

Impact of water deficit stress on biomass production of different gladiolus cultivars under rainfed condition

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ABSTRACT

Among environmental stresses, water deficit stress was recognized to be one of the most adverse factors for plant growth and productivity. The study aimed to comparatively evaluate the impact of water deficit stress on biomass of seven cultivars of gladiolus in terms of leaf area duration (LAD) and net assimilation rate (NAR) under rainfed conditions in northeastern region of India. In addition, productions in terms of marketable spikes were compared. The parameters were measured using standard procedures. Comparatively, higher LAD (116 days) and NAR were found in cultivars Aarti (116 days and $1.62 \text{ g/cm}^2/\text{day} \times 10^{-3}$ respectively) and Suchitra (98.0 days and $1.10 \text{ g/cm}^2/\text{day} \times 10^{-3}$) which account for their higher biomass production with larger spike size with good numbers of flowers. The highest marketable spikes (71111.11 spikes/ha) was found in cultivar Aarti followed by Suchitra (68148.14 spikes/ha) which might be due to its comparatively higher biomass production and less deviation, during stress condition, from normal characteristics. The tolerant cultivars are those that can adapt to the change without much change in their normal growth. Moreover, the responses of those species are commercially acceptable that promote adaptation without compromising much with the plant growth and crop production.

KEY WORDS: Biomass, gladiolus, leaf area duration, net assimilation rate, water stress

INTRODUCTION

Stress may be defined as the altered physiological condition caused by environmental factors that tends to alter equilibrium (Shao *et al.*, 2008). Of various ecological factors, water is one of the most important determining factors for plant growth and development; and water deficit stress plays a significant role in inhabiting normal performance and yield of crops (Jaleel *et al.*, 2007). It trigger a wide variety of plant responses, ranging from physiological, anatomical, and genetic variations influencing plant growth and performance (Chartzoulakis *et al.*, 2002; Jaleel *et al.*, 2008; Shao *et al.*, 2008; Pompelli *et al.*, 2010; Gratani *et al.*, 2013). The impact of water stress on plant growth can be seen in various level ranging from cellular to community (Colom and Colom, 2007; Blumwald *et al.*, 2004).

One way to ensure better performance of crops under water deficit stress condition should involve better use

of water by selection and development of crop cultivars that are tolerant (Jaleel *et al.*, 2007). Every plant cultivars responses to water deficit stress up to a certain degree, but their intensity vary with species. Plants underwent several physiological, morphological and anatomical changes to increase its tolerance toward adverse environmental conditions. However, those species can be regarded as economically tolerant that deviate minimum from its normal growth and performance. The common adverse effect of water stress on the plant is a reduction of biomass production (Zhao *et al.*, 2008). Morphological parameters such as fresh weight and dry weight have a profound effect in water-limited conditions (Shao *et al.*, 2008). Reduction of biomass in terms of number and size of leaves and flowers, shoot length, etc. are deleterious especially for cut flowers such as gladiolus. Gladiolus belonging to the family Iridaceae is an important commercial ornamental crop of northeastern region of India. However, the climatic variation causes water deficit condition during growing season due to erratic

rainfall that has a profound impact on its production and productivity. The objective of current study was to evaluate the impact of water deficit stress on biomass of seven popularly grown cultivars of gladiolus in terms of relative variation in their leaf area duration (LAD) and net assimilation rate (NAR; the rate of increase of biomass per unit of leaf area). Finally, their production in terms of marketable spikes was compared.

MATERIALS AND METHODS

Experimental Site

The investigation was conducted in the year 2010-2014 at the horticultural farm of Assam Agricultural University, Jorhat, Assam. The site is located nearly around 26°45'28.34" N and 94°12'35.36" E in the northeastern part of India.

Experimental Layout

The seven most popularly grown gladiolus cultivars viz. Suchitra, Jacksonville Gold, American Beauty, White Prosperity, Blue Isle, Aarti and Apollo, were grown under a similar condition in the horticultural farm for the study. The experiment was designed in Randomized Block Design and consisted of seven treatments and replicated thrice. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal doses. The crop was top dressed with remaining half dose of N at 45 days after planting. Well decomposed farm yard manure at 6 kg/m² was applied at the time of land preparation and 10 days prior to planting. Planting of cultivars was carried out in the first week of November 2010. Corms of three cultivars were Dehusked. The experimental site was kept weed-free by periodic hand weeding. Regular irrigation was given at an interval of 7-8 periods only.

Meteorological Parameters

The meteorological data during the period of investigation with monthly averages were taken at the Meteorological Observatory of Assam Agricultural University, Jorhat. The total rainfall during the crop season (November 2011 to April 2012) was 204.5 mm. The rainfall was found to be lowest in the month of December (10.4 mm) and highest in the month March (76.4 mm). The month of November had the highest number of rainy days (13 days), and December, January, and February (3 respectively) continuously had the lowest number of rainy days. The temperature was at its maximum in the month of April (28.7°C) and minimum at December (11.8°C). Soil moisture content was measured using gravimetric method (Dastane, 19678) (Table 1).

LAD and NAR

The biomass accumulated during the observation period was computed as the difference between initial and final dry matter and expressed as g/plant (gram per plants). LAD takes into account, both the duration and extent of photosynthetic tissue of crop canopy. LAD correlates dry matter with leaf area index. LAD is given by:

$LAD = \{(L_1 + L_2)/2\} / (t_2 - t_1)$, where L_1 and L_2 are initial and final leaf area indices during the observation period ($t_2 - t_1$).

The NAR expressed in g/cm/day was determined as the ratio of total dry matter during the period and LAD.

Statistical Analysis

The analysis was done using analysis of variance followed by Duncan's Multiple Range Test. The values are mean \pm standard deviation for all samples. $P \leq 0.05$ was considered as significant.

RESULTS

The cultivars have a wide variation in terms of LAD (Figure 1). Highest LAD value was observed in cultivar Aarti (116 days) followed by Suchitra (98.00 days) and Blue Isle (94.92 days) which were found to be

Table 1: Average monthly rainfall, number of rainy days, and soil moisture data of growing months during the period of experiment (2010-2014)

Month	Total rainfall (mm)	Total rainy days per month	Soil moisture (%)
November	20	13.1	23.6
December	20	2.7	21.4
January	19.5	2.8	17.7
February	28.2	2.6	18.2
March	78.1	10.2	24.8
April	52.02	10.5	24.0

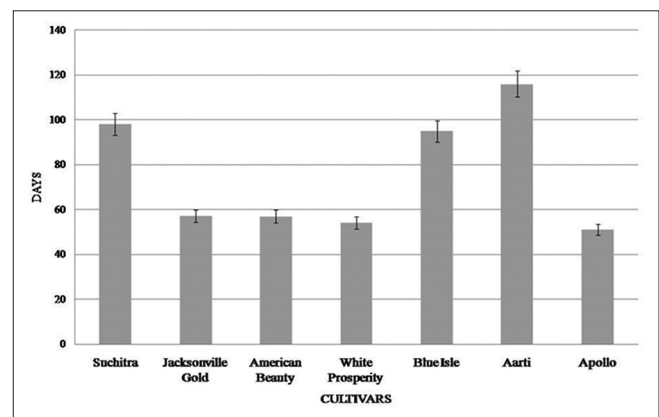


Figure 1: Relative variation of leaf area duration among the cultivars

significantly higher ($P < 0.05$) than that of cultivar Apollo (51 days), White Prosperity (54.12 days), American Beauty (56.92 days), and Jacksonville Gold (57.12 days) (Table 2). NAR had considerable variations among the cultivars (Figure 2), with highest NAR value in cultivar Aarti ($1.62 \text{ g/cm}^2/\text{day} \times 10^{-3}$) followed by Suchitra ($1.10 \text{ g/cm}^2/\text{day} \times 10^{-3}$). While NAR value was found to be lowest in the cultivar Apollo ($0.54 \text{ g/cm}^2/\text{day} \times 10^{-3}$) followed by Jacksonville Gold ($0.81 \text{ g/cm}^2/\text{day} \times 10^{-3}$) (Table 2). The NAR value of Apollo and Suchitra was found to be significantly higher than rest of the cultivars.

The results also reveals that the highest marketable spike was found in cultivar Aarti (71111.11 spikes/ha) followed by Suchitra (68184.14 spikes/ha) which were significantly higher than that of Apollo (34074.44 spikes/ha), American Beauty (50370.36 spikes/ha), Blue Isle (51851.85 spikes/ha) (Table 2).

DISCUSSIONS

The decrease in LAD under drought condition is in accordance with previous findings (Thakur and Kaur,

Table 2: Variability of LAD, NAR, and marketable spikes in different gladiolus cultivars at different stages of crop growth period under rainfed condition

Cultivar	LAD (days)	NAR ($\text{g/cm}^2/\text{day} \times 10^{-3}$)	Marketable spikes/ha
Suchitra	98.00 ^a	1.10 ^a	68148.14 ^a
Jacksonville gold	57.12 ^b	0.84 ^c	53333.33 ^c
American beauty	56.92 ^b	0.91 ^c	50370.36 ^c
White prosperity	54.12 ^b	0.91 ^c	53333.33 ^c
Blue isle	94.92 ^a	0.98 ^c	51851.85 ^c
Aarti	116.00 ^a	1.62 ^a	71111.11 ^a
Apollo	51.00 ^b	0.54 ^b	34074.44 ^b
Mean	75.44	0.98	54603.22
SE	10.07	0.12	4664.80

The values with same superscripts (a or b or c) are not significantly different while with different superscript are significantly different at $P < 0.05$. LAD: Leaf area duration, NAR: Net assimilation rate, SE: Standard error

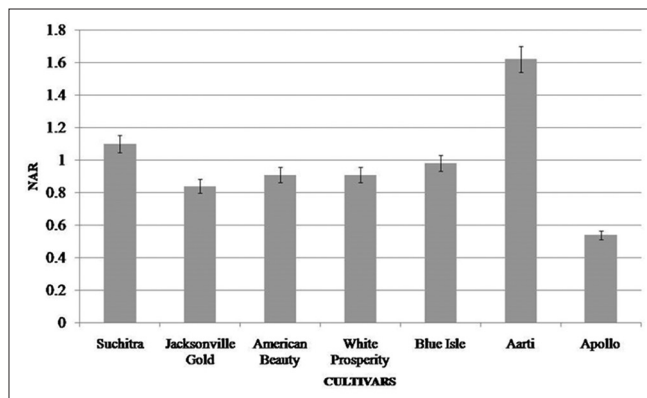


Figure 2: Relative variation of net assimilation rate among the cultivars

2001; Shivay *et al.*, 2002; Ramachandra Reddy *et al.*, 2004). Also, previous studies indicate that the NAR was relatively lower in drought-stress conditions (Vyas *et al.*, 2001). Increase LAD gave additional advantage to the plant for their development of leaves with large NAR resulting in bolder diameter in corm and large spike with good number of the flower. The production of the dry matter or biomasses of any plant is determined by the higher value of LAD and NAR (Escalante Estrada *et al.*, 1993). Decrease in LAD and NAR was found to be strongly correlated with a decrease in biomass (Chnappagoudar *et al.*, 2013). Furthermore, studies (Siemens and Zwiazek, 2003) shows that decrease in NAR strongly indicate stomatal closure factor for reduction in the presence of water stress conditions, consequently leads to decline in photosynthesis. It was also observed that the gladiolus cultivar Aarti flowered 4-5 days earlier and sustained flower initiation for a longer period (5-6 days) in comparison to other cultivars indicating that the plant has got more time for sink development and utilization for photoassimilates.

Significant differences were recorded among the cultivars with respect to marketable spikes which were found to be positively and strongly correlated with the LAD and NAR values. Cultivars under present study were varying significantly with respect to the spike length. In a similar type of study, Kamble (2001) reported that maximum spike length, spike weight, diameter of florets, and a number of florets per spike were noticed in cultivar Summer Sunshine and Vedanapali showed maximum spike girth and spike yield per hectare. Accordingly, he found a significant variability in terms of these characters in similar condition. Pragma *et al.* (2010) also asserted the significant variability among the cultivars of gladiolus in terms of spike length with cultivar *Pusa Jyotsna* having the longest spike length and cultivar *Pusa Jyotsana*, and *Pusa Swarnima* recorded maximum number of florets/spike.

CONCLUSION

The study indicate that water deficit stress do have a strong impact on plant biomass production influencing production and productivity. Though all the cultivars deviate from its normal characteristics during stress condition but its intensity vary. Those cultivars can be regarded as tolerant that compromise less with their production and productivity. Under similar water stress condition cultivars, Aarti and Suchitra perform best compared to other five cultivars in terms of marketable spikes. The information contained within the genome of each species dictates the plant response to the adverse

environmental condition. Identification of such traits can be useful toward the development of tolerant varieties.

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