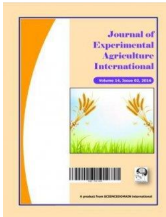

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Initial Development of Sunflower (*Helianthus annuus* L.) under Weed Competition with Different Species of Grasses

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: All cultivated plants are subject to intra and interspecific grass competition, once this competition may gradually increase within the crop cycle.

Objective: In view of the above, this work aims to evaluate the initial development of sunflower, when submitted to competition with different species of grasses.

Material and Methods: A randomized block design was installed in a 2x4 factorial scheme, with two grass species, *Urochloa decumbens* cv. Basilisk and *Panicum maximum* cv. Mombasa, with four densities of competition with grasses, plus a control group (absence of grass) and four replications, total of 36 plots.

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Results and Discussion: During the sowing of the grasses, the following densities were considered: low; average; high and very high density of competition. While there was an increase in density of competition, sunflower development was impaired.
Conclusion: The initial development of sunflower was impaired, with a yield of 49.06 cm^2 for each weed and Panicum maximum species caused greater damage to the crop. The aerial part and the sunflower stomata were compromised.

Keywords: Urochloa decumbens; Panicum maximum; weed; stress.

1. INTRODUCTION

The sunflower, due to the diversity of physical-chemical features of its by-products, has become an attractive option for the Brazilian agribusiness, due to its adaptability to different growing conditions [1,2]. However, all cultivated plants are subject to intra and interspecific grass competition, since this competition may gradually increase with the course of the crop cycle [3,4].

Inherent or weedy plants can influence crop yield decline through competition for water, light, nutrients and space, or even for the allelopathic action of some species [5]. This competition may affect the quality of the raw material, elevate the cost of producing the crop and can be a host of pests and diseases [6].

At the beginning of the productive cycle the invasive plants can coexist for a time without damage to the development of the cultivated crop, however, during the course of its phases it is possible to observe the damages caused by the grass competition, which makes necessary to understand the effects caused by this competition in order to set an ideal time for the control of invasive plants, mainly grass species, making necessary the knowledge of the period before weed interference (PBI) [7,8].

The damaging effect of grass competition on sunflower crop in the first 30 days after emergence is notorious due to its slow growth as compared to weeds, mainly grass species, which can vary from 23 to 70% of losses in the production. Some sunflowers cultivars showed a variation in PAI from 16 to 24 days after germination, in which a negative interference was verified in the stem diameter, grain yield and oil yield [9].

These negative responses to grass competition can be a reflection of the morpho-physiological changes in the cultivated plant, making necessary to understand these changes that can cause a greater foliar transpiration or even the reduction of the photosynthetic rate due to competition, which entails in a smaller accumulation of mass dry [4,10,11,12].

In view of the above, this work aims to evaluate the development of the sunflower, when submitted to competition with different grass species.

2. MATERIALS AND METHODS

The experiment was carried out during the month of August 2018, at the Andradina Educational Foundation (FEA), located in the city of Andradina, state of São Paulo, Brazil. A randomized block design was installed in a 2x5 factorial scheme, two grass species, that is, *Urochloa decumbens* cv. Basilisk and *Panicum maximum* cv. Mombasa with four densities of competition with grasses, plus a control group, with absence of grass, and four replications, total of 40 plots.

Sunflowers seeds variety Agrobel 960 was sowed at 3 cm deep in pots with a 7 dm^3 capacity and 490.6 cm^2 area, filled with soil originated from the 0 – 0.3 layer with chemical attributes according to Table 1. The soil was fertilised with urea – 0.0777 g; triple superphosphate – 1.36 g; and potassium chloride – 0.36 g per pot [13].

Table 1. Chemical attributes of the soil

pH	MO	P	K	Ca	Mg	H+Al	Al	SB	CTC	V%	m%	B	Cu	Fe	Mn	Zn
$CaCl_2$	g dm^{-3}	mg dm^{-3}	---------------------- $mmol_c\ dm^{-3}$ --------------------									------------ mg dm^{-3} ----------				
5.9	11	21	2.0	19	7	15	0	28	43	65	0	0.21	1	25	9	3.4

SB: Sum of bases; V%: Base saturation; m%: Aluminum saturation.

At the same time the grasses were sown and the following densities were considered: absence of the grass: only the sowing of the sunflower; low density of competition with grasses, where the presence of two grassy plants per pot was considered, providing 245.3 cm^2 per plant. For the medium density competing conditions, the presence of four grassy plants per pot was considered, providing 122.65 cm^2 per plant. In conditions of high competition density, the presence of eight grassy plants per pot was considered, being 61.32 cm^2 per plant. And for the conditions of very high competition density, the presence of sixteen grassy plants per pot was considered, being 30.66 cm^2 per plant. During the experiment, the vessels were irrigated whenever necessary, respecting the field capacity.

Thirty days after the planting, the following parameters were set: PHS and PHG - plant height of sunflower and plant height of grass, determined by using a millimeter ruler; NLS – number of leaves of the sunflower determined by the direct count in the plant; DMS and DMAPG – dry mass of sunflower and dry mass of aerial part of grass; DMSR and DMGR – dry mass of sunflower root and dry mass grass root, set by drying the wet mass in a circulation oven and renewing air at a constant temperature of 65°C until reaching constant weight.

The impression was also made on the inferior or abaxial epidermal surface of the fragments collected using cyanoacrylate ester, for the determination functionality of the stomatal inferior or abaxial surface (SFS) and stomatal density of the lower or abaxial surface (SDS) [14,15]. For all the characteristics 10 measurements per slide were performed. The plots were represented by the average value obtained from the measurements of each characteristic.

All variables were submitted to the F test (p <0.05) and the regression analysis was applied to the competition densities, where their models were tested: linear; quadratic and cubic, whereas for the grass species the Tukey test was applied at 5% probability [16]. The statistical program Assistat 7.7 was used [17].

3. RESULTS

3.1 Sunflower

U. decumbens species caused a greater reduction in the height of the sunflower as shown in Table 2.

To the number of leaves of the sunflower it was not observed a statistical difference between the grass species, whereas to the dry mass of the aerial part, *Panicum maximum* caused an approximate 16%-reduction; but in the dry mass of the root it was not observed a significant influence in the competition between grass species. In the same way, there was no significant effect between the influences of forage species competitions on stomatal density and functionality.

Table 3 shows the analysis of variance of the regressions of the sunflower as submitted to different densities of competition among grass species.

The Sunflower in competition with *Urochloa decumbens* presented a constant increase in its height till reached the maximum point of approximately nine plants, after this point a drop occurred in its development, similarly to competition with *Panicum maximum*, also presented a quadratic response, but its peak approximately occurred until six plants, after this density there was a reduction in its growth as Fig. 1 shows.

Table 2. Mean values of plant height (PH); number of leaves (NL); dry mass of aerial part of sunflower and root (DMAPS and DMRS); stomatal sunflower density (SDS) and stomatal sunflower functionality (SSF) as submitted to competition with different grass densities

	PH (cm)	NL	DMAPS (g)	DMRS (g)	SDS (n°S/mm^2)	SSF
U. decumbens	42.45b	15.45a	6.66a	2.28a	240.62a	3.17a
P. maximum	46.68a	15.80a	5.56b	1.67a	241.87a	3.02a
DMS	3.46	0.96	1.02	0.95	28.17	0.37
CV%	11.99	9.52	25.93	74.72	18.00	18.86
MG	44.56	15.62	6.11	1.97	241.25	3.09
Grass (G) of F	6.26*	0.55Ns	4.81*	1.71Ns	0.01ns	0.68Ns
Doses (D) of F	9.73**	9.88**	10.73**	12.56**	13.76**	3.12*
GxD of F	5,34**	1.29Ns	1.79Ns	0.13Ns	2.70Ns	3.05*

*DMS: Minimum significant difference. CV: Coefficient of variation. MG: Overall mean. F: value of F calculated in the analysis of variance; Nsp = 0.05; * 0.01 = <p <0.05; ** p <0.01. The averages in the column followed by the same letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level.*

Table 3. The analysis of variance of the regressions of the sunflower as submitted to different grass competition densities, the following models were tested: linear, quadratic and cubic

			Middle square					
Forage	**FV**	**GL**	**PH (cm)**	**NL**	**DMAPS (g)**	**DMRS (g)**	**SDS ($n°S/mm^2$)**	**SFS**
	Density	4	137.786	29.756	24.016	15.508	13819.982	2.685
U. decumbens	Residue	16	23.284	3.254	4.032	2.448	1194.041	0.506
	Regression	1	Q*	L**	Q*	Q*	Q**	L*
	Density	4	324.542	29.615	19.357	24.085	55316.406	1.570
P. maximum	Residue	16	64.185	2.326	1.032	2.317	2183.690	0.256
	Regression	1	Q*	Q*	Q*	Q*	L**	Q*

*Ns- p>=0.05; *0.01=<p<0.05; ** p < 0.01. L: polynomial of 1st degree. Q: polynomial of 2nd degree. PH – plant height; NL – number leaf; DMAPS – Dry mass of the air part of the sunflower; SDS – Stomata density of the sunflower and SFS – Stomata functionality of the sunflower.*

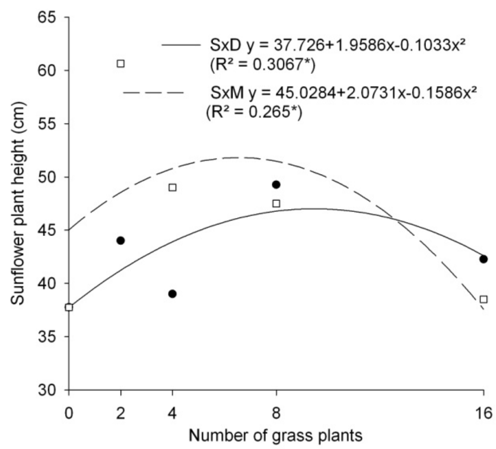


Fig. 1. Sunflower plant height as submitted to different densities of competition among grass species.

S= Sunflower; D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018.

Regarding the number of sunflower leaves, a negative linear response was observed by increasing *Urochloa decumbens* plant density. However, the sunflower presented a quadratic negative response to the competition with *Panicum maximum*, in which there was the minimum point of leaves until the competition of approximately eight plants as Fig. 2 shows.

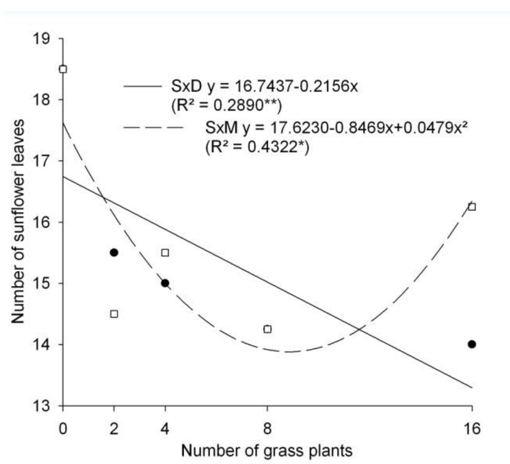


Fig. 2. Number of sunflower leaves as submitted to different densities of competition between grass species

S= Sunflower; D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018.

A quadratic response was observed to dry mass of aerial part of sunflower, in which a minimum of ten and eleven plants were respectively observed for *Urochloa decumbens* and *Panicum maximum*, as Fig. 3 shows.

Similarly, it was possible to observe that the dry mass of the sunflower root presented a quadratic negative response as the density of grassy plants increased, which presented a minimum point of ten plants regardless of grass species, as Fig. 4 displays.

According to Fig. 5, the stomatal density of the abaxial face of the sunflower showed a quadratic response under competition with the *Urochloa decumbens* species presenting a minimum reduction up to ten plants, whereas for the *Panicum maximum* species a negative linear response was observed whereas there was an increase in competition density.

A difference in the size and number of stomata on the abaxial face of the sunflower is noticeable when there was an increase in competition density with grass species as observed in Fig. 6.

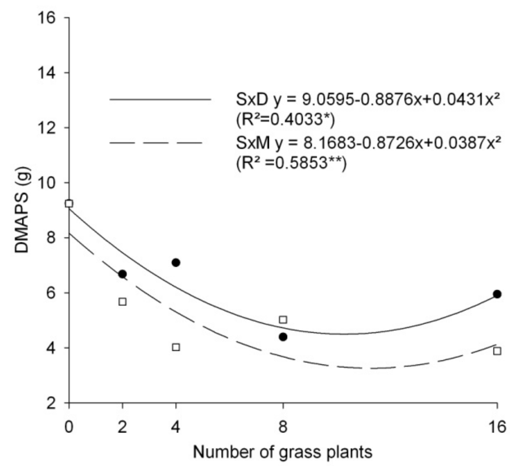


Fig. 3. Dry mass of leaves of sunflower as submitted to different densities of grass competitions

S= Sunflower; D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018.

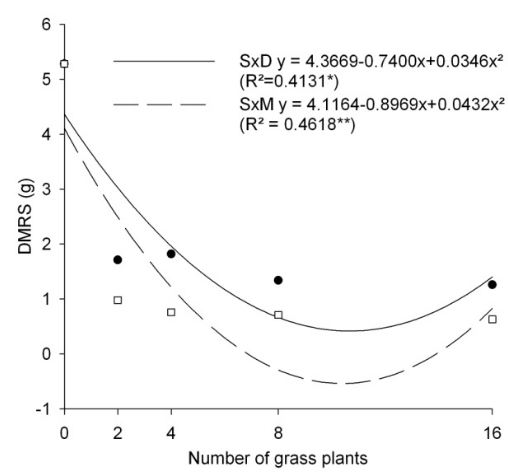


Fig. 4. Dry mass of root of sunflower (DMRS) as submitted to different densities of grass competitions

S= Sunflower; D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018

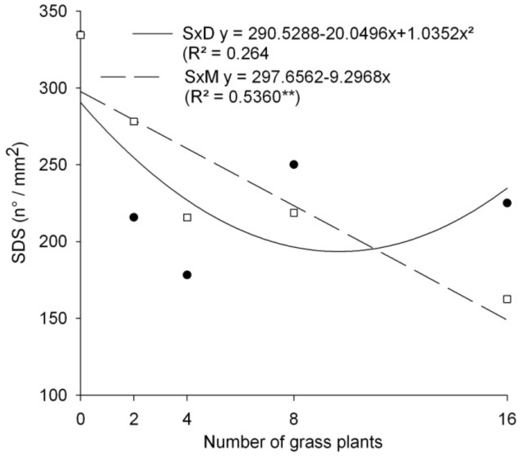
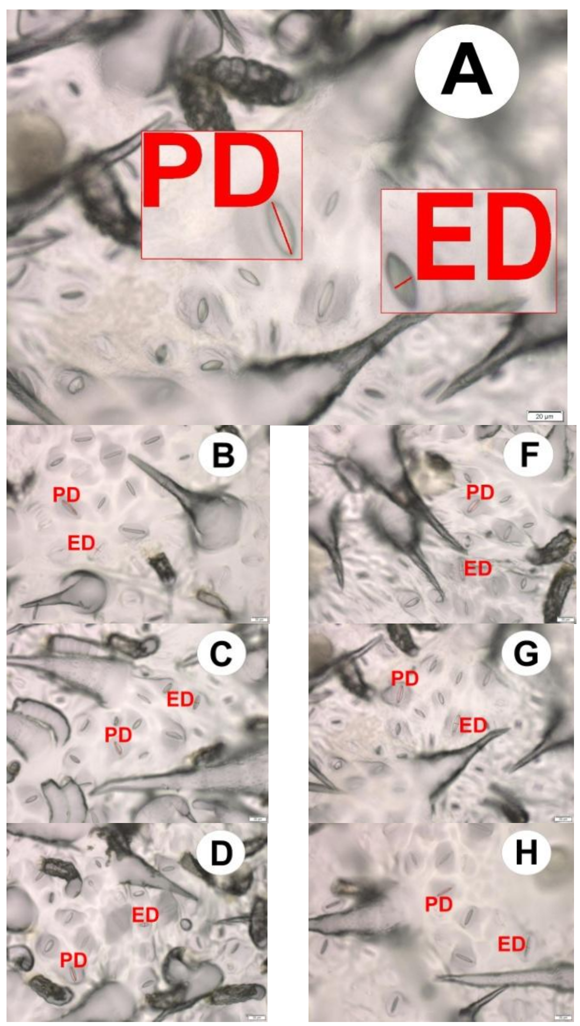


Fig. 5. Stomata density of sunflower (SDS) when submitted to different densities of grass competitions

S= Sunflower; D= Urochloa decumbens and M = Panicum maximum. Andradina, 2018.



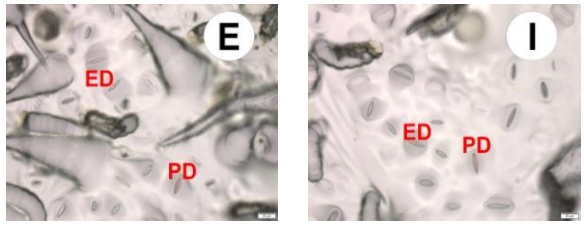


Fig. 6. Stomata of the abaxial sunflower leaf when submitted to different densities of grass competitions

A - Absence of competition; B - Two plants of Urochloa decumbens; C - Four plants of Urochloa decumbens; D - Eight plants of Urochloa decumbens; E - Sixteen plants of Urochloa decumbens; F - Two Panicum maximum plants; G - Four plants of Panicum maximum; H - Eight plants of Panicum maximum and I - Sixteen plants of Panicum maximum. PD – Polar diameter; ED – Equatorial diameter.

The competition with the *Urochloa decumbens* species caused a negative linear response in the stomata functionality of the sunflower, in which a quadratic response was observed that presented the minimum point with eight grassy plants in the competition, as Fig. 7 shows.

3.2 Grass

A linear response was observed at both grass heights according to Table 4.

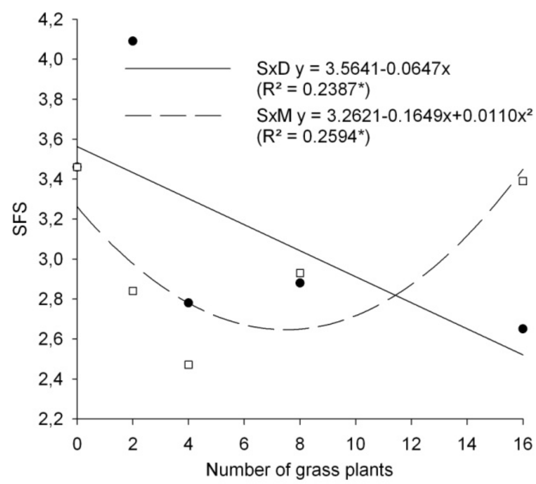


Fig. 7. Stomata functionality of sunflower (SFS) as submitted to different densities of grass competitions

S= Sunflower; D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018.

Table 4. The analysis of variance of the regressions of the grass in different densities competition, where the models were tested: linear, quadratic and cubic

			Middle square		
Forage	**FV**	**GL**	**PHG (cm)**	**DMAPG (g)**	**DMRG (g)**
	Density	4	226.802	39.326	18.043
U. decumbens	Residue	12	28.083	0.662	2.448
	Regression	1	L*	L*	L*
	Density	4	660.002	10.182	21.638
P. maximum	Residue	12	18.291	0.315	2.317
	Regression	1	L**	L*	L**

*Ns- p>=0.05; *0.01=<p<0.05; ** p < 0.01. L: polynomial of 1st degree. Q: polynomial of 2nd degree. PH – plant height; NL – number leaf; DMAP – Dry mass of the air part; S: Stomata; SD – Stomata density and SF – Stomata functionality.*

However their responses were antagonistic, once *Urochloa decumbens* presented a positive response to the increase of the number of grassy plants, while the *Panicum maximum* species showed a negative response as Fig. 8 shows.

According to Fig. 9, as the grass density increased, a linear response in dry mass in the aerial part occurred, regardless of the grass species.

Similarly, dry mass of grass root presented a positive response as the density of grassy plants increased, as Fig. 10 shows.

4. DISCUSSION

The constant growth of Sunflower height did not occur due to the reduced availability of nutrients and light, but rather, it triggered survival ability competition through its sowing. For the increase in height when in competition, it represents an adaptation to a future competition with neighboring plants, as it is a result of processes of the hormonal dynamics and cell division more accentuated in the search for light [18].

Thus, plants that are in free competition use a good part of their photoassimilates for root development, but, under competition the plant redirects these photoassimilates to growth of aerial part in order to gain more leaf area to minimize this competition effect [10,19]. Plants that are submitted to competition for light and are exposed to shading, a change in their morphological architecture causes an elongation of stem and leaf petioles [20].

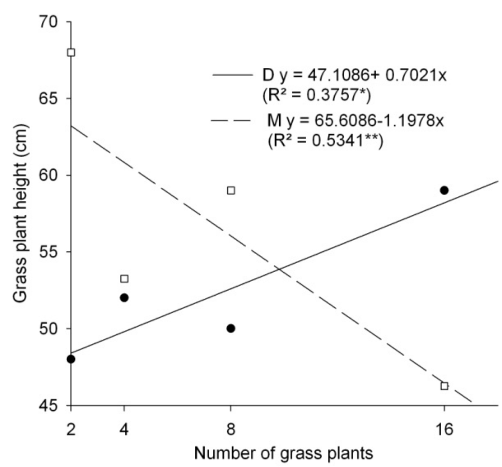


Fig. 8. Plant height of grasses under different densities of competitions
D= Urochloa decumbens and M= Panicum maximum. Andradina, 2018.

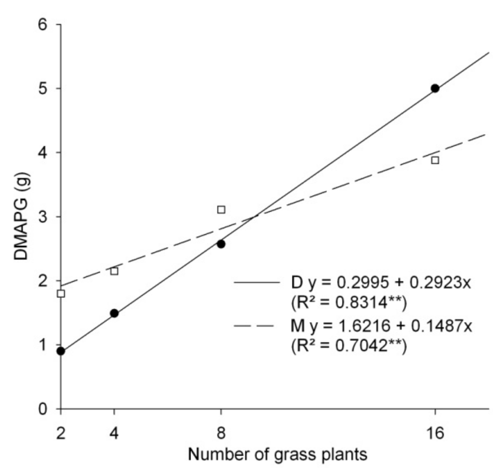


Fig. 9. Dry mass of aerial part of grass in different density of competition
D= *Urochloa decumbens* and M= *Panicum maximum*. Andradina, 2018.

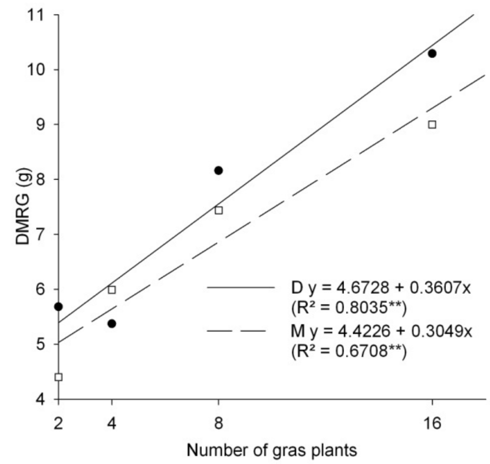


Fig. 10. Dry mass of root of grass in different density of competition
D= *Urochloa decumbens* and M= *Panicum maximum*. Andradina, 2018.

The interaction caused by the competition results in a lesser number of leaves due to the decrease of photoassimilate, entailing a lower dry mass [21,10]. The intensity of weed interference on the crop of economic interest may lead to a decrease in its development, since grasses presented negative and positive linear responses, it is possible to observe that this occured due to the natural difference between species [13]. *Urochloa decumbens* presents a lower nutritional requirement and more persistent and adaptive action in the environmental variations that is inserted, making it more tolerant to these variations. However, the *Panicum maximum* species extracts more nutrients from the soil, which impairs the development of the sunflower crop, in case of competition between them.

The competition for water, light and nutrients is a crucial factor for crops, if there is intense growth of the aerial part of the crop, a greater availability of water and nutrients from the soil is required, and the increase of dry matter of the root is directly related to this availability, so that, the competition with grassy plants entailed a reduction in the root dry mass of the sunflower. Other species, such as cotton, when submitted to competition with grasses suffered interference in its development, mainly in dry mass of aerial part and root, once the species competed for light, as this interference decreased their photosynthetic rate, leading to reduction in the accumulation of dry matter [20].

However, it is important to note that necessary a better understanding of the genetic factors involved in the development of this species [22,23]. In the aerial part, as well as in the root, the competition with the sunflower crop did not interfere in the development of the grasses, since both presented a positive linear response regarding the dry mass conteny, this result was already expected, since there was an increase in the number of plants by area.

Density and stomata functionality presented negative responses as the grass competition density increased, since the presence of weeds in the production environment can cause damage to the crop mainly due to the action of allelopathy or even accentuation of water stress, which influences the stomata conductance. In studies carried out by Graciano et al. [24] with the peanut crop, it was observed that the stomata behaviour of the crop presented a variation when there was a change in its environment mainly by the water restriction. When plants absorb CO_2 they lose water due to the opening of the stomata cleft, this natural loss can be accentuated when the plant is exposed to stress caused by competition between species [25,26,27].

In this way, it is well known that the competition between sunflower and different species of grasses significantly affects its initial development, requiring the crop to increase energy expenditure for its growth. It is necessary to take greater care with invasive plants, taking certain measures for their control or even chemical with an application of pre and postemergence, so that no major problems with their productivity will occur [28].

5. CONCLUSIONS

The initial development of sunflower was impaired, with a yield of 49.06 cm^2 for each weed and Panicum maximum species caused greater damage to the crop. The aerial part and the sunflower stomata were compromised.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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