Cultivation cycle and quality of floral stems of gladiolus cultivars in the Cerrado Brazilian

Ciclo de cultivo e qualidade de hastes florais de cultivares de gladíolo no Cerrado Brasileiro

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ABSTRACT
The growth and development of gladiolus, a cut flower widely used in decorations and commemorative dates, are influenced by the ambient temperature. Elevated temperatures shorten the growing cycle and accelerate flowering, while low temperatures delay development. Four gladiolus cultivars (White Goddess, Purple Flora, Green Star, Yester e Spic en Span) were evaluated for growth, development, and quality of floral stems, during autumn, in average temperatures of 24.31ºC. During the vegetative period, White Goddess presented the highest plant height. Entry into the reproductive stage R1 occurred between 56.81 and 65.41 days after planting and harvesting in R3 occurred between 63 and 77 days. Purple Flora stood out as the earliest cultivar and Spic en Span as the early. The gladiolus plants had a plant height greater than 90 cm and an inflorescence diameter greater than 5 mm at harvest, values within the required commercial standards. However, Green Star and Spic en Span had several rapiers below 8, an undesirable value. The cultivar White Goddess had the highest longevity, 6.75 days. The cultivation of gladiolus in regions with a Brazilian tropical climate allows a reduction in the cultivation cycle, and production of floral stems within commercialization standards.

Keywords: gladiolus, flowering bulbs, phenology, cut flower production, flower ornamental.

RESUMO
O crescimento e o desenvolvimento do gladíolo, uma flor de corte amplamente utilizada em decorações e datas comemorativas, são influenciados pela temperatura ambiente. As temperaturas elevadas encurtam o ciclo de crescimento e aceleram a floração, enquanto as baixas temperaturas atrasam o desenvolvimento. Quatro cultivares de gladiolo (White Goddess, Purple Flora, Green Star, Yester e Spic en Span) foram avaliadas quanto ao crescimento, desenvolvimento e qualidade das hastes florais, durante o outono, em temperaturas médias de 24,31ºC. Durante o período vegetativo, a White Goddess apresentou a maior altura de planta. A
entrada no estágio reprodutivo R1 ocorreu entre 56,81 e 65,41 dias após o plantio e a colheita em R3 ocorreu entre 63 e 77 dias. A Purple Flora se destacou como a cultivar mais precoce e a Spic en Span como a mais precoce. As plantas de gládio tinhem uma altura de planta superior a 90 cm e um diâmetro de inflorescência superior a 5 mm na colheita, valores dentro dos padrões comerciais exigidos. No entanto, a Green Star e a Spic en Span apresentaram vários rapiers abaixo de 8, um valor indesejável. A cultivar White Goddess teve a maior longevidade, 6,75 dias. O cultivo de gládio em regiões de clima tropical brasileiro permite a redução do ciclo de cultivo e a produção de hastes florais dentro dos padrões de comercialização.

**Palavras-chave:** gládio, bulbos floridos, fenologia, produção de flores de corte, flor ornamental.

### 1 INTRODUCTION

*Gladiolus* is a cut flower popularly known as Palma-de-Santa-Rita, originally from the African continent and belonging to the Iridaceae family (SCHWAB et al., 2019). Its inflorescences are found in the most diverse colors, shapes, and sizes, and are widely used for party decorations, and dates such as All Souls' Day and Mother's Day (TOMBOLATO et al., 2010; TOMBOLATO et al., 2005).

There are more than 1000 gladiolus cultivars in the world, some of which are suitable for winter planting, while others are suitable for summer planting (TOMBOLATO et al., 2005). The culture adapts to the most diverse types of soil and wide temperature range, ranging from 15 to 30°C, its cultivation can be carried out in a greenhouse or under full sun, not adapting to very low temperatures, as they can cause burns due to frost, delay, and loss of production (PAIVA et al., 1999).

Ambient temperature directly affects gladiolus growth and development. Elevated temperatures can advance flowering, while low temperatures can delay flowering (UHLMANN et al., 2020; SCHWAB et al., 2015). According to Boyle et al. (2009) in the Cerrado of Roraima, the accelerated metabolism caused by elevated temperatures resulted in a shortening of the cycle and stems with a reduced number of rapiers. Schwab et al. (2015) report that under elevated temperatures, stem size reduction, sepal burning, and wilting were observed in the hottest periods of the day.

The commercial cultivation of gladiolus in Brazil is concentrated in the South and Southeast, regions with a milder climate when compared to the Center-West region. The predominant climate in the Midwest is semi-humid tropical, with two defined seasons, dry winter
and very hot and rainy summer, with temperatures that can vary from 15°C in the coldest months to 40°C in the hottest months (EMBRAPA, 2022). Studies on the growth and development of gladiolus cultivars in the edaphoclimatic conditions of the Brazilian Midwest are scarce. As reported, temperature directly influences the development of the culture and can accelerate or delay the development of gladiolus plants.

In this sense, Streck et al. (2002) report that studies that characterize the development of cultivated species are important, especially flowering species, as they serve to guide producers in making decisions about the moment of planting, conducting cultural practices, and staggering production. Thus, the present study aimed to characterize the cultivation cycle and quality of floral stems of gladiolus cultivated in a Brazilian region with a tropical climate.

2 MATERIAL AND METHODS

2.1 EXPERIMENTAL AREA AND DESIGN

The experiment was carried out in the experimental area of the Center for Research, Studies and Agro-Environmental Development (CPEDA) of the State University of Mato Grosso (UNEMAT), Professor Eugênio Carlos Stieler University Campus, Tangará da Serra, Mato Grosso (latitude 14°37'55” S, longitude 57°28'05” W and altitude of 488 m).

The region has a tropical climate, with a dry season from May to September and a rainy season from October to April, with an average annual rainfall of 1830 mm (Dallacort et al., 2011). The soil is classified as Distroferric Red Latosol with a clayey texture and flat to slightly wavy relief (SANTOS et al., 2018). The maximum, minimum, and average temperatures during the experiment execution period are shown in Figure 1.
Figure 1. Maximum, minimum, and average temperatures during the experiment execution period. Tangará da Serra, Mato Grosso.

Source: INMET, 2022.

The experiment was conducted in randomized block design, with five cultivars and four replications, with five plants per plot. The cultivars evaluated were White Goddess, Purple Flora, Green Star, Yester, and Spic en Span (Figure 2). The planting was conducted in a greenhouse covered with a 30% shading screen.

Figure 2. Gladiolus cultivars White Goddess (a), Purple flora (b), Green Star (c), Yester (d) and Spic en Span (e). Tangará da Serra, Mato Grosso.

Source: Cordeiro et al., 2022.
2.2 IMPLEMENTATION OF THE EXPERIMENT AND CULTURAL PRACTICES

For planting, the soil was prepared 30 days before, with the addition of 50 g of monoammonium phosphate – MAP (48% P$_2$O$_5$; 11% N) and 10 L of cattle manure per m$^2$. The windrows were raised in the dimensions of 20 cm high, and 20 cm wide, and spaced 40 cm from each other. The bulbs were planted at a depth of 10 cm and spacing between bulbs of 20 cm.

During the conduction of the experiment, it was necessary to carry out crop management practices such as tutoring; micro-sprinkler irrigation once a day, in the morning; weed control by weeding; and pest control, through manual scavenging. The tutoring, which started when the plants were 30 cm high, was carried out using wooden slats fixed to the ends of the windrows and nylon threads that were tied to the stakes every 30 cm in height, forming a structure to support the plants, maintaining them upright and avoiding tipping over.

The inflorescence was harvested at the R3 stage when the corolla of the basal rapier of the cob is open, and the anthers are visible. The stems were harvested in the early hours of the morning, using a stylet to cut the inflorescence between the 5th and 6th leaf of the plant.

2.3 EVALUATIONS

Growth evaluations were performed weekly, from the 21st to the 56th day after planting. The number of leaves, plant diameter in mm, measured 1.0 cm above the ground and plant height, measured from the ground to the highest leaf, were determined.

To characterize the development of the cultivars, the number of days for the plants to enter the stages was determined: R1, fully visible cob; R2, when the first three rapiers at the base of the cob show their color; and R3, when the first rapier at the base of the cob is open, showing its internal structures.

At the time of harvest, the plant diameter in mm, measured at 1.0 cm above the soil, and the plant height, measured from the soil to the apex of the floral cob, were measured. In the laboratory, the following were determined: inflorescence diameter, measured below the insertion of the first floret; the number of rapiers; days from harvest until half of the flowers on the stem are open (IHFO); days from harvest until half of the flowers on the stem are senescent (IHFS); and days from harvest until all flowers on the stem are senescent (discard).
2.4 STATISTICAL ANALYSIS

The growth, development, and characterization data of the floral stems were submitted for analysis of variance. When significative by the F test, the description of growth variables was performed using regression analysis. For the reproductive stages and characterization of the floral stems, the means of the variables that presented significance were compared by Tukey's test at 5% probability.

3 RESULTS

3.1 VEGETATIVE GROWTH

Analysis of variance indicated a significant interaction between cultivars and days after planting for plant height. Plant diameter and number of leaves were significant only for the isolated effects.

Among the cultivars evaluated, White goddess significantly differed from Green Star, Yester, and Spic en Span, in terms of plant height (Figure 3). The cultivar Purple Flora differed significantly from White Goddess only on the 35th day after planting. The daily plant growth ranged from 1.13 cm observed for Spic en Span to 1.69 cm observed for Green Star. The cultivar Purple Flora had the second-highest daily growth rate, 1.44 cm.

Figure 3. Plant height of gladiolus cultivars White Goddess, Purple Flora, Green Star, Yester during the vegetative stage. Vertical bar indicates the minimum significant difference, by Tukey's test at 5% probability. Tangará da Serra, Mato Grosso.

Source: Cordeiro et al., 2022.
During the growing season, the daily plant diameter growth was 0.11mm (Figure 4a). Among the evaluated cultivars, Yester presented the smallest diameter, differing significantly from the others (Figure 4b), with an average 35.1% lower than the highest value that was verified for White Goddess. The average plant diameters ranged from 5.08 to 9.91 mm.

Figure 4. Plant diameter of gladiolus cultivars during the vegetative stage. a) Diameter growth over the days after planting; b) Average diameter of cultivars in the vegetative stage. Means followed by the same letter do not differ from each other by Tukey's test at 5% probability. Tangará da Serra, Mato Grosso.

The gladiolus plants, as shown in Figure 5a, emitted an average of one leaf every 10 days during the period from 21 to 56 days after planting. The average number of leaves varied between 4.33 and 5.57 cultivars (Figure 5b). The White Goddess cultivars differed significantly from the others, for presenting the highest average number of leaves in the period, and Yester, for presenting the lowest average.
3.2 REPRODUCTIVE STAGES

Entry into the reproductive stage occurred only for cultivars White Goddess, Purple Flora, Green Star, and Spic en Span. The cultivars entered the R1 stage between 56.81 and 65.41 days after planting (Figure 6), requiring an average of seven days to enter R2 and two days to enter R3.

The cultivar Purple Flora, proved to be the earliest, starting flowering at 56 days after planting and harvesting at 66 days (Figure 6). Spic en Span, presented the highest number of days to start flowering, and consequently the harvest, proving to be, in the Midwest conditions, the later cultivar. However, it did not significantly differ from Green Star and White Goddess. Heading of cultivar Spic en Span occurred 65 days after planting, and harvesting in R3, seven days later.
Figure 6. Number of days from planting to reproductive stages R1, earing, when the ear tip is visible in the cartridge; R2, when the corollas of the first three basal florets are visible; and R3, when the corolla of the first rapiers at the bottom of the ear is open, that is, when it is possible to visualize the anthers. Means followed by the same letter do not differ from each other by Tukey’s test at 5% probability. Tangará da Serra, Mato Grosso.

3.3 CHARACTERIZATION OF FLORAL STEMS

At harvest time (R3 stage), all cultivars were more than 100 cm high (Figure 7a) and plant diameters greater than 8.0 mm. The Green Star cultivar presented the highest plant height, 133.45 cm, however, it did not differ significantly from White Goddess, which presented a value 8.31% lower. The cultivars Purple Flora and Spic en Span presented plant heights of 103.17 and 108.03 cm respectively, not significantly differing from each other.

The plant diameter in R3 ranged from 12.01 mm observed for White Goddess to 8.99 mm observed for Spic en Span (Figure 7b), significant differences were observed only for these cultivars. The Purple Flora and Green Star cultivars had plant diameters respectively 15.25 and 9.82% lower than the highest average.
Figure 7. Height (a) and diameter (b) of the plant of gladiolus cultivars in the reproductive stage R3. Means followed by the same letter do not differ from each other by Tukey’s test at 5% probability. Tangará da Serra, Mato Grosso.

Source: Cordeiro et al., 2023.

Regarding the diameter of the inflorescence, only the White Goddess cultivar presented an average greater than 8.00 mm (Figure 8a), significantly differing from the others, which presented values of inflorescence diameter between 6.74 and 7.25 mm. No significant differences were observed between Purple Flora, Green Star, and Spic en Span.

The number of rapiers ranged from 6.67 observed for Spic en Span and 9.17 observed for White Goddess (Figure 8b). The White Goddess cultivar did not differ significantly from the Purple Flora and Green Star cultivars, which had an average number of rapiers of 8.60 and 7.50, respectively.
3.4 POSTHARVEST

The number of days between harvest and discard, the period called postharvest life, varied between cultivars. The cultivar White Goddess had the longest postharvest life, 10.2 days, while the shortest postharvest life was observed for Green Star, 7.56 days. There were no significant differences between the cultivars for IHFO, with an average of 2.80 days after harvest being verified for the floral stems to present half of the open flowers (Figure 9).

The number of days between half of the open flowers and half of the senescent flowers (IHFS) ranged from 4.20 days observed for Spic en Span and 2.0 days observed for Green Star (Figure 9). Significant differences were observed only between these cultivars. The discard occurred between 4.10 and 2.56 days after the inflorescences showed half of the senescent flowers. The cultivar White Goddess stood out for taking 4.10 days to reach the point of disposal.
4 DISCUSSION

The initial growth of gladiolus cultivars is directly influenced by temperatures (SHILLO & HALEVY, 1976). In the present study, it was observed that the vegetative phase lasted an average of 51 days, with the early cultivars showing, in this phase, greater plant height, and diameter, and the early cultivar Purple Flora, the lowest number of leaves. These results agree with Streck et al. (2002) who, when studying the vegetative and reproductive development of gladiolus, observed that the leaf emission speed and the number of leaves are determinants in the duration of the vegetative phase, early cultivars present higher leaf emission velocity and lower number of leaves.

The temperature during the growth and development of gladiolus plants can influence the onset of flowering, low temperatures tend to delay flowering, while high temperatures can decrease the number of days to flowering (UHLMANN et al., 2020; SCHWAB et al., 2015). Tombolato et al. (2005) emphasize that modern cultivars, resulting from hybridization, are less sensitive to photoperiod and low temperatures, with cultivars more suitable for winter production and others more adapted to summer.

Entry into R2 (flowering) occurred between 64 and 73 days after planting, with an average temperature of 24ºC in the place during the cultivation cycle. This result is close to that observed
in Roraima, where the period between planting and entry into R2 ranged from 54 to 75 days, and the average temperature observed at the site was 30.2ºC (BOYLE et al., 2009).

For Brazilian subtropical regions, due to lower temperatures, the number of days to start flowering is greater than that observed in this study. Rosa et al. (2014) under average temperatures of 22 ºC report that medium cycle cultivars entered R3 at 84.8 days after planting. In Rio do Sul-SC, Souza et al. (2020) observed that the beginning of flowering for the White Goddes cultivar varied according to planting date, the entry into R2 occurred at 69.1 days after planting carried out in late summer and 103.2 days for planting in early autumn. The authors relate this difference to temperatures during the initial development of plants.

The climatic conditions found in the Midwest region provided a reduction in the cycle of cultivars cultivation in places where temperatures are lower. According to Kadam et al. (2013), edaphoclimatic conditions influence the qualitative and quantitative characteristics of gladiolus floral stems.

The results found in this study for plant height and number of rapiers were like those observed by Boyle et al. (2009) in the Cerrado of Roraima. The authors found plant heights ranging from 92.84 to 117.62 cm and an average of 8 rapiers for short-cycle cultivars. The average temperatures during the vegetative development of the plants, in both places, were superior to 24 ºC.

According to Kadam et al. (2013) during the development of gladioli plants, as the temperature increases, there is an increase in plant height and ear length, and a reduction in the number of days for flowering to begin. However, Schwab et al. (2015) observed shorter stem length averages in gladiolus crops in the months of higher temperatures in the subtropical region.

Shillo & Halevy (1976) reported that under low temperatures at the end of the vegetative cycle, a lower number of rapiers is observed. As shown in Figure 1, at the end of the vegetative cycle, temperatures were lower, which may have influenced the lower number of rapiers observed in the present study. Boyle et al. (2009) suggest that the shortening of the cycle can also interfere with the number of rapiers, due to the reduction of the vegetative stage and, consequently, less availability of nutritional reserves for flowering.

Gladiolus floral stems are classified for commercialization according to the Holambra Veiling (2020) standard, where length and diameter are used as criteria; medium rods are those with a minimum length and diameter of 75 cm and 0.5 mm respectively, long rods 90 cm and 0.8
mm and extra rods 110 cm and 1.0 cm. Regardless of the cultivar, the stems harvested fit the average classification. However, using the criterion number of rapiers, applied by Bongers (2005) for having between 8 and 12 rapiers, White Goddess and Purple Flora would be classified in class II, Green Star and Spic en Span, in class III, due to the number of rapiers have been less than 8.

As for post-harvest longevity, the flower stems harvested in R3 took an average of 3 days to present half of the open flowers (IHFO). These results agree with Bolagam & Natarajan (2020) for gladiolus flower stalks grown in India and stored under ambient conditions.

Santos et al. (2021) report that the time for opening flowers on the gladiolus floral stem is crucial for commercialization, the higher the speed of floral opening, the faster the stems must be available for sale.

Ahmad & Rab (2020) observed that stems of the cultivar White Prosperity harvested in R2 and placed in a pot with distilled water, at an ambient temperature of 25ºC and relative humidity of 70%, took an average of 7.2 days to present all flowers open and 11 days to for the flowers to enter senescence. In the present study, the stems were harvested at R3, which may have influenced the lower number of days to discard the stems.

Discard was considered when all flowers on the stem are senescent. However, Santos et al. (2021) considered that gladiolus stems become unviable for use when they present 50% of the senescent flowers. In this case, the longevity of the stems ranged from 5 to 6.75 days, with the cultivar Spic en Span standing out with greater durability.

The cultivation of gladiolus in a Brazilian region with a tropical climate is possible. Under these conditions, a reduction in the cultivation cycle was observed, and it was observed that the heading occurred between the 56th and 65th day after planting. The floral stems produced, regardless of the cultivar, showed an average commercialization pattern, according to Holambra Veiling.

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DISCLOSURE STATEMENT

The authors report there are no competing interests to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, M.H.M. CORDEIRO, upon reasonable request.
REFERENCES


Santos, JJS, Pêgo, RG, Couto, BRM, Martins, RCF, Carvalho, DF 2021. Postharvest and anthochron of gladiolus floral stems produced in greenhouse under different seasons and irrigation levels. Science and Agrotechnology, 45: e009321.


Souza, AG, Broggiatto, FG, Azeredo Neto, DP, Bosco, LC, Jung, EA 2020. Effect of cropping system on gladioli production in Alto Vale do Itajaí, SC. *Santa Catarina Agriculture* 33: 59-64

