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Effects of water replacement levels and nitrogen fertilization on growth and production of gladiolus in a greenhouse

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ABSTRACT

The gladiolus is a cut flower used for interior decoration. It is a short cycle, easy driving crop with low implantation costs and fast payback. These factors allow for its cultivation in small areas in which commercial production of bulbs for domestic and foreign markets is also possible. Furthermore, it has high economic value because it is among the most important cut flowers grown in Brazil and is the third in product volume. This study aimed to evaluate the effect of different water replacement levels in the soil (50%, 75%, 100%, 125%, 150% of field capacity water volume) and nitrogen doses (0, 30, 60, 90, 120 mg dm^{-3}) on crop growth and production in a greenhouse. The species studied was the *Gladiolus x grandiflorus* L., White Friendship variety. The experimental design consisted of randomized blocks in a 5 × 5 factorial scheme with four replications. The growth and yield of gladiolus were characterized by the following variables: number of leaves, total plant height, floral spike and stem length, number and diameter of flowers, floral dry mass stem and number of days to bolting and flowering. Using the statistical software Sisvar, data were subjected to an analysis of variance at the 5% level of significance using the *F* test and to polynomial regressions. For nitrogen fertilization, there was a significant response only to the variable of floral stem dry mass. For the water replacement levels, responses were significant for all of the variables analyzed. The management of water irrigation at replacement levels above 75% of field capacity allowed for the length of the floral stems to be classified for commercial purposes, and for the number of flowers, water replacement levels above 100% provided a better commercial classification.

1. Introduction

The cultivation of ornamental plants is an expanding activity, with a growing market especially for species of cut flowers. As an intensive agricultural activity, it requires manpower in the field and promotes the exploration of small areas with high economic return (Kampf, 1989).

According to the Brazilian Institute of Floriculture (Ibraflor, 2012), approximately 9000 producers work in floriculture with a total cultivated area of 12,000 ha and an average field size of approximately 1.5 ha. In 2011, the value was R$ 4.3 billion, and growth is estimated at 12% for the year of 2012.

The gladiolus is a short cycle crop that is easy to manage with low implantation costs and fast payback. These factors allow for its cultivation in small areas where the commercial production of bulbs for domestic and foreign markets is also possible. Furthermore, it has high economic value because it is among the most important cut flowers grown in Brazil, the third in product volume (Vencato, 2007).

In the cultivation of gladiolus, water supply deficiency affects vegetative growth and flowering, forming inflorescences with reduced length, so the soil moisture must be close to field capacity (Paiva et al., 1999; Carvalho et al., 2001). Lack of water can also cause burns on the tips of the spikes and rush the life cycle, while excess water can cause retardation of the cycle and even rot the bulbs. Through frequent irrigation, it is possible to obtain early production (Paiva et al., 1999).

Pereira et al. (2001) observed that the water deficit decreases linearly with the number of flowers in a gladiolus crop, showing the sensitivity of culture to levels of water replacement. Borges (2005) noted that the number of plants, number of buttons per stems of flowers and floral stem length of gladiolus increased linearly with the levels of irrigation applied to all hybrids and that the production of stems of lower quality increased with decreasing application of lamina irrigation.

In experiments with gladiolus, Pereira et al. (2009) found that better results, in terms of plant size, flower stem and number of flowers, were obtained by keeping the water tension in the soil near

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field capacity by not allowing the tension of soil water to exceed the limit of 15 kPa.

Lehri et al. (2011) observed a positive response to increases in nitrogen fertilizer in the length of leaves, the number of leaves and flowers per stem and the length of the stems. Siraj and Al-Safar (2006) obtained significant results for plant length, number of leaves per plant, plant area and dry weight by increasing nitrogen fertilization.

Of all the nutrients required by the soil, nitrogen usually shows the most significant effects on growth and yield of the plant. However, some studies of the effects of nitrogen fertilization on gladiolus have reported contradictory results. Pandey et al. (2000) investigated the effect of nitrogen levels on the growth of gladiolus and observed no significant differences in plant weight characteristics, length of leaves, stem diameter, days to flower opening, length of stems and number of flowers per stem.

Information about the irrigation management for gladiolus is scarce, hence the need to develop work aimed at evaluating the effects of the availability of water and nitrogen fertilization on growth and yield of this crop in greenhouses. Considering the need for more information about the behavior of the gladiolus crop, the present study aimed to evaluate the effects of different levels of water replacement and nitrogen fertilization on the yield of the gladiolus, White Friendship variety, grown in greenhouses in Rondonópolis—MT, Brazil.

2. Materials and methods

The experiment was conducted from April to September 2012 in a greenhouse at the Institute of Agricultural Science and Technology, Federal University of Mato Grosso (UFMT), Campus of Rondonópolis, in the city of Rondonópolis—MT, which is located at 281 meters altitude, 16°28′S latitude and 54°38′W longitude. The species chosen for the experiment was the *Gladiolus x grandiflorus L.*, variety White Friendship, which has a short cycle equivalent to 60–65 days of cultivation (Severino, 2007). The greenhouse where the experiment was conducted is oriented from east to west with a ceiling height of 6 m, a total area of 450 m^2 and a transparent plastic cover of 200 μm. A thermo-hygrometer was installed inside the greenhouse to measure maximum and minimum humidity and air temperature. The readings were taken daily at 9 am. The temperature during the experiment varied from 17.4 to 40 °C for min and max, respectively, with an overall average of 27.47 °C. The relative humidity (RH) of the air showed values ranging between 45% and 99% humidity with the overall average being 74.04%.

The soil was collected from an area of native savannah vegetation classified as Dystrophic Red sandy loam texture (Embrapa, 2006), and the 0.0–0.20 m layer was passed through a 2 mm aperture sieve. The soil analysis showed the following chemical and textural characteristics (Table 1).

The soil chemical analysis revealed the need for liming to raise the soil pH within the recommended limits for the gladiolus crop. Liming was performed in pots to increase the base saturation to 70% (Ribeiro et al., 1999).

Phosphorus fertilization (P_2O_5) was performed in all pots using 200 mg dm^{-3} in the form of simple superphosphate on the same day of bulb planting. The potash (K_2O) was 75 mg dm^{-3} in the form of potassium chloride at 24 DAP (Ribeiro et al., 1999).

The experimental design was a randomized block in a 5 × 5 factorial scheme with four replications. Treatments consisted of five doses of nitrogen (0, 30, 60, 90, 120 mg dm^{-3}) using urea as a source and five levels of water replacement in the soil (50%, 75%, 100%, 125% and 150% of the volume of field capacity water replacement).

Table 1
Chemical and textural characteristics of oxisol collected from 0–20 cm in an area of native vegetation.

Particle size distribution (g kg^{-1})			pH ($CaCl_2$)	Phosphorus	Potassium	Organic matter
Sand	Silt	Clay		(mg dm^{-3})		(g dm^{-3})
549	84	167	3.8	1.2	24	23.4
Calcium + magnesium			Calcium	Magnesium	Aluminum	Hydrogen
(cmolc dm^{-3})						
0.2			0.1	0.1	0.9	4.8
Sum of bases		Cation exchange capacity		Bases saturation		Aluminum saturation
(cmolc dm^{-3})				(%)		
0.3		6.0		4.4		77.4

Nitrogen doses were divided into three applications, and those applications were made at 20, 31 and 40 days after planting (DAP). The fertilizer with micronutrients was composed of 0.5 mg dm^{-3} of boron as H_3BO_3 and 1 mg dm^{-3} of zinc as $ZnCl_2$ (Ribeiro et al., 1999) at 24 DAP. Each experimental unit consisted of one pot with dimensions of 230 × 240 × 240 mm. On 04.14.2012, two bulbs with perimeters of 12–14 cm (4.4 to 4.8 cm in diameter) were planted in each pot to a depth of 12 cm.

To evaluate soil moisture, the parameters of the characteristic curve of water retention in the soil were obtained with the aid of the software Soil Water Retention Curves (SWRC, version 3.0). According to the model of Van Genuchten (1980) that was developed by Dourado Neto et al. (2000), the characteristic curve describes the behavior of soil moisture as a function of tension (Eq. (1)) (Fig. 1).

$$\theta = \frac{0.468}{\left[1 + (0.0573|\Psi|)^{0.3545}\right]^{0.5724}} \quad (1)$$

θ is the soil moisture (cm^3 cm^{-3}); $|\Psi|$ is the soil water tension (cm).

For each observed value of soil water tension, the corresponding amount of moisture was calculated from the characteristic curve of water retention in the soil. After accounting for the volume of soil in the pots, this moisture value and the one corresponding to field capacity were used to calculate the volume of water replacement for each treatment (Eq. (2)).

$$V = (\theta cc - \theta f) \times 13,000 \quad (2)$$

V is the volume of water, (cm^3); θcc is the soil moisture at field capacity (cm^3 cm^{-3}); θf is the moisture from the retention curve according to the observed tension (cm^3 cm^{-3}).

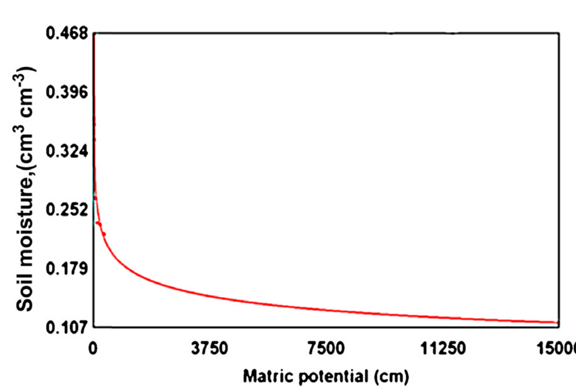

Fig. 1. Water retention curve.