased while leaf chlorophyll content decreased with increasing soil salinity. Also, leaf and stem content of sodium, calcium and magnesium increased with increasing salinity

levels both in vegetative parts and in grains. Increasing soil salinity increased ash and protein content of wheat grains but decreased moisture and total carbohydrate content.

Application of nitrogen fertilizer under saline conditions enhanced grain yield and its components and to some extent countered the adverse effect of soil salinity up to 0.4%. While added nitrogen did not increase growth and dry weight of wheat plant significantly, crop growth rate increased significantly. On the other hand spraying wheat crop with trace elements did not affect the growth and grain yield and its components except 1000 kernel weight under saline conditions.

The interaction effect between salinity and some environmental factors was significant on germination and growth. Under saline and non-saline conditions increasing temperature from 10 to 20°C increased germination capacity and depressed it between 20 and 30°C. Also, increased relative humidity from 47 to 92% increased germination capacity. For vegetative growth, generally, increasing temperature up to 20°C, relative humidity from 47 to 92%, and available soil water content from 20 to 100% increased vegetative growth and dry matter production of wheat plant under saline and non-saline conditions.

The interaction effect between salinity and presoaking with plant growth regulators (CCC, $GA_3$, IAA and Kinetin) and salt solutions (Nacl and $Cacl_2$ ) on germination and growth of wheat accelerated germination under saline and non-saline conditions. For some characters presoaking with these plant growth regulators or salt reduced the deleterious effect of salinity and improved plant performance at these early stages of growth under saline conditions.

Water and osmotic potentials, total and relative water content (RWC) and transpiration rate decreased and stomatal number per microscope field increased with increasing soil salinity, but turgor potential was essentially unchanged by increasing soil salinity indicating osmotic adjustment. Also, it is evident from the water relations, PEG and RH experiments that ion toxicity effect operated in addition to the osmotic one during early stages of growth.

CONTENTS

# CHAPTER I

## INTRODUCTION AND LITERATURE REVIEW

### Introduction

Salinity remains one of man's oldest environmental problems. For example, historical records show a shift in agriculture in the Tigris-Euphrates basin of ancient Mesopotamia from the Cultivation of wheat to the more salt-tolerant barley (1700 B.C.) as the fertile, but poorly drained, soils became increasingly saline (Jacobson and Adams, 1958). This was subsequently followed by a serious decline in the yield of barley and is considered to have played an important role in the break up of Sumerian Civilization in Mesopotamia (18th Century B.C.). Today millions of hectares of lands throughout the world are too saline to produce economic crop yields. It has been estimated that one third of the 230 x $10^6$ha currently under irrigation is affected by salinity, and more land becomes nonproductive each year because of salt accumulation (Carter, 1975). Salinity problems in agriculture are usually confined to arid and semiarid regions where high evaporation rates tend to further concentrate the salt near the soil surface and in surface waters and rainfall is not sufficient to leach the salts from the plant root zone (Carter, 1975). Salinity problems of economic importance may arise when previously non-saline soils become saline as a result of irrigation. Water used for irrigation may contain from 100 to 1000g of salt per cubic meter of water. Since the annual application of water may amount to 10000$m^3$/ha, the annual addition of salt to the soil may be between 1 and 10 tonnes/ha. The trend of salt accumulation in soil irrigated with waters having four different salt concentrations is illustrated in Fig. (1).

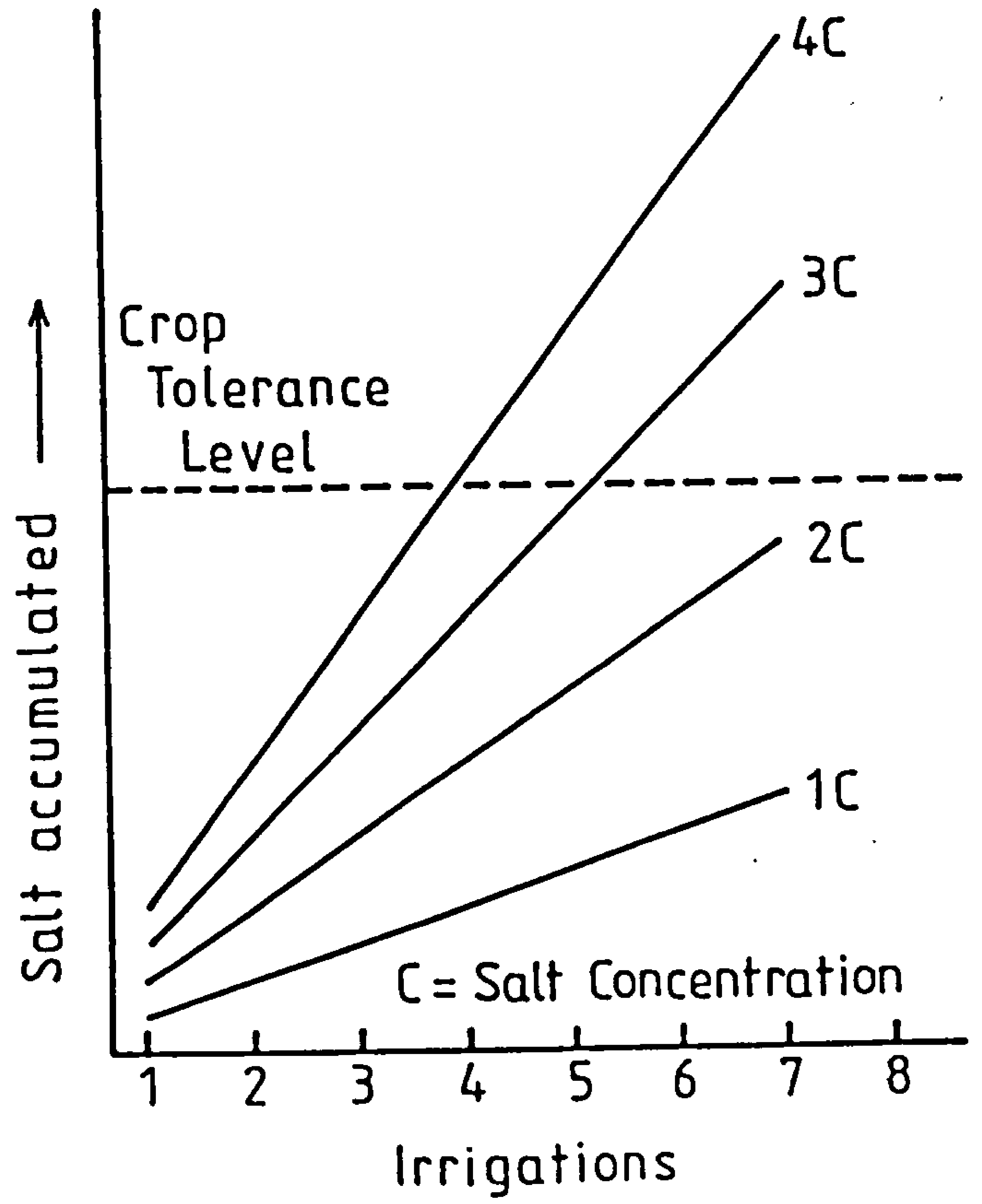



Fig. 1 Hypothetical salt accumulation in soil as related to the salt concentration in irrigation water and number of irrigations, in the absence of leaching. ( Carter, 1975 ).

Figure 1 is a generalized illustration. It should be realised that the tolerance level varies for different crops.

Drainage water that has passed through the soil has a higher salt concentration than irrigation water (Willcox and Resch, 1963; Carter et al., 1971). Most of this drainage water returns to the natural stream or river channel, downstream from the point where the irrigation water is diverted. As a result the salt concentration in rivers and streams in arid and semiarid regions generally increases from the headwaters to the mouth. This in itself, creates a salinity problem for agriculture.

Irrigation in one area may cause problems in another. Salts may be transported from one cropped area with adequate drainage to another with inadequate drainage where they accumulate. In many irrigated valleys, this problem has seriously limited productivity on the best agricultural soils.

Although salt accumulation resulting from evapotranspiration is the primary cause of salinity problems in agriculture, there are other sources of salt. Some soils naturally contain sufficient salt to limit or prohibit production of economic crops. Some of these soils were derived from saline parent material, and some contain natural salt deposits. Some soils have received sufficient salt from sea spray to become saline (Yaalon, 1963).

It is difficult to determine the extent of the inland saline and alkali lands because there is no accepted criterion as to when a soil is to be regarded as belonging to one category or the other. In most cases salinity of inland areas is related to high aridity plus a saline water table from rocks rich in sodium salt. Saline water tables are due to low physiographic gradients so that the water accumulates rather than drain away (Hayward, 1954).

Of the 14 billion hectares of land in the world only around 1.4 billion are non-stressed good crop land. Of the remainder, 2.9 billion have mineral stress (Fig (2)), 3.7 billion have drought stress, 1.6 billion have excess water, 3.2 billion have shallow soil profiles

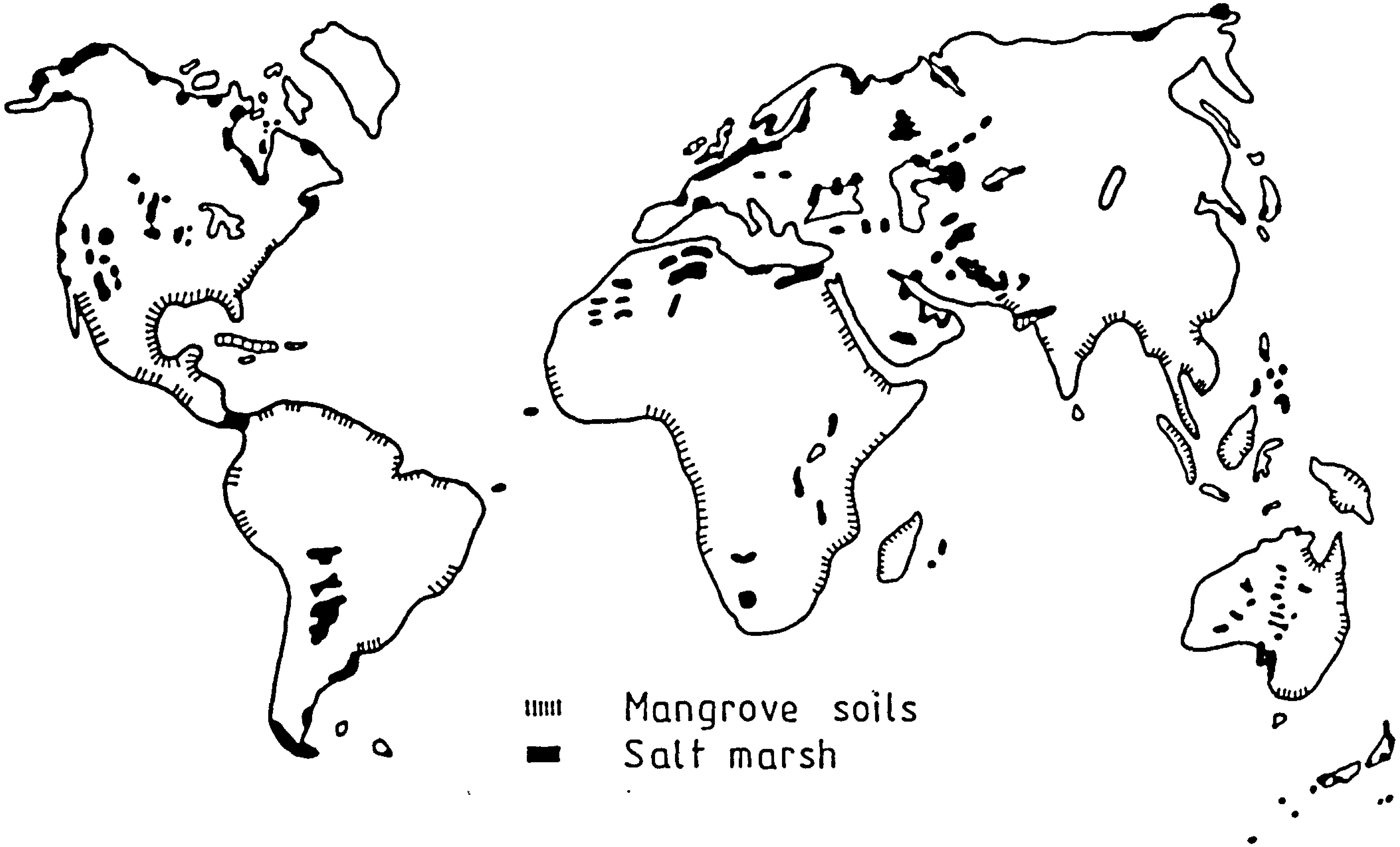



Fig. 2 Distribution of naturally saline soils.

and 2.0 billion have permanent freezing (Christiansen, 1982). Arable and potentially arable world land which could produce reasonable crop returns is usually estimated at 3.2 billion hectares.

In terms of specific mineral stresses approximately 1.0 billion hectares are affected by excess salt, principally sodium (Massoud, 1974). This represents 31% of current or potential croplands. Sodium toxicity is an important problem in arid regions, in irrigated areas and in estuarine regions. The build up of sodium salts in irrigated regions is of particular concern since 14% of cultivated land which is irrigated supplies approximately half of the world's food (Christiansen, 1982).

In Egypt, especially in North Delta of the river Nile, the problem of salinity in agriculture becomes increasingly acute because:

1. too much irrigation water is applied by farmers, rather than risk applying too little. These applications, together with bad drainage systems and hot weather increase evaporation and tend to create salinity.

2. the construction of the High Dam nearest Aswan prevents the Nile flooding. Prior to the building of the Dam, flooding leached the salts from the soil on a fairly regular basis.

3. the excess water applied raises the water table, causing damage not only by water-logging the soil but also increasing the movement of salts into the upper root zone.

4. North Delta soils are close to the coast of the Mediterranean sea, so salinity occurs naturally in coastal areas subject to seawater intrusion or flooding Also close to the coast

there is a high concentration of salts in rain fall during the winter season and the ionic composition of rain fall resembles that of sea water. Soil salinity causes great losses to agriculture by lowering the yields of various crops. Combating soil salinization is of the utmost importance in the national economy of Egypt.

Investigations of the physiology of salt injury and tolerance have practical implications, because they provide the basis for selection of salt-tolerant species, and for devising methods to increase the salt tolerance of plants.

Salinization of soil creats extremely unfavourable conditions for plant growth. Accumulation, even of harmless salts, decreases the osmotic potential of the soil solution, making less steep the gradient of water potential from the soil to plant. Some salts affect plants also as specific poisons. It is difficult to distinguish between the osmotic and toxic effects of salts, since this distinction depends on the concentration and the physio-chemical properties of the salts.

According to recent concepts, plants can be divided, depending on their reaction to salinity into two basic groups. These are halophytes and glycophytes. According to Genkel (1954), halophytes are plants growing in saline habitats. They easily become adapted during their Ontogenesis, to high salt content in the soil. Glycophytes are plants growing in non-saline soil habitats. They are comparatively limited in their ability to adapt themselves to salinity during their individual development, because the conditions prevailing during their evaluation did not favour the development of such properties

(Genkel, 1954). Halophytes and glycophytes are met among both higher and lower plants. In nature there is no strict division of plants into glycophytes and halophytes since plants with intermediate properties exist. There are also facultative halophytes, e.g. Cotton (Novikov, 1942). As a result of many observations on the salt resistance of plants, including cultivated plants, it is possible to distinguish degrees of halophytism and glycophytism. Halophytes of various families form, on saline soils, the so-called "solonchakous" vegetation, having typical morphological - anatomical features. According to Varming (1902) plants of several families (Chenopodiaceae, Portulacaceae, Plumbaginaceae, Tamaricaceae, Aizoaceae, Frankeniaceae) require a comparatively high salt content in the soil, as an obligatory condition for their normal growth and development. Numerous investigators (Chermezon, 1910; Keller, 1923; Genkel, 1946; Hass, 1945; Arnold, 1955; Shakhov, 1956; Balck, 1960; Blumental-Goldschmidt and Poljakoff-Mayber, 1968; Pallayhy, 1970; Waisel, 1972; Chimiklis and Karlander, 1973; Stewart and Lee, 1974, Stewart et al. 1972, 1973; Flowers et al 1977; Yeo, 1981) have studied the ecology, morphology and physiology of numerous halophytes. They demonstrated that halophytes are capable of growing on saline soils containing 0.3-20% salt, but most halophytes grow on soils with salt content of 2-6%. The adaptation of halophytes to such high concentration of salts is so great, that their development is impaired in the absence of salts.

Biological adaptation of halophytes to salinity is very variable and is achieved in different ways. Some halophytes absorb comparatively small amounts of salts, while others absorb considerable amounts, accumulating salts in the tissues and, with their aid, regulating their internal osmotic potential. Halophytes are able to regulate their salt balance. When excess salt is accumulated it may be excreted by special glands, or lost by leaf abscission. Root excretion is also possible. Halophytes may accumulate very large amounts of salts in their organs (Keller, 1940). According to Keller, the absorbed nonnutrient salts play an important part in the life of halophytes as regulators of the water holding capacity of the organs. Due to great accumulation of salt, the root cells of halophytes have a lower osmotic potential than that of the soil solutions thus enabling them to absorb water, from saline soil down a gradient of potential. Unfortunately, agriculturally important species, with the exception of sugar beet, are not considered to be halophytes. Sugar beet is a halophyte in the sense that it benefits from fertilisation with sodium salts. It cannot however withstand excessive amount, up to 32mS/cm, (El-Sheik et al. 1967).

Glycophytes, including most agricultural species, differ from halophytes in their unfavourable reaction to an excess of water-soluble salts in the soil. Glycophytes growing on saline soils are usually also characterised by lowered metabolism. It is difficult, however, to establish this unequivocally, especially for cultivated plants (Strogonov, 1962). However, degrees of salt tolerance have been found in agricultural crops allowing them to be grown on saline soils. The degree of tolerance must of course be matched to the degree of salinity of the soil, but crops of cotton, barley, rye, sweet clover, asparagus and wheat can be grown on moderately saline soils, Table (1) : Salt tolerance of cultivated plants

| Salinity | Salt content, % dry weight of soil | Plant growing at given salinity |
|---|---|---|
| Negligible... | <0.1 | All crops possible, including Maize, salinity only effects certain vegetables and fruit trees. |
| Slight | 0.1 - 0.4 | All grains except nontolerant Maize Sorghum, millet, peas, vicia faba var. equina, alfalfa and vetch. |
| Medium | 0.4 - 0.6 | Cotton, barley, rye, asparagus, agrostis alba, timothy, Dactylis, sweet clover, wheat, oats (for hay) |
| Medium to high | 0.6 - 0.8 | Brassica napus, fodder cabbage, Festuca pratensis, lolium multiflorum Agropyron tenerum, sorghum, barley (for hay) |
| High<br>Very high<br>Extremely high | 0.8 - 1.0<br>1.0 - 1.5<br>>1.5 | Sugar beet, agropyron (western), Bromus inermis, Arrhenatherum P.B. |

(From Strogonov, Physiological basis of salt tolerance of plants, as affected by various types of salinity, 1964)

| Sensitive<br>EC 0-0.8 siemen/m | Moderately sensitive<br>0.8 - 1.6 siemen/m | Moderately tolerant<br>1.6 - 2.5 siemen/m | tolerant<br>2.5 - 3.2 siemen/m |
|---|---|---|---|
| e.g. Bean | e.g. Alfalfa | e.g. Barley (forage) | e.g. Barley (grain) |
| Carrot | Clover | Beet | Cotton |
| OKra | Corn | Ryegrass | Sugarbeet |
| Onion | Flax | Safflower | Wheatgrass (tall) |
| Strawberry | Millet | Sorghum | |
| | Rice | Soybean | |
| | Sugar cance | Wheat | |
| | | Wheatgrass (crested) | |

Table (2) : Relative salt tolerance of crop plants based on the yield response boundaries of.fig. (3)

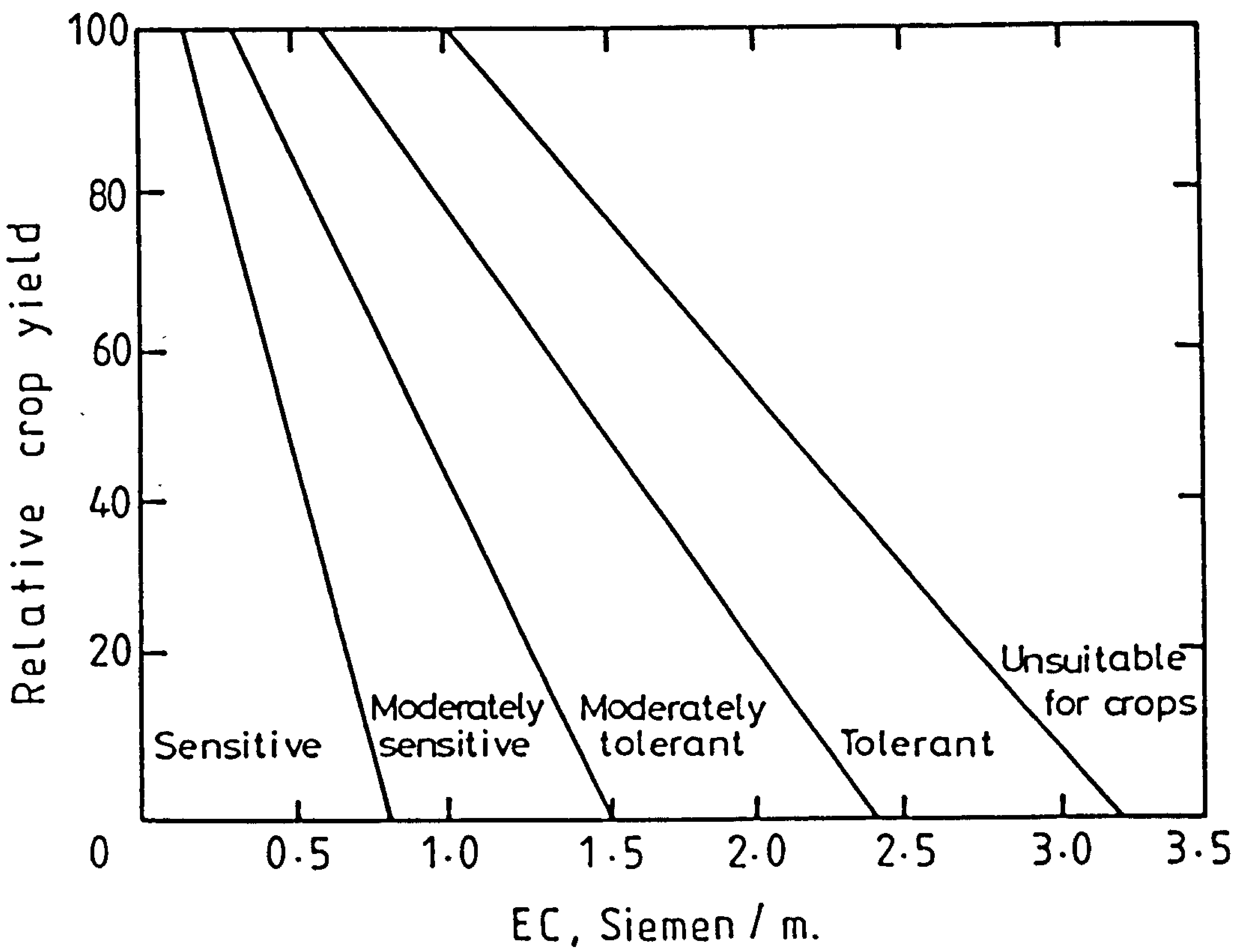



Fig. 3 Classification of crop tolerance to salinity based on relative crop yield as a function of the electrical conductivity of soil saturation extracts (EC). (From Maas E.V. and Hoffman G.J., J. Irrig. Drain. Div., 103, 115, 1977).

from 0.4-0.6% Table (1) / of salt mixtures based on the dry weight of the soil, (Strogonov, 1962). A recent assessment of crop tolerance to salinity by Maas and Hoffman (1977), employing an extensive literature survey covering 30 years, has classified crops into four general tolerance categories based on the electrical conductivity of soil saturation extracts at which yields begin to decline (Table 2 and Fig. 3). Yields above these thresholds were generally found to decline linearly with increased salinity. For crops plants, differences in salt resistence exist not only among different genera and species (Ayers and Westcot, 1976; Maas and Hoffman, 1977), but even within a species which may on the whole be considered salt sensitive (see literature review).

The choice of wheat for the work described in this thesis was dictated by the facts that:

1. Wheat is the principal winter crop in Egypt and it is the most important grain crop in the world. The production exceeds that of any other grain crop, and in many respects it is superior to any other human food (table 3).

*The estimated world production of each of the principal cereals in 1983, is shown in Table 3.

Table 3

| Crop | Production (tonnes x $10^6$) | % of total cereals prod. |
|---|---|---|
| Wheat | 498.182 | 30.4% |
| Rice | 449.827 | 27.5% |
| Maize | 344.103 | 21.0% |
| Barley | 167.176 | 10.2% |
| Other cereals | 179.559 | 10.9% |
| Total | 1638.847 | 100% |

*Published data, F.A.O., United Nations, 1983.

In Egypt, the estimation of cultivated area in 1983 was 570.000 hectares produced 1.996 million metric tons.

2. Wheat is the major breadmaking cereal and Egypt has to supplement production by importing just over half of its needs to supply the annual demand.

3. Wheat is reputed to be moderately tolerant of salinity.

4. The crop has a high economic standing.

The aim of this thesis is to study physiological adaptation to soil salinity in the wheat cultivars suitable for Egyptian climatic conditions. The results of such a study should be relevant to the selection and breeding of cultivars more tolerant of the increasingly saline soils of the Egyptian wheat growing areas.

## Literature Review

As a plant grows through its life cycle, begining with seed germination and progressing through vegetative growth, floral development, and seed filling stages, the dominant physiological processes may vary from one stage to the next. Because of this, one may expect to find different responses to salt stress at various life cycle stages.

I. Germination:

A. Effect of salinity on germination and emergence:

Salinity may affect the germination of seeds in two ways: (a) by decreasing soil osmotic potential such that water uptake by the seed is reduced or even prevented; and/or (b) by providing conditions for the entry of ions which may be toxic to the embryo or developing seedling. The relative importance of these two possibilities has been discussed by Rudolfs, 1925; Novikoff, 1946; Uhvits, 1946; Ayers, 1952; Mehta and Desai, 1958; Bernstein, 1961; and Bewley and Black, 1982.

Malik (1975), from the results of his studies on the effects of two components of soil water potential, matric potential and osmotic potential (produced by adding different amounts of water, Nacl and Kcl solution differing in electrical conductivity) on germination of wheat, concluded that creation of drought conditions and selection of the critical salt levels for different crops should ideally not be based on free single salt solution but, on mixtures of salts simulating the soil solution because of the quantitatively different effects and behaviour of osmotic and matric potentials acting simultaneously under field conditions. Because of the complex nature of the soil solution such simulation would be very difficult.

Studies on germination of wheat and barley seeds generally reveal that germination capacity decreases in the range of 100% to zero when treated with salinity in the range of 0.05 to 2.14 siemen/m. (Bhumbla and Singh , 1965; Selim and Ahamed, 1975; Singh and Saxeva, 1976; Ashour et al., 1977; Sidhardham, 1977; Al-Yasiri and Alzubaidi, 1978; Hana et al., 1978; Bhatnagor and Yadav, 1980; Cedillo and Saaveda, 1980; Alka et al., 1981; Gill and Dutt, 1982 and Kuhad and Garg, 1984). However, Alejar (1978) and Sung (1981) reported that germination percentage of barley seeds was not affected by increasing salinity but that the rate of germination decreased with increasing salinity. Also, Ansari et al. (1980) observed that germination of the seeds of two wheat cultivars (H-68 and Mexipak) was not affected by salinity. Sayed and Mashhady (1983) obtained significant differences among wheat and tritcale seeds in germination percentage due not to salinity but to some unknown factors and their results imply that the seeds of wheat cultivars (Florence aurore, Super X and Arz) and triticale line (Armadillo "S" x 308-3N) were tolerant of high salinity during germination.

B. Interaction effect of salinity and temperature on germination and emergence:

Salinity and temperature stresses are primary limiting environmental conditions which restrict successful wheat (*Triticum aestivum* L.) establishment in irrigated arid and semi-arid regions. Wheat is most susceptible to salt damage in the early stages of development.

Temperature is a dominant factor in the germination of seeds under saline and sodic conditions. Germination tests with strawberry clover and alfalfa showed that at higher temperatures salinity was increasingly detrimental to germination (Ahi and Powers, 1938; Uhvits, 1946; Stone et al., 1979 and Rizk et al., 1981).

Highly significant interactions between salinity and temperatures were reported in lettuce (*Lactuca sativa*), sugar beet (*Beta vulgaris* L.) and wheat (*Triticum aestivum* L.) and these interactions were such that salinity had little effect on germination at low temperature, but that the effect of salinity was increasingly inhibitory as temperature increased (Odegbaro and Simith, 1969; Francois and Goadin, 1972 and El-Sharkawi and Springuel, 1979). Also, El-Sharkawi and Springuel (1979) during their studies on the effect of decreased osmotic potential induced by increased salinity, and temperature and their interaction on the germination of wheat, found that plumule emergence was generally more sensitive to reduced osmotic potential than radicle emergence. Under optimum temperature, radicle emergence decreased at osmotic potential lower than - 1.3 MPa. Plumule emergence was immediately affected when osmotic potential fell below zero MPa and the interaction of salinity and temperature on plumule emergence was always highly significant.

However, Rizk *et al.* (1981) reported that germination percentage in alfalfa was not affected by temperature under $CaCl_2$ salinity conditions.

C. Effect of soaking seeds before planting on germination and emergence

Extremely poor germination of seeds has been reported under high salinity. The high salt content in the soil reduces the gradient of water potential between the soil and cell-sap of the seed, thereby decreasing the physiological availability of water needed for optimum germination and plant growth (Eaton, 1942, 1944; Richards, 1954).

Presowing soaking treatment of wheat, barley, maize and pear millet in solutions of growth regulators or in salt solutions significantly enhanced germination percentage and emergence under saline conditions and increased salt tolerance of these crops (Chandhuri and Wiebe, 1968; Dara _et al._, 1970, 1973; Babu and Kumar, 1975; Franke and Hassanein, 1976; Ashour _et al._, 1977; El-Sharkawi and Springuel, 1979; Bozcuk, 1981; Roth, 1981; Balki and Padole, 1982 and Madan and Kumar, 1983).

Also, Idris and Aslam (1975) showed that soaking of wheat seeds in water or $CaCl_2$ solutions followed by air-drying before planting accelerated the germination but did not affect the final percentage of germination under normal conditions. But, under conditions of 0.5% Nacl (5000 ppm) salinity, the soaking and drying of seeds before planting stimulated the germination percentage. On the other hand this treatment failed to improve the germination percentage under increasing salinity of 1.0 and 1.5% Nacl (10,000 and 15,000 ppm Nacl). However, soaking in distilled water enhanced germination under saline conditions as much as any other pretreatment (Shannon and Francois, 1977 and Khan and Khan, 1978).

3. <u>Effect of water stress induced by polyethylene glycol (PEG) or mannitol on germination of wheat seeds</u>

Studies on germination affected by water stress induced by using osmoticum solutions of PEG or mannitol have been reported by many investigators. Germination percentage and water uptake of wheat seeds declined with an increase in water stress conditions, using PEG and mannitol at various external water potentials, (Wiggans and Gardner, 1959; McGinnies, 1960; Parmar and Moore, 1966; Tadmor *et al.*, 1969; Singh and Singh, 1983 and Kuhad and Garg, 1984). However, Chen *et al.* (1982) found that there was no effect on germination of wheat seeds (maintained in mannitol solution at various levels of water potential) of water potential $<-1.5$ MPa. With decreases in water potential from 0 to $-1.8$ MPa there were progressive decreases in rate of water intake and speed of germination.

## II Vegetative Growth

### A. Effect of salinity on growth and growth analysis characters.

There is no doubt that salinity adversely affects the growth of plants. Growth reduction in plants under salt stress may be due to (1) an osmotic stress due to a lowering of the external water potential, (2) a specific ion effect on metabolic reactions, or (3) an indirect effect of ions competing with or otherwise affecting uptake of nutrients. Under saline conditions, the growth processes of plants are inhibited and dwarfed plants result. High concentration of non-nutrient salts in the soil markedly enhance the stage of heading and ripening of wheat so that the vegetative period is shortened (Strogonov, 1964).

Studies on growth and growth analysis of wheat and barley plants generally reveal that growth and dry matter of all parts of the plant tended to decreases with increasing soil salinity

(Hassan et al., 1970; Balasubramania and Sarin, 1974; Poonia and Jharar, 1974; El-Leboudi and Maoukhtar, 1975; Gandhi and Paliwal, 1975; Abdel-Halim et al., 1976; Monadjemi, 1977; Bhatnoger and Yadov, 1980; Mahajan and Sonar, 1980; Alka et al., 1981; Hussain, 1981; Sung, 1981; Joshi et al., 1982). Also, Selim and Ahamed (1975) observed that dry matter production of wheat cultivars Giza 155, Mexipak and Super X was lowest at high salinity levels (1.47 - 2.14 siemen/m), Giza 155 being the most and super X the lowest tolerant of salinity.

Aboul-Saod and Ashour (1974), Ashour et al. (1977), and Ansari et al. (1978) reported that fresh and dry weight production and plant height of wheat plants declined progressively as sulphate and chloride soil salinity increased from 0 to 0.9% (based on soil dry weight), compared with the untreated controls. The shoot was more severely affected by chloride salinity than the root, since shoot/root ratio showed decrease.

Numerous investigators (Fawzi and Abed, 1975; Paliwal et al., 1976; Singh and Saxena, 1976; Kandaswamy, 1981; Yadav and Girdhar, 1980; Ziwaik, 1980; Hussain, 1981 and Kingsbury et al., 1984) studied the effect of irrigation with saline water on growth and growth analysis of wheat and barley. They demonstrated that growth and dry matter production of all parts of the plant decreased by increasing salt content in irrigation water. Wagenet et al. (1980) showed that dry matter production of barley was reduced with decreasing irrigation frequency (2 to 8 days) and increasing salinity of irrigation water (0.05 to 1.35 siemen/m).

El-Fouly and Jung (1981) found that, in the early stage of growth of the wheat cultivar Opal, plant height and fresh and dry weight decreased with increasing salinity in irrigation water from 250-15000 ppm of Nacl, with much less effect on dry than on fresh weight. Kumar (1983) showed that salinity of irrigation water (0.21 to 1.2 siemen/m) caused adverse effects of different magnitudes on different plant characters of wheat cvs used under the conditions of this experiment. Also, varying degrees of decreased plant height and growth characters in the mutants and var. 'HD1553, with rising salinity levels corroborate the phenomenon of morphological adaptation, which in turn might lead to the osmotic adjustment of plants (Kumar and Yadav, 1983).

Salinity had a significant effect on seedling height, plant height, tiller number, shoot growth and dry matter production of barley and rice (Alejar, 1978; AL-Yasiri and Alzubaidi, 1978; Lehaman et al., 1984; and Verma dn Neue, 1984). However, El-Kady et al. (1981) showed that leaf area and leaf and stem dry weight increased with increasing salinity up to 4000 ppm in sand culture. Also, Singh et al. (1979), Poonia et al. (1974), and Tripathi and Pal (1979) reported that no significant reduction of wheat growth up to 1.2 siemen/m of irrigation water.

B. Effects of salinity and fertilization on growth and growth analysis characters:

Plant growth requires the movement of essential nutrients from the soil system into the plant. The effect of excess amounts of soluble salts on this process is extremely variable and can be generalized only with the statement that plant yield is eventually depressed at high salinity levels. The exact amount of depression, and the ECe (electrical conductivity of saturation extract of soil sample) to produce the effect are dependent on crop and soil (Jurink and Wagenet, 1981).

These variable factors can be elaborated. Studies of corn and cotton (Bernstein and Ayears, 1953; Broadbent and Nakashima, 1971) have shown that dry matter yields decrease with increasing salinity and at any level of salinity increase with nitrogen application. At low levels of soil fertility, nitrogen is limiting to crop growth, with variations due to salinity becoming more evident as N stress is relieved. These effects become particularly pronounced above an ECe of 0.8 siemen/m (8 mmho/cm), with dry matter production by stem decreased more than leaves, which in turn is decreased more than tassels. It was also observed that the percent nitrogen in these two crops increased with nitrogen applied and with increasing salinity. This apparently indicates that cotton and corn tend to continue to accumulate nitrogen under saline conditions despite reduced dry matter yield.

Studies on growth of wheat, barley, rice and tomato generally reveal that dry matter production and growth of all parts of the plant increased with the increase in nitrogen level and the decrease in soil salinity or salt content of irrigation water and application of nitrogen fertilizer reduced the effects of salinity (Langdale et al., 1973; Dhir et al., 1975; Singh and Singh, 1975; El-sharkawy et al., 1977; Hassan et al., 1980; Wagenet et al., 1980; and Papadopoulos and

Rending, 1983). However, Kumar and Singh (1980) showed that wheat dry weight and plant numbers/m decreased only at the highest salinity level 1.6 siemen/m (16 mmho/cm) and there was no effect on dry weight and plant numbers/m of nitrogen levels or pre-soaking seeds treatments. Also, Sameni et al. (1980) found that growth and nitrogen uptake generally decreased with increasing irrigation with saline water at all nitrogen fertilizer rates.

An additional factor which aroused interest is the application of the micronutrients elements, which are essential in plant development and often responsible for stimulating growth (Lamb et al., 1958; Mortvedt et al., 1972; Stiles, 1961 and Abo and Pinta, 1982).

The studies of Sorour et al. (1975) and Sorour and Abou el-Leil (1969) showed that spraying cotton plants or soaking cotton seeds with trace elements increased the cotton yield and growth under salinity conditions. Also Ravikovitch and Navrot (1976) observed that plant growth and yield of Berseem (Egyptian clover), Millet and Tomato decreased sharply as soil salinity increased 0-1.3 siemen/m (0-13 mmho/cm), addition of Mn and Zn increased growth, straw and yield of all these crops significantly. However, Farrag (1978) found that, with Broad Bean, foliar sprays with B or Cu + Zn + Mn did not significantly overcome the negative influence of salinity on plant height. Reduction in dry matter was small in plants sprayed with B or the mixture.

## C. The combined effect of environmental factors and salinity on plant growth:

For many years it has been noted that the relative effect of salinity on plant growth is often, if not always, a function of weather (Trelease and Livingston, 1924; Ahi and Powers, 1938; Wall and Hartman, 1942; Bernstein and Ayers, 1951). Generally an increase of the "severity" of the weather (heat, wind, dryness) is associated with increased severity of the symptoms of salt damage.

### 1. Temperature and salinity

Temperature is the least specific of all the environmental factors as it affects movement of salts in the soil, uptake of salts, overall biochemical processes in the plant and transpiration (Gale, 1975).

Ahi and Powers (1938) grew plants in diluted sea water and obtained much greater growth in a cool than in a hot greenhouse. Similar results were obtained by Bernstein and Ayers (1951, 1953) with vegetable crops. Many of the plants in their experiments showed salinity damage only when transferred to hot conditions.

Rizk et al. (1981) showed that increasing temperature from 10 to 20°C increased seedling length of two medic species (Medicago spp). However, no significant effect on seedling dry weight under Nacl and $Cacl_2$ salinity. Also, Lunt et al. (1960a,b) studied the interaction of salt and heat as affecting the growth of a number of horticultural plants. They found that there was no significant interaction between salinity and temperature.

## 2. Air humidity and salinity

Recently attention has been paid to the influence of atmospheric humidity or salt damage. High levels of humidity result in better growth for red Kidney beans growing in saline conditions than low relative humidity (Lunt *et al.*, 1960). High levels of humidity result in lowered rates of transpiration and hence could be expected to alleviate the effects of any water imbalance due to salinity. Furthermore the fresh:dry weight ratio is increased under humid conditions (Gale, 1975). This could reduce the concentration of electrolytes, and such was found to be the case for leaves of bean and cotton plants grown under saline conditions (Niemen and Poulsen, 1967).

Hoffman and Rawlins (1970) reported that Bean plants were shown to react strongly to humidity. In both the controls and plants grown under saline conditions growth increased with increasing humidity. The salinity level at which growth was reduced by 50% was raised by each increase in the level of atmospheric humidity. Also, shoot, root and total dry weight and total leaf area of Bean plants decreased due to salinity in both low and high humidities when compared with control plants grown under the same conditions. However, salt-treated plants grew better under high than low humidity (Prisco and O'Leary, 1973 and O'Leary, 1975).

Independent of RH (relative humidity), increased salinity consistently reduced the growth of all plants parts for all three crops (barley, wheat and corn) and their dry weights. But RH had no significant affected on the height of wheat plants and the opposite was true for salinity (Hoffman and Jobes, 1978).

3. Salinity and drought conditions:

Soil salinity and drought conditions are major constraints that limit crop area, yield, and total production in arid and semi-arid regions. They are permanent characteristics of about 28% of the soil of the world (Dudal, 1976). Very often saline and drought conditions occur together and plant tolerance to combined stress is, therefore, of considerable interest (Mashhady et al., 1982).

Adverse effects of both stresses are primarily due to the restricted water uptake by plant roots. Two distinct mechanisms are usually realized. Salinity stress produces low osmotic potential of the soil solution (Hayward and Spurr, 1943), whereas water stress impairs soil moisture transmission (Gingrich and Russell, 1957; Jefferies and Rudmik, 1979). However, it is recognised that the level of one stress is highly dependent on the other. As the plant roots absorb water, the salt concentration of the remaining soil water must increase thereby decreasing its osmotic potential and the matric potential also decreases.

Mashhady et al. (1982) found that soil salinity (0.35, 0.60, 0.85 and 1.1 siemen/m) and water content (100%, 40% and 20% of the available water) significantly effected the vegetative growth of wheat cultivars Arz, Florence aurore and super X and triticale line Armadillo 'S'X 308-3N. Their nitrogen and phosphorus contents were also affected by salinity and available water treatments, but chloride content was affected by salinity only. Also, interaction between soil salinity and available water content induced significant effects on dry matter production of wheat and triticale cultivars. The stress conditions caused by high soil salinity (0.85 and 1.1 siemen/m) and limited soil moisture (20 and 50% available water) progressively decreased the dry matter content (Sayed and Mashhady, 1983).

D. Effect of pre-sowing treatment on the salt resistance:

On saline soils the metabolism of crops is more or less affected by more difficult water absorption (physiological drought), toxic effects of absorbed ions, and antagonistic impediment of the absorption of essential nutrients causing growth depressions. Suitable irrigation and drainage, proper fertilization of soil and plant, selection of adequate species and varieties as well as breeding for salt tolerance are demanded in order to meet these harmful effects of soil salinity. Furthermore, investigations aim at establishing whether metabolic disturbances and thus growth depressions of plants under salinity can be moderated by pre-sowing treatments with growth regulators or inorganic salts like Nacl or $Cacl_2$ (Henckel, 1954; Bhardwaj and Rao, 1955; Gandhi and Bhatnagar, 1961; Sankhla and Mathur, 1968; Singh and Darra, 1971 and Bastianpillai et al., 1982).

Miyamoto (1962) soaked seeds of winter wheat cultivar 'Carstens VIII' in an aqueous 0.5% solution of CCC for fourteen hours at room temperature. The seeds were then dried and planted in a neutral sandy soil. Eleven days after sowing, ammonium nitrate was added to the soil at the rate of 7g per 100g of soil. The water content of the soil was allowed to fall until it reached approximately 50% of field capacity and was then held at this level. Within 72 hours after the ammonium nitrate was added 100% of the control planted were wilted, compared with 40.5% of those treated with CCC. Also, a greenhouse experiment showed that CCC increases the resistance of 'Opal' spring wheat to salinity (El-Damaty et al., 1964). Wheat kernels were soaked in CCC at concentration of 500ppm for 14 hrs at room temperature and were then planted in coarse white sand having a moisture content of approximately 50% at field capacity. 10 days after planting, the seedlings were irrigated with saline water (0-50,000 ppm of Nacl, $Cacl_2$ and Mgcl). Concentration of salt higher than 5000ppm resulted in much more wilting and damage to the untreated plants than to those treated with CCC, also, CCC reduced the height of the plants and the leaves were also somewhat thicker and greener in colour.

The application of the growth regulator $GA_3$ in salt solution slightly increased the coleoptile growth but the length of main root did not change. The length of coleoptile and main root was depressed by CCC (Cycocel). A combined supply of $GA_3$ and CCC decreased the coleoptile growth but less than CCC alone and growth of main root was not affected (Sarin and Narayman , 1968). Also, pretreatment of wheat seeds with $GA_3$ (100ppm) caused highly significant increases in root and shoot length under mannitol stress medium (Salim and Todd, 1968).

Darra et al. (1973) concluded that at all salinity levels (0-0.9 MPa osmotic potential) wheat shoot length was increased by four growth regulators in increasing order of concentration up to 100ppm except NAA and IAA up to 50ppm. For primary root growth GA and NAA reduced the length significantly with increasing concentration (0-100ppm). However, IAA increased the root length up to 50ppm while IBA was ineffective under this study condition. The four growth regulators at all salinity levels helped in the production of lateral roots and root/shoot ratio decreased with increase concentration of the four growth regulators at all salinity levels. Water absorption was increased by all treatments. Also, the application of 50ppm BA or Kinetin reduced the adverse effects of salinity on root and shoot growth and dry matter accumulation by seedling of wheat cultivar 1553 (Babu and Kumar, 1975).

Idris and Aslam (1975) reported that root and shoot growth of wheat plants was accelerated by presowing soaking treatments in water or $Cacl_2$ under saline conditions but not under normal conditions. This suggests that this treatment creates some resistance to salinity. Consequently the fresh and dry weights and the number of roots of the seedlings grown from treated seeds was also higher under saline conditions. Ashour et al. (1977) observed that if seeds of the wheat cultivar Giza 155 were salt-hardened with by soaking in 100ppm boric acid ($H_3BO_3$) for 48hr. before sowing, the dry matter accumulation by the developed seedlings growing under chloride saline conditions was improved as compared with that of water-soaked seeds.

Roth (1981) showed that wheat shoot length, shoot and root dry weights were reduced by salt stress (Nacl at 0-0.2% sand dry wt.). 1000ppm $GA_3$ increased shoot length at 0.1% Nacl. NAA reduced shoot length at 0 and 0.1% Nacl and at the highest rates reduced it at 0.2% Nacl. Kinetin at ≥ 250ppm increased shoot length at 0.2% Nacl. Shoot dry weight was increased by $GA_3$ and kinetin and decreased by NAA. Root dry weight was generally not affected by $GA_3$, was increased by NAA and was reduced by kinetin except at 0.2% Nacl. But, Bastianpillai _et al._ (1982) pointed out that kinetin effected a slight increase in shoot dry matter of wheat plant under saline conditions. NAA caused an increase in number of tillers and $GA_3$ increased the plant height. Also, $GA_3$, IAA and ethrel mitigated the effects of salinity on coleoptile, shoot and root growth at the lower salt levels (Madan and Kumar, 1983).

Pawar and Kadam (1983) investigated the effects of seed treated with cycocel, $Cacl_2$, Nacl, $Na_2 SO_4$ or $Mgcl_2$ solution and distilled water on root/top ratio of plants from wheat cv. N15439 and found that root:top length and dry matter weight ratios were highest with CCC followed by $Cacl_2$. Nacl and distilled water gave lower and the other treatments gave higher root:top length ratios than the untreated control. All treatments except distilled water increased the root:top dry wt. ratio. CCC significantly decreased plant height and shoot DM.

E. _Effect of isosmotic solutions on plant growth:_

Comparisons of plant performance between isosmotic concentrations of different solutes have been used in attempts to distinguish between adverse water relations and specific ion toxicity.

Several chemicals were studied as to their effect in various osmotic potential concentrations on seedling growth of radish and sorghum. Concentrations of 5 bars (0.5 MPa) of PVP and Nacl almost completely inhibited radicle growth of both sorghum and radish while 5 bars (0.5 MPa) concentrations of sucrose, glucose, and D-mannitol had only a slight effect on reducing the growth. Concentrations of 10 bars (1 MPa) more greatly reduced growth (Wiggans and Gardner, 1959). Also, Lopina et al. (1968) reported on the toxic effects of sodium salts as compared with the effects of an isosmotic dextran solution on maize plants.

Studies on wheat crop showed that increasing water stress conditions (using osmotic solution of polyethylene glycols (PEG) or mannitol of various external water potential) decreasing rate of water intake, rate of root and shoot growth and lateral root development (Parmar and Moore, 1966; Chen et al., 1982; Singh and Singh, 1982 and 1983).

Kuhad and Garg (1984) during their work on the effect of osmotic and specific ionic on wheat, found that depletion in fresh and dry weight of endosperm was least with PEG treatment than that caused by $Na_2SO_4$ . Similarly osmotic effect proved to be more inhibitory to length of coleoptile, fresh and dry weight of embryoaxis. However, reduction in radicle length was more under $Na_2SO_4$ treatment than PEG at iso-osmotic levels and thus indicating specific ion effect.

## III. Grain yield and its components:

### A. Effect of salinity on yield and its components:

Soil salinity can affect the yield of most field crops. Wheat, relative to other crops, is considered moderately salt tolerant. Salinity effects on yield may be a direct result of increasing soil moisture stress or of disturbance of nutrient balance of both (Hayward and Wadleigh, 1949). Reports on effects of soil salinity on vegetative growth have been discussed. This section deals with the literature on effects of salinity on grain yield.

Studies on yield and its components of wheat and barley crops generally reveal that grain yield and yield components decreases when the plants exposed to soil salinity in the range of $EC_0$ to 1.6 siemen/m (Hassan _et al._, 1970; Hira and Singh, 1973; Sidhardham, 1977; Murthy _et al._, 1978; Janerdham _et al._, 1979; Bhatngo and Yadav, 1980; Gill and Dutt, 1982; Joshi _et al._, 1982; Chauhen _et al._, 1983; Kumar _et al._, 1983; Lehman _et al._, 1984; Verma and Neve, 1984).

Aboul-Saod and Ashour (1974), Abdel-Halim _et al._ (1976), Ansari _et al._ (1978) and Selim _et al._ (1978) reported that grain and straw yields, tillers number/plant, spikes/plant of wheat cultivars Giza 155, Sonora 64, Ciete serros, H-68 and Mexipak all decreased as sulphate and chloride salinity levels increased from 0.0 to 0.9% (based on soil dry weight).

Data on yield components indicate that the major factor involved in yield depression due to salinity was number of heads per plant, which shows that salinity depressed tillering, also in general, plants in salinized cultures exhibited less marked fluctuations in plant N% during flowering stage (Jadav et al., 1976). Also, Joshi (1976) concluded that reductions in wheat yield due to salinity were mainly due to a reduction in the number of fertile tillers. Grain number per spike and 1000 kernel weight were also adversely affected with increasing salinity up to ESP 60.

Hoffman and Jobes (1978) during their work on the effect of relative humidity and salinity on some cereal crops, found that, independent of RH, increased salinity consistently reduced the number of spikes per plant and grain yield of wheat crop. Similarly, Cerda et al. (1978) found that increasing salinity levels decreased the grain yield and number of tillers per plant and grain weight per tiller in wheat cultivar Inia 66. Also, the interaction between soil salinity and available water content induced significant effects on grain yield, grain number and 1000 grain weight of wheat and tritical cultivars (Sayed and Mashhady, 1983).

Numerous investigators (Verma, 1971; Gandhi and Paliwal, 1975; Korkor and Hilal, 1975; Paliwal et al. , 1976; Prasad and Paliwal, 1976; Sharma et al., 1977; Saliman et al., 1978; Tripathi and Pal, 1979; Yadav and Girdhar, 1980; Bastianpillai et al., 1982; Mali et al., 1982; Pal and Tripathi, 1982; Kadam et al., 1983; Kumar and Yadav, 1983; and Pal et al., 1984) studied the effect of irrigation with saline water on yield and its components of wheat and barley. They concluded that grain yield and yield components tended to decrease with increasing salt content in irrigation water.

Sorour _et al_. (1977) showed that grain and straw yields, ear length and numbers of tillers, ears and grain per plant of three wheat cultivars all decreased with increasing salinity levels of irrigation water (0 to 9000 ppm 1:1 Nacl:$Cacl_2$ sol.). Harvest index, number of grains/ear and plant height were unaffected by treatments. Sidi Misril gave a highest harvest index as compared with the other cvs. El-Badri, Florence Aurora. The reduction in yield due to saline irrigation was attributed mainly to reduction in number of fertile tillers/plant. Also, Singh and Narain (1980) reported that, irrigation of wheat with saline water of up to 0.8 siemen/m caused a small reduction in grain yield but irrigation with saline water of 1.2 and 1.6 siemen/m decreased yeilds by 29% and 69%, respectively. However, Khalil _et al_. (1977) found that at different exchangeable sodium percentage (ESP), irrigation with water containing 10% sea water tended to increase wheat grain and straw yields more than those treatments which irrigated with tap water or water containing 20% sea water. Mondal and Sharma (1979) pointed out that in dune sand yield of wheat remained unaffected even at EC of 1.6 siemen/m. of irrigation water, but in the absence of sufficient summer and winter rains the upper limit of EC reduced to 0.8 siemen/m. For heavier sandy loam soil the safe limit of EC varied from 0.8 to 1.2, depending on the rainfall pattern. Also, El-Kady _et al_. (1981) indicated that wheat tillers, grain and straw yields increased with increasing salinity levels up to 4000 ppm. With an increase in salinity of irrigation water from 0.2 to 0.7 siemen/m wheat grain yield or weight of 1000 seeds did not affect during 1976. However yields of 1977 were significantly reduced by that level of salinity, although 1000 grain wt. was not affected (Labanauskas *et al.*, 1981). Kumar *et al.* (1981) also showed that 1000 grain weight and grain yield were not adversely affected until 1.2 siemen/m of irrigation water and tillers per plant and grains per spike remained unaffected until 1.6 siemen/m. Mutant BhP28 derived from HD2009 was more salt tolerant in terms of yield.

B. Effects of salinity and fertilizer on yield and yield components:

The interactive effects of soil fertility and salinity are of major concern in the agricultural utilization of salt-affected lands or saline irrigation waters. Information about these two factors (fertilizer and salinity) are very important in selecting for adaptation to salt and crop yield prediction on salt affected soil.

El-Gabaly (1959), during his work on the effect of both salinity and nitrogen fertilization on wheat in Northern Delta, found that wheat yield differed from year to year due to climatic conditions. He advised that maximum economic fertilizer must not exceed 24 to 36 kg nitrogen/faddan (Faddan = 0.42 ha.) if the soil is high in salt concentration or if the water table is near to the surface or if the soil conditions (e.g. soil structure, aeration etc.) are not suitable.

Studies on nitrogen application to wheat, barley and rice crops under saline conditions generally reveal that grain yield and yield components increased with increasing nitrogen rates and decreasing salinity levels (Barakat *et al.*, 1970; Dhir *et al.*, 1975;

Dhir et al., 1977; Gaswani et al. , 1977; Hummadi, 1977; Hassan et al., 1980; Wagent et al., 1980; Garg et al., 1982; and Chhillar and Swarup, 1984).

Sharma and Lal (1973) reported that increasing salinity levels of irrigation water (0.25 to 0.63 siemen/m) decreased wheat grain yield and uptake of N, P and K; the decreases were greater on clay loam soil than on sandy soil, increasing nitrogen rates (120 to 180 kg N/ha) increased yields and nutrient uptake and slightly decreased the adverse effect of increased salinity of the irrigation water. Also, Ata et al. (1977) pointed out that grain yield in three wheat cultivars (Giza 155, Super X and Mexipak) was found to tolerate salinity up to 4000ppm and after that increasing salinity up to 6000 ppm did not affect grain yield very much. There was no effect of increasing salinity up to 6000 on straw yield in the two seasons of the experiment. Any increment in nitrogen fertilizer rate increased highly significantly both grain and straw yields. Fawzy et al. (1977) noted that at low salinity and low nitrogen both cultivars (Giza 155 and Mexican Super X) had equal grain and straw yields. At higher levels of salinity and nitrogen Giza 155 outyielded Mexican Super X by approximately 20%.

Positive interaction between salinity levels and nitrogen fertilizer was obtained by Kumar and Singh (1980). They indicated that grain yield of wheat cultivar HD2009 at salinity levels 0.21 to 1.6 siemen/m were significantly decreased at the highest level of salinity yields were higher with 80 than with 40 kg N/ha. However, Chauhan et al. (1983) found that at salinity contents of >0.65 siemen/m, grain yield decreased and N or p application (0 to 200 kg N or 0 to 80 kg $P_2O_5$/ha) had no effect on grain yield.

An additional factor which aroused interest is the application of the micronutrients (Trace elements), which are essential in plant development and often responsible for stimulating growth (Lamb et al., 1958; Mortvedt et al., 1972; Stiles, 1961). The effects which naturally occuring micronutrients or those supplied as fertilizers have on plants may be influnced by various soil properties, among them an excess of soluble salts which often occurs in arid soils (Ravikovitch and Navrot, 1976).

Sorour et al. (1975) reported that the yield of seed cotton per plant was increased only with 2500 ppm of salinity level; whereas at the 5000 ppm significant decrease in yield was observed. The increase in yield due to spraying with trace elements was attributed to the increase in number of bolls retained. Boll size was not affected by both salinity and trace elements treatments. Soaking cotton seed in trace elements increased flowering, boll set and the yield of seed cotton (Sorour and Abou El-leil, 1969). Also, Ravikovitch and Navrot (1976) concluded that straw and yield of Berseem, Millet and Tomato decreased sharply as soil salinity increased (0 to 1.3 siemen/m), addition of Mn and Zn increased straw and yield of all these crops significantly.

## IV Effect of salinity on chemical characters of wheat plants:

### A. Effect of salinity on mineral composition:

Recently, much attention has been given to the problem of salinity as one of the major external factors which affect mineral metabolism.

Studies on mineral composition of wheat, barley, bean and cotton crops generally reveal that leaf, stem and seeds sodium and chloride contents increased, potassium and calcium contents decreased while magnesium content was remarkably constant with increasing salinity levels (Nieman and Poulsen, 1967; Hassan et al., 1970; Hira and Singh, 1973; Fawzi and Abed, 1975; Finck, 1976; Ansari et al., 1978; Devitt et al., 1981; and Kumar and Yadav, 1983).

Increasing soil salinity and ESP (exchangeable sodium percentage) increased plant sodium and chloride absorption and decreased nitrogen, phosphorus, calcium, magnesium and potassium absorption in wheat plants (Gandhi and Paliwal, 1975 and Hana et al., 1978).

Ashour et al. (1977) showed that, under chloride saline conditions, the concentrations of phosphorus and calcium in the shoot of wheat seedlings were not greatly different from that of the control, and under such conditions, the concentrations of potassium markedly decreased, whereas that of sodium markedly increased. Heikal (1977) found that the sodium and calcium content of wheat leaves increased progressively with increasing soil salinity while potassium was significantly reduced by salinity. There was no significant effect on magnesium content. Also, Sameni et al. (1980) reported that the concentration and uptake of chloride and sodium in beans increased with increasing soil salinity, and salinity tended to increase potassium, calcium and magnesium concentrations in plant tops. El-Kady et al. (1981) found that N, P and K contents of wheat leaves and stems increased with increasing soil salinity and levelled off at 4000 ppm. Sodium contents however increased progressively up to 10,000 ppm chloride salinity.

Pal et al. (1984) showed that the starch, N and P contents of barley grains decreased and that of K and Na increased with the use of saline waters in irrigation. But, Mali et al. (1982) observed that Ca:Mg ratios in irrigation water had no effect on N, P and Na contents of wheat grains; K content decreased with increasing proportion of Mg in Ca:Mg ratios of irrigation water having salt concentration from 20.2 to 80.2 meq/L. However, Hassan et al. (1980) reported that grain mineral contents in rice cultivar Giza 159 decreased with increasing soil salinity and this effect was reduced by nitrogen fertilizer.

Abdel Fattah and Moustafa (1982) indicated that at high Kcl concentration in the medium, decreasing osmotic potential decreased K uptake by barley and rice. Plant Na and Ca contents increased as their levels were raised in the medium; K content was depressed under saline conditions. Kingsbury (1984) pointed out that the major effects of salt stress were increases in Na and Cl content in shoots and roots of wheat cultivars. With decreases in K also concentrations of Ca were slightly lower, while Mg concentrations were tripled with salt stresss.

## B. Effect of salinity on technological characters of grains, chlorophyll and leaf proline content of wheat plants:

### 1. Technological characters:

The technological characters of the wheat grain is of particular interest to us from the standpoint of human nutrition. Broadly, these generally include crude protein, carbohydrates, ash and moisture content. Studies on technological characters of wheat grain generally reveal that grain protein content are increased when the crop exposed to salinity (Barakat et al., 1970; Khalil et al., 1977; (Murthy et al., 1978; El-Kady et al., 1981; Kumar et al., 1981; Labanauskas et al., 1981; Kumar and Yadav, 1983). But, Bhola et al. (1980) observed that there were no significant differences in grain protein content of wheat irrigated with saline waters of 300-16000 mmho/cm (30-1600 siemen/m). Application of 40-80 km N/ha increased the CP content. Cultivar Kharchia 65 (salt tolerant) and Kalyan sona had similar CP content of 12.7 - 12.78%. However, Asaliev and Mikhailova (1977) concluded that cultivation of winter wheat on soils with chloride sulphate type salinity decreased the grain technological qualities and application of nitrogen alone and in combination with phosphorus increased quality. Also, Fawzy et al. (1977) pointed out that total nitrogen content in grains was equal in both cultivars Giza 155 and Super X and it decreased slightly with increasing salinity levels.

2. Leaf proline content

It has been established that a striking accumulation of the amino acid proline occurs in many plants when the tissue water potential falls. Such a decrease in tissue water potential and consequent proline accumulation may follow depletion of the water in the rooting medium, exposure of the roots to a solution of a non-penetrating osmoticum (Singh *et al.*, 1973) raising the ambient temperature (Chu *et al.*, 1976). A similar accumulation of proline occurs in the tissues of plants exposed to a saline substrate (Palfi and Juhaz, 1970; Stewart and Lee, 1974) and it has been suggested that proline acts as an endogenous osmotic regulant in halophytes. Proline which increases proportionately faster than other amino acids in plants under salinity stress, has been suggested as an evaluating parameter for selecting salt-resistant cultivars.

Studies on proline amino acid accumulation in wheat, wheatgrass and barley generally reveal that proline accumulation increased with increasing soil salinity (Chu *et al.*, 1976; Shannon, 1978; Qadar *et al.*, 1981; and Dreier, 1983).

Sairam and Dube (1984) indicated that wheat accumulated a high amount of proline when there was moisture stress. There were varietal differences in the extent of proline accumulation. Varieties that accumulated more proline under moisture stress showed symptoms of wilting at much lower soil-moisture levels than those which accumulated less proline. However, Chauhan *et al.* (1983) found that leaf proline content of wheat cultivar W1711 and K68 decreased with increasing concentration of Nacl and increased with increasing concentration of $Cacl_2$ and $Mgcl_2$ . Also free proline accumulation increased with leaf age and was maximum in the evening.

3. Leaf chlorophyll content

Plant growth may be evaluated by: fresh weight (FW) or dry weight (DW) increment, or by extension growth (length). The first and the last may depend more directly on osmotic adaptation and maintenance of a positive water balance (Hassan et al., 1982). ~~Hassan et al. (1982) as quoted by (Gale, 1975; Schwarz, 1981)~~. Dry weight, which depends on photosynthetic activity and allocation of photosynthate, is also affected by salinity (Hassan et al. (1982) as quoted by (Gale, 1975; Schwarz,

Ashour et al. (1977) showed that chloride salinity caused significant reduction in the concentration of chlorophyll a+b in leaf blades of wheat seedlings, but under sulphate salinity conditions, the concentration of chlorophyll a+b was not significantly affected except at the highest salinity level (0.65 siemen/m). However, Tesu et al. (1977) concluded that, with wheat cultivars Auraa and Decia, at tillering stage there was an increase in chlorophyll a, carotene + chlorophyll b and Xanthophyll + chlorophyll a contents with increasing salinity (in Aurora cultivar only); at boot stage the reverse was true. Garg et al. (1982) indicated that, under both normal and saline conditions, high nutrient status (nitrogen - phosphorus - potassium) led to higher chlorophyll concentration in the leaves.

V. Water relation and salinity:

The problem of water relations and the water supply of plants on saline soils, has not been adequately investigated. The study of these problems is rather difficult because the effect of salts on the plants is dual in nature. On one hand accumulation of salts in soil decreases the osmotic potential of the soil solution and greatly decreases the availability of water to roots. On the other hand several salts affect plant as specific toxins (Strogonov, 1964).

Studies on leaf water potential, osmotic potential and turgor potential, transpiration rate/unit leaf area, relative water content, and stomata numbers/unit area generally reveal that all these characters decreased except turgor potential which was constant and stomata numbers which increased when bean, alfalfa, wheat and barley plants were exposed to salinity (Lunin and Gallatin, 1965; Meiri, Kamburoff and Poljakoff-Mayber, 1971; Hira and Singh, 1973; Prisco and O'Leary, 1973; Tal and Gardi, 1976; Morgan, 1977; Hoffman and Jobes, 1978; Etchevers et al., 1982; Gill and Dutt, 1982; and Kirkham, 1984). However, Shalhevet and Bernstein (1968) observed that transpiration rate/unit of leaf area was constant, except possibly at the highest salinities 1 to 1.5 siemen/m (10-15 mmhos/cm), which were approximately equivalent to the 50 per cent yield decrement value of alfalfa. Tal and Gardi (1976) showed that the number of stomata per unit area of leaf tomato decreased under salinity conditions. Also, Heikal (1977) during his work on the effect of the irrigation with saline nutrient solution on the water content of wheat found that water content of wheat leaves was not affected by salinity.

Aceves et al. (1975) reported that high salinity in the rooting medium reduced transpiration of wheat cultivar Inia 66 and increased leaf resistance to water diffusion. Leaf total water potential and osmotic potential were decreased with increasing soil salinity. Also, leaf turgor potential was constant and unaffected by decreasing the osmotic potential of the soil solution due to a parallel decrease in the total and osmotic potential of the plant leaves. Dutt (1976) concluded that the water potential of wheat and barley leaves considerably decreased with the decrease of the soil moisture percentage, with the increase of the electrical conductivity of the soil solution and with the increase in the exchangeable sodium percentage (ESP) level. Also the leaf insertion level affected the values of water potential and the most negative values were found in the top leaves.

From this review, it appears that salinity has been and will continue to be a major factor limiting agricultural productivity in many areas of the world. To combat this problem, intense management of saline waters and soils will be required. In addition, however, the genetic approach - that of genetically adapting crops to saline conditions should prove useful in increasing the productivity of these problem soils.

# CHAPTER II

## PART A

## The effect of sodium chloride salinity on germination and the growth of radicle and plumule of wheat variety, Giza 155, (Triticum aestivum L.)

### Introduction

Wheat is generally classified as being moderately tolerant of salinity (Strogonov, 1964; Ayers & Westcot, 1976). This reputation is based on a ranking among crops rather than among the terrestrial angiosperms in general. The salinity tolerance of bread wheat pales beside that of some of its wild relatives such as Elymus and Agropyron, for example (McElgum and Lawrence, 1973; McGiure and Dvorak, 1981). Yet germinating seeds of wheat and seedlings in their early stages of growth have been reported to be highly susceptible to salinity (Malewal-Palewal, 1967). Higher levels of salinity aggravate the delay in emergence and also decrease final germination percentage (Ayears & Hayward, 1948). Ashour et al (1977) found that germination capacity of wheat grains decreased markedly with increasing level of chloride soil salinity. Ansari et al (1980) showed that germination in two wheat cvs. was not affected by the presence of salts but that in the seedlings the roots were more sensitive than shoots. Sung (1981) reported that, in barley, the speed of germination decreased with increasing NaCl concentration, but germination percentage was not affected. Growth of the radicle and plumule decreased with increasing NaCl concentration. As a preliminary experiment the germination and early growth of wheat cv Giza 155 at different levels of salinity was investigated.

## Materials and Methods

This experiment was carried out in the laboratory. Plant material in this study consisted of one variety of vulgare wheat, (*Triticum aestivum* L.) namely Giza 155 (medium tall local variety in Egypt). There was not enough seed of the only other Egyptian wheat cultivars available at this time to cover the requirements of experiments 1 and 2. Accordingly this preliminary experiment used only Giza 155. This variety is recommended for all wheat growing areas in Egypt.

A complete randomized block design with four replicates was used. Five concentrations of NaCl; 0, 2000, 4000, 6000 and 8000 ppm were used. Each replicate of each treatment consisted of twenty seeds placed in a dish on discs of Whatman no.2 filter paper moistened by the appropriate NaCl solution. The dishes were placed in the dark throughout the germination period. Grains were considered to have germinated when the radicle emerged from the testa.

## Results and Discussion

The results (fig. 1 and table 1) show that NaCl reduced germination percentage significantly at all concentrations at 24h, but that by 48h only the highest concentrations had adverse effect. However, even up to 96h, all concentrations had adverse effects on plumule and radicle lengths. It therefore appears that at concentrations up to 6000 ppm sodium chloride in the bathing solution the water potential of the seed is nevertheless sufficiently low to bring about influx of adequate amount of water for the various

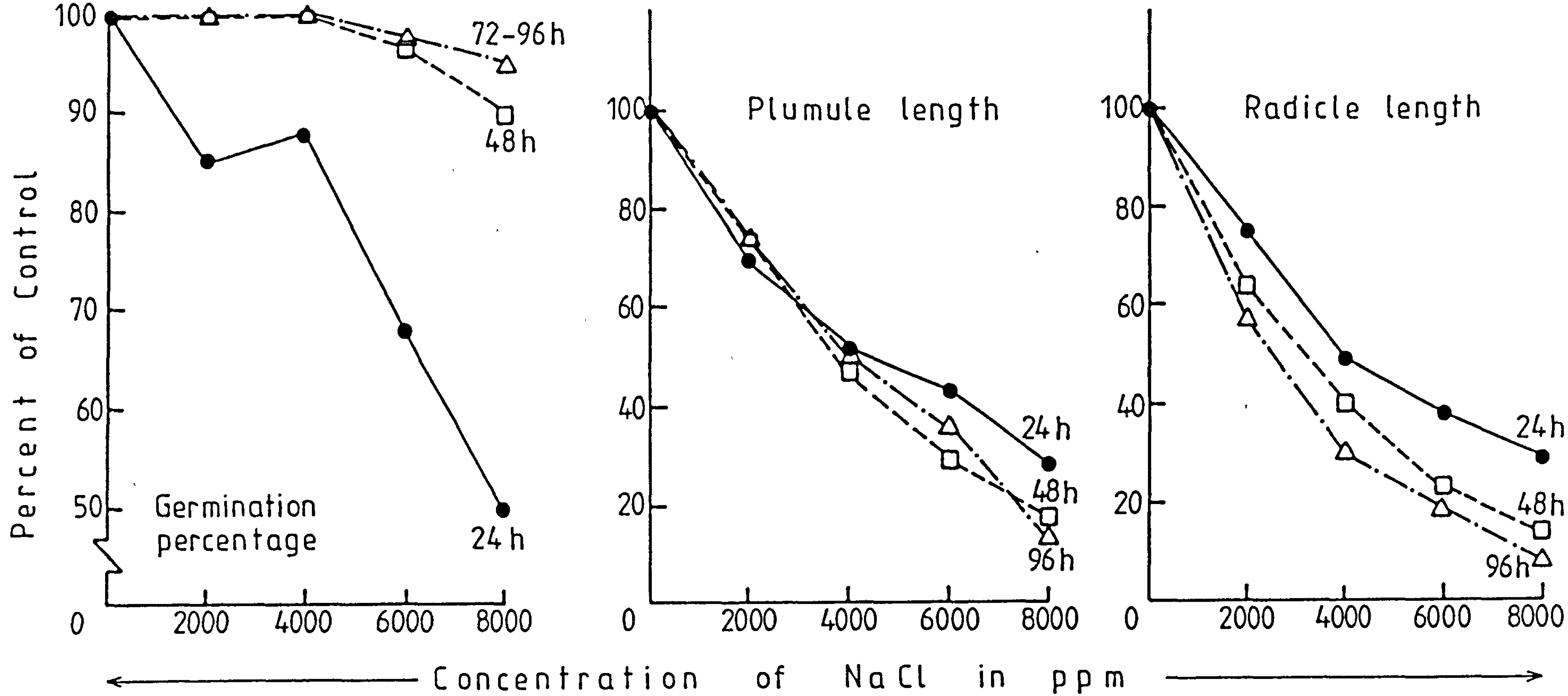



Fig. 1 Effect of Na Cl salinity on germination and the growth of radicle and plumule of wheat var. G.155.

Table (1) : Averages of Germination percentage and radicle and plumule lengths under different levels of sodium chloride (Nacl) salinity.

| characters / NaCl salinity (ppm) | Germination percentage | | | Length of Radicle and Plumule (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 48h | | 72h | | 96h | |
| | 24h | 48h | 72-96h | radicle | plumule | radicle | plumule | radicle | plumule |
| 0.000 | 85.0 a* | 100 a | 100 | 12.4a | 5.0 a | 43.8 a | 22.0 a | 63.3 a | 42.8 a |
| 2000 | 72.5 ab | 100 a | 100 | 9.28b | 3.48b | 28.0 b | 16.3 b | 36.0 b | 31.3 b |
| 4000 | 75.0 ab | 100 a | 100 | 6.05c | 2.55c | 17.5c | 10.3c | 19.0 c | 21.5 c |
| 6000 | 57.5 bc | 97.5a | 97.5 | 4.75cd | 2.13c | 10.0 d | 6.5 d | 12.3 cd | 15.3 d |
| 8000 | 42.5 c | 95.0b | 95.0 | 3.60d | 1.40d | 5.8 d | 3.8 d | 5.0 d | 5.8 e |
| Mean | 66.5 | 97.5 | 98.5 | 7.22 | 2.91 | 21.0 | 11.8 | 27.1 | 23.3 |

* Averages within column of salinity levels followed by the same letter are not significantly different according to Duncan's test.

metabolic processes leading to germination. However, the actual amount of water absorbed and the rate of absorption will be affected in inverse proportion to the salt concentration and it is this which probably accounts for the inverse relationship between salt concentration and rate of germination and length of plumule and radicle. Similar findings have been reported by Ansari et al. (1980) and Sung (1981) who found no effect of salts up to 3% NaCl sol. (30,000 ppm) for barley and 100 mN (5845 ppm) for wheat on germination percentage. Alejar (1978) with barley found that percentage germination of barley seeds after 24h in the dark decreased with increasing concentration of NaCl up to 216 mM (12625 ppm) but after 48h germination was almost 100%. Also, Ansari et al.(1980), Bazcuk (1980), and Sung (1981) reported that NaCl affected the speed of germination adversely. However, Chaudhuri and Wiebe (1968), Idris and Aslam (1975) and Ashour et al. (1977) found that germination capacity of wheat seeds decreased markedly with increasing the level of chloride salinity. These observations apply up to only 96h after sowing. In the next experiment observations are made on plants of Giza 155 and on other cultivar from the seedling stage through to grain maturity.

PART B

Effect of different levels of soil salinity on growth, chemical composition, yield and yield components of two wheat varieties (*Triticum aestivum* L., cvs. Giza 155 and Falchetto)

## Introduction

This study deals with the effect of a mixture of salts (chloride type) on two cultivars of wheat. A number of studies exist on the effect of salinity on wheat. These studies cover the effect of salinity on grain yield and its components, plant height, straw yield, growth characters and chemical composition, and in general their findings show that with increasing salinity there are increasingly adverse effects on all these characters. (Verma, 1970/71; Hira & Singh, 1973; Torres & Bingham, 1973; Poonia *et al*., 1974; Jadan *et al*., 1976; Sorour *et al*., 1977; Kushwaka & Vima, 1979; Wagent *et al*., 1980; Labanauskas *et al*., 1981; Chhillar and Swarup, 1984).

The effect on plant growth of excessive concentration of soluble salts in the root medium may be mediated by osmotic inhibition of water absorption, by specific effects of the constituent ion(s) in the saline media or a combination of the two. Specific ion effects may involve direct toxicity or a variety of nutritional effects (Bernstein & Hayward, 1951). Under natural conditions, plants growing on saline soils usually suffer from lack of water (physiological drought) and of nutrient salts (mineral nutrient deficiency), as well as from an excess of non-nutrient salts, which penetrate into the cell. Therefore it is especially difficult to differentiate between osmotic and toxic effects of salts, because the relative importance of these effects change with the nature of salinity, salt content of the medium and salt accumulation in the plant. In addition, salts affect the relation of the plant with its environment (Strogonov, 1964).

Wheat is generally considered to be medium tolerant crop (Strogonov, 1962), but the sensitivity changes with cultivars. Ansari et al. (1978) reported that of two cultivars, H-68 (Local Indian origin) and Mexipak (introduced). H-68 exhibited more salt tolerance than Mexipak. Also, Tripath & Pal (1979) found with two Indian wheat cultivars that the tolerance of highly saline water was higher in cv. K-68 than in cv. Kalyan sona. In India, Joshi et al. (1982) showed that with three groups of wheat, Triticum monococcum (diploid), Triticum durum (tetraploid) and Triticum aestivum (hexaploid), hexaploid spp were more tolerants than the other spp in sodicity tolerance.

This experiment was designed to study the effect of five salinity levels on the growth, components of yield and chemical composition of two cultivars of wheat. One, Giza 155 is widely grown on salt affected soils in Egypt, but is not classified as salt tolerant, the other, Falchetto is an Italian spring variety, which has been used in Sudan because of its tolerance of high temperatures. Wheat is a winter crop in Egypt, but can experience temperatures in excess of 25°C from before anthesis (March) to maturity (May). Hence Falchetto is potentially useful in Egypt, but its salt tolerance is unknown.

## Materials and Methods

This experiment was carried out in a greenhouse at Close House Field station. The soil which was used in this experiment was John Innes no.2 potting compost. This is composed of 7 parts steam sterilized medium loam, 3 parts peat and 2 parts coarse sand. To every bushel ($0.03637m^3$) of the compost are added ¼lb (113.5g) J.I. base fertilizer and ¾ oz (21.27g) ground chalk. The J.I. base fertilizer is obtainable through the usual trade channels and is constituted as follows:

| | |
|---|---|
| Parts by weight | 2 parts hoof-and-horn, 1/8in(3.2mm) grist (13 per cent N) |
| | 2 parts superphosphate (18 per cent $P_2O_5$) |
| | 1 part sulphate of potash (48 per cent $K_2O$) |

giving an approximate analysis of nitrogen 5.1%, soluble phosphoric acid 7.2% and potash 9.7%. The soil was artifically salinized with mixtures of salts including chloride salinization as described by Strogonov (1964) and presented in table (A). Five levels of soil salinity: 0.087 (control), 0.14, 0.20, 0.27 and 0.30 siemen/m at 25°C for 1:5 soil-water extract, were being tested. Such saline levels were attended by the addition of the following amount of salt mixtures based on the dry weight of the soil: 0.0 (control), 0.2, 0.4, 0.6 and 0.8% salts. The salt mixtures were mixed with the soil before sowing. These levels of salinity were chosen based on the work of Strogonov (1964) and his classification of crops into five general tolerance categories based on the degree of soil salinity (see introduction, table 1).

Table (A):The components of salt mixture used for chloride salinization.

| Percent of the total salt content | | | | | Percent of the total m.eq. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $MgSO_4$ | $CaSO_4$ | NaCl | $MgCl_2$ | $CaCO_3$ | $Na^+$ | $Mg^{2+}$ | $Ca^{2+}$ | $SO_4^{--}$ | $Cl^-$ | $CO_3^{--}$ |
| 10 | 1 | 78 | 2 | 9 | 38 | 6 | 6 | 5 | 40 | 5 |

The experimental design for this experiment was a randomized complete block with three replicates. Each replicate consisted of ten treatments, each treatment consisting of 30 pots in 6 rows. Four rows were allocated for growth analysis sampling, one for chlorophyll determinations and the last for yield and its components. Sampling was carried out at four stages at 15 days intervals, the first sample being 21 days after sowing. The first to the 4th sampling dates, in order, coincided with the jointing, tillering, booting and earing stages. Each sample consisted of 5 plants from each treatments to determine the growth analysis, chlorophyll and chemical composition.

The plants were subjected to normal cultural practices in the greenhouse. The grains were sown on 14.2.1982 in non saline soil and seedlings transplanted into the saline soils on 20.2.1982 in pots (7.62 cm diam). All pots had saucers under them to prevent leaching after irrigation.

Characters Studied

I. Yield and its components:

1. Grain yield per 5 plants (g)
2. Number of spikes per 5 plants.
3. Number of spikelets per spike.
4. Number of grains per spike.
5. Kernel yield per spike (g).
6. Weight of 1000 kerenels (g)
7. Spike length at harvest (cm).
8. Harvest index.
9. Number of tillers per 5 plants at harvest.
10. Straw yield per 5 plants (g).

II. Growth and growth analysis characters:

1. Plant height at harvest (cm).
2. Peduncle internode length at harvest (cm).
3. Number of leaves per plant
4. Number of tillers per plant.
5. Plant height (cm).

6. Leaf area per plant ($cm^2$) LA the total leaf area of the plant material. (Lambda leaf area meter was used).

7. Crop growth rate (g. week $^{-1}$) CGR at an instant in time (t) is defined (as the increase of plant material per unit of time).

$$\text{Mean CGR} = \frac{W2 - W1}{t2 - t1} \qquad \text{(Radford, 1967)}$$

where W1 and W2 are the values of W at time t1 and t2 respectively.

8. Relative growth rate ($g.g^{-1}$ $week^{-1}$) RGR at an instant in time (t) is defined as (the increase of plant material per unit of material present per unit of time).

$$\text{Mean RGR} = \frac{\text{Loge } W2 - \text{Loge } W1}{(t2 - t1)}$$

9. Net assimilation rate ($g.cm^{-2} week^{-1}$) NAR at an instant in time (t) is defined as (the increase of plant material per unit of assimilatory material per unit of time).

$$\text{Mean NAR} = \frac{W2 - W1}{A2 - A1} \cdot \frac{(\text{loge } A2 - \text{loge } A1)}{(t2 - t1)}$$

10. Leaf area ratio ($cm^2.g$) LAR, at an instant in time (t) is defined (as the ratio of the assimilatory material per unit of plant material present).

$$\text{Mean LAR} = \frac{A2-A1}{W2 - W1} \cdot \frac{(\text{loge } W2 - \text{loge } W1)}{(\text{loge } A2 - \text{loge } A1)}$$

11. Dry weight

a. Leaves dry weight per plant (g)

b. Stems dry weight per plant (g)

c. Roots dry weight per plant (g)

d. Total dry weight per plant (g)

III. Chemical Composition:

1. Chlorophyll content in leaf blades.
2. Na, Ca, and Mg contents in leaves, stems and grains.
3. Crude protein, moisture, ash and total carbohydrate contents in grains.

The methods of chlorophyll determination was based on work by Mackinney (1941) on the absorption of light by aqueous acetone (80%) extracts of chlorophyll. The concentrations of chlorophyll a and b were determined by measuring the denstiy of 80% acetone chlorophyll extracts with spectrophotometer at 663 and 645 nm.

$$\text{Total chlorophyll (C)} = (20.2 \times A645 + 8.02 \times A663) \times \frac{\text{V (Acetone volume)}}{1000 \times \text{sample wt. (g)}} = \text{mg.g fresh w}^{-1}.$$

Determination of Na, Ca, and Mg was performed using a flame photometer and atomic absorption spectrophotometer respectively. Determination of moisture, ash, crude protein and total carbohydrate by using the methods published by A.O.A.C. 1970. A few days after transplanting all plants of the 0.8% salinity treatment died.

The statistical analyses was carried out by mainframe computer, MTS system, ANOVA program, June 1978.

## Results and Discussion

### I. Yield and its components:

#### 1. Grain yield:

The analyses of variance for grain yield show that mean squares for varieties and salinity levels were highly significant indicating that the semi-dwarf variety, Falchetto produced significantly higher grain yield compared with the medium tall variety Giza 155, Table (1) and Fig. (1). Data show, in Table (1), that grain yield decreased significantly with increasing salinity and there was no significant difference between the varieties grain yield in response to salt.

#### 2. Number of spikes per 5 plants:

There were no significant differences between varieties and also for interaction between salinity and varieties in number of spikes per 5 plants, but salinity levels showed highly significant effect on number of spikes per 5 plants. The average number of spikes at the level of 0.6% was significantly lower than all other levels tested (Table 1 and Fig. 1).

#### 3. Number of spikelets per spike:

Varietal differences were highly significant, the medium tall variety Giza 155 showing a higher number of spikelets per spike as compared with the semi-dwarf variety Falchetto (Table 1 and Fig.1). Also the data show that salinity levels were highly significantly differed in number of spikelets per spike and with increasing

Table (1) : Averages of Grain yield per five plants, number of spikes per 5 plants, number of spikeletes per spike and kernel number per spike of two wheat varieties grown under different salinity levels.

| Char. & Var. / Salinity levels | Grain yield per 5 plants (g) | | | Number of spikes per 5 plants | | | Number of spikelets per spike | | | Number of kernels per spike | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 23.47 | 29.98 | 26.73* a | 19.33 | 20.00 | 19.67* a | 19.37 | 17.30 | 18.33* a | 40.43 | 45.07 | 42.75* a |
| 0.2% | 15.25 | 19.34 | 17.30 b | 13.00 | 15.00 | 14.00 b | 17.17 | 14.23 | 15.70 b | 33.87 | 34.37 | 34.12 b |
| 0.4% | 5.06 | 9.89 | 7.47 c | 6.67 | 10.33 | 8.50 c | 14.80 | 12.37 | 13.58 c | 23.33 | 26.10 | 24.72 c |
| 0.6% | 1.73 | 1.17 | 1.45 d | 5.00 | 5.00 | 5.00 d | 11.40 | 9.73 | 10.57 d | 14.27 | 14.40 | 14.33 d |
| Mean | 11.38 b | 15.10 a | 13.24 | 11.00 | 12.58 | 11.79 | 15.68 a | 13.41 b | 14.55 | 27.98 | 29.98 | 28.98 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

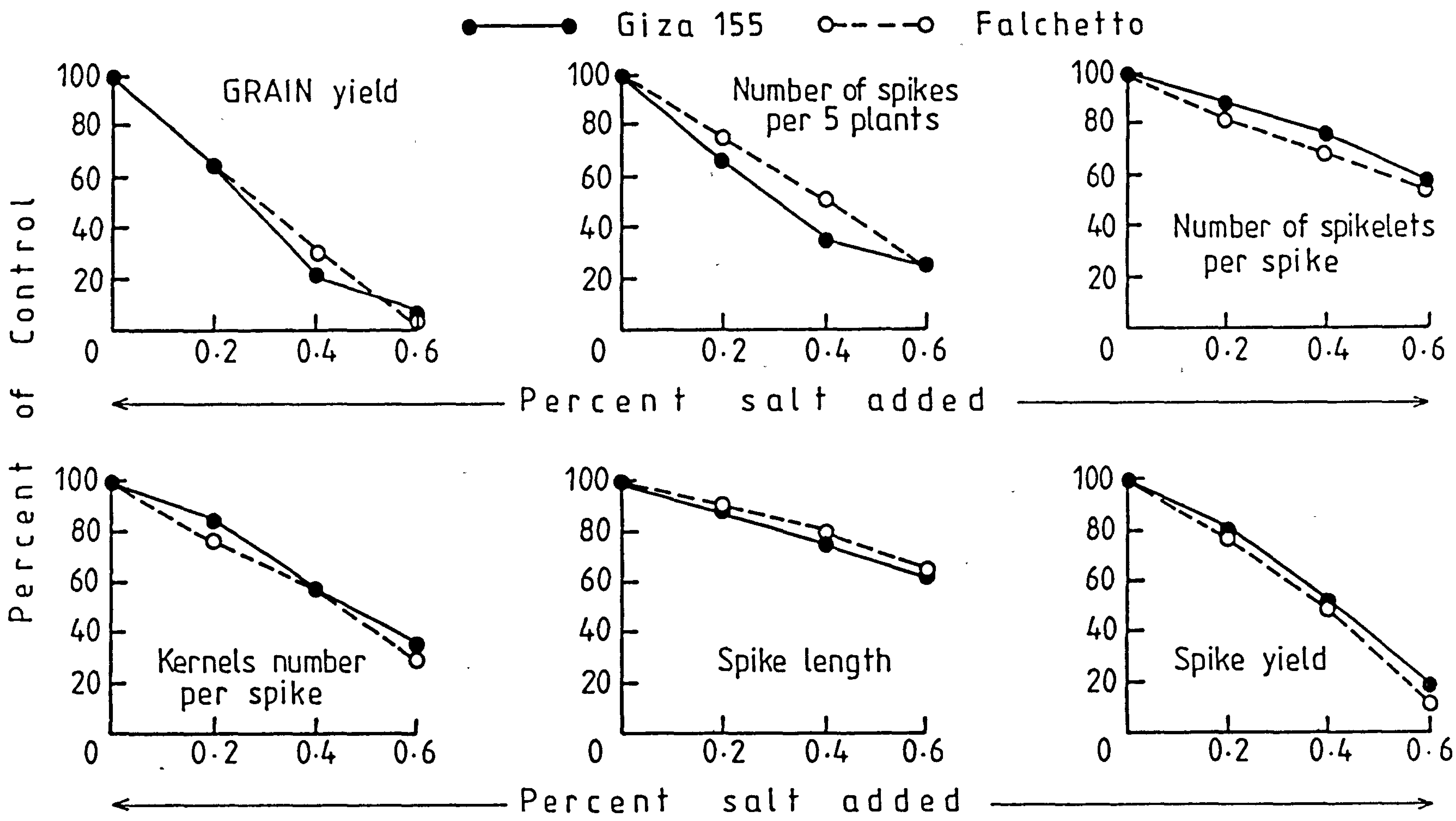



Fig. 1 Effect of different salinity levels on yield and yield components.

salinity the number of spikelets decreased and there was no significant interaction between varieties and salinity was obtained.

4. Number of kernels per spike:

From Table (1) and Fig. (1) the number of grains per spike showed no significant varietal differences. Salinity had a highly significant decreasing effect on this character and the interaction between salinity and varieties was not significant.

5. Spike length (cm):

The two varieties were not significantly different from each other in this character, but highly significant decreases due to salinity were obtained, Table (2) and Fig. (1), although there were no significant varietal differences in response to salinity.

6. Spike Yield (g):

Data in Table (2) and Fig. (1) show that there were no significant differences between wheat varieties or in the interaction between salinity and wheat varieties. However, salinity levels had a high significant effect in reducing the weight of spike yield.

7. 1000 kernels weight:

There were no significant varietal differences (Table 2 and Fig. 2), but salinity had a highly significant effect in decreasing the 1000 kernel weight. However no significant differences occurred between the means of 1000 grains weight produced at 0.0 and 0.2% salinity levels and reference to Fig. 2 shows this to be due more to Falchetto than to Giza 155. Nevertheless there were no significant varietal differences in response to salinity.

able (2): Averages of spike length, spike yield, 1000-kernels weight and Harvest index of two wheat varieties grown under different salinity levels.

| char. & var. / alinity levels | Spike length (cm) | | | Spike yield (g) | | | 1000 kernels weight (g) | | | H.I. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 7.60 | 7.70 | 7.65* a | 1.92 | 2.21 | 2.07* a | 51.93 | 49.50 | 50.22* a | 0.43 | 0.53 | 0.48* a |
| 0.2% | 6.67 | 6.87 | 6.77 b | 1.55 | 1.66 | 1.61 b | 43.90 | 46.40 | 45.15 a | 0.48 | 0.54 | 0.51 a |
| 0.4% | 5.67 | 6.10 | 5.88 c | 1.01 | 1.12 | 1.06 c | 37.23 | 40.57 | 38.90 b | 0.41 | 0.52 | 0.46 a |
| 0.6% | 4.77 | 4.90 | 4.83 d | 0.34 | 0.23 | 0.29 d | 23.57 | 17.57 | 20.57c | 0.31 | 0.26 | 0.28 b |
| Mean | 6.18 | 6.39 | 6.28 | 1.21 | 1.31 | 1.26 | 39.16 | 38.26 | 28.71 | 0.41 b | 0.46 a | 0.43 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test

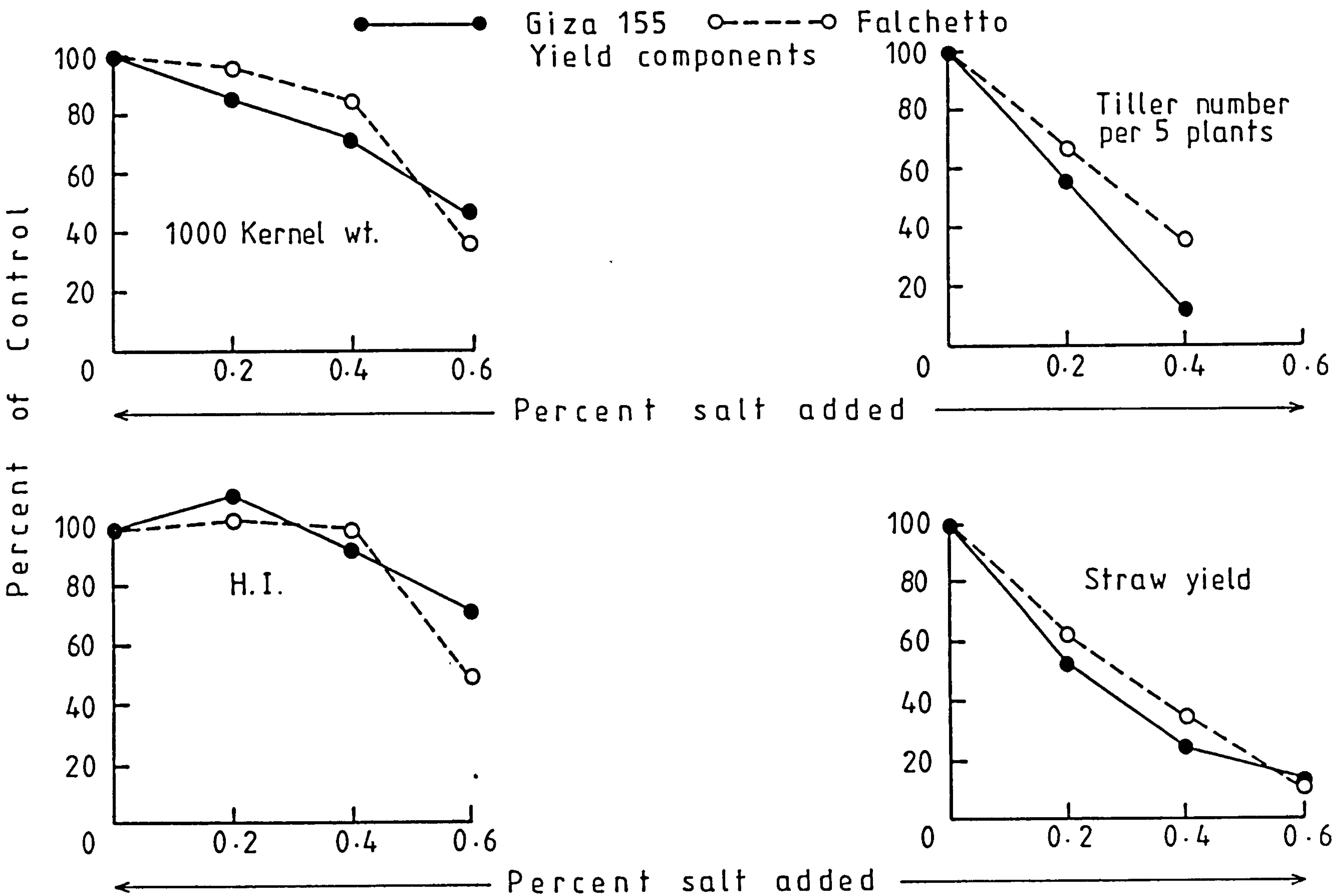



Fig. 2 Effect of different salinity levels on yield components.

Table (3) : Averages of number of tillers per 5 plants (1981-82).

| varieties / salinity levels | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 14.333 | 15.000 | 14.667* a |
| 0.2% | 8.000 | 10.000 | 9.000 b |
| 0.4% | 1.667 | 5.333 | 3.500 c |
| 0.6% | 0.000 | 0.000 | 0.000 d |
| Mean | 6.00 | 7.583 | 6.7917 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (4) : Averages of straw yield per 5 plants, in grams, (1981-82).

| varieties / salinity levels | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 30.667 | 26.867 | 28.767* a |
| 0.2% | 16.300 | 16.500 | 16.400 b |
| 0.4% | 7.467 | 9.233 | 8.350 c |
| 0.6% | 3.967 | 3.400 | 3.683 d |
| Mean | 14.600 | 14.000 | 14.300 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

8. Harvest index (H.I.):

Wheat varieties showed high significant differences in the harvest index. The semi-dwarf variety Falchetto was significantly higher in harvest index than the medium tall variety Giza 155 (Table 2 and Fig. 2). Salinity levels had no significant effect on H.I. up to 0.4% but between 0.4 and 0.6% harvest index was decreased by increasing salinity. There were no varietal differences in response to salinity.

9. Number of tillers per 5 plants:

The analyses of variance show that varieties did not differ significantly in this character and also no significant interactions were found. However, increasing salinity levels progressively decreased the number of tillers per 5 plants significantly. Also no tillers were produced at the highest salinity level (Table 3 and Fig. 2).

10. Straw yield per 5 plants (g):

The data presented in Table (4) indicate that there were no significant differences between the two varieties. Also, no significant interaction between varieties and salinity was obtained. But salinity levels showed highly significant progressive decrease in straw yield with increasing salinity.

In general these results show that grain yield and its components decreased significantly with increasing soil salinity in both cultivars. Decrease in grain yield and its components have been widely reported for wheat grown under saline conditions, e.g. Verma (1970/71), Hira & Singh (1973), Poonia *et al.* (1974), Korkor and

and Hilal (1975), Jadaw et al. (1976), Sorour et al. (1977), Ansari and Naqui (1978), Janardhan et al. (1979), Zwaik (1980), Labanauskas et al. (1981), Qadar et al. (1981), Kumar et al. (1983) and Pal et al. (1982). However, Singh et al. (1979) reported that wheat crop can be grown without significant reduction in grain yield up to EC12mmho/cm (1.2 siemen/m) of irrigation saline water, and Tripathi and Pal (1979) showed that irrigation with water of EC8.4 mmho/cm (0.84 siemen/m) gave no significant reduction in the yield of K-68 and Kalyan Sona cultivars. The reduction in yield and its components from control values can be seen in Fig. (1 and 2). Overall grain yeild is particularly sensitive, being reduced to a very small value at 0.6% (0.30 siemen/m) salinity. An interesting feature is that the number of spikelets per spike and therefore spike length are not as sensitive as other components, being reduced by only 40%, at the highest salt concentration. There appears to be three possible explanations for overall grain yield reduction: (a) fewer florets per spikelet; (b) reduced fertilization of florets; (c) poor grain filling. Since kernel number per spike is more sensitive to salt than number of spikelets per spike, (a) and/or (b) are indicated and since 1000 kernel weight is less sensitive, especially up to 0.4% salt, than grain yield, (c) seems less likely. The indications are therefore that salinity reduces grain yield by reducing grain number. This might be due to the initiation of a lesser number of florets or to reduced fertilization due to salinity. The former cannot at this stage be ruled out but seems less likely in view of the fact that spikelet initiation is less sensitive to salt and floret initiation is a similar process.

Yield per unit land area is the product of grain yield per tiller and the number of tillers per unit land area. Tiller numbers are therefore a major component of agricultural yield and can be seen in Fig. 2 to be very sensitive to salinity. The reduced tiller numbers can also be seen in the reduced number of spikes. It appears therefore that one way in which salt reduced wheat yields per plant in this experiment was by reducing the number of tillers per plant and the number of grains per ear. Ear size was less effected. Improvement of grain yield in wheat under saline conditions might therefore come from selecting for improvement of this response or by somehow ameliorating conditions at the time of tiller initiation, floret initiation and fertilization. Tillering might be increased by use of CCC or other chemical which can effect tillering pattern.

The major difference in response between cultivars is in tiller numbers and 1000 kernel weight, Falchetto showing smaller reductions than G.155 up to 0.4% salt. Thus genetic variability in response to salt of two major grain yield components of wheat has been demonstrated in this experiment.

II. Growth and growth analysis characters:

1. Plant height and peduncle length at harvest:

It is apparent that the varieties differed significantly in their height and peduncle length under saline conditions as evidenced in Fig. 3 and Tables (5-6). In general these two characters decreased with increasing salinity levels. The medium tall var. G.155 is taller and varied significantly in plant height and peduncle length

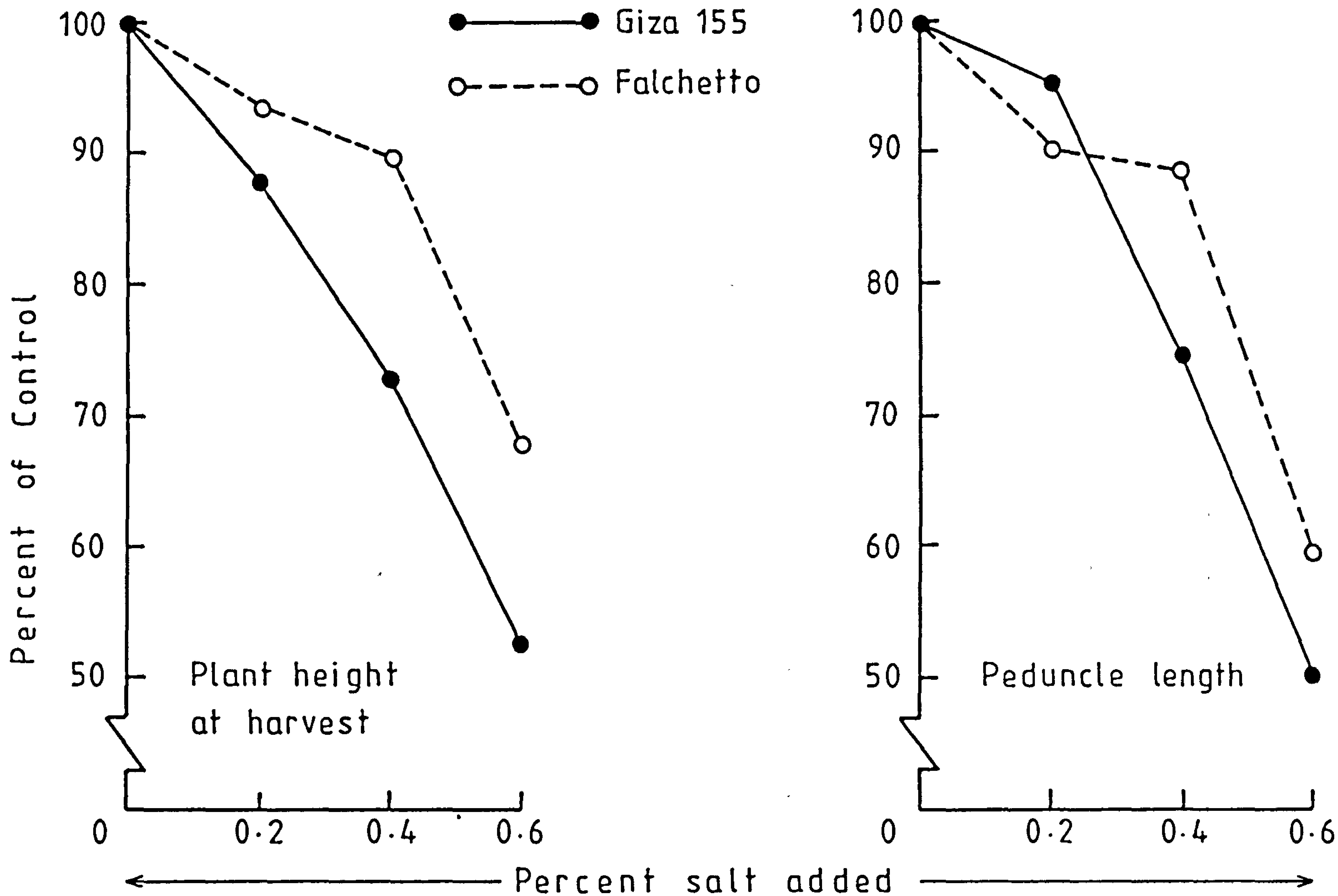



Fig. 3 Effect of different salinity levels on plant height and peduncle length at harvest.

Table (5) : Averages of plant height at harvest, in cm, (1981-82)

| varieties / salinity levels | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 84.800* a | 56.833 cd | 70.817 a |
| 0.2% | 74.367 b | 53.067 d | 63.717 b |
| 0.4% | 61.633 c | 51.133 de | 56.383 c |
| 0.6% | 44.467 ef | 38.533 f | 41.500 d |
| Mean | 66.317 a | 49.892 b | 58.1041 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (6) : Averages of Peduncle length, in cm, (1981-82)

| varieties / salinity levels | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 37.133* a | 32.900 b | 35.017 a |
| 0.2% | 35.300 ab | 29.667 c | 32.483 b |
| 0.4% | 26.667 c | 29.100 c | 28.383 c |
| 0.6% | 18.500 d | 19.633 d | 19.067 d |
| Mean | 29.650 a | 27.825 b | 28.7375 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

as compared with the semi-dwarf variety Falchetto. The percentage reductions in plant height and penduncle length in response to salinity were generally less in the semi-dwarf variety Falchetto than the medium tall variety Giza 155 (Fig. 3). Similar results were obtained by Poonia et al. (1974), Sidhardha (1977), Hoffman and Jobes (1978), Kumar and Yadav (1983), and Lehman et al. (1984). On the other hand, Singh et al. (1979) reported no reduction in plant height of wheat plant up to electrical conductivity (EC) 12m mho/cm (1.2 siemen/m) of irrigation water.

2. Number of leaves, tillers, plant height and leaf area:

The data obtained concerning the number of leaves, number of tillers, plant height and leaf area (Fig 4,5) and Tables (7-10) indicated that there were significant effects due to salinity levels and all these characters reduced with increasing salinity levels. The semi-dwarf variety Falchetto had a significantly higher number of leaves than the medium tall variety Giza 155 at 1st and 2nd samples. Also, the effect of salinity was more pronounced at the two highest salinity levels at the time of 1st and 4th sample, (Table 7). Falchetto had a significantly higher number of tillers than Giza 155 at 3rd sample only (Table 8), but at 2nd and 3rd and 4th samples the height of Giza 155 was greater than that of Falchetto (Table 9 and Fig. 5) and at the 2nd sample the leaf area of Giza 155 was greater than that of Falchetto (Table 10 and Fig. 5). Also, it could be observed (Table 10), that cv Giza 155 exhibited more than 72% reduction in leaf area at the level of 0.6%, while Falchetto showed less reduction (60%) at 1st sample, as compared with control. However, at the 3rd

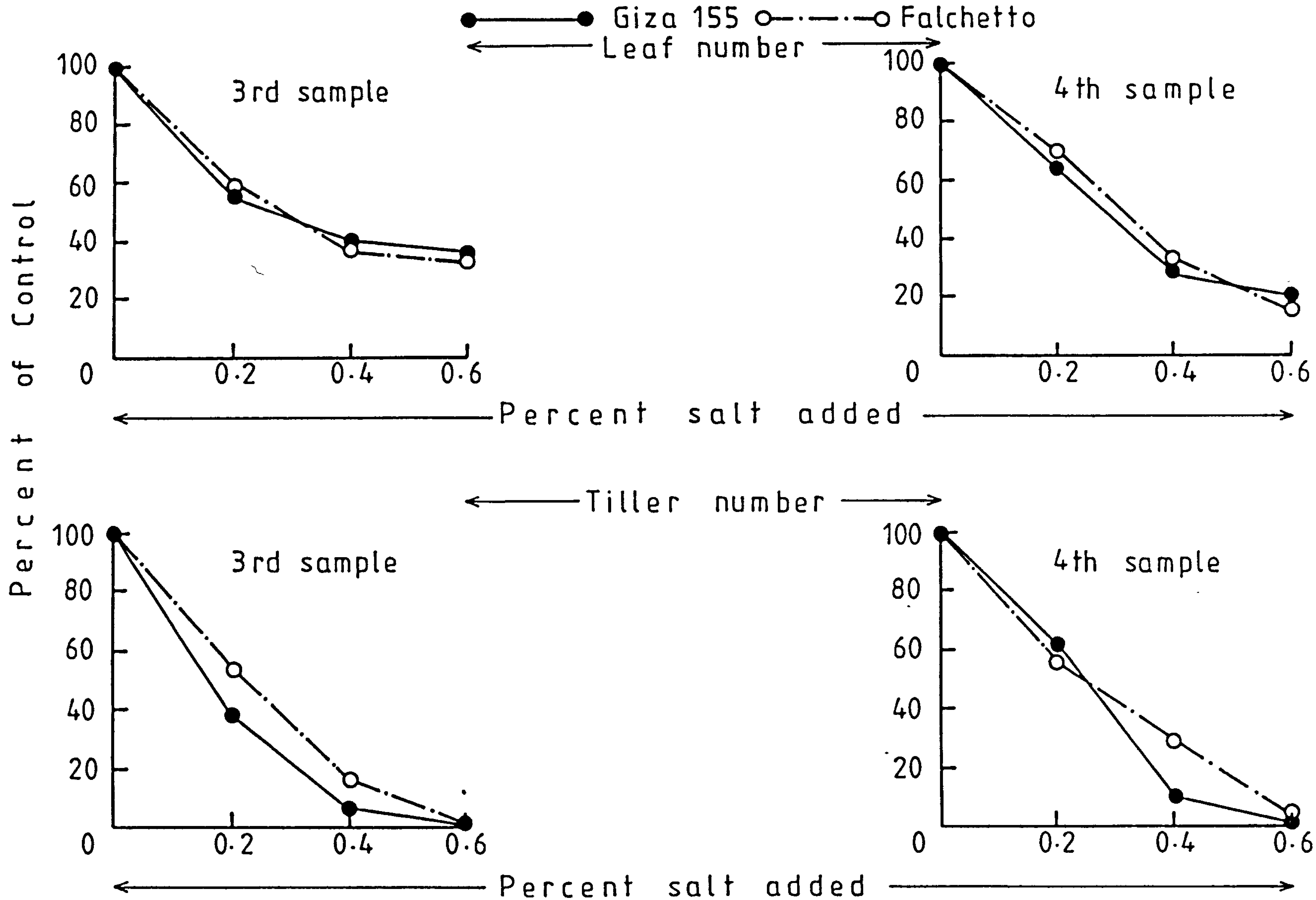



Fig. 4 Effect of different salinity levels on leaf and tiller number.

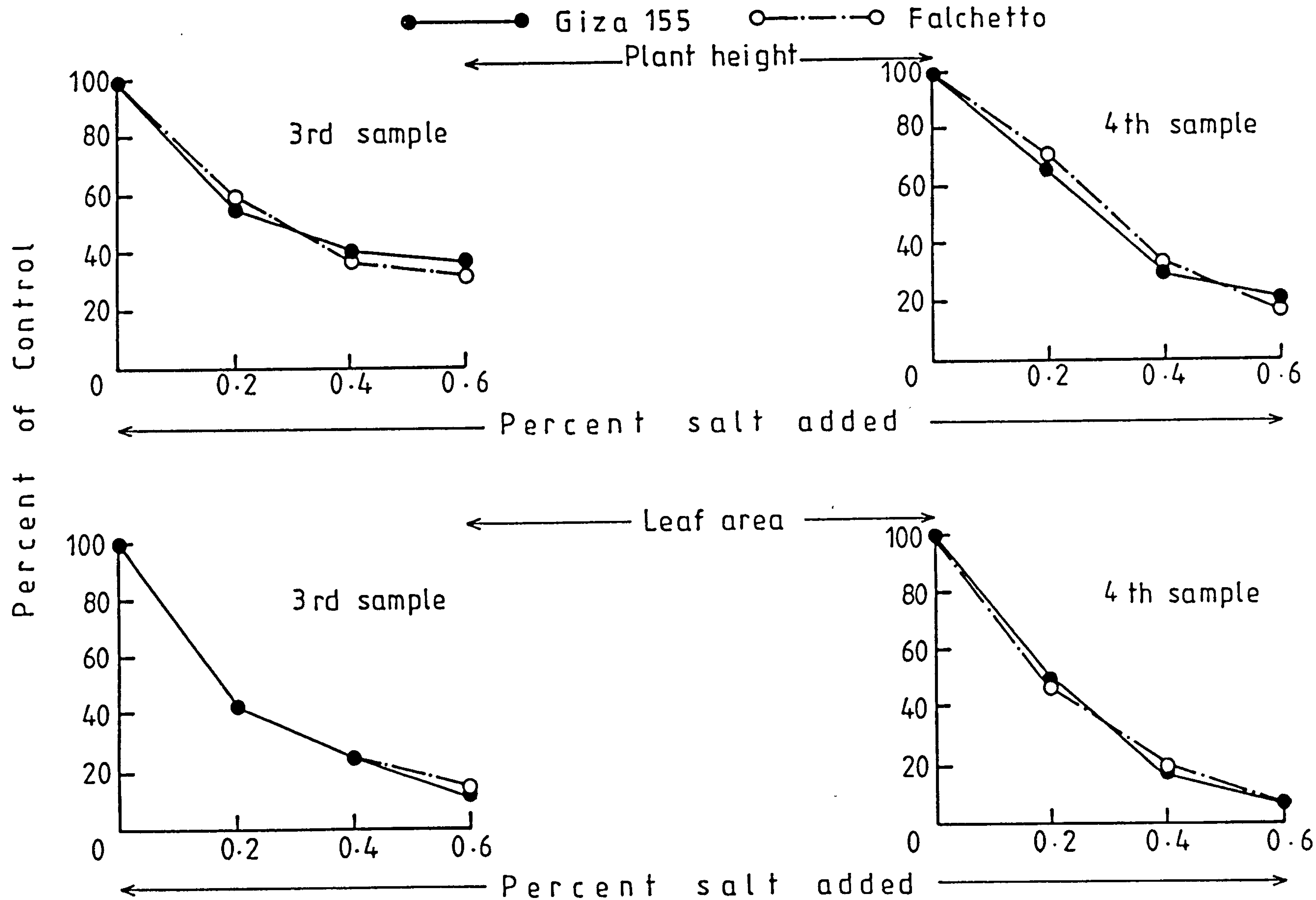



Fig. 5 Effect of different salinity levels on plant height and leaf area.

Table (7): Averages of leaf numbers per plant of two wheat varieties grown under different salinity levels (1981-82).

| varieties / salinity | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 3.000 | 3.400 | 3.200* a | 9.800 | 11.333 | 10.567 a | 17.400 | 18.200 | 17.800 a | 18.133 | 18.733 | 18.433 a |
| 0.2% | 2.733 | 3.200 | 2.967ab | 5.667 | 6.533 | 6.100 b | 9.733 | 10.533 | 10.133 b | 11.867 | 13.133 | 12.500 b |
| 0.4% | 2.600 | 3.000 | 2.800 b | 5.267 | 5.800 | 5.533 b | 7.067 | 6.933 | 7.000 c | 5.400 | 6.200 | 5.800 c |
| 0.6% | 1.867 | 2.667 | 2.267 c | 5.433 | 4.867 | 4.700 c | 6.267 | 5.933 | 6.100 c | 3.600 | 3.200 | 3.400 d |
| Mean | 2.550 b | 3.067 a | 2.8083 | 6.317 b | 7.133 a | 6.7250 | 10.117 | 10.400 | 10.2583 | 9.750 | 10.317 | 10.0333 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (8) : Averages of tiller numbers per plant of two wheat varieties grown under different salinity levels (1981-82).

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | - | - | - | 1.600 | 2.000 | 1.800* a | 2.200 | 2.533 | 2.367 a | 3.267 | 3.000 | 3.133 a |
| 0.2% | - | - | - | 0.400 | 0.467 | 0.433 b | 0.867 | 1.333 | 1.100 b | 2.000 | 1.667 | 1.833 b |
| 0.4% | - | - | - | 0.067 | 0.067 | 0.067 c | 0.133 | 0.400 | 0.267 c | 0.333 | 0.867 | 0.600 c |
| 0.6% | - | - | - | 0.000 | 0.000 | 0.000 c | 0.000 | 0.000 | 0.000 c | 0.000 | 0.067 | 0.033 b |
| Mean | - | - | - | 0.517 | 0.633 | 0.5750 | 0.800 b | 1.067 a | 0.9333 | 1.400 | 1.400 | 1.4000 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (9): Averages of plant height of two wheat varieties grown under different salinity levels, in cm., 1981-82.

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 6.420 | 5.533 | 5.977* a | 15.00 | 12.233 | 13.617 a | 43.033 a | 26.333c | 34.683 a | 85.567 a | 53.900 c | 69.733 a |
| 0.2% | 5.740 | 4.753 | 5.247ab | 13.167 | 10.967 | 12.067 b | 41.100ab | 25.700c | 33.400ab | 74.467 b | 51.667cde | 63.067 b |
| 0.4% | 4.573 | 4.660 | 4.617 b | 12.033 | 10.467 | 11.250 b | 36.100 b | 24.200c | 30.150 b | 57.267 c | 45.400de | 51.333 c |
| 0.6% | 3.487 | 3.873 | 3.680 c | 8.900 | 8.733 | 8.817 c | 27.300 c | 22.633 c | 24.967 c | 41.333ef | 35.800 f | 38.567 d |
| Mean | 5.055 | 4.705 | 4.8800 | 12.274 a | 10.600 b | 11.4375 | 36.883 a | 24.717 b | 30.8000 | 64.658 a | 46.692 b | 55.6750 |

* Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (10) : Averages of leaf area per plant of two wheat varieties grown under different salinity levels in,$cm^2$, 1981-82.

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 17.447 | 12.583 | 15.015* a | 88.030 | 73.513 | 80.772 a | 246.133 | 239.933 | 243.033a | 268.333 | 272.367 | 270.350a |
| 0.2% | 11.233 | 9.897 | 10.565 b | 47.757 | 39.047 | 43.402 b | 104.267 | 100.233 | 102.250b | 128.600 | 131.133 | 129.867b |
| 0.4% | 8.297 | 9.100 | 8.698 b | 34.297 | 28.520 | 31.408 c | 60.100 | 56.900 | 58.500c | 44.200 | 51.900 | 48.050c |
| 0.6% | 4.760 | 5.023 | 4.892 c | 15.297 | 15.797 | 15.547 d | 29.233 | 30.067 | 29.650d | 18.033 | 17.633 | 17.833d |
| Mean | 10.434 | 9.151 | 9,7925 | 46.345a | 39.219 b | 42.7821 | 109.933 | 106.783 | 108.3583 | 114.792 | 118.258 | 116.5250 |

* Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

and 4th samples both cultivars showed similar reduction (60 and 80%) respectively, Fig (5) and Table (10). At 4th sample more than 90% reduction in leaf area for both cvs occurred at 0.6% level. Similar findings have been reported by Torres and Bingham (1973), Poonia *et al.* (1974), Jadev *et al.* (1976), Hammadi (1977), Cerda and Bingham (1978), Day (1981) and Kummar (1983). However, Singh *et al.* (1979) found no significant reduction of growth of cv. HD 1593 up to 12 mmho/cm (1.2 siemen /m) of salt water irrigation and Tripathi and Pal (1979) reported that irrigation with saline water of conductivity (EC 8.4 mm ho/cm) (o.84 siemen/m) gave no significant growth reduction in wheat cvs. K-68 and Kalyan sona. All these varieties (HD1593, K-68 and Kalyan Sona) are local Indian cvs, which have been selected for salt tolerance. Also, El-Kady *et al.* (1981) showed that leaf area of wheat plant increased with increasing salinity up to 4000 ppm in sand culture.

3. Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) and leaf area ratio (LAR):

All these characters were determined for three intervals (Figs. 6 and 7, Tables 11-13). The mean squares of the analyses of variance showed highly significant reductions with increasing salinity levels in all these characters at all intervals except NAR at 1st and 2nd intervals. RGR of Falchetto at 3rd interval was less sensitive (i.e. less reduced) to salinity of 0.2 and 0.4 than the RGR of Giza 155. Examination of LAR and NAR shows that of these two components of RGR, it is Falchetto's NAR rather than LAR which is less sensitive. Falchetto's ability to synthesise dry matter appears at this mature

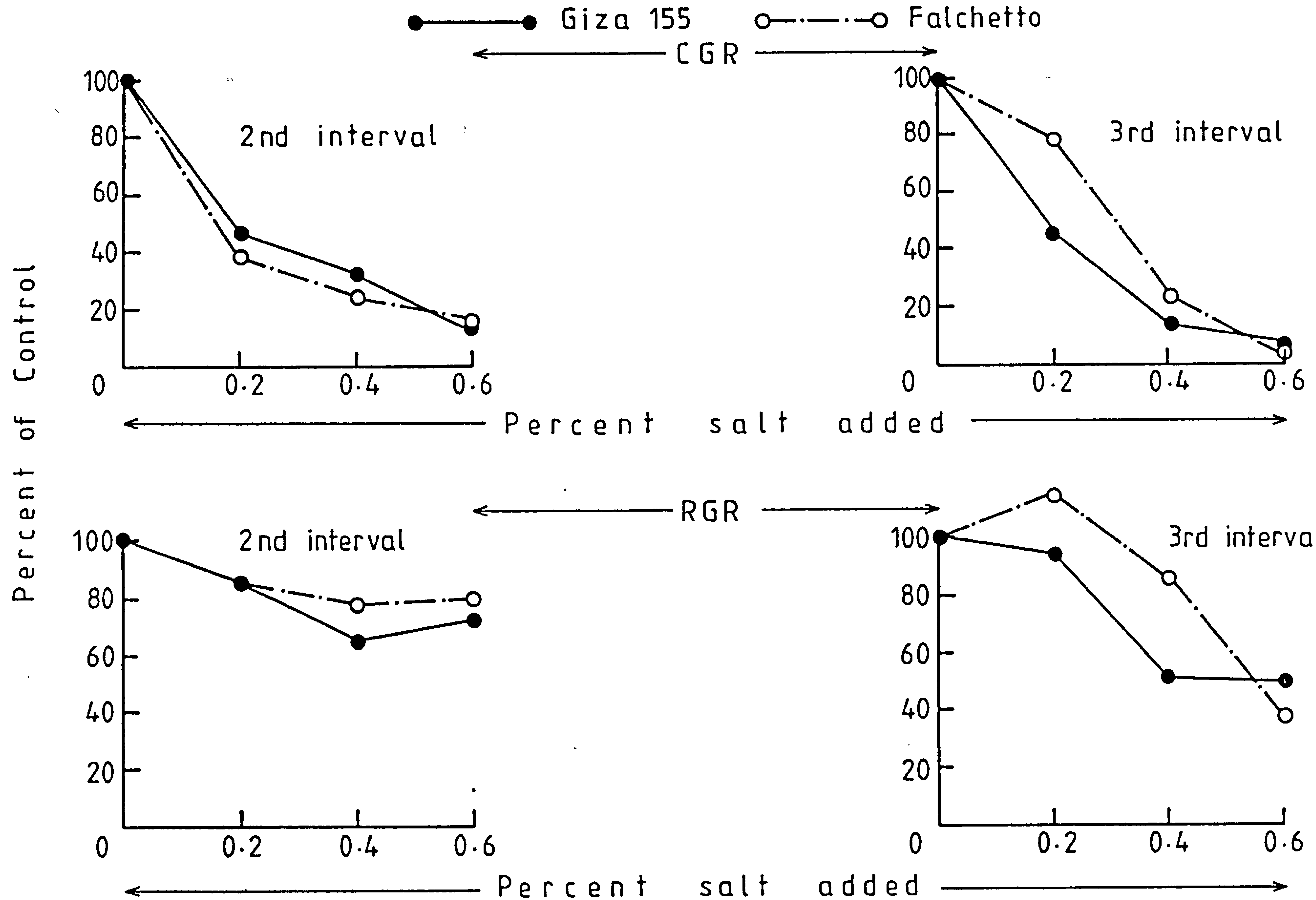



Fig. 6 Effect of different salinity levels on crop growth rate (CGR) and relative growth rate (RGR).

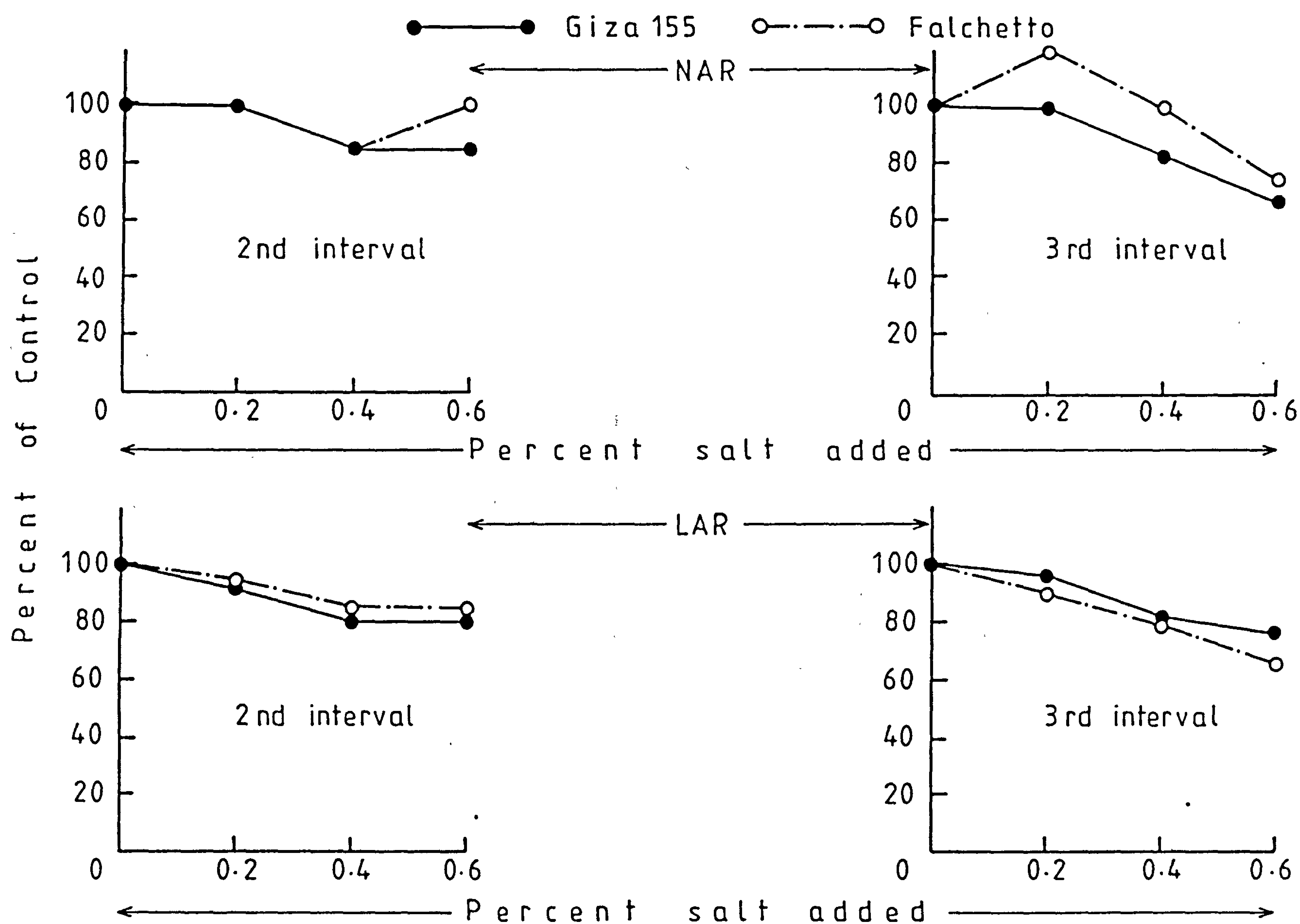



Fig. 7 Effect of different salinity levels on net assimilation rate (NAR) and leaf area ratio (LAR).

Table (11) : Averages of $\overline{CGR}$, $\overline{RGR}$, $\overline{NAR}$ and $\overline{LAR}$ (1st - 2nd samples) of two wheat varieties grown under different salinity levels. 1981-82

(First interval)

| varieties / salinity levels | $\overline{CGR}$ (g.week$^{-1}$) | | | $\overline{RGR}$ (g.g$^{-1}$ week$^{-1}$) | | | $\overline{NAR}$ (g. cm$^{-2}$ week$^{-1}$) | | | $\overline{LAR}$ (cm$^{2}$.g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.273 | 0.317 | 0.295* a | 0.963 | 1.137 | 1.050 a | 0.006 | 0.009 | 0.008 | 153.300a | 122.707bc | 138.003a |
| 0.2% | 0.153 | 0.150 | 0.152 b | 0.843 | 0.823 | 0.833 b | 0.006 | 0.007 | 0.006 | 140.73ab | 118.443bc | 129.587ab |
| 0.4% | 0.130 | 0.110 | 0.120 b | 0.793 | 0.840 | 0.817 b | 0.007 | 0.007 | 0.007 | 112.740c | 127.320bc | 120.030bc |
| 0.6% | 0.050 | 0.063 | 0.057 c | 0.637 | 0.550 | 0.593 c | 0.005 | 0.005 | 0.005 | 113.33c | 107.413c | 110.373c |
| Mean | 0.152 | 0.160 | 0.1558 | 0.809 | 0.837 | 0.8233 | 0.006 | 0.007 | 0.0066 | 130.026a | 118.971b | 124.4983 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (12) : Averages of $\overline{CGR}$, $\overline{RGR}$, $\overline{NAR}$ and $\overline{LAR}$ (<u>2nd</u> - <u>3rd</u> samples) of two wheat varieties grown under different salinity levels. (1981-82).

(second interval)

| varieties / salinity levels | $\overline{CGR}$ (g. week$^{-1}$) | | | $\overline{RGR}$ (g.g$^{-1}$ week$^{-1}$) | | | $\overline{NAR}$ (g. cm$^{-2}$ week$^{-1}$) | | | $\overline{LAR}$ (cm$^2$.g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.983 | 1.077 | 1.030* a | 0.723 | 0.697 | 0.710 a | 0.007 | 0.007 | 0.007 | 107.067 | 98.300 | 102.683 a |
| 0.2% | 0.453 | 0.423 | 0.438 b | 0.620 | 0.590 | 0.605 ab | 0.007 | 0.007 | 0.006 | 98.767 | 91.800 | 95.283 a |
| 0.4% | 0.310 | 0.263 | 0.287 c | 0.467 | 0.533 | 0.500 b | 0.006 | 0.006 | 0.006 | 85.433 | 83.167 | 84.300 b |
| 0.6% | 0.130 | 0.153 | 0.142 d | 0.527 | 0.563 | 0.545 b | 0.006 | 0.007 | 0.006 | 86.267 | 82.867 | 84.567 b |
| Mean | 0.469 | 0.479 | 0.4742 | 0.584 | 0.596 | 0.5900 | 0.006 | 0.007 | 0.0065 | 94.383 | 89.033 | 91.7083 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (13) : Averages of $\overline{CGR}$, $\overline{RGR}$, $\overline{NAR}$ and $\overline{LAR}$ (3rd - 4th samples) of two wheat varieties grown under different salinity levels. (1981-82).

(Third interval)

| varieties / salinity levels | $\overline{CGR}$ (g. week$^{-1}$) | | | $\overline{RGR}$ (g.g$^{-1}$ week$^{-1}$) | | | $\overline{NAR}$ (g. cm$^{-2}$ week$^{-1}$) | | | $\overline{LAR}$ (cm$^{2}$.g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 1.643 | 0.910 | 1.277* a | 0.397 | 0.237 | 0.317ab | 0.006 | 0.0054 | 0.005ab | 62.100 | 69.967 | 66.033a |
| 0.2% | 0.733 | 0.720 | 0.727 b | 0.370 | 0.363 | 0.367 a | 0.006 | 0.006 | 0.006 a | 59.833 | 63.00 | 61.417 a |
| 0.4% | 0.213 | 0.200 | 0.207 c | 0.210 | 0.203 | 0.207bc | 0.005 | 0.005 | 0.005ab | 50.333 | 55.700 | 53.017 b |
| 0.6% | 0.093 | 0.047 | 0.070 c | 0.197 | 0.090 | 0.143 c | 0.004 | 0.003 | 0.003 b | 47.100 | 46.300 | 46.700 c |
| Mean | 0.671 | 0.469 | 0.5700 | 0.293 | 0.231 | 0.2621 | 0.005 | 0.004 | 0.0049 | 54.842b | 58.742a | 56.7916 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

stage of growth to be better adapted to salinity than that of Giza 155. Since leaf areas did not differ (Fig. 5) the differences in the sensitivity of CGR to salinity (Fig. 6) can similarly be attributed to the lesser sensitivity of Falchetto's NAR. The higher NAR of Falchetto at this stage of growth, when vegetative stores of carbohydrate which contribute to grain - filling are being laid down may account in part for Falchetto's superior response at 0.2 and 0.4% salinity to that of Giza 155 in terms of 1000 kernel weight, and straw yield. Balasubramanian and Sarin (1974) reported that salinity depressed the RGR of wheat seedlings. The salt treatment had relatively more adverse effect on LAR than on NAR and the decrease in RGR was due to depression in LAR. In fact, NAR of wheat seedlings grown in saline soils was practically not affected. Also, a marked reduction in RGR due to salinity was observed even in relatively more salt tolerant barley crop by Greenway (1962). Hummadi (1977), sidhardahan (1977) and Hoffman and Jobes (1978), Kingsbury et al. (1984) and Pandey et al. (1984) all found that increased salinity consistently reduced the growth analyses characters, but Poonia et al. (1974) found no reduction in RGR, NAR, LAR upt ot 8mmho/cm (0.8 siemen/m) of irrigation saline water in cv. Kalyan Sona 227 (salt tolerance cv.).

4. Leaf, stem, root and whole plant dry weight:

In general, dry weight for all parts of the plant tended to decrease with increasing salinity levels (Fig 8 and Tables 14-17). The analyses of variance show that for all these characters there were

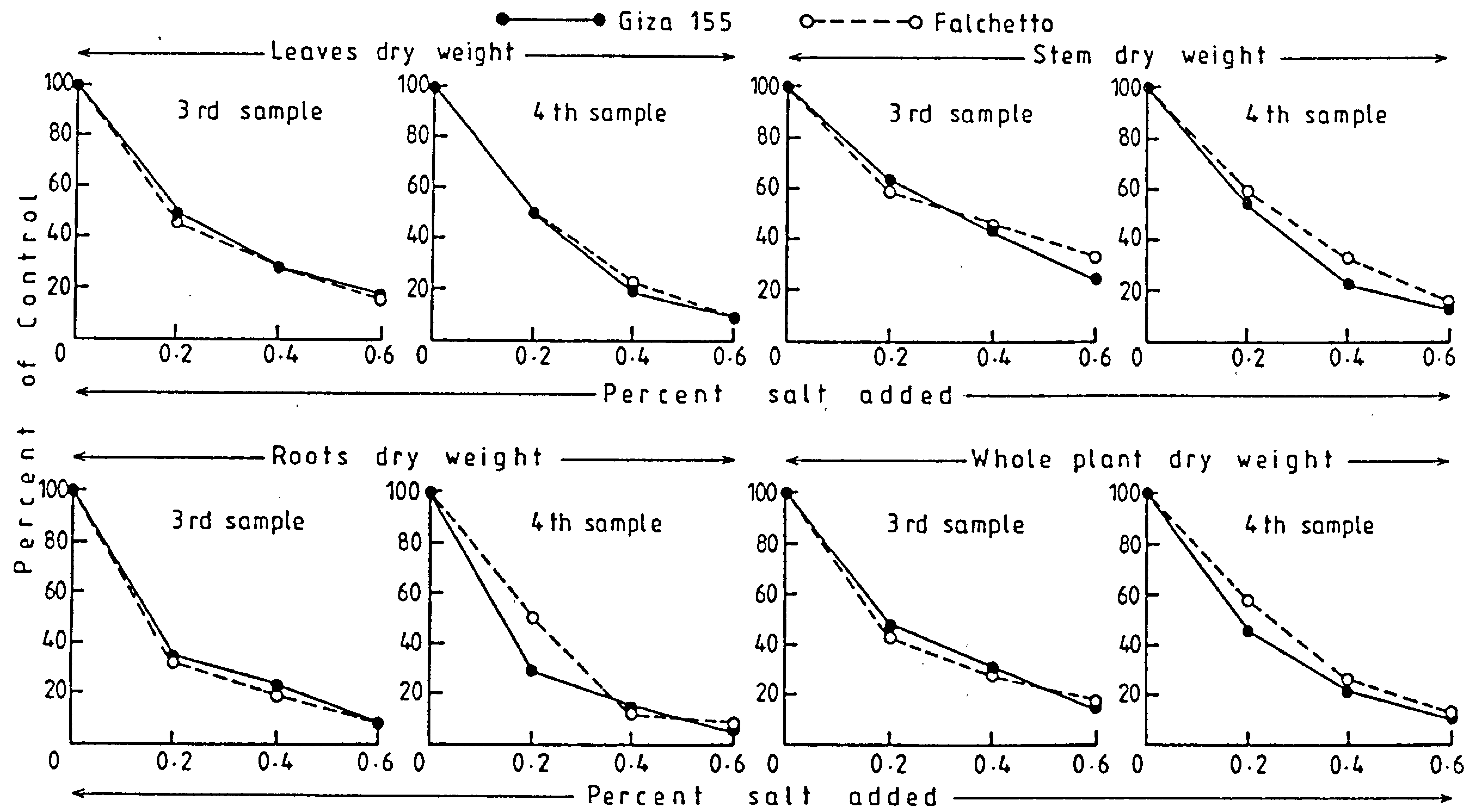



Fig. 8 Effect of different salinity levels on leaf, stem, root and whole dry matter weight.

Table (14) : Averages of leaf dry weight (g) per plant of two wheat varieties grown under different salinity levels (1981-82).

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.054 | 0.045 | 0.050* a | 0.270 | 0.230 | 0.250 a | 0.740 | 0.727 | 0.733 a | 0.917 | 0.910 | 0.913 a |
| 0.2% | 0.037 | 0.039 | 0.038ab | 0.163 | 0.133 | 0.148 b | 0.363 | 0.337 | 0.350 b | 0.463 | 0.467 | 0.465 b |
| 0.4% | 0.028 | 0.033 | 0.030 b | 0.130 | 0.107 | 0.118 c | 0.210 | 0.207 | 0.208 c | 0.177 | 0.197 | 0.187 c |
| 0.6% | 0.012 | 0.023 | 0.017 c | 0.057 | 0.070 | 0.063 d | 0.123 | 0.113 | 0.118 d | 0.077 | 0.070 | 0.073 d |
| Mean | 0.033 | 0.035 | 0.0337 | 0.155 a | 0.135 b | 0.1450 | 0.359 | 0.346 | 0.3525 | 0.408 | 0.411 | 0.4096 |

* Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (15) : Averages of stem dry weight (g) per plant of two wheat varieties grown under different salinity levels. (1981-82).

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.011 | 0.015 | 0.013* a | 0.129 | 0.120 | 0.125 a | 0.803 | 0.690 | 0.747 a | 2.137 a | 1.543 b | 1.840 a |
| 0.2% | 0.006 | 0.009 | 0.008 b | 0.078 | 0.073 | 0.076 b | 0.507 | 0.390 | 0.448 b | 1.150 c | 0.907 d | 1.028 b |
| 0.4% | 0.009 | 0.007 | 0.008 b | 0.062 | 0.063 | 0.063 b | 0.350 | 0.310 | 0.330 c | 0.493 e | 0.507 e | 0.500 c |
| 0.6% | 0.004 | 0.009 | 0.007 b | 0.029 | 0.040 | 0.034 c | 0.193 | 0.227 | 0.210 d | 0.287ef | 0.223 f | 0.255 d |
| Mean | 0.007 | 0.010 | 0.0087 | 0.074 | 0.074 | 0.0743 | 0.463 a | 0.404 b | 0.4337 | 1.017 a | 0.795 b | 0.9058 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (16) : Averages of root dry weight (g) per plant of two wheat varieties grown under different salinity levels (1981-82).

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.029 | 0.019 | 0.024 | 0.243* a | 0.357 a | 0.300 a | 1.167 | 1.440 | 1.303 a | 2.260 | 1.500 | 1.880 a |
| 0.2% | 0.026 | 0.022 | 0.024 | 0.127bc | 0.160 b | 0.143 b | 0.400 | 0.480 | 0.440 b | 0.663 | 0.777 | 0.720 b |
| 0.4% | 0.030 | 0.017 | 0.024 | 0.130 b | 0.110bc | 0.120 b | 0.267 | 0.273 | 0.270 c | 0.307 | 0.187 | 0.247 c |
| 0.6% | 0.023 | 0.016 | 0.020 | 0.057cd | 0.037 d | 0.047 c | 0.087 | 0.110 | 0.098 d | 0.093 | 0.100 | 0.097 c |
| Mean | 0.027 a | 0.018 b | 0.0227 | 0.139 | 0.166 | 0.1525 | 0.480 b | 0.576a | 0.5279 | 0.831 | 0.641 | 0.7358 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (17) : Averages of whole plant dry weight (g) per plant of two wheat varieties grown under differnt salinity levels (1981-82).

| Varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.062 | 0.047 | 0.054 | 0.643 | 0.707 | 0.675* a | 2.710 | 2.860 | 2.785 a | 5.993 | 4.680 | 5.337 a |
| 0.2% | 0.069 | 0.071 | 0.070 | 0.370 | 0.367 | 0.368 b | 1.270 | 1.207 | 1.238 b | 2.730 | 2.643 | 2.687 b |
| 0.4% | 0.066 | 0.057 | 0.061 | 0.323 | 0.280 | 0.302 b | 0.827 | 0.790 | 0.808 c | 1.247 | 1.183 | 1.215 c |
| 0.6% | 0.039 | 0.048 | 0.044 | 0.140 | 0.147 | 0.143 c | 0.403 | 0.450 | 0.427 d | 0.593 | 0.527 | 0.560 c |
| Mean | 0.059 | 0.056 | 0.0573 | 0.369 | 0.375 | 0.3721 | 1.302 | 1.327 | 1.3146 | 2.641 | 2.258 | 2.4496 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

highly significant differences due to salinity levels in all samples except 1st sample for roots and whole plant dry weight. Giza 155 had the higher dry weight value for leaves at 2nd sample, stems at 3rd and 4th samples and roots of 1st sample as compared with Falchetto, but the opposite was true at 3rd sample for root dry weight. However, the percentage reduction in dry weight was less in Falchetto at 4th sample for root, stem and whole plant dry weight as compared with Giza 155. The reduction in dry weight from control values can be seen in Fig. (8). These results can explain the higher yeild of Falchetto as compared with Giza 155 grain yield, because Falchetto had the higher NAR, CGR and RGR at 3rd interval (see Fig. 6 and 7). A significant salinity and varieties interaction was obtained at 4th and 2nd samples for stem and root dry weight, respectively and this indicates that here were a significant varietal differences in response to salinity (Tables 15 and 16).

4A. Spike dry weight:

This character was determined at 4th sample only. Highly significant effects due to salinity were obtained in spike dry weight. The reduction in spike dry weight (Table 18) can be, at least partly, attributed to the decrease in grain number per spike and 1000 kernel weight (see Fig. 1 and 2). Such results are in harmony with those obtained by Aboul-Saod and Ashour (1974), Selim and Ahamed (1975), Prasad and Paliwal (1976), Ashour *et al*. (1977), Hoffman and Jobes (1978), Kushwaka and Vima (1979), El-Kady *et al*. (1981) and Sayed and Mashhady (1983). On the other hand, Poonia *et al*. (1974) and Singh *et al*. (1979) showed no reduction in DM up to 8 and 12 mmho/cm (0.8 and 1.2 siemen/m) of irrigation saline water, respectively.

Table (18) : Averages of spike dry weight (g.) per plant (4th sample).

| salinity levels \ varieties | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 0.680 | 0.727 | 0.703* a |
| 0.2% | 0.453 | 0.493 | 0.473 b |
| 0.4% | 0.270 | 0.293 | 0.282 c |
| 0.6% | 0.137 | 0.133 | 0.135 d |
| Mean | 0.385 | 0.412 | 0.398 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (19) : Averages of spike number per plant (4th sample)

| salinity levels \ varieties | Giza 155 | FAL. | Mean |
|---|---|---|---|
| 0.0% | 2.067 | 2.333 | 2.200* a |
| 0.2% | 1.467 | 1.667 | 1.567 b |
| 0.4% | 1.000 | 1.000 | 1.000 c |
| 0.6% | 1.000 | 1.000 | 1.000 c |
| Mean | 1.383 | 1.500 | 1.442 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (20): Averages of total chlorophyll (mg.g fresh $w.^{-1}$) of two wheat varieties grown under different levels of salinity (1981-82).

| varieties / salinity levels | 1st sample | | | 2nd sample | | | 3rd sample | | | 4th sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 2.513 | 2.613 | 2.563* a | 2.783 | 2.577 | 2.680 a | 2.823 | 2.583 | 2.703 | 2.787 | 2.713 | 2.750 |
| 0.2% | 2.500 | 2.460 | 2.480 a | 2.557 | 2.310 | 2.433ab | 2.747 | 2.560 | 2.653 | 2.630 | 2.867 | 2.748 |
| 0.4% | 2.327 | 2.440 | 2.383 a | 2.537 | 2.137 | 2.337ab | 2.400 | 2.570 | 2.485 | 2.587 | 2.663 | 2.625 |
| 0.6% | 1.820 | 2.180 | 2.000 b | 2.210 | 2.123 | 2.167 b | 2.693 | 2.527 | 2.610 | 2.277 | 1.880 | 2.078 |
| Mean | 2.290 | 2.423 | 2.3567 | 2.522 | 2.287 | 2.4042 | 2.666 | 2.560 | 2.6129 | 2.570 | 2.531 | 2.5504 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

## III. Chemical Characters:

### 1. Chlorophyll content:

Results (Table 20), indicate that only the highest salinity levels caused significant reduction at 1st and 2nd samples in chlorophyll leaves content. At the 3rd and 4th samples there was no significant effect of salinity. The percentage reduction in chlorophyll content are comparatively small. The larger reductions seen in other growth characters do not therefore appear to be primarily due to reduction of photosynthetic capacity as a result of a salinity effect on chlorophyll content. This might account for the relative insensitivity of NAR (see Fig. 7). Similar findings have been reported by Ashour *et al.* (1977), Ashour and Thaloath (1971a) and Dostanova (1966). However, Tesu *et al.* (1977) reported that, in wheat cultivar Aurora, there was an increase in chlorophyll content with increasing salinity levels at tillering stage, but at boot stage the reverse was true.

### 2. $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in leaves and stems:

In general Na, Ca, and Mg content increased with increasing salinity levels Fig. (9-12), Tables (21-26). These characters were determined in the last three samples. Giza 155 was significantly higher in $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in stems at 2nd sample, in $Mg^{2+}$ at 3rd sample and in $Ca^{2+}$, $Mg^{2+}$ in 4th sample only compared with Falchetto. Also, for leaves, Giza 155 was significantly higher than Falchetto in $Ca^{2+}$ and $Mg^{2+}$ contents at 2nd and 3rd samples, but in

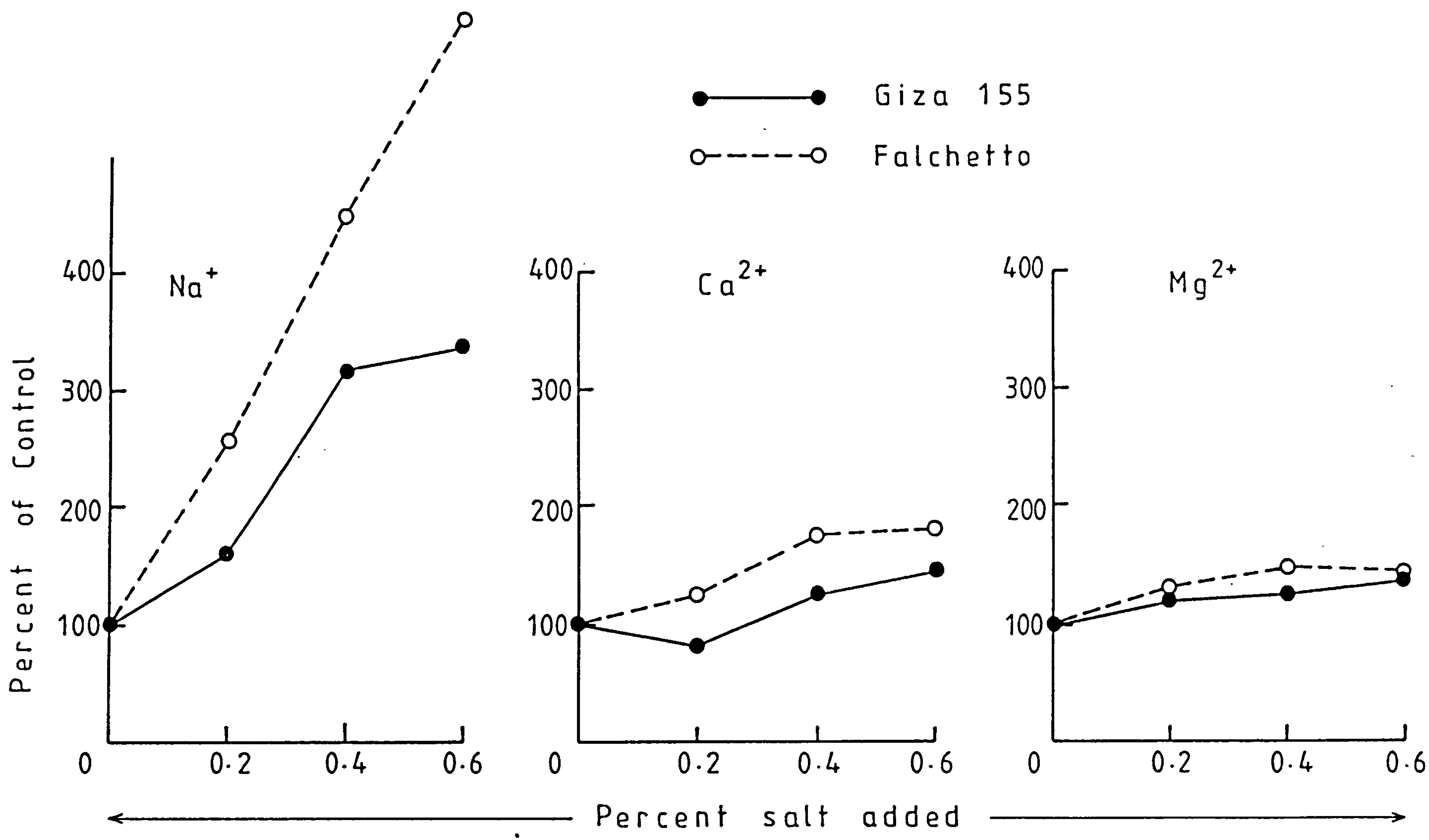



Fig. 9 Effect of different salinity levels on $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ content in stems ( 3rd sample )

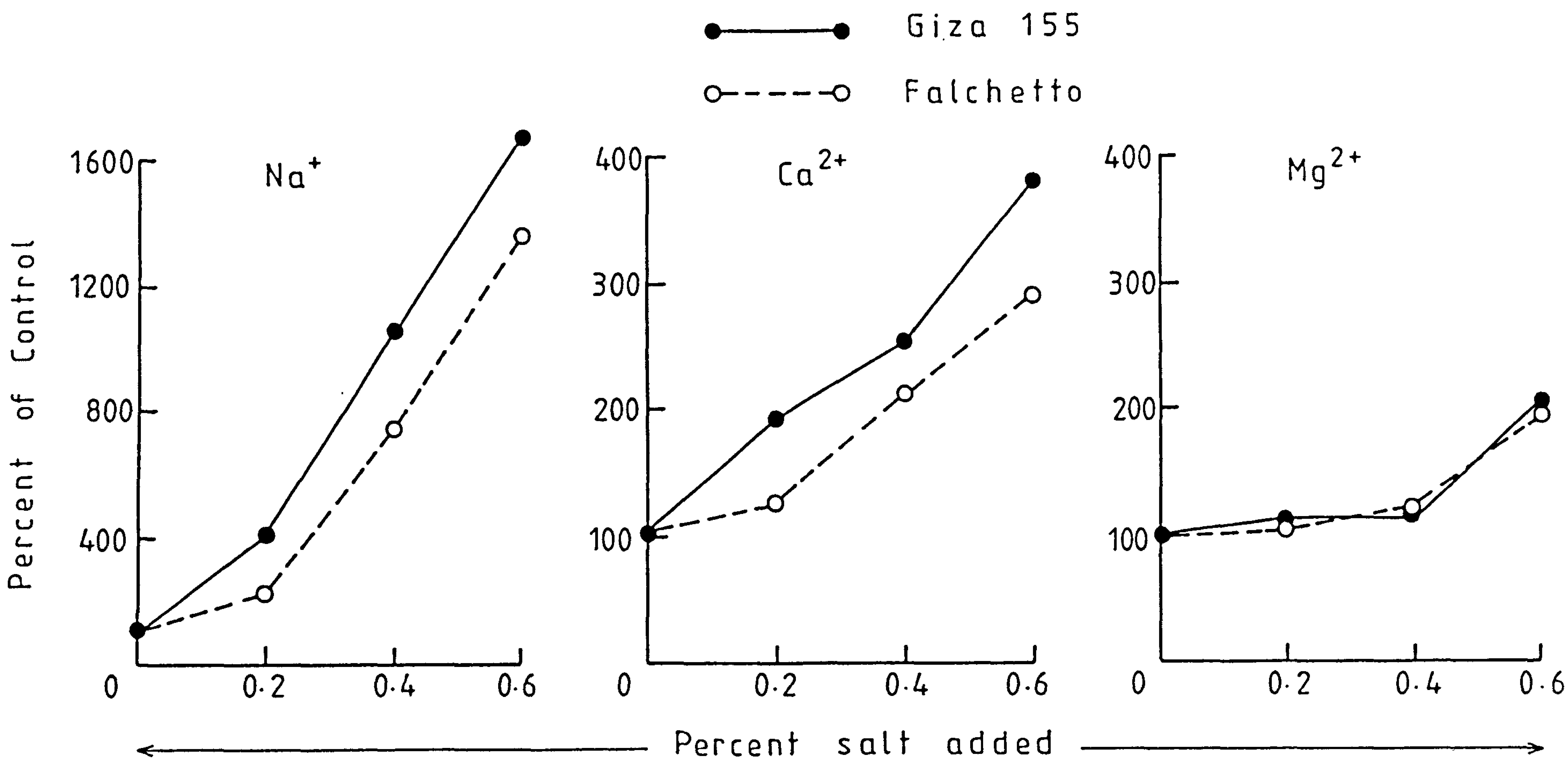



Fig. 10 Effect of different salinity levels on $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in stems (4th sample)

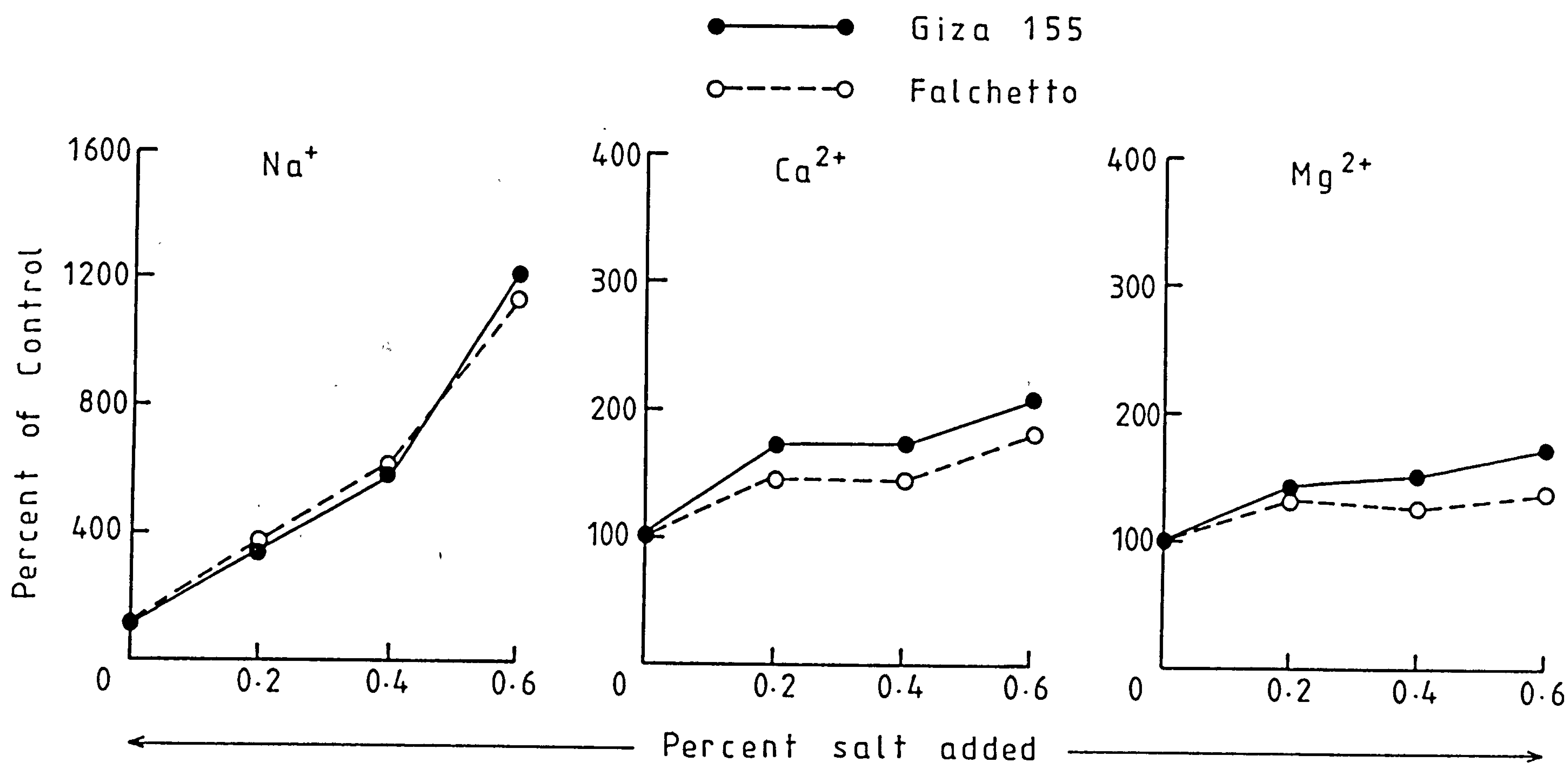



Fig. 11 Effect of different salinity levels on $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in leaves (3rd sample).

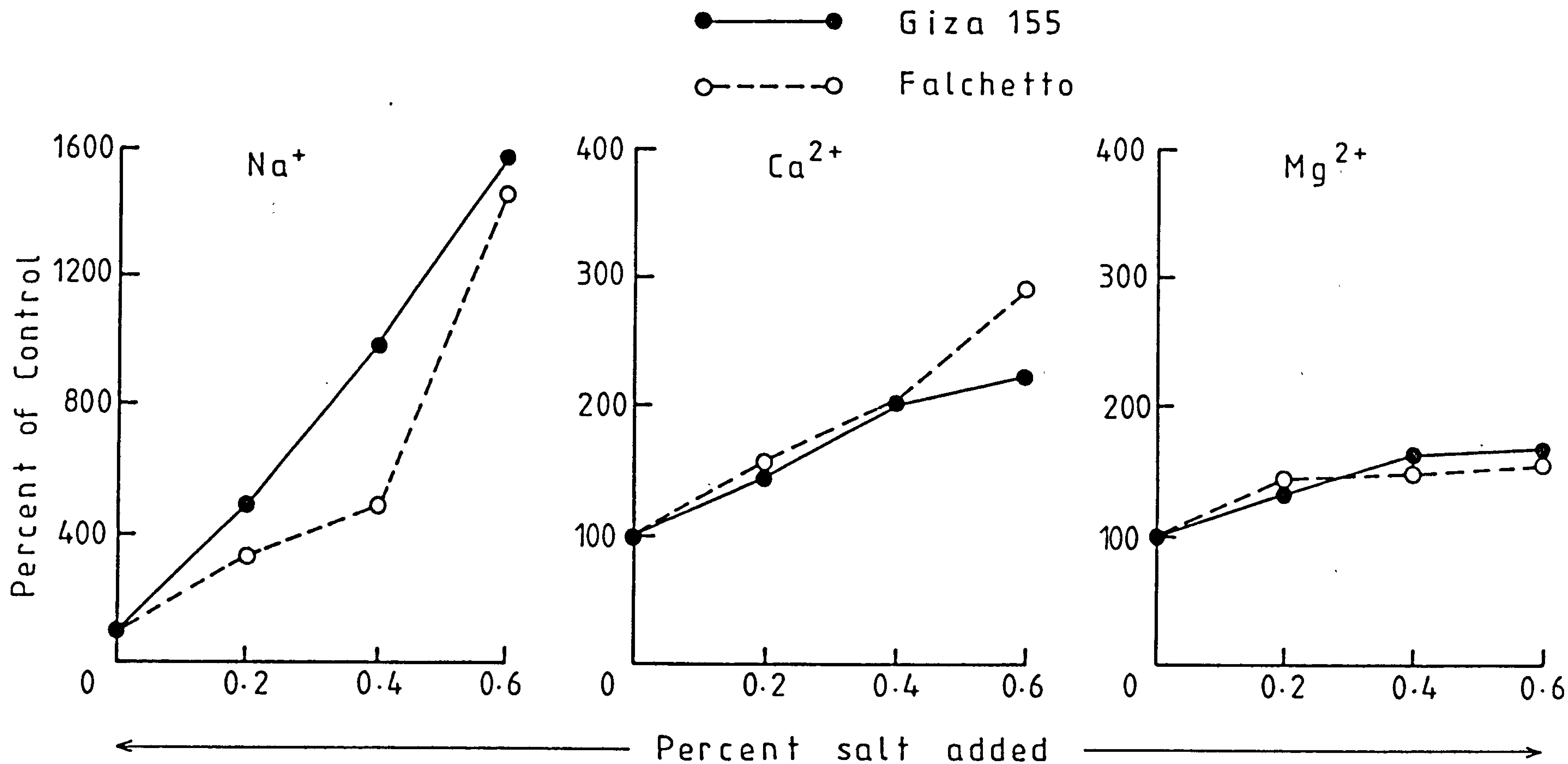



Fig. 12 Effect of different salinity levels on $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in leaves (4th sample).

Table (21) : Effect of different salinity levels on the concentration of Na, Ca and Mg in stems of two wheat varieties (2nd sample)

| varieties / salinity levels | Na ($mg.g.dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 1.290 G | 1.200* G | 1.245 d | 7.973cd | 6.463 d | 7.218 d | 1.913 f | 1.830 f | 1.872 c |
| 0.2% | 3.503 e | 3.033 f | 3.268 c | 11.013 b | 8.393 c | 9.703 c | 2.317 d | 2.153 e | 2.235 b |
| 0.4% | 5.937 c | 4.890 d | 5.413 b | 13.353 a | 8.980 c | 11.167 b | 2.430 c | 2.160 e | 2.295 b |
| 0.6% | 11.460 a | 9.450 b | 10.455 a | 13.760 a | 14.120 a | 13.940 a | 2.767 a | 2.663 b | 2.715 a |
| Mean | 5.547 a | 4.643 b | 5.0954 | 11.525 a | 9.489 b | 10.5071 | 2.357 a | 2.202 b | 2.2792 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (22) : Effect of different salinity levels on the concentration of Na, Ca and Mg in stems of two wheat varieties (3rd sample) (1981-82)

| varieties / salinity levels | Na ($mg.g.dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 1.700 | 0.917 | 1.308* c | 4.557 | 3.040 | 3.798 b | 1.187 | 0.993 | 1.090 b |
| 0.2% | 2.733 | 2.367 | 2.550bc | 3.667 | 3.743 | 3.705 b | 1.430 | 1.283 | 1.357 a |
| 0.4% | 5.400 | 4.133 | 4.767ab | 5.510 | 5.347 | 5.428 a | 1.480 | 1.473 | 1.477 a |
| 0.6% | 5.793 | 5.767 | 5.780 a | 6.460 | 5.423 | 5.942 a | 1.620 | 1.363 | 1.492 a |
| Mean | 3.907 | 3.296 | 3.6012 | 5.048 | 4.388 | 4.7183 | 1.429 a | 1.278 b | 1.3537 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (23) : Effect of different salinity levels on the concentration of Na, Ca and Mg in stems of two wheat varieties (4th sample

| varieties / salinity levels | Na ($mg.g.dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.833 | 1.000 | 0.917* c | 2.927 | 2.897 | 2.912 d | 0.800 | 0.753 | 0.777 c |
| 0.2% | 3.380 | 2.167 | 2.773 c | 5.610 | 3.557 | 4.583 c | 0.880 | 0.800 | 0.840bc |
| 0.4% | 8.917 | 7.383 | 8.150 b | 7.363 | 6.080 | 6.722 b | 0.917 | 0.883 | 0.900 b |
| 0.6% | 15.583 | 13.500 | 14.542 a | 11.110 | 8.403 | 9.757 a | 1.670 | 1.487 | 1.578 a |
| Mean | 7.178 | 6.013 | 6.5954 | 6.752 a | 5.234 b | 5.9933 | 1.067 a | 0.981b | 1.0237 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (24) : Effect of different salinity levels on the concentration of Na, Ca and Mg in leaves of two wheat varieties (2nd sample)

| varieties / salinity levels | $Na (mg.g.dw^{-1})$ | | | $Ca (mg.g.dw^{-1})$ | | | $Mg (mg.g.dw^{-1})$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.853* f | 1.000 f | 0.927 d | 9.163 | 8.783 | 8.973 | 2.067 | 1.960 | 2.013 c |
| 0.2% | 2.747 e | 4.027 d | 3.387 c | 11.877 | 9.700 | 10.788 | 2.450 | 2.043 | 2.247ab |
| 0.4% | 5.667 c | 5.367 c | 5.517 b | 12.323 | 9.427 | 10.875 | 2.360 | 1.953 | 2.157bc |
| 0.6% | 12.113 a | 10.913 b | 11.513 a | 12.820 | 8.160 | 10.490 | 2.573 | 2.190 | 2.382 a |
| Mean | 5.345 | 5.327 | 5.3358 | 11.546 a | 9.017 b | 10.2817 | 2.362 a | 2.037 b | 2.1996 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (25) : Effect of different salinity levels on the concentration of Na, Ca and Mg in leaves of two wheat varieties (1981-82) (3rd sample)

| varieties / salinity levels | Na ($mg.g.dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.800 | 0.667 | 0.733* c | 6.810 | 5.780 | 6.295 b | 1.873 | 1.683 | 1.778 b |
| 0.2% | 2.750 | 2.400 | 2.575bc | 11.683 | 8.480 | 10.082 a | 2.630 | 2.190 | 2.410 a |
| 0.4% | 4.677 | 3.307 | 3.992 b | 11.647 | 8.280 | 9.963 a | 2.813 | 2.097 | 2.455 a |
| 0.6% | 9.650 | 7.600 | 8.625 a | 14.190 | 10.387 | 12.288 a | 3.207 | 2.257 | 2.732 a |
| Mean | 4.469 | 3.493 | 3.9812 | 11.082 a | 8.232 b | 9.6571 | 2.631 a | 2.057 b | 2.3437 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (26) : Effect of different salinity levels on the concentration of Na, Ca and Mg in leaves of two wheat varieties (4th sample

| varieties / salinity levels | Na ($mg.\ g.dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.733 | 0.700 | 0.717* d | 8.300 | 7.300 | 7.800 d | 2.160 | 2.070 | 2.115 b |
| 0.2% | 3.600 | 2.400 | 3.000 c | 12.247 | 11.357 | 11.802 c | 2.887 | 2.920 | 2.903 a |
| 0.4% | 7.277 | 3.450 | 5.363 b | 16.697 | 14.743 | 15.670 b | 3.497 | 3.050 | 3.273 a |
| 0.6% | 11.600 | 10.123 | 10.862 a | 18.613 | 21.497 | 20.055 a | 3.553 | 3.140 | 3.347 a |
| Mean | 5.802 a | 4.168 b | 4.9854 | 14.714 | 13.699 | 14.2067 | 3.024 | 2.795 | 2.9096 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

$Na^+$ content at <u>4th</u> sample. Significant difference between the varieties was seen in sodium, calcium and magnesium content at <u>2nd</u> sample for stems, but only in $Na^+$ for leaves. At either of two sampling dates for which salt contents have been expressed as a percentage of control values (Figs. 9-12) a general increase in contents of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ in both stems and leaves occurred with increase in soil salinity. The amount observed appears therefore to be directly related to soil salinity. The largest relative increase is in $Na^+$ (max. 1600%), with $Ca^{2+}$ and $Mg^{2+}$ showing smaller relative increases (max 400%). However, Tables 21-26 show that the absolute content of $Ca^{2+}$ is greater in general than that of $Na^+$ or $Mg^{2+}$, particularly in leaves. This is an interesting observation in view of the fact that $Na^+$ is present in the soil in a concentration of 7 x greater than the concentration of either $Ca^{2+}$ or $Mg^{2+}$ in any of the salinisation treatments. But from Table (26-a) in which $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ are presented as total weights of these ions in leaves and stems [i.e. wt per g dw x dw.(g)] at <u>2nd</u>, <u>3rd</u> and <u>4th</u> samples, a general increase in $Na^+$ amount and decrease in $Ca^{2+}$ and $Mg^{2+}$ amounts with increasing salinity levels can be seen. Looking at the effect of time within treatments, a common feature is increase in ion content from second to fourth sample (Table 26a). The reason for changes with time could be [illegible] a steady rate of uptake from <u>2nd</u> to the <u>4th</u> periods, but changing rate of dry matter production. Thus an increase in the rate of DM production would have the effect of reducing content per unit dry matter and decrease in rate of DM production would cause an apparent increase in salt content. These is no evidence in the measured growth rates, however (Tables 11-13)

Table (26a) : Total weight of salt = (mg.g.dry.w$^{-1}$) salt x d.w. (g)

| | samples | varieties / Treatments | Na G.155 | Na FAL. | Ca G.155 | Ca FAL. | Mg G.155 | Mg FAL. |
|---|---|---|---|---|---|---|---|---|
| stems | 2nd sample | 1 | 0.166 | 0.144 | 1.029 | 0.776 | 0.247 | 0.220 |
| | | 2 | 0.273 | 0.221 | 0.859 | 0.613 | 0.181 | 0.157 |
| | | 3 | 0.368 | 0.308 | 0.828 | 0.566 | 0.151 | 0.136 |
| | | 4 | 0.332 | 0.378 | 0.399 | 0.565 | 0.080 | 0.107 |
| | 3rd sample | 1 | 1.365 | 0.633 | 3.659 | 2.095 | 0.953 | 0.685 |
| | | 2 | 1.387 | 0.923 | 1.859 | 1.460 | 0.725 | 0.500 |
| | | 3 | 1.890 | 1.281 | 1.929 | 1.658 | 0.518 | 0.457 |
| | | 4 | 1.118 | 1.309 | 1.247 | 1.231 | 0.313 | 0.309 |
| | 4th sample | 1 | 1.780 | 1.543 | 6.255 | 4.470 | 1.710 | 1.162 |
| | | 2 | 3.887 | 1.966 | 6.452 | 3.226 | 1.012 | 0.726 |
| | | 3 | 4.396 | 3.743 | 3.630 | 3.083 | 0.452 | 0.448 |
| | | 4 | 4.472 | 3.011 | 3.189 | 1.874 | 0.479 | 0.332 |
| leaves | 2nd sample | 1 | 0.230 | 0.230 | 2.474 | 2.020 | 0.558 | 0.451 |
| | | 2 | 0.448 | 0.536 | 1.936 | 1.290 | 0.399 | 0.272 |
| | | 3 | 0.737 | 0.574 | 1.602 | 1.009 | 0.307 | 0.209 |
| | | 4 | 0.690 | 0.764 | 0.731 | 0.571 | 0.147 | 0.153 |
| | 3rd sample | 1 | 0.592 | 0.485 | 5.039 | 4.202 | 1.386 | 1.224 |
| | | 2 | 0.998 | 0.809 | 4.241 | 2.858 | 0.955 | 0.738 |
| | | 3 | 0.982 | 0.685 | 2.446 | 1.714 | 0.591 | 0.434 |
| | | 4 | 1.187 | 0.859 | 1.745 | 1.174 | 0.395 | 0.255 |
| | 4th sample | 1 | 0.672 | 0.637 | 7.611 | 6.643 | 1.981 | 1.884 |
| | | 2 | 1.667 | 1.121 | 5.670 | 5.304 | 1.337 | 1.364 |
| | | 3 | 1.228 | 0.680 | 2.955 | 2.885 | 0.619 | 0.601 |
| | | 4 | 0.893 | 0.709 | 1.433 | 1.504 | 0.274 | 0.220 |

to support this. The general results obtained for these characters are similar to those reported by Ranter (1935, 1944), Bains and Fireman (1964), Ashour et al. (1977), Ansari and Naqui (1978), El-Fauly and Jung (1981), Kumar and Yadav (1983) and Kingsbury (1984). Hummadi (1977) found that grain yield was negatively correlated with $Na^+$ level of leaves sampled at spike emergence in wheat cultivar Sonora 64.

2.A $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ content in grains:

It was apparent that the salinity levels have a highly significant effect in increasing the content of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ in whole grain, Fig. (13), Table (27). As leaf and stem contents of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$, the increase of $Na^+$ content of the grain relative to control values was greater with increasing soil salinity (Fig. 13) than that of $Ca^{2+}$ and $Mg^{2+}$. Again, however, the absolute amount of $Ca^{2+}$ and $Mg^{2+}$ were greater than those of $Na^+$ except at 0.6% salinity (Table 27). But, from Table (27a) in which $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ are presented as total weight of these ions in the harvested grain, a general decrease in $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ amounts with increasing salinity levels can be seen. Also, the average content of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ (in mg per 100g d.w.) of whole wheat grain as reported in literature (Kent, 1970) are 24, 51 and 157 for $Na^+$, $Ca^{2+}$ and $Mg^{2+}$, respectively and the safe human intakes of salt (Nacl) $<$ 5g per day. (Langford et al. 1979 and MacGregor et al. 1982a). The averages in comparison with the results in Table (27) show that it could be possible to use the flour of wheat grains grown on saline soils without any problems in public health. The results are similar to those obtained by Hira

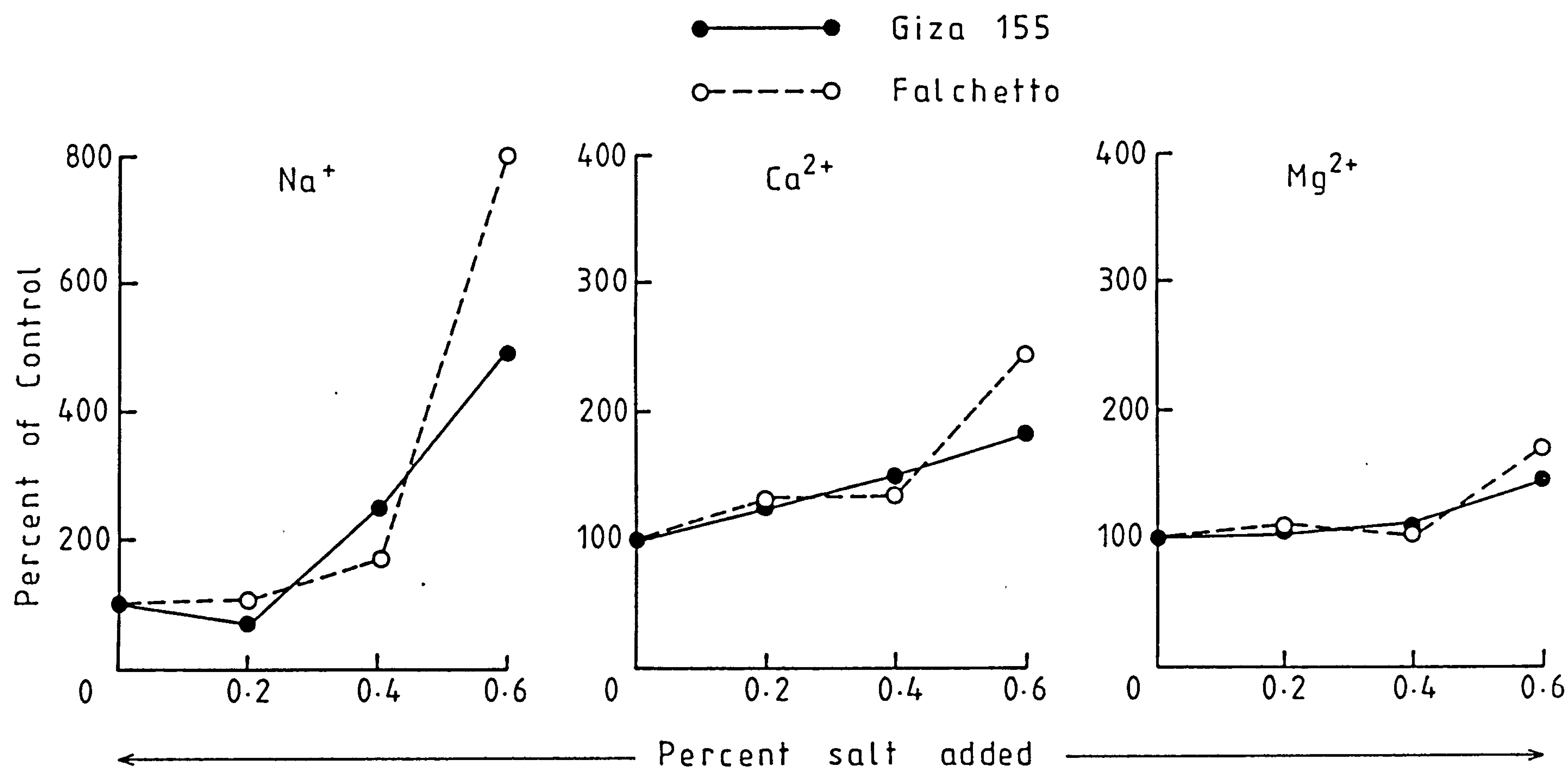



Fig. 13 Effect of different salinity levels on $Na^{+}$, $Ca^{2+}$ and $Mg^{2+}$ content in wheat grain.

Table (27) : Effect of different salinity levels on the concentration of Na, Ca and Mg of whole grains of wheat varieties (G.155 & FAL).

| varieties / salinity levels | Na ($mg.g\ dw^{-1}$) | | | Ca ($mg.g.dw^{-1}$) | | | Mg ($mg.g.\ dw^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 0.279 | 0.175 | 0.227 bc* | 0.537 e | 0.513 e | 0.525 d | 0.883 d | 0.840 e | 0.862 c |
| 0.2% | 0.200 | 0.183 | 0.192 c | 0.663 d | 0.660 d | 0.662 c | 0.903 cd | 0.873 de | 0.888 b |
| 0.4% | 0.704 | 0.300 | 0.502 b | 0.787 c | 0.687 d | 0.737 b | 0.937 c | 0.890 d | 0.913 b |
| 0.6% | 1.365 | 1.400 | 1.383 a | 0.970 b | 1.263 a | 1.117 a | 1.307 b | 1.367 a | 1.337 a |
| Mean | 0.637 | 0.552 | 0.596 | 0.739 | 0.781 | 0.7600 | 1.007 | 0.992 | 1.000 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

Table (27a) : Total weight of salt (mg) in grain yield dry weight (in grams) of 5 plants.

| varieties / salinity levels | Na | | Ca | | Mg | |
|---|---|---|---|---|---|---|
| | G.155 | FAL. | G.155 | FAL. | G.155 | FAL. |
| 0.0% | 5.734 | 4.561 | 11.035 | 13.370 | 18.146 | 21.899 |
| 0.2% | 2.667 | 3.079 | 8.842 | 11.105 | 12.042 | 14.688 |
| 0.4% | 3.113 | 2.591 | 3.480 | 5.932 | 4.143 | 7.685 |
| 0.6% | 2.076 | 1.417 | 1.475 | 1.278 | 1.988 | 1.383 |

Averages of Grain yield dry matter (in grams) per 5 plants

| varieties / salinity levels | Giza 155 | Falchetto |
|---|---|---|
| 0.0% | 20.550 | 26.064 |
| 0.2% | 13.336 | 16.825 |
| 0.4% | 4.422 | 8.635 |
| 0.6% | 1.521 | 1.012 |

Table (28) : Averages of grain moisture content (% oven dry wt.), Ash content (% oven dry wt.), Protein and carbohydrate content of two wheat varieties grown under different salinity levels.

| varieties / salinity levels | Moisture % | | | Ash(d.m basis) | | | Protein % (d.m basis) | | | Total carbohydrate%(d.m basis) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean | G.155 | FAL. | Mean |
| 0.0% | 12.443 | 13.063 | 12.753 | 2.227 | 2.103 | 2.165* d | 10.207 | 8.300 | 9.253 c | 75.123 | 76.533 | 75.828a |
| 0.2% | 12.550 | 13.007 | 12.778 | 2.507 | 2.300 | 2.403 c | 12.417 | 11.087 | 11.752 b | 72.527 | 73.607 | 73.067b |
| 0.4% | 12.610 | 12.687 | 12.648 | 2.867 | 2.503 | 2.685 b | 14.707 | 13.053 | 13.880 a | 69.817 | 71.757 | 70.787c |
| 0.6% | 12.073 | 13.470 | 12.772 | 3.167 | 3.030 | 3.098 a | 14.330 | 15.013 | 14.672 a | 70.430 | 69.480 | 69.955c |
| Mean | 12.419b | 13.057a | 12.7379 | 2.692 a | 2.484 b | 2.5879 | 12.915 a | 11.863 b | 12.3892 | 71.974 | 72.844 | 72.4092 |

*Averages within column of varieties or salinity levels followed by the same letter are not significantly different according to Duncan's test.

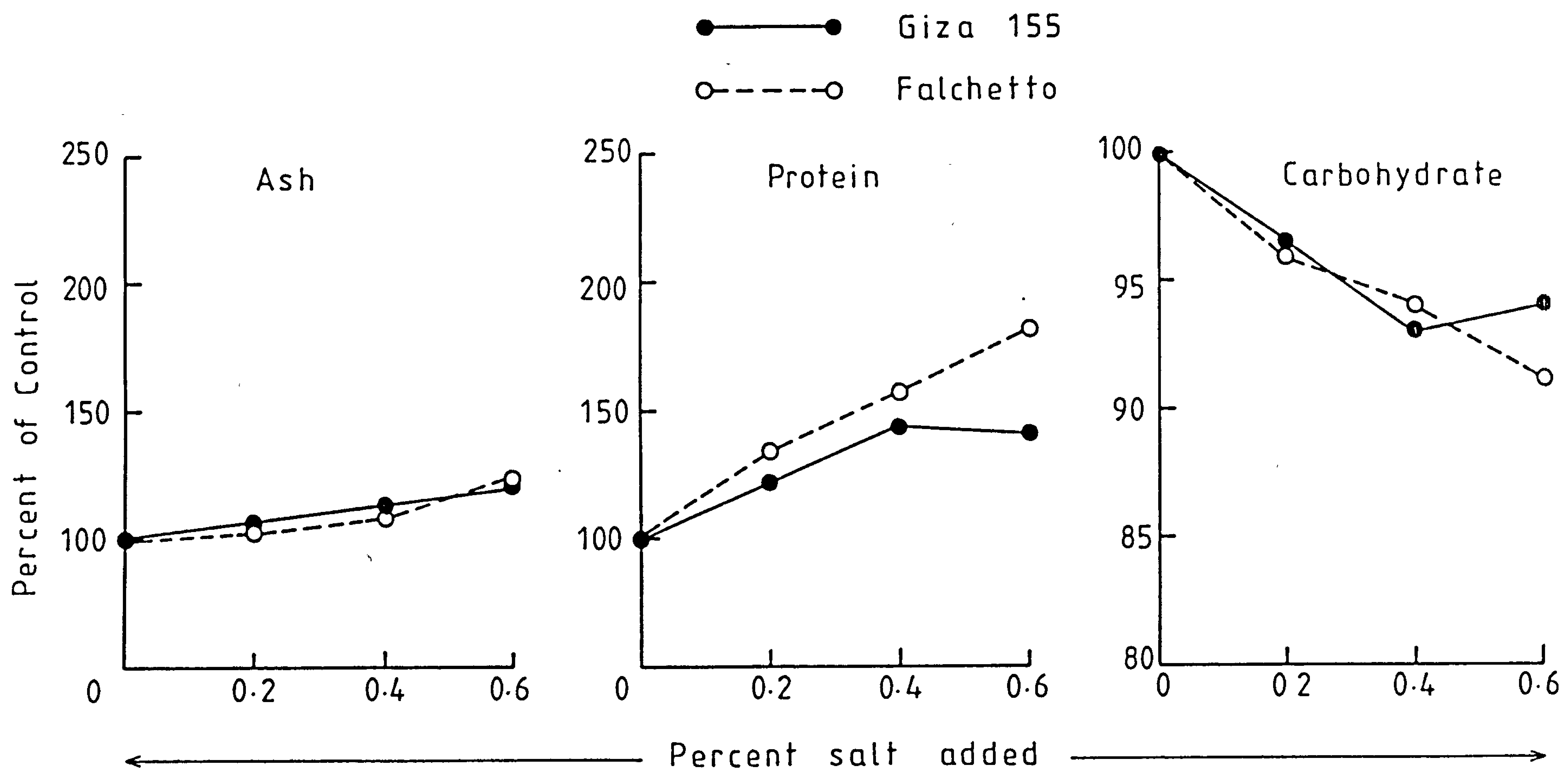



Fig. 14 Effect of different salinity levels on grain ash, protein and carbohydrate content.

and Singh (1973), Kumar *et al*. (1981), Pal *et al*. (1984). But, Asliev and Mikkailova (1977), Hassan *et al*. (1980) reported that salinity decreased mineral content in the grains of wheat and rice. However, Mali *et al*.(1982) showed that irrigated wheat plants with water having salt concentration from 20.2 to 80.2 meq/L with 4 Ca:Mg ratio (65:35 to 20:80) had no effect on N, P and $Na^+$ contents of grains.

3. Grain moisture, ash, protein and total carbohydrate contents:

Significant differences were obtained between varieties in moisture, ash and protein contents. The medium tall variety Giza 155 had the highest content in ash and protein but for moisture Falchetto had the highest content (Table 28). However, Falchetto was less sensitive to salinity for grain protein content than var. Giza 155 (Fig. 14). High significant effects due to salinity levels were observed in all these characters except moisture content. Also, ash and protein contents increase with increasing salinity but the opposite is true for the total carbohydrate content.

Wheat grain is commonly ground into flour before being used for baking. Loaf volume and Crumb texture are closely related to the protein (gluten) content of the grain. From the economic point of view, and from these results generally, it could be possible to mix the flour of wheat grains grown on saline soils (higher in protein cotnent) with the flour of other wheat grains which are lower in protein content to improve the baking quality of the flour. Similar results were obtained by Barakat *et al*. (1970), Abdel-Halim *et al*. (1976), Murthy *et al*. (1978) Labanauskas *et al*. (1981), Bangal *et al*.

(1982), Kumar and Yadav (1983). On the other hand, Asliev and Mikkailova (1977) reported that salinity decreased protein and Ash grain contents of wheat. Also, Bhala et al. (1980) showed that there was no significant differences in grain protein content of wheat cultivars irrigated with saline water of (30-1600 siemen/m) 300 - 1600 mmho/cm.

Summary

The target of the work described in this chapter was to study the effect of salinity levels on grain yield and its components, and on growth and chemical composition of two wheat varieties. A greenhouse experiment was conducted using *Triticum aestivum* L., varieties Giza 155 and Falchetto. Chloride type salinization was applied to soil and the salinity levels used (on soil dry weight basis) were 0.0, 0.2, 0.4 and 0.6% in a complete randomized block design with three replicates. In both cultivars, all yield and growth characters were reduced by increasing soil salinity. The most sensitive yield character was number of kernels per spike, but it was not possible to determine whether this was due to initiation of fewer florets or to reduced fertilisation, although the latter appears to be more likely since number of spikelets per spike is the least sensitive component at all levels of salinity. Falchetto gave higher grain yeilds than Giza 155, this superiority appearing to be based on higher tiller numbers and higher number of kernels per spike. The most sensitive growth character was leaf area, however net assimilation rate was less sensitive to salinity. the retarded growth of wheat plants under

salt stress may, therefore, result from reduction of leaf area for photosynthesis.

Chlorophyll content was significnatly reduced only by the highest salt levels in early samples and reductions in growth and yield do not therefore appear to be due to reduced chlorophyll contents.

In contrast, leaf and stem content of $Na^{+}$ , $Ca^{2+}$ and $Mg^{2+}$ increased with increasing salinity both in vegetative parts and in kernels. Levels of salt in the grain do not however approach levels hazardous to human health.

Grain ash and protein content increased but carbohydrate and moisture content decreased with increasing soil salinity.

# CHAPTER IIIA

## RESPONSE OF WHEAT VARIETIES TO NITROGEN FERTILIZER UNDER SALINITY CONDITIONS

### Introduction

Wheat is one of the main field crops in Egypt and it is the most important grain crop in the world. Nitrogen as an essential plant nutrient and soil salinity are factors which amongst others, have a great effect on productivity. Information about these two factors is very important in adaptation of crop plants to salinity and in prediction of yield in salt affected soil. The limited literature on the question of maximizing productivity of salt-affected soils through fertilizer application generally indicates that under a particular soil fertility level growth and crop yields decrease with increases in salinity but for a given salinity level there is an increase in yield with fertilizer application (Luken, 1962; Amer *et al*., 1964; Lunin and Gallatin, 1965a; Barakat *et al*., 1970; Ata *et al*., 1977; Fawzy *et al*., 1977; Hassan *et al*., 1980; Gary *et al*., 1982).

The purpose of the work described in this chapter (Part A) was to study the response of two wheat varieties to nitrogen fertilizer under different salinity levels by measuring the growth, yield and its components and leaf proline content. Proline increases proportionately faster than other amino acids in plants under a number of environmental stresses, e.g. drought, low temperature, salinity and has therefore been suggested as an evaluating parameter for selecting salinity resistant varieties.

Materials and Methods

A greenhouse experiment (at Close House Field Station) was designed involving a complete factorial analysis of nitrogen level, salinity level and wheat variety. These were 3 levels of applied nitrogen, 3 levels of soil salinity, 2 wheat cultivars and three replications giving a total of 54 experimental units in a completely randomised block. Each replicate consisted of 18 treatments, each treatment consisting of 25 pots in 5 rows. Four rows were for growth analysis sampling and proline content and the last row was for analysis of yield and its components. Sampling was carried out at 15 day intervals, the 1st sample being one month after sowing date. Each sample consisted of 5 plants, from each treatment to determine the growth analysis and proline content.

Plant material in this study consisted of two varieties of vulgare wheat, (*Triticum aestivum* L.) namely Shakha 62, local Egyptian spring variety, widely grown on all wheat growing areas in Egypt and Falchetto, an Italian spring variety. The John Innes No.2 Compost was artificially salinized with mixtures of salts including chloride salinization as described by Strogonov, 1964, and detailed in exp. 2 sec. B. Chapter II. The three levels of salinity were 0.0, 0.4 and 0.6% (based on soil dry weight) and the nitrogen fertilizer was applied as ammonium nitrate [$NH_4NO_3$] at rates of 0, 28.57 and 38.10 mg/pot. These correspond to rates of 0, 60 and 80 kg N/Faddan or 0, 144 and 192 kg N/ha. (Faddan = 0.42 ha.). Each rate was split into two applications, given successively 21 and 36 days after sowing. Nitrogen applied in this experiment was given in addition to the nitrogen already present in John Innes No.2 compost.

The plants were subjected to normal cultural practices in the greenhouse. The seeds were sown on 14/1/1983 in non-saline soils and transplanted into the saline soils on 20/1/1983 in 9.4 cm diam. containing the salinised compost.

Characters studied

I Yield and its components. (see M & M exp.2 Chapter IIB).

II. Growth and growth analysis characters. (see M & M exp.2 Chapter IIB).

III. Leaf proline content: the method of proline extraction and determination was based on work by Bates et al. (1973).

Procedure

1. Approximately 0.5g of plant material was homogenized in 10ml of 3% aqueous sulfosalicylic acid and the homogenate filtered through Whatman No.2 filter paper.

2. Two ml of filtrate was reacted with 2 ml acid-ninhdrin and 2 ml of glacial acetic acid in test tube for 1 hour at 100°C, and the reaction terminated in an ice bath.

3. The reaction mixture was extracted with 4 ml toluene, and mixed vigorously with a test tube stirrer for 15-20 sec.

4. The chromophore containing toluene was aspirated from the aqueous phase, warmed to room temperature and the absorbance read at 520 nm using toluene for a blank.

5. The proline concentration was determined from a standard curve and calculated on a fresh weight basis as follows:

$$\frac{[(\mu g \text{ proline/ml x ml toluene})/115.5\ \mu g/\mu \text{ mole}]}{(\text{g sample})/5} = \mu \text{ moles proline/g}$$

of fresh weight material.

Statistical analysis was carried out by mainframe computer MTS system Anova program, June 1978.

## Results and Discussion

### I. Grain yield and its components

#### 1. Grain Yield

Statistical analysis showed that varieties had highly significant (p=0.01) variation in grain yield. The medium tall variety Shakha 62 produced a significantly higher grain yield than the semi-dwarf variety Falchetto (Table 1).

The effect of salinity, averaging the results from the two cultivars was a tendency to decrease grain yield with increasing salinity levels, depression being 70% and 90% at 0.4 and 0.6% salinity levels, respectively, (Table 1).

Table (1) : Grain yield (g) and its components after growth at different levels of salinity and nitrogen fertilizer

| Character | Varieties (means of all treat.) | | Salinity levels (means of both cvs.) | | | Nitrogen fertilizer (means of both cvs.) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 kgN/ha | $N_3$ 192 |
| Grain yield (g) | 14.951*A | 12.950 B | 31.292 A | 7.884 B | 2.676 C | 11.298 B | 14.921 A | 15.633 A |
| Spike number per 5 plants | 10.74 | 11.48 | 17.67 A | 10.11 B | 5.56 C | 10.11 B | 11.6 A | 11.6 A |
| Spikelet number per spike | 15.76 A | 15.07 B | 20.31 A | 15.09 B | 10.83 C | 14.11 B | 15.97 A | 16.16 A |
| Grain number/spike | 34.10 | 35.80 | 53.46 A | 32.44 B | 18.96 C | 31.49 B | 35.89 A | 37.48 A |
| Spike yield (g) | 1.531 A | 1.341 B | 2.401 A | 1.329 B | 0.579 C | 1.193 B | 1.573 A | 1.543 A |
| 1000 kernel weight (g) | 38.719 A | 31.685 B | 47.650 A | 32.644 B | 25.311 C | 30.861 B | 36.844 A | 37.900 A |
| H.I. | 0.345 | 0.339 | 0.419 A | 0.322 B | 0.285 C | 0.308 B | 0.355 A | 0.363 A |
| Spike length (cm) | 7.8 A | 5.3 B | 7.88 A | 6.63 B | 5.24 C | 6.19 B | 6.76 A | 6.79 A |
| Straw yield (g) | 24.376 A | 20.949 B | 44.606 A | 16.666 B | 6.716 C | 21.377 | 23.312 | 23.298 |
| Tiller number | 5.74 | 6.48 | 12.67 A | 5.11 B | 0.56 C | 5.11 B | 6.61 A | 6.61 A |

*Averages within rows for each character of cultivars or salinity or nitrogen fertilizer followed by the same letter are not significantly different according to Duncan's test.

Table (1A) Averages of yield and its components after growth at different levels of salinity and nitrogen fertilizer

| Characters | Nitrogen levels / Salinity Levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| Grain | 0.0% | 26.98 | 23.99 | 25.49* b | 34.80 | 31.42 | 33.11 a | 36.80 | 33.76 | 35.28 a |
| Yield (g) | 0.4% | 7.13 | 5.06 | 6.09 d | 9.99 | 7.44 | 8.72 c | 10.12 | 7.57 | 8.85 c |
| per 5 plants | 0.6% | 2.53 | 2.10 | 2.32 e | 3.07 | 2.80 | 2.94 e | 3.13 | 2.42 | 2.78 e |
| Spike number | 0.0% | 15.67 | 15.33 | 15.5 b | 19.33 | 18.00 | 18.7 a | 18.00 | 19.67 | 18.8 a |
| per | 0.4% | 8.67 | 10.33 | 9.5 c | 10.00 | 11.67 | 10.8 c | 9.00 | 11.00 | 10.0 c |
| 5 plants | 0.6% | 5.00 | 5.67 | 5.3 d | 5.00 | 5.67 | 5.3 d | 6.00 | 6.00 | 6.0 d |
| Spikelet | 0.0% | 18.80 | 17.73 | 18.30 b | 20.60 | 21.33 | 20.97 a | 21.50 | 21.87 | 21.68 a |
| number | 0.4% | 15.00 | 13.00 | 14.00 d | 16.17 | 15.07 | 15.62 c | 16.50 | 14.83 | 15.67 c |
| per spike | 0.6% | 10.37 | 9.73 | 10.05 f | 11.60 | 11.03 | 11.32 e | 11.27 | 11.00 | 11.13 e |

*Averages within column or row for each character of salinity or nitrogen levels followed by the same letter are not significantly different according to Duncan's test.

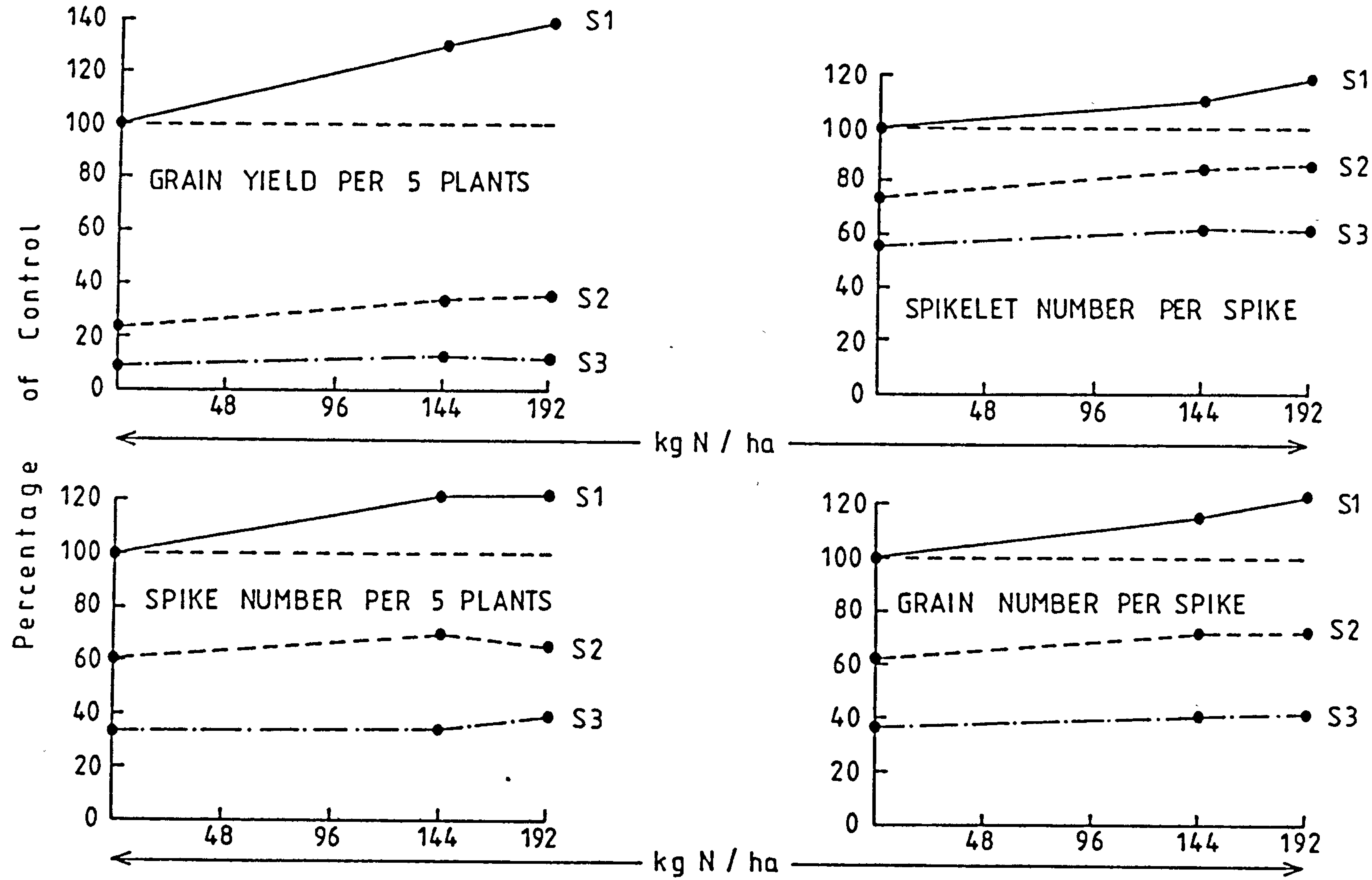



Fig. 1 Effect of different levels of soil salinity and nitrogen fertilizer on yield and yield components. ( Mean of 2 cvs )

With regard to other variables tested in the present experiment grain yield was increased by increasing nitrogen fertilizer. Adding 144 and 192 kgN/ha increased the grain yield by about 130% and 137% of control, respectively, (Table 1). However, there was no significant difference between 144 and 192 kgN/ha.

The interaction between salinity levels and nitrogen fertilizer was highly significant for grain yield and the largest average for grain yield resulted from the highest nitrogen level and salinity check treatment, (Table 1A and Fig. 1).

2. Yield Components

Analysis of variances for yield components showed highly significant varietal effects except spike number per 5 plants, grain number per spike, harvest index and tiller numbers. Shakha 62 produced larger yield components as compared with Falchetto, (Table 1).

The average spike number per 5 plants, as indicated in Table 1 was highly significantly reduced by salinity levels and increased by nitrogen levels. It was observed that reductions in this character by salinity were 48% and 68%, respectively at 0.4 and 0.6% salinity, also nitrogen rates increased spike number per 5 plants by 15% of control at both nitrogen levels. A high significant interaction was found between nitrogen fertilizer and salinity levels, (Table 1A and Fig. 1).

The average number of spikelets per spike was highly significantly affected by both salinity and nitrogen fertilizer (Table 1). There was a significant decrease by all salinity levels.

In addition, this character increased as the nitrogen rate increased. A highly significant interaction was obtained, the highest number of spikelets per spike resulting from the highest nitrogen level and the lowest salinity level (Table 1A and Fig. 1). However, this character was less sensitive as compared with the other yield components except spike length, 1000 kernel weight and H.I., being reduced by 45%, at highest level of salinity.

The data of Table 1 indicate that the average grain number per spike was highly significantly affected by the nitrogen level and the salinity levels. This number was increased by increasing the nitrogen rate and decreasing salinity level. In addition, a highly significant interaction was observed between nitrogen levels and soil salinity. The highest number of grains per spike resulted from the application of 192 kgN/ha at check salinity treatment, (Table 1B and Fig. 1).

The average spike yield was highly significantly increased with nitrogen fertilizer and decreased with increasing salinity level (Table 1). The highest value (1.57 and 1.54 g/spike) resulted at 144 and 192 kgN/ha. There was a significant NxS interaction, (Table 1B and Fig. 1A). This character was very sensitive to salinity, being depressed by 75% by salinity levels. However, spike yield was increased with nitrogen level to 135% of control.

The 1000-grain weight (grain size) as shown in Table 1, was generally increased with the increase in nitrogen level and the decrease in soil salinity. A highly significant interaction was obtained, the highest value resulting at the highest level of

Table (1B) Averages of yield components after growth at different levels of salinity and nitrogen fertilizer

| Characters | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| Grain | 0.0% | 41.53 | 53.20 | 47.37* b | 47.33 | 61.80 | 54.57 a | 54.60 | 62.67 | 58.43 a |
| number | 0.4% | 32.33 | 26.53 | 29.43 d | 35.90 | 31.33 | 33.62 c | 36.97 | 31.60 | 34.28 c |
| per spike | 0.6% | 18.10 | 17.23 | 17.67 e | 19.50 | 19.47 | 19.48 e | 20.63 | 18.80 | 19.72 e |
| Spike | 0.0% | 2.10 | 2.05 | 2.07 b | 2.45 | 2.63 | 2.54 a | 2.48 | 2.70 | 2.59 a |
| yield | 0.4% | 1.29 | 0.72 | 1.01 d | 1.78 | 1.18 | 1.48 c | 1.73 | 1.27 | 1.50 c |
| (g) | 0.6% | 0.62 | 0.38 | 0.50 e | 0.71 | 0.69 | 0.70 e | 0.63 | 0.45 | 0.54 e |
| 1000 kernel | 0.0% | 45.23 | 38.20 | 41.72 c | 50.63 | 44.83 | 47.73 b | 56.03 | 50.97 | 53.50 a |
| weight | 0.4% | 28.20 | 25.57 | 26.88 e | 40.63 | 32.57 | 36.30 d | 39.40 | 30.10 | 34.75 d |
| (g) | 0.6% | 28.83 | 19.13 | 23.98 e | 29.77 | 23.23 | 26.50 e | 30.33 | 20.57 | 25.45 e |
| Tiller | 0.0% | 10.67 | 10.33 | 10.50 b | 14.33 | 13.00 | 13.67 a | 13.00 | 14.67 | 13.83 a |
| number | 0.4% | 3.67 | 5.33 | 4.50 c | 5.00 | 6.67 | 5.83 c | 4.00 | 6.00 | 5.00 c |
| per 5 plants | 0.6% | 0.00 | 0.67 | 0.33 d | 0.00 | 0.67 | 0.33 d | 1.00 | 1.00 | 1.00 d |

*Averages within column or row for each character of salinity or nitrogen levels followed by the same letter are not significantly different according to Duncan's test.

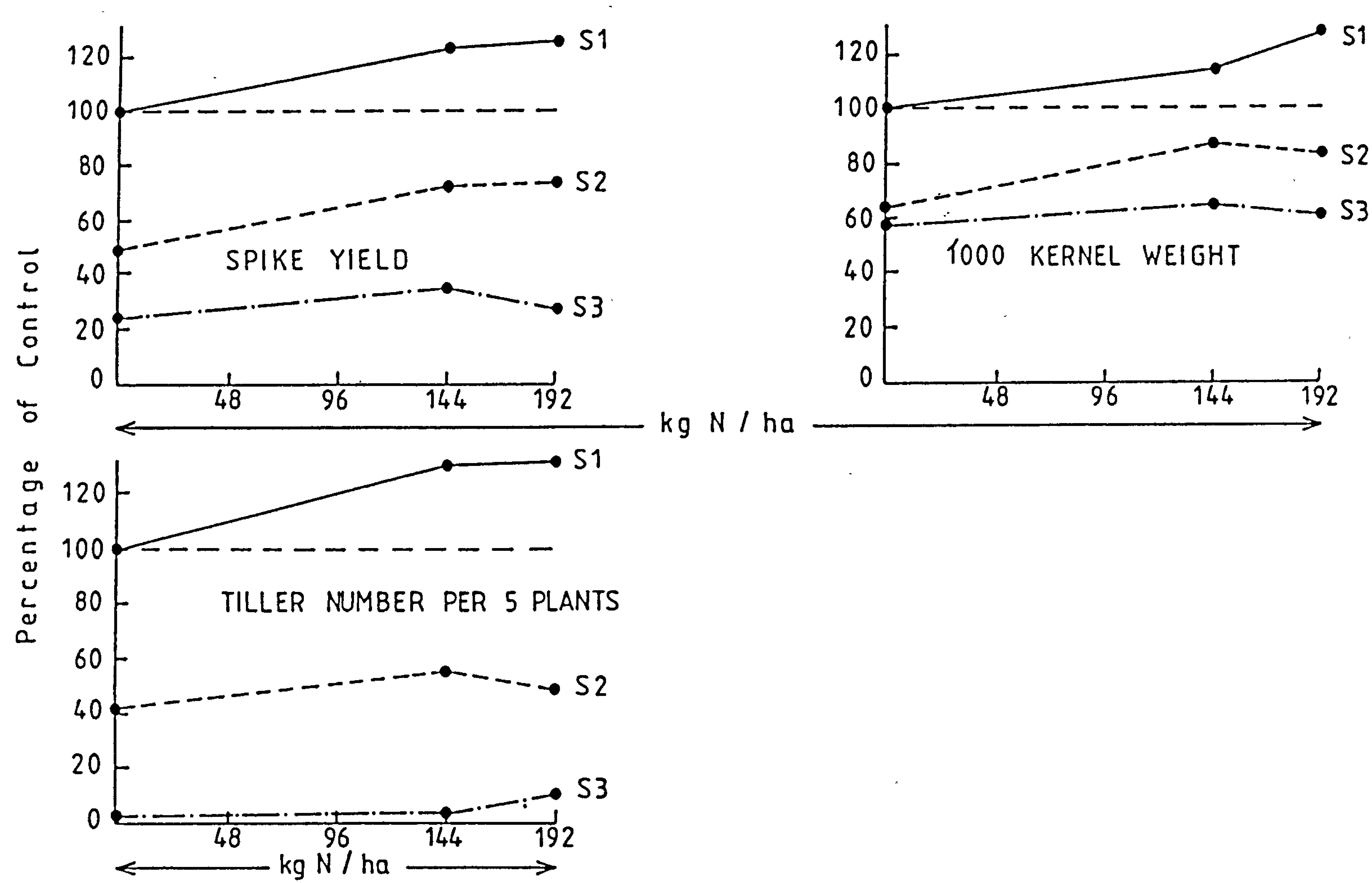



Fig. 1a Effect of different levels of soil salinity and nitrogen fertilizer on yield components. (Mean of 2 cvs)

nitrogen (192 kgN/ha) and lowest level of salinity (control). This character was less sensitive to salinity and very sensitive to nitrogen fertilizer, (Table 1B and Fig. 1A).

Table 1 shows that both the average spike length and harvest index (percentage of grain to total yield) was generally increased with the increase in nitrogen level and the decrease in soil salinity. The effect of salinity and nitrogen fertilizer on these characters were independent of each other. There were no significant interactions. These two characters plus spikelet number per spike and 1000 kernel weight are not as sensitive as other components, being reduced by only 40% or less at the highest level of salinity (Table 1).

Table 1 reveals the positive effect of soil salinity only on the average straw yield and there was no effect of nitrogen fertilizer on this character. However, straw yield tended to increase with nitrogen application but the trend was not marked enough to approach the 5% significance level.

The data of Table 1 and 1B indicate that the average number of tillers per 5 plants was highly affected by nitrogen rates and salinity levels. This measurement was generally increased by nitrogen fertilizer and decreased markedly with salinity levels and it was observed that the tiller number was depressed by 95% at the highest level of salinity (0.6%). However, with the application of the nitrogen fertilizer, a significant increase in the average number of tillers was noted. A high significant interaction between salinity levels and nitrogen fertilizer was obtained. The highest number of tillers per 5 plants resulted (13.83 tillers/5 plants) from a nitrogen level of 192 kgN/ha at check treatment of salinity (Table 1B and Fig. 1A). Similar results were reported by El-Gabaly, 1959; Barakat et al., 1970; Sharma and Lal, 1973; Aboul-Saod and Ashour, 1974; Dhir et al., 1975; Joshi, 1976, Fawzy et al., 1977; Goswami et al., 1977; Hassan et al., 1980; Kumar et al., 1983. However, Chauhan et al., (1980) reported that, with wheat cv. Raj 911, at salinity contents of >6.5 mmho/cm (0.65 siemen/m), grain yields decreased but nitrogen or phosphate applications had no effect with increase in salinity content. But, Fawzy et al., (1977) studied the effect of nitrogen and salinity on Giza 155 and Mexican wheat cultivars and they noted that at low salinity and low nitrogen both cvs had equal grain and straw yields. At higher levels Giza 155 outyielded Mexican super X by approx. 20%. Also, Chhillar and Swarp (1984) observed that, after 8 years field study on sodic soil, continuous application of nitrogen fertilizer significantly enhanced the yields of both rice and wheat grown in sequence.

From these results, it could be observed that the application of nitrogen fertilizer under soil salinity conditions enhanced the grain yield and its components and to some extent countered the adverse effect of soil salinity up to 0.4%. From the economic point of view, it would be unnecessary to use more than 144 kgN/ha (60 kgN/Faddan) for the tested varieties (Shakha 62 and Falchetto). Also the medium tall variety Shakha 62 would be recommended for high yield. It is doubtful however, if the use of such a relatively large dressing of nitrogen would be justified for such a relatively small increase in yield. The relatively lower grain yield under 0.6%

salinity with application of nitrogen fertilizer could be due to the dissolved nitrogen in soil solution which is therefore additive to the total salt in soil solution and tend to reduce PH, resulting in increases of dissolved $Ca^{2+}$, $Mg^{2+}$, and $K^{+}$ in solution, a factor that will serve to increase the measured electrical conductivity of the saturation extract ($EC_e$), and to decrease grain yield. In situations where added nitrogen counters the adverse effects of salinity, the beneficial effect, however it acts, must outweigh the adverse effects of salinity increased by the added nitrogen. A possible reason for the beneficial effect of added nitrogen under saline conditions is that the salts present in the soil interfere with the uptake of nitrogen such that a reduced proportion of the available nitrogen is observed and addition of nitrogen to the soil therefore increases the total amount of nitrogen absorbed.

## II. Growth and growth analysis characters

### 1. Plant height and peduncle length at harvest

The data in Tables 2,2A and Fig. 2 indicate that the average plant height and average peduncle length were similarly affected by the nitrogen level and soil salinity treatments. These measurements were generally increased by increasing the nitrogen level and decreasing salinity levels. Also, it was observed that the two characters were depressed by 40% and 50% at the highest level of salinity (0.6%). No significant interaction was obtained between nitrogen rates and salinity levels. This means that the effect of

Table (2) : Averages of plant height and Peduncle length, in cm, at harvest after growth at different levels of salinity and nitrogen fertilizer

| Characters (cm) | Varieties | | Salinity levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | 0 | 144 | 192 |
| Plant height | 56.46* a | 50.73 b | 66.35 a | 54.18 b | 40.25 c | 52.39 b | 54.04 a | 54.36 a |
| Peduncle Length | 26.42 a | 22.29 b | 31.63 a | 25.16 b | 16.26 c | 23.41 b | 24.73 a | 24.91 a |

*Averages within row for each character of varieties or salinity or nitrogen fertilizer followed by the same letter are not significantly different according to Duncan's test.

Table (2A) : Averages of plant height and Peduncle length, in cm, at harvest after growth at different levels of salinity and nitrogen fertilizer

| Characters (cm) | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| Plant Height | 0.0% | 66.27 | 64.13 | 65.20 | 69.13 | 64.47 | 66.80 | 68.83 | 65.27 | 67.05 |
| | 0.4% | 57.30 | 49.83 | 53.57 | 57.77 | 50.87 | 54.32 | 57.63 | 51.70 | 54.67 |
| | 0.6% | 40.83 | 35.96 | 38.40 | 44.30 | 37.70 | 41.00 | 46.03 | 36.67 | 41.35 |
| Peduncle Length | 0.0% | 32.90 | 28.83 | 30.87 | 34.00 | 29.40 | 31.70 | 34.97 | 29.70 | 46.35 |
| | 0.4% | 27.90 | 21.10 | 24.50 | 28.17 | 22.37 | 25.27 | 28.13 | 23.30 | 25.72 |
| | 0.6% | 15.37 | 14.37 | 14.87 | 18.67 | 15.77 | 17.22 | 17.63 | 15.73 | 16.68 |

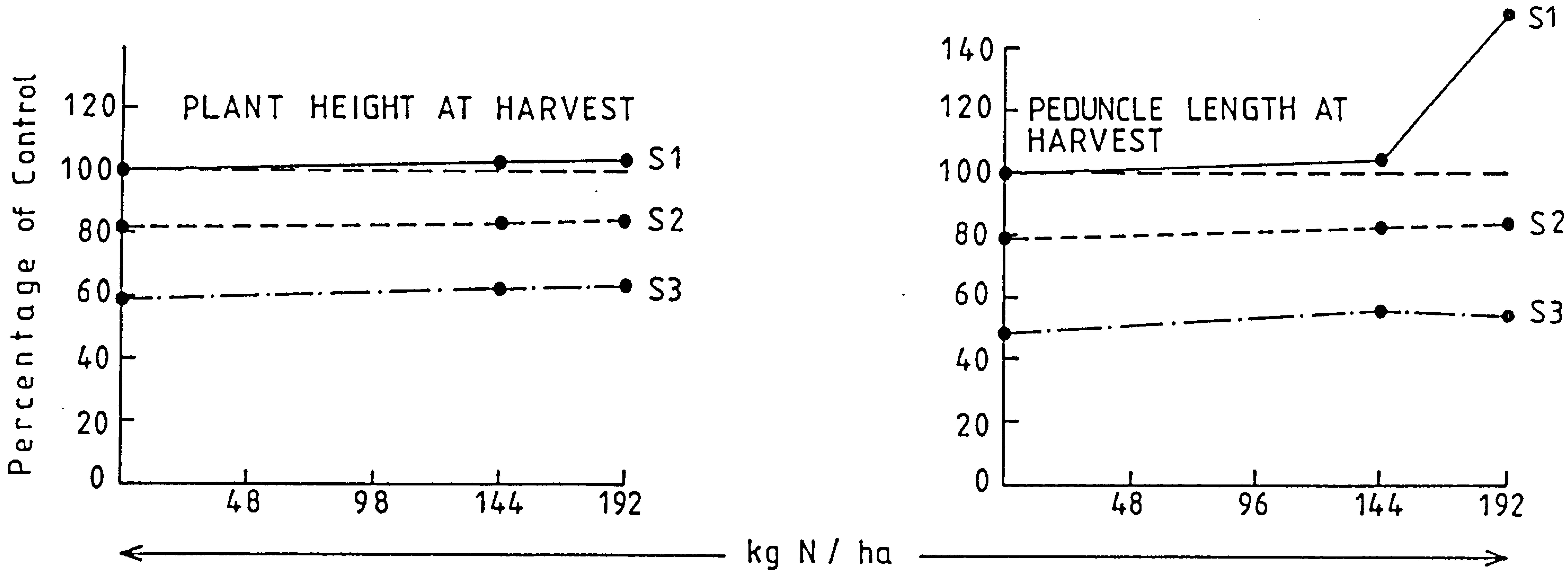



Fig. 2 Effect of different levels of soil salinity and nitrogen fertilizer on plant height and peduncle length at harvest. ( Mean of 2 cvs )

all these variables on plant height and peduncle length were independent of each other. The analysis of variances for plant height and peduncle length showed a highly significant varietal effect. Shakha 62 had the higher height and penduncle length with significant differences as compared with Falchetto. These results are in conformity with those of Aboul-Saod and Ashour, 1974; El-Sharkawy et al., 1977; Suganuma, 1978; Kumar and Singh, 1980; and Kumar, 1983.

2. Number of leaves, tillers, plant height and leaf area

Tables 3 - 6A and Figs 3 - 5 shows that there were significant effects due to salinity levels and nitrogen fertilizer, except at the 1st sample for nitrogen fertilizer, on all these characters. These characters generally increased with increasing nitrogen rates and decreased by further increase in the soil salinity. A highly significant interaction betwen nitrogen and salinity was obtained for all characters except plant height and at all samples except the 1st sample for leaf number and the first two samples for leaf area and tillers number. This interaction means that the effect of salinity and nitrogen fertilizer on these characters were dependent on each other. Falchetto had a significantly higher number of leaves and tillers (except at 1st sample) and higher leaf area compared with Shakha 62 and the opposite is true for plant height except at 1st sample (Tables 3-6A). However, it can be observed from Table A4 that both cultivars showed similar reduction in leaf area at 2nd, 3rd and 4th sample, respectively. On the other hand Table 4A shows that

Table (3) : Averages of leaf number per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | 0 | 144 | 192 |
| 1st sample | 15.78 | 15.88 | 19.50*a | 15.50 b | 12.50 c | 16.0 | 15.83 | 15.67 |
| 2nd sample | 26.82 b | 30.56 a | 43.22 a | 23.33 b | 19.50 c | 27.83 | 29.28 | 28.94 |
| 3rd sample | 35.67 b | 41.37 a | 66.17 a | 29.17 b | 20.22 c | 35.28 b | 39.44 a | 40.83 a |
| 4th sample | 39.41 b | 44.52 a | 80.11 a | 25.67 b | 20.11 c | 37.67 b | 44.28 a | 43.94 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (3A) : Averages of leaf number per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 18.67 | 20.33 | 19.50 | 20.33 | 19.00 | 19.67 | 20.67 | 18.00 | 19.33 |
| | 0.4% | 15.67 | 16.00 | 15,83 | 14,33 | 15.67 | 15.00 | 15.33 | 16.00 | 15.67 |
| | 0.6% | 12.00 | 13.33 | 12.67 | 13.33 | 12.33 | 12.83 | 11.67 | 12.33 | 12.00 |
| 2nd | 0.0% | 40.33 | 46.67 | 43.50 | 41.00 | 45.33 | 43.17 | 39.33 | 46.67 | 43.00 |
| | 0.4% | 20.33 | 23.67 | 22.00 | 22.67 | 25.00 | 23.83 | 22.67 | 25.67 | 24.17 |
| | 0.6% | 17.00 | 19.00 | 18.00 | 19.67 | 22.00 | 20.83 | 18.33 | 21.00 | 19.67 |
| 3rd | 0.0% | 54.33 | 64.67 | 59.50* b | 62.67 | 72.67 | 67.67 a | 68.67 | 74.00 | 71.33 a |
| | 0.4% | 24.33 | 30.67 | 27.5o c | 26.00 | 34.00 | 30.00 c | 26.00 | 34.00 | 30.00 c |
| | 0.6% | 17.33 | 20.33 | 18.83 d | 20.67 | 20.67 | 20.67 d | 21.00 | 21.33 | 21.17 d |
| 4th | 0.0% | 58.33 | 79.33 | 68.83 b | 79.33 | 90.67 | 85.00 a | 78.33 | 94.67 | 86.50 a |
| | 0.4% | 23.00 | 25.33 | 24.17 cd | 24.67 | 29.33 | 27.00 c | 26.00 | 25.67 | 25.83 cd |
| | 0.6% | 21.33 | 18.67 | 20.00 d | 23.33 | 18.33 | 20.83 cd | 20.00 | 18.67 | 19.50 d |

*Averages within column or row for each sample of varieties or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (4) : Averages of leaf area per 4 plants, In $cm^2$, at four samples dates of 2 wheat cvs growingat different levels of salinity and nitrogen fertilizer.

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 118.90*b | 144.76 a | 217.88 a | 108.35 b | 69.24 c | 132.81 | 128.54 | 134.13 |
| 2nd sample | 298.29 b | 374.79 a | 619.48 a | 249.63 b | 140.51 c | 313.76 b | 344.34 a | 351.52 a |
| 3rd sample | 589.29 b | 758.94 a | 1396.54 a | 445.69 b | 180.13 c | 601.98 b | 706.52 a | 713.85 a |
| 4th sample | 819.10 b | 1100.09 a | 2190.87 a | 483.54 b | 204.38 c | 847.60 b | 1001.10 a | 1030.09 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (4A) : Averages of leaf area per 4 plants, in $cm^2$, at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 185.27 | 251.79 | 218.53 | 187.81 | 234.75 | 211.28 | 224.47 | 223.23 | 223.85 |
| | 0.4% | 101.83 | 124.46 | 113.15 | 86.76 | 119.09 | 102.92 | 97.46 | 120.52 | 108.99 |
| | 0.6% | 57.74 | 75.80 | 66.77 | 69.27 | 73.53 | 71.41 | 59.44 | 79.66 | 69.55 |
| 2nd | 0.0% | 501.81 | 657.15 | 579.48 | 547.47 | 711.59 | 629.53 | 572.39 | 726.46 | 649.43 |
| | 0.4% | 204.95 | 239.73 | 222.34 | 225.33 | 279.40 | 252.36 | 266.21 | 282.15 | 274.18 |
| | 0.6% | 109.19 | 169.72 | 139.45 | 133.29 | 168.98 | 151.14 | 123.95 | 137.93 | 130.94 |
| 3rd | 0.0% | 1054.23 | 1394.65 | 1224.44*b | 1279.82 | 1638.79 | 1459.31 a | 1363.56 | 1648.16 | 1505.86 a |
| | 0.4% | 344.11 | 492.55 | 418.33 c | 401.96 | 539.53 | 470.75 c | 400.86 | 495.13 | 447.99 c |
| | 0.6% | 124.39 | 201.94 | 163.16 d | 160.52 | 218.50 | 189.51 d | 174.19 | 201.21 | 187.70 d |
| 4th | 0.0% | 1569.69 | 2209.12 | 1889.41 b | 2011.87 | 2570.17 | 2291.02 a | 1958.82 | 2825.54 | 2392.18 a |
| | 0.4% | 381.42 | 551.14 | 466.28 c | 411.90 | 568.29 | 490.09 c | 461.99 | 526.52 | 494.26 c |
| | 0.6% | 165.72 | 208.53 | 187.13 d | 216.54 | 227.82 | 222.18 d | 193.95 | 213.72 | 203.83 d |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (5) : Averages of plant height, in cm, at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer.

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 7.33 b | 7.79*a | 9.79 a | 7.41 b | 4.59 c | 7.57 | 7.48 | 7.62 |
| 2nd sample | 12.65 | 12.24 | 15.36 a | 12.39 b | 9.58 c | 11.96 b | 12.76 a | 12.62 a |
| 3rd sample | 24.74 a | 21.50 b | 27.08 a | 24.77 b | 17.49 c | 22.37 b | 23.95 a | 23.03 ab |
| 4th sample | 36.00 a | 33.22 b | 41.16 a | 36.48 b | 26.20 c | 32.84 b | 35.56 a | 35.44 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (5A) : Averages of plant height, in cm, at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 9.09 | 10.51 | 9.80 | 9.25 | 10.64 | 9.95 | 9.29 | 9.96 | 9.63 |
| | 0.04% | 7.61 | 7.71 | 7.66 | 6.66 | 7.16 | 6.91 | 7.42 | 7.88 | 7.65 |
| | 0.06% | 5.13 | 5.40 | 5.27 | 5.81 | 5.39 | 5.60 | 5.70 | 5.48 | 5.59 |
| 2nd | 0.0% | 14.30 | 15.37 | 14.83 | 15.17 | 16.10 | 15.63 | 15.43 | 15.77 | 15.60 |
| | 0.4% | 12.03 | 10.87 | 11.45 | 13.20 | 12.20 | 12.70 | 13.13 | 12.93 | 13.03 |
| | 0.6% | 9.87 | 9.30 | 9.58 | 10.50 | 9.40 | 9.95 | 10.20 | 8.23 | 9.22 |
| 3rd | 0.0% | 28.86 | 21.83 | 25.40 | 33.58 | 23.46 | 28.52 | 30.63 | 24.04 | 27.33 |
| | 0.4% | 23.54 | 25.38 | 24.46 | 27.06 | 25.40 | 26.23 | 24.21 | 23.04 | 23.63 |
| | 0.6% | 17.99 | 16.52 | 17.25 | 18.04 | 16.17 | 17.11 | 18.61 | 17.64 | 18.13 |
| 4th | 0.0% | 40.75 | 37.71 | 39.23 | 43.21 | 40.28 | 41.74 | 44.21 | 40.79 | 42.50 |
| | 0.4% | 35.29 | 34.25 | 34.77 | 38.91 | 35.64 | 37.27 | 38.44 | 36.36 | 37.40 |
| | 0.6% | 24.92 | 24.11 | 24.51 | 29.78 | 25.56 | 27.67 | 28.57 | 24.27 | 26.42 |

Table (6) : Averages of tiller number per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 1.00 | 0.85 | 2.78* a | 0.00 b | 0.00 b | 1.00 | 1.00 | 0.78 |
| 2nd sample | 2.59 b | 4.00 a | 8.78 a | 1.11 b | 0.00 c | 3.22 | 3.39 | 3.28 |
| 3rd sample | 3.07 b | 4.44 a | 10.39 a | 0.89 b | 0.00 c | 3.33 | 3.94 | 4.00 |
| 4th sample | 3.63 b | 4.37 a | 11.50 a | 0.50 b | 0.00 b | 3.28 b | 4.22 a | 4.5 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (6A) : Averages of tiller number per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer.

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 2.67 | 3.33 | 3.00 | 3.33 | 2.67 | 3.00 | 3.00 | 1.67 | 2.33 |
| | 0.4% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.6% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2nd | 0.0% | 7.33 | 11.00 | 9.17 | 7.67 | 10.00 | 8.83 | 7.00 | 9.67 | 8.33 |
| | 0.4% | 0.00 | 1.00 | 0.50 | 0.33 | 2.33 | 1.33 | 1.00 | 2.00 | 1.50 |
| | 0.6% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3rd | 0.0% | 7.00 | 10.67 | 9.83* b | 10.00 | 12.33 | 11.17 a | 10.33 | 12.00 | 11.17 a |
| | 0.4% | 0.33 | 2.00 | 1.17 c | 0.00 | 1.33 | 0.67 c | 0.00 | 1.67 | 0.83 c |
| | 0.6% | 0.00 | 0.00 | 0.00 c | 0.00 | 0.00 | 0.00 c | 0.00 | 0.00 | 0.00 c |
| 4th | 0.0% | 8.33 | 10.67 | 9.50 b | 12.00 | 12.33 | 12.17 a | 11.33 | 14.33 | 12.83 a |
| | 0.4% | 0.00 | 0.67 | 0.33 c | 0.00 | 1.00 | 0.50 c | 1.000 | 0.33 | 0.67 c |
| | 0.6% | 0.00 | 0.00 | 0.00 c | 0.00 | 0.00 | 0.00 c | 0.00 | 0.00 | 0.00 c |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

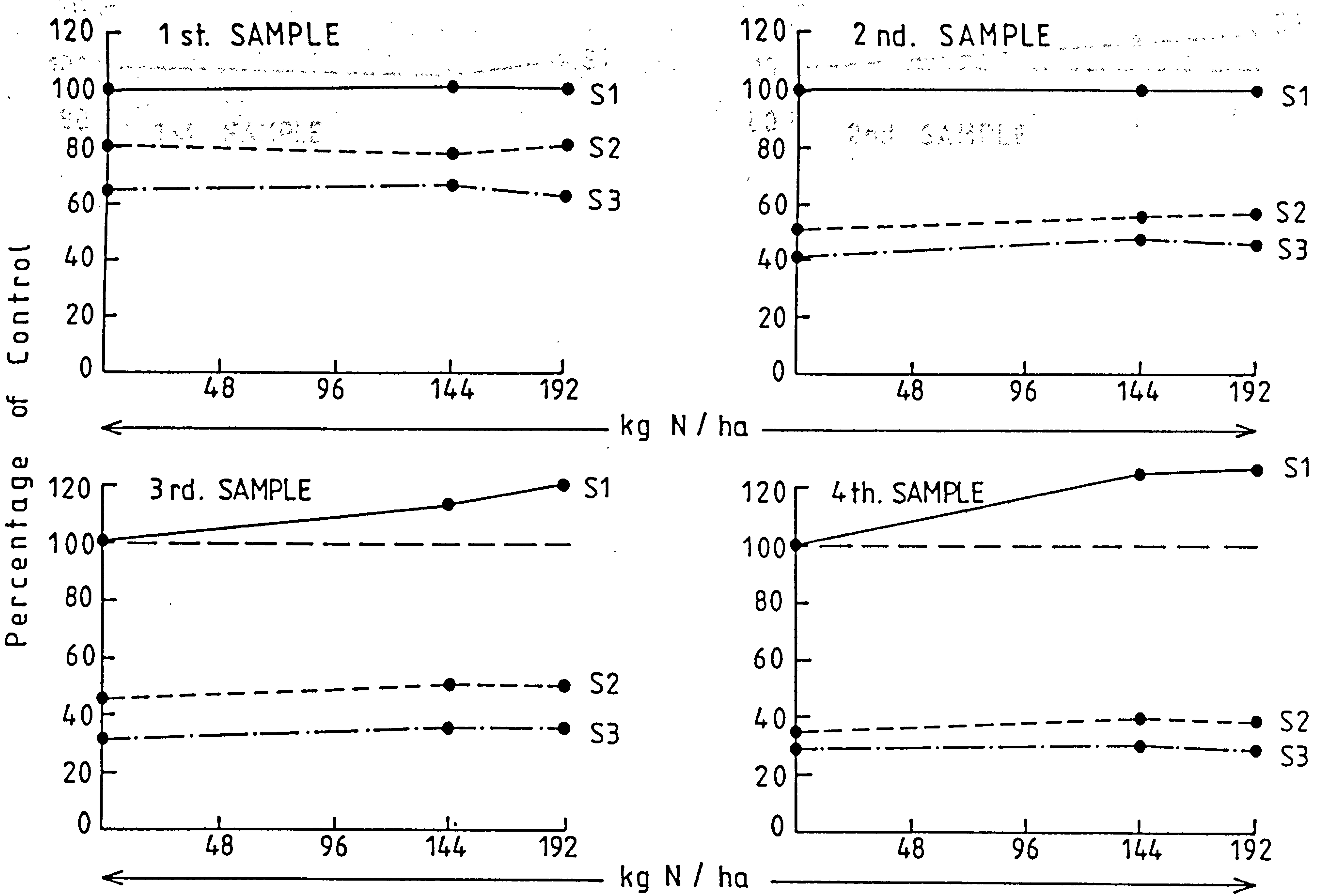



Fig. 3 Effect of different levels of soil salinity and nitrogen fertilizer on leaf number per 4 plant at four samples dates. ( Mean of 2 cvs )

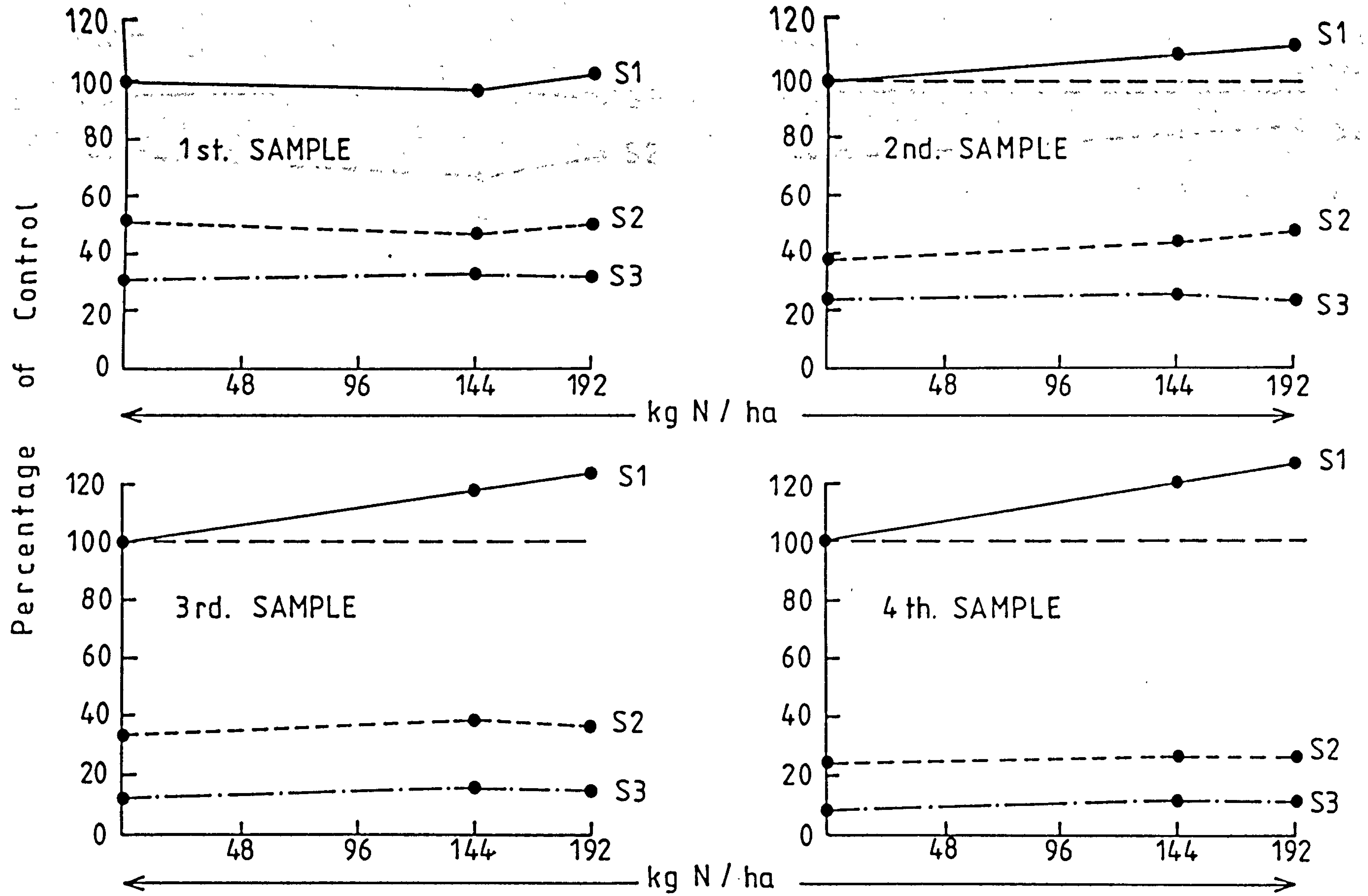



Fig. 4 Effect of different levels of soil salinity and nitrogen fertilizer on leaf area per 4 plants at 4 samples dates. ( Mean of 2 cvs )

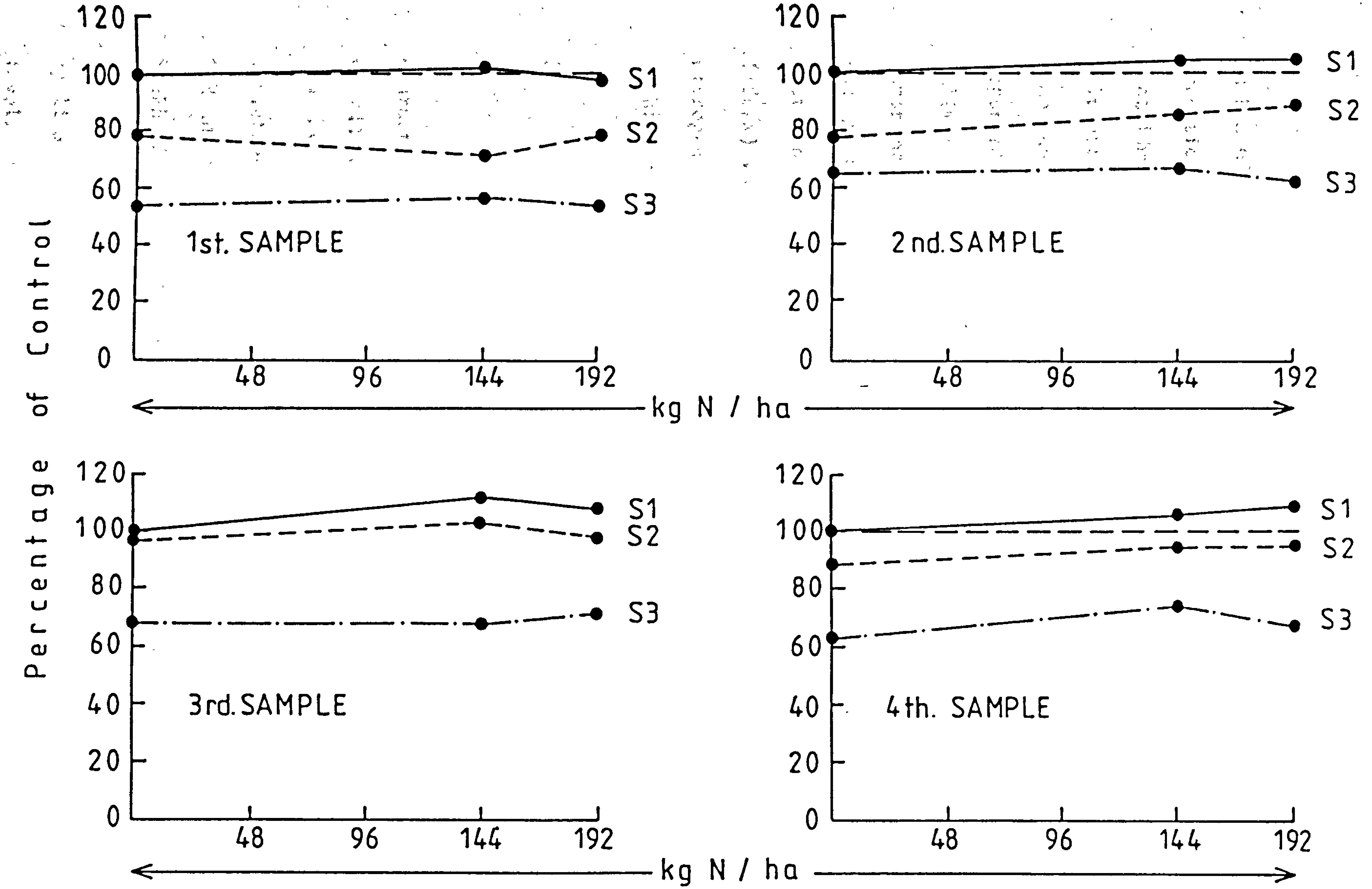



Fig. 5 Effect of different levels of soil salinity and nitrogen fertilizer on plant height at four samples dates. (Mean of 2 cvs)

Shakha 62 was more responsive to nitrogen application under salinity conditions than Falchetto. Generally data for these characters showed that Shakha 62 exhibited higher response to nitrogen fertilizer than Falchetto under salinity conditions, while the two cultivars had the same degree of sensitivity to salt. Similar findings have been reported by Dhir et al. (1975), El-Laboudi and Maoukhtar (1975), Paliwal et al. (1976), El-Sharkawy et al. (1977), Hassan et al. (1980), Kumar and Singh (1980), Verma and Neue (1984). However, Papadapoulos and Rending (1983) found that tomato plants responded to increasing nitrogen levels (8-120 ppm $NO_3$—N) only at the lowest salinity levels (1ds/m) while at the higher salinity levels (5 and 9 ds/m), increasing nitrogen did not counteract the adverse effect on plant growth caused by high salinity levels.

3. Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) and leaf area ratio (LAR)

The data of Tables 7-10A and Figs. 6-9 show that all these characters decreased significantly with increasing salinity levels at all intervals, the only exceptions being NAR at the last interval and LAR at the first. There were significant differences between varieties, Falchetto had higher LAR values at all intervals and higher CGR at the 1st interval only as compared with Shakha 62. However, Shakha 62 had a higher NAR at the last interval than Falchetto.

RGR, NAR and LAR tended to increase with nitrogen application but the trend was not enough to reach the 5% significance level. However, CGR increased significantly with increasing nitrogen

Table (7) : Averages of crop growth rate (g. $week^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer.

| Intervals | Varieties | | Salinity Levels | | | Nitrogen levels (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st interval | 0.462*b | 0.527 a | 0.961 a | 0.353 b | 0.170 c | 0.421 b | 0.512 a | 0.551 a |
| 2nd interval | 1.058 | 1.195 | 2.264 a | 0.869 b | 0.246 c | 0.998 | 1.232 | 1.149 |
| 3rd interval | 1.604 | 1.857 | 3.952 a | 0.853 b | 0.386 c | 1.365 b | 1.890 a | 1.936 a |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (7A) : Averages of crop growth rate (g.week$^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.747 | 0.931 | 0.839*b | 0.916 | 1.075 | 0.996 a | 0.887 | 1.208 | 1.047 a |
| | 0.4% | 0.237 | 0.248 | 0.242de | 0.405 | 0.298 | 0.352cd | 0.549 | 0.382 | 0.465 c |
| | 0.6% | 0.143 | 0.218 | 0.180 e | 0.147 | 0.230 | 0.189 e | 0.126 | 0.155 | 0.141 e |
| 2nd | 0.0% | 1.793 | 2.007 | 1.900 | 2.529 | 2.325 | 2.427 | 2.550 | 2.383 | 2.466 |
| | 0.4% | 0.679 | 1.058 | 0.868 | 0.816 | 1.216 | 1.016 | 0.495 | 0.952 | 0.723 |
| | 0.6% | 0.154 | 0.300 | 0.227 | 0.232 | o.276 | 0.254 | 0.280 | 0.235 | 0.257 |
| 3rd | 0.0% | 2.375 | 3.586 | 2.981 b | 4.116 | 4.690 | 4.403 a | 3.970 | 4.976 | 4.473 a |
| | 0.4% | 0.791 | 0.679 | 0.735 c | 0.884 | 0.815 | 0.850 c | 1.022 | 0.926 | 0.974 c |
| | 0.6% | 0.468 | 0.293 | 0.381 c | 0.467 | 0.369 | 0.418 c | 0.340 | 0.381 | 0.360 c |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (8) : Averages of relative growth rate ($g.g^{-1}.week^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Varieties | | Salinity Levels | | | Nitrogen levels (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st interval | 0.462 | 0.460 | 0.564* a | 0.467 a | 0.351 b | 0.406 | 0.495 | 0.481 |
| 2nd interval | 0.375 | 0.412 | 0.473 a | 0.446 a | 0.263 b | 0.395 | 0.410 | 0.377 |
| 3rd interval | 0.303 | 0.267 | 0.362 a | 0.236 b | 0.257 b | 0.269 | 0.293 | 0.293 |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (8A) : Averages of relative growth rate ($g.g^{-1}.week^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.508 | 0.534 | 0.521 | 0.568 | 0.566 | 0.567 | 0.530 | 0.678 | 0.604 |
| | 0.4% | 0.313 | 0.326 | 0.319 | 0.643 | 0.412 | 0.527 | 0.639 | 0.471 | 0.555 |
| | 0.6% | 0.360 | 0.393 | 0.377 | 0.332 | 0.451 | 0.392 | 0.261 | 0.307 | 0.284 |
| 2nd | 0.0% | 0.458 | 0.438 | 0.448 | 0.520 | 0.451 | 0.486 | 0.521 | 0.449 | 0.485 |
| | 0.2% | 0.418 | 0.545 | 0.482 | 0.433 | 0.572 | 0.502 | 0.251 | 0.460 | 0.355 |
| | 0.4% | 0.230 | 0.278 | 0.254 | 0.225 | 0.258 | 0.242 | 0.323 | 0.261 | 0.292 |
| 3rd | 0.0% | 0.292 | 0.358 | 0.325 | 0.368 | 0.396 | 0.382 | 0.357 | 0.402 | 0.380 |
| | 0.4% | 0.254 | 0.182 | 0.218 | 0.244 | 0.209 | 0.226 | 0.293 | 0.233 | 0.263 |
| | 0.6% | 0.358 | 0.170 | 0.264 | 0.321 | 0.220 | 0.270 | 0.239 | 0.236 | 0.237 |

Table (9) : Averages of net assimilation rate (g.cm$^{-2}$ week$^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Varieties | | Salinity Levels | | | Nitrogren levels (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st interval | 2.244 | 1.988 | 2.505 a | 2.158 a | 1.685 b | 1.939 | 2.248 | 2.161 |
| 2nd interval | 2.192 | 2.137 | 2.422 a | 2.531 a | 1.542 b | 2.180 | 2.273 | 2.042 |
| 3rd interval | 2.379 a | 1.815 b | 2.245 | 1.934 | 2.112 | 2.020 | 2.161 | 2.11 |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (9A) : Averages of net assimilation rate (g.cm$^{-2}$week$^{-1}$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 2.378 | 2.179 | 2.278 | 2.737 | 2.519 | 2.628 | 2.378 | 2.840 | 2.609 |
| | 0.4% | 1.648 | 1.766 | 1.707 | 3.025 | 1.575 | 2.300 | 3.370 | 1.566 | 2.468 |
| | 0.6% | 1.783 | 1.882 | 1.833 | 1.496 | 2.136 | 1.816 | 1.383 | 1.431 | 1.407 |
| 2nd | 0.0% | 2.641 | 2.026 | 2.333 | 2.908 | 2.089 | 2.499 | 2.758 | 2.110 | 2.434 |
| | 0.4% | 2.497 | 2.971 | 2.734 | 2.655 | 3.024 | 2.839 | 1.518 | 2.522 | 2.020 |
| | 0.6% | 1.319 | 1.626 | 1.472 | 1.536 | 1.423 | 1.480 | 1.899 | 1.447 | 1.673 |
| 3rd | 0.0% | 1.827 | 2.019 | 1.923 | 2.599 | 2.279 | 2.439 | 2.471 | 2.273 | 2.372 |
| | 0.4% | 2.186 | 1.361 | 1.774 | 2.272 | 1.630 | 1.951 | 2.409 | 1.745 | 2.077 |
| | 0.6% | 3.236 | 1.419 | 2.363 | 2.549 | 1.640 | 2.094 | 1.860 | 1.899 | 1.879 |

Table (10) : Averages of leaf area ratio ($cm^2.g$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Varieties | | Salinity Levels | | | Nitrogen levels (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st interval | 206.68*b | 229.74 a | 226.49 | 219.67 | 208.49 | 213.52 | 225.48 | 215.84 |
| 2nd interval | 137.87 b | 194.71 a | 199.03 a | 176.86 b | 176.98 b | 179.85 | 185.94 | 187.09 |
| 3rd interval | 126.00 b | 146.43 a | 162.34 a | 125.84 b | 120.47 b | 131.97 | 136.51 | 140.18 |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (10A) : Averages of leaf area ratio ($cm^2.g$) per 4 plants at three intervals of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Intervals | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 209.39 | 245.12 | 227.26 | 209.29 | 227.87 | 218.58 | 221.91 | 245.36 | 233.64 |
| | 0.4% | 190.73 | 230.00 | 210.36 | 215.99 | 259.02 | 237.50 | 193.86 | 228.40 | 211.13 |
| | 0.6% | 199.38 | 206.50 | 202.94 | 221.65 | 219.07 | 220.36 | 197.96 | 206.34 | 202.15 |
| 2nd | 0.0% | 177.29 | 217.58 | 197.44 | 180.27 | 217.22 | 198.74 | 188.73 | 213.08 | 200.90 |
| | 0.4% | 165.36 | 184.93 | 175.15 | 162.22 | 195.03 | 178.63 | 165.79 | 187.85 | 176.85 |
| | 0.6% | 163.37 | 170.55 | 166.96 | 180.90 | 180.00 | 180.45 | 180.91 | 186.18 | 183.55 |
| 3rd | 0.0% | 159.20 | 176.72 | 167.96* a | 142.16 | 174.06 | 158.11 a | 144.89 | 176.99 | 160.94 a |
| | 0.4% | 115.94 | 138.24 | 127.09bc | 111.84 | 129.58 | 120.71 b | 125.92 | 133.57 | 129.74 b |
| | 0.6% | 79.70 | 122.02 | 100.86 c | 127.56 | 133.86 | 130.71 b | 126.83 | 132.88 | 129.85 b |

*Averages within column or row for each interval of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test

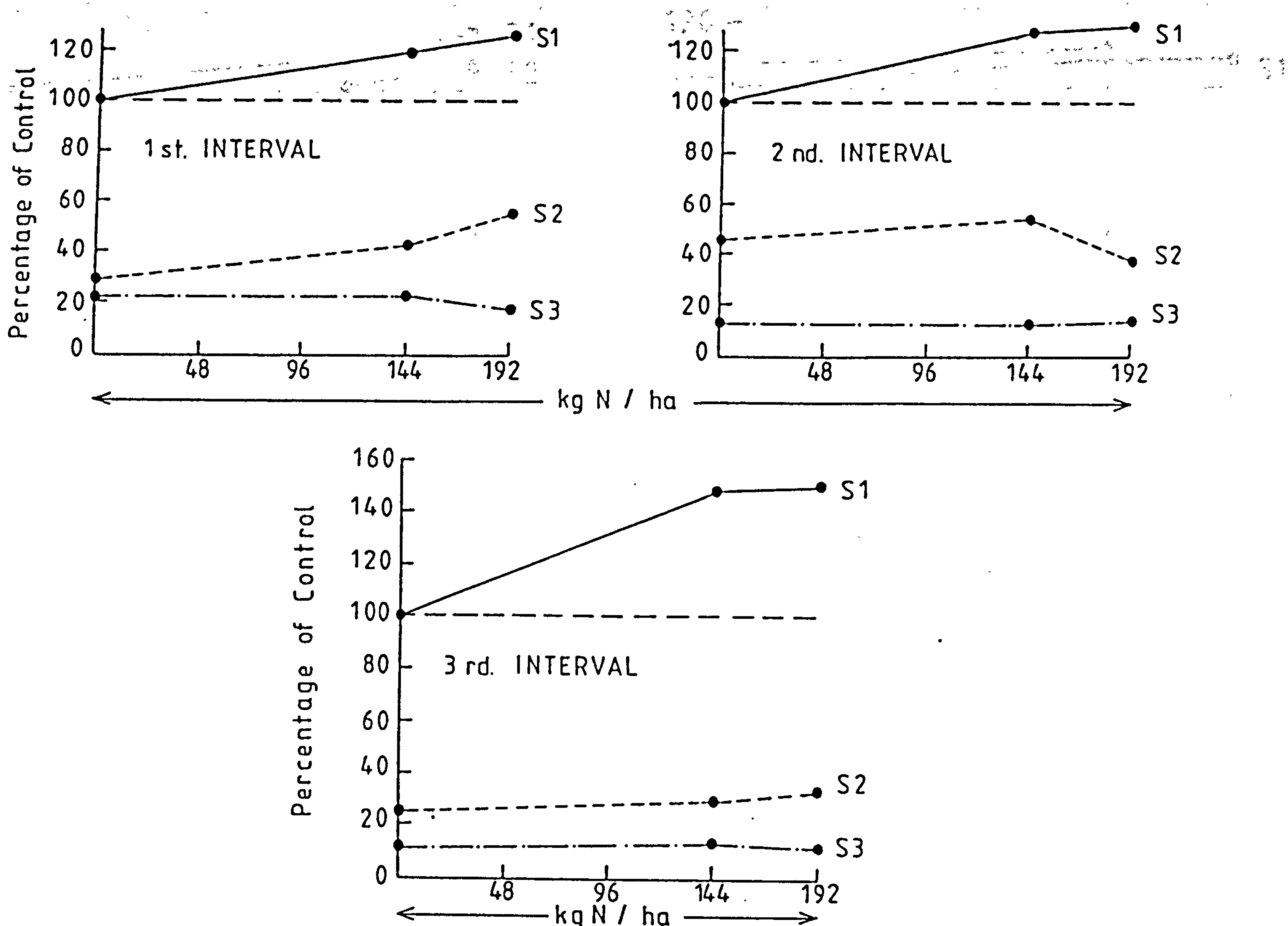



Fig. 6 Effect of different levels of soil salinity and nitrogen fertilizer on crop growth rate (CGR) at three intervals. (Mean of 2 cvs)

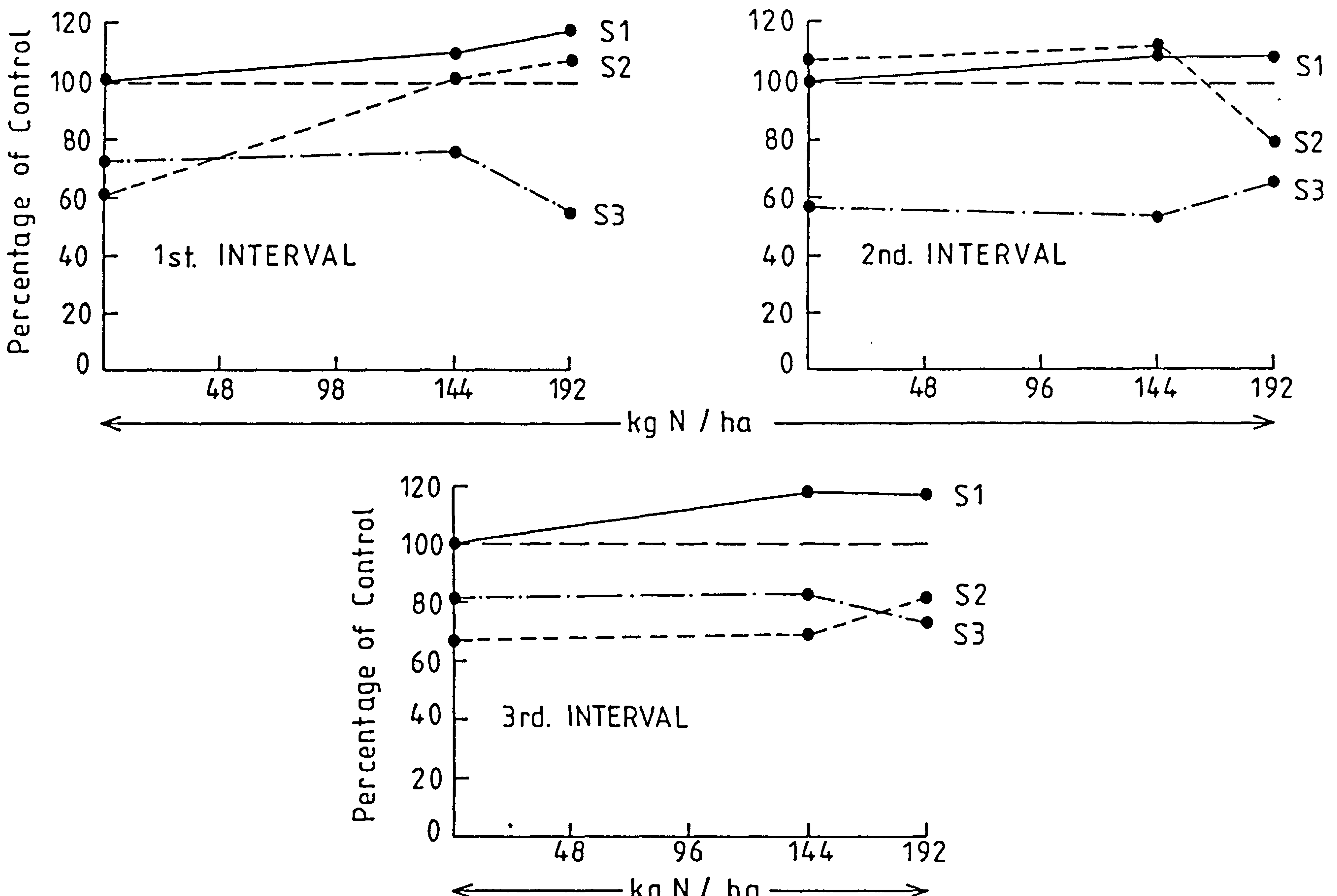



Fig. 7 Effect of different levels of soil salinity and nitrogen fertilizer on relative growth rate (RGR) at three intervals. (Mean of 2 cvs)

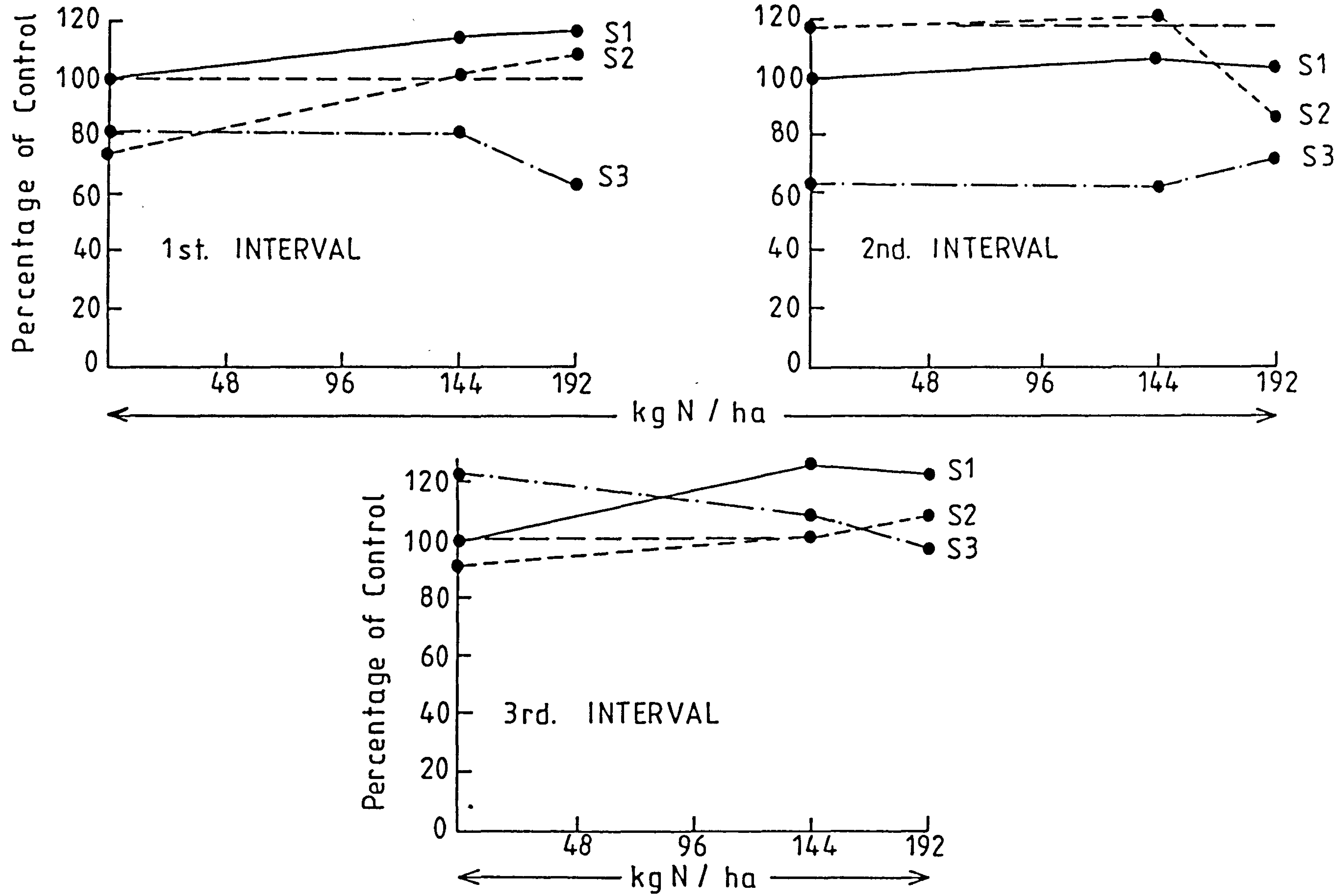



Fig. 8 Effect of different levels of soil salinity and nitrogen fertilizer on net assimilation rate ( NAR ) at three intervals. (Mean of 2 cvs )

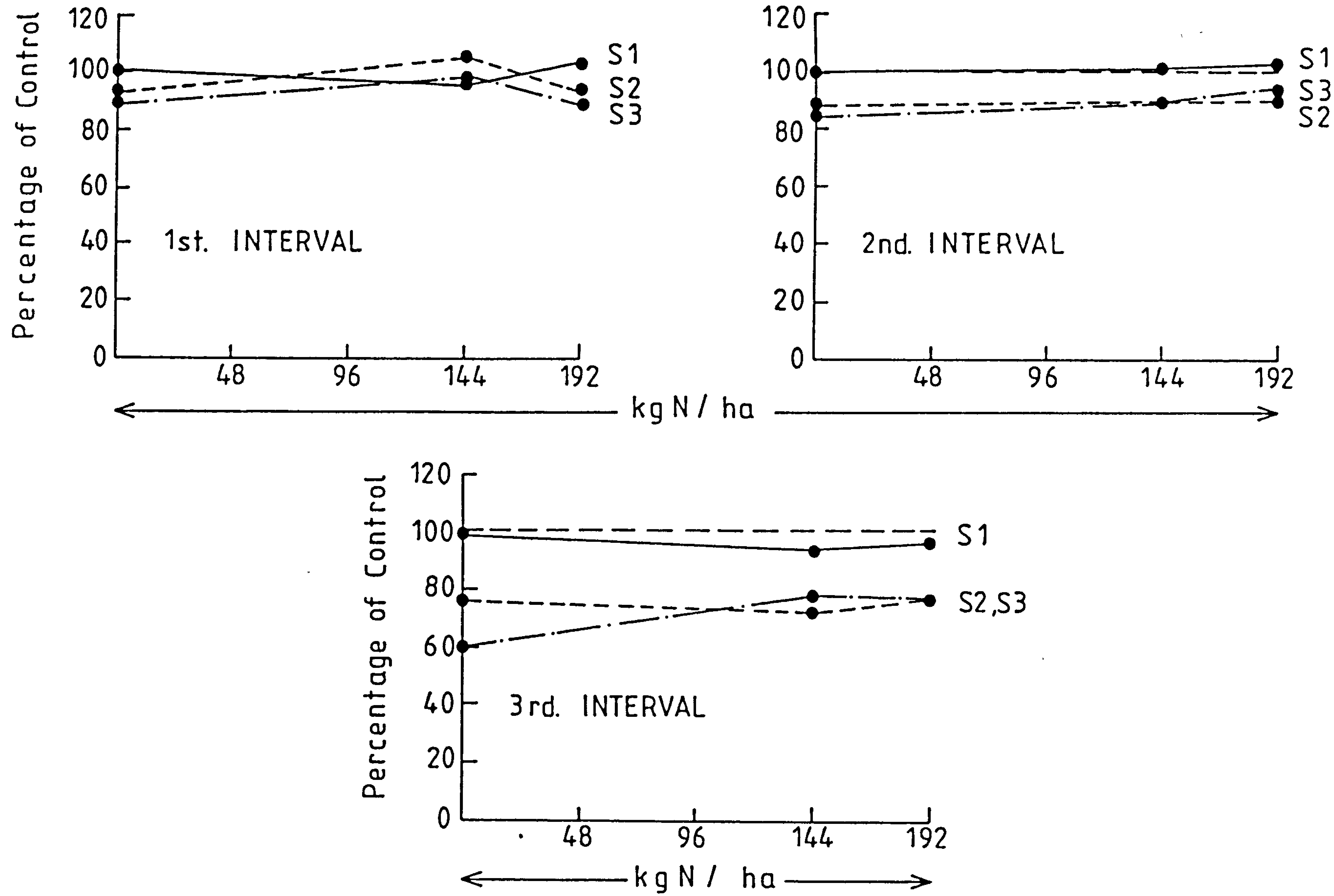



Fig. 9 Effect of different levels of soil salinity and nitrogen fertilizer on leaf area ratio (LAR) at three intervals. (Mean of 2 cvs)

levels at the first and last intervals (Tables 7-10A and Figs. 6-9). Also, it is apparent that Shakha 62 was more responsive to nitrogen appication, in general, for all these growth attributes as compared to Falchetto except at the 3rd interval for RGR and NAR (Tables 7-10A).

A highly significant interaction was obtained between nitrogen rate and salinity level at the first and last interval for CGR and at the last interval only for LAR. This interaction means that the effect of salinity and nitrogen fertilizer on CGR and LAR were dependent on each other and the application of nitrogen under saline conditions up to 0.4% increased dry matter of wheat plants, which led to a significant increase in CGR at the 1st and the 3rd interval and in LAR at last interval only (Tables 7A and 10A and Figs. 10-13). These results are in harmony with those reported by Balasubramania and Sarian, 1974; Dhir et al., 1975; Abdel-Halim et al., 1976; Hoffman and Jobes, 1978; Sameni et al., 1980; Abdul-Kadir and Paulsen; 1982 and Kingsbury et al., 1984.

4. Leaf, stem, root and whole plant dry weight

Tables 11-14A and Figs. 10-13 show that all plant parts were generally increased by increased nitrogen rate and decreasing salinity level. However, there was no significant difference between the last two nitrogen rates. Falchetto had the higher dry weight value for leaves at all samples, roots at 3rd sample and whole plant at the last three samples as compared with Shakha 62. However, the percentage reduction in dry weight was generally the same for both cultivars, especially at 0.6% salinity level, except at 3rd sample

Table (11) : Averages of leaf dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 0.245 b | 0.300* a | 0.460 a | 0.221 b | 0.137 c | 0.289 | 0.259 | 0.269 |
| 2nd sample | 0.650 b | 0.794 a | 1.346 a | 0.543 b | 0.278 c | 0.707 | 0.723 | 0.737 |
| 3rd sample | 1.542 b | 1.881 a | 3.482 a | 1.225 b | 0.429 c | 1.596 | 1.789 | 1.750 |
| 4th sample | 2.246 b | 2.934 a | 5.881 a | 1.360 b | 0.529 c | 2.397 | 2.686 | 2.686 |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (11A) : Averages of leaf dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.420 | 0.544 | 0.482 | 0.408 | 0.486 | 0.447 | 0.448 | 0.456 | 0.452 |
| | 0.4% | 0.241 | 0.256 | 0.248 | 0.154 | 0.233 | 0.193 | 0.182 | 0.258 | 0.220 |
| | 0.6% | 0.125 | 0.150 | 0.137 | 0.113 | 0.159 | 0.136 | 0.116 | 0.157 | 0.136 |
| 2nd | 0.0% | 1.142 | 1.523 | 1.332 | 1.229 | 1.474 | 1.351 | 1.170 | 1.539 | 1.354 |
| | 0.4% | 0.472 | 0.523 | 0.498 | 0.513 | 0.514 | 0.514 | 0.662 | 0.571 | 0.616 |
| | 0.6% | 0.204 | 0.376 | 0.290 | 0.252 | 0.355 | 0.303 | 0.206 | 0.274 | 0.240 |
| 3rd | 0.0% | 2.897 | 3.469 | 3.183 | 3.367 | 3.896 | 3.632 | 3.388 | 3.871 | 3.630 |
| | 0.4% | 0.984 | 1.405 | 1.195 | 1.099 | 1.467 | 1.283 | 1.068 | 1.327 | 1.198 |
| | 0.6% | 0.278 | 0.543 | 0.411 | 0.384 | 0.521 | 0.453 | 0.413 | 0.432 | 0.422 |
| 4th | 0.0% | 4.249 | 6.336 | 5.293* b | 5.508 | 6.807 | 6.158 a | 5.202 | 7.181 | 6.191 a |
| | 0.4% | 1.232 | 1.512 | 1.372 c | 1.164 | 1.530 | 1.347 c | 1.281 | 1.444 | 1.363 c |
| | 0.6% | 0.492 | 0.563 | 0.528 d | 0.567 | 0.543 | 0.555 d | 0.520 | 0.490 | 0.505 d |

* Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (12) : Averages of stem dry weight (g) per 4 plants at four samples dates of 2 wheat cvs at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 0.112 | 0.132 | 0.213* a | 0.096 b | 0.056 c | 0.133 | 0.116 | 0.116 |
| 2nd sample | 0.339 | 0.428 | 0.742 a | 0.316 b | 0.183 c | 0.391 | 0.420 | 0.430 |
| 3rd sample | 1.386 | 1.365 | 2.588 a | 1.090 b | 0.448 c | 1.266 | 1.458 | 1.401 |
| 4th sample | 3.188 | 3.482 | 6.563 a | 2.375 b | 1.067 c | 3.006 b | 3.474 a | 3.524 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (12A) : Averages of stem dry weight (g) per 4 plants at four samples dates of 2 wheat cvs at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.207 | 0.243 | 0.225 | 0.210 | 0.224 | 0.217 | 0.202 | 0.189 | 0.196 |
| | 0.4% | 0.122 | 0.113 | 0.117 | 0.058 | 0.099 | 0.078 | 0.089 | 0.097 | 0.093 |
| | 0.6% | 0.041 | 0.075 | 0.058 | 0.037 | 0.067 | 0.052 | 0.041 | 0.078 | 0.059 |
| 2nd | 0.0% | 0.657 | 0.752 | 0.705 | 0.720 | 0.801 | 0.760 | 0.726 | 0.798 | 0.762 |
| | 0.4% | 0.274 | 0.284 | 0.279 | 0.299 | 0.315 | 0.307 | 0.383 | 0.342 | 0.362 |
| | 0.6% | 0.176 | 0.205 | 0.191 | 0.180 | 0.207 | 0.193 | 0.180 | 0.149 | 0.165 |
| 3rd | 0.0% | 2.146 | 2.320 | 2.233*b | 2.988 | 2.536 | 2.762 a | 2.942 | 2.595 | 2.768 a |
| | 0.4% | 0.981 | 1.218 | 1.099 c | 1.164 | 1.163 | 1.164 c | 1.025 | 0.989 | 1.007c |
| | 0.6% | 0.395 | 0.538 | 0.466 d | 0.428 | 0.471 | 0.449 d | 0.406 | 0.452 | 0.429 d |
| 4th | 0.0% | 5.257 | 6.248 | 5.752 b | 6.925 | 6.659 | 6.792 a | 7.102 | 7.187 | 7.144 a |
| | 0.4% | 1.875 | 2.464 | 2.169 c | 2.382 | 2.690 | 2.536 c | 2.123 | 2.717 | 2.420 c |
| | 0.6% | 1.026 | 1.170 | 1.098 d | 1.041 | 1.149 | 1.095 d | 0.962 | 1.055 | 1.008 d |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significnatly different according to Duncan's test

Table (13) : Averages of root dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 0.187 | 0.182 | 0.249* a | 0.154 b | 0.151 b | 0.181 | 0.185 | 0.187 |
| 2nd sample | 0.440 | 0.443 | 0.753 a | 0.334 b | 0.228 c | 0.352 b | 0.459 a | 0.513 a |
| 3rd sample | 0.676 b | 0.809 a | 1.309 a | 0.615 b | 0.3o3 c | 0.585 b | 0.817 a | 0.825 a |
| 4th sample | 1.343 | 1.345 | 2.838 a | 0.850 b | 0.343 c | 0.723 b | 1.672 a | 1.636 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (13A) : Averages of root dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_1$ 144 kgN/ha | | | $N_2$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.242 | 0.208 | 0.225 | 0.220 | 0.312 | 0.266 | 0.309 | 0.203 | 0.256 |
| | 0.4% | 0.173 | 0.181 | 0.177 | 0.126 | 0.140 | 0,133 | 0.168 | 0.136 | 0.152 |
| | 0.6% | 0.123 | 0.160 | 0.142 | 0.175 | 0.139 | 0,157 | 0.150 | 0.159 | 0.154 |
| 2nd | 0.0% | 0.565 | 0.581 | 0.573*b | 0.770 | 0.897 | 0.833 a | 0.836 | 0.927 | 0.881 a |
| | 0.4% | 0.298 | 0.237 | 0,267 d | 0.396 | 0.238 | 0.317cd | 0.492 | 0.340 | 0.416 c |
| | 0.6% | 0.195 | 0.238 | 0.217 d | 0.189 | 0,263 | 0.226 d | 0.216 | 0.267 | 0.241 d |
| 3rd | 0.0% | 0.906 | 1.081 | 0,993 | 1,412 | 1.390 | 1.401 | 1.501 | 1.561 | 1.531 |
| | 0.4% | o.436 | 0.537 | 0,486 | 0.576 | 0.869 | 0.722 | 0.433 | 0.841 | 0.637 |
| | 0.6% | 0.209 | 0.339 | 0.274 | 0.272 | 0.386 | 0.329 | 0.335 | 0.277 | 0.306 |
| 4th | 0.0% | 1.193 | 1.458 | 1,326 b | 3.566 | 3.736 | 3,651 a | 3.466 | 3.612 | 3.539 a |
| | 0.4% | 0,572 | 0.542 | 0.557 c | 1.062 | 0.910 | 0.986 b | 1.166 | 0.846 | 1.006 b |
| | 0.6% | 0.301 | 0.272 | 0.287 c | 0.409 | 0.348 | 0.378 c | 0.350 | 0.377 | 0.364 c |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (14) : Averages of whole plant dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 0.446 | 0.468 | 0.546 | 0.476 | 0.350 | 0.447 | 0.407 | 0.518 |
| 2nd sample | 1.484 b | 1.666* a | 2.850 a | 1.192 b | 0.682 c | 1.451 b | 1.601 a | 1.673 a |
| 3rd sample | 3.604 b | 4.055 a | 7.378 a | 2.93o b | 1.180 c | 3.447 b | 4.065 a | 3.976 a |
| 4th sample | 6.811 b | 7.769 a | 15.282 a | 4.636 b | 1.952 c | 6.177 b | 7.845 a | 7.847 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (14A) : Averages of whole plant dry weight (g) per 4 plants at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | C. ined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.553 | 0.337 | 0.445 | 0.566 | 0.374 | 0.470 | 0.598 | 0.848 | 0.723 |
| | 0.4% | 0.569 | 0.550 | 0.560 | 0.338 | 0.472 | 0.405 | 0.439 | 0.490 | 0.465 |
| | 0.6% | 0.289 | 0.385 | 0.337 | 0.326 | 0.365 | 0.345 | 0.340 | 0.394 | 0.367 |
| 2nd | 0.0% | 2.364 | 2.857 | 2.610*b | 2.710 | 3.172 | 2.941 a | 2.732 | 3.263 | 2.998 a |
| | 0.4% | 1.044 | 1.045 | 1.044 d | 1.208 | 1.067 | 1.138 d | 1.537 | 1.253 | 1.395 c |
| | 0.6% | 0.575 | 0.820 | 0.697 e | 0.620 | 0.826 | 0.723 e | 0.562 | 0.690 | 0.626 e |
| 3rd | 0.0% | 5.949 | 6.870 | 6.410 b | 7.768 | 7.822 | 7.795 a | 7.831 | 8.028 | 7.929 a |
| | 0.4% | 2.401 | 3.160 | 2.780 c | 2.839 | 3.500 | 3.169 c | 2.527 | 3.156 | 2.841 c |
| | 0.6% | 0.882 | 1.42o | 1.151 d | 1.084 | 1.378 | 1.231 d | 1.154 | 1.160 | 1.157 d |
| 4th | 0.0% | 10.699 | 14.042 | 12.371 b | 15.999 | 17.202 | 16.601 a | 15.770 | 17.979 | 16.874 a |
| | 0.4% | 3.981 | 4.517 | 4.249 c | 4.608 | 5.129 | 4.868 c | 4.570 | 5.008 | 4.789 c |
| | 0.6% | 1.819 | 2.006 | 1.912 d | 2.018 | 2.116 | 2.067 d | 1.833 | 1.922 | 1.877 d |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertlizer levels followed by the same letter are not significantly different according to Duncan's test.

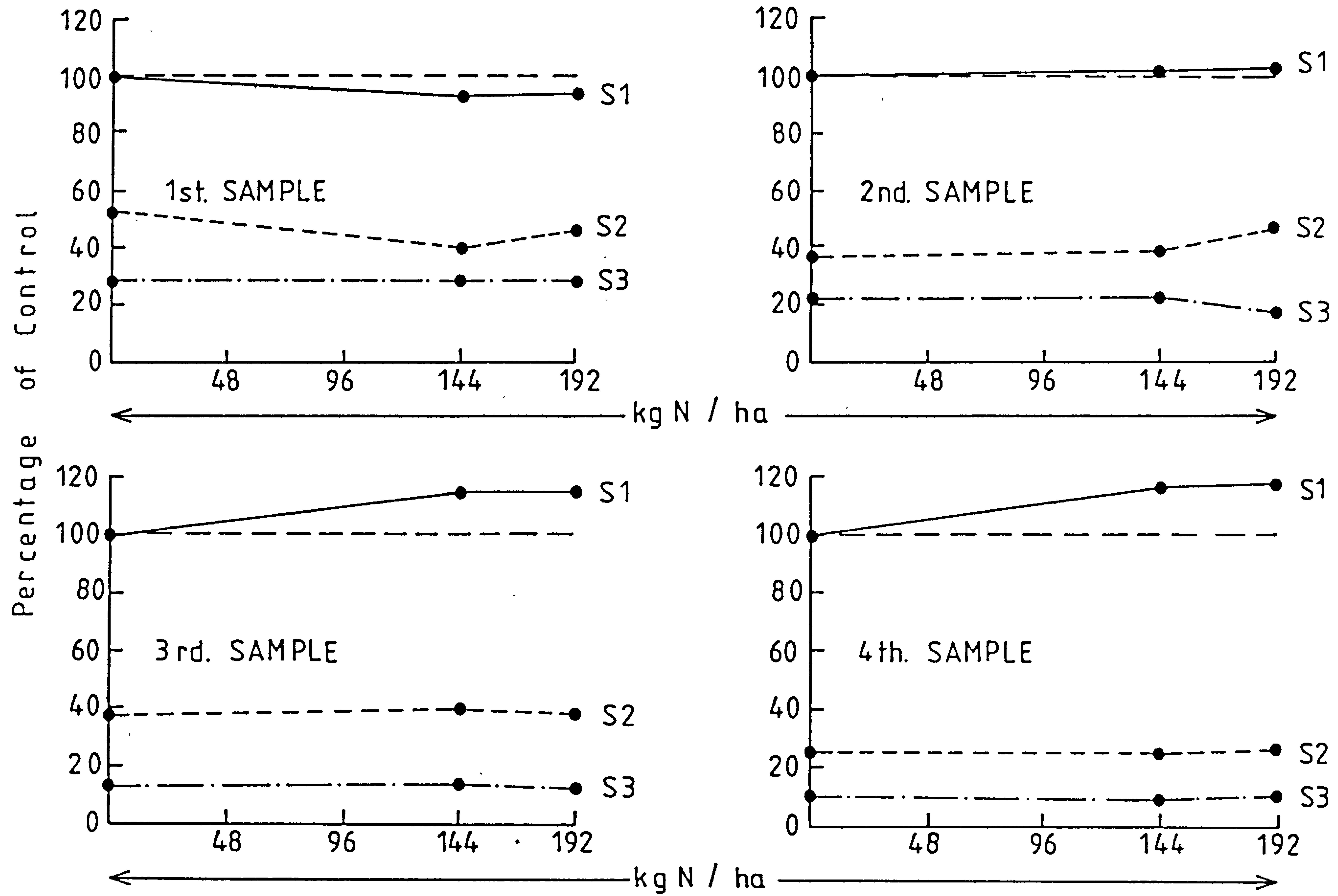



Fig. 10 Effect of different levels of soil salinity and nitrogen fertilizer on leaf dry weight at four samples dates. (Mean of 2 cvs)

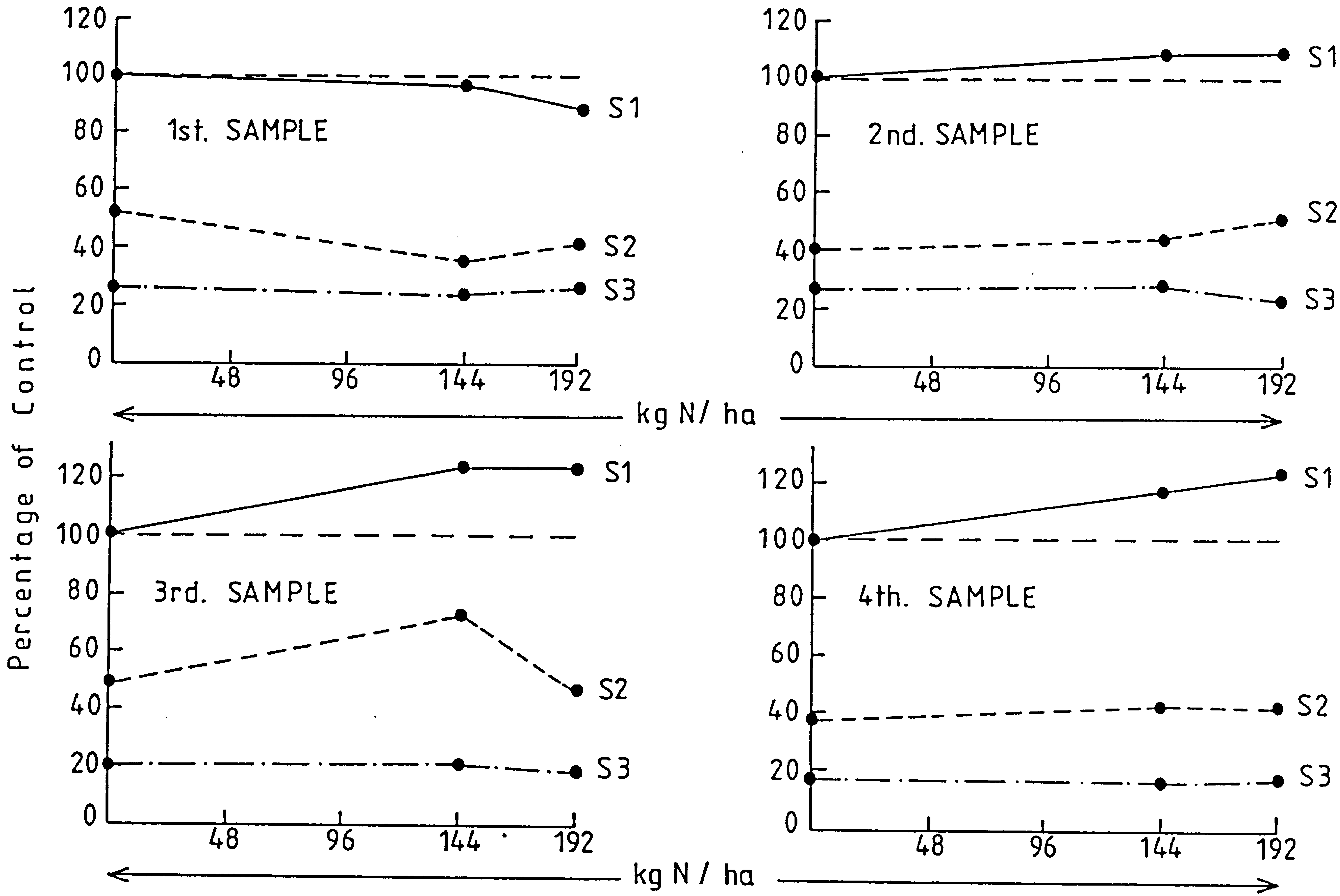



Fig. 11 Effect of different levels of soil salinity and nitrogen fertilizer on stem dry weight at four samples dates. (Mean of 2 cvs )

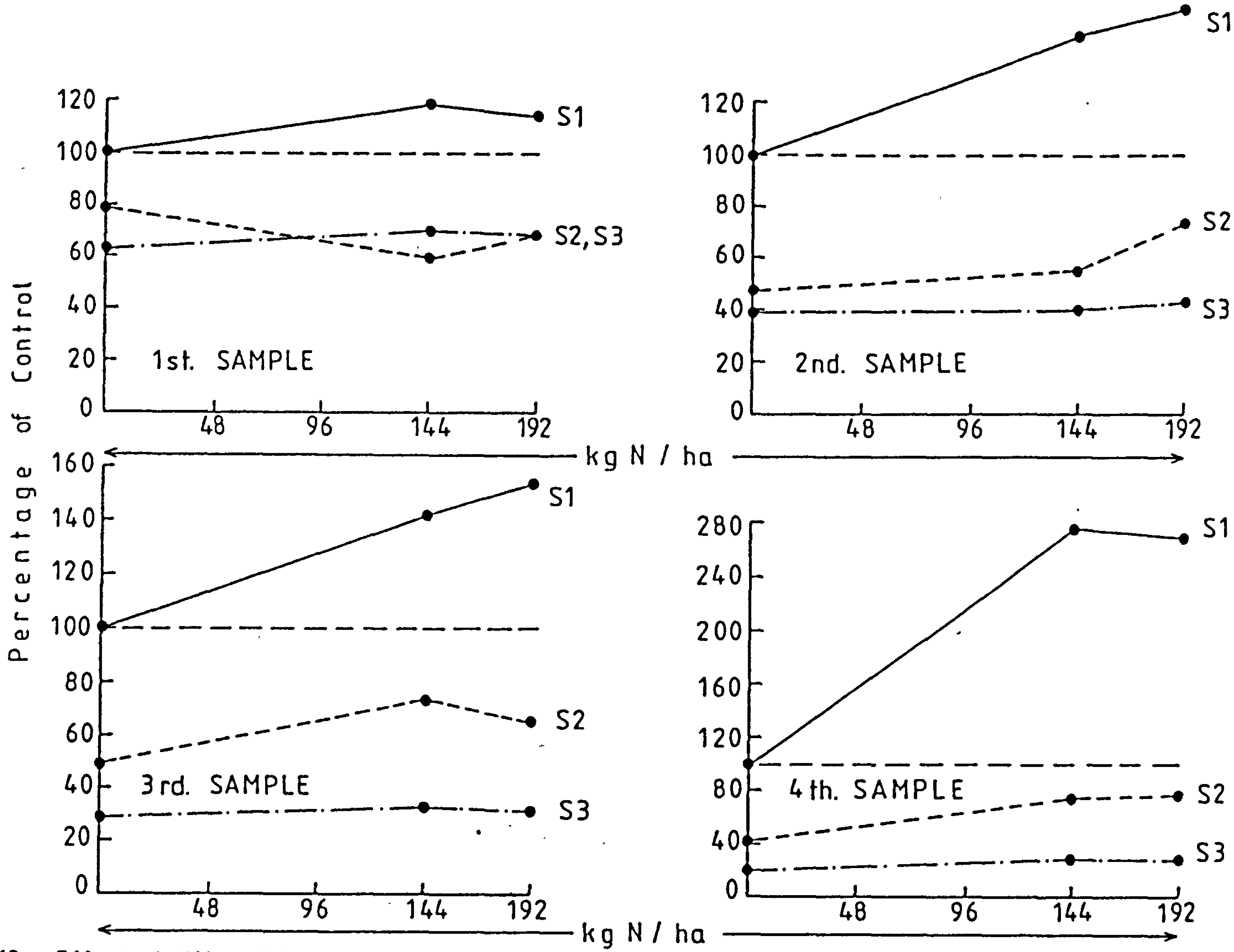



Fig. 12 Effect of different levels of soil salinity and nitrogen fertilizer on root dry weight at four sample dates. (Mean of 2 cvs)

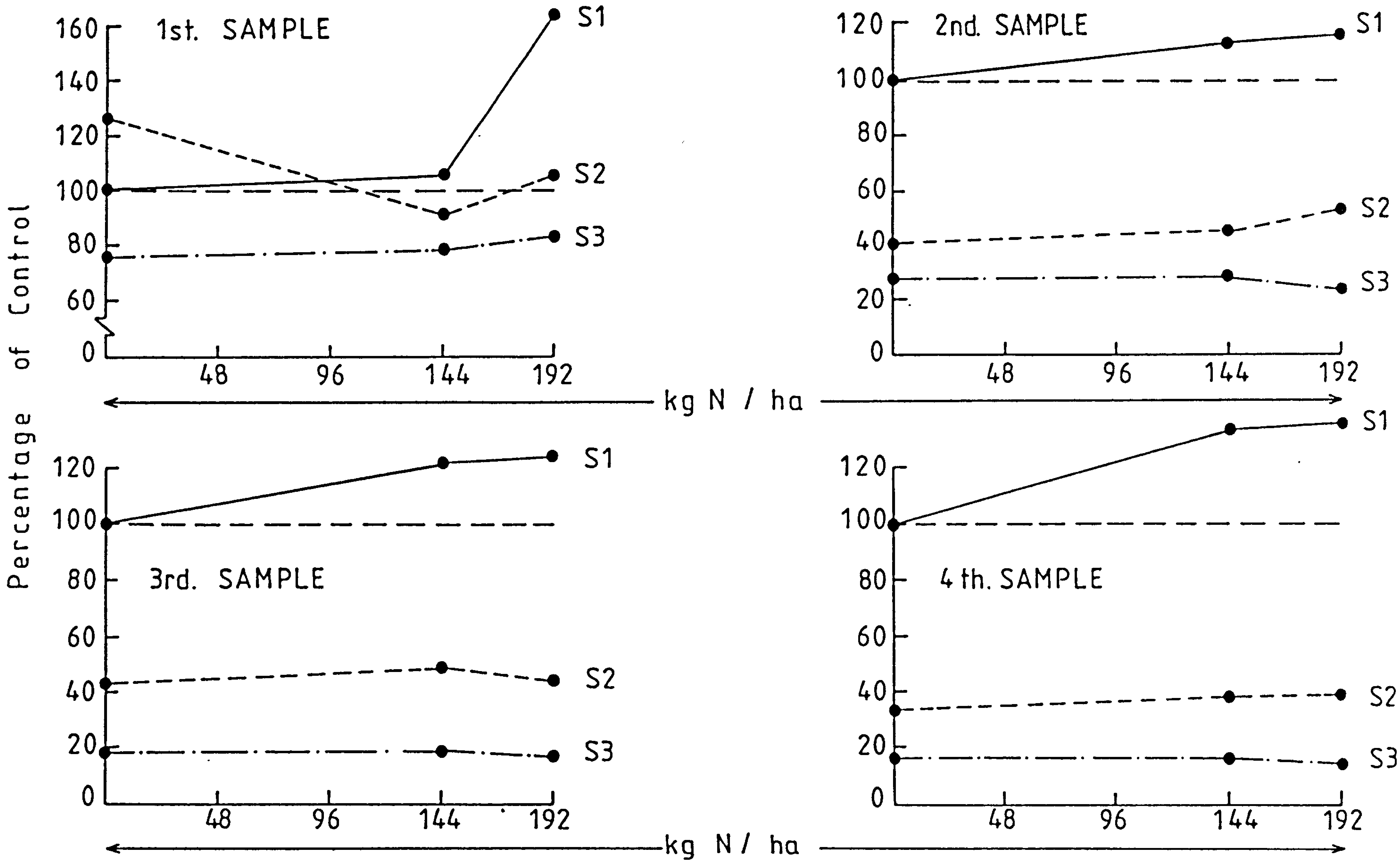



Fig. 13 Effect of different levels of soil salinity and nitrogen fertilizer on whole plant dry weight at four samples dates ( Mean of 2 cvs )

for stem dry weight in Falchetto. However, Shakha 62 was more sensitive to nitrogen fertilizer than Falchetto (Table 14A).

A significant interaction between salinity levels and nitrogen rates was obtained at all samples for whole plant dry weight, at the 4th sample for leaf and stem dry weight and at the 2nd and 4th samples for root dry weight (Tables 14A, 11A, 12A and 13A). This interaction showed that application of nitrogen fertilizer increased dry weight under salinity conditions, and the highest was at 0.4% level and 144 kgN/ha. Also, data of these characters showed that the percentage increment in dry weight due to nitrogen fertilizer was higher in Shakha 62 than Falchetto. These results can explain the higher yield of Shakha 62 as compared with Falchetto grain yield because Shakha had the higher NAR at 3rd interval (see Table 9), and also at the 1st and 2nd interval for NAR and all intervals for RGR, but the trend was not marked enough to approach the 5% significance level (see Tables 7-9). Similar general findings have been reported by Sarin and Narayman, 1968; Poonia and Jharor, 1974; Zwaik, 1980; Mahajan and Sonar, 1980; Papudopouls and Rending, 1983; Kingsbury *et al.*, 1983; and Verma and Neue, 1984. However, Nouri *et al.*, (1970); Poonia *et al.* (1974) and Singh *et al.* (1979) observed no reduction in dry weight up to 12 mmho/cm (1.2 siemen/m) for wheat and barley plants. Also, Kumar and Singh (1980) showed that there was no effect of nitrogen application on the dry matter production of wheat crop grown at different levels of soil salinity. But, Langdale *et al.* (1973) observed that dry matter production was significantly affected by the soil salinity -

nitrogen fertilizer interaction and maximum and minimum yields were produced with highest levels of nitrogen (200 mg/kg soil) and salinity (14.4 mmho/cm or 1.44 siemen/m), respectively.

III Leaf proline content

The leaf proline content, as shown in Tables 15 and 15A and Figs. 14-17, generally increased with increasing salinity levels and nitrogen application at all samples. However, there was no significant difference between 144 kgN/ha and 192 kgN/ha. Also, the percentage of proline accumulated in the case of salinity from control was between 280% to 500%, while between 120% to 137% in the case of nitrogen fertilizer alone (see Fig. 16).

Falchetto had significantly higher leaf proline content than Shahka 62 at 4th sample only, and there was no significant difference between cultivars at other samples (Table 15). However, Shakha 62 was more sensitive to nitrogen than Falchetto (Fig. 15).

Highly significant interaction between salinity levels and nitrogen rates was obtained at the 4th sample only. The highest value of proline was at the highest salinity level (0.6%) and highest nitrogen rate (192 kgN/ha). These results showed an adaptive role of proline for survival and maintenance of growth under the salt stress. Similar findings have been reported by Singh et al., 1973; Chu et al., 1976; Shannon, 1978; Qadar et al., 1981; Abdul-Kadir and Paulsen, 1982; Dreier, 1983 and Sairam and Dube, 1984. However, Chauhan et al. (1983) observed that leaf free proline content of wheat cv. WL711 and K68 decreased with increasing concentration of Nacl

Table (15) : Averages of leaf proline content (u moles.g.fw$^{-1}$) at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Varieties | | Salinity Levels | | | Nitrogen fertilizer (kgN/ha) | | |
|---|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | $N_1$ 0 | $N_2$ 144 | $N_3$ 192 |
| 1st sample | 0.779 | 0.789 | 0.290* c | 0.593 b | 1.469 a | 0.818 | 0.748 | 0.786 |
| 2nd sample | 0.788 | 0.784 | 0.353 c | 0.565 b | 1.441 a | 0.678 | 0.784 | 0.897 |
| 3rd sample | 0.616 | 0.631 | 0.356 c | 0.517 b | 0.998 a | 0.553 | 0.656 | 0.662 |
| 4th sample | 0.573 b | 0.628 a | 0.257 c | 0.544 b | 1.001 a | 0.492 b | 0.635 a | 0.674 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

Table (15A) : Averages of leaf proline content (u moles.g.fw$^{-1}$) at four samples dates of 2 wheat cvs growing at different levels of salinity and nitrogen fertilizer

| Samples | Nitrogen levels / Salinity levels | $N_1$ 0 kgN/ha | | | $N_2$ 144 kgN/ha | | | $N_3$ 192 kgN/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined | Shakha 62 | Falchetto | Combined |
| 1st | 0.0% | 0.260 | 0.270 | 0.265 | 0.273 | 0.257 | 0.265 | 0.267 | 0.413 | 0.340 |
| | 0.4% | 0.617 | 0.553 | 0.585 | 0.683 | 0.573 | 0.628 | 0.580 | 0.550 | 0.565 |
| | 0.6% | 1.760 | 1.447 | 1.603 | 1.287 | 1.417 | 1.352 | 1.283 | 1.620 | 1.452 |
| 2nd | 0.0% | 0.363 | 0.340 | 0.352 | 0.373 | 0.317 | 0.345 | 0.380 | 0.343 | 0.362 |
| | 0.4% | 0.530 | 0.433 | 0.482 | 0.597 | 0.510 | 0.553 | 0.663 | 0.657 | 0.660 |
| | 0.6% | 1.233 | 1.167 | 1.200 | 1.410 | 1.497 | 1.453 | 1.543 | 1.797 | 1.670 |
| 3rd | 0.0% | 0.357 | 0.327 | 0.342 | 0.363 | 0.330 | 0.347 | 0.397 | 0 363 | 0.380 |
| | 0.4% | 0.450 | 0.503 | 0.477 | 0.460 | 0.647 | 0.553 | 0.527 | 0.513 | 0.520 |
| | 0.6% | 0.783 | 0.900 | 0.842 | 1.110 | 1.023 | 1.067 | 1.097 | 1.077 | 1.087 |
| 4th | 0.0% | 0.263 | 0.250 | 0.257*G | 0.267 | 0.257 | 0.262G | 0.260 | 0.247 | 0.253 G |
| | 0.4% | 0.443 | 0.503 | 0.473 F | 0.530 | 0.563 | 0.547 e | 0.587 | 0.637 | 0.612 d |
| | 0.6% | 0.650 | 0.843 | 0.747 C | 1.060 | 1.133 | 1.097 b | 1.100 | 1.217 | 1.158 a |

*Averages within column or row for each sample of varieties or salinity or nitrogen fertilizer levels followed by the same letter are not significantly different according to Duncan's test.

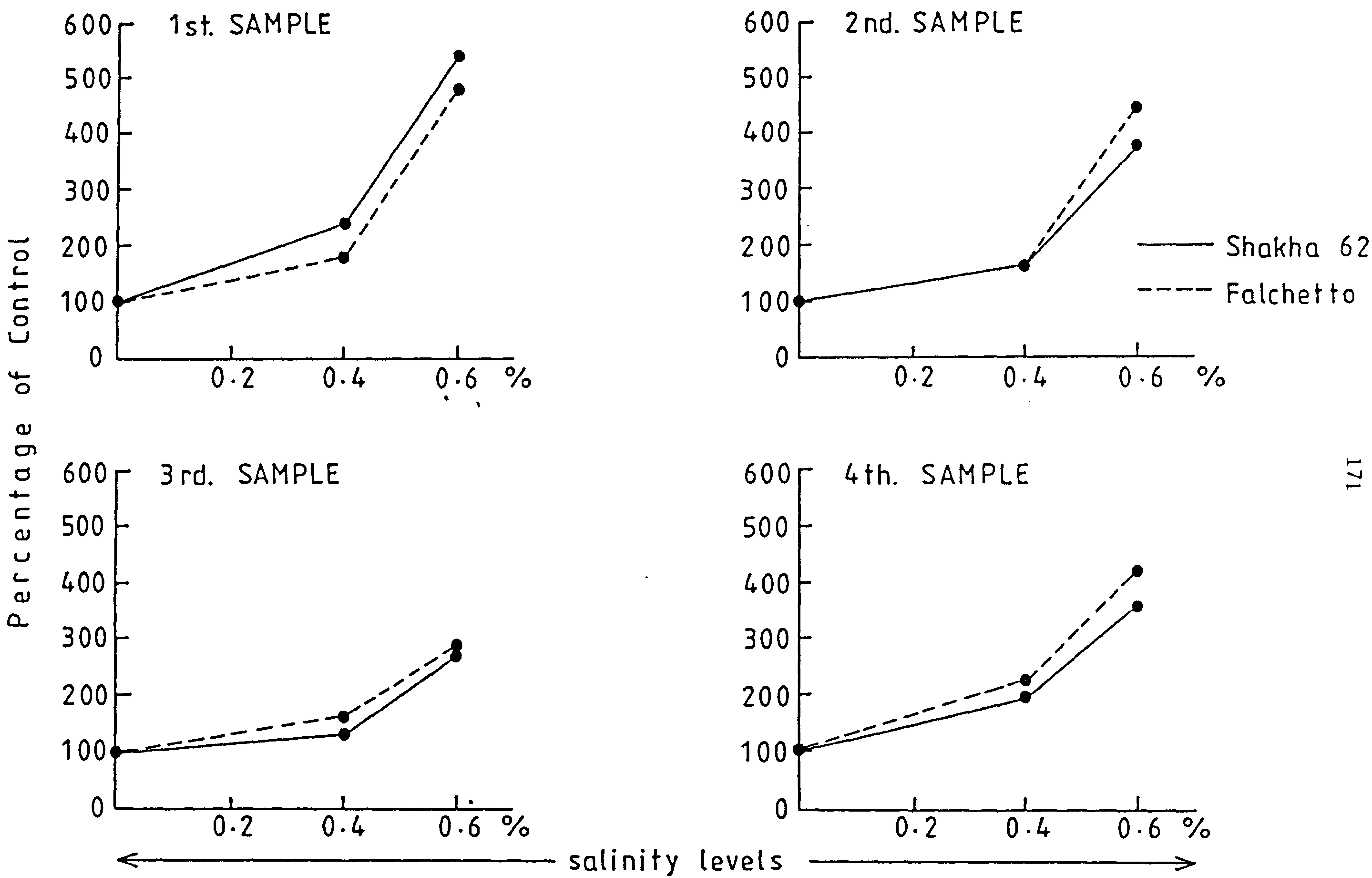



Fig. 14 Effect of different levels of soil salinity on proline content at four samples dates.

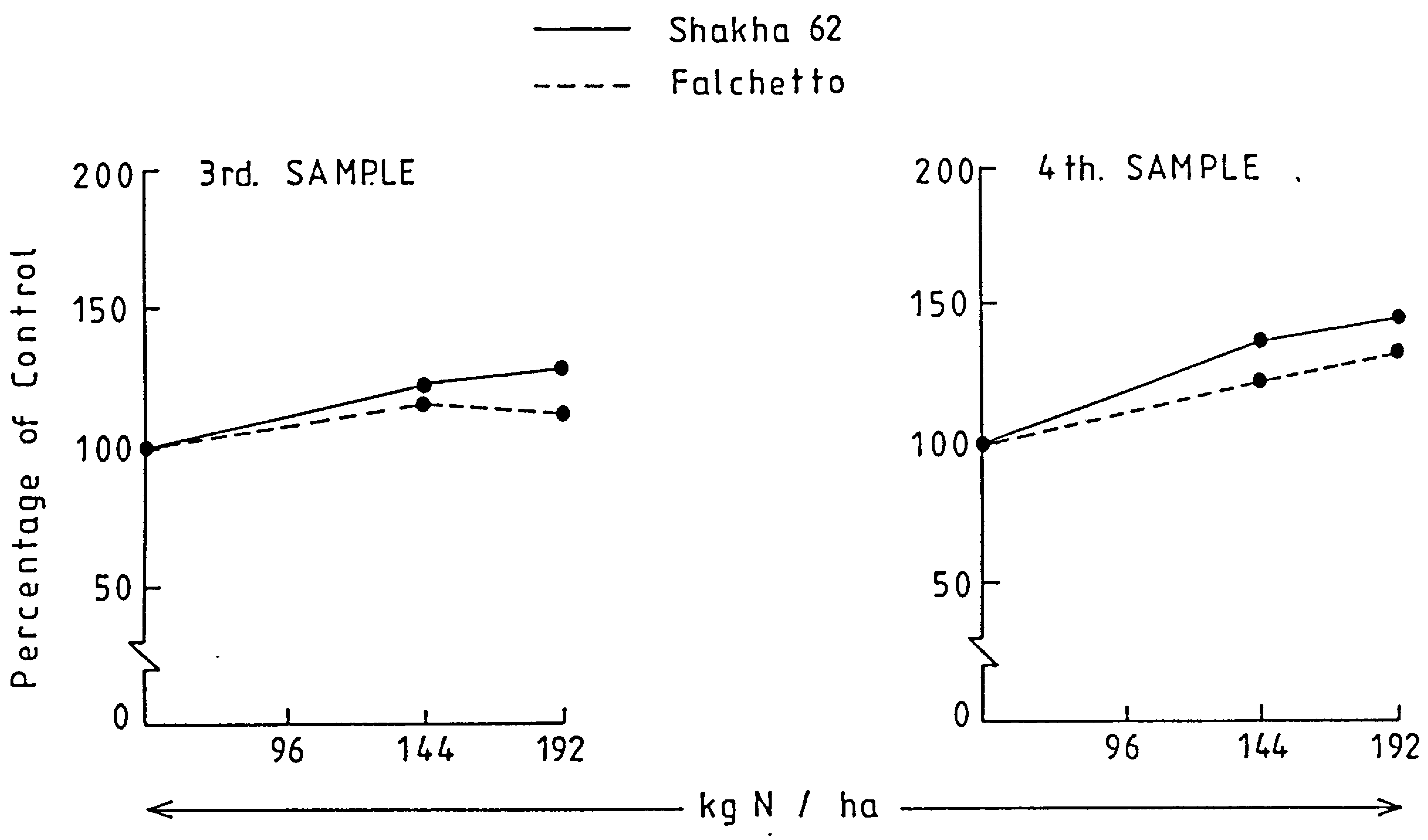



Fig. 15 Effect of different rates of nitrogen fertilizer on leaf proline content.

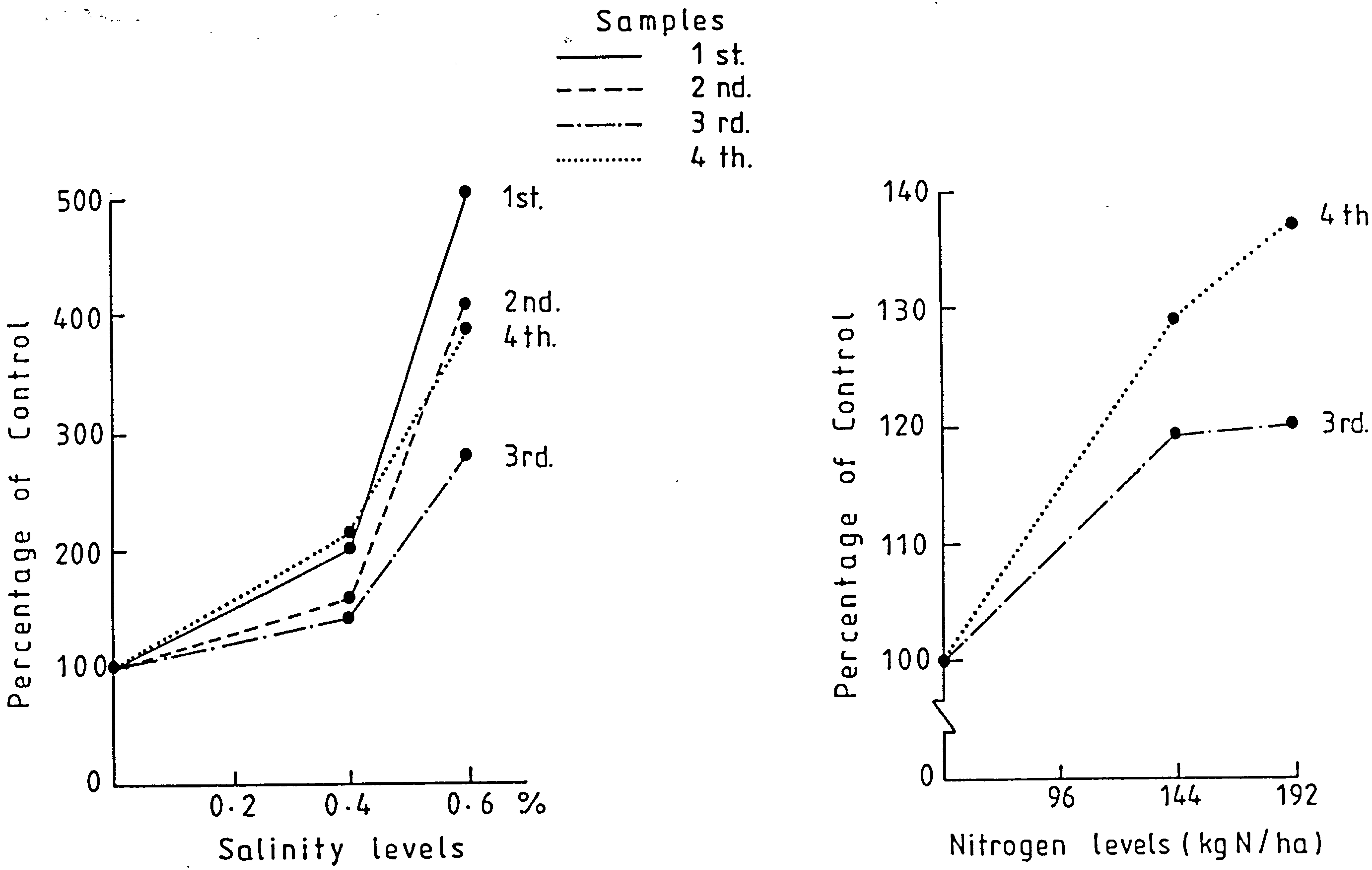



Fig. 16 Effect of different levels of soil salinity and nitrogen fertilizer on leaf proline content at four samples dates. ( Mean of 2 cvs )

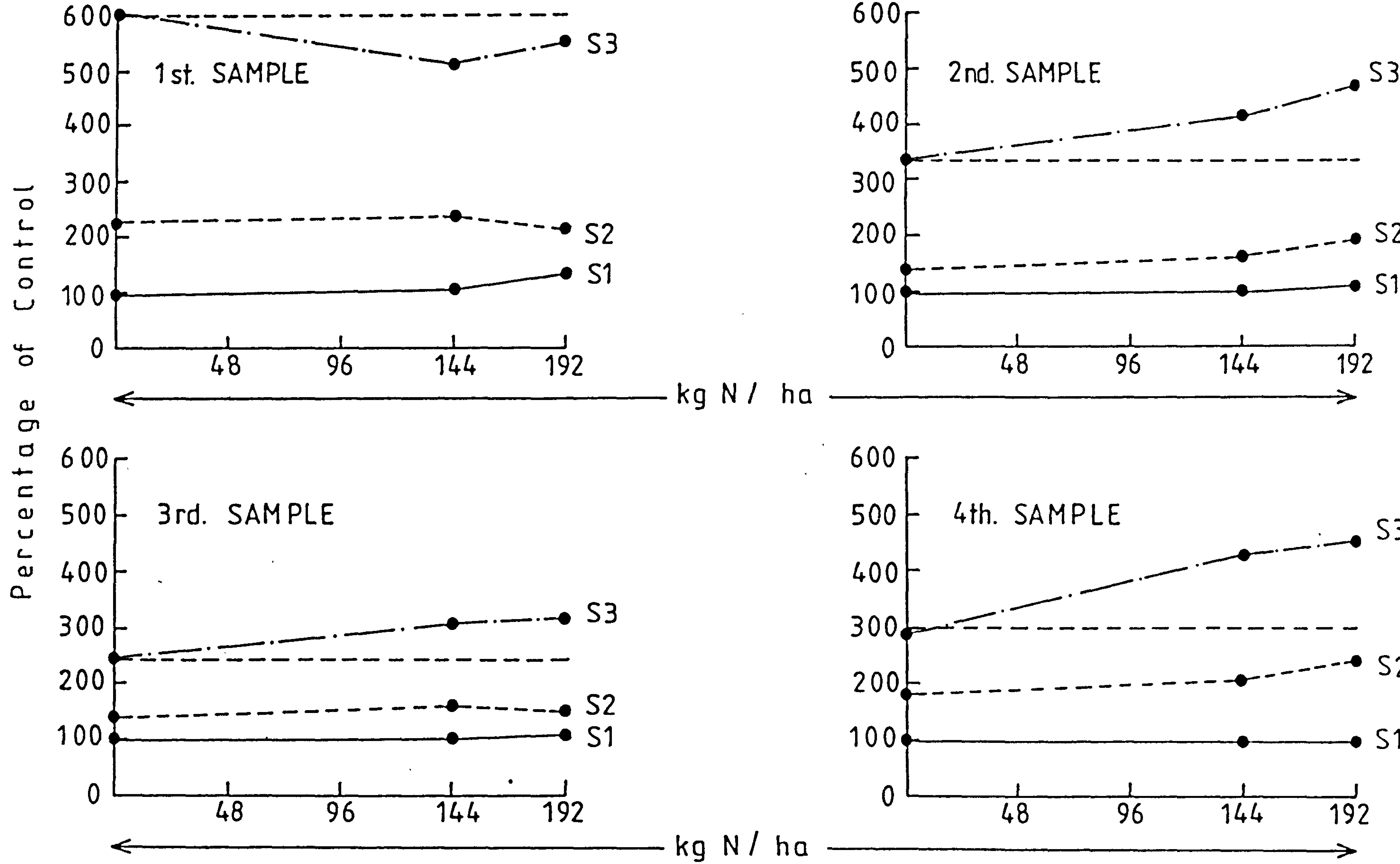



Fig. 17 Effect of different levels of soil salinity and nitrogen fertilizer on leaf proline content at four samples dates. (Mean of 2 cvs.)

and increased with increasing concentration of $CaCl_2$ and $MgCl_2$. They observed that free proline accumulation increased with leaf age and was maximum in the evening. In this experiment, there was a trend towards an opposite effect of age, i.e. lower proline contents at later sample dates, except the 4th sample (Fig. 16).

These is little evidence of increasing proline concentrations with increasing nitrogen application at any level of salinity (Fig. 17 and Table 15). It seems unlikely therefore that any beneficial effect of added nitrogen in saline conditions is due to its facilitating the synthesis of the amino acid proline.

Proline accumulation appears to be a common response to salinity (Stewart and Lee, 1974 and Dreier, 1983) and these results add to the body of evidence. In saline conditions salts accumulate in the vacuole to a higher concentration than in non-saline soils, lowering cell and tissue water potential below that of the soil and thus allowing some uptake of water. Reduced vacuolar water potential necessitates osmotic adjustment of the cytoplasm to prevent its dehydration by flux of water down a gradient of water potential to the vacuole. Adjustment by means of accumulating inorganic salts is not feasible since the cytoplasmic enzymes and organelles even of halophytes are sensitive to concentrations of salts above normal levels (Flowers *et al.*, 1977). Proline is thought to be a substance which can be accumulated for osmoregulation without damaging the cytoplasmic contents (Greenway and Munns, 1980).

Summary

The response of wheat crop to yield variables such as salinity and soil fertility often depends upon the integrated and simultaneous effects of these factors. A greenhouse study was therefore conducted to investigate the interactive effect of soil salinity and nitrogen fertilizer on the growth, grain yield and yield components of two wheat cultivars (*Triticum aestivum* L.), namely Shakha 62 and Falchetto. Three soil salinity levels used (on soil dry weight basis) were 0.0, 0.4 and 0.6% and three nitrogen fertilizers rates used were 0.0, 144 and 192 kgN/ha in a complete randomized block design with three replicates. Generally growth and all yield characters were reduced with increasing salinity levels and increased with application of nitrogen fertilizer up to 144 kgN/ha. Spike yield and grain number per spike were the most sensitive yield characters to salinity and nitrogen. Shakha 62 produced higher grain yield than Falchetto, because Shakha 62 had the higher spike yield, spikelet number and 1000 kernel weight. The interaction between salinity levels and nitrogen fertilizer showed that application of nitrogen fertilizer under saline conditions increased CGR but did not increase the growth and dry weight of both cultivars although, there was a non significant increase with increasing nitrogen application up to 0.4% salinity level. Leaf proline content increased with increasing salinity level and nitrogen application but the trend was lower for nitrogen fertilizer.

# CHAPTER IIIB

## EFFECT OF FOLIAR APPLICATION OF TRACE ELEMENTS AND IRRIGATION WITH SALINE WATER ON GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

### Introduction

Trace elements deficiencies often occur in crops grown with irrigation. Most newly reclaimed soils and the water used to irrigate them contain measurable salinity and plants cultivated under such conditions give yields below the normal average (Shainberg, 1975). The decrease in yield depends on the kind of the crop. Wheat is known to be moderately tolerant of salinity (Ayers and Westcot, 1976). The effect of micronutrients on rice, Cotton, tomato, millet, berseem (Egyptian clover) and broad bean plants grown under salinity conditions have been reported by Sorour and Abou Elleil (1969), Sorour *et al*. (1975), Ravikovitch and Navrot (1976), Farrag (1978) and Verma and Neue (1984), their findings show that increasing salinity in irrigation water resulted in reduction in growth and yield and its components and that the application of trace elements enhanced the growth and yield of these crops under salinity conditions.

The objective of this work was to study the effect of spraying with certain trace elements on growth, yield and yield components of two wheat varieties under different salinity levels of irrigation water. The plants in this experiment were grown in John Innes No. 2 compost, the trace element content of which is not precisely known but which can be assumed to be adequate since plants can be grown to maturity in it. Also no special precautions were taken to exclude trace elements from the chemicals used in salinisation or from the water used to make up the saline solutions. Therefore any beneficial effect of added trace elements under saline conditions found in this experiment can only be interpreted as indicating that salinity may interfere with the uptake of trace elements from the soil.

## Materials and Methods

The experiment was conducted in 1983 in a controlled environment room (Temp. 20±2, photoperiod 12 hr at the start of the experiment and then increased by $\frac{1}{2}$hr each week until the day length reached 15 hr) of the Faculty of Agriculture, Newcastle University. The experimental design for this experiment was a randomized complete block with three replicates. The number of treatments was 2 times of spraying, 3 salinity levels, 2 wheat varieties and 3 replications giving a total of 36 experimental units. Each unit consisted of 25 pots in 5 rows, 4 for growth analysis sampling and the last row for yield and yield components.

Plant material of this experiment consisted of two cultivars of vulgare wheat (Triticum aestivum L.) namely Shakha 62 and Falchetto. The three levels of saline irrigation water were 0, 2000 and 4000 ppm of 1:1 $Cacl_2$ and Nacl. The spraying solution contained the following concentration of trace elements:

| Element | Concentration in ppm | Source |
|---|---|---|
| Zn | 40 | Zinc sulphate |
| Mo | 50 | Ammonium molybdate |
| Mn | 20 | Manganese chloride |
| Cu | 20 | Copper sulphate |
| B | 80 | Boric acid |
| F | 40 | Ferrous sulphate |

Plants were sprayed two times (by covering all the aerial parts of the plant with spray droplets) during the experiment, the first on 1st of April and the 2nd on the 15th April 1983. Seeds were planted on 12 March 1983 and transplanted on 16 March 1983 and the first irrigation with saline water was given on 28 March 1983. The subsequent 15 irrigations were given during the experiment period. The plants were subjected to normal cultural practices in the growth room and the harvest day was on 20 June 1983.

Characters studied

I. Yield and yield components. (see M & M exp.2 Chap.II B).

II. Growth and growth analysis (see M & M exp.2 Chap.II B).

Statistical analysis were carried out by main frame computer using the MTS system ANOVA program, June 1978.

## Results and Discussion

### I. Grain yield and yield components

#### 1. Grain yield

Shakha 62 produced higher grain yield than Falchetto but the difference was not sufficient to reach the 5% significance level (Table 1 and Fig. 1).

Table 1 shows that spraying treatment did not significantly affect the grain yield, but that there was an inverse relationship between the salinity of irrigation water and grain yield. The data show that with increasing salinity of irrigation water, the grain yield decreased substantially although significant reductions did not occur until a salt concentration of 4000 ppm.

There was no significant interaction between salinity of irrigation water and spraying with trace element, although trace elements increased grain yield under the two salinity levels in comparison with unsprayed control (Table 2 and Fig. 1).

#### 2. Yield components

It is apparent that the varieties varied significantly in their yield components except spikelet numbers and 1000 kernel weight. Shakha 62 had a higher grain number, spike yield, spike length and harvest index and the opposite is true for spike numbers and straw yield as compared with Falchetto (Table 1 and Figs. 2-4).

Table 1 shows that salinity of irrigation water had a highly significant effect in decreasing yield components, except at 2000 ppm

Table (1) : Average grain yield and yield components as affected by irrigation with saline water and foliar spray with trace elements.

| Characters | Varieties | | Salt content ppm | | | Treatments with trace ele. | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| Grain yield (g) | 2.286 | 1.614 | 2.432 A* | 2.360 A | 1.059 B | 1.838 | 2.063 |
| Spike length (cm) | 8.7 A | 6.6 B | 8.2 A | 7.7 A | 7.0 B | 7.7 | 7.6 |
| Grain number per spike | 32.04 A | 17.82 B | 22.08 B | 30.24 A | 22.46 B | 24.4 | 25.4 |
| Spike yield (g) | 0.493 A | 0.281 B | 0.532 A | 0.435 A | 0.194 B | 0.377 | 0.397 |
| Spikelet number per spike | 16.32 | 15.96 | 17.25 A | 16.43 A | 14.73 B | 16.06 | 16.22 |
| Spike number (5 plants) | 5.22 B | 6.72 A | 5.25 B | 7.50 A | 5.17 B | 5.94 | 6.00 |
| 1000 kernel weight (g) | 16.60 | 16.31 | 25.35 A | 15.13 B | 8.88 C | 15.52 B | 17.39 A |
| H.I. | 15.13 A | 9.72 B | 13.27 A | 14.66 A | 9.34 B | 11.75 | 13.10 |
| Straw yield (g) | 11.39 B | 14.12 A | 15.35 A | 13.36 A | 9.54 B | 12.65 | 12.86 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

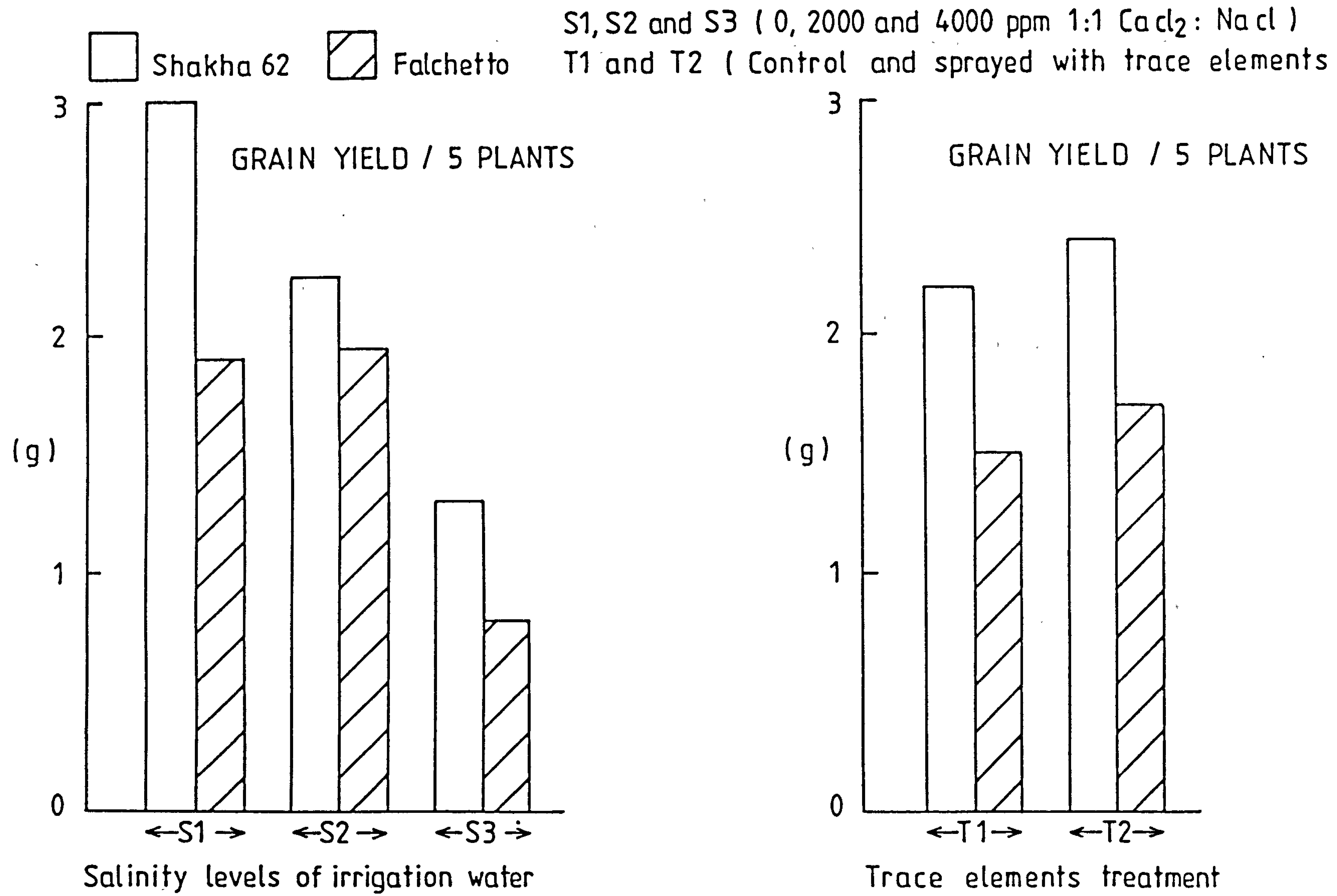



Fig. 1 Effect of salinity levels of irrigation water and foliar application of trace elements on grain yield.

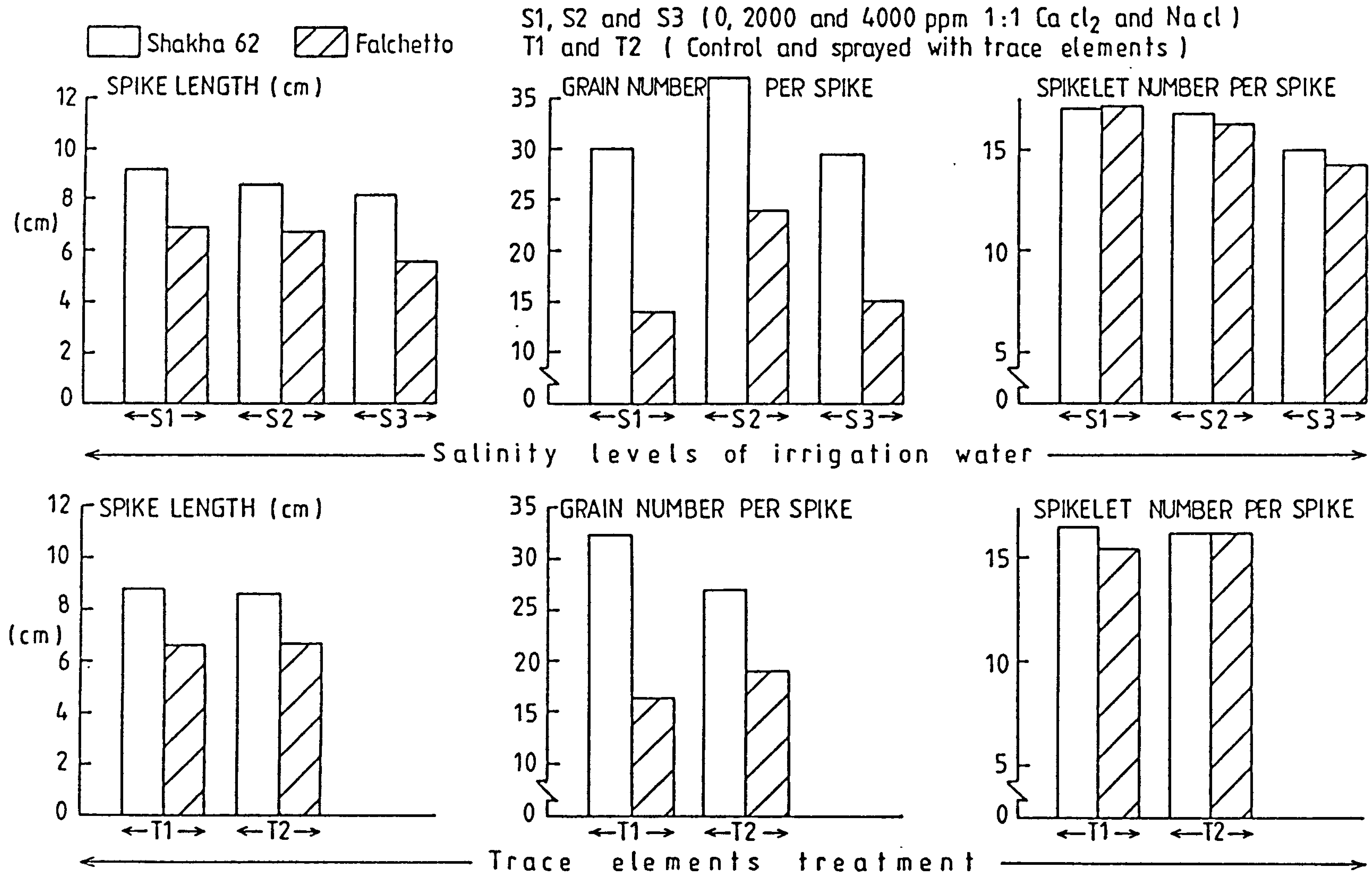



Fig. 2 Effect of salinity levels of irrigation water and foliar application of trace elements on yield components.

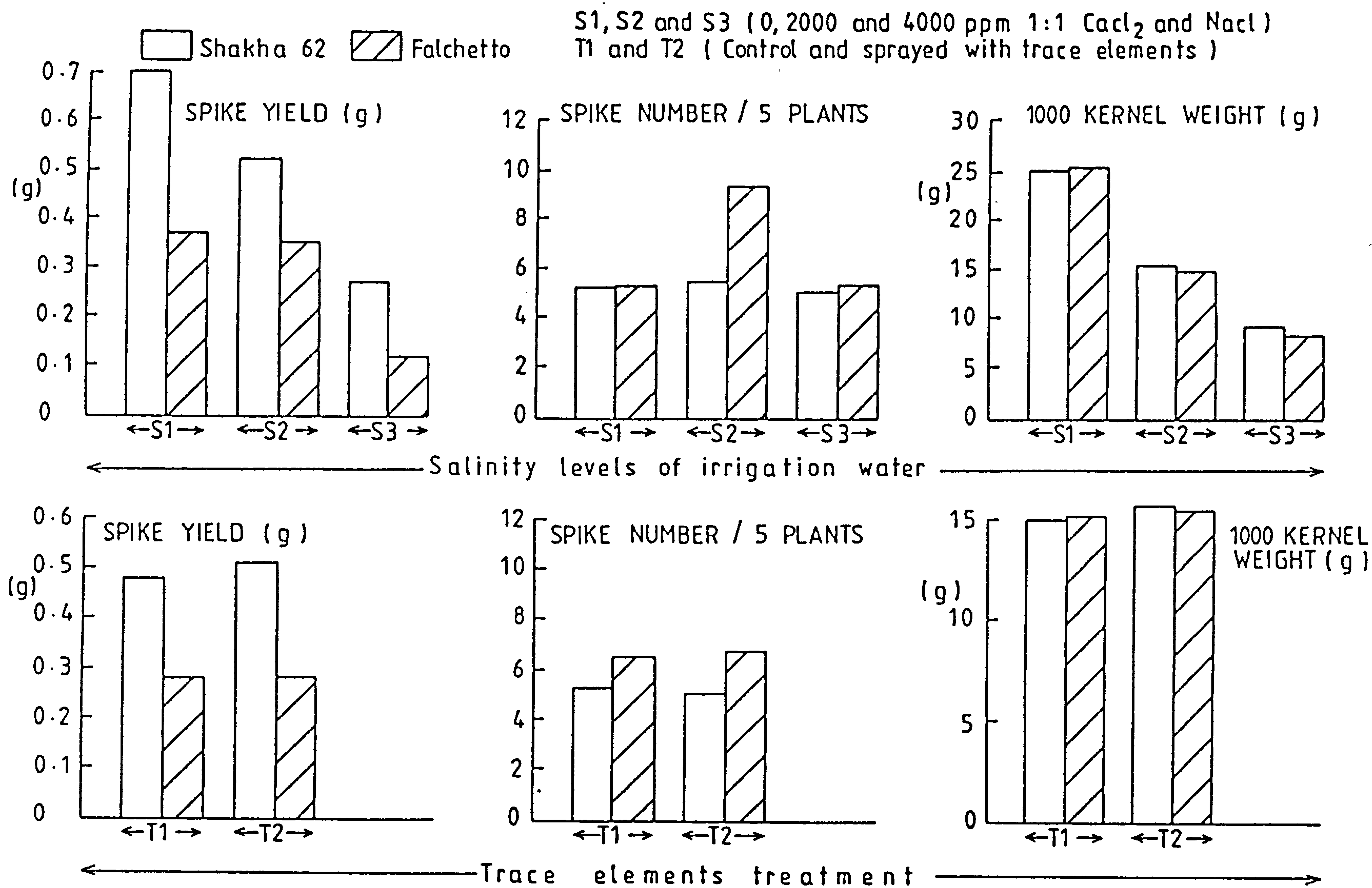



Fig. 3 Effect of salinity levels of irrigation water and foliar application of trace elements on yield components.

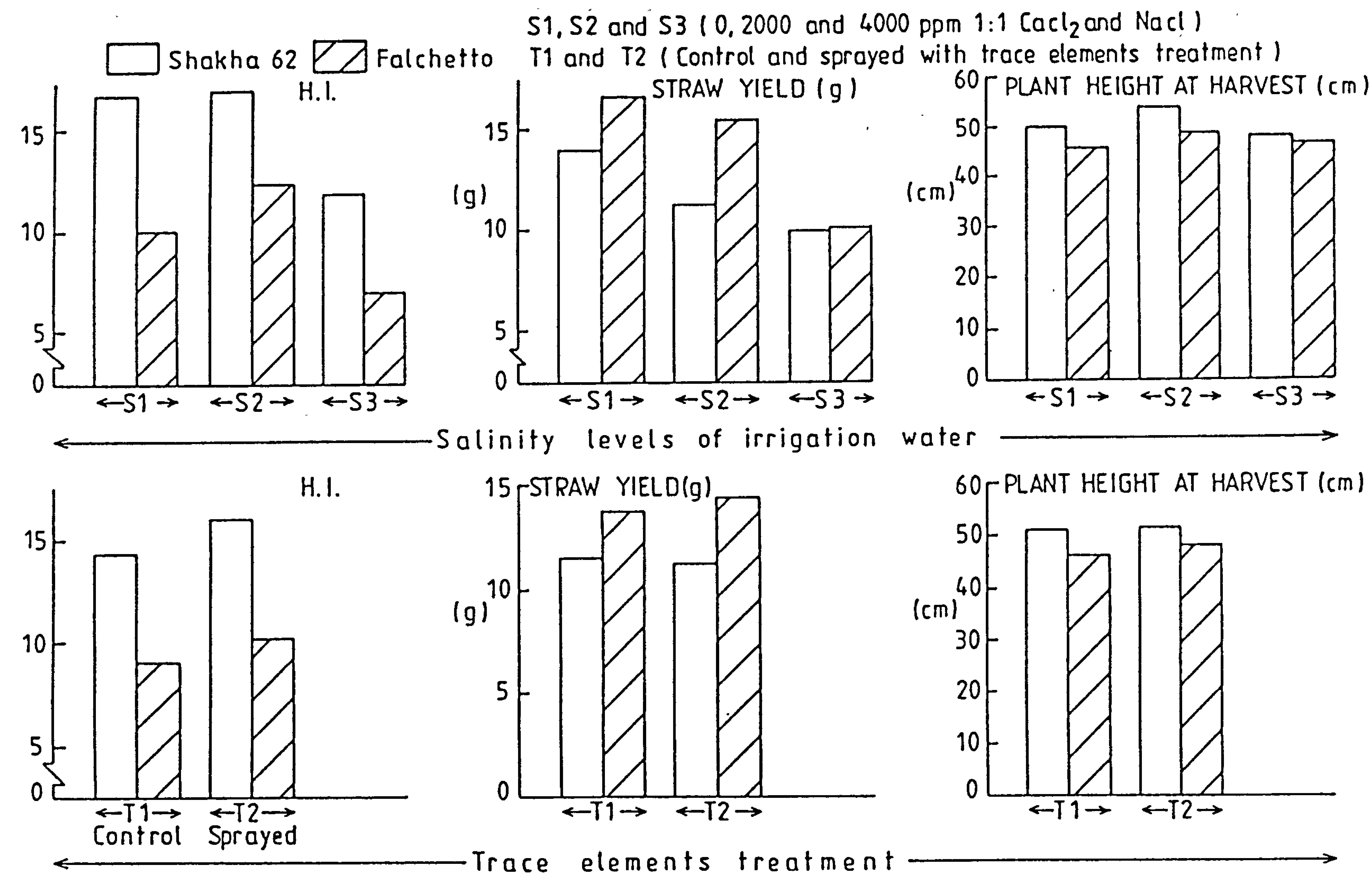



Fig. 4 Effect of salinity levels of irrigation water and foliar application of trace elements on yield components.

salinity level for grain number per spike and spike number per 5 plants which increased over the control and 4000 ppm salinity level. However, there was no significant difference between 2000 ppm salinity level and control for all yield components except grain number per spike and spike number per 5 plants.

Spraying with trace elements significantly increased the 1000 kernel weight only but generally increased most of the yield components as compared with the unsprayed control even though the differences were not significant. A highly significant interaction was obtained for 1000 kernel weight between spraying treatment and salinity, Table (2).

It is apparent from the results of yield and its components that wheat can grow without reduction in yield up to 2000 ppm and generally spraying with trace elements at 2000 ppm salinity was more effective than at higher salinity level 4000 ppm or control treatment, except in the case of 1000 kernel weight, where trace element application resulted in a significant increase at 4000 ppm, but not at 2000 ppm salt (Table 2). These results are in harmony with the finding of Verma 1970/71; Korkor and Hilal, 1975; Abdel-Halim et al., 1976; Jadav et al., 1976; Soliman et al., 1978; Murthy et al., 1979; Singh and Narain, 1980; Gill and Dutt, 1982: Chauhan et al., 1983 and Lehwan et al., 1984. However, Khalil et al. (1977) found that at various ESP (Exchangeable Sodium percentage) values from <15 to 40, irrigation with water containing 10% sea water tended to increase wheat grain and straw yields as compared with irrigation with tap water or water containing 20% sea water. Also, Kumar et al. (1981) and

Table (2) : Averages of grain yield and yield components as affected by spraying with trace elements and salt content of irrigation water.

| Characters | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| Grain yield per 5 plants (g) | Control<br>Sprayed | 2.613<br>2.250 | 2.080<br>2.640 | 0.820<br>1.298 |
| Spike length (cm) | Control<br>Sprayed | 8.133<br>8.183 | 7.717<br>7.733 | 7.133<br>6.917 |
| Grain number per spike | Control<br>Sprayed | 23.6<br>20.6 | 28.2<br>32.3 | 21.5<br>23.5 |
| Spike yield (g) | Control<br>Sprayed | 0.557<br>0.507 | 0.413<br>0.457 | 0.160<br>0.228 |
| Spikelet number per spike | Control<br>Sprayed | 17.4<br>17.1 | 16.2<br>16.7 | 14.6<br>14.9 |
| Spike number per 5 plants | Control<br>Sprayed | 5.5<br>5.0 | 7.3<br>7.7 | 5.0<br>5.3 |
| 1000 kernel weight (g) | Control<br>Sprayed | 23.17*b<br>27.53 a | 15.60 c<br>14.67 c | 7.78 e<br>9.97 d |
| H.I. | Control<br>Sprayed | 13.96<br>12.58 | 13.21<br>16.11 | 8.08<br>10.61 |
| Straw yield (g) | Control<br>Sprayed | 16.14<br>14.57 | 13.04<br>13.68 | 8.76<br>10.32 |

*Averages within column or rows of salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Labanauskas et al. (1981) reported that grain yield, 1000 kernel weight, tillers number and grain number/spike were not adversely affected by irrigation wheat crop with saline water up to 1.6 siemen/m. Sorour et al. (1977) found that increasing salinity levels of irrigation water from 0 to 9000 ppm (1:1 Nacl: $CaCl_2$sol.) did not effect the H.I. (harvest index) and grains number per spike of wheat crop. Sorour and Abou-Elleil (1969), Sorour et al. (1975) and Ravikovitch and Navrot (1976) showed that spraying or addition of trace elements to crop plants under saline conditions increased straw and seed yields of cotton, Millet, Berseem and Tomato as compared with untreated plants.

## II Growth and growth analysis characters

### 1. Number of leaves, tillers, plant height and leaf area

Tables 3-6 and Figs. 5-6 show that wheat varieties varied significantly with regard to these characters except at 4th sample for tiller numbers. Falchetto had the higher leaf numbers, leaf area and tiller numbers except at 4th sample, while Shakha 62 had the higher plant height except at 1st sample.

These characters were affected significantly by salinity level of irrigation water except at 1st sample for leaf numbers and leaf area, at 1st and 2nd samples for tiller numbers and at 2nd, 3rd and 4th samples for plant height (Tables 3-6). Also, it could be observed from Fig. 5 that both cultivars exhibited 68% reduction in leaf area at 4th sample at salinity level of 4000 ppm as compared

Table (3) The average of leaf number per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 20.9 B | 23.7*A | 22.8 | 22.8 | 21.3 | 21.9 | 22.7 |
| 2nd sample | 34.3 B | 42.2 A | 42.5 A | 37.3 B | 34.8 B | 37.4 | 39.1 |
| 3rd sample | 39.4 B | 46.2 A | 47.4 A | 43.0 B | 38.0 C | 43.1 | 42.6 |
| 4th sample | 43.3 B | 52.3 A | 57.0 A | 48.8 B | 37.7C | 47.8 | 47.8 |

Table (3A)

| Samples | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 22.3<br>23.3 | 23.0<br>22.5 | 20.5<br>22.2 |
| 2nd sample | Control<br>Sprayed | 42.3<br>42.7 | 36.3<br>38.3 | 33.5<br>36.2 |
| 3rd sample | Control<br>Sprayed | 48.2<br>46.7 | 42.8<br>43.2 | 38.2<br>37.8 |
| 4th sample | Control<br>Sprayed | 57.7<br>56.3 | 48.0<br>49.7 | 37.8<br>37.5 |

*Averages within colum or rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (4) The average of leaf area ($cm^2$) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 265.5B | 363.9*A | 323.4 | 313.0 | 303.2 | 315.2 | 311.3 |
| 2nd sample | 595.7B | 811.4 A | 769.7A | 704.8AB | 636.1B | 686.6 | 720.5 |
| 3rd sample | 780.7B | 1015.0 A | 1023.1A | 893.0B | 777.5C | 876.5 | 919.2 |
| 4th sample | 756.0B | 943.6A | 1102.0A | 869.3B | 578.0C | 849.6 | 849.9 |

Table (4A)

| Samples | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 339.6<br>307.3 | 319.2<br>306.7 | 286.7<br>319.7 |
| 2nd sample | Control<br>Sprayed | 784.4<br>755.1 | 684.7<br>725.0 | 590.7<br>681.5 |
| 3rd sample | Control<br>Sprayed | 1025.9<br>1020.3 | 862.1<br>923.9 | 741.4<br>813.6 |
| 4th sample | Control<br>Sprayed | 1126.0<br>1078.1 | 856.1<br>882.5 | 566.8<br>589.1 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (5) The average of plant height (cm) as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 10.4 B | 12.1 A | 11.8 A | 11.1 B | 10.7 B | 11.0 | 11.4 |
| 2nd sample | 17.4 A | 16.2 B | 17.0 | 16.9 | 16.6 | 16.7 | 17.0 |
| 3rd sample | 31.4 A | 24.6 B | 27.0 | 28.6 | 28.5 | 28.4 | 27 7 |
| 4th sample | 42.8 A | 36.9 B | 39.3 | 41.9 | 38.3 | 39.8 | 39.8 |
| At harvest | 50.9 A | 47.6 B | 48.1 B | 51.6 A | 48.1 B | 49.0 | 49.5 |

Table (5A)

| Samples | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 11.6<br>12.1 | 11.0<br>11.3 | 10.6<br>10.9 |
| 2nd sample | Control<br>Sprayed | 17.3<br>16.8 | 16.7<br>17.1 | 16.0<br>17.2 |
| 3rd sample | Control<br>Sprayed | 27.3<br>26.6 | 29.3<br>27.9 | 28.6<br>28.5 |
| 4th sample | Control<br>Sprayed | 39.4<br>39.3 | 42.2<br>41.6 | 37.9<br>38.6 |
| At harvest | Control<br>Sprayed | 48.6<br>47.6 | 51.5<br>51.7 | 47.6<br>49.1 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (6) The average of tiller number per 5 plant as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 3.9 B | 6.6*A | 5.6 | 5.0 | 5.2 | 5.2 | 5.3 |
| 2nd sample | 6.5 B | 11.9 A | 10.0 | 8.8 | 8.8 | 8.9 | 9.4 |
| 3rd sample | 6.4 B | 10.2 A | 9.9 A | 8.0AB | 7.0 B | 8.5 | 8.1 |
| 4th sample | 8.8 | 9.4 | 14.3 A | 7.6 B | 5.3 B | 8.6 | 9.6 |

Table (6A)

| Samples | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 5.7<br>5.5 | 5.0<br>5.0 | 4.8<br>5.5 |
| 2nd sample | Control<br>Sprayed | 10.3<br>9.7 | 8.0<br>9.5 | 8.5<br>9.2 |
| 3rd sample | Control<br>Sprayed | 10.2<br>9.7 | 8.2<br>7.8 | 7.2<br>6.8 |
| 4th sample | Control<br>Sprayed | 13.5<br>15.2 | 6.8<br>8.3 | 5.3<br>5.3 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

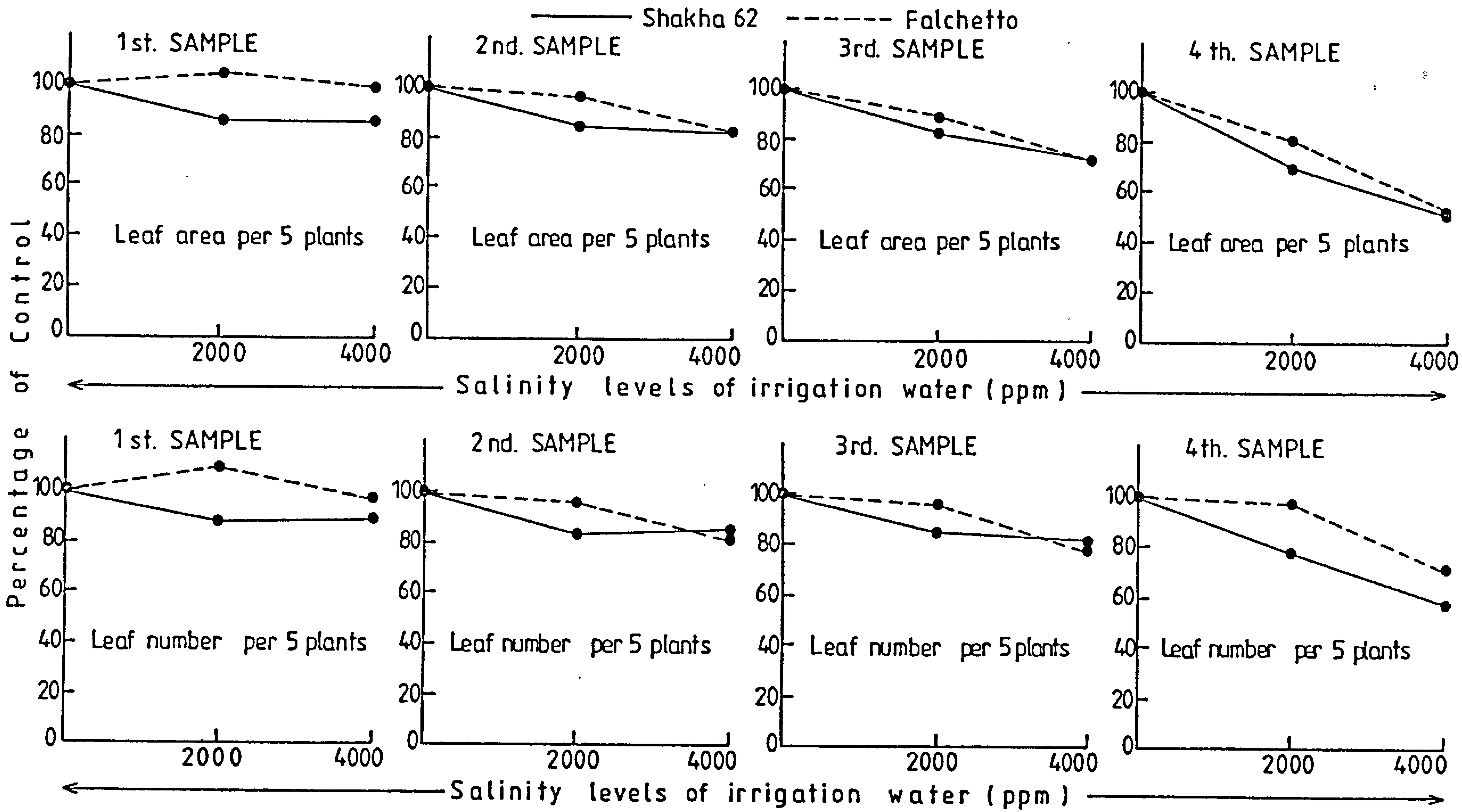



Fig. 5 Effect of salinity levels of irrigation water on leaf area and leaf number per 5 plants.

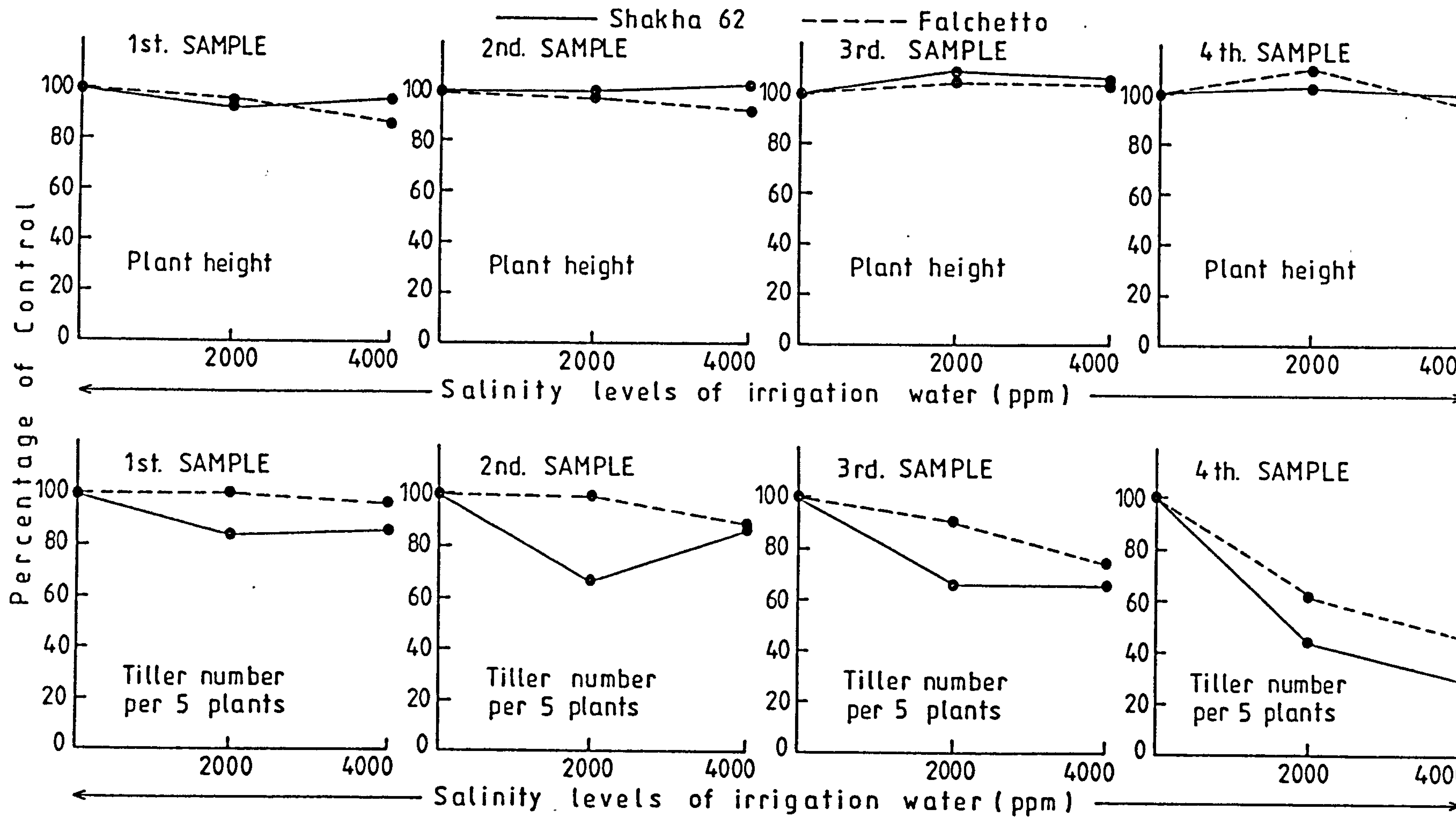



Fig. 6 Effect of salinity levels of irrigation water on plant height and tiller number per 5 plants.

with control. There were no significant effects of trace elements on all these characters. However, trace elements increased leaf area under the two level of saline irrigation water as compared with unsprayed treatments but the difference was not marked enough to reach the 5% significance level (Table 4 and 4A). Similar results were obtained by Gandhi and Paliwal (1975), Singh and Saxena (1976), Suganuma (1978), Bhatnagor and Yadav (1980), Abdul-Kadir and Paulsen (1982), Kumar (1983). However, El-Kady et al. (1981) showed that leaf area of wheat plants increased with increasing salinity up to 4000 ppm in sand culture. Also, Farrag (1981) observed that spraying Broad beans with trace elements did not significantly over come the negative influence of salinity in plant height.

## 2. Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) and leaf area ratio (LAR)

Analysis of variance showed significant reductions due to irrigation with saline water in all these characters at all intervals except at 1st interval for CGR, 1st and 2nd intervals for RGR and NAR, however there was no significant differences among control and 2000 ppm salinity level for CGR at the 2nd interval, RGR and NAR at the 3rd interval and LAR at the 1st interval. Also, the spraying treatment did not significantly affect any of these characters (Tables 7-10A).

Fig. 7 and 8 show that CGR, RGR, NAR and LAR of Shakha 62 at all intervals were less sensitive (i.e. less reduced) to salinity of irrigation water of 4000 ppm than Falchetto except for CGR, RGR and NAR at 2nd interval only. This result shows the ability of

Table (7) The average of crop growth rate (g.week$^{-1}$) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Intervals | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st interval | 0.952*B | 1.149 A | 1.101 | 1.025 | 1.026 | 0.995 | 1.106 |
| 2nd interval | 1.177 | 1.338 | 1.359A | 1.350A | 1.064B | 1.334 | 1.181 |
| 3rd interval | 1.181 | 1.203 | 1.680A | 1.251B | 0.646C | 1.195 | 1.190 |

Table (7A)

| Intervals | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st interval | Control<br>Sprayed | 1.076<br>1.127 | 1.006<br>1.043 | 0.902<br>1.149 |
| 2nd interval | Control<br>Sprayed | 1.482<br>1.235 | 1.394<br>1.306 | 1.125<br>1.002 |
| 3rd interval | Control<br>Sprayed | 1.765<br>1.594 | 1.225<br>1.277 | 0.594<br>0.698 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (8) The average of relative growth rate ($g.g^{-1}week^{-1}$) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Intervals | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st interval | 0.507 | 0.471 | 0.505 | 0.486 | 0.477 | 0.470 | 0.509 |
| 2nd interval | 0.292 | 0.276 | 0.296 | 0.305 | 0.252 | 0.304 | 0.264 |
| 3rd interval | 0.187 | 0.153 | 0.225*A | 0.182A | 0.103B | 0.167 | 0.173 |

Table (8A)

| Intervals | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st interval | Control<br>Sprayed | 0.487<br>0.522 | 0.481<br>0.491 | 0.441<br>0.513 |
| 2nd interval | Control<br>Sprayed | 0.317<br>0.274 | 0.313<br>0.296 | 0.283<br>0.220 |
| 3rd interval | Control<br>Sprayed | 0.221<br>0.229 | 0.182<br>0.182 | 0.099<br>0.108 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (9) The average of net assimilation rate ($g.cm^{-2}week^{-1}$) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Intervals | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st interval | 2.271 | 2.040 | 2.132 | 2.120 | 2.214 | 2.027 | 2.284 |
| 2nd interval | 1.709 | 1.500 | 1.553 | 1.716 | 1.545 | 1.730A | 1.479B |
| 3rd interval | 1.550*A | 1.159B | 1.618A | 1.507A | 0.939B | 1.379 | 1.330 |

Table (9A)

| Intervals | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st interval | Control<br>Sprayed | 2.019<br>2.245 | 2.105<br>2.136 | 1.956<br>2.472 |
| 2nd interval | Control<br>Sprayed | 1.681<br>1.424 | 1.816<br>1.616 | 1.693<br>1.396 |
| 3rd interval | Control<br>Sprayed | 1.651<br>1.585 | 1.573<br>1.440 | 0.914<br>0.964 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (10) The average of leaf area ratio ($cm^{-2}$ g) of 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Intervals | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st interval | 217.19B | 232.68*A | 238.65A | 227.12A | 209.03B | 225.44 | 224.43 |
| 2nd interval | 170.80B | 185.1 A | 192.36A | 178.14B | 163.34C | 176.56 | 179.34 |
| 3rd interval | 118.94B | 129.62 A | 138.77A | 123.09B | 110.98C | 121.92 | 126.63 |

Table (10A)

| Intervals | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st interval | Control<br>Sprayed | 242.97<br>234.33 | 223.25<br>230.99 | 210.10<br>207.97 |
| 2nd interval | Control<br>Sprayed | 189.82<br>194.90 | 173.75<br>182.54 | 166.12<br>160.57 |
| 3rd interval | Control<br>Sprayed | 133.98<br>143.56 | 119.83<br>126.34 | 111.97<br>109.99 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

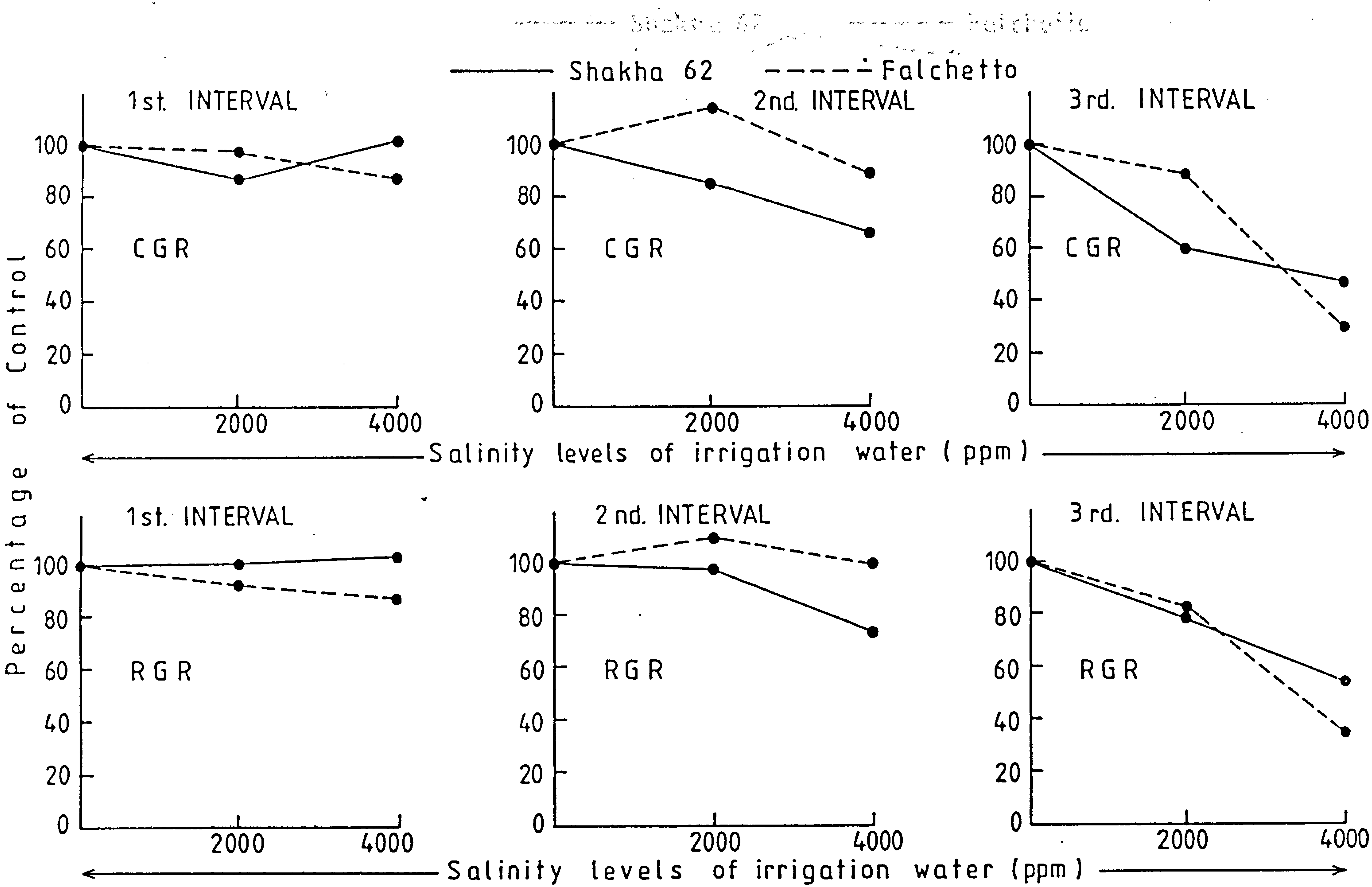



Fig. 7 Effect of salinity levels of irrigation water on CGR and RGR at 3 intervals.

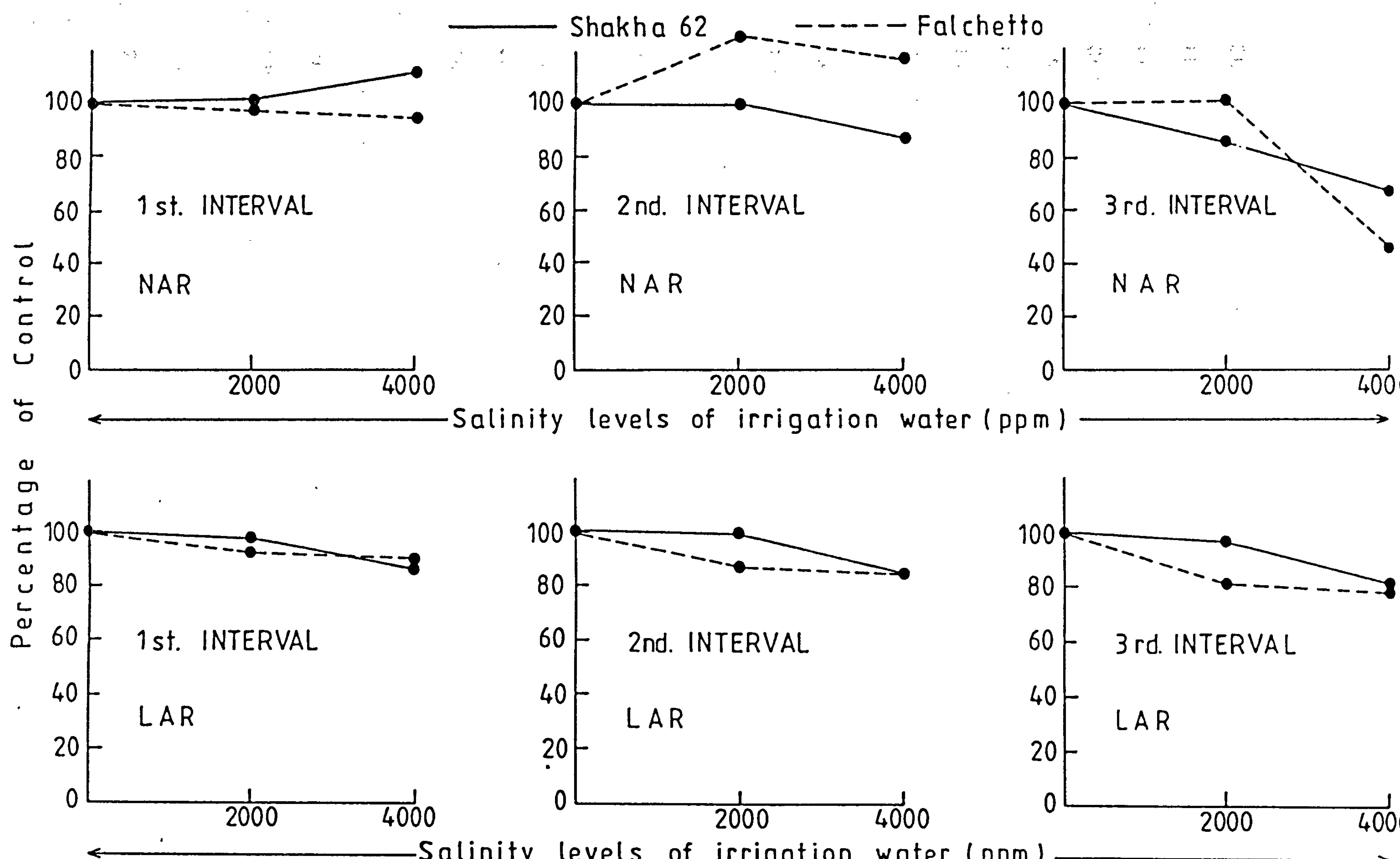



Fig. 8 Effect of salinity levels of irrigation water on NAR and LAR at 3 intervals.

Shakha 62 to produce more dry matter (as percentage of control) at this mature stage (3rd interval) of growth than Falchetto. The significantly higher NAR (Table 9) of Shakha 62 at this stage of growth can explain the higher grain yield and its components of Shakha 62 as compared with Falchetto eventhough the difference was not marked enough to reach the 5% significance level for grain yield. These results are in harmony with those reported by Balasubramania and Sarin (1974), El-Leboudi and Maoukhtar (1975), Monadjemi (1977), Kumar and Yadav (1983) and Kingsbury et al. (1984). However, Ravikovitch and Navrot (1976) showed that addition of Mn and Zn increased the plant growth of Berseem, Millet and Tomato under saline conditions.

3. Leaf, stem, root and whole dry weight

Data in Tables 11-14A show significant effects due to salinity on all these characters at 3rd and 4th samples only for leaf, root and whole plant dry weight and 4th sample for stem dry weight. The semi-dwarf cultivar Falchetto had a significantly higher dry weight for all parts of the plant as compared with Shakha 62 except at 3rd and 4th samples for stem dry weight and 1st sample for root dry weight. However, the percentage reduction in dry weight was the same in both cultivars for all parts of the plant, especially at 4th sample. The reduction in dry weight from control values can be seen in Figs. 9 and 10. Also no significant effect on dry matter production due to spraying with trace elements was obtained (Table 7-10). Similar results were reported by Nouri et al. (1970), Poonia

Table (11) The average of leaf dry weight (g) per 5 plants as affected by spraying with trace elements and salt content of irrigation water

| Samples | Varieties | | Salt Content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 0.523*B | 0.781A | 0.659 | 0.639 | 0.657 | 0.652 | 0.651 |
| 2nd sample | 1.502 B | 2.035A | 1.807 | 1.737 | 1.763 | 1.720 | 1.817 |
| 3rd sample | 2.251 B | 2.926A | 2.703A | 2.660A | 2.403B | 2.621 | 2.557 |
| 4th sample | 2.348 B | 3.191A | 3.338A | 2.887B | 2.094C | 2.825 | 2.714 |

Table (11A)

| Samples | Treatment | Salt content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 400 |
| 1st sample | Control<br>Sprayed | 0.695<br>0.624 | 0.639<br>0.638 | 0.622<br>0.691 |
| 2nd sample | Control<br>Sprayed | 1.827<br>1.787 | 1.732<br>1.741 | 1.602<br>1.924 |
| 3rd sample | Control<br>Sprayed | 2.820<br>2.585 | 2.685<br>2.635 | 2.357<br>2.450 |
| 4th sample | Control<br>Sprayed | 3.551<br>3.124 | 2.897<br>2.876 | 2.027<br>2.141 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (12) The averages of stem dry weight (g) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | salt content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 0.287*B | 0.407A | 0.355 | 0.341 | 0.345 | 0.340 | 0.353 |
| 2nd sample | 0.981 B | 1.142A | 1.061 | 1.050 | 1.074 | 1.040 | 1.084 |
| 3rd sample | 2.307 | 2.439 | 2.324 | 2.409 | 2.387 | 2.400 | 2.346 |
| 4th sample | 4.652 | 4.736 | 5.020A | 4.932A | 4.130B | 4.729 | 4.659 |

Table (12A)

| Samples | Treatment | Salt Content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control | 0.364 | 0.328 | 0.328 |
| | Sprayed | 0.345 | 0.354 | 0.361 |
| 2nd sample | Control | 1.065 | 1.060 | 0.994 |
| | Sprayed | 1.057 | 1.039 | 1.154 |
| 3rd sample | Control | 2.406 | 2.501 | 2.294 |
| | Sprayed | 2.242 | 2.316 | 2.480 |
| 4th sample | Control | 5.236 | 5.029 | 3.923 |
| | Sprayed | 4.805 | 4.835 | 4.338 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (13) The average of root dry weight (g) per 5 plants as affected by spraying with trace elements and salt content of irrigation water

| Samples | Varieties | | Salt content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 0.266 | 0.271 | 0.251 | 0.271 | 0.283 | 0.275 | 0.262 |
| 2nd sample | 0.495B | 0.606*B | 0.600 | 0.553 | 0.498 | 0.524 | 0.577 |
| 3rd sample | 0.772B | 1.083A | 1.158A | 0.952B | 0.672C | 0.918 | 0.937 |
| 4th sample | 0.727B | 1.159 A | 1.185A | 0.740B | 0.532C | 0.793 | 0.845 |

Table (13A)

| Samples | Treatment | Salt content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 0.254<br>0.248 | 0.285<br>0.258 | 0.286<br>0.281 |
| 2nd sample | Control<br>Sprayed | 0.573<br>0.627 | 0.555<br>0.551 | 0.445<br>0.552 |
| 3rd sample | Control<br>Sprayed | 1.203<br>1.114 | 0.912<br>0.992 | 0.640<br>0.705 |
| 4th sample | Control<br>Sprayed | 1.172<br>1.199 | 0.695<br>0.785 | 0.513<br>0.551 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

Table (14) The average of whole plant dry weight (g) per 5 plants as affected by spraying with trace elements and salt content of irrigation water.

| Samples | Varieties | | Salt content ppm | | | Treatment | |
|---|---|---|---|---|---|---|---|
| | Shakha 62 | Falchetto | 0 | 2000 | 4000 | Control | Sprayed |
| 1st sample | 1.074B | 1.459*A | 1.265 | 1.249 | 1.285 | 1.267 | 1.266 |
| 2nd sample | 2.978B | 3.756 A | 3.468 | 3.298 | 3.336 | 3.256 | 3.478 |
| 3rd sample | 5.331B | 6.433 A | 6.185 A | 5.997AB | 5.463B | 5.924 | 5.840 |
| 4th sample | 7.732 B | 8.839 A | 9.544A | 8.559B | 6.754C | 8.353 | 8.218 |

Table (14A)

| Sample | Treatment | Salt content ppm | | |
|---|---|---|---|---|
| | | 0 | 2000 | 4000 |
| 1st sample | Control<br>Sprayed | 1.313<br>1.217 | 1.252<br>1.246 | 1.237<br>1.333 |
| 2nd sample | Control<br>Sprayed | 3.464<br>3.471 | 3.264<br>3.331 | 3.041<br>3.631 |
| 3rd sample | Control<br>Sprayed | 6.429<br>5.941 | 6.051<br>5.943 | 5.291<br>5.635 |
| 4th sample | Control<br>Sprayed | 9.959<br>9.128 | 8.621<br>8.496 | 6.478<br>7.030 |

*Averages within rows of varieties or salinity levels or trace elements treatment followed by the same letter are not significantly different according to Duncan's test.

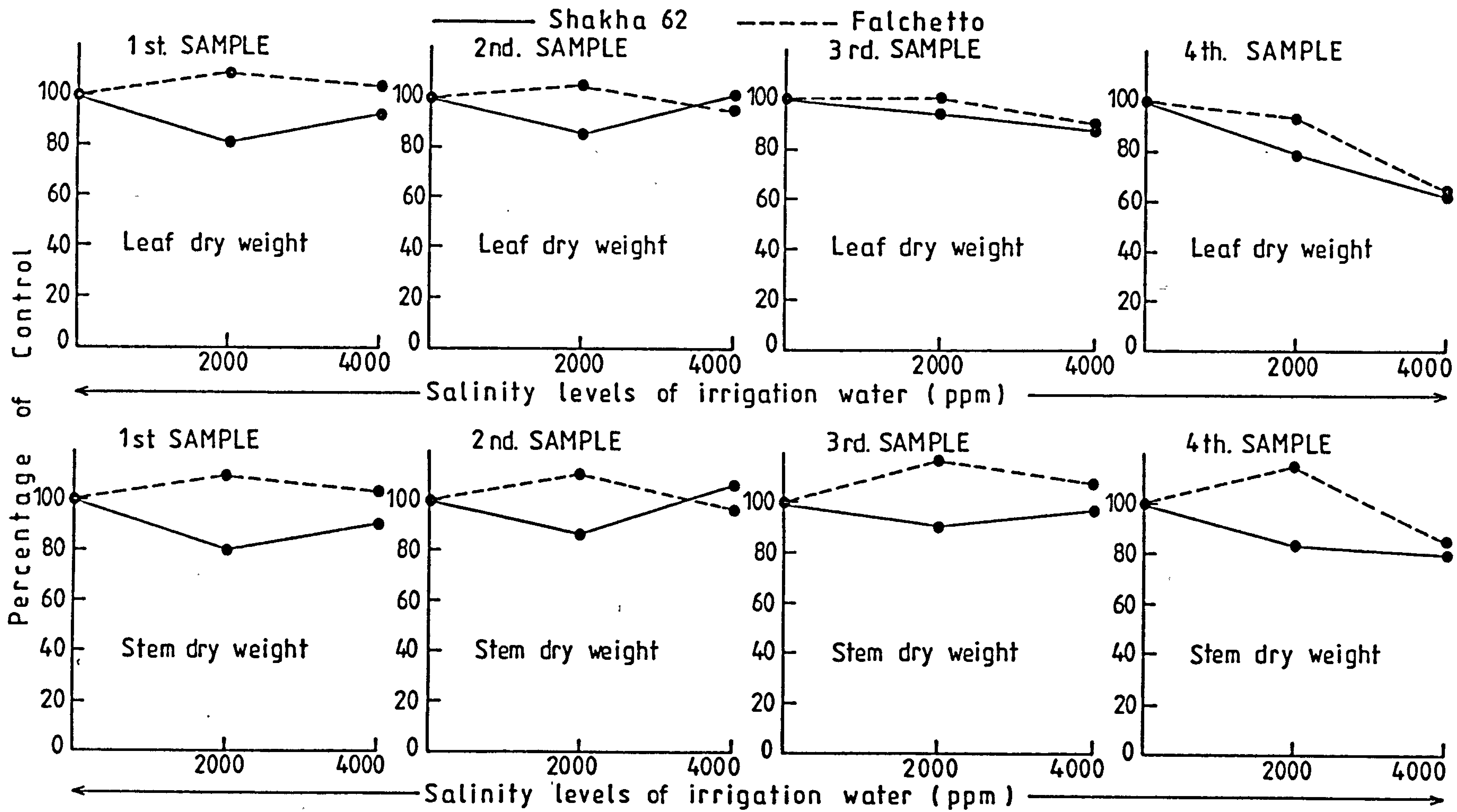



Fig. 9 Effect of salinity levels of irrigation water on leaf and stem dry weight at four samples dates.

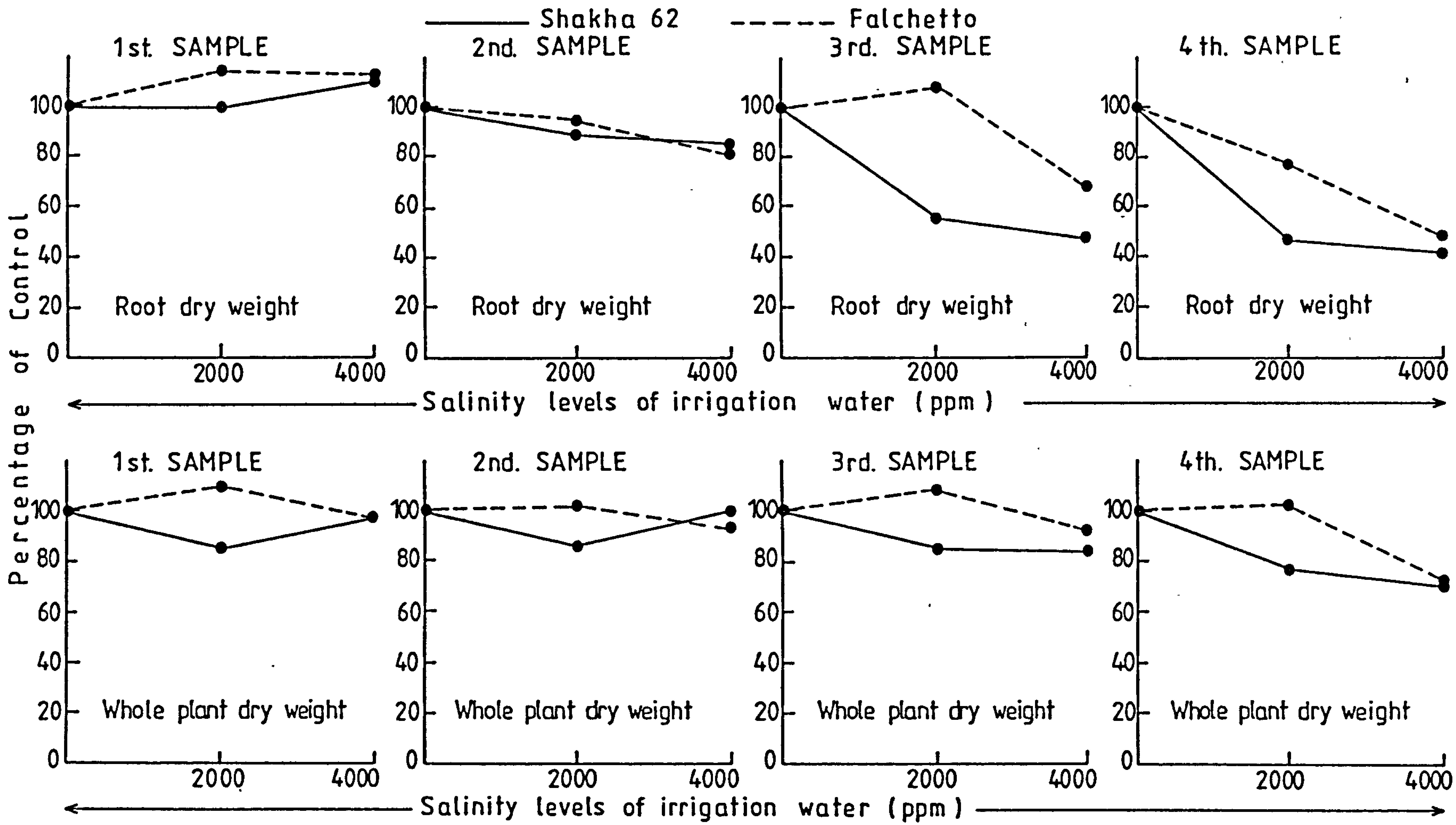



Fig. 10 Effect of salinity levels of irrigation water on root and whole plant dry weight at four samples dates.

and Jharar (1974), Fawzi and Abed (1975), Mahajan and Sonar (1980), Hussain (1981) and Lehman _et al_. (1984). However, El-Kady _et al_. (1981) reported that leaf and stem dry weight of wheat plant increased with increasing salinity level up to 4000 ppm in sand culture. Farrag (1978) observed that reduction in dry matter of broad bean plants sprayed with boron or mixture of trace elements was small under salinity conditions. Also, Ravikovitch and Navrot (1976) found that addition of Mn or Zn increased dry matter of Berseem, Millet and Tomato plants under salinity conditions.

Since no beneficial effect of additional trace elements under saline conditions was observed, there is no evidence that salinity interferes with the uptake of trace elements. On the other hand, from the economic point of view, and from these results generally, it could be recommended to use saline water for irrigation up to 2000 ppm (0.27 siemen/m) for wheat crop without significant loss of yield. However, it should be pointed out that these recommendations represents only the material studied in that particular conditions.

Summary

The effect of spraying with trace elements under different levels of saline irrigation water on growth, yield and its components was studied in controlled environment.

While spraying with trace elements did not affect growth, grain yield and its components except 1000 kernel weight, a direct positive relationship was obtained between salinity and grain number per spike and spike number per 5 plants. Both characters were increased with increasing salt content up to 2000 ppm. An inverse relationship was obtained between salt content and 1000 grain weight. Grain yield and other components were not affected by salt content up to 2000 ppm but decreased with 4000 ppm. All growth characters were affected by salt content except 1st sample and at 4th sample NAR and RGR which were not affected by salt content up to 2000 ppm while plant height increased at 2000 ppm. Shakha 62 gave higher grain yield than Falchetto, although the difference between the two cultivars was not significant.

# CHAPTER IV A

## DETERMINATION OF LEAF WATER POTENTIAL, LEAF OSMOTIC POTENTIAL AND TURGOR POTENTIAL AT EARLY STAGES OF WHEAT VAR. (SHAKHA 8) UNDER DIFFERENT SALINITY LEVELS

### Introduction

Soil salinity reduces the availability of water as a result of decrease in soil osmotic potential. Plant growth depression on saline soil has been related to this osmotic reduction in water availability and to specific nutritional and toxic effects (Strogonov, 1964). Previous studies have indicated that plants are highly susceptible at all the early growth stages (Ansari and Naqvi, 1978; Ashour et al., 1977). Dutt (1977) found that the water potential of wheat leaves considerably decreased with the decrease of soil moisture percentage, with the increase of electrical conductivity of the soil solution ($EC_e$) and with the increase in the exchangeable sodium percentage level.

These is considerable evidence of osmotic adjustment by leaf tissue in response to drought e.g. Hsaio, 1976; Greacen and Oh, 1972: by reducing osmotic potential in line with decreasing water potential, turgor potential is maintained at steady value. Turgor is essential for growth by cell expansion. If salinity imposes physiological drought it may be that the plant will respond by adjusting osmotically. The results of the mineral analyses (experiment 2, Chapter II) show there is a possible supply of electrolytes for such adjustment in wheat plants growing in saline soils.

## Materials and Methods

The experiment was carried out at Close House Field Station, during 1981-82. Plant material consisted of one variety of vulgare wheat (*Triticum aestivum* L.) namely Shakha 8 (Medium tall and local wheat var. in Egypt). This variety is recommended for cultivation in all wheat growing areas of Egypt. This variety was used in this experiment because of shortage of seed of the other varieties (G.155 and Falchetto). Single plants of Shakha 8 wheat var. were greenhouse grown in 7.62 cm pots in soils of 0.0, 0.2, 0.4, 0.6 and 0.8% salinity prepared as described in experiment 2 chapter II. Seeds were sown in trays on May 8th and transplanted into pots on 15th, 1982. The 1st sample was taken 21 days after sowing and the 2nd sample 15 days after the 1st sample. The experimental design was a complete randomized block with three replicates. The water potential of a disc cut from the 2nd leaf from the top of the plant was measured using the thermocouple psychrometer method. Leaf osmotic potential of each sample was measured by the same method after dipping the leaf disk in liquid nitrogen to rupture the cell membranes. Turgor potential was determined by subtracting osmotic potential from leaf water potential. All seedlings of the 0.8% treatment died after transplanting.

Table (1) : Effect of different salinity levels on germination percentage

| Treatments | 0.0% | 0.2% | 0.4% | 0.6% | 0.8% |
|---|---|---|---|---|---|
| No. of seeds | 80 | 80 | 80 | 80 | 80 |
| No. of seedlings | 34 | 27 | 20 | 14 | 4 |
| % | 42.5 | 33.8 | 25 | 17.5 | 5 |

Table (2) : Effect of different salinity levels on leaf water potential, osmotic potential and turgor potential (MPa). at 1st and 2nd sample.

| Characters / Samples / Treatments | Water potential | | Osmotic potential | | Turgor potential | |
|---|---|---|---|---|---|---|
| | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| 0.0% | -0.60*a | -0.58 a | -1.50 a | -1.38 a | +0.90 a | +0.80 a |
| 0.2% | -1.31 b | -0.89 b | -1.83 b | -1.53 a | +0.52 b | +0.64 b |
| 0.4% | -1.43 c | -1.01 c | -1.94 b | -1.62 a | +0.51 b | +0.62 b |
| 0.6% | -1.74 d | -1.38 d | -2.30 c | -1.99 b | +0.56 b | +0.61 b |

*Means followed by the same letter in each colum for water potential, osmotic potential and turgor potential are not significantly different according to Duncan's test.

## Results and Discussion

The analysis of variance show that in both samples leaf water potential and osmotic potential were significantly reduced by each increase in salinity. Turgor potential fell between 0 and 0.2% salinity, but then remained essentially unchanged with increasing salinity levels from 0.2 to 0.6% indicating marked osmotic adjustment (Tables 2). This result was in agreement with Bernstein, 1961; Aceves et al., 1975; Dutt, 1976; Morgan, 1977; Hoffman and Jobes, 1978 and Kirkham, 1984. However, Bernstein's (1961) and Hoffman and Jobes (1978) their data did not indicate complete osmotic adjustment. The maintenance of turgor pressure of 0.5 to 0.6 MPa should have maintained leaf growth rate (Hsaio, 1976). However, in experiment 2 Chapter II leaf growth decreased with increasing salinity. Therefore indications of toxic effects can be seen in these results.

# CHAPTER IV B

## THE WATER USE OF WHEAT PLANTS AS AFFECTED BY SOIL SALINITY

### Introduction

Water-use by the crop is positively related to dry matter yield. Soil salinity reduces the availability of water as a result of increase in total soil-moisture stress (Strogonov, 1964; Lunin and Gallatin, 1965 and Heikal, 1977). Hence, the determination of the rate of water-use in wheat plants is very important.

### Materials and Methods

This experiment was carried out in a controlled environment room in the Faculty of Agriculture, University of Newcastle upon Tyne. Plant material consist of vulgare wheat (*Triticum aestivum* L.) namely Shakha 61 (Medium tall and local wheat var. in Egypt). The soil was artificially salinised with mixtures of salt (see M & M exp. 2 Chapter II). Four levels of chloride salinity were used 0.0, 0.2, 0.4 and 0.6% (based on soil dry weight). The experimental design for this experiment was a randomized complete block with three replicates. Each replicate conssited of four treatments, each treatment consisting of 20 pots in 4 rows for determination all the characters listed below at each of four sampling dates.

Seeds were sown in trays on October 20th and transplanted into pots (7.62 cm diam.) on 25th, 1982. Sampling was carried out at 7 days intervals, the 1st sample was taken one month after sowing.

The plants were subjected to normal cultural practices in the growth room.

Characters studied

1. Leaf area per 4 plants ($cm^2$) (by using leaf area meter, LAMBDA)

2. Fresh and dry weight of leaves per 4 plants (g)

3. Total water content of leaves per 4 plants (g)

4. Transpiration rate: This character was determined by weighing the pots before and after a transpiration period of 8 hours. Due to variation in size of plants as a result of the salinity effect, the transpiration is given as specific transpiration by dividing with the leaf area (see results). The soil surface of each pot was covered by a polythene film to prevent evapotranspiration.

5. Relative water content (RWC%): Samples for RWC were taken from 2nd leaf from the plant top. Each sample weighing about 0.1g contained 10-15 leaf segments. The fresh wt. was taken with Mettler balance ($\pm 10^{-4}$ g). Tissue segments were then floated over distilled water and turgid weights were taken after 4h, the water from the surface of tissue segments having been first removed by sandwiching them in 4-sheet layer of filter paper (Whatman No.4). These samples were then oven-dried.

$$RWC = \frac{\text{fresh weight - oven dry weight}}{\text{turgid weight - oven dry weight}} \times 100.$$

6. Number of stomata per field microscope (X10): Number of stomata per field of microscope (X10) was determined on the upper surface of the 3rd leaf from the plant top. This character was determined two times (at 2nd and 4th sample) only.

## Results and Discussion

### 1. Water content and relative water content

Determination of water content and relative water content in leaves showed that the degree of hydration of cells changes, depending on the conditions of cultivation of the wheat crop (Table 1 and 2). The data of Tables 1 and 2 indicated that the average water content and average relative water content were highly significantly decreased by the increase of soil salinity at all samples. However, relative water content (R.W.C.) was less reduced as compared with total water content (Fig. 1). The relation between the degree of hydration of the plant cells and degree of soil salinity can be more clearly seen if the water content and dry weight are expressed per unit of leaf area (Table 3).

The data summarized in Table 3 show that under conditions of salinity, generally there is a decrease in fresh weight per unit leaf area in wheat. With the exception of the 2nd sample, this decrease in weight per unit area is due more to a decrease in water content than to that of dry matter. Similar results have been reported by Prisco and O'Leary (1973) and Tal and Gardi (1976). However, Heikal (1977) during his work on the effect of the irrigation

Table (1) : The performance of total water content in wheat leaves as affected by different soil salinity

| Salinity levels | 1st sample | | 2nd sample | | 3rd sample | | 4th sample | |
|---|---|---|---|---|---|---|---|---|
| | T.W.C. (g) | T.W.C. % of fresh wt | T.W.C. (g) | T.W.C. % of fresh wt | T.W.C. (g) | T.W.C. % of fresh wt | T.W.C. (g) | T.C.W. (%) of fresh wt |
| 0.0% | 2.277*a | 81.87 | 1.983 a | 76.42 | 2.493 a | 77.17 a | 1.830 a | 75.08 |
| 0.2% | 1.782 b | 81.29 | 1.673 a | 77.06 | 1.273 b | 74.72 b | 1.147 b | 73.81 |
| 0.4% | 0.964 c | 79.41 | 0.980 b | 76.33 | 0.913 c | 72.60 c | 0.820 bc | 72.07 |
| 0.6% | 0.676 d | 78.90 | 0.430 c | 77.10 | 0.680 c | 71.47 c | 0.580 c | 70.64 |

*Averages within column of samples followed by the same letter are not significantly different according to Duncan's test

Table (2) : The performance of relative water content (R.W.C.) of wheat leaves under different soil salinity levels

| Salinity levels | Relative water content (R.W.C.) % | | | |
|---|---|---|---|---|
| | 1st sample | 2nd sample | 3rd sample | 4th sample |
| 0.0% | 89.13*a | 91.16 a | 93.73 a | 92.15 a |
| 0.2% | 86.42 ab | 89.54 b | 92.75 a | 90.89 a |
| 0.4% | 85.07 b | 88.84 b | 92.50 a | 87.17 ab |
| 0.6% | 83.19 b | 85.57 c | 89.34 b | 80.47 b |

*Averages within column of samples followed by the same letter are not significantly different according to Duncan's test.

Table (3) : Changes in the water content and dry matter in wheat leaves as affected by soil salinity

| Samples | Salinity levels | Fresh weight/ 100 cm²LA (g) | Amount of | | % of control | |
|---|---|---|---|---|---|---|
| | | | water (g) | DM (g) | Water | DM |
| 1st sample | $S_1$ | 1.497*a | 1.227 a | 0.270 | 100.0 a | 100.0 |
| | $S_2$ | 1.510 a | 1.230 a | 0.283 | 100.1 a | 106.2 |
| | $S_3$ | 1.290 b | 1.030 b | 0.263 | 84.0 b | 98.3 |
| | $S_4$ | 1.293 b | 1.020 b | 0.277 | 83.8 b | 102.2 |
| 2nd sample | $S_1$ | 1.327 | 1.017 | 0.310 | 100.0 | 100.0 |
| | $S_2$ | 1.400 | 1.083 | 0.320 | 107.1 | 103.2 |
| | $S_3$ | 1.400 | 1.070 | 0.330 | 105.9 | 106.3 |
| | $S_4$ | 1.280 | 0.983 | 0.293 | 98.3 | 94.2 |
| 3rd sample | $S_1$ | 1.497 a | 1.157 a | 0.340 | 100.0 a | 100.0 |
| | $S_2$ | 1.423 a | 1.063 ab | 0.360 | 92.3 ab | 105.5 |
| | $S_3$ | 1.403 a | 1.020 b | 0.383 | 88.5 b | 112.5 |
| | $S_4$ | 1.220 b | 0.873 c | 0.347 | 75.8 c | 101.9 |
| 4th sample | $S_1$ | 1.496 | 1.123 a | 0.373 | 100.0 | 100.0 |
| | $S_2$ | 1.493 | 1.093 a | 0.400 | 97.2 | 107.9 |
| | $S_3$ | 1.403 | 1.013 ab | 0.390 | 90.3 | 104.7 |
| | $S_4$ | 1.353 | 0.953 b | 0.400 | 85.0 | 102.8 |

* Averages within column of characters followed by the same letter are not significantly different according to Duncan's test.

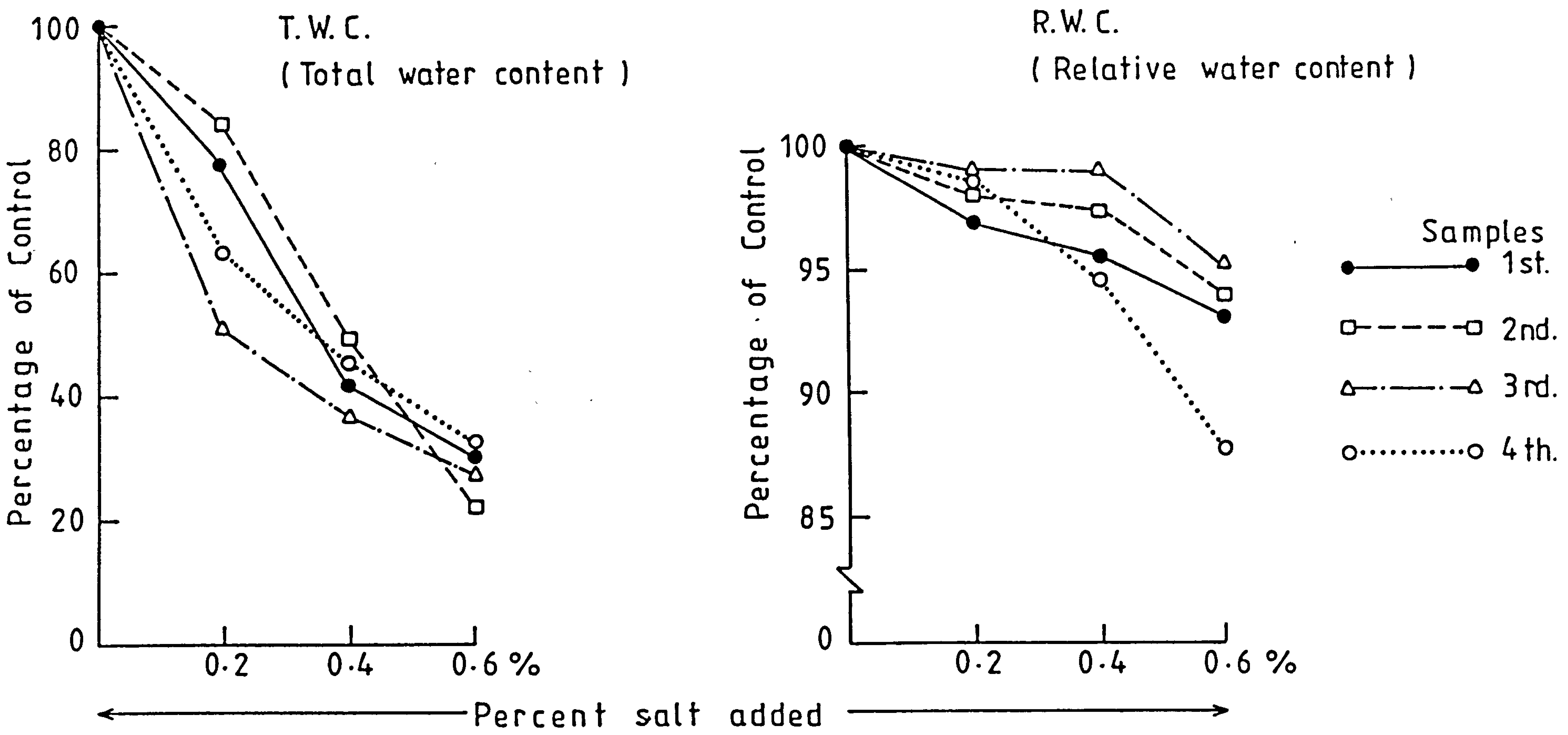



Fig. 1 Effect of different salinity levels on leaf total water content and relative water content.

with saline nutrient solution on the water content of wheat, found that water content of wheat leaves was not affected by salinity. Also, Strogonov (1964) found an increase in water content of cotton leaves with increasing soil chloride salinity.

## 2. Transpiration rate

Analysis of the results in Table 4 shows that the rate of transpiration of the plants was significantly affected by the soil salinity. This character was generally decreased with the increase in soil salinity. There was a highly significant difference between the untreated plants, and those at any of the salinity levels (Table 4 and Fig. 2). However, the percent reduction in transpiration (Fig. 2) was less in 4th sample (16% reduction) as compared with the 1st sample (38% reduction), showing a tendency towards control values with increasing time of exposure to saline conditions. Gradual osmotic adjustment of the guard cells may be responsible for this trend, the adjustment being, nevertheless, incomplete even by the time of the 4th sample. These results are in harmony with those obtained by Lunin and Gallatin, 1975; Hira and Singh, 1973; Aceves *et al.*, 1975; Tal and Gardi, 1976 and Hoffman and Jobes, 1978. However, Shalhevet and Bernstein (1968) observed that transpiration rate per unit of leaf area was constant, except at salinities approximately equivalent to the 50% yield decrement value in alfalfa (*Medicago sativa* L.).

Table (4) : Transpiration rates of wheat plants under different salinity levels

| Salinity levels | 1st sample | | 2nd sample | | 3rd sample | | 4th sample | |
|---|---|---|---|---|---|---|---|---|
| | Transpiration rate | | Transpiration rate | | Transpiration rate | | Transpiration rate | |
| | g/plant/hr | g/100cm$^2$LA/hr | g/plant/hr | g/100cm$^2$LA/hr | g/plant/hr. | g/100cm$^2$LA/hr | g/plant/hr | g/100cm$^2$LA/hr |
| 0.0% | 0.510*a | 1.107 a | 0.607 a | 1.233 | 0.700 a | 1.307 a | 1.163 a | 2.907 |
| 0.2% | 0.283 b | 0.787 b | 0.433 b | 1.127 | 0.370 b | 1.253 a | 0.697 b | 2.607 |
| 0.4% | 0.160 c | 0.683 b | 0.270 c | 1.160 | 0.253 c | 1.143 ab | 0.493 c | 2.553 |
| 0.6% | 0.113 c | 0.683 b | 0.090 d | 0.820 | 0.177 d | 0.910 b | 0.367 d | 2.430 |

*Averages within column of samples followed by the same letter are not significantly different according to Duncan's test

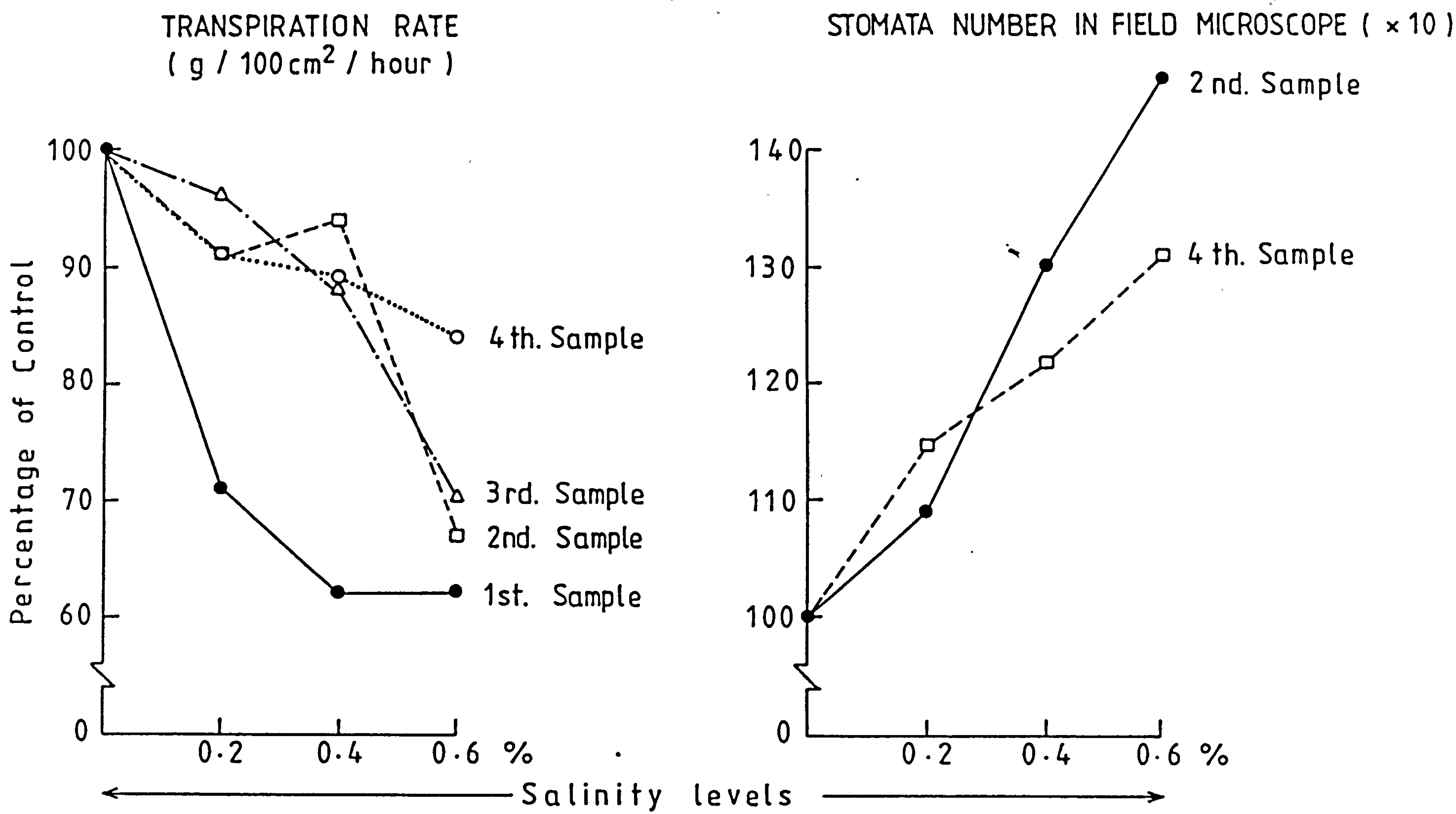



Fig. 2 Effect of different salinity levels on transpiration rate and stomata number per field microscope.

3. Stomata number in field microscope (X10)

This character was determined for two samples only. The data obtained concerning the stomata number per field microscope (X10), Table 5 and Fig (2) indicated that there were significant effectS due to salinity levels and the number of stomata per field microscope increased with increasing soil salinity. The percentage increment in stomata number was 146% as compared with control at 2nd sample, at the level of 0.6% salinity, while at 4th sample the percentage was 131% (Fig. 2). Similar findings have been reported by Strogonov (1964), Prisco and O'Leary (1973) and Gill and Dutt (1982). However, Tal and Gardi (1976) showed that the number of stomata per unit leaf area of tomato plants decreased under salinity conditions. Since numbers of stomata are expressed per field of view and since absolute numbers of stomata are probably genetically fixed any factor causing a decrease in leaf area will cause an increase in number of stomata per field of view. A field of view represents a fixed area. Therefore increasing salinity increased stomatal numbers per unit area probably through its reducing effect on leaf area. The measured number of stomata per unit leaf area with time could be partly responsible for the tendency of transpiration rates under saline conditions to increase to control values with time.

Table (5) : Averages of stomata number on upper leaf surface (3rd leaf) of wheat plants grown under different soil salinity levels.

| Salinity levels | Stomata number in field microscope (x10) | |
|---|---|---|
| | 2nd sample | 4th sample |
| 0.0% | 31.1*d | 33.5 c |
| 0.2% | 33.8 c | 38.5 b |
| 0.4% | 40.3 b | 40.7 ab |
| 0.6% | 45.5 a | 43.7 a |

* Averages within column of samples followed by the same letter are not significantly different according to Duncan's test

# CHAPTER IV C

# EFFECT OF POLYETHYLENE GLYCOL SOLUTIONS (PEG 1000 M.W.) AT VARIOUS OSMOTIC POTENTIAL (CONCENTRATIONS) ON GERMINATION AND GROWTH OF WHEAT PLANTS (*Triticum aestivum* L.)

## Introduction

Deleterious effects of saline soils in general are attributed to two main factors (a) decrease in the osmotic potential of the medium leading to decreased uptake of water and, (b) direct and/or indirect ion toxicity effects (Strogonov, 1964). Similarly Nieman and Paulson (1964) emphasize salinity effects on plant as being two fold i.e. it may either promote or aggravate water stress and in addition it affects cellular activity directly. However, Younis and Hatata (1971) emphasized the toxic effect of salt and Kuhad and Garg (1984) showed that the ionic effect operates in addition to osmotic one during early growth stage in wheat.

The measurements in experiment A. chapter IV indicated that turgor potential was maintained at a more or less steady value by adjustment of osmotic potential over the soil salinity range 0.2 - 0.6%. This and other results suggest that the inverse relationship between growth and salinity is due to more toxic effects than to drought induced by salinity. Therefore the present study was undertaken to attempt to separate the osmotic and specific ion effects on germination and growth of wheat.

## Materials and Methods

The seeds of three wheat varieties (*Triticum aestivum* L.) namely Falchetto, Shakha 62 and Shakha 61 were growthroom grown in pots (7.62 cm diam) containing vermiculite irrigated with PEG (1000 M.W.) solutions having osmotic potentials of -0.159, -0.318, -0.476, -0.635 and -0.795 MPa prepared according to the following formula.

$$\psi_{\pi} = -\frac{m}{v}\,iRT,\ \text{where:}$$

$\psi_{\pi}$ = osmotic potential (kPa)  m = no. of moles of solute in V liters ($m^3 \times 10^{-3}$) of water

i = a constant that accounts for ionization of the solute and or other deviations from perfect solutions.

R = gas constant 8.3144 $J°K^{-1}mol^{-1}$

T = absolute temperature (°K).

Irrigation with distilled water served as control. Ten seeds per pot were sown on October 19th and harvested on November 9th, 1984. The experimental design for this experiment was a randomized complete block with three replicates. Each replicate consisted of 18 treatments. At the end of the experiment period the following data were recorded:

1. Germination percentage
2. Leaf number per 10 plants
3. Shoot length (cm).
4. Tiller number per 10 plants
5. Fresh weight (g) per 10 plants
6. Shoot dry matter (g) per 10 plant
7. Root dry matter (g) per 10 plant
8. Whole plant dry matter (g) per 10 plant
9. Shoot/root ratio

## Results and Discussion

### 1. Germination percentage

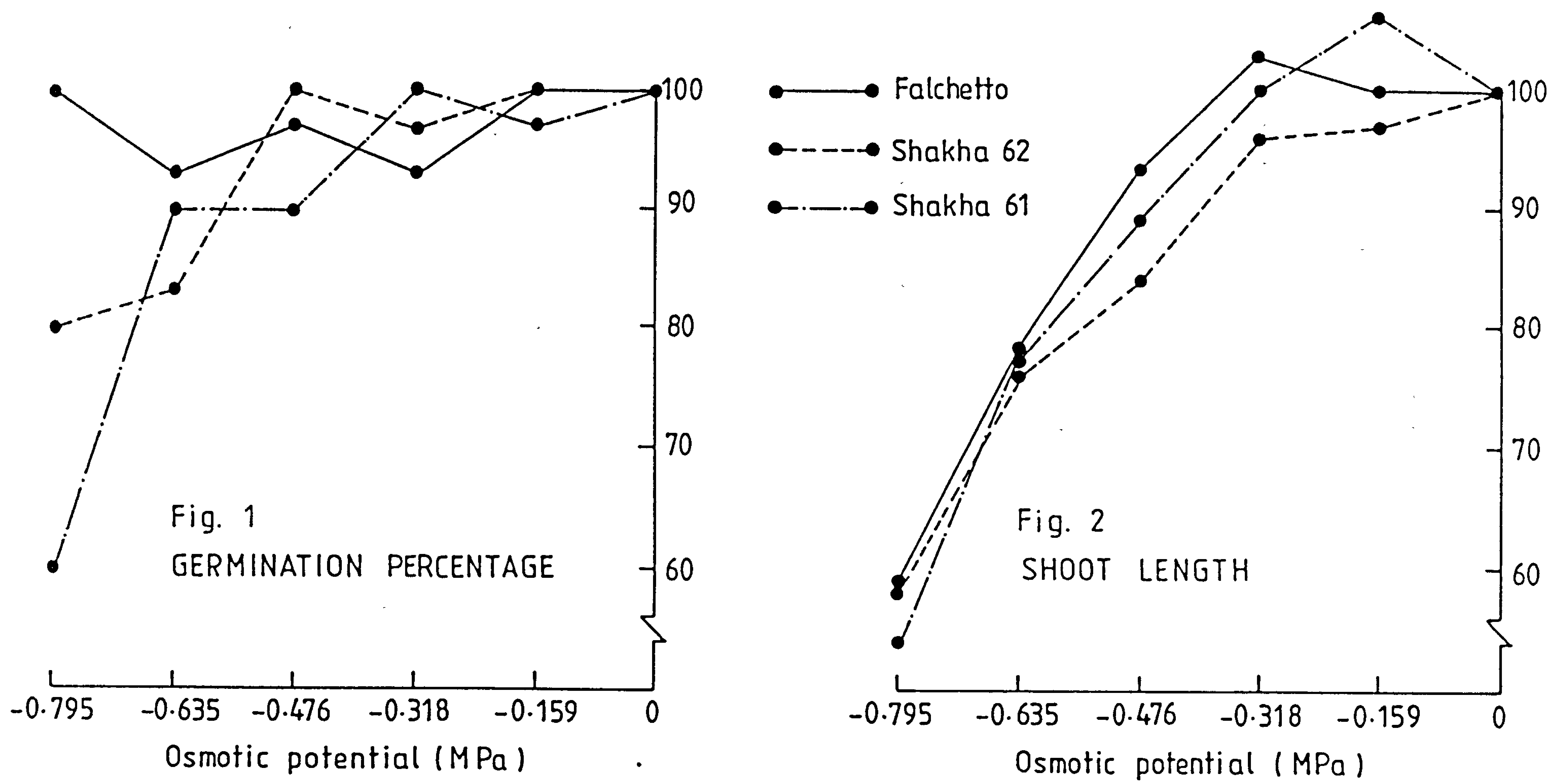
The data presented in Table (1) show significant differences in germination percentage between wheat varieties. Apparently, Falchetto had the highest germination percentage and Shakha 61 had the lowest. However, there were no significant differences between Falchetto and Shakha 62 or between Shakha 62 and Shakha 61.

This character was affected significantly by stress levels as evidenced by highly significant mean squares obtained. Generally increasing level of stress resulted in the progressive decrease and delay in germination percentage over control (Table 1 and Fig 1). However, there were only significant differences between the last stress level and all other treatments, also between level of -0.635 MPa and check treatment. Highly significant interaction was obtained between levels of PEG and varieties. Similar results have

Table (1) : Effect of different levels of PEG (1000 Mol. wt.) solution on germination percentage, shoot length and tiller numbers of three wheat varieties (Triticum aestivum L.)

| Characters | Germination percentage % | | | | Shoot length (cm) | | | | Tiller number per 10 plants | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Varieties / Osmotic Potential | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean |
| 0.0 | 100.0 a | 100.0 a | 100.0 a | 100.0*a | 32.6 | 31.5 | 28.6 | 30.9*a | 1.67 a | 0.67 b | 0.67 b | 1.0*a |
| -0.159 MPa | 100.0 a | 100.0 a | 96.7 a | 98.9 ab | 32.7 | 30.6 | 30.6 | 31.3 a | 2.00 a | 0.00 b | 0.33 b | 0.78a |
| -0.318 MPa | 93.3 abc | 96.7 ab | 100.0 a | 96.7 ab | 33.6 | 30.2 | 28.7 | 30.8 a | 0.33 b | 0.00 b | 0.00 b | 0.11b |
| -0.476 MPa | 96.7 ab | 100.0 a | 90.0 abc | 95.6 ab | 30.4 | 26.5 | 25.7 | 27.5 b | 0.33 b | 0.00 b | 0.00 b | 0.11b |
| -0.635 MPa | 93.3 abc | 83.3 bc | 90.0 abc | 88.9 b | 25.4 | 23.9 | 22.1 | 23.8 c | 0.00 b | 0.00 b | 0.00 b | 0.00b |
| -0.795 MPa | 100.0 a | 80.0 c | 60.0 d | 80.0 c | 19.3 | 18.2 | 15.4 | 17.6 d | 0.00 b | 0.00 b | 0.00 b | 0.00b |
| Mean | 97.2 a | 93.3 ab | 89.4 b | | 29.0 a | 26.8 b | 25.2 c | | 0.72 a | 0.11 b | 0.17 b | |

*Averages within column of varieties or PEG levels followed by the same letter are not significantly different according to Duncan's test.




Effect of polyethylene glycol solutions at various osmotic potential on germination and shoot length.

been reported by Wiggans and Gardner (1959), McGinnies (1960), Parwar and Moore (1966), Tadmor et al., (1969), Singh and Singh (1983) and Kuhad and Garg (1984). However, Chen et al., (1982) found that there was no effect on germination of wheat seeds (maintained in mannitol solution at various levels of water potential) of water potential $< -1.5$ MPa.

2. Leaf number, shoot length, tiller number and fresh weight

In general leaf number, tiller number, shoot length and fresh weight decreased with decreasing osmotic potential of PEG solution Figs. (2-5) and Tables (1 and 2). Falchetto cultivar was significantly higher in all these characters as compared with the other two cultivars, while Shakha 61 had the lowest values for all these characters. However, Shakha 62 and Shakha 61 were not significantly different from each other in tiller number and leaf number. Also, it could be observed from Fig. 4 that all the cultivars exhibited about 80% reduction in fresh weight at the level of -0.795 MPa as compared with control. The reduction in fresh weight can also explain that the water absorbed by seedlings as reflected by their fresh weights (Table 2 and Fig. 4) was decreased by decreasing the osmotic potential of PEG. High and highly significant interaction were obtained between varieties and PEG levels for tillers number and fresh weight, Tables (1 and 2). These results are in conformity with those obtained by Parmar and Moor (1966), Chen et al. (1982), Singh and Singh (1982, 1983) and Kuhad and Garg (1984).

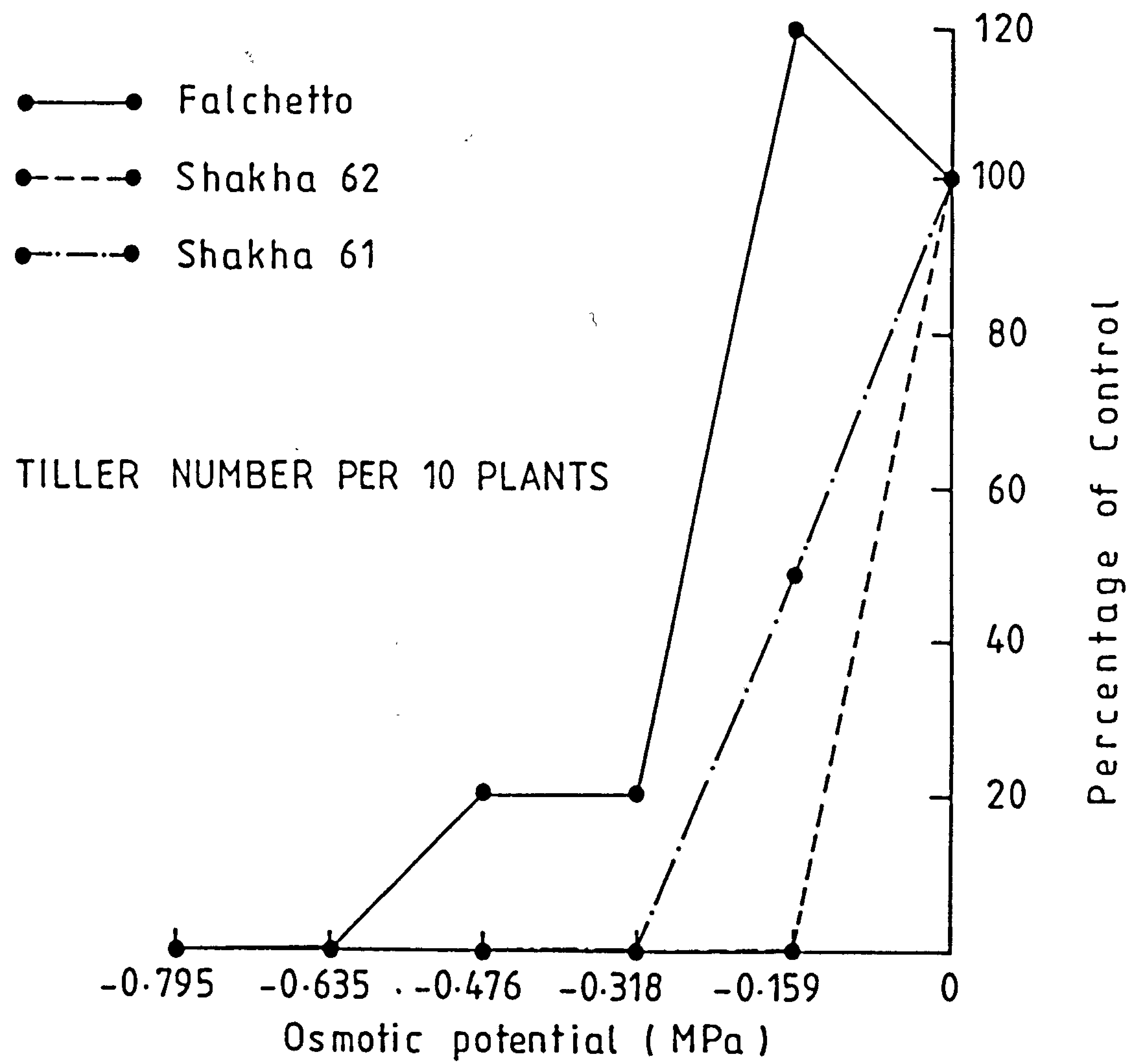
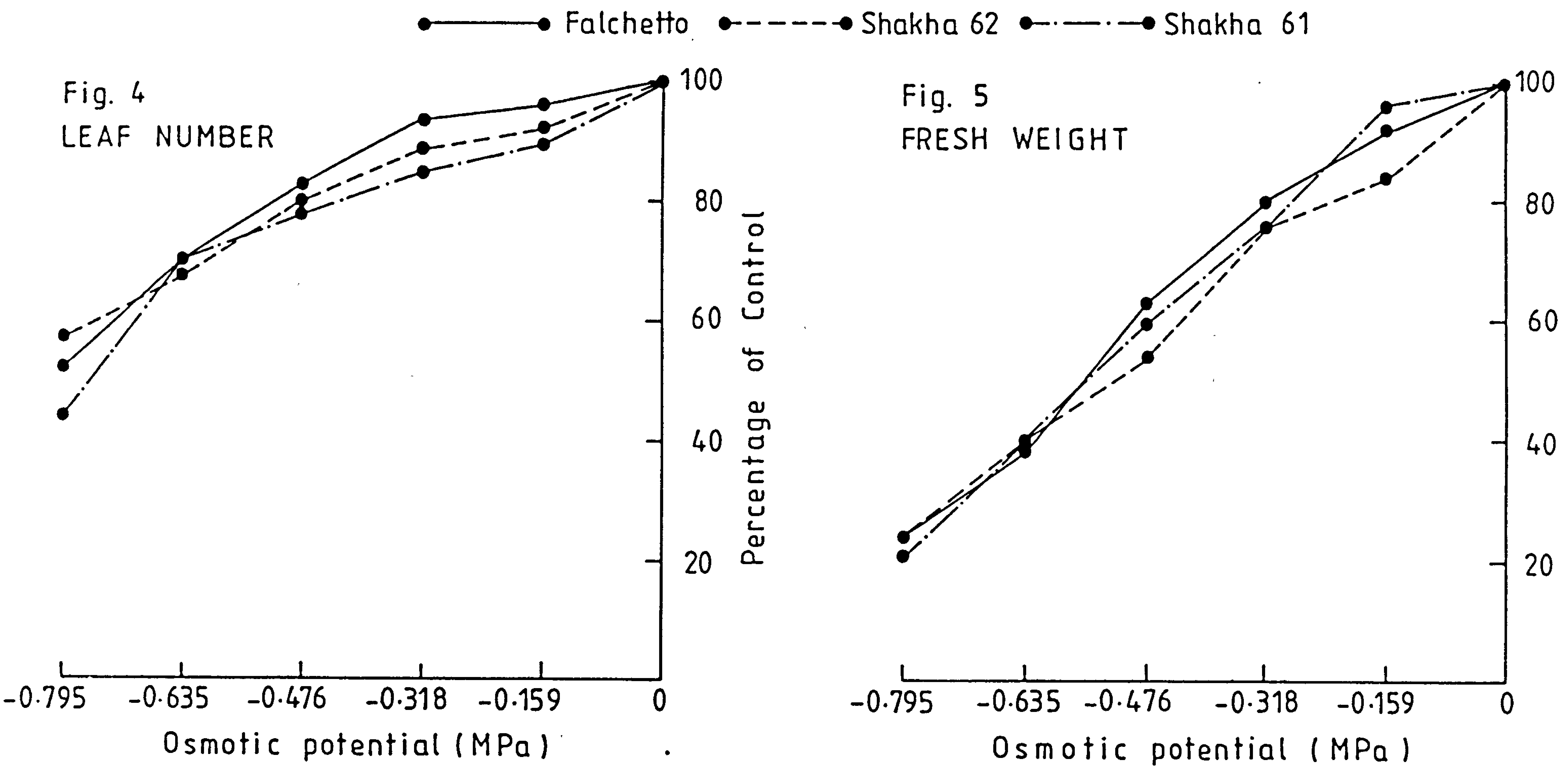



Fig. 3 Effect of polyethylene glycol solutions at various osmotic potential on tiller number.




Effect of polyethylene glycol solutions at various osmotic potential on leaf number and fresh weight.

Table (2) : Effect of different levels of PEG (1000 M.W) solution on leaf number, fresh weight, shoot dry matter per 10 plants of three wheat varieties (*Triticum aestivum* L.)

| Characters | Leaf number | | | | Fresh weight (g) | | | | Shoot dry matter (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Varieties / Osmotic Potential | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean |
| 0.0 MPa | 31.0 | 24.7 | 24.3 | 26.7*a | 8.383 a | 7.193 bc | 6.400 d | 7.326 a | 0.828 | 0.783 | 0.726 | 0.782 a |
| -0.159 MPa | 29.7 | 22.7 | 22.0 | 24.8 ab | 7.703 b | 6.003 de | 6.230 d | 6.646 b | 0.826 | 0.701 | 0.733 | 0.754 ab |
| -0.318 MPa | 29.3 | 22.0 | 20.7 | 24.0 b | 6.680 cd | 5.530 ef | 4.953 f | 5.721 c | 0.808 | 0.696 | 0.623 | 0.709 b |
| -0.476 MPa | 25.7 | 19.7 | 19.3 | 21.6 c | 5.277 f | 3.910 g | 3.863 g | 4.350 d | 0.692 | 0.531 | 0.539 | 0.587 c |
| -0.635 MPa | 21.7 | 17.0 | 17.0 | 18.6 d | 3.207 h | 2.860 h | 2.580 hi | 2.882 e | 0.488 | 0.427 | 0.387 | 0.434 d |
| -0.795 MPa | 16.0 | 14.0 | 10.7 | 13.6 e | 2.020 ij | 1.723 jk | 1.343 k | 1.696 f | 0.354 | 0.278 | 0.231 | 0.288 e |
| Mean | 25.6 a | 20.0 b | 19.0 b | | 5.545 a | 4.537 b | 4.228 c | | 0.666 a | 0.571b | 0.540b | |

*Averages within colum of varieties or PEG levels followed by the same letter are not significantly different according to Duncan's test.

3. Shoot, root and whole plant dry weight and shoot/root ratio

It is apparent that the cultivars varied significantly in their dry matter weights as evidenced by the data obtained in this experiment (Tables 2 and 3). The cultivar Falchetto produced the highest dry matter weight for all parts of the plant with significant differences over the other two cultivars. However, Shakha 62 and Shakha 61 cultivars were not significantly different from each other in all these characters, except shoot/root ratio. Shakha 62 had the higher value with significant difference as compared with Shakha 61.

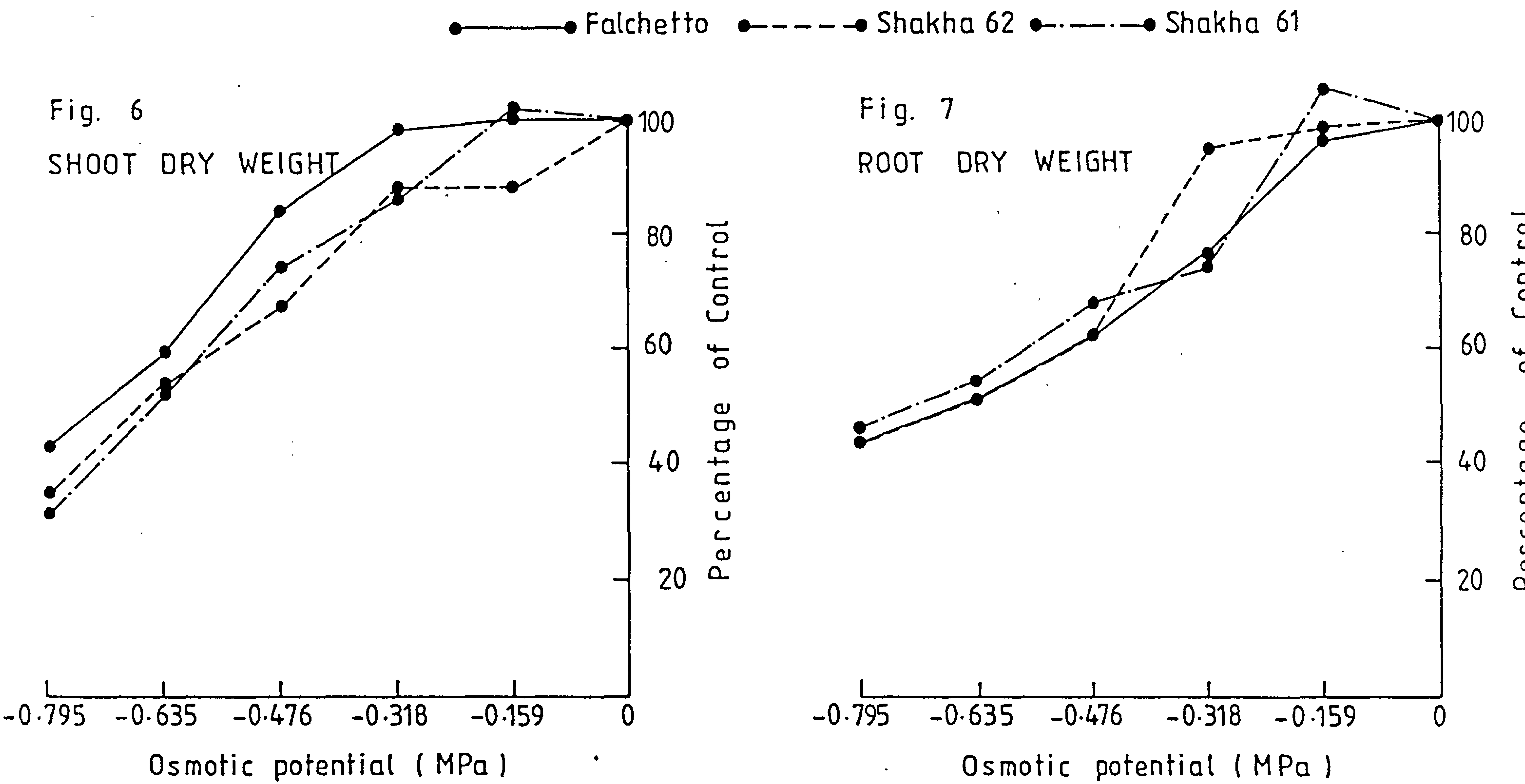
These characters were affected significantly by the levels of osmotic potential produced by PEG solution and generally decreasing osmotic potential decreased the dry matter production of all parts of the plant, except for shoot/root ratio where there was no reduction down -0.635 MPa (Figs. 6, 7 and 8). Shakha 62 and Shakha 61 exhibited about 65% reduction in whole plant dry matter at the lowest osmotic potential (-0.795 MPa), while Falchetto showed the lesser reduction of 57% as compared with control (Fig. 7). Significant interaction was obtained between cultivars and osmotic potentials for shoot/root ratio. Similar results were obtained by Chen *et al.* (1982), Singh and Singh (1982 and 1983) and Kuhad and Garg (1984).

In order to try to distinguish between the osmotic effect and any other effects (e.g. ion toxicity) on plant performance, dry weights and osmotic potential of the PEG (Chap. IV) and of the electrical conductivity of soil saturation extract (Chap. II) were correlated (Figs. 9 and 10). Although correlation coefficients were similar for the two relationships the slopes were highly significantly

Table (3) : Effect of different levels of PEG (1000 Mol. wt.) solution on root dry matter, whole plant dry matter per 10 plants and shoot/root ratio of three wheat varieties (*Triticum aestivum* L.)

| Characters | Roots dry matter (g) | | | | Whole plant dry weight (g) | | | | Shoot/root ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Varieties / Osmotic potential | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean | Falchetto | Shakha 62 | Shakha 61 | Mean |
| 0.0 MPa | 0.301 | 0.257 | 0.261 | 0.273*a | 1.129 | 1.050 | 0.987 | 1.055 a | 2.8 cde | 3.11 cde | 2.8 cde | 2.9 cd |
| -0.159 MPa | 0.280 | 0.253 | 0.275 | 0.272 a | 1.116 | 0.954 | 1.009 | 1.026 a | 2.9 cde | 2.8 de | 2.7 de | 2.8 d |
| -0.318 MPa | 0.230 | 0.243 | 0.195 | 0.223 b | 1.038 | 0.939 | 0.818 | 0.932 b | 3.5 ab | 2.9 cd | 3.2 bc | 3.2 ab |
| -0.476 MPa | 0.185 | 0.160 | 0.175 | 0.173 c | 0.877 | 0.690 | 0.713 | 0.760 c | 3.7 a | 3.3 ab | 3.1 bcd | 3.4 a |
| -0.635 MPa | 0.152 | 0.132 | 0.140 | 0.141 d | 0.640 | 0.559 | 0.527 | 0.575 d | 3.2 bc | 3.2 bc | 2.8 cde | 3.1bc |
| -0.795 MPa | 0.127 | 0.112 | 0.117 | 0.119 d | 0.482 | 0.390 | 0.348 | 0.406 e | 2.8 cde | 2.5 ce | 1.9 f | (2.4) s.4 e |
| Mean | 0.214 a | 0.193 b | 1.94 b | | 0.880 a | 0.764 b | 0.734 b | | 3.2 a | 3.0 b | 2.7 c | |

*Averages within column of varieites or PEG levels followed by the same letter are not significantly different according to Duncan's test.




Effect of polyethylene glycol solutions at various osmotic potential on shoot and root dry weight.

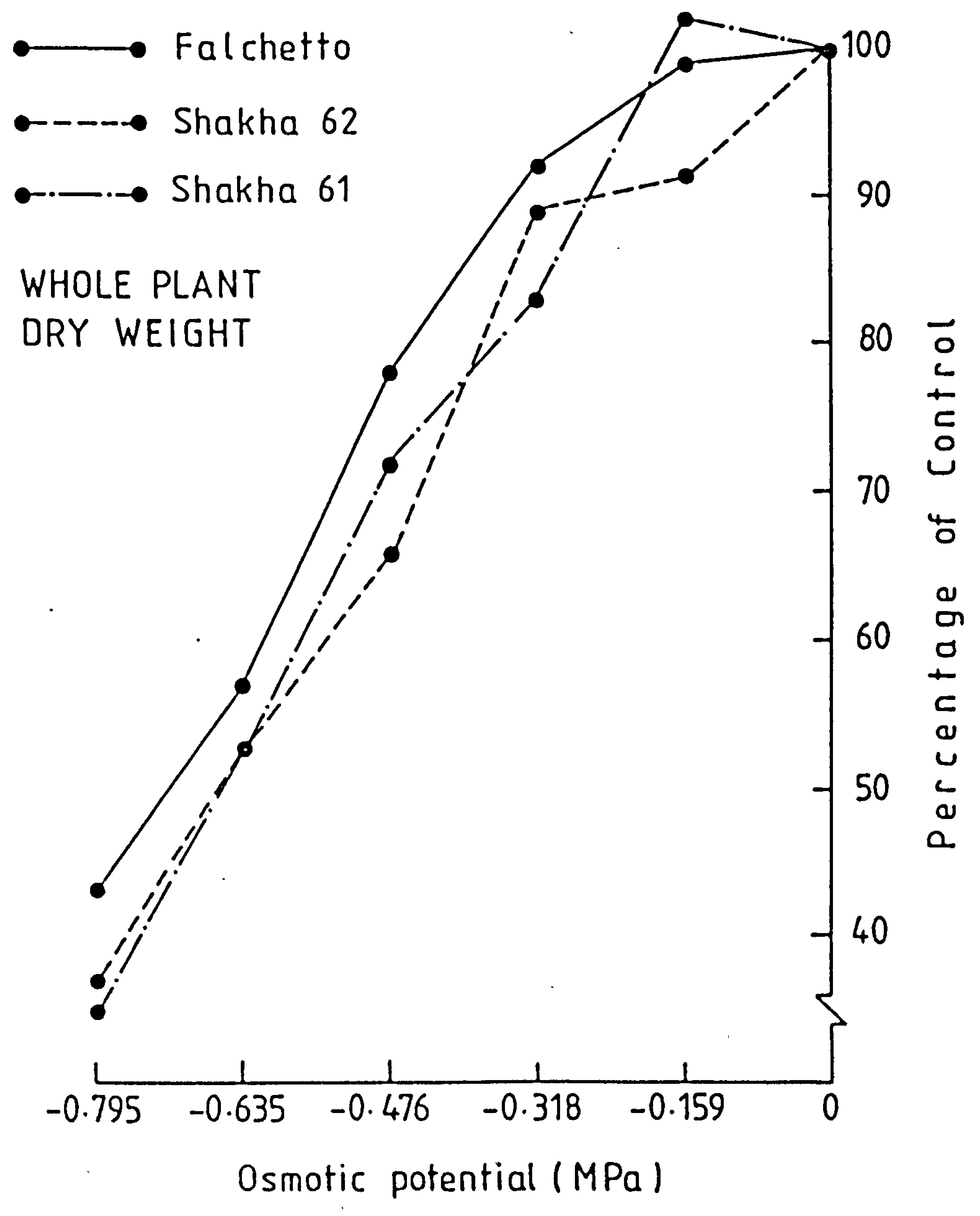



Fig. 8 Effect of polyethylene glycol solutions at various osmotic potential on whole plant dry weight.

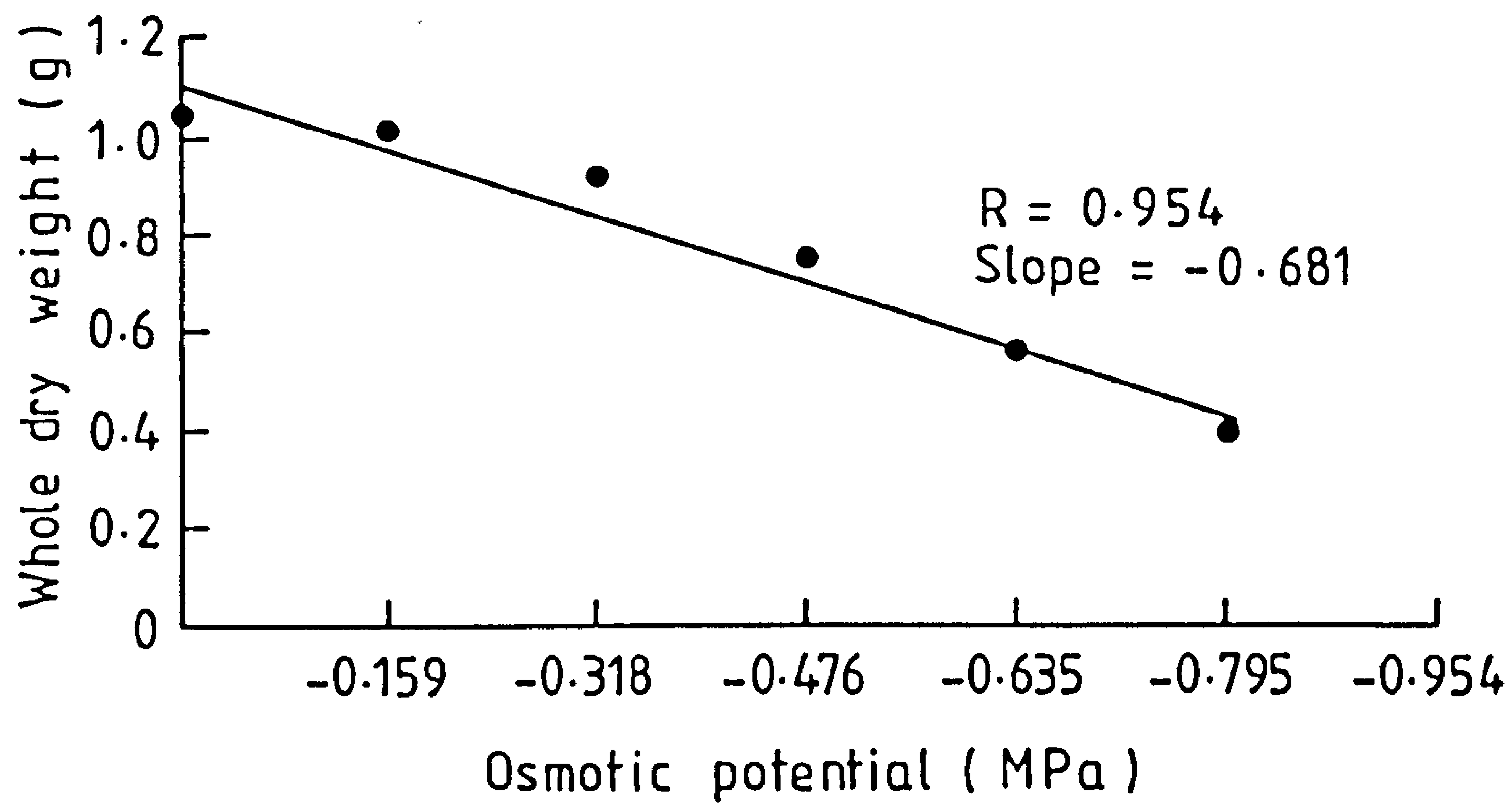



Fig. 9 Effect of PEG solution at various osmotic potential on whole dry weight.

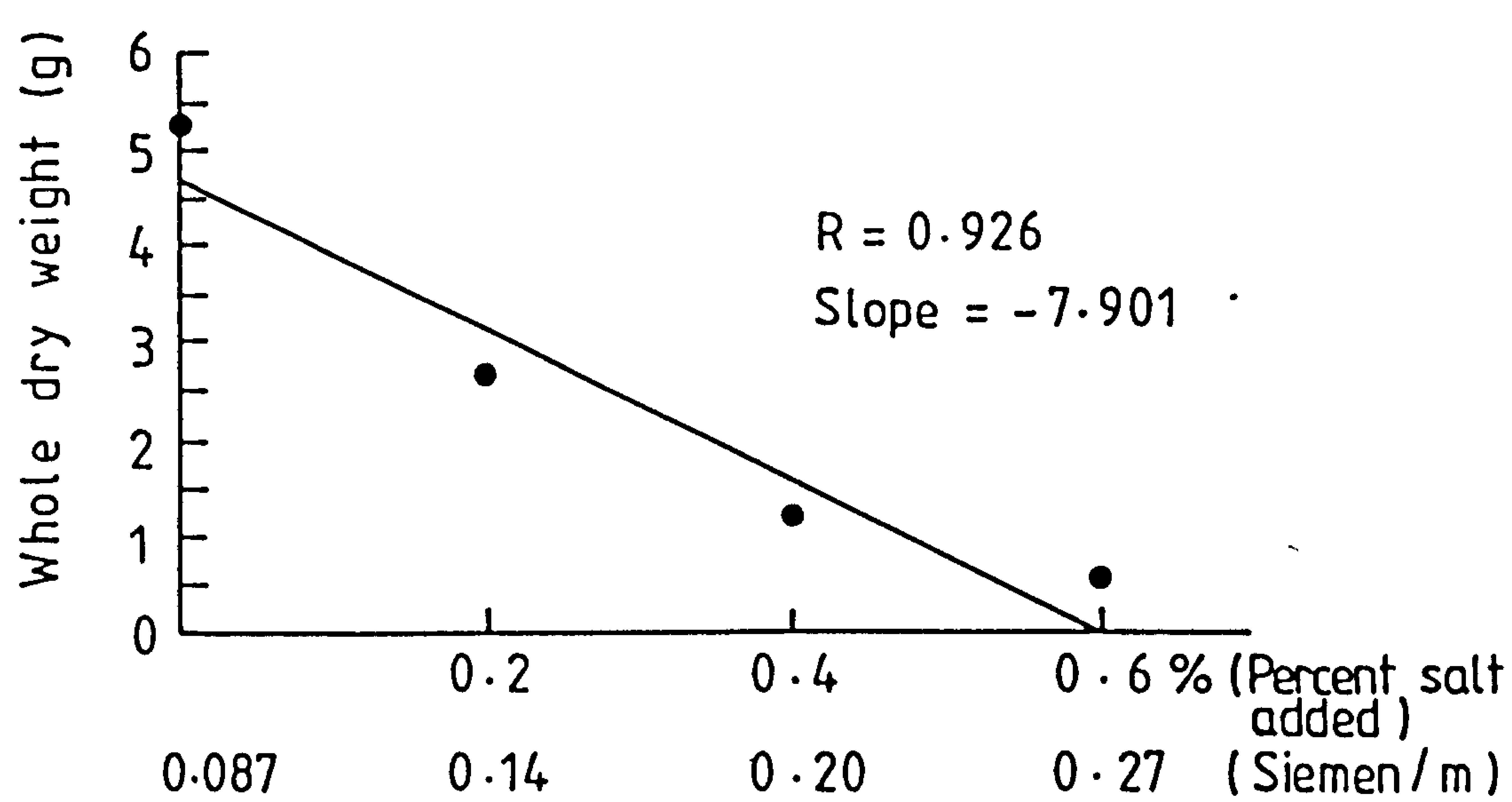



Fig. 10 Effect of soil salinity at different levels on whole dry weight.

different ($P \leq 0.01$). The slope for the salinised soil experiment (Fig. 10) was steeper ($b = -7.901$) than that for the PEG experiment ($b = -0.681$), indicating that in salinised soil some factor or factors in addition to the osmotic effect was exerting an effect. Generally, it is evident from the present study with PEG and from the previous results with soil salinity that the ionic effect did operate in addition to the osmotic one during growth stages in wheat plants.

Summary

IV.A The water potential and osmotic potential of wheat leaves (cv. Shakha 8) decreased with increasing soil salinity from 0 to 0.6% (based on soil dry weight). Turgor potential fell between 0 and 0.2%, but remained essentially unchanged with increasing salinity levels from 0.2 to 0.6% indicating marked osmotic adjustment.

IV.B Wheat plants (cv. Shakha 61) were grown under different salinity levels (0.0 to 0.6%). Growth was supressed by increasing salinity and total water content (T.W.C), relative water content (R.W.C), transpiration rate/100 $cm^2$ leaf area decreased and stomatal number per unit area increased with increasing salinity levels.

IV.C Seed germination of three wheat cultivars (Falchetto, Shakha 62, and Shakha 61) was reduced under osmotic stress produced by PEG-1000 (polyethylene glycol). Fresh and dry weight, leaf number, shoot length and shoot/root ratio were also adversely affected by increasing osmotic potentials. Falchetto had the highest values for all these characters with significant difference as compared with the other two cultivars and Shakha 62 and Shakha 61 did not significantly differ from each other in all these characters except in shoot length, fresh weight and shoot/root ratio in which Shakha 62 was the higher.

# CHAPTER V

## A. INFLUENCE OF TEMPERATURE AND SALINITY ON GERMINATION AND GROWTH OF SOME WHEAT VARIETIES (*Triticum aestivum* L.)

### Introduction

Salinity and temperature stresses are primary limiting environmental conditions which restrict successful wheat (*Triticum aestivum* L.) establishment in irrigated arid and semi-arid regions. Wheat is most susceptible to salt damage in the early stages of development. Germination may be adversely affected both by decreasing rate and total amount of water absorbed, and by increasing the entry of certain ions into the seed which are toxic in high concentration. Also, vegetative growth decreases as salinity increases (Bernstein and Hayward, 1958).

Many workers have reported that salinity depresses germination percentage and growth of a wide range of crop plants, and this depression appears to increase with increasing temperature (Ahi and Powers, 1938; Sharma, 1976 and Stone *et al*., 1979). High temperatures alone have been found to depress germination percentage and growth but increase the rate of germination, (the opposite of these effects occurred at low temperatures) (Uhvits, 1946; Tadmor *et al*., 1969 and Rizk *et al*., 1981).

At higher temperatures, salinity has been reported to be increasingly detrimental to alfalfa germination (Ahi and Powers, 1938; Uhvits, 1946 and Ungar, 1967). However, comparatively little is known about the interaction of temperature and salinity on germination and early growth of the wheat crop, and no work has been reported on the cultivars tested in this experiment. The objective of this study was to investigate the interactive effects of temperature and sodium chloride salinity at different levels on germination percentage and early growth of three wheat cultivars.

## Materials and Methods

Seeds of three wheat cultivars (*Triticum aestivum* L.) namely Falchetto (Italian spring variety), Shakha 62 and Shakha 61 (medium tall local varieties in Egypt) were grown in a Fison's 600 H controlled environment chamber in pots with four replications, three salinity levels (0,5000 and 10,000 ppm Nacl or 0, 0.66 and 1.34 siemen/m), and three constant day and night temperatures (10°C, 20°C and 30°C). Day length was 12 hours, RH was 88% ± 1 and irradiance 180 μmol $m^{-2}$ $s^{-1}$ (P.A.R.). Ten seeds per pot were sown and each replicate consisted of 27 treatments. At the end of the experimental period (2 weeks), the following characters were studied:

1. Germination capacity of seeds (G.Cap)

$$G.Cap = \frac{\text{Maximum emergent seedlings}}{\text{Total number of seeds}} \times 100$$

2. Shoot length (cm)
3. Root length (cm)
4. Root number/seedling
5. Fresh weight (g)

6. Shoot dry weight (g)
7. Root dry weight (g)
8. Whole seedling dry weight (g)
9. Shoot/root ratio

## Results and Discussion

### 1. Germination capacity of seeds

It is apparent that there were no significant differences between cultivars in germination capacity as evidenced by the data obtained in (Table 1 and Figs. 1 and 2). Germination capacity was significantly affected both by salinity levels and temperatures (Table 1 and Figs. 1 and 2). The available data demonstrate clearly that there was no significant reduction in germination capacity up to 5000 ppm and that the highest salt concentration (10000 ppm Nacl) depressed the germination capacity by 9.1% of control (Table 1).

Results in Table 1 also indicate that increasing temperature of the germination medium increased germination capacity significantly up to 20°C followed by a significant decrease between 20 and 30°C. A highly significant interaction between salinity levels and temperatures on germination capacity was obtained as shown in Table 2 and Fig. 3. This interaction indicates that increasing germination temperature from 10 to 20°C did not affect germination capacity up to 5000 ppm salinity. But under the highest level of salinity (10000 ppm Nacl) increasing temperature up to 20°C increased germination capacity, but increase to 30°C significantly reduced it. Although

Table (1) : Effect of temperatures and salinity levels on germination and early growth of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Cultivars | | | Salinity levels | | | Temperatures | | |
|---|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | $S_1$** | $S_2$ | $S_3$ | 10°C | 20°C | 30°C |
| Germination capacity | 96.7 | 95.6 | 94.7 | 98.3 *a | 99.2 a | 89.4 b | 95.6 b | 98.9 a | 92.5 c |
| Shoot length (cm) | 21.3 a | 16.5 b | 15.7 c | 20.6 a | 18.5 b | 14.4 c | 11.3 b | 21.1 a | 21.0 a |
| Root length (cm) | 25.6 a | 22.3 b | 17.6 c | 28.2 a | 23.0 b | 14.3 c | 12.8 c | 28.0 a | 24.8 b |
| Root number per seedling | 4.96 a | 4.78 b | 4.74 b | 4.98 a | 4.91 a | 4.59 b | 4.91 | 4.82 | 4.76 |
| Fresh weight (g) | 0.874 a | 0.615 b | 0.589 b | 0.840 a | 0.727 b | 0.510 c | 0.443 c | 0.850 a | 0.784 b |
| Shoot dry wt. (g) | 0.111 a | 0.081 b | 0.092ab | 0.121 a | 0.093 b | 0.071 b | 0.066 b | 0.109 a | 0.110 a |
| Root dry wt. (g) | 0.048 a | 0.050 a | 0.044 b | 0.060 a | 0.048 b | 0.035 c | 0.033 c | 0.060 a | 0.049 b |
| Whole seedling dry weight (g) | 0.159 a | 0.131 b | 0.124 b | 0.168 a | 0.140 b | 0.106 c | 0.085 c | 0.169 a | 0.159 b |
| Shoot/root ratio | 2.34 a | 1.68 b | 1.79 b | 1.79 c | 1.95 b | 2.07 a | 1.66 c | 1.85 b | 2.30 a |

*Averages within rows of cultivars or salinity levels or temperatures of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

Table (2) : Interaction effect of salinity levels and temperatures on germination capacity, shoot and root length and fresh weight of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Temperatures | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10°C | | | | 20°C | | | | 30°C | | | |
| | | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined |
| Germination capacity (%) | $S_1$** | 100.00 | 100.00 | 97.50 | 99.17* a | 100.00 | 100.00 | 97.50 | 99.17 a | 97.50 | 100.00 | 92.5 | 96.67 a |
| | $S_2$ | 100.00 | 100.00 | 97.50 | 99.17 a | 100.00 | 100.00 | 100.00 | 100.00 a | 97.50 | 100.00 | 97.50 | 98.33 a |
| | $S_3$ | 95.00 | 82.50 | 87.50 | 88.33 b | 97.00 | 97.50 | 97.50 | 97.50 a | 82.5 | 80.00 | 85.00 | 82.50 c |
| Shoot length (cm) | $S_1$ | 15.20 | 13.63 | 12.28 | 13.70 | 29.35 | 21.05 | 22.08 | 24.16 | 29.08 | 21.98 | 20.85 | 23.97 |
| | $S_2$ | 12.93 | 11.48 | 10.98 | 11.79 | 27.08 | 19.68 | 18.80 | 21.85 | 26.75 | 20.68 | 18.08 | 21.83 |
| | $S_3$ | 9.23 | 8.80 | 7.45 | 8.49 | 20.63 | 15.70 | 15.90 | 17.41 | 21.48 | 15.35 | 14.83 | 17.22 |
| Root length (cm) | $S_1$ | 19.80 | 15.95 | 14.15 | 16.63 d | 42.83 | 37.70 | 28.18 | 36.23 a | 31.00 | 35.65 | 28.73 | 31.79 b |
| | $S_2$ | 17.03 | 12.70 | 11.25 | 13.66 e | 35.20 | 31.08 | 23.45 | 29.91 b | 28.70 | 27.85 | 20.10 | 25.55 c |
| | $S_3$ | 11.60 | 6.38 | 6.20 | 8.06 f | 22.33 | 17.38 | 13.70 | 17.80 d | 21.98 | 15.93 | 12.98 | 16.96 d |
| Fresh weight (g) | $S_1$ | 0.740 | 0.500 | 0.443 | 0.561 d | 1.212 | 0.909 | 0.990 | 1.037 a | 1.146 | 0.815 | 0.805 | 0.922 b |
| | $S_2$ | 0.635 | 0.358 | 0.392 | 0.462 e | 1.174 | 0.817 | 0.702 | 0.898 b | 1.053 | 0.744 | 0.666 | 0.821 c |
| | $S_3$ | 0.403 | 0.269 | 0.247 | 0.306 f | 0.760 | 0.544 | 0.545 | 0.616 d | 0.739 | 0.576 | 0.508 | 0.608 d |

*Averages within rows or columns of salinity levels or temperatures of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)


Fig. 1 Influence of Nacl salinity on germination, shoot and root length, fresh weight, and shoot and root dry weight.


Fig. 2 Influence of temperatures on germination, shoot and root length, fresh weight, and shoot and root dry weight.

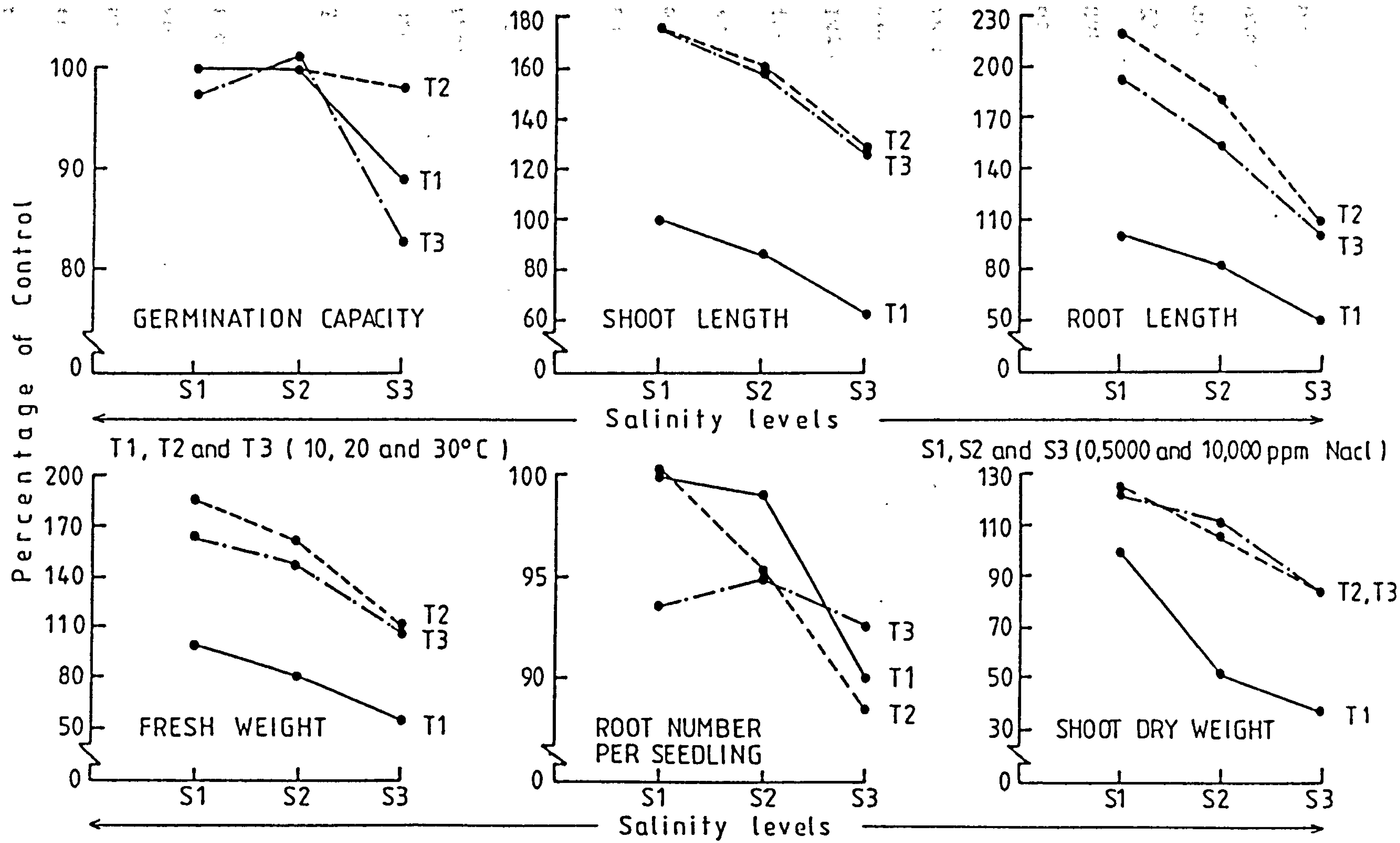



Fig. 3 Interaction effect of salinity levels and temperatures on germination capacity, shoot and root length, fresh weight, root number per seedling and shoot dry weight.

no significant differences between cultivars were obtained, Falchetto had the highest germination percentage at the lowest temperature (10°C) and highest salinity level, but the trend was not enough to reach the 5% significant level (Table 2). It is also noteworthy that Falchetto's germination percentage remained at or above 95% at all combinations of temperature and salinity except 30°C and 10,000 ppm and that at 30°C, root length of Falchetto appears to be less sensitive to increased salinity than the same character in Shakha 62 and Shakha 61. Similar results have been reported by Ahi and Powers, 1938; Uhvits, 1946; Stone et al., 1979 and Rizk et al., 1981. Also, highly significant interactions between salinity and temperatures were reported in lettuce, sugar beet and wheat and these interactions were such that salinity had a little effect on germination at low temperature, but that effect of salinity was increasingly inhibitory as temperature increased (Odegbaro and Simith, 1969; Francois and Goadin, 1972 and El-Sharkawi and Springuel, 1979). However, Rizk et al. (1981) showed that germination percentage in alfalfa was not affected by temperature under $Cacl_2$ salinity conditions.

2. Shoot and root length, root number and fresh weight

The data concerning shoot and root length, root number and fresh weight, Figs. 1, 2, 4 and 5 and Table 1 indicated that there were highly significant effects due to salinity levels and temperatures except root number for temperatures effect. All these characters reduced significantly with increasing salinity and increased, except root number, with increasing temperature up to 20°C and then fell significantly between 20 and 30°C, with the exception of shoot length


Fig. 4 Influence of temperatures on whole seedling dry weight, shoot / root ratio, and number of roots.

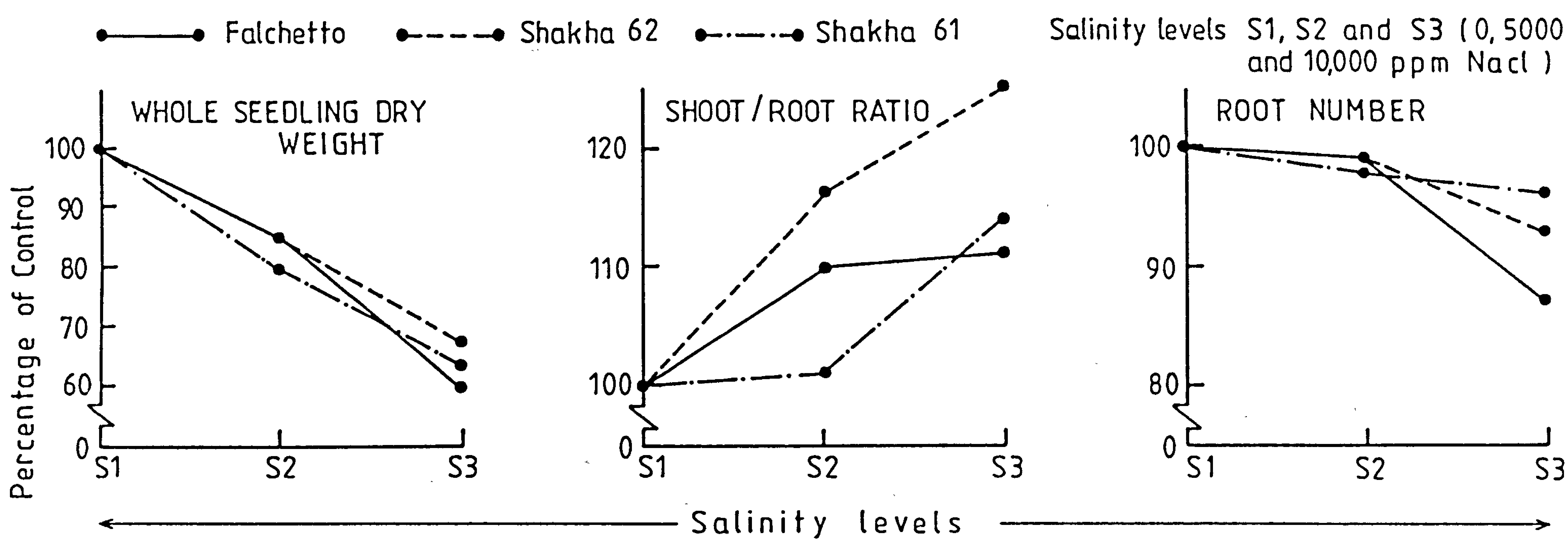



Fig. 5 Influence of Nacl salinity on whole seedling dry weight, shoot / root ratio and root number.

in which there was no significant difference between 20 and 30°C. The semi-dwarf cultivar Falchetto had significantly highest values for all these characters and Shakha 61 had the lowest. For root number and fresh weight however there was no significant difference between Shakha 62 and 61 (Table 1).

The interaction between salinity levels and temperatures was significant for root length, root number and fresh weight only and the data demonstrate that the highest values of root length, root numbers, and fresh weight were obtained at 20°C and zero salinity (control) and the lowest values were obtained at 10°C for root length and fresh wt. and at 20°C for root number under the highest level of salinity (10,000 ppm Nacl) (Tables 2 and 3 and Fig. 3). It could be observed from the interaction between salinity and temperature (Table 2) that Falchetto had the highest averages for all these characters at all temperatures under all salinity levels and this demonstrates the superiority of Falchetto as compared with the other two cultivars at early growth stages. Similar findings, have been reported by Ahi and Powers, 1938; Bernstein and Ayers, 1951, 1953 and El-Sharkawi and Springuel, 1979. Also, Rizk et al. (1981) observed that increasing temperature from 10 to 20°C increased seedling length under salinity conditions of two medic species (Medicago spp.). However, Lunt et al., (1960b) found that there was no significant interaction between salinity and temperature on the growth of some horticultural plants.

Table (3) : Interaction effect of salinity levels and temperatures on root number and shoot, root and whole plant dry weight of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Temperatures | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10°C | | | | 20°C | | | | 30°C | | | |
| | | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined |
| Root number per seedling | $S_1$ ** | 5.65 | 5.00 | 4.60 | 5.08* a | 5.20 | 5.05 | 5.05 | 5.10 a | 4.75 | 4.65 | 4.85 | 4.75 bc |
| | $S_2$ | 5.55 | 4.80 | 4.80 | 5.05 a | 5.00 | 4.90 | 4.65 | 4.85 ab | 4.85 | 4.85 | 4.80 | 4.83 ab |
| | $S_3$ | 4.90 | 4.60 | 4.25 | 4.58 bc | 4.45 | 4.35 | 4.70 | 4.50 c | 4.25 | 4.85 | 5.00 | 4.70 bc |
| Shoot dry weight (g) | $S_1$ | 0.086 | 0.059 | 0.166 | 0.104 | 0.150 | 0.108 | 0.132 | 0.130 | 0.165 | 0.111 | 0.111 | 0.129 |
| | $S_2$ | 0.070 | 0.045 | 0.046 | 0.054 | 0.135 | 0.101 | 0.093 | 0.110 | 0.146 | 0.105 | 0.093 | 0.115 |
| | $S_3$ | 0.049 | 0.036 | 0.032 | 0.039 | 0.096 | 0.083 | 0.081 | 0.086 | 0.101 | 0.084 | 0.076 | 0.087 |
| Root dry weight (g) | $S_1$ | 0.051 | 0.046 | 0.035 | 0.044 cd | 0.074 | 0.070 | 0.074 | 0.076 a | 0.058 | 0.063 | 0.058 | 0.060 b |
| | $S_2$ | 0.038 | 0.031 | 0.028 | 0.033 e | 0.064 | 0.066 | 0.057 | 0.062 b | 0.046 | 0.051 | 0.048 | 0.048 c |
| | $S_3$ | 0.029 | 0.022 | 0.017 | 0.022 f | 0.043 | 0.045 | 0.040 | 0.043 cd | 0.032 | 0.044 | 0.040 | 0.039 d |
| Whole seedling dry weight (g) | $S_1$ | 0.137 | 0.105 | 0.084 | 0.109 | 0.225 | 0.187 | 0.206 | 0.206 | 0.223 | 0.174 | 0.169 | 0.189 |
| | $S_2$ | 0.108 | 0.076 | 0.075 | 0.086 | 0.199 | 0.166 | 0.150 | 0.172 | 0.192 | 0.156 | 0.142 | 0.163 |
| | $S_3$ | 0.078 | 0.056 | 0.049 | 0.061 | 0.139 | 0.128 | 0.121 | 0.129 | 0.133 | 0.128 | 0.117 | 0.126 |
| Shoot/root ratio | $S_1$ | 1.702 | 1.272 | 1.407 | 1.461 | 2.052 | 1.385 | 1.782 | 1.740 | 2.810 | 1.780 | 1.922 | 2.171 |
| | $S_2$ | 1.855 | 1.572 | 1.617 | 1.682 | 2.132 | 1.540 | 1.622 | 1.765 | 3.245 | 2.032 | 1.925 | 2.401 |
| | $S_3$ | 1.727 | 1.805 | 1.935 | 1.822 | 2.282 | 1.867 | 2.000 | 2.050 | 3.260 | 1.885 | 1.880 | 2.342 |

*Averages within rows or columns of salinity levels or temperatures of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

3. Shoot, root and whole seedling dry weight and shoot/root ratio

The mean squares of the analysis of variance of these characters showed highly significant reductions with increasing salinity levels and highly significant increment with increasing temperature up to 20°C and reductions with increasing temperature up to 30°C, except for shoot/root ratio and shoot dry weight which increased significantly with increasing both salinity and temperatures, (Table 1 and Figs. 1, 2, 4 and 5). However, shoot dry weight remained essentially unchanged with increasing salinity from 5000 to 10,000 ppm Nacl, and temperature from 20 to 30°C. Falchetto produced the highest dry weight for all these parts and shoot/root ratio over the other two cultivars. However, there were no significant differences between Falchetto and Shakha 61 or 62 for shoot and root dry weight, respectively. Also, there were no significant differences between Shakha 62 and Shakha 61 for shoot dry weight, whole seedlings dry weight and shoot/root ratio, (Table 1).

Significant interaction between salinity and temperature was obtained only for root dry weight (Table 3 and Fig. 6). The highest root dry weight was obtained at 20°C temperature and zero salinity (control) and the lowest was obtained at 10°C and highest salinity level (10,000 ppm Nacl). Even though the effect of interaction between salinity and temperature was not significant on whole dry weight of all wheat cultivars, Falchetto produced higher dry weights at all temperatures under all salinity levels than the other two cultivars (Table 3). These results suggest that Falchetto can synthesise dry matter under these conditions and is better adapted to salinity under


Fig. 6 Interaction effect of salinity levels and temperatures on root and whole seedling dry weight and shoot / root ratio.

hot weather than other two cultivars at early growth stages. These results are in harmony with those obtained by Ahi and Powers, 1938; Bernstein and Ayers, 1951, 1953; Fawzi and Abed, 1975; Ashour et al., 1977; Ziwaik, 1980, Joshi et al., 1982. However, Rizk et al. (1981) showed that increasing salt concentrations (Nacl or $Cacl_2$) caused increases in seedling dry weight and increasing temperature from 10 to 20°C showed no significant effect on seedling dry weight under salinity conditions. Ashour et al. (1977) indicated that increasing chloride salinity from 0.35 to 0.65 siemen/m decreased shoot/root ratio of wheat seedlings.

Summary

Three factorial experiments in complete randomized block design were conducted for studying the effect of different levels of Nacl salinity under three constant temperatures viz. 10, 20 and 30°C on germination and early growth of wheat cultivars, Falchetto, Shakha 62 and Shakha 61. Falchetto was superior in all characters studied except germination capacity in which there were no significant differences between cultivars. Increased temperature up to 20°C increased germination capacity as well as growth characters except for root number per seedling which was not affected by temperatures. Between 20°C and 30°C all these characters reduced significantly except shoot dry weight which remained essentially unchanged with increasing temperature. However, shoot/root ratio increased with increasing temperature up to 30°C. Results also show a progressive and consistent depression in germination capacity and growth characters due to the increases in salt concentration, but the opposite is true for shoot/root ratio.

The effect of the interaction between temperatures and salinity levels was significant on germination capacity, root length, fresh weight, root number and root dry weight. Values being higher at 20°C under the highest salinity level as compared with the other two temperatures.

# CHAPTER V

## B. INFLUENCE OF RELATIVE HUMIDITY AND SALINITY ON GERMINATION AND GROWTH OF SOME WHEAT VARIETIES (*Triticum aestivum* L.)

### Introduction

Soil salinity and atmospheric relative humidity influence plant growth (Hoffman *et al.*, 1971). High levels of humidity could result in lowered rates of transpiration and hence could be expected to alleviate the effects of any water imbalance due to salinity. Furthermore the fresh:dry weight ratio is increased under humid conditions (Gale, 1975). This reduces the concentration of electrolytes, and such was found to be the case for leaves of bean and cotton plants grown under saline conditions (Niemen and Paulsen, 1967). On the other hand Laouar *et al.* (1973) found that in *Sinapis alba*, grown in culture solutions whose osmotic potential was lowered by polyethylene glycol (PEG), osmotic adjustment was faster in 50% than in a 70% RH atmosphere (as quoted by Gale, 1975). However, as general rule high humidity has been found to ameliorate growth under conditions of salinity (e.g. Prisco and O'Leary, 1973, working with beans and Nacl). The following experiment was carried out to study the effect of humidity on wheat growing under saline conditions, since there are few reports in the literature on this aspect of wheat growth.

## Materials and Methods

A randomized complete block design with four replicates was carried out in a Fison's 600 H controlled environment chamber. Each replicate consisted of 18 treatments which were the combination of 3 salt concentrations (0, 5000 and 10000 ppm Nacl), two constant relative humidities (RH 92% and 47%) and three wheat cultivars (Triticum aestivum L.) namely Falchetto, Shakha 62 and Shakha 61. Ten seeds per pot (7.62 cm diam) were sown in vermiculite culture. The experiment was carried out at a constant day and night temperature of 22°C. Irradiance during the 12h day was 180 μ mol $m^{-2}$ $s^{-1}$(P.A.R.). After two weeks, the following data were recorded.

1. Germination capacity of seeds (G.Cap)

$$G.Cap = \frac{\text{Maximum number of the emergent seedlings}}{\text{Total number of seeds}} \times 100.$$

2. Shoot length (cm)
3. Root length (cm)
4. Root number/seedling
5. Fresh weight (g)
6. Shoot dry weight (g)
7. Root dry weight (g)
8. Whole seedling dry weight (g)
9. Shoot/root ratio

## Results and Discussion

### 1. Germination Capacity

Figs. 7 and 8 and Table 4 shows that the germination capacity of wheat seeds decreased markedly with increasing level of Nacl salinity, but remained unchanged with increasing relative

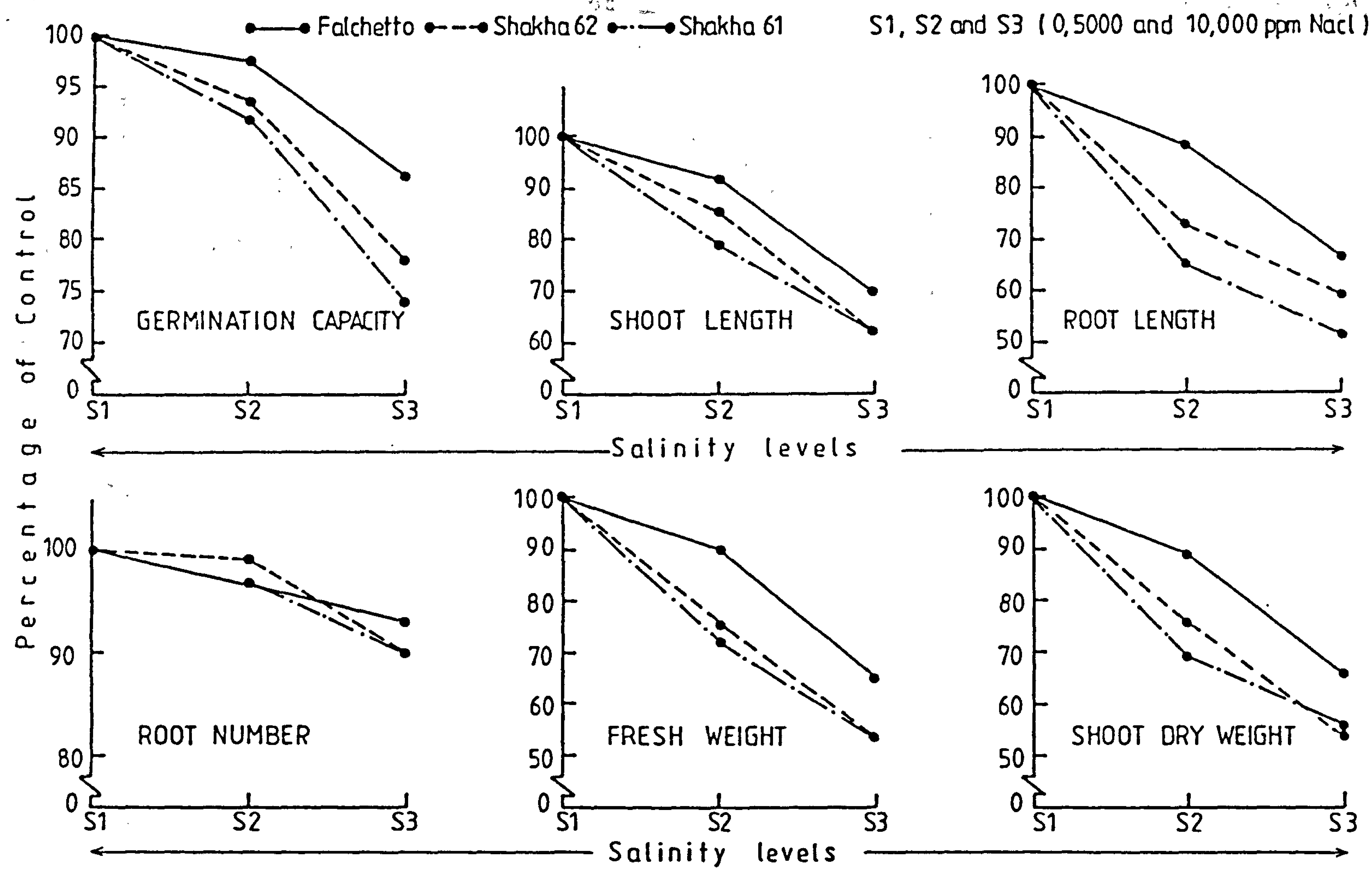



Fig. 7 Influence of Nacl salinity on germination, shoot and root length, root number, fresh weight and shoot dry weight.


Fig. 8 Influence of relative humidity on germination, shoot and root length, number of roots, fresh weight and shoot dry weight.

Table (4) : Effect of relative humidity and salinity levels on germination and early growth of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Cultivars | | | Salinity | | | Relative humidity | |
|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | $S_1$ ** | $S_2$ | $S_3$ | RH 92 | RH 47 |
| Germination Capacity | 94.6 *a | 88.3 ab | 85.4 b | 97.9 a | 92.5 a | 77.9 b | 90.3 | 88.6 |
| Shoot length (cm) | 20.6 a | 16.4 b | 15.3 c | 20.9 a | 17.8 b | 13.5 c | 19.3 a | 15.5 b |
| Root length (cm) | 28.2 a | 24.0 b | 19.8 c | 30.6 a | 23.3 b | 18.1 c | 27.1 a | 20.9 b |
| Roots number per seedling | 4.8 | 4.8 | 4.7 | 5.0 a | 4.9 a | 4.5 b | 5.0 a | 4.6 b |
| Fresh weight (g) | 0.823 a | 0.564 b | 0.528 b | 0.801 a | 0.643 b | 0.470 c | 0.717 a | 0.559 b |
| Shoot dry weight (g) | 0.108 a | 0.072 b | 0.069 b | 0.105 a | 0.082 b | 0.062 c | 0.094 a | 0.072 b |
| Root dry weight (g) | 0.059 a | 0.057 ab | 0.053 b | 0.072 a | 0.055 b | 0.042 c | 0.064 a | 0.049 b |
| Whole seedling dry weight (g) | 0.170 a | 0.129 b | 0.118 b | 0.177 a | 0.140 b | 0.100 c | 0.157 a | 0.120 b |
| Shoot/root ratio | 1.846 a | 1.267 b | 1.319 b | 1.457 | 1.502 | 1.474 | 1.489 | 1.466 |
| Shoot water content (g) | 0.714 a | 0.492 b | 0.458 b | 0.697 a | 0.560 b | 0.409 c | 0.623 a | 0.487 b |

* Averages within rows of cultivars or salinity levels or relative humidity of each character followed by the same letter are not significantly different according to Duncan's test.

** $S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

Table (5) : Interaction effect of salinity levels and relative humidity on germination, shoot and root length and shoot fresh weight of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Relative humidity | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH 92% | | | | RH 47% | | | |
| | | Falchetto | Shakha 62 | Shakha 61 | Combined | Falchetto | Shakha 62 | Shakha 61 | Combined |
| Germination Capacity | $S_1$** | 100.0 | 95.0 | 95.0 | 96.7 | 100.0 | 100.0 | 97.0 | 99.2 |
| | $S_2$ | 97.5 | 92.0 | 92.5 | 94.2 | 97.5 | 90.0 | 85.0 | 90.8 |
| | $S_3$ | 90.0 | 80.0 | 70.0 | 80.0 | 82.5 | 72.5 | 72.5 | 75.8 |
| Shoot length (cm) | $S_1$ | 27.3 | 20.2 | 19.4 | 22.3* a | 20.0 | 19.6 | 18.7 | 19.4 b |
| | $S_2$ | 25.7 | 18.8 | 17.0 | 20.5 b | 17.6 | 15.0 | 13.0 | 15.2 c |
| | $S_3$ | 17.0 | 14.7 | 13.7 | 15.1 c | 15.9 | 10.0 | 9.8 | 11.9 d |
| Root length (cm) | $S_1$ | 34.8 | 37.9 | 31.7 | 34.8 | 31.5 | 24.3 | 23.4 | 26.4 |
| | $S_2$ | 31.9 | 25.1 | 20.4 | 25.1 | 26.8 | 18.9 | 15.2 | 20.3 |
| | $S_3$ | 24.5 | 21.3 | 15.1 | 20.3 | 19.6 | 15.4 | 12.9 | 16.0 |
| Root number per seedling | $S_1$ | 5.0 | 5.1 | 5.1 | 5.1 | 4.9 | 5.0 | 4.8 | 4.9 |
| | $S_2$ | 5.0 | 5.4 | 4.9 | 5.1 | 4.7 | 4.5 | 4.7 | 4.6 |
| | $S_3$ | 4.8 | 5.0 | 4.8 | 4.9 | 4.4 | 4.1 | 4.1 | 4.2 |
| Shoot fresh weight (g) | $S_1$ | 1.056 | 0.746 | 0.745 | 0.849 a | 0.876 | 0.727 | 0.656 | 0.753 b |
| | $S_2$ | 1.057 | 0.647 | 0.591 | 0.765 b | 0.684 | 0.461 | 0.415 | 0.520 c |
| | $S_3$ | 0.671 | 0.489 | 0.449 | 0.537 c | 0.591 | 0.314 | 0.307 | 0.404 d |

*Averages within rows or columns of salinity levels or relative humidity of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

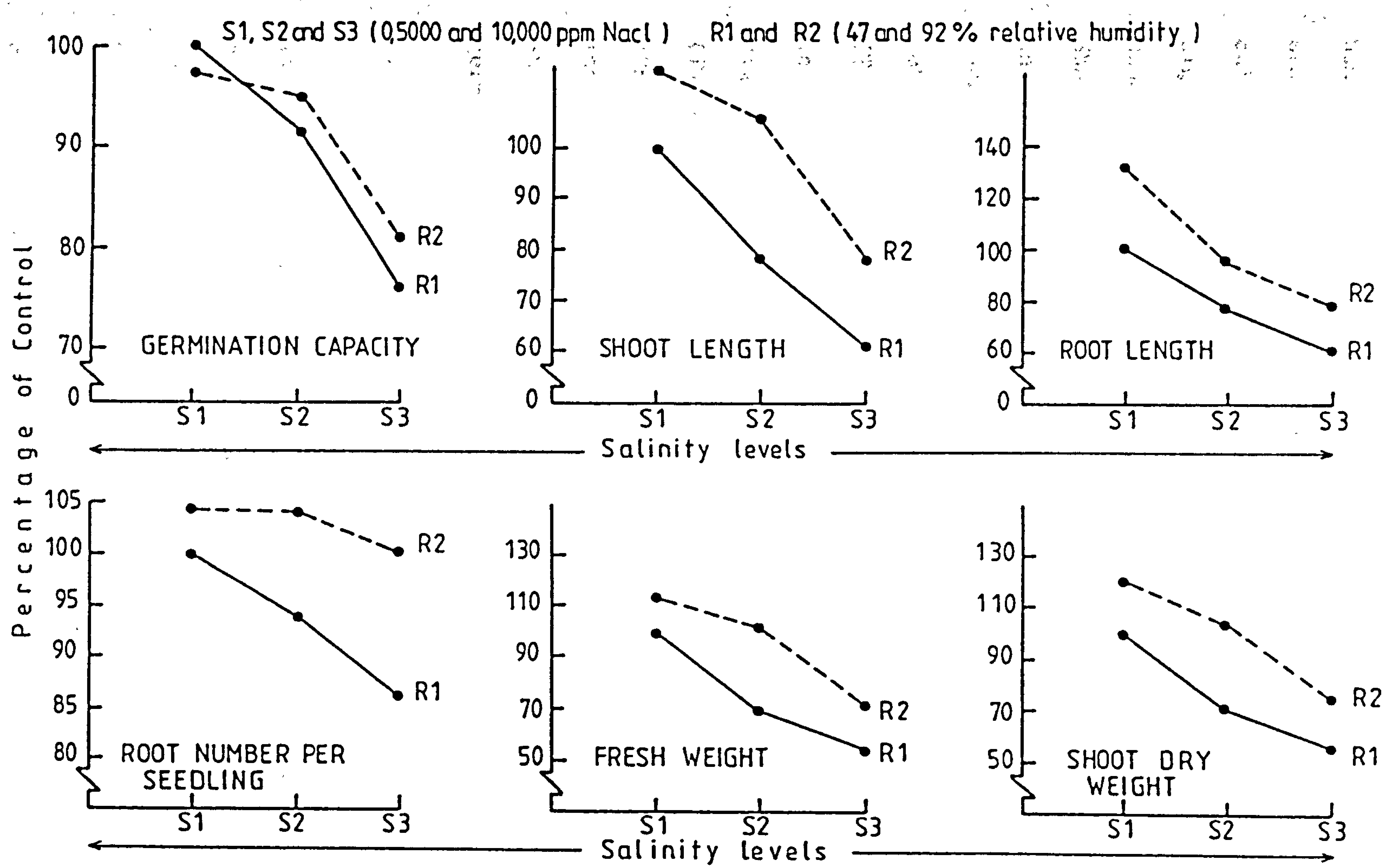



Fig. 9 Interaction effect of salinity levels and relative humidity on germination capacity, shoot and root length, root number per seedling, fresh weight and shoot dry weight of three wheat cultivars.

humidity from 47 to 92%. However, the salinity effect did not become statistically significant until 5000 ppm Nacl. The semi-dwarf cultivar Falchetto had the highest germination capacity with significant difference as compared with the other two cultivars. However, there was no significant difference between Shakha 62 and Shakha 61 and between Falchetto and Shakha 62. the effect of salinity and relative humidity on germination capacity of wheat cultivars were independent of each other, i.e. there was no significant interaction between salinity and relative humidity for germination capacity (Table 5 and Fig. 9). However, Falchetto had the lowest reduction in germination capacity under the highest level of salinity at both high and low relative humidity as compared with the other cultivars (Table 5). Similar results have been reported by Bhumbla and Singh, 1965; Selim and Ahamed, 1975; Ashour et al., 1977; Gill and Dutt, 1982 and Kuhad and Garg, 1984. However, Sayed and Mashhady (1983) obtained significant differences among wheat and triticale seeds in germination capacity due not to salinity but to some unknown factors.

2. Shoot and root length, root number and fresh weight

It is apparent that the cultivars differed significantly in all these characters except for root number per seedling under salinity and humidity conditions as seen in Figs. 7 and 8 and Table 4. In general all these characters decreased with increasing salinity and decreasing relative humidity. Falchetto had significantly the highest values and Shakha 61 had the lowest for all these characters except for root number per seedling. However, there was no significant difference between Shakha 62 and 61 for fresh weight, and there was no effect of salinity on root number up to 5000 ppm Nacl (Table 4).

Significant interaction between salinity and atmospheric humidity was obtained for shoot length and fresh weight only. The highest values for shoot length and fresh weight were obtained at RH 92% and zero salinity (control) and the lowest value were obtained at RH 47% and 10,000 ppm Nacl salinity (highest salinity level) (Table 5 and Fig. 9). Again, Table 5 shows that at both high and low RH and under highest salinity levels Falchetto is superior the other two cultivars in all these characters, except root number per seedling in which there were no differences between all cultivars. These findings are in harmony with those obtained by Lunt _et al._, 1960; Niemen and Paulsen, 1967; Prisco and O'Leary, 1973 and O'Leary, 1975. Hoffman and Jobes (1978) found in their study on the interaction effect of salinity and relative humidity on barley, wheat and corn, that RH had no significant effect on the height of barley and wheat plants, but significantly increased the height of corn under all salinity levels, whereas in this study RH had a significant effect on shoot length at all levels of salinity.

### 3. Shoot, root and whole seedling dry weight, shoot/root ratio and shoot water content

the data of Table 4 and Figs. 7, 8, 10 and 11 indicated that the average shoot, root and whole seedling dry weight and shoot water content similarly was reduced by increasing salinity and by decreasing atmospheric humidity. Shoot/root ratio however was not


Fig. 10 Influence of Nacl salinity on root and whole seedling dry weight, shoot / root ratio and shoot water content.


Fig. 11 Influence of relative humidity on root and whole seedling dry weight, shoot/root ratio and shoot water content.

Table (6) : Interaction effect of salinity levels and relative humidity on shoot, root and whole seedling dry weight, shoot/root ratio and shoot water content of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Relative humidity | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RH 92% | | | | RH 47% | | | |
| | | Falchetto | Shakha 62 | Shakha 61 | Combined | Falchetto | Shakha 62 | Shakha 61 | Combined |
| Shoot dry wt (g) | $S_1$ ** | 0.143 | 0.099 | 0.099 | 0.114 | 0.111 | 0.088 | 0.087 | 0.095 |
| | $S_2$ | 0.135 | 0.084 | 0.075 | 0.098 | 0.092 | 0.056 | 0.052 | 0.067 |
| | $S_3$ | 0.084 | 0.066 | 0.062 | 0.071 | 0.083 | 0.036 | 0.040 | 0.053 |
| Root dry wt. (g) | $S_1$ | 0.076 | 0.081 | 0.076 | 0.078 | 0.065 | 0.067 | 0.066 | 0.066 |
| | $S_2$ | 0.069 | 0.069 | 0.055 | 0.065 | 0.056 | 0.039 | 0.038 | 0.044 |
| | $S_3$ | 0.044 | 0.053 | 0.048 | 0.048 | 0.043 | 0.032 | 0.031 | 0.035 |
| Whole seedling dry weight (g) | $S_1$ | 0.220 | 0.181 | 0.174 | 0.192 | 0.176 | 0.156 | 0.153 | 0.162 |
| | $S_2$ | 0.221 | 0.154 | 0.130 | 0.168 | 0.148 | 0.095 | 0.091 | 0.111 |
| | $S_3$ | 0.128 | 0.119 | 0.085 | 0.111 | 0.126 | 0.068 | 0.071 | 0.088 |
| Shoot/root ratio | $S_1$ | 1.877 | 1.220 | 1.310 | 1.469 | 1.712 | 1.312 | 1.307 | 1.444 |
| | $S_2$ | 1.952 | 1.222 | 1.367 | 1.514 | 1.625 | 1.472 | 1.375 | 1.491 |
| | $S_3$ | 1.932 | 1.250 | 1.270 | 1.484 | 1.977 | 1.127 | 1.285 | 1.463 |
| Shoot water content (g) | $S_1$ | 0.912 | 0.646 | 0.647 | 0.735*a | 0.765 | 0.639 | 0.569 | 0.658 b |
| | $S_2$ | 0.922 | 0.563 | 0.516 | 0.667 b | 0.592 | 0.404 | 0.363 | 0.453 c |
| | $S_3$ | 0.587 | 0.423 | 0.387 | 0.466 c | 0.508 | 0.277 | 0.268 | 0.351 d |

* Averages within rows or columns of salinity levels or relative humidity of shoot water content followed by the same letter are not significantly different according to Duncan's test.

** $S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

S1, S2 and S3 (0,5000 and 10,000 ppm Nacl)    R1 and R2 (47 and 92 % relative humidity)

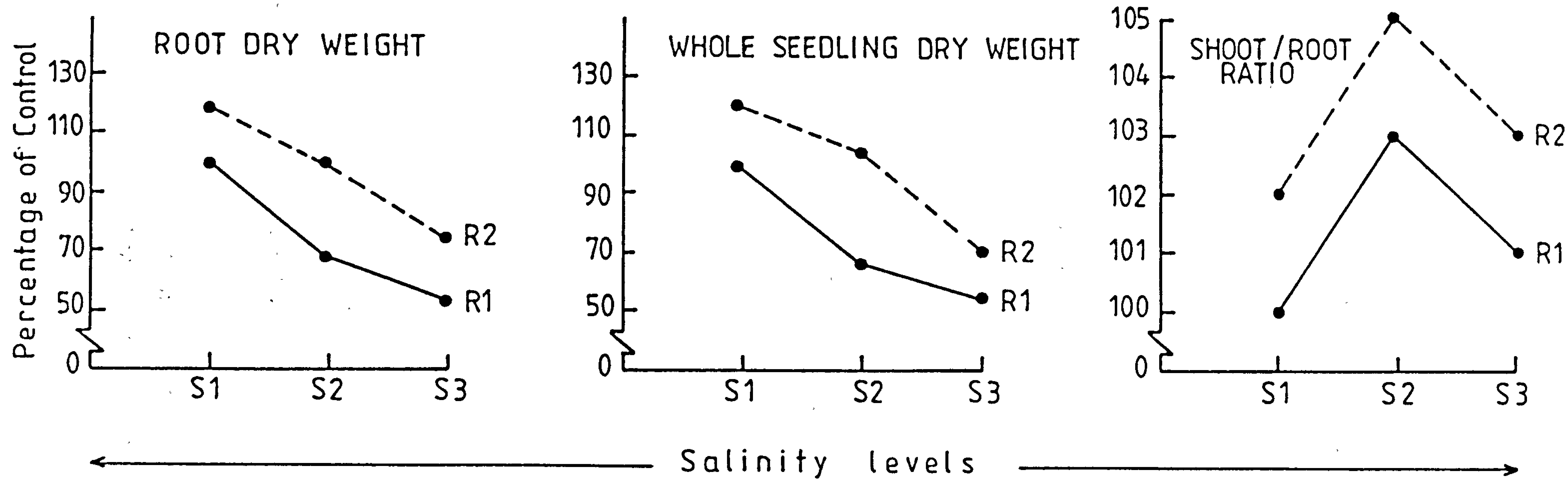



Fig. 12 Interaction effect of salinity levels and relative humidity on root and whole seedling dry weight and shoot / root ratio of three wheat cultivars.

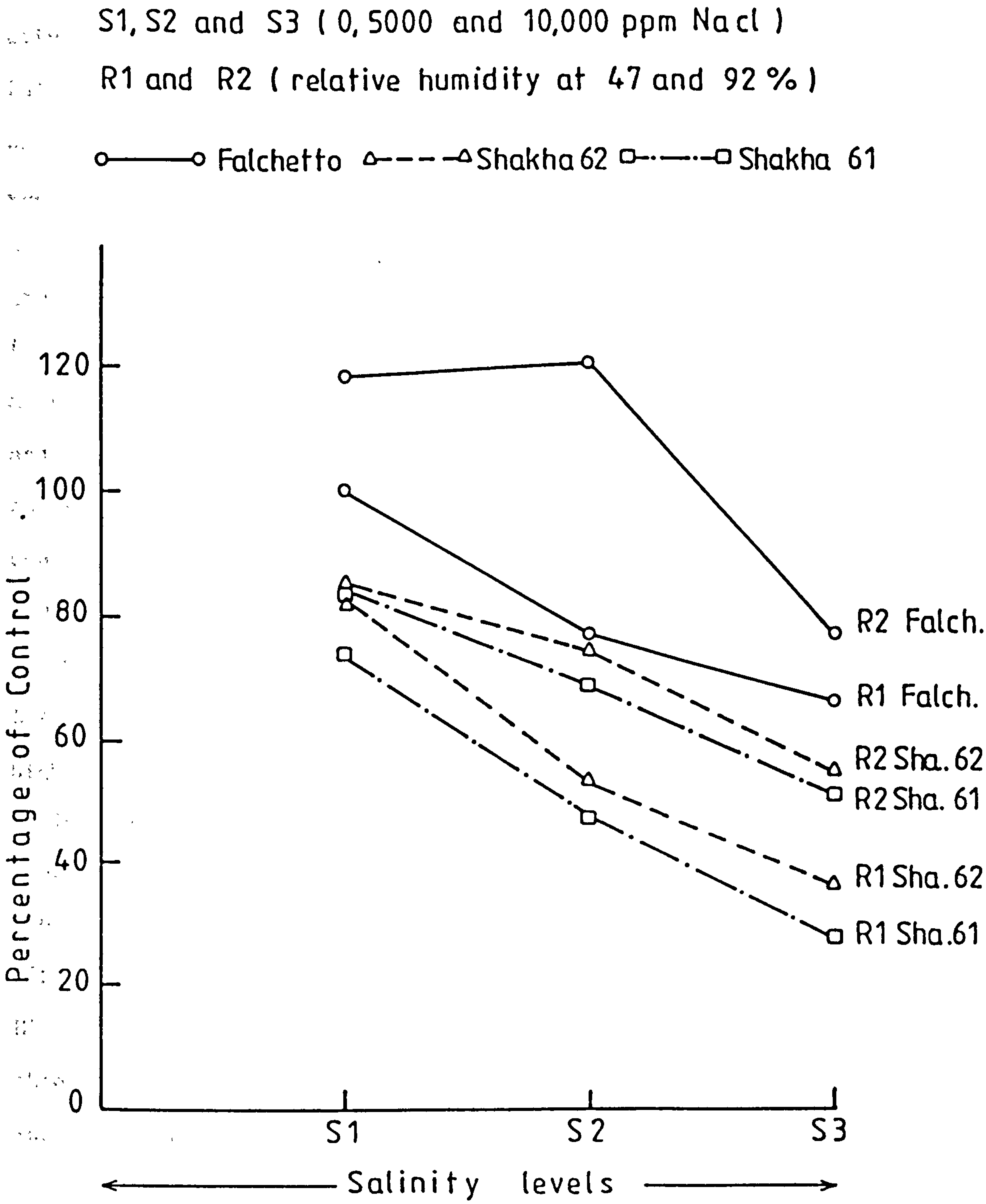



Fig. 12 a. Interaction effect of salinity levels and relative humidity on shoot water content of three wheat cultivars.

affected by salinity or relative humidity. The semi-dwarf cultivar Falchetto produced the highest dry weight for all parts of the plants and also had the highest values for shoot/root ratio and shoot water content and the medium tall cultivar Shakha 61 had the lowest for all these characters, the differences being significant. However, there was no significant difference between Falchetto and Shakha 62 for root dry weight or between Shakha 62 and Shakha 61 for all these measurements. There was no significant interaction between salinity and relative humidity for all these characters except shoot water content (Table 6, Figs, 9, 12 and 12a) and this means that shoot water content at any level of salinity increased with increasing relative humidity. This may result in dilution of toxic ions or reduction of the effect of physiological drought by high relative humidity. Also, Table 6 shows that under highest salinity level and at both high and low RH Falchetto outyielded the other cultivars in shoot and whole seedling dry weight and in shoot water content. Similar findings have been reported by Lunt _et al._, 1960; Niemen and Paulsen, 1967; Ansari _et al._, 1978; Hoffman and Rawlins, 1970; Prisco and O'Leary, 1973; Ashour _et al._, 1977; Hoffman and Jobes, 1978 and El-Fouly and Jung, 1981. However, Ashour _et al._ (1977) found that shoot/root ratio of wheat plant dry matter showed a decrease with increasing salinity.

It is clear however that at all salinities used increased relative humidity reduced the harmful effects of salinity. Two possible explanations which could act separately or together are: (a) that the higher relative humidity reduces water loss and therefore reduces the effects of any physiological drought arising from the reduced water potential of the saline soils, (b) that the increased humidity reduces water loss from the plants so that they are able to maintain a higher water status and salt contents are therefore more dilute and less toxic. The water content data certainly show higher values at 92% relative humidity (Table 6) supporting the suggestions that water loss is less, but the question remains as to whether the higher water content at 92% relative humidity improves performance by reducing salt induced physiological drought or by diluting ion contents to less toxic concentrations. Correlations of water content and dry matter however give some indication that ion toxicity may be involved to some extent. Shoot dry matter of all cvs in the two saline treatments at 92%, relative humidity was correlated with water content. A similar correlation was performed with the 47% relative humidity data. Results of the correlations are given in Table (6A). The $r^2$ values (Table 6A) show that only water content (as affected by salinity) affcted dry weight at high humidity (since $r^2 = 1.0$), but some additional factors contributes to variation in dry matter at low humidity (since $r^2 = 0.765$ only 76.5% of the variation in dry matter is accounted for by water content). At low humidities water contents are generally lower (as a result of increased transpiration) and ion concentrations will be higher overall. It is possible that the factor or one of the factors contributing to variation in dry matter at low relative humidity is ion toxicity while at the higher relative humidity the higher overall water contents are sufficient to keep ion concentrations below toxic

Table (6A) : Correlation of water content and dry matter production of three wheat cultivars under saline conditions (5,000 and 10,000 ppm Nacl)

| Regression Components | Relative humidity | |
|---|---|---|
| | 92% | 47% |
| a | 0.006 | -0.008 |
| b | 0.137 | 0.169 |
| r | 1.0 | 0.875 |
| $r^2$ | 1.0 | 0.765 |

levels. The effect of water content, which accounts for all the variation in dry matter at 92% and 76.5% of it at 47%, is presumably that water content affects turgidity and therefore the stomatal resistanceand photosynthetic production of dry matter.

These experiments indicate that high relative humidity can reduce the harmful effects of soil salinity. However it must be remembered that these experiments were carried out on very young plants (up to 10 days old only). Further experiments on plants at later stages of development would be worthwhile. it would also be important to use a wider range of relative humidity. Further experimentation to resolve the question of whether high relative humidity reduces salt induced physiological drought or dilutes ion concentrations might involve quantification of water potential and its components, especially osmotic potential, and chemical analysis of cell sap. Wheat grown in humid, saline areas of Egypt, e.g. north Delta, might have an advantage over wheat grown in similarly saline, but less humid areas. This requires investigation .

Summary

Interactive effects of salinity and atmospheric humidity on germination and early growth stages of wheat cultivars, Falchetto, Shakha 62 and Shakha 61 were studied. Increased RH from 47% to 92% did not affect germination capacity of any of the cultivars under any of the salinity levels. Also, up to 5000 ppm Nacl no significant reduction in germination capacity was obtained and germination capacity decreased with increasing salinity above 5000 ppm Nacl. In general, all growth characters except shoot/root ratio tended to reduce with increasing salinity levels and decreasing relative humidity. Falchetto had the highest values for all these characters except root number) with significant difference as compared with the other two cultivars. However, there was no significant difference between Falcehtto and Shakha 62 for germination and root dry weight or between Shakha 62 and 61 for all these characters except shoot and root length in which Shakha 62 was superior to 61. The interaction between salinity and relative humidity was significnat on shoot length, fresh weight and shoot water content, values being higher at the higher relative humidity. A similar, but not significant trend was seen for all other characters studied.

# CHAPTER V

## C. EFFECT OF SOIL SALINITY AND DROUGHT CONDITIONS ON GROWTH OF SOME WHEAT CULTIVARS (*Triticum aestivum* L.)

### Introduction

Salinity and drought problems are major factors affecting crop production in arid and semiarid regions (Nabors, 1983). Very often saline and drought conditions occur together and plant tolerance to combined stress is, therefore, of considerable interest. Salinity stress reduces the availability of water as a result of decrease in soil osmotic potential (Strogonov, 1964), whereas water stress impairs soil moisture transmission (Gingrich and Russell, 1957 ; Jefferies and Rudmik, 1979). Moreover, because both stresses seriously reduce growth, normal consumption will be reduced and, therefore, considerable changes in concentration of metabolites and intermediate materials are expected (Mashhady *et al.*, 1982). Therefore, it was considered important to study the tolerance of some selected wheat cultivars to stress conditions induced by high soil salinity and limited soil moisture content.

### Materials and Methods

The experiment was carried out in a Fisons 600 H controlled environment chamber, at 20°C, 70% relative humidity, night temperature 14°C, day length 12 hr and irradiance 180 $\mu$mole $cm^{-2}$ $s^{-1}$ (P.A.R.). Three levels of salinity 0.0, 0.4 and 0.6% salt, based on soil dry weight (see M & M Chapter IIB) were used. The moisture content in each level was kept more or less constant at three levels: 100%, 50% and 20% of available water. These levels were achieved by weighing the pots daily and the loss of water compensated by adding enough water to reach the required moisture level of the soil.

Three wheat cultivars (Triticum aestivum L.) were used, namely Falchetto (Italian semi-dwarf cultivar) and Shakha 62 and 61 (Egyptian medium tall cultivars). The experimental design for this experiment was a randomized complete block with three replicates, each replicate consisting of 27 treatments. The three cultivars were sown in non-saline soil (Table A) on 16.8.1984 and transplanted into saline soils on 23.8.1984 in pots of 7.62 cm diam.

After one month from sowing the following measurements were taken:

1. Leaf number per seedling
2. Shoot length (cm)
3. Fresh weight per seedling (g)
4. Tillers number/seedling
5. Shoot dry weight (g)
6. Root dry weight (g)
7. Whole seedling dry weight (g)

TABLE A: Soil moisture characteristics

| | |
|---|---|
| Field capacity | 26.2 % |
| Wilting point | 17.4 % |
| Available moisture | 8.8 % |

## Results and Discussion

### 1. Leaf number, shoot length, fresh weight and tiller number

Increasing soil salinity and decreasing available water content significantly reduced the leaf number, shoot length and fresh weight. Tiller numbers were not affected by available water content but were reduced by salinity (Table 7 and Figs. 13 and 14).

The semi-dwarf cultivar Falchetto produced higher leaf and tiller numbers with significant difference as compared with the other two cultivars. However, there was no significant difference between Shakha 62 and 61 for these two characters. No significant varietal differences in shoot length and fresh weight were obtained. There were few varietal differences in response to salinity. However Falchetto appeared to be more susceptible to reduced levels of available moisture than the other two cultivars when values were expressed as percentage of control values (Fig. 14).

Highly significant interaction between soil salinity and available water content was obtained for fresh weight only. The highest fresh weight was produced at 100% available water content and zero salinity, and the lowest fresh weight was produced at 20% available water content and 0.6% salinity level (Table 8 and Fig.15). In the combined varietal response there was no significant difference in fresh weight between 100% and 50% available water at 0% salt. Also at 0.6% salt there was no significant difference between 100% and 50% available water or between 50% and 20% available water. This lack of difference in response to available water especially between 50% and 20% at high salinity may indicate an overriding salt induced physiological drought.

Table (7) : Effect of soil salinity and drought conditions on the growth of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Cultivars | | | Salinity levels | | | Available water | | |
|---|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | $S_1$ 0.0% | $S_2$ 0.4% | $S_3$ 0.6% | 100% control | 50% | 20% |
| Leaf number per plant | 2.64 *a | 2.27 b | 2.19 b | 3.13 a | 2.30 b | 1.67 c | 2.70 a | 2.43 b | 1.98 c |
| Shoot length (cm) | 26.54 | 26.20 | 26.48 | 34.74 a | 27.20 b | 17.28 c | 30.69 a | 26.91 b | 21.63 c |
| Fresh weight (g) | 0.506 | 0.476 | 0.528 | 0.938 a | 0.391 b | 0.180 c | 0.629 a | 0.535 b | 0.345 c |
| Tillers number | 0.09 a | 0.00 b | 0.00 b | 0.09 a | 0.00 b | 0.00 b | 0.067 | 0.022 | 0.000 |
| Shoot dry weight (g) | 0.069 | 0.065 | 0.069 | 0.119 a | 0.056 b | 0.028 c | 0.084 a | 0.071 b | 0.048 c |
| Root dry weight (g) | 0.024 | 0.021 | 0.023 | 0.035 a | 0.020 b | 0.014 c | 0.030 a | 0.023 b | 0.016 c |
| Whole seedling dry weight (g) | 0.093 | 0.085 | 0.092 | 0.154 a | 0.075 b | 0.041 c | 0.113 a | 0.094 b | 0.064 c |

*Averages within rows of cultivars or salinity levels or available water content of each character followed by the same letter are not significantly different according to Duncan's test.

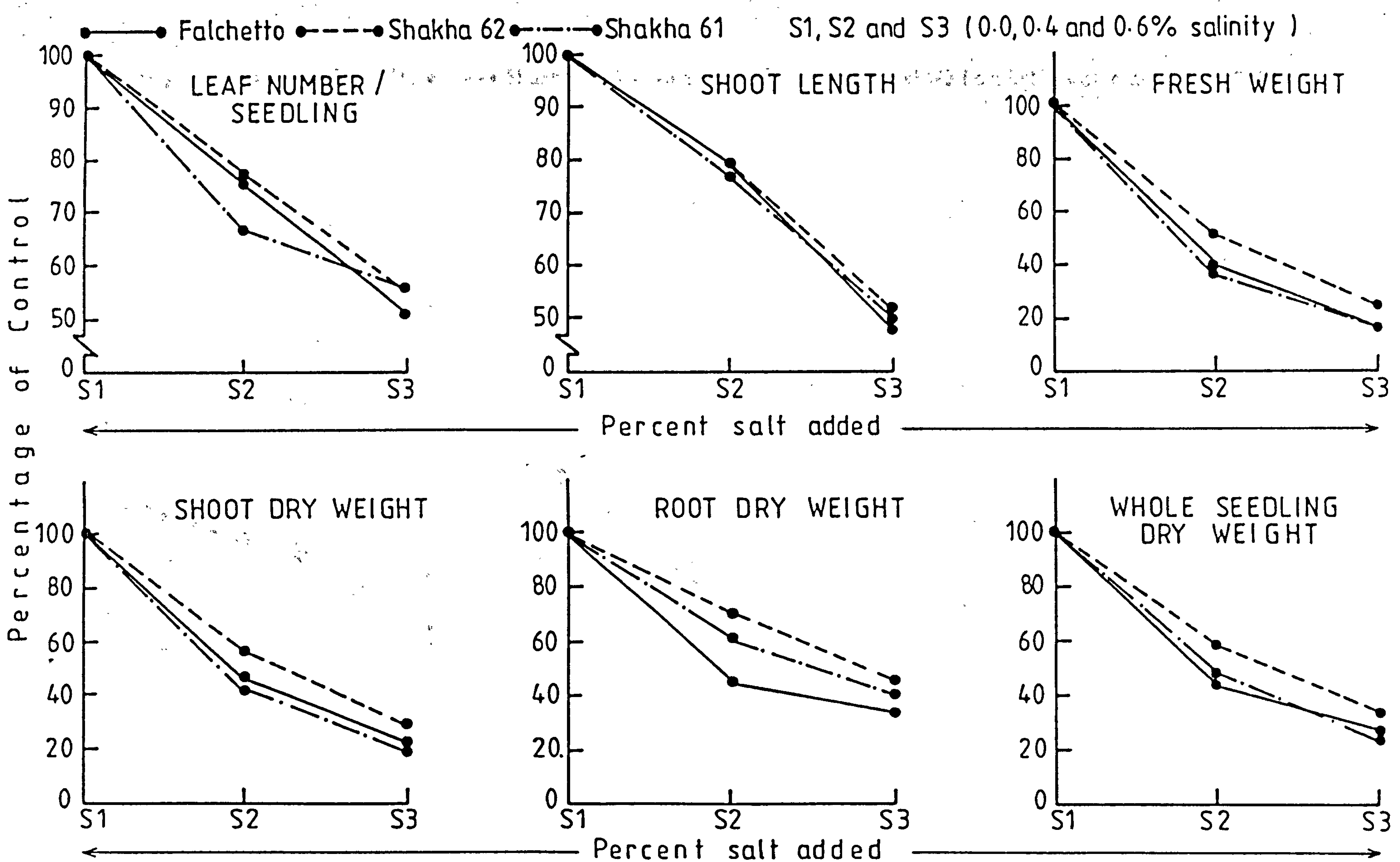



Fig. 13 Effect of different salinity levels on leaf number, shoot length, fresh weight and shoot, root and whole seedling dry weight.

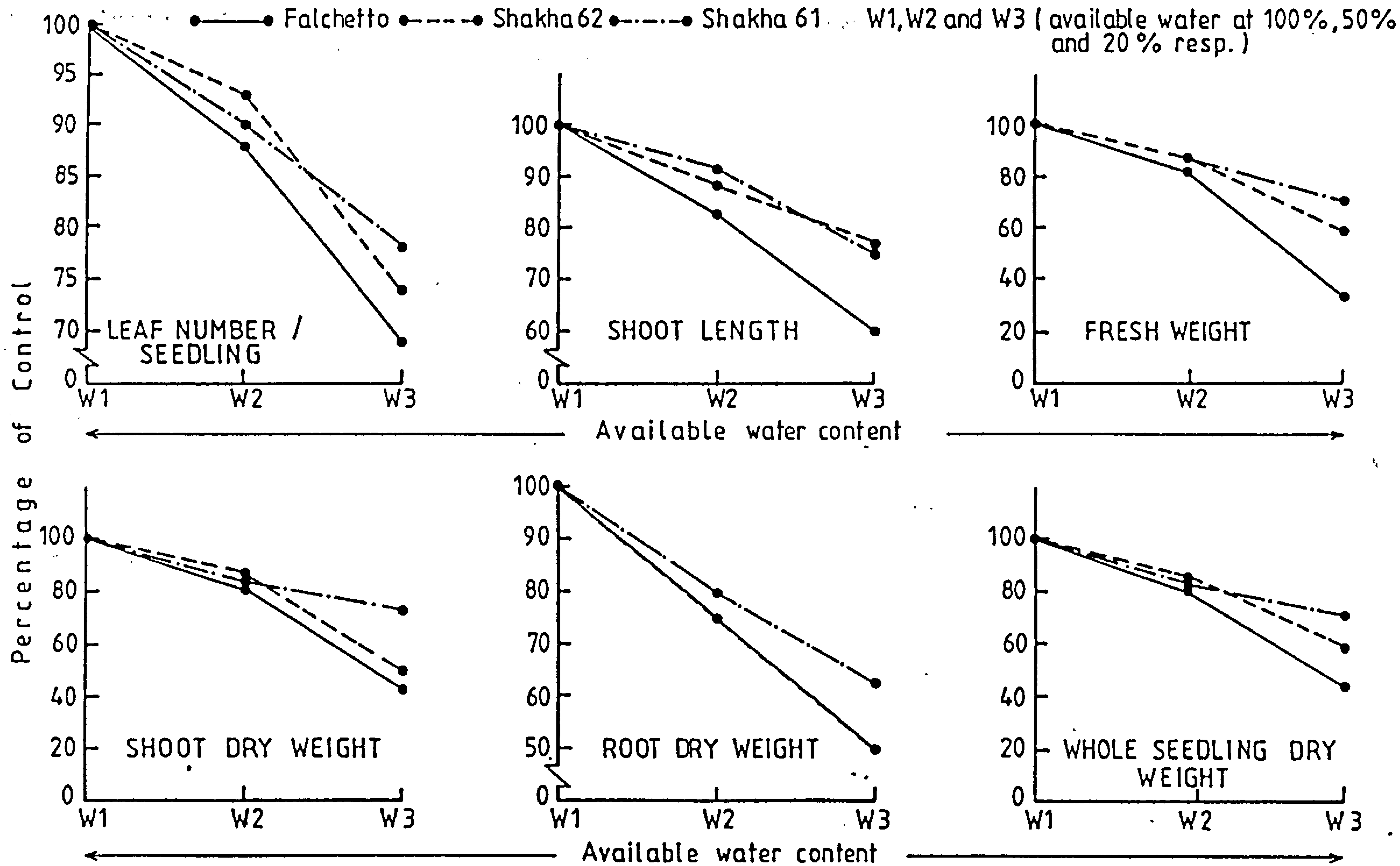



Fig. 14 Effect of drought conditions on leaf number/seedling, shoot length, fresh weight and shoot, root and whole seedling dry weight.

Table (8) : Interaction effect of soil salinity and drought conditions on leaf number, shoot length, fresh weight and tiller number of three wheat cultivars.

| Characters | Salinity levels | Available water | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 % | | | | 50 % | | | | 20 % | | | |
| | | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined |
| Leaf number per seedling | 0.0% | 3.93 | 3.00 | 3.00 | 3.31 | 3.80 | 2.93 | 2.93 | 3.22 | 2.80 | 2.87 | 2.93 | 2.87 |
| | 0.4% | 3.00 | 2.67 | 2.33 | 2.67 | 2.53 | 2.47 | 2.00 | 2.33 | 2.40 | 1.67 | 1.60 | 1.89 |
| | 0.6% | 2.33 | 2.00 | 2.00 | 2.11 | 1.80 | 1.73 | 1.67 | 1.73 | 1.20 | 1.13 | 1.20 | 1.18 |
| Shoot length (cm) | 0.0% | 40.0 | 36.0 | 37.7 | 37.9 | 36.8 | 34.2 | 35.2 | 35.4 | 28.3 | 32.2 | 32.3 | 30.9 |
| | 0.4% | 35.8 | 29.5 | 31.3 | 32.2 | 26.8 | 28.7 | 28.0 | 27.8 | 20.3 | 22.8 | 21.5 | 21.6 |
| | 0.6% | 22.5 | 23.0 | 20.3 | 21.9 | 17.8 | 16.2 | 18.5 | 17.5 | 10.3 | 13.3 | 13.5 | 12.4 |
| Fresh weight (g) | 0.0% | 1.298 | 0.954 | 1.126 | 1.126*a | 1.208 | 0.872 | 1.014 | 1.031 a | 0.410 | 0.616 | 0.946 | 0.657 b |
| | 0.4% | 0.559 | 0.501 | 0.493 | 0.518 c | 0.317 | 0.437 | 0.394 | 0.383 d | 0.267 | 0.306 | 0.247 | 0.273 e |
| | 0.6% | 0.230 | 0.284 | 0.218 | 0.244 e | 0.175 | 0.205 | 0.194 | 0.192 ef | 0.095 | 0.104 | 0.119 | 0.106 f |
| Tiller number | 0.0% | 0.600 | 0.000 | 0.000 | 0.200 | 0.200 | 0.000 | 0.000 | 0.067 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.4% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.6% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*Averages within rows or columns of soil salinity or available water of each character followed by the same letter are not significantly different according to Duncan's test.

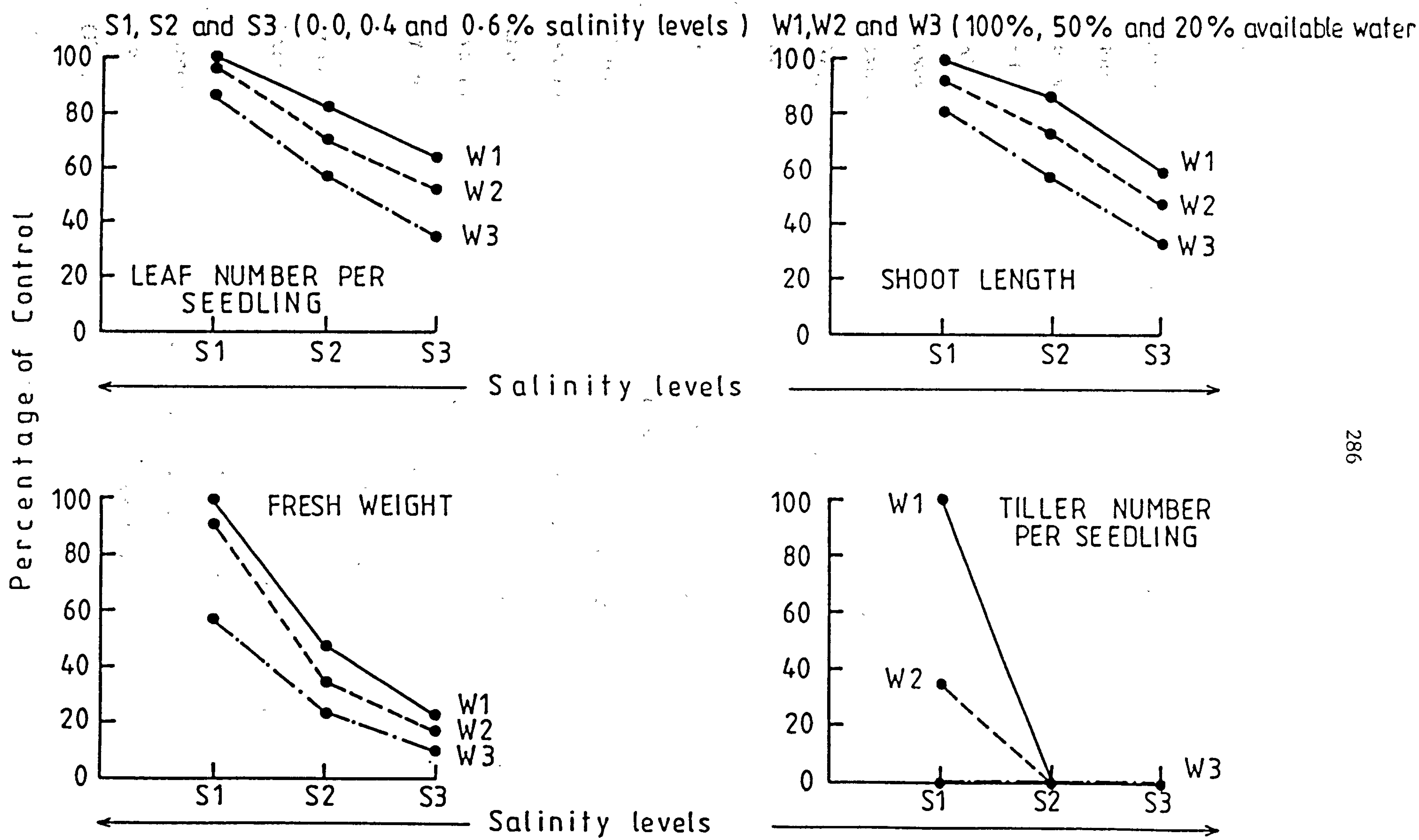



Fig. 15 Interaction effect of soil salinity and drought conditions on leaf number per seedling, shoot length, fresh weight and tiller number per seedling.

In terms of varietal response, Falchetto is generally superior but under some adverse conditions and for some characteristics this superiority is lost, mostly to Shakha 62 but in some cases to Shakha 61. For example at 0.6% salinity and 100% and 50% available water Shakha 62 had higher fresh weight than Falchetto or Shakha 61. At 0.6% salinity and 20% soil moisture, however, Shakha 61 had the highest fresh weight. Similar results have been reported by Abaul-Saod and Ashour, 1974; Gandhi and Paliwal, 1975; Ashour *et al.*, 1977; Hanna *et* al., 1978; Turk and Hall, 1980; Keim and Kronstad, 1981 and Mashhady *et al.*, 1982.

2. Shoot, root and whole seedling dry weight

The analysis of variance show that for all these characters there were highly significant differences due to salinity and available water content and generally, dry weight of all parts of the plant decreased with increasing soil salinity and decreasing of available water content. However, the shoot was more severely affected by both stresses than the root (Table 7 and Figs. 13 and 14).

Wheat cultivars did not show significant variation with regard to these characters except that the dry weight of roots of Falchetto reduced more rapidly in response to salinity than those of Shakha 61 and 62 (Fig. 13). Falchetto also appeared to be more susceptible to reduced levels of available moisture than the other two cultivars when values were expressed as percentages of control (Fig. 14).

A highly significant interaction was obtained for shoot and whole seedling dry weight only. The highest shoot and whole seedling dry weight was produced at 100% available water content and zero salinity. The lowest shoot and whole seedling dry weight was produced at 20% available water and 0.6% salinity level (Table 9 and Fig. 16). In the combined varietal response there was no significant difference in shoot dry weight between 100% and 50% available water at 0% salt. Also at 0.6% salt both for shoot and whole seedling dry weight there was no significant difference between 100% and 50% available water or between 50% and 20% available water. This lack of difference in response to available water at high salinity may indicate an overriding salt induced physiological drought.

In terms of varietal response Falchetto is generally superior, but under some adverse conditions this superiority is lost sometimes to Shakha 62 and sometimes to Shakha 61. For example at 100% available moisture and 0% salt, Falchetto has the highest shoot dry weight, but at the same level of water availability and 0.6% salt Shakha 62 gives the highest value for this character and at 20% available moisture Shakha 61 gives the highest whole seedling dry weight at 0% salt. These findings are in harmony with those obtained by Poonia and Jharar, 1974; Selim and Ahamed 1975; Ashour et al., 1977; Ansari et al., 1978 and Mashhady et al., 1982. Sayed and Mashhady (1983) concluded that interaction between soil salinity and available water content induced significant effects on dry matter content. The stress conditions caused by high salinity (0.85 and 1.1 siemen/m) and limited soil moisture (20 and 50% available water) progressively decreased the dry weight of wheat plants.

Table (9) : Interaction effect of soil salinity and drought conditions on shoot, root and whole seedling dry weight of three wheat cultivars.

| Characters | Salinity levels | Available water | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100 % | | | | 50 % | | | | 20 % | | | |
| | | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined | Falch. | Shakha 62 | Shakha 61 | Combined |
| Shoot dry weight (g) | 0.0% | 0.163 | 0.120 | 0.139 | 0.141*a | 0.152 | 0.115 | 0.125 | 0.131 a | 0.059 | 0.081 | 0.117 | 0.086 b |
| | 0.4% | 0.082 | 0.074 | 0.070 | 0.075 b | 0.048 | 0.061 | 0.054 | 0.054 c | 0.038 | 0.042 | 0.038 | 0.039 d |
| | 0.6% | 0.033 | 0.042 | 0.031 | 0.035 d | 0.029 | 0.030 | 0.026 | 0.028 de | 0.020 | 0.019 | 0.018 | 0.019 e |
| Root dry weight (g) | 0.0% | 0.054 | 0.040 | 0.042 | 0.045 | 0.045 | 0.028 | 0.033 | 0.035 | 0.025 | 0.020 | 0.029 | 0.025 |
| | 0.4% | 0.023 | 0.025 | 0.025 | 0.024 | 0.015 | 0.021 | 0.022 | 0.019 | 0.014 | 0.014 | 0.017 | 0.015 |
| | 0.6% | 0.020 | 0.019 | 0.019 | 0.019 | 0.014 | 0.013 | 0.014 | 0.014 | 0.009 | 0.007 | 0.009 | 0.009 |
| Whole seedling dry weight (g) | 0.0% | 0.217 | 0.0160 | 0.182 | 0.186 a | 0.197 | 0.143 | 0.158 | 0.166 b | 0.084 | 0.101 | 0.146 | 0.110 c |
| | 0.4% | 0.105 | 0.096 | 0.095 | 0.099 c | 0.062 | 0.082 | 0.076 | 0.074 d | 0.051 | 0.056 | 0.055 | 0.054 e |
| | 0.6% | 0.053 | 0.061 | 0.049 | 0.054 e | 0.042 | 0.044 | 0.041 | 0.042 ef | 0.029 | 0.026 | 0.027 | 0.027 f |

*Averages within rows or columns of soil salinity and available water of each character followed by the same letter are not significantly different according to Duncan's test.

S1, S2 and S3 (0.0, 0.4 and 0.6% salinity levels)  W1, W2 and W3 (100%, 50% and 20% available water)


Fig. 16 Interaction effect of soil salinity and drought conditions on shoot, root and whole seedling dry weight.

From the results of this experiment and especially Tables 8 and 9 (interaction between salinity and drought conditions) it can be seen that Falchetto had the lowest reduction (percentage of control) e.g. for fresh weight (77%) and whole seedling dry weight (66%) at the highest salinity level and the lowest available water content as compared with Shakha 62 (FW 83% and 74% dry weight) and Shakha 61 (fresh weight 87% and dry weight 81%). In this respect therefore Falchetto had the highest degree of drought tolerance than the other two cultivars under saline conditions. However in terms of absolute values one of the other two cultivars can in certain conditions of drought and salinity as noted earlier give better results than Falchetto.

Summary

A factorial experiment in randomized complete block design was carried out under growth chamber conditions (Temp. 20°C and 70% RH). Three wheat cultivars were grown in pots in soil adjusted to a range of salinities, viz. 0.0, 0.4 and 0.6% salts (based on soil dry weight). Moisture in pots was kept at 100% ($W_1$), 50% ($W_2$) and 20% ($W_3$) of the available water. All vegetative characters were affected significantly by salinity levels and moisture content levels except tiller number at all moisture levels, and in general all these characters tended to decrease with increasing salinity levels and decreasing available water content. Varietal effect was observed. Falchetto produced the highest leaf and tiller number with significant difference as compared with the other two cultivars Shakha 62 and 61 with no significant differences between cultivars for other characters. Under some adverse conditions Falchetto lost its superiority over the other two cultivars. The interaction between salinity levels and available water content affected only fresh weight, shoot and whole seedling dry weight. There were indications of salt induced drought acting in addition to the experimentally imposed drought.

# CHAPTER VI

## INCREASING SALT TOLERANCE OF SOME WHEAT CULTIVARS (*Triticum aestivum* L.)

### I. Effect of presoaking with some plant growth regulators on emergence and growth of three wheat cultivars under salinity conditions

#### Introduction

The effect of salinity on plants varies with the stage of their development. Generally the salt tolerance is greater in established plants than in germinating seeds (Sarin and Narayanan, 1968). Wheat is a plant which tolerates salinity less during germination than during later stages (Ashour *et al.*, 1977). The lower water potential in saline soils is caused by their higher soluble salt content. Water absorption by a seed depends upon the water potential gradient between it and the soil (Darra *et al.*, 1973). Any decrease in this gradient will decrease the rate of water intake into the seed which will affect germination and seedling growth (Uhvits, 1946; Ayers, 1952; Hunter and Ericksen, 1952). It has been suggested that a major effect of salinity in the root environment may be attributed to a reduced hormone delivery from root to leaves, which inhibits crop growth (Kessler, 1961 and Shah and Loomis, 1965) as quoted by Darra *et al.*, 1973. Presoaking seeds with optimal concentration of growth regulators has been shown to be beneficial to growth and yield of some crop species grown under saline conditions (Asana *et al.*, 1955; Dave and Gaur, 1970, Garg and Srivastav, 1970; Singh and Darra, 1971; Darra *et al*, 1973 and Bozcuk, 1981). The present study was undertaken to investigate the effects of presoaking wheat seeds in varying concentrations of some growth regulators upon their germination and early growth stages under different salinity levels.

I.A. Effect of presoaking with CCC and $GA_3$ on emergence and growth of three wheat cultivars under salinity conditions.

Materials and Methods:

This experiment was carried out in a controlled environment room (21°/17°C D/N; 16h day; 280 μmol $m^{-2} s^{-1}$ P.A.R.) and a complete randomized block design with three replicates was used. These were three levels of Nacl salinity viz, 0% 0.5% and 1% (0,5000 and 10,000 ppm Nacl). Two growth regulators (CCC and $GA_3$) were used at 0,250 and 500 ppm. Seeds of wheat cultivars (*Triticum aestivum* L.) Falchetto, Shakha 62 and Shakha 61 were soaked for 24 hrs at room temperature in petri dishes containing appropriate growth regulators solution at concentrations which are mentioned above. After the presoaking period, the seeds were surface dried on filter paper. Ten seeds selected at random from each treatment were sown in pots (7.6 cm diam) in vermiculite culture, in addition to dry seeds treatment as a control. Ten days after sowing, the following data were recorded:

1. Germination capacity
2. Shoot length (cm)
3. Root length (cm)
4. Shoot fresh weight (g)
5. Root number (Lateral roots)
6. Shoot dry weight (g)
7. Root dry weight (g)
8. Whole seedling dry weight (g)
9. Shoot/root ratio

## Results and discussion

### 1. Germination capacity of seeds;

Soil salinity depressed the germination of all wheat cultivars used and the reduction in germination increased with increase in level of salinity, but the degree of reduction at each level of salinity varied in different cultivars (Table 1 and Fig. 1). The semi-dwarf cultivar Falchetto had the highest value for germination capacity with significant difference compared with the other two cultivars (Table 1). Out of the three cultivars tested Shakha 62 and Shakha 61 showed almost similar reduction in germination capacity at the highest level of salinity but Falchetto was less sensitive at this level.

The presowing soaking of the seeds stimulated the germination process (Table 1 and Fig. 2). The germination started earlier in the seeds soaked in distilled water or CCC and $GA_3$ solutions as compared with the unsoaked seeds under all salinity levels. Data in Table 1 show there were significant differences betwen nonpretreated seeds (dry control) and the other pretreated seeds. However, there

Table (1) Effect of cycocel (CCC) and gibberellic acid ($GA_3$) directed presoaking on emergence and growth of three wheat cultivars (*Triticum aestivum* L.) under salinity conditions.

| Characters | Cultivars | | | Salinity levels (Nacl ppm) | | | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | 0 | 5000 | 10,000 | None (d.cont) | Dist H20 | CCC 250ppm | CCC 500ppm | GA3 250ppm | GA3 500ppm |
| Germination % | 97.8* a | 93.5 b | 91.7 b | 96.9 a | 94.5 ab | 91.5 b | 88.1 b | 93.3 a | 96.0 a | 97.1 a | 94.8 a | 96.6 a |
| Shoot length (cm) | 12.28 a | 10.55 b | 10.20 b | 13.86 a | 11.20 b | 7.98 c | 9.02 c | 10.98 b | 9.56 c | 9.45 c | 13.46 a | 13.61 a |
| Root length (cm) | 13.00 a | 11.81 b | 11.42 b | 16.17 a | 11.56 b | 8.49 c | 11.37 c | 12.17bc | 11.46 c | 11.67 c | 13.03 a | 12.75ab |
| Fresh weight (g) | 0.456 a | 0.332 b | 0.318 b | 0.466 a | 0.367 b | 0.272 c | 0.299 d | 0.378 b | 0.340 c | 0.353bc | 0.420 a | 0.423 a |
| Root number/ seedling | 4.89 | 4.94 | 4.85 | 4.83 | 4.93 | 4.93 | 4.72 | 4.92 | 4.91 | 5.09 | 4.81 | 4.94 |
| Shoot dry wt.(g) | 0.056 a | 0.047 b | 0.045 b | 0.058 a | 0.050 b | 0.040 c | 0.040 c | 0.052 b | 0.048 b | 0.049 b | 0.058 a | 0.050 b |
| Root dry wt. (g) | 0.043 b | 0.047 a | 0.045 b | 0.061 a | 0.042 b | 0.033 c | 0.040 b | 0.046 a | 0.045 a | 0.047 a | 0.047 a | 0.046 a |
| Whole seedling dry weight (g) | 0.105 a | 0.094 b | 0.088 c | 0.124 a | 0.091 b | 0.071 c | 0.079 c | 0.098ab | 0.093 b | 0.096 a | 0.104 a | 0.104 a |
| Shoot/root ratio | 1.431 a | 1.005 b | 1.036 b | 1.057 a | 1.203 b | 1.211 b | 1.082cd | 1.168bc | 1.103cd | 1.071 d | 1.240ab | 1.280 a |

*Averages within rows of cultivars or salinity levels or pretreatments followed by the same letter are not significantly different according to Duncan's test.

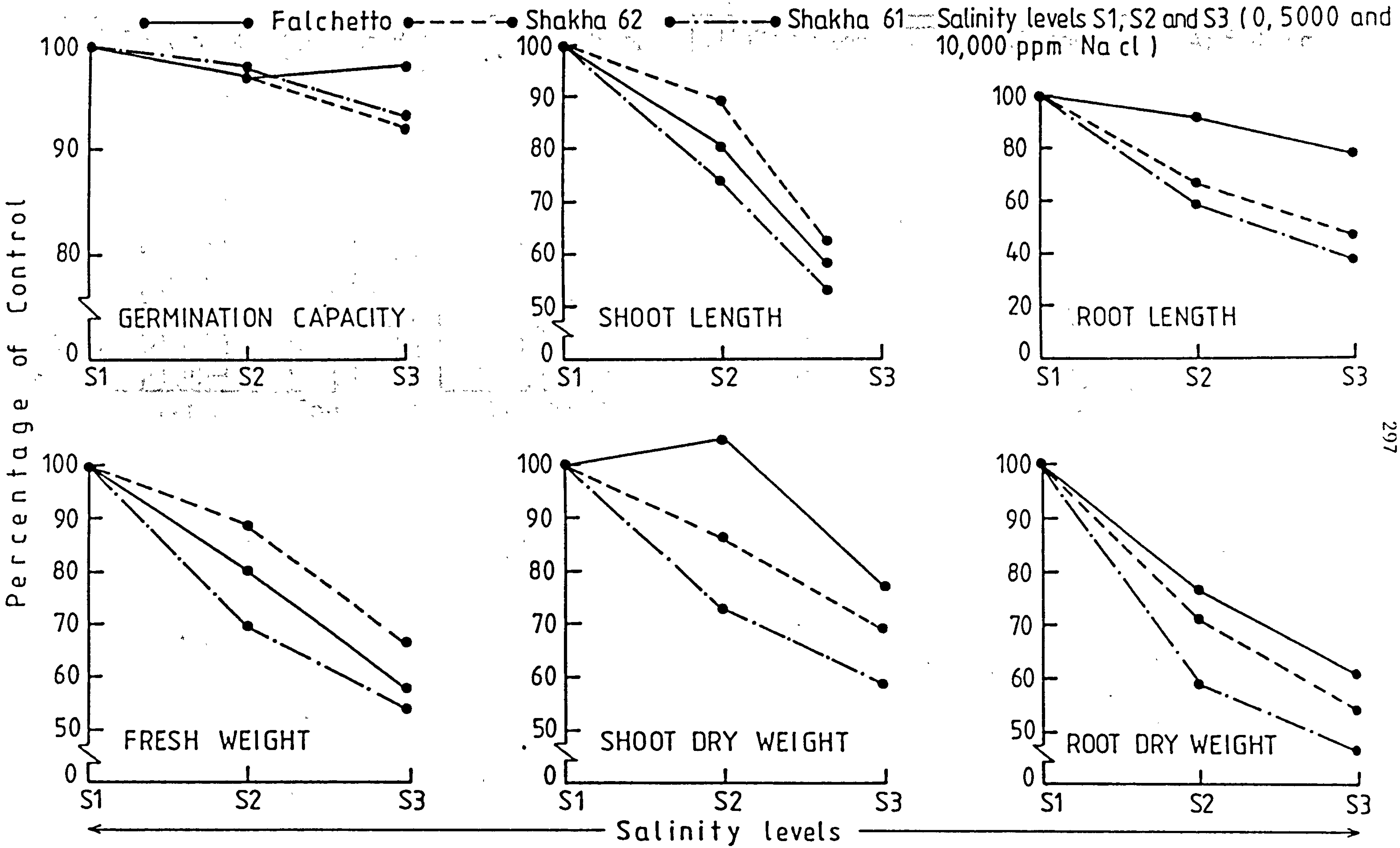



Fig. 1 Effect of different salinity levels on germination, shoot and root length, fresh weight and shoot and root dry weight.

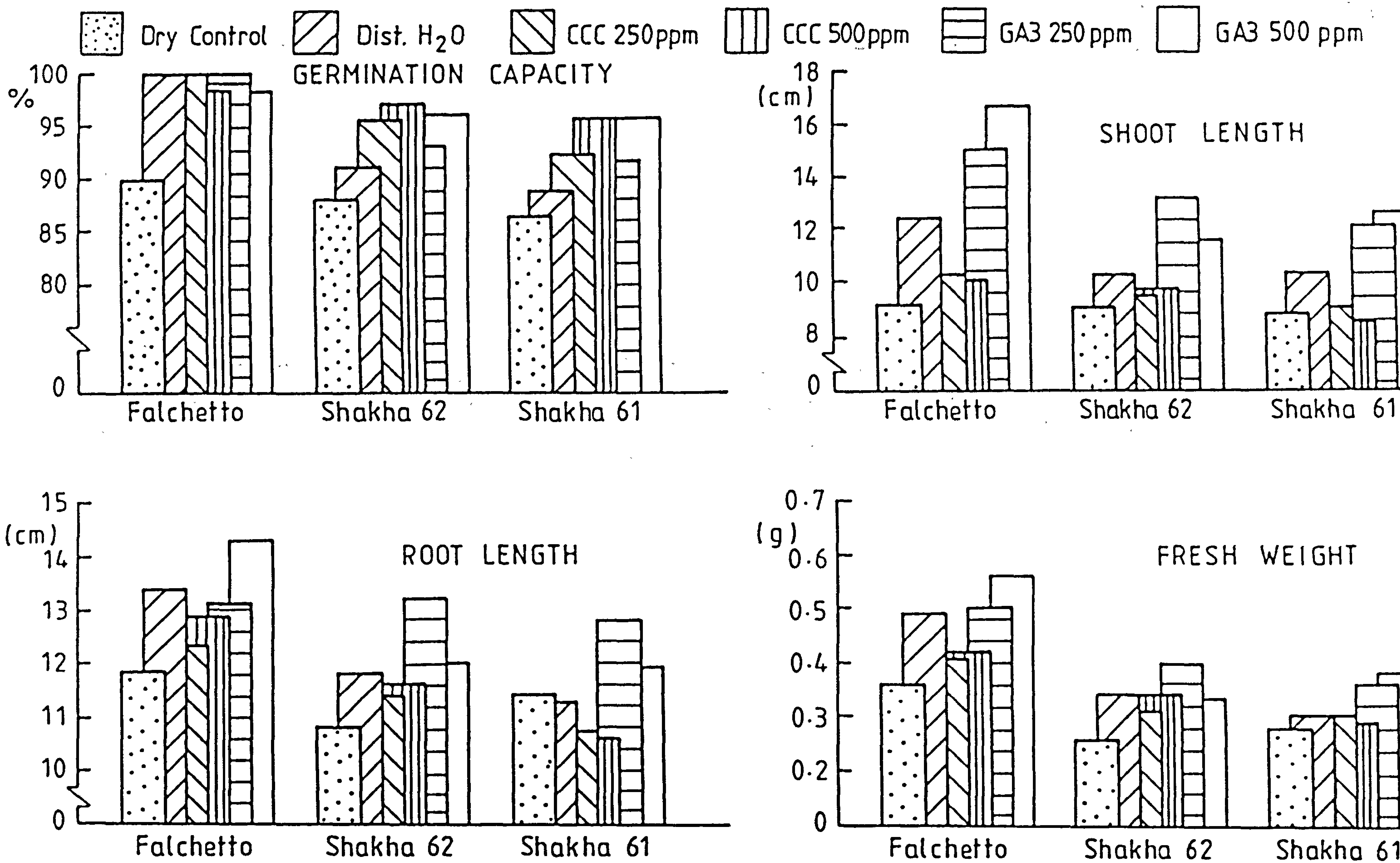



Fig. 2 Effect of cycocel and gibberellic acid-directed presoaking on germination, shoot and root length and fresh weight.

were no significant differences between the germination capacity of seeds pretreated with distilled water and those pretreated with CCC and $GA_3$ solutions. No significant interaction was obtained between salinity and presoaking treatments (Table 2 and Fig. 3), and this means that the effect of salinity and presoaking treatments on germination capacity were independent of each other. Similar findings have been reported by Sarin and Narayanan, 1968; Darra et al., 1970, 1973; Franke and Hassanein, 1976; Hana et al., 1978, Balki and Padole 1982 and Madan and Kumar, 1983. However, Shannon and Francois (1977) found that several pretreatments (11 seed pretreatment including growth regulators and salts) hastened germination of cotton seeds under salinity by at least one day over nontreated control. However, soaking in distilled water enhanced germination under saline conditions as much as any other pretreatment. Also, Bastianpillai et al. (1982) observed that $GA_3$ promoted germination under non saline conditions only and caused retarded germination under salt stress.

2. Shoot and root length, root number and shoot fresh weight

The analysis of variance for all these characters showed that there were highly significant differences between cultivars except for root number. The data obtained in table 1 and Figs 1 and 2 show that Falchetto had the highest value for shoot and root length and fresh weight with significant difference as compared with the other two cultivars. However, there was no significant difference between Shakha 62 and Shakha 61.

Table 1 and Fig. 1 demonstrate that increasing salinity

Table (2) : The effect of interaction between salinity and presoaking treatments with CCC and $GA_3$ on emergence and growth of three wheat cultivars (Triticum aestivum L.)

| Characters | Salinity Levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | CCC 250 ppm | CCC 500 ppm | $GA_3$ 250 ppm | $GA_3$ 500 ppm |
| Germination % | $S_1$ ** | 93.1 | 97.3 | 96.9 | 98.4 | 97.2 | 98.7 |
| | $S_2$ | 90.2 | 95.6 | 94.3 | 97.0 | 92.9 | 97.1 |
| | $S_3$ | 81.0 | 87.1 | 96.8 | 95.9 | 94.3 | 94.1 |
| Shoot length (cm) | $S_1$ | 12.94* c | 14.06 c | 11.79 d | 11.86 d | 15.59 b | 16.91 a |
| | $S_2$ | 9.11 f | 11.61 d | 9.44 f | 9.39 f | 13.91 c | 13.74 c |
| | $S_3$ | 4.99 h | 7.27 g | 7.46 g | 7.11 g | 10.89 de | 10.17 ef |
| Root length (cm) | $S_1$ | 16.02 b | 16.40 ab | 15.79 b | 14.03 c | 17.64 a | 17.13 ab |
| | $S_2$ | 10.97 de | 11.80 de | 10.49 ef | 11.59 de | 12.22 d | 12.29 d |
| | $S_3$ | 7.12 h | 8.31 gh | 8.10 gh | 9.39 fg | 9.21 fg | 8.82 g |
| Shoot fresh weight (g) | $S_1$ | 0.384 fg | 0.499 bd | 0.425 def | 0.455 bc | 0.488 bc | 0.548 a |
| | $S_2$ | 0.308 hi | 0.342 ef | 0.317 hi | 0.338 gh | 0.440 cde | 0.407 def |
| | $S_3$ | 0.204 k | 0.243 jk | 0.277 ij | 0.265 ij | 0.333 h | 0.314 hi |
| Root number per seedling | $S_1$ | 4.53 | 4.93 | 4.64 | 5.07 | 4.91 | 4.89 |
| | $S_2$ | 5.09 | 5.07 | 4.91 | 4.04 | 4.67 | 4.82 |
| | $S_3$ | 4.54 | 4.76 | 5.17 | 5.16 | 4.86 | 5.10 |

*Averages within rows or column of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)


Fig. 3 Interaction effect of different salinity levels and presoaking treatments with CCC and GA3 on germination percentage, shoot and root length.

progressively suppressed growth as shown by the declining values for all growth indices except root number (lateral roots), which was not affected by the salt under the conditions of this experiment.

It is evident from the data concerning all these characters except root number (Table 1 and Fig. 2) that $GA_3$ at the concentration of 250 ppm was the best pretreatment with significant difference as compared with the other pretreatments and dry seeds control. However, there was no significant difference between the two concentrations of $GA_3$. Cycocel had no significantly effect on the length of shoot or main root. Since cycocel is thought to act as an "anti-gibberellin", the decrease in shoot length compared with $GA_3$ and distilled water pretreatments was to be expected.

Highly significant interaction between salinity levels and presoaking treatments was obtained for shoot and root length and shoot fresh weight only (Table 2 and Figs. 3 and 4) indicating that for some characters presoaking with these plant growth regulators can reduce the deleterious effects of salinity. The highest values for shoot length, root length and shoot fresh weight were obtained at zero salinity and 500 and 250 ppm $GA_3$, respectively. However, there was no significant difference between 250 and 500 ppm for root length and the lowest values for these characters was obtained at 10,000 ppm salinity and non-presoaking treatment (dry control). At the highest level of salinity all presoaking treatments resulted in significantly longer shoots than the non-presoaked control and of these pre-treatments the two concentrations of $GA_3$ were most effective, whereas with root length only the higher CCC concentrations and the


Fig. 4 Interaction effect of different salinity levels and presoaking treatments with CCC and GA3 on fresh weight, root number per seedling and shoot / root ratio.

two concentrations of $GA_3$ resulted in significantly higher values than the dry control. With shoot fresh weight, all pre-treatments except distilled water gave higher values than the dry control. Therefore in the early stages of growth certain pre-soaking treatments can improve wheat plant performance under saline conditions. Similar results have been reported by El-Damaty et al., 1964; Darra et al., 1970, 1973; Roth, 1981; Bastianpillai et al., 1982; Madan and Kumar, 1983 and Pawar and Kadam, 1983. However, Sarim and Narayman (1968) showed that the application of the growth regulator $GA_3$ in salt solution slightly increased the coleoptile growth but that the length of the main root did not change. CCC depressed the length of the coleoptile and main root but a combined supply of $GA_3$ and CCC decreased coleoptile growth but less than CCC alone and growth of the main root was not affected.

3. Shoot, root and whole seedling dry weight and shoot/root ratio

It is apparent that the cultivars varied significantly in their dry weight of all plant parts and shoot/root ratio as evidenced by the data obtained in Table 1. Falchetto has significantly higher values than other two cultivars for all these characters except for root dry weight for which Shakha 62 had the highest value. However, there was no significant difference between Shakha 62 and Shakha 61 for shoot dry weight and shoot/root ratio or between Falchetto and Shakha 61 for root dry weight.

Data in Table 1 and Figs. 1 and 5 show that, in general,

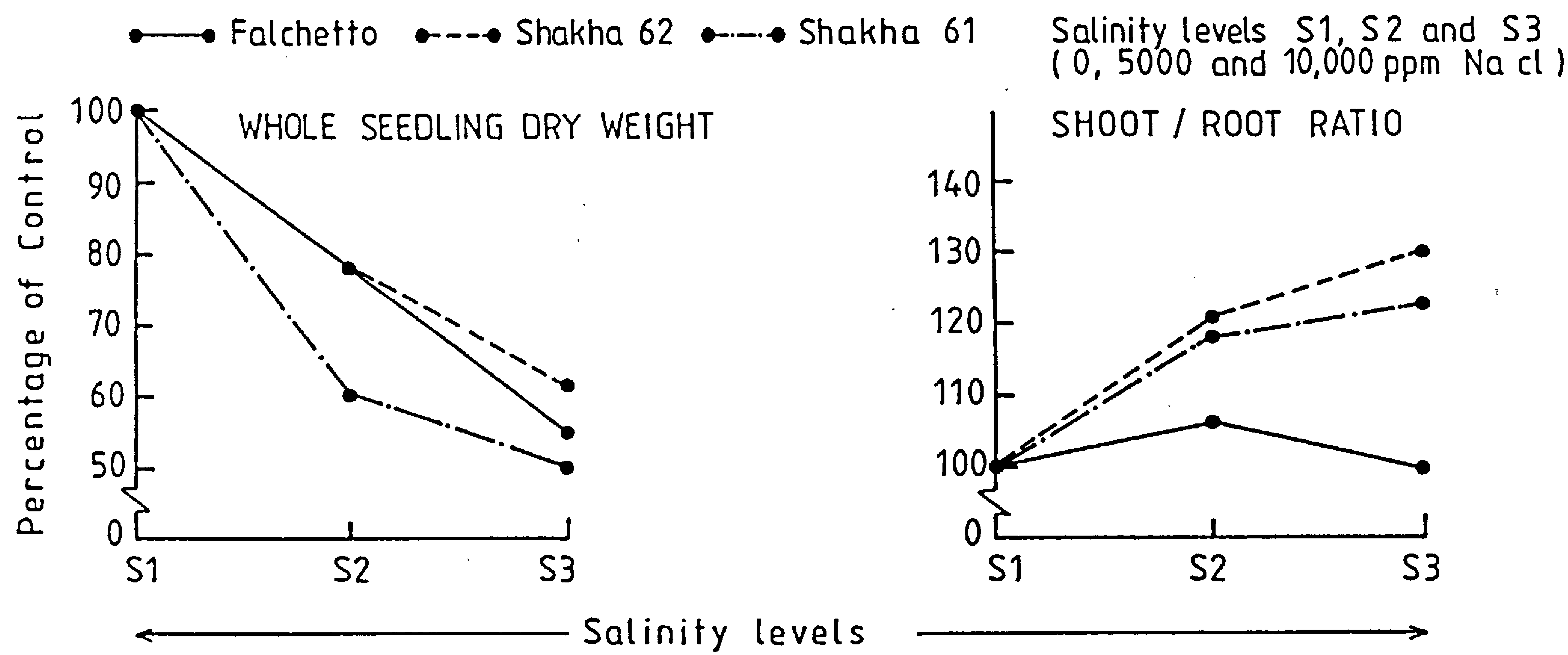



Fig. 5 Effect of different salinity levels on whole seedling dry weight and shoot/root ratio.

mean values for these characters decreased significantly with increasing salinity levels. However, there was no significant difference between 5000 and 10000 ppm Nacl for shoot/root ratio.

Presoaking of seeds in CCC and $GA_3$ solutions or in distilled water, generally significantly increased dry weight of all parts of the plant compared with non-presoaking of seeds (dry control), Table 1 and Fig. 6. $GA_3$ gave the highest shoot dry weight at 250 ppm and highest whole seedling dry weight and shoot/root ratio at both 250 and 500 ppm with significant difference as compared with the other pretreatments and dry control. However there were no significant differences between all pretreatments for root dry weight nor any significant differences between both concentrations of CCC and distilled water for shoot and whole seedling dry weight.

The interaction between salinity and presoaking treatments was highly significant only for shoot dry weight (Table 3 and Figs. 4 and 7). The highest shoot dry weight was obtained at zero salinity level (control) and with $GA_3$ at 250 ppm and the lowest shoot dry weight was obtained at 10,000 ppm Nacl salinity and with non-presoaking of seeds (dry control). At the highest salinity presoaking with CCC at 250 ppm and with $GA_3$ at 250 and 500 ppm resulted in significantly higher shoot dry weight than the dry control or pre-soaking with distilled water. This is further evidence that certain pre-soaking treatments can improve plant performance of wheat at these early stages of growth under saline conditions. These results are in harmony with those obtained by Nieman and Bernstein, 1959; Singh and Darra, 1971; Roth, 1981 and Madan and Kumar, 1983. However, Bastianpillai et al.


Fig. 6 Effect of cycocel and gibberellic acid-directed presoaking on shoot, root and whole seedling dry weight and shoot / root ratio.

Table (3) : The effect of interaction between salinity levels and presoaking treatments on dry matter production of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | CCC 250 ppm | CCC 500 ppm | $GA_3$ 250 ppm | $GA_3$ 500 ppm |
| Shoot dry wt. | $S_1$ ** | 0.046* fgh | 0.065 ab | 0.057 bcd | 0.061 abc | 0.068 a | 0.050 defg |
| | $S_2$ | 0.044 ghi | 0.054 cdef | 0.045 gh | 0.047 efgh | 0.058 bcd | 0.055 cde |
| | $S_3$ | 0.031 j | 0.035 ij | 0.041 ghi | 0.039 hij | 0.046 efgh | 0.044 gh |
| Root dry wt. (g) | $S_1$ | 0.054 | 0.064 | 0.063 | 0.063 | 0.061 | 0.062 |
| | $S_2$ | 0.038 | 0.044 | 0.038 | 0.043 | 0.045 | 0.043 |
| | $S_3$ | 0.028 | 0.029 | 0.034 | 0.035 | 0.036 | 0.034 |
| Whole seedling dry wt. (g) | $S_1$ | 0.106 | 0.130 | 0.120 | 0.123 | 0.130 | 0.137 |
| | $S_2$ | 0.078 | 0.099 | 0.083 | 0.090 | 0.100 | 0.098 |
| | $S_3$ | 0.053 | 0.064 | 0.075 | 0.074 | 0.082 | 0.078 |
| Shoot/root ratio | $S_1$ | 1.009 | 1.048 | 0.949 | 0.983 | 1.133 | 1.221 |
| | $S_2$ | 1.146 | 1.213 | 1.171 | 1.101 | 1.276 | 1.313 |
| | $S_3$ | 1.092 | 1.242 | 1.190 | 1.128 | 1.312 | 1.304 |

*Averages within rows or column of each characters followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)


Fig. 7 Interaction effect of different salinity levels and presoaking treatments on shoot, root and whole seedling dry weight.

(1982) found that $GA_3$ did not affect the dry matter of wheat shoots under saline conditions. Also, Pawar and Kadam (1983) observed that CCC significantly decreased shoot dry matter of wheat.

## I.B. Effect of presoaking with IAA and Kinetin on emergence and growth of three wheat cultivars under saline conditions

### Materials and Methods

The same procedure as in the previous section of this chapter was used to investigate the effects on the early growth of three wheat cultivars of presoaking with the auxin IAA and the cytokinin kinetin.

### Results and Discussion

#### 1. Germination capacity of seeds

The available data demonstrate clearly the inhibitory effect of increasing the salinity on germination capacity (Table 4). Results reveal that there was a progressive and consistent depression in this character due to the increase of salt concentration. Falchetto had the highest value for germination capacity with significant difference as compared with the other two cultivars. However there was no significant difference between Shakha 62 and Shakha 61 in this character (Fig. 8 and Table 4).

Germination capacity was highly significantly increased by all presoaking treatments (Table 4 and Fig. 9). Pretreatment with 250 ppm kinetin gave the highest germination capacity with significant

Table (4) : Effect of IAA and Kinetin - directed presoaking on emergence and growth of three wheat cultivars (<u>Triticum aestivum</u> L.) under salinity conditions

| Characters | Cultivars | | | Salinity levels (ppm) | | | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | 0 | 5000 | 10,000 | None (d.con.) | Dist. $H_2O$ | IAA 250 ppm | IAA 500 ppm | Kinetin 250 ppm | Kinetin 500 ppm |
| Germination % | 91.7* a | 87.0 b | 84.6 b | 94.3 a | 90.0 b | 79.1 c | 77.4 d | 85.2 c | 90.7 ab | 87.8 bc | 93.7 a | 91.9 ab |
| Shoot length (cm) | 10.89 | 10.51 | 10.63 | 12.49 a | 11.54 b | 8.0 c | 10.16 b | 11.21 a | 10.46 b | 9.49 c | 11.59 a | 11.16 a |
| Root length (cm) | 13.02 a | 9.79 b | 10.28 b | 14.53 a | 10.89 b | 7.66 c | 11.93 a | 12.76 a | 12.21 a | 9.84 b | 9.83 b | 9.62 b |
| Root number | 5.36 | 5.37 | 5.36 | 5.39 | 5.36 | 5.34 | 4.40 c | 4.88 b | 6.26 a | 6.49 a | 5.15 b | 5.00 b |
| Fresh weight (g) | 0.442 a | 0.312 c | 0.334b | 0.454 a | 0.383 b | 0.260 c | 0.309 c | 0.374 b | 0.381 b | 0.334 c | 0.415 a | 0.382 b |
| Shoot dry wt. (g) | 0.059 a | 0.048 c | 0.052 b | 0.066 a | 0.055 b | 0.038 c | 0.045 c | 0.053 b | 0.045 c | 0.040 d | 0.070 a | 0.066 a |
| Root dry wt. (g) | 0.054 a | 0.039 b | 0.042 b | 0.059 a | 0.044 b | 0.032 c | 0.042 c | 0.050ab | 0.053 a | 0.047 b | 0.041 c | 0.039 c |
| Whole seedling dry weight (g) | 0.120 a | 0.087 b | 0.094 b | 0.124 a | 0.106 b | 0.070 c | 0.086 b | 0.103 a | 0.097ab | 0.100ab | 0.110 a | 0.106 a |
| Shoot/root ratio | 1.119 b | 1.324 a | 1.331 a | 1.171 b | 1.340 a | 1.264 a | 1.064 b | 1.075 b | 0.883 c | 0.941bc | 1.801 a | 1.784 a |

*Averages within rows of cultivars or salinity levels or pretreatments followed by the same letter are not significantly different according to Duncan's test


Fig. 8 Effect of different salinity levels on germination, shoot and root length, fresh weight, and shoot and root dry weight.


Fig. 9 Effect of IAA and Kinetin – directed presoaking on germination, shoot and root length, and fresh weight.

difference as compared with the other pretreatments and the dry control. However, there was no significant difference between kinetin at concentrations of 250 ppm and 500 ppm or IAA at 250 ppm. Also, there was no significant difference between the two concentrations of IAA or between IAA at 500 ppm and distilled water pretreatments.

In contrast to pretreatment with $GA_3$ and CCC (previous section) the interaction between salinity levels and presoaking treatments with IAA and kinetin on germination capacity were highly significant (Table 5 and Fig. 10). The highest germination capacity was obtained with all pretreatments under zero salinity (control) and the lowest value was obtained with dry control and distilled water pretreatments under 10,000 ppm Nacl salinity. Highest germination at this level of salinity resulted from presoaking with 250 ppm kinetin, the value of 90% being not significantly different from those obtained at any presoaking treatment and zero salinity. Therefore presoaking with 250 ppm kinetin completely nullified the effect of 10,000 ppm salt on germination capacity of these cultivars. Distilled water and both concentrations of IAA and kinetin nullified the effect of 5000 ppm Nacl. Similar results were obtained by Darra et al., 1970, 1973; Babu and Kumar, 1975; Bozcuk, 1981; Balki and Padole, 1982 and Madan and Kumar, 1983. Roth (1981) showed that salt stress with 0.1 and 0.2% Nacl increased the germination period of wheat seeds to 3.5 - 4.4 and 6.5 - 7.6 days, respectively, compared with 3.1 - 3.3 days in the control. 500 - 1000 ppm kinetin reduced it to 3.8 - 3.9 and 5.3 - 5.4 days at the low and high salt levels, respectively. However, Shannon and Francois (1977) found that pretreatment with auxin (IAA) decreased

Table (5) : The interaction effect between salinity and presoaking treatments with IAA and kinetin on emergence and growth of three wheat cultivars (*Triticum aestivum* L.)

| Characters | Salinity levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | IAA 250 ppm | IAA 500 ppm | Kinetin 250 ppm | Kinetin 500 ppm |
| Germination Capacity | $S_1$** | 86.7* cde | 96.7 ab | 97.8 a | 92.2 abc | 96.7 ab | 95.6 ab |
| | $S_2$ | 81.1 e | 91.1 abc | 92.2 abc | 90.0 abc | 94.4 abc | 91.1 abc |
| | $S_3$ | 64.4 f | 67.8 f | 82.2 de | 81.1 e | 90.0 abc | 88.9 bcd |
| Shoot length (cm) | $S_1$ | 12.77 ab | 13.36 a | 12.68 ab | 10.31 c | 13.17 a | 12.69 ab |
| | $S_2$ | 11.83 b | 12.96 a | 10.74 bc | 9.92 cd | 11.92 b | 11.89 b |
| | $S_3$ | 5.87 g | 7.32 f | 7.97 ef | 8.24 ef | 9.69 cd | 8.89 de |
| Root length (cm) | $S_1$ | 16.69 a | 16.51 a | 16.71 b | 11.74 c | 12.90 bc | 12.61 bc |
| | $S_2$ | 12.42 bc | 13.88 b | 11.49 c | 9.49 d | 9.31 d | 8.78 de |
| | $S_3$ | 6.67 f | 7.88 def | 8.42 de | 8.28 de | 6.28 ef | 7.46 ef |
| Root number per seedling | $S_1$ | 4.27 | 5.36 | 6.01 | 6.61 | 5.07 | 5.02 |
| | $S_2$ | 4.69 | 4.62 | 6.53 | 6.33 | 5.14 | 4.84 |
| | $S_3$ | 4.24 | 4.66 | 6.23 | 6.51 | 5.23 | 5.13 |
| Shoot fresh weight (g) | $S_1$ | 0.416 cd | 0.474 b | 0.448 bc | 0.365 de | 0.552 a | 0.474 b |
| | $S_2$ | 0.335 ef | 0.414 cd | 0.401 cd | 0.365 de | 0.401 cd | 0.389 de |
| | $S_3$ | 0.177 i | 0.235 h | o.294 fg | 0.272 gh | 0.292 fg | 0.291 fg |

*Averages within column or row of each character followed by the same letter are not significantly different according to Duncan's test.

**$S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)


Fig. 10 Interaction effect of different salinity levels and presoaking treatments with IAA and Kinetin on germination percentage, shoot and root length.

the germination rate of cotton seeds to the level of dry control or lower. Also, Bastianpillai et al. (1982) reported that auxin (I.NAA) and cytokinin (Kinetin, 6-FAP) caused retarded germination in wheat seeds.

2. Shoot and root length, root number and shoot fresh weight

Table 4 and Fig. 8 show that all these characters except root number generally decreased with increasing salinity levels. The semi-dwarf cultivar Falchetto had the highest values with significant difference for root length and fresh weight. However there was no significant difference between Shakha 62 and 61 for root length (Table 4).

There were highly significant affects due to presoaking treatments in all these characters. Kinetin at both concentrations and distilled water gave the highest shoot length with significant differences as compared with other treatments. IAA at 500 ppm gave the lowest shoot length of all treatments. However there was no significant difference between IAA at 250 ppm and the dry control. Both concentrations of kinetin and IAA at 500 ppm decreased root length significantly as compared with the other pretreatments and dry control. However, there were no significant differences between the other treatments. Numbers of roots were increased by all pretreatments with significant differences as compared with dry control and IAA at both concentrations produced the highest number of roots. Kinetin at 250 ppm gave the highest fresh weight with significant differences as compared with the other pretreatments and the dry control.

However there were no significant differences between kinetin at 500 ppm, IAA at 250 ppm and distilled water or between IAA at 500 ppm and the dry control (Table 4 and Fig. 9).

Highly significant interaction was obtained between salinity levels and presoaking treatments for shoot length, root length and fresh weight. The highest values for shoot length, root length and fresh weight were obtained at zero salinity with distilled water, dry control and 250 ppm kinetin, respectively. The lowest values for these characters were obtained at 10,000 ppm Nacl and with dry control only (Table 5 and Figs. 10-11). At 10,000 ppm the effects of salinity on shoot length were reduced, but not nullified, by any of the treatments imposed, the most successful of these being 250 ppm kinetin. At 5000 ppm however all treatments except 250 ppm kinetin nullified the saline effect. Pretreatment was relatively ineffective on root length in that no pretreatment nullified the effect of 5000 ppm Nacl and at 10,000 ppm some (distilled water and 250 and 500 ppm kinetin) were not better than the dry control. With shoot fresh weight, 250 ppm IAA nullified the effect of 5000 ppm Nacl, distilled water and 250 ppm kinetin reduced the effect and 500 ppm IAA and kinetin were ineffective. At 10,000 ppm Nacl all pretreatments reduced the effects of salt, but only to a small extent. Similar findings have been reported by Darra _et_ _al_., 1971, 1973; Babu and Kumar, 1975; Roth, 1981 and Bastianpillai _et_ _al_., 1982. However, Madan and Kumar (1983) reported that IAA mitigated the effects of salinity on shoot and root growth at the lower salt levels.


Fig. 11 Interaction effect of different salinity levels and presoaking treatments of IAA and Kinetin on root number per seedling, fresh weight and shoot / root ratio.

3. Shoot, root and whole seedling dry weight and shoot/root ratio

The results given in Table 4 show that all these characters were affected significantly by salinity and growth regulators. In general, all these characters tended to decrease with increasing salinity levels with the exception of shoot/root ratio for which the opposite was true (Figs. 8 and 12). Falchetto produced the highest dry weight for all these characters with significant difference as compared with the other two cultivars and the opposite was true for shoot/root ratio. However there was no significant difference between Shakha 62 and Shakha 61 for all these characters except shoot dry weight of which Shakha 62 had the lowest value Table (4).

Table 4 and Fig. 13 indicate that kinetin at both concentrations produced the highest shoot and whole seedling dry weights and the highest values for shoot/root ratio, while IAA at 250 ppm produced the highest root dry weight with significant differences as compared with the other presoaking treatments and the dry control.

The interaction between salinity levels and presoaking treatments was highly significant for shoot dry weight only. The highest shoot dry weight was produced at both kinetin concentrations under zero salinity and the lowest shoot dry weight produced with dry control under 10,000 ppm Nacl salinity (Table 6 and Figs. 11 and 14). Pretreatment nullified the effect of salinity in only one case: 500 ppm IAA at 5,000 ppm Nacl. At that salinity, however, presoaking with distilled water and with both concentrations of kinetin reduced the effects of salinity. At 10,000 ppm all pre-treatments except IAA at

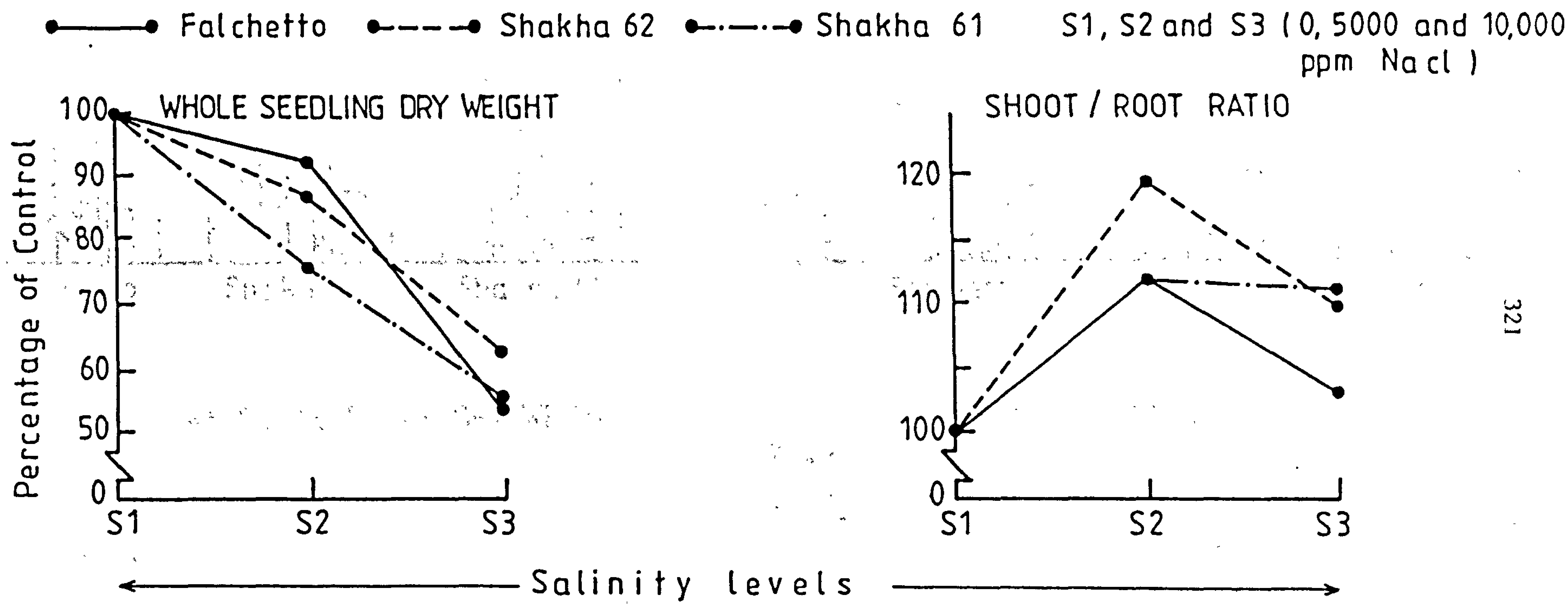



Fig. 12 Effect of different salinity levels on whole seedling dry weight and shoot / root ratio.


Fig. 13 Effect of IAA and Kinetin-directed presoaking on shoot, root and whole seedling dry weight and shoot / root ratio.

Table (6) : The interaction effect between salinity and presoaking treatments with IAA and kinetin on dry matter production of three wheat cultivars (Triticum aestivum L.)

| Characters | Salinity levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | IAA 250 ppm | IAA 500 ppm | Kinetin 250 ppm | Kinetin 500 ppm |
| Shoot dry wt. (g) | $S_1$** | 0.058* cd | 0.067 b | 0.054 de | 0.046 fg | 0.087 a | 0.082 a |
| | $S_2$ | 0.051 defg | 0.057 cd | 0.047 efg | 0.046 g | 0.069 b | 0.063 bc |
| | $S_3$ | 0.026 i | 0.034 h | 0.033 h | 0.028 hi | 0.053 def | 0.053 de |
| Root dry wt. (g) | $S_1$ | 0.056 | 0.065 | 0.067 | 0.058 | 0.056 | 0.051 |
| | $S_2$ | 0.044 | 0.050 | 0.052 | 0.046 | 0.038 | 0.035 |
| | $S_3$ | 0.025 | 0.033 | 0.039 | 0.038 | 0.028 | 0.030 |
| Whole seedling dry wt. (g) | $S_1$ | 0.112 | 0.133 | 0.120 | 0.104 | 0.143 | 0.133 |
| | $S_2$ | 0.095 | 0.108 | 0.099 | 0.131 | 0.107 | 0.098 |
| | $S_3$ | 0.049 | 0.067 | 0.072 | 0.066 | 0.081 | 0.086 |
| Shoot/root ratio | $S_1$ | 1.047 | 1.041 | 0.827 | 0.906 | 1.568 | 1.636 |
| | $S_2$ | 1.143 | 1.146 | 0.899 | 1.062 | 1.913 | 1.878 |
| | $S_3$ | 1.002 | 1.039 | 0.922 | 0.857 | 1.923 | 1.838 |

* Averages within column or rows of each character followed by the same letter are not significantly different according to Duncan's test.

** $S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl)

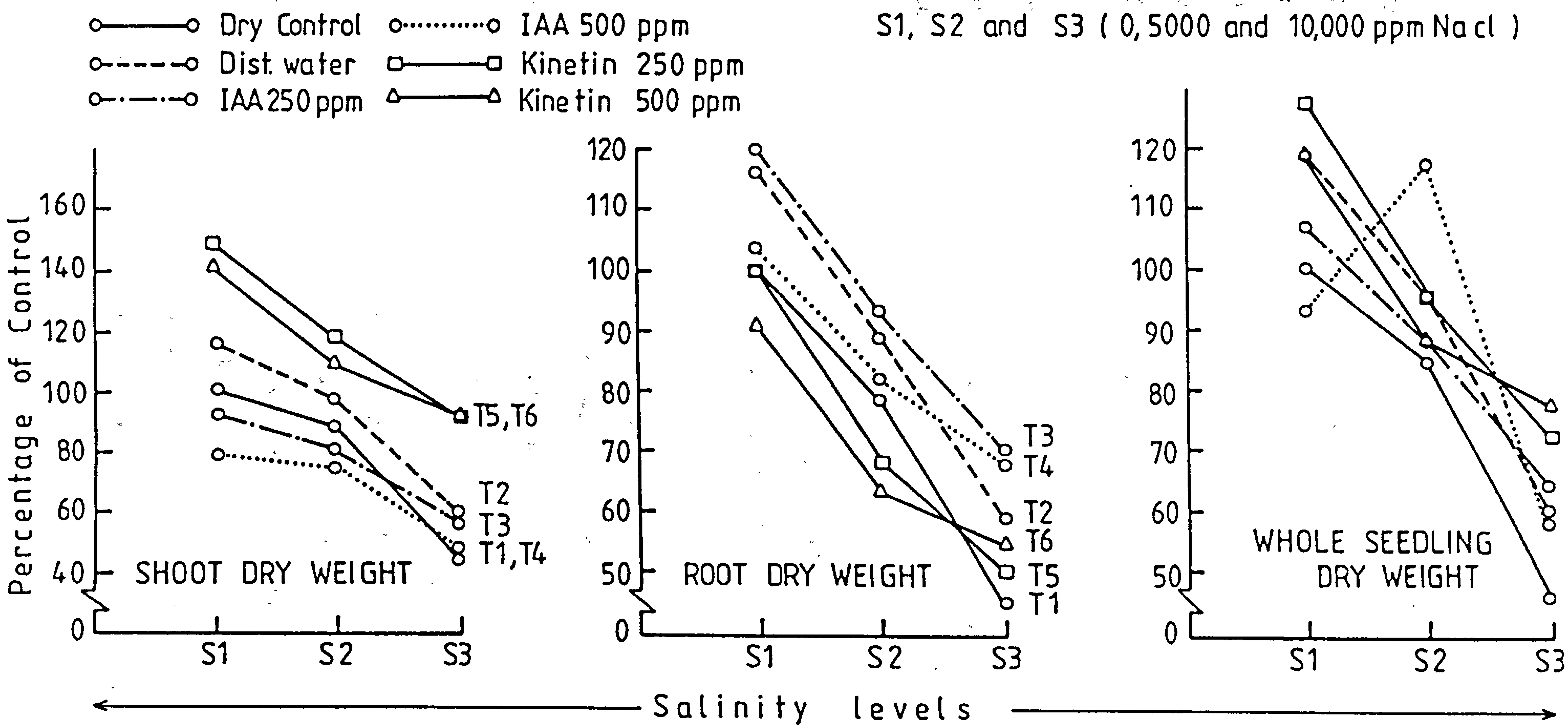



Fig. 14 Interaction effect of different salinity levels and presoaking treatments of IAA and Kinetin on shoot, root and whole seedling dry weight.

500 ppm successfully reduced the effects of salt, both concentrations of kinetin being more effective than the other two successful pretreatments. Similar results have been reported by Babu and Kumar, 1975; Ashour et al., 1977; Roth, 1981 and Bastianpillai et al., 1982. However, Singh and Darra (1971) found that IAA increased the dry weight of wheat shoots significantly under saline conditions and the best treatment was IAA at 200 ppm, in which gave a 64% increase in the dry weight of shoots. Also, Kumar and Singh (1980) reported that treatment with presoaking of wheat seeds in irrigation water for 4 or 8 hours did not give significant effects on dry matter production.

## II. Effect of salt (Nacl and Cacl2) pretreatments on germination and growth of the wheat cultivars (*Triticum aestivum* L.)

### Introduction

Investigations carried out by many authors have shown that presowing treatment of seeds with saline solutions induces marked changes in the physiology of the embryo and increases its resistance to the harmful effect of salts. As a result of these changes the ability to germinate of seeds treated in this way, as compared to untreated seeds, increases markedly and the plants adapt more easily and quickly to conditions of salinity in the soil (Strogonov, 1964). Pretreatment of wheat and cotton seeds with salt solutions prior to sowing on saline soils has been reported to increase production by as much as 30 per cent (Henckel and Strogonov, 1961). Sodium chloride pretreatments were reported to give beneficial results when the grains were planted on soils high in chlorides, while sulphate pretreated grains grow better on sulphate dominated soils. Chaudhuri and Wiebe (1968) reported that $Cacl_2$ pretreatments increased wheat germination in Nacl medium. Interestingly, and perhaps significantly, presoaking salt hardening of wheat seeds with a different ion species from that which dominates in the soil can be effective. For example, presoaking in boric acid seems to be an effective method of increasing both the germination capacity of wheat seeds and the salt tolerance of the developed seedlings under chloride saline conditions (Ashour et al., 1977).

## Materials and Methods

This experiment was carried out in a controlled environment room (21°C/17°C D/N; 16h day; 280 μmol $m^{-2}s^{-1}$ P.A.R.) and a complete randomized block design with three replicates was used. Three levels of Nacl salinity, viz 0%, 0.5 and 1% (0, 5000 and 10,000 ppm Nacl) were used to salinise the growth medium. Two salts (Nacl and $Cacl_2$) at 0, 0.25 and 0.5% were used as presowing soaking treatments. Wheat seeds (*Triticum aestivum* L.) of cultivars Falchetto, Shakha 62 and Shakha 61 were soaked for 24 hrs at room temperature in petri dishes containing appropriate salt solution at the concentrations given above. After the presoaking period, the seeds were surface dried on filter paper. Ten seeds selected at random from each treatment were grown in pots (7.6 cm diam) in vermiculite culture, in addition to dry seeds treatment as a control. Ten days after sowing, the following data were recorded.

1. Germination capacity
2. Shoot length (cm)
3. Root length (cm)
4. Shoot fresh weight (g)
5. Root number per seedling
6. Shoot dry weight (g)
7. Root dry weight (g)
8. Whole seedling dry weight (g)
9. Shoot/root ratio

## Results and Discussion

### 1. Germination capacity of seeds

Table 7 and Fig. 15 show that the germination capacity of wheat seeds decreased significantly with increasing salinity, but without significant difference up to 5,000 ppm Nacl. Falchetto had the highest capacity of seed germination with significant difference and the Shakha 61 had the lowest. The presowing salt hardening of seeds with Nacl and $Cacl_2$ at both concentrations could overcome to some extent the retarding effect of chloride salinity on seed germination as compared with distilled water soaked and dry seeds controls (Table 7 and Fig. 17). Although there was no significant interaction between salinity and presoaking treatments for germination capacity, the pretreatment with salt solutions increased the germination capacity of wheat seeds under salinity conditions as compared with dry seeds control, but the trend was not marked enough to reach the 5% significance level (Table 8 and Fig. 18). These results are in harmony with those obtained by Chaudhuri and Wiebe (1964), Cocks and Donald (1973), Idris and Aslam (1975), Ashour et al.

Table (7) : Effect of presoaking of seeds with Nacl and $Cacl_2$ on emergence and growth of three wheat cultivars (<u>Triticum aestivum</u> L.) under salinity conditions

| Characters | Cultivars | | | Salinity levels (ppm) | | | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Falchetto | Shakha 62 | Shakha 61 | 0 | 5000 | 10,000 | None (d.con.) | Dist. $H_2O$ | Nacl 0.25% | Nacl 0.5% | $Cacl_2$ 0.25% | $Cacl_2$ 0.5% |
| Germination Capacity | 96.7* a | 94.1 b | 91.1 c | 96.7 a | 95.6 a | 89.6 b | 88.9 b | 91.1 b | 96.7 a | 95.2 a | 95.9 a | 95.9 a |
| Shoot length (cm) | 15.5 a | 13.5 b | 12.8 c | 16.2 a | 14.7 b | 11.0 c | 12.2 d | 12.8 c | 14.7 a | 14.1 b | 14.9 a | 15.1 a |
| Root length (cm) | 18.9 a | 13.1 c | 17.2 b | 22.9 a | 15.7 b | 10.5 c | 14.7 b | 15.7 ab | 17.4 a | 16.6 a | 17.3 a | 16.6 a |
| Root number | 5.27 a | 5.02 b | 4.8 c | 4.90 b | 5.06 a | 5.13 a | 4.41 d | 4.69 c | 5.37 a | 5.26ab | 5.16 b | 5.29 ab |
| Fresh weight (g) | 0.684 a | 0.471 b | 0.423 c | 0.653 a | 0.541 b | 0.383 c | 0.428 d | 0.472 c | 0.588 a | 0.526 b | 0.559 a | 0.582 a |
| Shoot dry wt. (g) | 0.091 a | 0.065 b | 0.058 c | 0.086 a | 0.074 b | 0.054 c | 0.059 d | 0.065 c | 0.078 a | 0.070 b | 0.076 a | 0.080 a |
| Root dry wt. (g) | 0.061 a | 0.050 b | 0.050 b | 0.071 a | 0.054 b | 0.036 c | 0.044 d | 0.051 c | 0.060 a | 0.053bc | 0.057ab | 0.057ab |
| Whole seedling dry weight (g) | 0.152 a | 0.116 b | 0.108 c | 0.158 a | 0.127 b | 0.091 c | 0.104 c | 0.118 b | 0.138 a | 0.123 b | 0.133 a | 0.136 a |
| Shoot/root ratio | 1.504 a | 1.359 b | 1.238 c | 1.218 c | 1.393 b | 1.489 a | 1.390 | 1.309 | 1.349 | 1.323 | 1.394 | 1.435 |

*Averages within rows of cultivars or salinity levels or presoaking treatments followed by the same letter are not significantly difference according to Duncan's test.


Fig. 15 Effect of different salinity levels on germination, shoot and root length, fresh weight and shoot and root dry weight.


Fig. 17 Effect of Na cl and Ca $cl_2$-directed presoaking on germination, shoot and root length and fresh weight.

Table (8) : The effect of interaction between salinity and presoaking treatments with Nacl and $Cacl_2$ on emergence and growth of three wheat cultivars (<u>Triticum aestivum</u> L.)

| Characters | Salinity levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | Nacl 0.25% | Nacl 0.5% | $Cacl_2$ 0.25% | $Cacl_2$ 0.5% |
| Germination Capacity | $S_1$ | 94.4 | 94.4 | 98.9 | 95.6 | 98.9 | 97.8 |
| | $S_2$ | 92.2 | 93.3 | 97.8 | 96.7 | 98.8 | 95.6 |
| | $S_3$ | 80.0 | 85.6 | 93.3 | 93.3 | 91.1 | 94.4 |
| Shoot length (cm) | $S_1$ | 14.5 | 15.2 | 17.2 | 15.6 | 17.0 | 17.4 |
| | $S_2$ | 13.0 | 13.4 | 15.3 | 15.0 | 15.9 | 15.4 |
| | $S_3$ | 9.0 | 9.6 | 11.5 | 11.6 | 11.8 | 12.5 |
| Root length (cm) | $S_1$ | 20.8 | 22.5 | 24.9 | 23.4 | 24.5 | 21.4 |
| | $S_2$ | 13.6 | 15.3 | 16.0 | 15.1 | 16.6 | 17.7 |
| | $S_3$ | 9.5 | 9.3 | 11.4 | 11.4 | 10.8 | 10.7 |
| Root number | $S_1$ | 4.38* i | 4.73 g | 5.13 de | 4.83 fg | 5.00 ef | 5.30 bcd |
| | $S_2$ | 4.40 i | 4.64 ghi | 5.51 ab | 5.33 abcd | 5.18 cde | 5.29 bcd |
| | $S_3$ | 4.44 hi | 4.68 gh | 5.47 abc | 5.60 a | 5.29 bcd | 5.29 bcd |
| Fresh weight (g) | $S_1$ | 0.522 | 0.618 | 0.742 | 0.639 | 0.680 | 0.716 |
| | $S_2$ | 0.461 | 0.474 | 0.601 | 0.540 | 0.596 | 0.575 |
| | $S_3$ | 0.301 | 0.323 | 0.42 | 0.397 | 0.402 | 0.454 |

* Averages within rows or column of salinity levels or pretreatments followed by the same letter are not significantly different according to Duncan's test.

** $S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl salinity)


Fig. 18 Interaction effect of different salinity levels and presoaking treatments with Nacl and $CaCl_2$ on germination percentage, shoot and root length.

(1977). However, Chaudhuri and Wiebe (1968) reported that germination of water pretreated wheat seeds on 1% Nacl was 8 per cent, while pretreatment with 1% $Cacl_2.2H_2O$ resulted in 90 per cent germination on 1% Nacl. Pretreatment with sodium and potassium chlorides enhanced germination only slightly. Also, Shannon and Francois (1978) found that soaking cotton seeds in distilled water enhanced germination under saline conditions as much as any other pretreatment.

2. <u>Shoot, root length, root number and shoot fresh weight</u>

The data obtained concerning the shoot length, root length, root number and fresh weight (Table 7 and Fig. 15) indicated that there were significant effects due to salinity levels and all these characters except root number reduced with increasing salinity levels and the opposite is true for roots number. Falchetto had significantly the highest values for all these characters as compared with the other cultivars and Shakha 61 had the lowest values except for root length of which Shakha 62 had the lowest value.

The effects of different concentrations of Nacl and $Cacl_2$ as a presowing treatment on all these characters are presented in Table 7 and Fig. 17. These measurements were generally increased by presoaking treatments. Presoaking with $Cacl_2$ at both concentrations and Nacl at 0.25% gave the highest values for shoot length and fresh weight with significant difference as compared with the other presowing treatments. Nacl at both concentrations and $Cacl_2$ at 0.5% gave the highest root number, but for root length there were no significant differences among all presoaking treatments.

Highly significant interaction between salinity and presoaking treatments was obtained for root number only. However, under all levels of salinity all these characters increased with all presoaking treatment as compared with dry control, but the trend was not marked enough to reach the 5% significance level (Table 8 and Fig. 18-19). In contrast to the significant interactions of plant growth regulators with salinity of the growing medium which reduced or even nullified the deleterious effect of salinity, presoaking with some saline solutions interacted with increasing concentration of salt in the growth medium such that root number increased, the highest value being 5.6 at 10,000 ppm Nacl after presoaking in 0.5% Nacl. Distilled water and $Cacl_2$ at 0.5% did not however show this positive, stimulatory effect. Certain salt pre-treatments can therefore interact to stimulate the number of roots produced in a saline growth medium. Similar findings have been reported by Henckel, 1960; Idris and Aslam, 1975; Ashour et al., 1977 and Pawar and Kadam, 1983. However, Idris and Aslam (1975) reported that root and shoot growth and fresh weight of seedlings grown from treated seeds was accelerated by presowing soaking treatments in water or $Cacl_2$ under saline conditions but not under normal conditions.

3. Shoot, root and whole seedling dry weight and shoot/root ratio

It is apparent that cultivars differed significantly in all these characters under salinity conditions as evidenced in table 7 and Figs. 15-16. Generally, all these characters except shoot/root ratio decreased with increasing salinity levels and the opposite is true

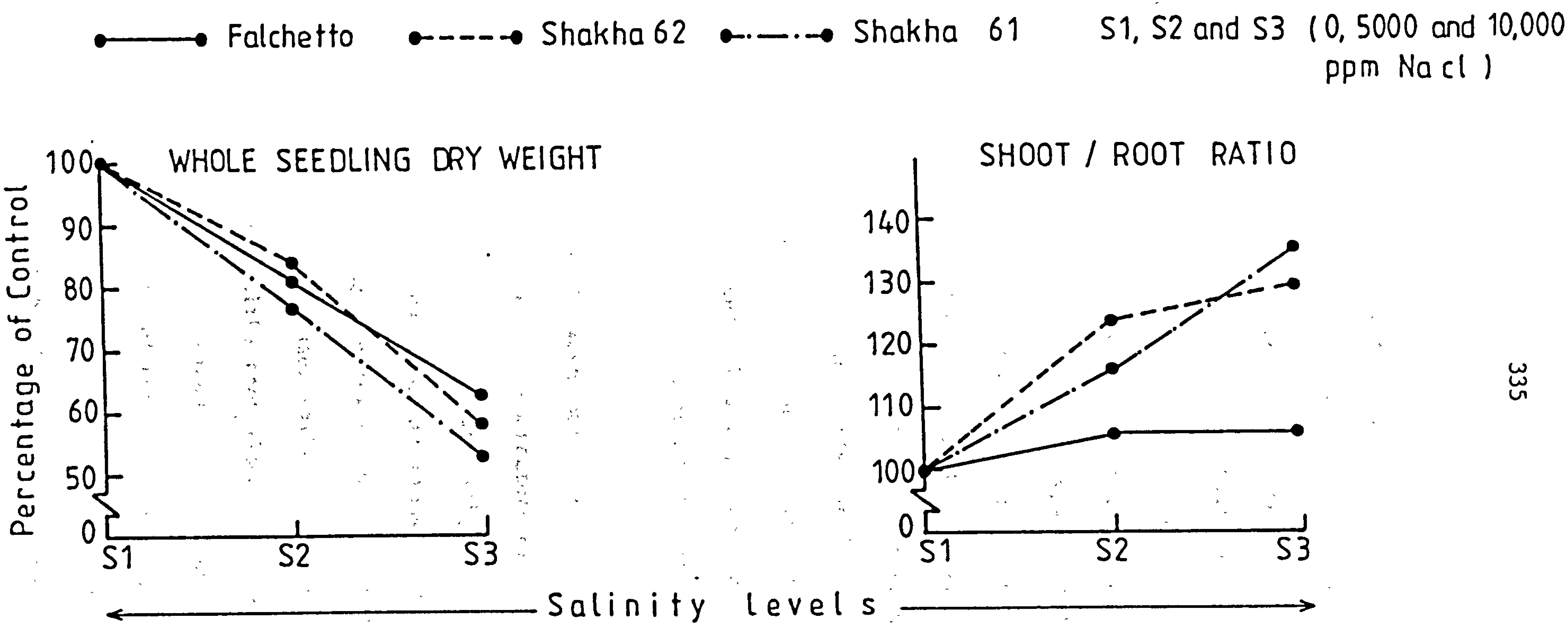



Fig. 16 Effect of different salinity levels on whole seedling dry weight and shoot / root ratio.

for shoot/root ratio. Falchetto produced the highest dry weight for all parts of the plant and the highest shoot/root ratio with significant difference as compared with the other two cultivars. The increase of 30% in shoot/root ratio of Shakha 62 and 61 over Falchetto at 10,000 ppm Nacl (Fig. 16) may be explained by Falchetto's higher root dry weights compared with the other two cultivars (0.046, 0.032, 0.031g for Falchetto, Shakha 62 and 61, respectively).

Highly significant effects on dry matter production by all plant parts were obvious due to presoaking treatments, (Table 7 and Fig. 20). $Calcl_2$ pretreatment at both concentrations and Nacl at 0.25% produced the highest values of dry matter production by all plant parts with significant differences as compared with the other pretreatments and the dry control. In general all presoaking treatments increased dry matter production with significant difference as compared with the dry control.

The interaction between salinity and presoaking treatments was highly significant for all characters except shoot/root ratio. The highest shoot dry weight, root dry weight and whole seedling dry weight were obtained at both concentrations of $Cacl_2$ and 0.25% Nacl under nomral conditions and the lowest dry weight for all these parts were obtained at dry control under highest salinity level (Table 9 and Fig. 19 and 21). While, unlike root number, there was no stimulatory interaction, many salt pre-treatments interacted with salinity of the growth medium such that its effects were reduced. In only one case (shoot dry weight, 0.25% Cacl ; 5,000 ppm), however, was the effect nullified. All salt treatments except 0.5% Nacl at 5,000 ppm Nacl

Table (9) : The effect of interaction between salinity and presoaking treatments with Nacl and $Cacl_2$ on dry matter production of three wheat cultivars (<u>Triticum aestivum</u> L.)

| Characters | Salinity levels | Presoaking treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | None (dry cont.) | Dist. $H_2O$ | Nacl 0.25% | Nacl 0.5% | $Cacl_2$ 0.25% | $Cacl_2$ 0.5% |
| Shoot dry wt. (g) | $S_1$** | 0.072*ef | 0.081 cd | 0.094 ab | 0.083 cd | 0.089 bc | 0.100 a |
| | $S_2$ | 0.065 fg | 0.066 fg | 0.082 cd | 0.071 ef | 0.083 cd | 0.075 de |
| | $S_3$ | 0.042 i | 0.048 ij | 0.059 gh | 0.056 hi | 0.055 hi | 0.065 fg |
| Root dry wt. (g) | $S_1$ | 0.056 de | 0.068 c | 0.080 a | 0.069 bc | 0.076 ab | 0.078 a |
| | $S_2$ | 0.046 fg | 0.051 ef | 0.058 de | 0.052 ef | 0.060 d | 0.053 def |
| | $S_3$ | 0.030 i | 0.034 hi | 0.040 gh | 0.039 h | 0.035 hi | 0.040 gh |
| Whole seedling dry weight (g) | $S_1$ | 0.128 de | 0.149 c | 0.175 a | 0.152 bc | 0.165 ab | 0.178 a |
| | $S_2$ | 0.111 fgh | 0.118 efg | 0.140 cd | 0.123 ef | 0.143 c | 0.127 de |
| | $S_3$ | 0.072 k | 0.087 j | 0.099 hij | 0.094 ij | 0.090 ij | 0.104 ghi |
| Shoot/root ratio | $S_1$ | 1.299 | 1.197 | 1.181 | 1.189 | 1.171 | 1.272 |
| | $S_2$ | 1.504 | 1.279 | 1.392 | 1.366 | 1.394 | 1.421 |
| | $S_3$ | 1.368 | 1.451 | 1.474 | 1.414 | 1.617 | 1.612 |

*Averages within rows or column of salinity or pretreatments followed by the same letter are not significantly different according to Duncan's test.

** $S_1$, $S_2$ and $S_3$ (0, 5000 and 10,000 ppm Nacl salinity)


Fig. 19 Interaction effect of different salinity levels and presoaking treatments with Nacl and $CaCl_2$ on root number per seedling, fresh weight and shoot / root ratio.

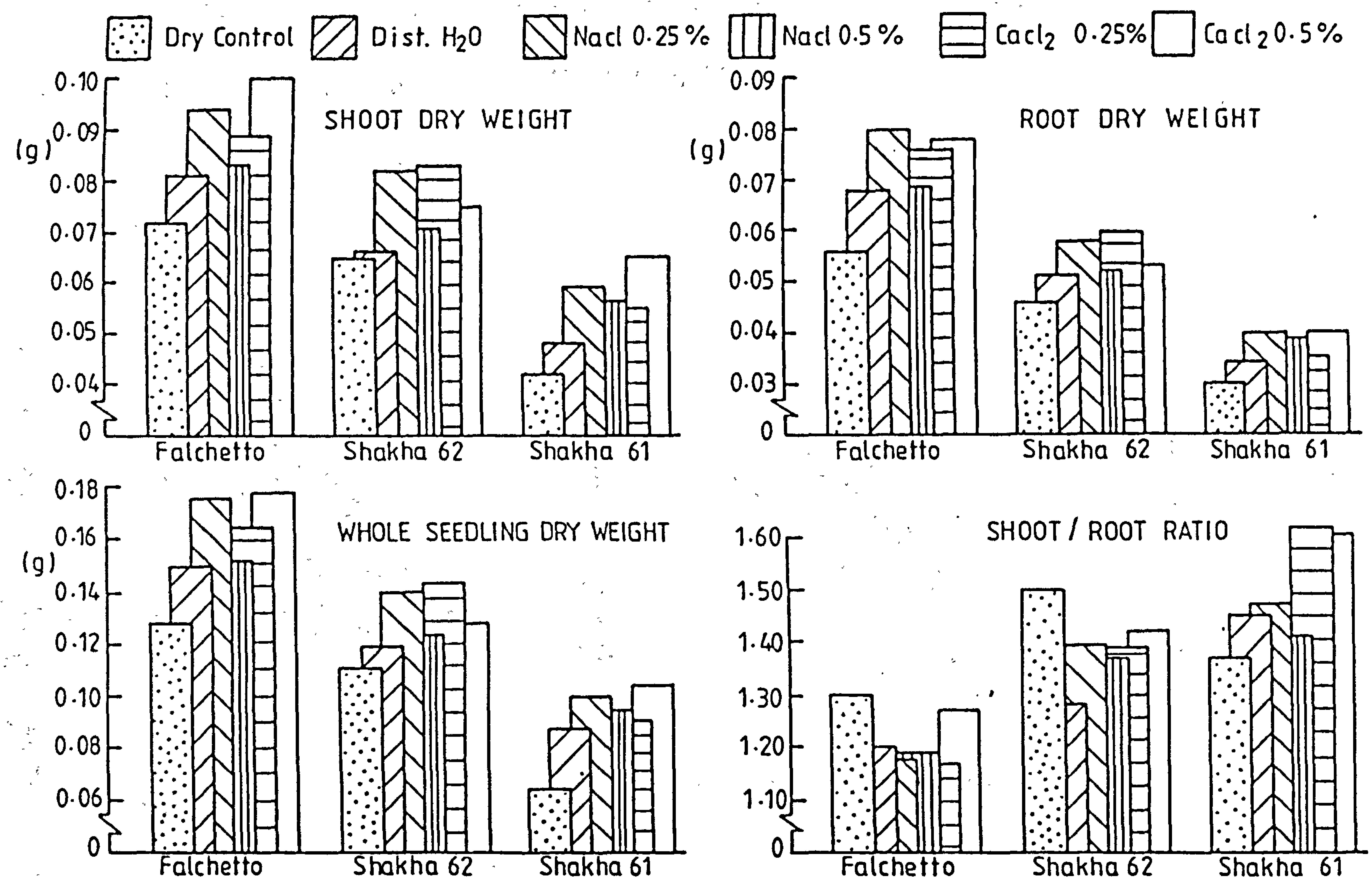



Fig. 20 Effect of Nacl and Cacl$_2$-directed presoaking on shoot, root and whole seedling dry weight and shoot / root ratio.


Fig. 21 Interaction effect of different salinity levels and presoaking treatments with Nacl and $Cacl_2$ on shoot, root and whole seedling dry weight.

and 0.5% Nacl and 0.25% $Cacl_2$ at 10,000 ppm Nacl successfully reduced the effect of salinity on shoot dry weight.

The stimulatory interaction seen in root number is not seen in root dry weight, suggesting that the stimulation represented an increased number of small roots. There was however a reduction in the effect of salinity on root dry weight as a result of pre-soaking. Only 0.25% $Cacl_2$ was effective with 5,000 ppm of Nacl in the growth medium but with 10,000 ppm all but 0.25% $Cacl_2$ were effective, but no more so than distilled water.

With whole seedling dry weight significant interactions indicate reductions in the deleterious effect of salt in the growing medium as a result of pre-soaking. 0.25% Nacl and $Cacl_2$ were effective at 5,000 ppm, but at 10,000 ppm only 0.5% $Cacl_2$ was more effective than distilled water. These results are similar to those obtained by Henckel, 1960; Idris and Aslam, 1975; Ashour et al., 1977 and Pawar and Kadam, 1983. However, Kumar and Singh (1980) found that presoaking of seeds in saline irrigation water did not give significant effects on dry matter production of wheat cultivar HD 2009. Also, Ashour et al. (1977) reported that shoot/root ratio of treated seeds with boric acid showed a decrease under chloride salinity conditions.

The results of experiments described in this chapter are encouraging. Given that the early stages of growth of wheat are more susceptible to salinity than later stages, it is clear from the results that the effects of salinity on the seedlings of these three cultivars can be reduced and even in some cases nullified by certain 24 hour presoaking treatments. While distilled water was in some cases effective, best results were obtained from plant growth regulators and inorganic salts. The latter are obviously cheaper and more readily available to the small farmer in the saline areas of Egypt and could represent an important cultural practice for improving establishment of wheat seedlings in saline soils. These farmers sow by broadcasting so there would be no problems of moist seed not flowing freely in a mechanical seed drill. Presoaked seed is however much heavier than dry seed and broadcasting of this of presoaked seed would therefore be more laborious. Further experiments are required to see if presoaked, re-dried seed retains the resistance to soil salinity induced by the presoaking treatment.

Summary

The effect of 13 seed pretreatments on germination and early growth of three wheat cultivars (Triticum aestivum L.) under saline conditions were studied in three experiments in the growth room to determine usefulness in increasing relative salt tolerance. Distilled water, growth regulators ($GA_3$, CCC, IAA and kinetin), and salts (Nacl and $Cacl_2$) were used in seed pretreatments and their effectiveness was tested by growing the presoaked seeds in pots in vermiculite culture under different salinity levels. All presoaking treatments enhanced germination under saline and non-saline conditions. However, soaking in distilled water did not give significant effects in the third experiment (soaking with salts). The effect of interaction between salinity and presoaking treatments on germination was significant only in exp. 2 (soaking with IAA and kinetin). Increasing salinity levels decreased all growth characters except root number per seedling which was not effected by salinity in 1st experiment and increased root number in 2nd experiment and shoot/root ratio in 2nd and 3rd experiments.

In 1st experiment generally GA3 at both concentrations was the best pretreatment with significant difference as compared with other presoaking treatments and dry control for all growth characters and CCC at both concentrations had the lowest values for all growth characters as compared with presoaking treatments. There were significant differences between presoaking treatments and salinity for shoot, root length, shoot fresh weight and shoot dry weight. In 2nd experiment kinetin at 250 ppm had the highest values for all growth

characters with significant differences than the other pretreatment and dry control except root number, root length and root dry weight for which IAA at 250 ppm had the highest values for root length, root dry weight and root number, however no significant differences between both concentrations of IAA for root number or between IAA 250 and distilled water for root length. The interaction between presoaking with IAA, kinetin and distilled water and salinity was highly significant for shoot length, root length, fresh weight and shoot dry weight. In 3rd experiment presoaking with Nacl at 0.25% give the best results as compared with the other pretreatment for all growth characters except shoot/root ratio which was not affected by any presoaking treatments. There was highly significant interaction between salinity levels and presoaking with salts for root number and shoot, root and whole seedling dry weight.

In general, all presoaking treatments with plant growth regulators or with salts enhanced seed germination and early growth of seedling under saline conditions for all the three wheat cultivars. In terms of varietal response Falchetto is generally superior as compared with the other two cultivars.

# CHAPTER VII

## GENERAL DISCUSSION

To plant life, salinity is just one inimical factor of the environment. To man, salinity creates a problem due to its effects on his crop species which are predominantly sensitive to the presence of high concentrations of salts in the soil. Difficulties arise because of the widespread nature of saline soils and are compounded by the geographical distribution of man's population and by agricultural practice which has largely succeeded in increasing salinization in arid and semi-arid lands (Flowers *et al.*, 1977).

### 1. Effect of salinity on wheat crop

#### A. Effect of salinity on germination

Under saline conditions, germination is strongly retarded, the growth processes of plants are inhibited and dwarfed plants result. The wheat plant is generally known to be medium salt tolerant (Strogonov, 1964), yet germination and seedlings in their early stages of growth have been reported to be highly susceptible to salinity (Malewal and Palewal, 1967). The effect of salinity on germination was studied in a number of experiments described in this thesis.

Evidence from the work presented in this thesis demonstrate that the rate and percentage of seeds germinating were decreased by increasing soil salinity (Chapters 2 part A, 4 part A, 5 and 6). These results are in harmony with those obtained by Idris and Aslam, 1975; Ashour *et al.*, 1977; Ansari *et al.*, 1980; Sung, 1981 and Kuhad and Garg, 1984. the results show that cultivars varied significantly in their germination under saline conditions. The semi-dwarf cultivar Falchetto had the highest germination percentage and Shakha 61 had the lowest (Chap. 5 and 6), indicating that Falchetto was more tolerant of salinity than the other cultivars under the conditions of this work. Sarin and Narayanan (1968) showed that soil salinity depressed the germination of all wheat cultivars used and the reduction in germination increased with increase in the level of salinity, but the degree of reduction at each level of salinity varied in different cultivars.

B. Effect of salinity on vegetative growth

Salinity may inhibit growth through disturbances in the water balance and reduction of turgor or ion toxicity acting possibly to deplete energy required for the metabolism involved in growth, or both. These disturbances may result either from difficulties in water uptake and transport within the plant or from toxic effects caused by excess of mineral ions in the tissues (Poljakoff - Mayber, 1982). There is no doubt that salinity adversely affects the growth of plants (Strogonov, 1964).

The data obtained from this study showed that increasing salinity consistently reduced the growth and decreased dry matter production of all wheat cultivars used in this work. The most sensitive growth character was leaf area. Net assimilation rate (NAR) however was less sensitive to salinity and sometimes not affected by salinity. The retarded growth of wheat plants under salt stress may, therefore, result from reduction of leaf area for photosynthesis while the photosynthetic reaction itself is not affected. This is in conformity with the findings of Balasubramanian and Sarin (1973) who reported that net assimilation rate of wheat plants grown in saline soils was practically not affected and the reduction of growth may, therefore, result from reduced leaf area for photosynthesis. Greenway and Munns (1980) suggest that there are four alternative causes for reduced growth: ion excess or water deficits in either expanded or expanding tissues. They suggest that nonhalophytes are usually affected by either ion excess in the expanded leaves or by water deficits in the expanding tissues. Hoffman and Jobes (1978) observed that increased salinity consistently reduced the growth of all plant parts of wheat crop.

Wheat cultivars differ significantly in their vegetative growth under saline conditions. In this study, generally the semi-dwarf cultivar Falchetto had the highest values for most of growth characters during vegetative stages than the other cultivars used in this study, but under some adverse conditions for some characteristics this superiority is lost, mostly to Shakha 62 but in some cases to Shakha 61. For example at 0.6% salinity and 100% and 50% available water Shakha 62 had higher fresh weight than Falchetto or Shakha 61. At 0.6% salinity and 20% soil moisture, however, Shakha 61 had the highest fresh wegiht (Chapter 5 part C). Giza 155 had higher protein and ash content than Falchetto (Chapter 2 part B). This general superiority of Falchetto means that Falchetto is more tolerant to salinity during vegetative stages than the other cultivars used in this study.

C. <u>Effect of salinity on grain yeild and yield components of wheat crop</u>

In wheat plants, grain yield is strongly linked with vegetative dry matter production and in this thesis grain yield is generally seen to be reduced in proportion to the salt-induced decrease in plant growth (Chapters 2 and 3). In this study, the performance of grain yield and yield components showed a significant decrease with increasing soil salinity (0.0 - 0.6%) or irrigation with saline water (0 - 4000 ppm salt). However, grain yield and its components were not affected by salt content of irrigation water up to 2000 ppm.

Shakha 62 gave significantly higher grain yield than Falchetto at 0.4% and 0.6% salinity levels in experiment 3 but there was no significant difference at 2000 and 4000 ppm of saline irrigation water in experiment 4 (chapter 3). But Falchetto produced significantly higher grain yield than Giza 155 at 0.2% and 0.4% salinity levels (chapter 2). Spike yield and grain number per spike were more sensitive to salinity and spike length and spikelet number per spike were less sensitive as compared with the other components of yield. Since 1000 kernel weight was less sensitive, especially up to 0.4% salt, salinity appears to reduce grain yield by reducing grain number per spike. Also, the results obtained from this study showed that salinity reduced tiller number per plant. Tiller number is a major component of grain yield and the reduction in tiller number can also be seen in the reduced spike number per plant. It appears therefore that one way in which salt reduced grain yield was by reducing tiller number per plant and grain number per spike. Aboul-Saod and Ashour (1974), Abdel-Halim et al. (1976), Ansari et al. (1978) and Selim et al. (1978) reported that grain yield, tiller number per plant and spike number per plant of wheat cultivars (Giza 155, Sonora 64, Ciete serros, H-68 and Mexipak all decreased as sulphate and chloride levels increased from 0 to 0.9% (based on soil dry weight). Also, Jadav et al. (1976) concluded that the major factor involved in yield depression due to salinity was number of heads per plant, which shows that salinity depressed tillering.

## D. Effect of salinity on chemical characters

Soil salinity caused significant reduction in the concentration of chlorophyll in leaf blades at 1st and 2nd samples (jointing and tillering stages). The chlorophyll content decreased with increasing salinity levels, with no significant differences between cultivars under the conditions of this experiment (chapter 2 part B). Ashour et al. (1977) found that chloride salinity reduced the chlorophyll concentration in leaf blades of wheat seedling cv. Giza 155. Also, salinity had a highly significant effect on technological characters of wheat grains (moisture, ash, crude protein and total carbohydrate). Crude protein and ash content increased and moisture and total carbohydrate content decreased with increasing salinity levels. This is in line with the results reported by Khalil et al., 1977; Murthy et al., 1978; and Kumar and Yadav, 1983.

In contrast to total carbohydrate and moisture content, leaf and stem of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ increased with increasing salinity both in vegetative parts and in kernels. The increase of $Na^+$ content in both vegetative parts and in grains relative to control values was greater with increasing soil salinity than that of $Ca^{2+}$ and $Mg^{2+}$ (chapter 2B). Similar results have been reported by Hassan et al. (1970), Hira and Singh (1973), Ansari et al. (1978) and Kumar and Yadav (1983).

The results of proline accumulation in wheat leaves (chapter 3A) indicate that increasing soil salinity from 0 - 0.6% (based on soil dry weight) increased proline accumulation in wehat leaves. There were no varietal differences in the extent of proline accumulation except at 4th sample in which Falchetto was higher in proline accumulation than Shakha 62. This rise in proline level with increasing salinity could simply be a stress reaction to physiological drought rather than any kind of adaptive response. It has been suggested that proline functions as a source of solute for intracellular osmotic adjustments under saline conditions (Stewart and Lee, 1974). Also, Greenway and Munns (1980) suggested that the simplest hypothesis is that proline accumulates due to reduced turgor potential and/or growth.

Further experiments on the effects of different types of soil salinity such as sulphate, carbonate, chloride-sulphate and sulphate-chloride will be worthwhile and it would be important to use a wider range of salinity levels and cultivars to determine the acceptable salinity levels for economic production under field conditions.

## 2. Interactions and counteraction of salinity

### A. Salinity and fertilizers

The interaction between soil salinity and nitrogen fertilizer showed that nitrogen application under saline conditions of this study increased crop growth rate (CGR), but did not increase the growth and dry weight of both cultivars, although there was a non significant increase with increasing nitrogen application up to 0.4% salinity level. On the other hand spraying wheat plants with trace elements under saline conditions did not affect the growth. Also, application of nitrogen fertilizer under saline conditions enhanced grain yield and its components and to some extent countered the adverse effect of soil salinity up to 0.4%. However, spraying with trace elements did not increase the grain yield and its components except 1000 kernel weight. Shakha 62 gave significantly higher grain yield than Falchetto under nitrogen x salinty conditions but there was no significant difference in the trace elements x salinity interaction. These results are in harmony with the findings of Amer et al., 1964; Sorour et al., 1975; Kumar and Singh, 1980 and Wagent et al., 1980.

### B. Temperatures, relative humidity, drought and soil salinity

The effect of interaction between salinity and temperature was significant on germination capacity (chapter 5 part A). Under saline and non-saline conditions increasing temperature from 10 to 20°C increased germination capacity and it depressed between 20 and 30°C. Although there was no significant interaction between relative humidity and salinity (chapter 5 part B), under saline conditions increasing relative humidity from 47 to 92% increased germination capacity, but the trend was not marked enough to approach the 5% significance level. This suggests that the best germination of wheat seeds in saline soils is at 20°C and higher relative humidity. Also, the interaction was significant on root length, root dry weight, root number per seedling and fresh weight for temperatures and salinity (chapter 5 part A) and for shoot length, fresh weight and shoot water content for relative humidity and salinity (chapter 5 part B). Fresh weight and shoot and whole seedling dry weight were significant in the drought and salinity interaction (chapter 5 part C). Generally, increasing temperature up to 20°C, RH from 47 to 92%, and available soil water content from 20 to 100% increased vegetative growth and dry matter production of wheat crop under saline and non-saline conditions. In terms of varietal response Falchetto was generally superior, but under some adverse conditions this superiority was lost sometimes to Shakha 62 and sometimes to Shakha 61. Similar observations have been reported by Odegbaro and Simith, 1969; Francois and Goadin, 1972, Hoffman and Jobes, 1978; Rizk et al., 1981 and Mashhady et al., 1982.

C. Plant growth regulators and salts as a pretreatment to increase salt tolerance and soil salinity

The soaking of wheat seeds in distilled water or growth regulators [CCC, $GA_3$, IAA and kinetin] (chapter 6 part IA and IB) or in salt [Nacl and $Cacl_2$] (chapter 6 part II) solutions before planting in pots in vermiculite culture under different salinity levels accelerated the germination under saline and non-saline conditions. However, soaking in distilled water had no effect on germination in the 3rd experiment (soaking with salt solutions). Also the interaction effect between salinity and presoaking treatments was significant on shoot and root length, fresh weight and shoot dry weight in the case of growth regulators, and on shoot, root and whole seedling dry weight and root number in the case of salt solutions, indicating that for some characters presoaking with these plant growth regulators or salt solutions can reduce the deleterious effect of salinity and improve plant performance of wheat at these early stages of growth under saline conditions, e.g. 500 ppm IAA at 5,000 ppm Nacl salinity nullified the effect of salinity for shoot dry weight (chapter 6.IB). At the highest salinity level 10,000 ppm Nacl, presoaking with CCC at 250 ppm or $GA_3$ at 250 and 500 ppm resulted in significantly higher shoot dry weight than the dry control or presoaking with distilled water (chapter 6.IA). Also at 10,000 ppm Nacl salinity presoaking with 0.5% Nacl and 0.2% $Cacl_2$ successfully reduced the effect of salinity on shoot dry weight (chapter 6.II). There is no doubt that phytoharmones are involved in the response of plants to salinity stress. The content of gibberellins, IAA and ethylene change on exposure to salinity but the most marked changes occur in the content of two hormones - cytokinin and ABA (Poljakoff-Mayber, 1982). Also, Singh and Darra (1971) found that the detrimental effects of high salt content in conjunction with boron on the growth of wheat may be minimized economically to some extent by the use of specific growth hormones. Ashour et al. (1977) reported that presowing salt hardening of wheat seeds, especially with boric acid under chloride salinity seems to be an effective methods for increasing both the germination capacity of seeds and the salt tolerance of the developed seedlings. The semi-dwarf cultivar Falchetto was generally superior as compared with the other cultivars in germination and vegetative growth, but under some adverse conditions this superiority was lost sometimes to Shakha 62 and sometimes to Shakha 61.

Further experiments would be worthwhile to investigate the interaction effect of different types of fertilizer (e.g. NPK) on the response of wheat cultivars under saline conditions in the field to determine the optimum level of these fertilizers. Also, further experiments on pre-soaked wheat at later stages of development would be important. A wider range of relative humidity could be studied to resolve the question of whether high relative humidity reduces salt induced physiological drought or dilutes ion concentrations. This might involve quantification of water potential and its components, especially osmotic potential and chemical analysis of cell sap.

3. Ion toxicity

The subject of specific ion toxicity was approached by some indications (a) in water relations experiment (chapter 4 part A) turgor potential remained essentially unchanged with increasing salinity levels (0.2 - 0.6% salt). The maintenance of turgor potential should have maintained leaf growth, however, in experiment 2 chapter 2 leaf growth was seen to decrease with increasing salinity (0 - 0.6% salt). Therefore indications of toxic effects can be seen in these results. (b) In PEG (polyethylene glycol) experiment equal salt - and P.E.G. - generated osmotic potentials were arranged in the rooting medium, but in salt plant growth was worse than in PEG solutions and this result also indicates a toxic effect. (c) In the relative humidity experiment at low RH (low water content) variation in dry matter was only partly accounted for by water content, another factor, possibly salt, exerting an effect. (d) If there is a toxic effect, there are indications that it doesn't act on the photosynthetic apparatus, since NAR is not reduced.

## 4. Recommendations

From the results presented in this thesis, it appears that if the total amount of salt in the soil exceeds 0.4% (by weight) or 2000 ppm (2g/litre) in irrigation water, it is economically impractical to grow a crop of wheat on this soil. However yield reductions of only 35.5% were found at salinities as high as 0.2% dry weight in cv Falchetto. Falchetto and Shakha 62 generally outyielded Shakha 61 and Giza 155 under saline conditions. These two cultivars should therefore be seriously considered for trials in saline soils up to 0.4% salinity. Although yields of grain are reduced by salinity, the protein content is increased and it could be possible to mix the flour of wheat grains grown on saline soils with the flour of other wheat grains which are lower in protein content to improve the baking quality and nutritive value of the flour. The level of salt in such grain does not approach levels hazardous to human health.

The effect of soil salinity on wheat production can also be countered by using special agrotechnical techniques for sowing, dosage and time of fertilizers. The application of nitrogen fertilizer enhanced the growth and yield of wheat cultivars under saline conditions and generally it could be recommended to use not more than 144 kg N/ha for the tested cultivars under the conditions of this investigation. On the other hand, there was a beneficial effect of additional trace elements under saline conditions and under the conditions of this work, there is no evidence that salinity interferes with the uptake of trace elements. In contrast presoaking wheat seeds for 24 hr in solutions of plant growth regulators or salt solutions reduced the adverse effect of soil salinity and even in some cases nullified it. The results of this study illustrate the potential importance of using presoaking treatments with plant growth regulators and/ or inorganic salt. The latter are obviously cheaper and more readily available to small former in the saline areas of Egypt. Experiments in this thesis also indicate that high relative humidity can reduce the harmful effects of soil salinity apparently through maintaining a high plant water content and this means that it could be possible to use chemical anti transpirants under saline conditions to reduce transpiration rate and increase the water content in the plant and thereby reduce the adverse effects of salt.

From the point of plant breeding the results of this study illustrate the importance, indeed the pressing necessity of establishing and maintaining sources of genetic diversity for use in crop improvement and to counter present and future agricultural dilemmas. Breeding for salt tolerance might involve selection for high water content e.g. by selecting cultivars with fewer stomata to avoid excessive loss to transpiration or for the ability to exclude salt from tissues. Selecting for higher proline accumulation under saline conditions might also be worthwhile. Also, genotypic values (semi-dwarf cultivar Falchetto and medium tall cultivar Shakha 62) must be measured over a period of years at a number of locations differing in their type and degree of salinity.

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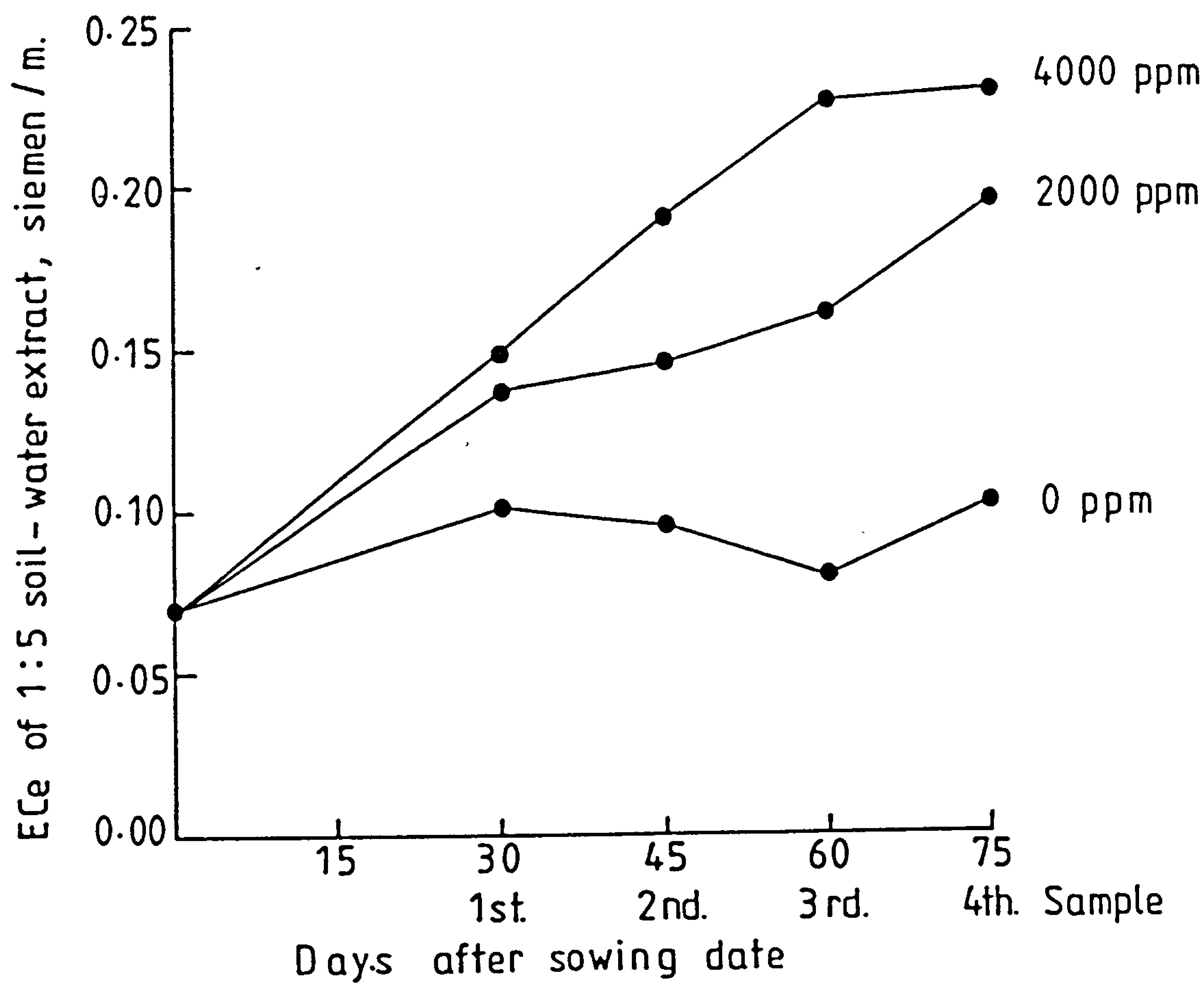
Appendix 1 : Formulas for the Analysis of Variance for t treatments arranged in A Randomized Complete - Block Design for r Blocks.

| Source of variation | Degrees of freedom | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| Replications | (r-1) | $\Sigma \frac{R_j^2}{t} - C$ | $\Sigma \frac{R_j^2}{t} - C/(r-1)$ | |
| Treatments | (t-1) | $\Sigma \frac{T_i^2}{r} - C$ | $\Sigma \frac{T_i^2}{r} - C/(t-1)$ | |
| Error | (r-1)(t-1) | (Total S.S.) - (Replic. S.S.)- (Treat S.S.) | $\frac{\text{Error S.S.}}{(r-1)(t-1)}$ | |
| Total | (rt-1) | $\Sigma y^2 - C$ | | |

This design was used in factorial experiments in this thesis. The relative advantages of randomized complete block design is the same with factorial as with non-factorial sets of treatments (Snedecor and Cochran, 1967).

APPENDIX 2




Effect of irrigation with saline water on electrical conductivity (ECe) of soil.

APPENDIX 3

## SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| EC | Electrical conductivity in Siemen/m . |
| ECe | Electrical conductivity of saturation extract . |
| ECi | Electrical conductivity of irrigation water . |
| mho | Recipracal ohm . |
| mmho | Millmho . |
| ESP | Exchangeable-sodium-percentage . |
| SAR | Sodium-adsorption-ratio . |
| meq | Milliequivalent . |
| mg./L | Milligrams of solute per liter of solution . |
| ppm | Parts per million .As commonly measured and used parts per million is numerically equivalent to milligrams per liter . |
| Siemen/m | 10 mmho |
| Hectare | 10000 $m^2$. |
| Faddan | 4200 $m^2$. |