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Organic gladiolus cultivation in first-year no-tillage system

Cultivo de gladíolo em sistema de plantio direto orgânico

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ABSTRACT

Cut flowers are considered an important alternative for property diversification, especially in family farming. The culture of gladiolus (Gladiolus x grandiflorus Hort.) is easy to conduct and has good added value. The traditional way of cultivating gladiolus is carried out with intense soil revolution, which can generate losses in the system. Thus, the adoption of sustainable systems becomes important for the balance of agroecosystems, with the No-Till System being one of these options. The objective of this work is to evaluate the agronomic performance of gladiolus in the organic no-tillage system. The experiment was carried out in the Horticulture sector of the Federal University of Fronteira Sul, Laranjeiras do Sul-PR campus. The experiment was carried out in completely randomized blocks with plots containing a mix of ground cover plants composed of black oat (*Avena strigosa* Schreb) + Vetch (*Vicia sativa* L.) + forage turnip (*Raphanus sativus* L.) and cultivation without cover, followed by cultivation of gladiolus. The gladiolus cultivar used was Yester intermediate cycle II. The evaluations carried out were: phenological and morphological characteristics of the crop, physical and biological characteristics of the soil, incidence of phytophagous insects, diseases and weeds, post-harvest viability and productivity. The results of basal soil respiration, soil temperature, weed incidence, total chlorophyll, rod length, largest leaf length, classification of floral stems classification and productivity showed significant differences between the systems. Cultivation with ground cover obtained higher productivity, with an average of 79,666 stems per hectare. The no-tillage system with organic management showed satisfactory agronomic results, being indicated for the cultivation of gladioli.

KEYWORDS: Yester; *Gladiolus x grandiflorus* Hort.; organic.

RESUMO

As flores de corte são consideradas uma importante alternativa para diversificação da propriedade, principalmente na agricultura familiar. A cultura do gladíolo (*Gladiolus x grandiflorus* Hort.) possui fácil condução e tem bom valor agregado. A forma tradicional de cultivar o gladíolo é realizada com intenso revolvimento do solo, o que pode gerar perdas no sistema. Assim, a adoção de sistemas sustentáveis torna-se importante para o equilíbrio dos agroecossistemas, sendo o Sistema de Plantio Direto uma destas opções. O objetivo nesse trabalho é avaliar o desempenho agronômico de gladíolo em sistema de plantio direto orgânico. O experimento foi realizado no setor de Horticultura da Universidade Federal da Fronteira Sul, campus Laranjeiras do Sul-PR. O experimento foi conduzido em blocos completamente casualizados com parcelas contendo mix de plantas de cobertura de solo composto por aveia preta (*Avena strigosa* Schreb) + ervilhaca (*Vicia sativa* L.) + nabo forrageiro (*Raphanus sativus* L.) e cultivo sem cobertura, seguido do cultivo do gladíolo. A cultivar de gladíolo utilizada foi Yester ciclo intermediário II. As avaliações realizadas foram: características fenológicas e morfológicas da cultura, características físicas e biológicas do solo, incidência de insetos fitófagos, doenças e plantas espontâneas, qualidade das hastes florais e produtividade. Os resultados de respiração basal do solo, temperatura do solo, incidência de plantas espontâneas, clorofila total, comprimento da haste, comprimento da maior folha, classificação das hastes florais e produtividade apresentaram diferenças significativas entre os sistemas. O cultivo com cobertura de solo obteve maior produtividade, apresentando a média de 79.666 hastes por hectare. O sistema de plantio direto com manejo orgânico demonstrou resultados agronômicos satisfatórios sendo indicado para o cultivo de gladíolos.

PALAVRAS-CHAVE: Yester; *Gladiolus x grandiflorus* Hort.; orgânico.

INTRODUCTION

The cultivation of cut flowers is considered an alternative for diversification of property, especially in family farming. The gladiolus culture (*Gladiolus x grandiflorus* Hort.) features ease in driving, short cycle (60 to 120 days) and rapid financial return (PORTO et al. 2012). Crop yield is approximately 300,000 stems per hectare depending on planting density and number of stems per plant (ROSA et al. 2014). Its flowers are marketed for different purposes, being used in the composition of bouquets, ornaments, and floral arrangements. Another positive characteristic of the crop is the postharvest durability of the stems, which can reach 15 days when submitted to a temperature of approximately 5 °C (SCHWAB et al. 2015ab)**.**

Gladiolus, also known as Palma-de-Santa-Rita, belongs to the family Iridaceae. It is a herbaceous plant, with a height between 1.0 and 1.3 m, an underground solid bulb stem, called corm. Its leaves are narrow and elongated, similar to a sword (origin of the popular name Gladiolus). Its inflorescences are of the simple raceme type and contain between 8 and 16 flowers. The color of the flowers is varied, with various combinations and shades. Multiplication is performed by means of solid bulbs (corms), bulbs or by micropropagation. Cultivation can be done in full sun in sheltered lodging or in a protected environment. The ideal temperatures for cultivation are between 15 and 25 °C. The soil should preferably be sandy-clayey, well drained and with medium fertility. The crop cycle may vary according to the cultivars but is generally considered short (60 to 120 days) (TOMBOLATO et al. 2005).

The traditional way of cultivating gladiolus is performed with intense soil revolving, which comprises the plowing followed by grading and later the enchantment, without the use of soil cover practices. Thus, it can generate losses of nutrients and organic matter, causing changes in soil structure, promoting a decline in agricultural soil productivity (SOUZA et al. 2014, COELHO et al. 2013). However, the implantation of crops without revolving, provides several benefits to the soil, such as greater moisture conservation, lower temperature variation, and also improvement in physical, chemical and biological conditions. As an example, it promotes greater root development, cycling and nutrient availability and increased microbial community (MATHEW et al. 2012).

The adoption of sustainable systems becomes important for the balance of agroecosystems, and among these is the No-Tillage System (SPD). The SPD has three basic principles: non-soil rotation, the use of cover crops for straw formation and crop rotation (PACHECO et al. 2021). This system revolutionized soil and water management in agricultural areas, by minimal soil revolving in the sowing line, maintenance of crop residues on the surface and crop rotation (MICHELON et al. 2019)

The SPD provides the use of different species for straw formation. Among the materials that can be used for soil cover formation are black oat *(Avena strigosa* Schieb, Poaceae), common vetch (*Vicia Sativa* L., Fabaceae) and forage turnip (*Raphanus sativus* L., Brassicaceae). These species are common for other agricultural purposes, considered easy to obtain in different regions. In addition, they provide numerous benefits, such as black oats that present high dry matter accumulation, obtaining a higher amount of straw and increasing weed suppression (BALBINOT JUNIOR et al. 2007).

On the other hand, vetch has as advantages the slower release of nitrogen (N) in relation to synthetic nitrogen fertilizers, generating a lower risk of pollution of the environment (SILVA et al. 2006). Furthermore, it is efficient in accumulating in its tissues the elements N, phosphorus (P), potassium (K), magnesium (Mg) and, especially, Calcium (Ca), concentrating more on the aerial part of the plant (WOLSCHICK et al. 2016). Forage turnip is widely used in green fertilization due to its pivoting roots penetrating the soil with ease. It has high nutrient recycling capacity, mainly N and P. Its development is fast, covering about 70% of the soil in 60 days (BARROS & JARDINE 2012).

The use of consortia of Poaceae, Fabaceae and Brassicaceae provide efficiency in soil vegetation cover, also contributing to a greater fixation or recycling of nutrients, especially N. In addition, the intercropping provides the formation of residues under the soil and release of nutrients more adequate than single cultivation (ZIECH et al. 2015). However, one should consider the characteristics of each one, in relation to dry mass production, growth speed, decomposition time and production of allelopathic compounds (OLIBONE et al. 2006).

The use of SPD enables crops organically, without the use of herbicides. This system contributes to increasing the biodiversity of agroecosystems, allowing several positive ecological interactions. In addition, it can increase the profit of the farmer with the lowest use of inputs, also generating a lower risk of environmental contamination (BONJORNO et al. 2010). Thus, the purpose of organic systems is to produce in a way that preserves nature, aiming at the maintenance and better use of natural resources, also optimizing production (ALENCAR et al. 2013).

In view of the above, it is important to make production systems sustainable, combined with the use and conservation of natural resources. In relation to gladiolus culture, studies related to production in SPD with organic management are scarce, demanding research aimed at this production system. Thus, the objective of this work is to evaluate the performance of gladiolus in first year organic no-tillage system.

MATERIAL AND METHODS

The experiment was carried out in the experimental area of the Federal University of Fronteira Sul, Laranjeiras do Sul-PR campus, horticulture sector, located at 25°24'28" S and 52°24'58" W and altitude of 840 m. The type of soil present in this site is classified as Eutrophic RED LATOSOL, according to the Brazilian Soil Classification System (EMBRAPA 2018).

The climate of the region is classified as Cfa, Humid Subtropical Climate (Mesothermal) (APARECIDO et al. 2016**,** ALVARES et al. 2013), with average annual temperature between 18 and 19 ºC and precipitation from 1800 to 2000 mm.year^{-1} (CAVIGLIONE et al. 2000). During the experiment execution period, which was from July to December 2020, the average minimum and maximum temperatures remained between 15.85 °C and 26.5 °C, respectively, and the accumulated precipitation in the period was 1047 mm (Figure 1) (UFFS 2020).

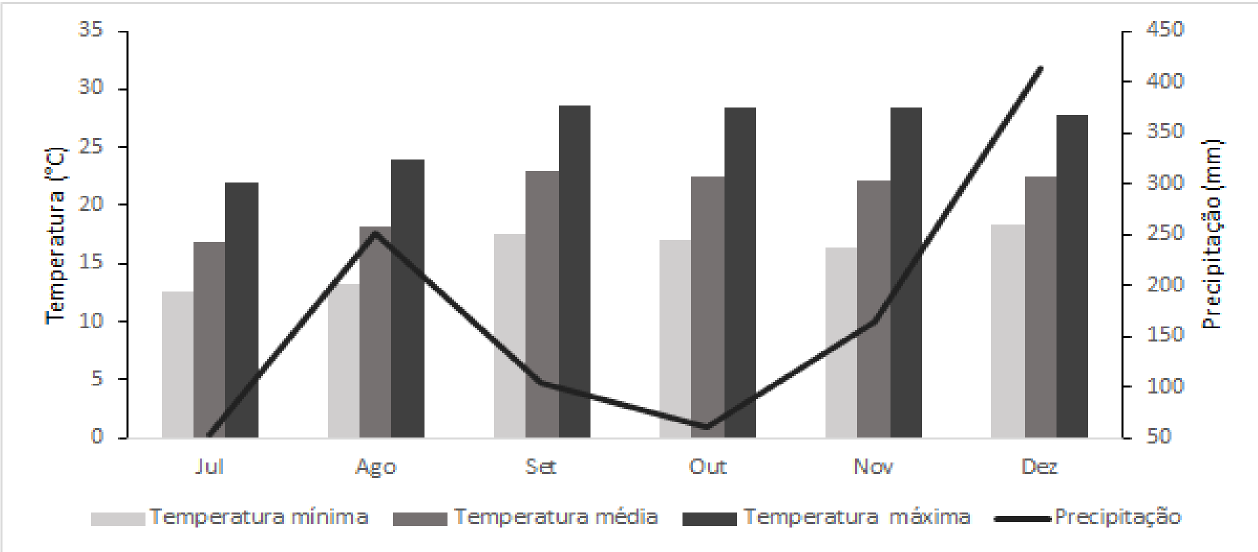

Figure 1. Average values of precipitation (mm), minimum, average and maximum air temperatures (°C) from July to December 2020, Laranjeiras do Sul/PR. Data obtained at the UFFS weather station - Laranjeiras do Sul/PR.

The experiment was conducted using plots with a mix of cover crops in an organic no-tillage system and without soil cover. The species mix used was black oat (*Avena strigosa* Schreb) + vetch (*Vicia sativa* L.) + forage turnip (*Raphanus sativus* L.) followed by the cultivation of gladiolus (*Gladiolus x grandiflorus* Hort.). The gladiolus cultivar used was the Yester intermediate cycle II, which blooms between 78 and 131 days after planting (SCHWAB et al. 2019, FERREIRA 2008).

The experimental design adopted was in completely randomized blocks being unifactorial (presence and absence of soil cover). Six blocks were used, each 0.60 m wide and 25 m long, each block contained two plots of 12.5 m, in addition to two blocks of the ends that constituted the surround.

Before the implementation of the experiment, soil was collected at two depths (0-10 and 10-20 cm) to verify pH and fertility (Table 1). Subsequently, the soil was prepared conventionally, including subsoiling, plowing, and grading, being performed twice each, at a depth of approximately 30 cm (VAZ et al. 2020).

The recommendation of fertilization of the cover plants was based on soil analysis of the area, following the guidelines of the Manual of Fertilization and Cathem (PAVINATO et al. 2017). A total of 2.8 tons $^{ha-1}$ of limestone (PRNT of 80%), 100 kg.ha^{-1} of N, 30 kg.ha^{-1} P_2O_5 and 200 kg.ha^{-1} of K_2O. The fertilizer sources used were aviary lodging (2% N), natural rock phosphate (9% P) and ash (5% K).

Green fertilizers were sowing on 08/01/2020 to obtain the cover. Sowing was carried out at the rate of 30 kg.ha^{-1} of oats + 30 kg.ha^{-1} of vetch + 25 kg.ha^{-1} of forage turnip adapted from SILVA et al. (2006). The green fertilizers were layered at 75 days when the development of the species was close to flowering with a wooden timber.

Table 1. Data from the chemical analysis of the soil carried out prior to the implementation of the experiment, Laranjeiras do Sul/PR, 2021. Source: Prepared by the authors, 2021.

Soil analysis of the area											
Layer	pH	MO	P	K	Ca	Mg	Al	H+Al	SB	CTC	V
cm	CaCL	g/dm^3	mg/dm^3	******************** cmol/dm^3 *********** ****						%	
0-10	5,23	41,05	16,67	0,17	5,47	1,87	0,0	4,96	7,51	12,47	60,2
10-20	4,59	34,29	7,88	0,07	3,89	1,72	0,2	6,54	5,68	12,22	46,5

Gladiolus bulbs were characterized for caliber, diameter, and mass. The mean caliber values were 12/14, diameter 0.039 m and mass of 0.169 kg. These values classify the material as large (Jumbo) being indicated for the production of cut flowers (SCHWAB et al. 2019). Subsequently, garlic syrup was applied to the bulbs to protect against the attack of pests and diseases (FERNANDES et al. 2005) and immediately planted on 14/10/2020.

Grooves of 0.10 m depth were prepared, fertilized with 1 kg.m linear worm humus (1.5% N), adapted from RICCI (1996) and liquid biofertilizer Supermagro at a concentration of 4% (LEITE & MEIRA 2016). The planting spacing was 0.60 m between lines and 0.20 m between bulbs, totaling 732 bulbs, planting at a depth of 0.05 m.

A drip irrigation system was installed five days after planting, with drip points distances of 0.20 m with a drip tape on each side of the planting line, totaling 12 tapes of 25 m. Irrigation was performed according to the need.

The necessary cultural treatments were carried out according to the demand of the crop, following the organic production standards LEI No. 10,831, DECEMBER 23, 2003 (BRASIL 2003) and ORDINANCE No. 52, DE 15 MARCH 2021 (MAPA 2021). All operations were carried out manually, being: weeding in the plots in cultivation without cover or weeding in the plots in no-tillage system, both being carried out at 20, 49 and 65 days after planting (DAP) (phenological stage of gladiolus (EFG) - V2, V7 and R1.1) (SCHWAB et al. 2015b); organic fertilization with worm humus, performed at 27 DAP (EFG V3 and V4), and in the cultivation with cover was only deposited at the base of gladiolus without revolving.

The removal of shoots was performed twice at 30 and 50 DAP (EFG V4 and V7) leaving only one stem per plant. The application of phytoprotective broths and leaf fertilizers was performed four times during the cycle, being at 15, 30, 45 and 60 DAP, respectively (EFG V2, V3, V6 and V8). The leaf syrups used were “bordalesa” syrup and milk syrup, while the fertilizers were superlean (4%) and cow urine (4%).

From the 42 DAP (EFG V6) to the 68 DAP (EFG R1.2) were also tutored and conducted the plants, using wooden cuttings with 1.50 m long and 0.10 m wide buried in the soil at 0.35 m. The tutors were inserted at the end of each plot, using four horizontal lines of phytos (0.30, 0.60, 0.90 and 1.10 m from the ground), supporting and favoring vertical growth. A black shading screen was also implanted with a percentage of 50% fixed on the wooden cuttings at 57 DAP (EFG V8), the objective of this practice is to reduce the damage of the sun and high temperatures under the floral ears.

The evaluations were performed in plants and soil, in addition to the incidence of insects, diseases and spontaneous plants.

In the plants, the dates of occurrence of the different stages of development were evaluated, determined when 30% of the plant population in the plot presented change, according to the scale proposed by SCHWAB et al. (2015b), from the emergency phase (MS), leaf emission (EFG V1 to V8) to the reproductive phase (EFG R1.0 to R2).

The total chlorophyll index was determined nondestructively using the Falker Clorofilog chlorophyll meter model CFL 1030, using as unit of measurement the ICF - Falker Chlorophyll Index. The readings were performed at intervals of 15 days, with two random readings in the lower third (basal), of 30% of the plants of each plot in the periods of 20 (EFG V2), 38 (EFG V5), 56 (EFG V8), 74 (EFG R2) DAP.

At harvest, the following morphological measurements were performed (FERRON et al. 2021): length of the largest leaf (distance, in centimeters, between the soil surface and the apex of the highest leaf); number of buds per floral spike; plant height (distance, in centimeters between the soil surface and the insertion of the apical floral bud); length of the floral ear (distance, in centimeters, between the insertion of the basal floral bud and apical); and rod diameter (cm).

The harvest and classification of floral stems was performed when the plants reached the EFG of R2 (when the color of the first three florets was livable) (74 to 76 DAP). In total, two harvests were carried out.

The floral stems were classified according to the criteria of the VEILING HOLAMBRA Cooperative (2013). To classify the rods in terms of their dimensions, the ranges of values were: length from 0.75 to 1.10

m, diameter from 0.5 to 1.0 cm and size of the tassel with at least 40% of the total length of the rod. The stems were separated into three classes, being medium, long, and extra, presenting respectively up to 0.75 m, 0.90 and 1.10 m in length. The diameter of the rod that must be at least 0.5 cm for middle class, 0.8 mm for long class and minimum diameter of 1.0 cm for extra class. Productivity was calculated using the average number of stems per plot determined in hectares.

Physical and biological characteristics were evaluated in the soil. For the physical parameters, soil water retention capacity (CRA) (adapted from MONTEIRO & FRIGHETTO 2000) and soil moisture performed by the mass difference method were determined, with soil samples collected in the center of the plots, 10 cm deep, packed in Styrofoam recipients and immediately weighed (initial mass). Subsequently, the samples were placed in greenhouses at 105 °C until the soil was completely dried and then weighed (final mass). The soil moisture content was obtained by the difference between the final and initial mass of the samples, and the result expressed as a percentage. For biological characteristics, basal soil respiration (RBS) (adapted from ALEF 1995) was evaluated.

The evaluations of CRA, RBS and soil moisture were performed three times during the entire experiment, being: before the implantation of cover crops, at 40 days after lodging (EFG V6) and at the end of the experiment at 75 days DAP (EFG R2).

Soil temperature was determined using a Scan Temp/series-1000 infrared thermometer, with measurements at 16 hours in each plot, on the soil surface. In the plots, two sampling points were verified, in three periods of the experiment (before the implantation of the cover crops, after 20 days of their layer (EFG V2) and at 75 Gladiolus DAP (EFG R2).

For the survey of spontaneous plants, a square of 0.25m x 0.25m (internal area of 0.0625$^{m2)}$ was randomly launched at two plot sites. For each sampling, the number of spontaneous plants was counted based on the PITELLI methodology (2000). After counting the species, they were classified as Monocotyledons and Eudicotyledons. This evaluation was performed in three periods of the experiment, being: before the implantation of cover crops, 20 days after lodging cover (before the first weeding - EFG V2) and 50 days after the lodging of the cover (before the second weeding - EFG V7). To measure the decomposition of the straw (cm and %), a millimeter ruler was used, measuring the height in three random places of each plot.

Pitfall and Moericke traps were used to estimate the diversity of phytophagous insects and natural enemies. Pitfall traps were arranged in 2 locations per plot and two Moericke traps installed at 0.40 m height randomly in the plot. A solution consisting of water, detergent and formaldehyde was used in the concentration of 2% of the amount of water used. The traps remained in the camp for 72 hours. The collected material was filtered in voil fabric and deposited in bottles containing 70% alcohol for the preservation of the material. The specimens were identified at the taxonomic level (Order). The samples were collected every two weeks.

For the determination of the incidence of phytophagous and phytopathogens, the percentage of plants with symptoms of disease or insect attack was calculated in relation to the total of plants evaluated. Severity levels were identified with the aid of a diamatic scale, adapted by AZEVEDO (1997), which considers values from zero to four, being: zero: plants without signs of disease or attack of phytophagous insects; one: only small lesions of up to five millimeters; two: plants with 35-70% of leaves with symptoms; three: plants with 70-100% of leaves with symptoms and four: dead plants. The evaluations were carried out every two weeks.

The data obtained were submitted to variance analysis and the mean values found in plots with soil cover and in cultivation without cover were compared by Tukey test at 5% probability of error.

RESULTS AND DISCUSSION

The phenological attributes of water retention capacity (CRA), soil moisture, diversity of insects and natural enemies, incidence and severity of insects and diseases, did not present significant differences (data not presented). However, for the incidence and severity of diseases, some plants were affected by *Botrytis,* but with low incidence in leaves. In addition, there was an attack by leaf-cutting ants in the initial period of crop development, also with low incidence.

The average incidence values of monocodenite and eudicotyledonean weeds in the evaluation before the implantation of cover crops, total chlorophyll in EFG V8 and R2, RBS in the evaluations before the implantation of cover crops and layered coverings after 40 days, soil temperature in the evaluation before the implantation of cover crops, number of flower buds per stem, plant height, floral ear length and stem diameter also showed no significant differences (data not shown).

The cycle between planting and harvesting (EFG - R2) was 74 days, considering that the cultivar

Yester has intermediate cycle II, which blooms between 78 and 131 days after planting (SCHWAB et al. 2019). In this crop, there was an advance of the cycle, attributed to the temperature that presented a maximum average of approximately 26.5 °C, and may have contributed to the reduction of the cycle (STRECK et al. 2012). Phenological phases, although not significant at the 5% probability level, developed according to (Table 2).

Table 2. Phenological stages of gladiolus, performed in treatments with and without ground cover, Laranjeiras do Sul/PR, 2021.

Gladiolus phenological stages	Days after planting (DAP)
VE - The bud is visible above ground level	9
V1 - Blade of the first leaf can be viewed in the cartridge	13
V2 - When two leaf blades appear	20
V3 - Three apparent leaf blades	25
V4 - Four apparent leaf blades	31
V5 - Five apparent leaf blades	38
V6 - Six apparent leaf blades	42
V7 - Seven apparent leaf blades	47
V8 - Eight apparent leaf blades	56
R1.0 - Floral spike becomes visible in cartridge	64
R1.1 - Half of the spike is visible in the cartridge	66
R1.2 - The spike is completely visible in the cartridge	68
R2 - First three floral buds show the color in gladiolus.	74

(Adapted from SCHWAB et al. 2015b)

Regarding the analysis of total chlorophyll content in gladiolus, the highest values were verified in plants in cultivation without soil cover at 20 and 38 DAP (EFG V2 and V5) (Table 3). These results are different from those verified in a research by FERRON et al. (2021). These authors did not find significant difference for chlorophyll content in gladiolus cultivation under different shading screens. Just as STANCK (2019) also did not observe difference in chlorophyll content in gladiolus in two cultivation systems (minimum and conventional).

Table 3. Total chlorophyll (ICF- Chlorophyll Falker Index) obtained in the phenological stages of gladiolus culture (EFG) V2 and V5, as a function of soil cover. Laranjeiras do Sul/PR, 2021.

Soil cover	Total chlorophyll (ICF – Falker Chlorophyll Index)	
	Phenological stages	
	V2	V5
With coverage	59.00 b	59.10 b
No coverage	63.38 a	64.60 a
CV (%)	2.51	1.04

* Means followed by the same letter in the column do not differ by the Tukey test, at 5% error probability. Source: Prepared by the authors (2021).

The results obtained for total chlorophyll may be related to the higher solar reflectivity that the systems containing straw provide. In the system without soil cover the reflected light is lower, with this the photosystems increase the synthesis of chlorophyll b to increase the capture of the smallest amount of reflected light. In general, the lower the amount of light, the higher chlorophyll content (FERREIRA et al. 2012). Therefore, considering that in the initial stages of the crop the straw index on the soil was higher, this may have influenced lower values of total chlorophyll in the cultivation with soil cover.

The environment in which the plant is inserted influences the intensity of light absorption. However, excess luminosity activates mechanisms that decrease light absorption in order to protect the plant and can inhibit photosynthesis through two processes: photoinhibition (reversible) and photo-oxidation (irreversible). In addition, chlorophylls are unsteady pigments, dependent on environmental factors such as water stress, pH, reduced luminosity, enzymatic changes, temperature, and ethylene increase (STREIT et al. 2005).

Plants with longer floral stem length and larger leaf were obtained in the presence of soil cover (Table

4). Results similar to the length performance of gladiolus floral stems were verified by SOUZA et al. (2020). The authors verified that the floral stems of the cultivars White Goddess and Red Beauty (intermediate cycle II) were higher when cultivated in a minimal cultivation system with the use of straw.

Table 4. Flower stem length (cm) and largest leaf length (cm) as a function of soil cover. Laranjeiras do Sul/PR, 2021.

Soil cover	Rod length (cm)	Length of largest leaf (cm)
With coverage	102.38 a	74.04 a
No coverage	90.00 b	70.10 b
CV (%)	3.35	1.86

* Means followed by the same letter in the column do not differ by tukey test to 5% error probability. Source: Prepared by the authors (2021).

It is believed that less soil revolving and cover use, practices performed in the SPD, contribute to greater length of the stems because it provides in the soil reduction of soil erosion, increased infiltration of rainwater, improvement in chemical, physical and biological characteristics of the soil (OLIVEIRA et al. 2015). The length of the rods influences their durability, and the longer ones are desirable so that in the post-harvest cuts are made at the base in order to renew the tissues and restore the absorption of water, keeping them with commercial size (SCHWAB et al. 2015b).

One of the factors that may have contributed to the higher quality of stems in the cultivation with cover, is the behavior of nutrients, because they are mainly in the surface layers. In the work of BERTOL et al. (2000) when comparing the management with plow-powered animal traction in conventional planting in relation to the no-tillage system, these authors verified that the extractable phosphorus content was 50% lower at the depth of 0-5 cm in the conventional system. In addition, the cultivation with soil cover allows greater availability of K in the first 5 to 10 cm of the soil, contributing to the lower use of maintenance fertilization, without affecting crop yield (LOPES et al. 2004).

One of the main nutrients demanded for the proper development of gladiolus is Nitrogen (N). This nutrient is associated with the composition of amino acids, proteins, and chlorophyll of plants, being important to obtain quality bulbs and flowers (ROSA et al. 2014). It also contributes to the growth and development of cover crops, increasing the production of dry matter for soil cover in the no-tillage system and consequently crop productivity (COSTA et al. 2012). Thus, the cultivation system should contribute to the growth and development of the crop in a way that meets its demands and maintains the floral stems with commercial standard.

The largest number of stems classified as long and extra came from the soil cultivation system with cover (Table 5). In a research conducted by SOUZA et al. (2020), the minimum cultivation system where soil cover is used provided greater diameter and length of gladiolus stems when compared to the conventional system. Thus, straw cover systems combined with minimal soil revolving contribute to the production of quality rods.

Table 5. Classification of gladiolus floral stems (medium, long, and extra) according to Veiling Holambra's criteria, as a function of soil cover. Laranjeiras do Sul/PR, 2021.

Soil cover	Classification of floral stems		
	Classes		
	Mean	Long	Extra
With coverage	5,50 b	33,25 a	21,00 a
No coverage	13,25 a	26,25 b	17,50 b
CV (%)	13,60	13,41	21,05

* Means followed by the same letter in the column do not differ by tukey test to 5% error probability. Source: Prepared by the authors Means followed by the same letter in the column do not differ by Tukey test to 5% error probability. Source: Prepared by the authors (2021).

According to CASTRO et al. (2007), the diameter and length of the stem can influence the postharvest durability, the floral stems that presented higher dry matter production and larger diameters showed greater durability. In addition, rods classified between long and extra may have higher commercial value than middle-class rods.

Regarding productivity, considering the spacing of 0.20 m between plants and 0.60 m between rows with the number of stems harvested, where each plant contained a stem, discounting the dead plants in the plots, it was found that the cultivation with soil cover obtained an average productivity of 79,666 stems per hectare, and the cultivation without soil cover 78,666 stems per hectare.

In a research conducted by MICHELON et al. (2019), the authors verified that the consortium of black oat + vetch + forage turnip before corn crop, resulted in higher yields, besides increasing the levels of organic matter, availability of phosphorus and potassium in the soil. In the cultivation of cauliflower (*Brassica oleracea* var. botrytis) conducted by SCHULTZ et al. (2020), the authors also obtained higher productivity in a no-tillage system compared to the conventional one. In this sense, the use of green fertilizers associated with adequate crop management can contribute to increased productivity.

The highest RBS values were verified in the presence of soil cover in the three periods evaluated (Table 6). However, there was no significant difference between the means for the treatments evaluated before the implantation of cover crops and in the cover of lodging soil after 40 days (EFG - V7).

Table 6. Basal Soil Respiration (C-CO_2 mg kg^{-1} h^{-1}), in three evaluation periods (before the implantation of cover crops, at 40 days after lodging of the covers (EFG -V6) and at the end of the experiment (EFG - R2)), as a function of soil cover. Laranjeiras do Sul/PR, 2021.

Soil cover	Basal soil breathing – RBS (C-CO_2 mg kg^{-1} h^{-1})		
	Evaluation periods		
	Before the implementation of the cover crops	Ground cover layered after 40 days (DAP)	End of Experiment (75 DAP)
With coverage	211.46 ns	222.46 ns	191.93 a
Without coverage	196.95 ns	191.72 ns	153.11 b
CV (%)	9.06	10.90	11.65

* Means followed by the same letter in the column do not differ by the Tukey test, at 5% error probability; ns - not significant. Source: Prepared by the authors (2021).

In the last evaluation period, the cultivation with soil cover obtained a higher value of RBS. These results may be related to soil microbial activity, as this is dependent on the presence of decomposition roots and organic materials, including animal and plant residues where carbon is released into the atmosphere in carbon dioxide, indicating greater activity of microorganisms (ARAÚJO et al. 2007, CORREIA & OLIVEIRA 2006).

In the cultivation without soil cover, there was a decrease in RBS values, showing lower microbial activity in the soil. For BUZINARO et al. (2009), the growth of microorganisms in the soil is restricted when there is no carbon source. In addition, when lower soil respiration rates occur it is indicative of lower microbial activity and a slow decomposition of organic material causing lower release of nutrients to plants (PAVINATO & ROSOLEM 2008).

In research conducted by PEREZ et al. (2004) and COSTA et al. (2006) it was found that conventional methods of soil tillage consisting of plows and gradations, associated with the low return of plant residues to the system, provide lower levels of organic carbon in the soil. Furthermore, in the no-tillage system, the highest rates of biological activity occur, and the carbon values of the soil microbial biomass are more stable.

Although the no-tillage system can influence basal soil respiration, some variables such as the physiological state of microbial cells, temperature, humidity, soil structure, texture, amount of organic matter, among others should be considered (SILVA et al. 2010). In this sense, the adoption of conservation practices that benefit microorganisms is essential to maintain the sustainability of agricultural systems.

The lowest soil temperature values were verified in the presence of soil cover in the last two evaluation periods (after 40 days of cover-up (EFG V6) and end of the experiment (EFG R2)) (Table 7). In the first evaluation (before the implantation of cover crops) the cover was still developing, so, both in the cultivation with and without cover, they were without protection, obtaining higher temperature values, with no difference between the means between treatments.

The largest difference in the mean values of soil temperature between the cover systems was observed in the second evaluation period (lodging cover after 40 days), in which the values in the cultivation without soil cover were 47.26 °C and in the cultivation with coverage of 31.66 °C. It is important to highlight that high soil temperatures cause nutrient volatilization, mainly N, and losses of up to 50% may occur if submitted to temperatures around 35 °C (TASCA et al. 2011). In addition, temperature directly influences microbial activity and indirectly exerts changes in nutrient cycle and water activity (CARDOSO & ANDREOTE 2016).

Table 7. Soil temperature (°C) in three periods evaluated (before the implantation of cover crops, at 40 days after lodging the covers (EFG - V6) and at the end of the experiment (75 DAP, EFG - R2)), as a function of the ground cover. Laranjeiras do Sul/PR, 2021.

Soil cover	Soil temperature (°C)		
	Evaluation periods		
	Before the implementation of the cover crops	Ground cover layered after 40 (DAP)	End of Experiment (75 DAP)
With coverage	46.83 ns	31.66 b	25.65 b
Without coverage	48.80 ns	47.26 a	29.28 a
CV (%)	6.45	10.86	3.77

* Means followed by the same letter in the column do not differ by the Tukey test, at 5% probability of error, ns - not significant. Source: Prepared by the authors (2021).

The high temperature in systems without cover culture can considerably decrease the microbial activity of psychrophiles and mesophiles, which are beneficial microorganisms that have optimal temperatures of activity and growth of 15 and 37 °C respectively (CARDOSO & ANDREOTE 2016). In the present research, the cultivation with soil cover presented values within this interval in the last two evaluation periods, when the cover crops had already developed and were layered. On the other hand, the plots with cultivation without cover presented a temperature of 29.28 °C only after the use of the shading screen.

In the last evaluation period, for planting system with soil cover, although the straw height is not expressive and the soil temperature values are at 25.65 °C, these results are still lower than those obtained for plots without soil cover that reached 29.28 °C. In the third evaluation period, soil temperature was lower in the plots submitted to both treatments, when compared to previous evaluations, probably due to the use of shading screen (50%). This screen was implanted 57 days after planting the bulbs to reduce the damage of the sun and the high temperatures on the flowers. In a research conducted by FURLANI et al. (2008), it was found that the no-tillage system resulted in lower soil temperatures than those obtained in soil with conventional tillage. This author performed the temperature readings at the same time of this research (16:00 hours), obtained 27.5 °C in the cultivation with soil cover and 32.2 °C without cover.

There was a higher incidence of spontaneous plants in plots without soil cover in the last evaluation periods (Table 8). At 20 days after lodging, the incidence of spontaneous plants in the cultivation with cover was 74.40% lower than that observed in the cultivation without soil cover. At 50 days of lodging, the incidence of spontaneous plants was 66.20% lower than that estimated in cultivation without soil cover, in an evaluated area of 0.25 x 0.25^{m2}.

Table 8. Incidence of weeds in three evaluation periods, before the implantation of cover crops, coverings in layers after 20 (EFG - V2) and 50 days (EFG - V7), as a function of the ground cover. Laranjeiras do Sul/PR, 2021.

Incidence of spontaneous plants in 0,25 x 0,25 m^2 (0,0625 m^2)			
Soil cover	Evaluation periods		
	Before the implementation of the cover crops	Layered ground cover after 20 days	Layered ground cover after 50 days
With coverage	0.00 ns	2.62 b	3.00 b
Without coverage	0.00 ns	10.25 a	8.87 a
CV (%)	-	33,22	30,12
		Monocotyledons	
With coverage	0.00 ns	2.00 b	2.62 b
Without coverage	0.00 ns	7.75 a	8.00 a
CV (%)	-	52.80	35.37
		Eudicotyledons	
With coverage	0.00 ns	0.62 b	0.37 ns
Without coverage	0.00 ns	2.50 a	0.87 ns
CV(%)	-	64.99	136.63

* Means followed by the same letter in the column do not differ by the Tukey test, at 5% probability of error, ns - not significant. Source: Prepared by the authors (2021).

In the research of KOZLOWSKI (2002), the critical period of prevention of weed interference for corn crop (*Zea mays* L.), occurred between phenological stages V2 and V7. According to this author, the predominance of weeds in these periods reduced on average 87% the grain yield throughout the cycle. For gladiolus culture, it is important to perform management mainly in the initial stages (V2), or in periods of greater competition. In the present study, the manual control of spontaneous plants was performed in the phenological stages of gladiolus culture V2, V7 and R1.1, but this may vary depending on the level of incidence of weeds.

Most of the spontaneous plants identified in the area belonged to the monocotyledones group. In the evaluation period after 20 days of lodging, the percentage of monocotyledonous plants was 74.20% (7.75 plants in 0.0625^{m2}) higher in cultivation without cover. The same behavior was verified in the last evaluation period (50 days after lodging) in which the percentage of spontaneous plants was 67.25% (8.0 plants at 0.0625^{m2}) higher than that observed in the crop with cover. These results may be related to the history of use of the planting area, where it has an incidence mainly of brachiaria grass (*Brachiaria decumbens* Stapf.), a species that normally has a high population density.

The incidence of spontaneous plant species classified as eudicotyledons was higher in cultivation without cover. The highest percentage of plants classified in this group was verified at 20 days after lodging, with 75.2% of the species (2.50 plants at 0.0625^{m2}). In a research conducted by KOZLOWSKI (2002), eudicotyledons represented 22.3% of the weeds and monocotyledons constituted 77.7%, *brachiaria plantaginea* (Link) Hitchc. the most prevalent.

In the evaluation carried out by RODRIGUES et al. (2007) on the incidence of weeds in the cultivation of ornamental species belonging to the botanical family Bromeliaceae, it was verified that the pots containing land cover showed little or no invasion by weeds, similar results were found in the present study, where the incidence of weeds was lower in the cultivation with soil cover.

The dead cover in the soil generates a physical protection that can interfere in the germination and survival rate of seedlings of some weed species, especially positive photoblastic ones, which require a certain wavelength to germinate (LAMEGO et al. 2015). In addition, it is believed that the allelopathic effect of plants used as cover, mainly black oats, may have contributed to the suppression of weeds (PINTO et al. 2021).

However, weed management in PdS without the use of herbicides is still a challenge in agriculture. Some criteria should be considered in order to reach this purpose, such as the recovery of soil fertility, tied to the decrease in the weed population and improvement in the competitiveness of crops, which may include localized manual control of weeds, among others (GOMES JR & CHRISTOFFOLETI 2008).

Regarding the height of the straw (mix of cover crops), there was a decrease throughout the experiment, reaching close to zero at 75 days after planting (Figure 2). The average height of the straw immediately after lodging was 7.0 cm. In the first 15 days after lodging, the mean reduction in straw height was approximately 4.0 cm. Subsequently, the mean decomposition was around 1.5 to 2.0 cm until 45 days, maintaining straw height between 0.7 cm and 0.5 cm until 75 days. The percentage of coverage decomposition at 15 days after lodging was approximately 39%. The rapid decrease may be related to the action of high temperature on the newly lodging material causing the loss of straw water.

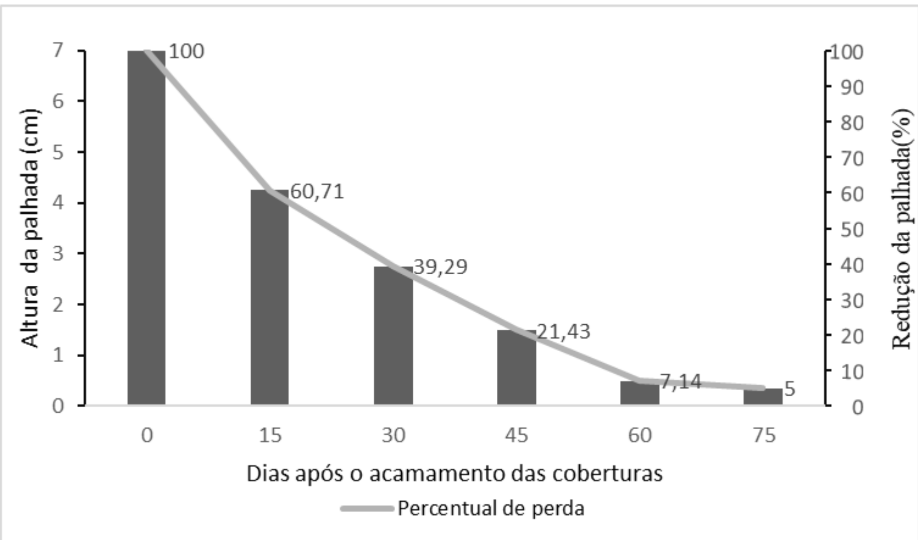

Figure 2. Decomposition of straw (cm and %) over the days after lodging, as a function of soil cover. Laranjeiras do Sul/PR, 2021.

Between the period of lodging of the cover plants and gladiolus harvest, there was an increase in precipitation, which ranged from 60 to 400 mm. When precipitation increases decomposition tends to increase, being a determining factor for the permanence of straw on the soil (COSTA et al. 2013). In addition, the average air temperature of the present study was between 23 and 24 °C after lodging. Thus, the combination of precipitation and the rise in temperature may have contributed to increase decomposition. Under these conditions, there is an increase in microbial activity and the decomposition of soluble components, including sugars, starches, and proteins (BOER et al. 2008).

The time of permanence of the dead cover on the soil surface depends on the speed of decomposition of the crop residues, that is, if the decomposition is fast the speed of nutrient release will be proportional, in this case, it can decrease the protection of the soil. However, if lignin content and C/N ratio in waste are high, its degradation will be slower (COSTA et al. 2013).

However, nutrient cycling varies according to each species and soil type (PRIMAVESI et al. 2002). In a research conducted by CRUSCIOL et al. (2008) black oat released in greater quantity the nutrients K and N, and the highest release occurred from 10 to 20 days after the lodging of the straw. Of the three species used in the present study, black oat is the one with the highest C/N ratio with slower decomposition, with this it is important to intercrop point the intercropping of species with different characteristics, to ensure the release of nutrients combined with the permanence of soil cover. These factors contribute to a satisfactory development of cultures of economic interest, including gladiolus.

CONCLUSION

The cultivation with soil cover (SPD) provided lower incidence of spontaneous plants, lower soil temperature, higher microbial activity, indicating greater soil biodiversity, in addition to greater length of floral stems than cultivation without soil cover.

The quality of the stems was higher in planting with soil cover (SPD). In addition, there was an increase in productivity compared to cultivation without soil cover.

In this sense, the no-tillage system with organic management according to the characteristics and conditions of this research is indicated for gladiolus culture.

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