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ALLELOPATHIC POTENTIAL OF STRAW AND WEED COMPETITION IN SOYBEAN

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ABSTRACT

The objective of this study was to evaluate the interference caused by competition and allelopathic effect of straw from weed species on soybean (Glicyne max L.). Two experiments were conducted at the experimental station of the Federal University of Tocantins, in Gurupi (11°44'46.5"S 49°03'10.5"W), Tocantins State, Brazil. The design was randomized blocks with four replications and ten treatments: nine weed species. In the first experiment, weeds coexisted with soybean throughout the cycle. And in the second, the plant residues of the weeds were placed on the soil surface. Plant height was analyzed at 30 and 60 days after emergence, first pod height, leaf area, shoot dry matter, number of pods per plant and soybean crop yield. All species have a negative effect on the soybean crop, varying in different intensities of interference. The straws of the weeds did not show an effect on the evaluated traits of soybean.

Keywords: Allelopathy. Interference. Weeds. *Glycine max* L.

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INTRODUCTION

Given its great economic and food importance, soybean (*Glycine max* L.) has become one of the most expressive crops in Brazil. Being largely destined for export, it generates wealth for the economy and is an important agricultural commodity. Brazil is one of the largest producers, with an average productivity of 3,201 kg ha-1. The crop has been growing in cultivated area and in the 2023/24 harvest, 147.7 million tons of grains were produced (CONAB, 2024).

One of the limiting factors to obtain high yields in soybean is the effects caused by weeds. In addition, the control of these plants represents a high cost. In soybean crops with glyphosate-resistant weeds, these costs can rise, from 42% to 222%. The values rise between 42% and 48% for isolated infestations of horseweed and ryegrass, respectively, and 165% if there is sourgrass (Adegas et al., 2017).

Weed interference refers to the set of actions that a crop resulting from the presence of weeds receives, with the most important interference mechanisms being: competition and allelopathy (Pitelli, 2014). According to Mahé et al. (2022), competition differs from allelopathy, as it encompasses the reduction or removal of some factor from the environment necessary for the other plant.

Weeds compete with soybeans for water, nutrients, space, light, and gases. These resources are most often limited and competition causes a reduction in productivity and quality of the harvested product. They also exert a negative influence on the release of allelochemicals (Ali et al., 2017).

The degree of interference in soybeans is determined by factors related to the production environment, the crop and the weeds. Species and cultivars show differences in competitiveness, and the earlier the period of coexistence between weeds and cultivated plants is established, the greater the drop in productivity (Datta et al., 2017).

The study of the coexistence of soybean with weeds, as well as the effect of their dry matter on the soil, is necessary to understand how and how much it interferes in the development of the crop. This information helps producers and technicians in making decisions about when and how to carry out control (Renton & Chauhan, 2017), and contributes to new studies on the use of weed straw in soybean crops.

Therefore, the objective of this study was to evaluate the interference of straw and coexistence of nine weed species in soybean crop.

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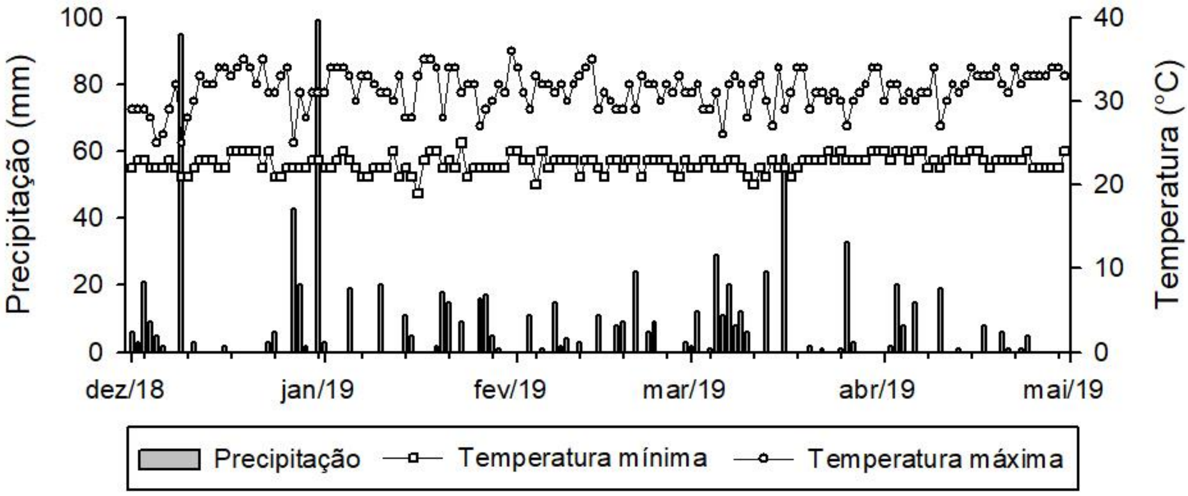
METHODOLOGY

CHARACTERIZATION OF THE STUDY SITE

The experiments were carried out at the experimental station of the Federal University of Tocantins, in Gurupi (11°44'46.5"S 49°03'10.5"W), Tocantins State, Brazil. The climate (Figure 1) of the region is of the Aw type, tropical with a dry season in winter. (Dubreuil et al., 2018).

Figure 1. Rainfall, minimum and maximum temperature from December 2018 to May 2019 in the municipality of Gurupi, state of Tocantins, Brazil.



Source INMET, 2020.

The soil used was considered eutrophic, with a clayey texture, and phosphorus and potassium contents: very low and low, respectively (RIBEIRO et al., 1999). The chemical and physical attributes (0 – 20 cm) were: pH CaCl2 5.0; phosphorus 4.0 mg dm-3, potassium 39 mg dm-3, calcium 2.4 $cmol_c$ dm-3, magnesium 1.1 cmolc dm-3, potential acidity 2.2 cmolc dm-3, organic matter 2.7 dag $^{kg-1}$, clay 375 g $^{kg-1}$, silt 25 g $^{kg-1}$, and sand 600 g $^{kg-1}$.

EXPERIMENTAL DESIGN

The design used was a complete block design, with four replications and ten treatments. Nine weed species were used (Table 1), and the control. The experimental unit consisted of an area of 1.0 m x 0.5 m, which had two rows of soybeans spaced 0.5 m apart.

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Table 1. Scientific names, codes, common names, weed families, and amount of straw from the allelopathy experiment

Treatment	Code1	Common name	Family	Straw kg $^{ha-1}$
Amaranthus spp.	AMARA2	Caruru	Amarantaceae	42,6
Commelina benghalensis	COMBE	Trapoeiraba	Comelinaceae	958,8
Conyza bonariensis	ERIBO	Buva	Asteraceae	1087,6
Cyperus rotundus	CYPRO	Tiririca	Cyperaceae	57,2
Digitaria insularis	TRCIN	Bittergrass	Poaceae	257,8
Euphorbia heterophylla	EPHHL	Milkmaid	Euphorbiaceae	243,6
Ipomoea triloba	IPOTR	Viola string	Convolvulaceae	73,2
Senna obtusifolia	CASOB	Kills pasture	Fabaceae	266,4
Verticillata spermacoce	DRINK	White poaia	Rubiaceae	191,6
Witness	TEST2			0

Source: Author himself, 2024.

In the allelopathy experiment, the straw of the weeds was deposited on the soil surface after soybean sowing, the amount used corresponds to the mass of six plants $^{m-2}$. And in the competition experiment, weeds coexisted with soybean throughout the cycle.

The collection of seeds and straw of weeds occurred at the experimental station. The straw was dried in an oven at 70°C for 72 hours, and chopped into pieces of 1.0 to 1.5 cm.

The soybean cultivar 8579RSF IPRO, which occupies a large cultivated area in the Cerrado, was used. Sowing of soybean and weeds in the competition experiment occurred simultaneously. The weeds were sown on the sides and between the rows of soybean, in a population of 12 plants $^{m-2}$. And the soybean stand was 13 plants m-1.

Sowing fertilization was carried out with 150 kg $^{ha-1}$ of P2O5, and 40 kg $^{ha-1}$ K2O. And at 30 days after sowing, top dressing was carried out with 80 kg $^{ha-1}$ K2O.

DATA COLLECTION AND STATISTICAL ANALYSIS

The evaluations of the variables occurred in eight central plants. At 30 days after emergence (DAE), plant height (AP1), number of leaves, length and width of the last expanded leaf were measured. The equation of Richter et al. (2014) was used to calculate leaf area (FA).

At 60 DAE, plant height (AP2) and first varge insertion height (APV) were measured. Also during this period, three plants were collected, placed in an incubator until a constant mass was reached, and shoot dry matter (MSPA) was determined.

Harvest was carried out when soybean reached the R9 stage (harvest maturation), and the number of pods per plant (LB) and grain yield (PG) were evaluated. In the

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competition experiment, the following were evaluated: number of grains per plant (NG) and the weight of one hundred grains (M100).

The variables underwent tests of normality of the residuals, homogeneity of variance, analysis of variance and Tukey's test, using the GENES software (Cruz, 2013).

RESULTS AND DISCUSSION

ALLEOPATHY EXPERIMENT

There was no significant difference (Table 2) in the straw of weeds in soybean for the variables evaluated. These results are in line with those of Pinheiro et al. (2023), who also did not observe the effects of weed straw on soybean growth and productivity.

Table 2. Summary of the analysis of variance of plant height at 30 DAE (AP1) and 60 DAE (AP2), height of first pod (AV), shoot dry mass (MSPA), number of pods per plant (NV) and grain yield (PG) of soybean cv. 8579RSF IPRO in the 2018/19 harvest. Gurupi – TO, Brazil, 2024,

Source of variation	Degree of Freedom	Medium Square					
		AP1	AP2	OF	MSPA	NV	PG
Block	3	13,05	158,54	5,66	31,59	796,10	4011876,01
Treatment	9	7,41ns	10,24ns	2,53ns	3,77ns	21,35ns	158249,39ns
Residue	27	8,98	9,48	1,83	8,30	50,46	373855,24
Average		24,56	54,12	9,72	12,07	41,12	2521,11
CV (%)		12,20	5,69	4,15	23,87	17,28	24,25

^{ns} not significant by the F test ($p<0.05$).

When the mean AP2 was evaluated, higher means were found than those found by Pinheiro et al. (2023). The VA was lower than those found by Carmo et al. (2018), and Farias et al. (2018). And the LB was lower than that found by Carmo et al. (2018) and Farias et al. (2018).

Soybean presents different responses to weed straw. With the use of *Parthenium hysterophorus* straw at doses above 1 Mg $^{ha-1}$, Shehzad et al. (2016) found a decrease in productivity, while Siddiqui et al. (2018) found an increase in productivity.

The difference in soybean response is explained by the allelopathic effect of plant residues depending on many variables, especially those related to species, soil and decomposition conditions. The interaction of these variables leads to the formation of toxic, non-toxic, or stimulant compounds (Kostina-Bednarz and Barchanska, 2023).

In other crops such as corn, and using a higher dose of sorghum straw than that of this study (8 Mg $^{ha-1}$), Sheheryar et al. (2020) also found no difference for grain yield. And in beans, Alsaadawi et al. (2019) found a drop in productivity only at a dose above 5 Mg $^{ha-1}$.

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The allelopathic effect is linked to the species and amount of straw. As seen in the study by Salvator et al (2020), which found variation in the initial growth of corn and beans as a function of the weed, and the number of leaves used, with greater effects with higher amounts of leaves.

According to Choudhary et al. (2023), rapidly decomposing plant residues have an intense allelopathic action, but are short-lived. The greater the amount kept on the soil, the more allelopathic substances it can contain, the greater the amount it can be leached into the soil and the greater its influence on the plants.

Although no effect of weed straw on soybean was found, the literature shows that in high amounts of straw some compounds released can act as germination inhibitors, affect the initial development of the crop, interfere with root development, which can lead to a drop in productivity (Fabiani et al., 2019).

COMPETITION EXPERIMENT

In the analysis of variance (Table 3) of the coexistence trial, there was a significant effect for all the variables evaluated. The coefficients of AP1 and AP2 were classified as low, and of NV, NG, M100 and PG were classified as medium (CARVALHO et al., 2003).

Table 3. Summary of the analysis of variance of plant height at 30 DAE (AP1) and 60 DAE (AP2), height of first pod (AV), leaf area (FA), number of pods per plant (NV), number of grains per plant (NG), weight of one hundred grains (M100) and grain yield (PG) of soybean cv. 8579RSF IPRO in coexistence with weeds. Gurupi – TO, Brazil, 2024.

FV	GL	Medium Square								
		AP1	AP2	OF	OF	MSPA	NV	NG	M100	PG
Block	3	1,96	12,97	0,83	33502,36	3,76	7,16	32,73	10,76	291847,16
Treatment	9	7,69*	36,39*	4,11*	47595,58*	13,07*	264,50*	265,2*	9,19*	2623488,4*
Error	27	1,88	4,70	0,81	18414,65	4,87	30,88	74,10	2,70	269102,12
Average		25,28	57,25	11,75	837,98	9,88	32,18	47,2	18,53	2337,96
CV (%)		5,43	3,79	7,68	16,19	22,35	17,27	18,24	8,87	22,19

* Significant by the F test (p<0.05). FV: source of variation. GL: degree of freedom. QM: Medium square. CV: coefficient of variation.

For the AP1 variable (Table 4), the control did not differ from the other treatments. For AP2, the witness differed from AMARA, EPHHL and IPOTR. This demonstrates that up to 30 DAE the coexistence did not interfere in the plant height, and that the longer the period of coexistence, the greater the interference. A similar behavior was reported by Ferdous et al. (2017), who at 30 days after sowing did not interfere with plant height, but had at 60 days.

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Table 4. Average plant height at 30 DAE (AP1), plant height at 60 DAE (AP2), height of first pod (AV), leaf area (FA), dry mass of the area part (MSPA), number of pods per plant (NV), number of grains per plant (NG) and weight of one hundred grains (M100) of soybean cv. 8579RSF IPRO in coexistence with weeds. Gurupi – TO, Brazil, 2024.

Treatment	AP1	AP2	OF	OF
	Cm		cm2 plant-1	
BITTER	24,50 from	55,00 bc	11,25 bc	846,50 from
COMBE	27,75 a	58,00 from	10,00 c	813,25 from
ERIBO	27,00 from	60,00 from	11,25 bc	1026,25 a
CYPRO	24,25 b	57,75 from	13,50 a	629,75 b
TRCIN	23,75 b	59,00 from	12,50 from	782,75 from
EPHHL	25,00 from	54,75 bc	11,75 abc	810,00 from
IPOTR	26,00 from	50,75 c	11,25 bc	889,50 from
CASOB	24,00 b	59,75 from	11,75 abc	833,50 from
DRINK	24,25 b	57,00 from	13,00 from	778,00 from
TEST	26,25 from	60,50 a	11,25 bc	970,25 a
Treatment	MSPA	NV	NG	M100
	g plant-1	unit		g
BITTER	10,00 from	33,75 b	50,00 from	18,25 from
COMBE	10,25 from	31,75 b	48,00 from	19,50 a
ERIBO	9,00 b	28,00 b	40,00 b	17,50 from
CYPRO	9,75 from	27,25 b	44,00 b	19,00 a
TRCIN	9,00 b	30,00 b	45,00 from	19,25 a
EPHHL	8,75 b	28,00 b	43,75 b	18,50 from
IPOTR	9,75 from	26,25 b	34,75 b	15,00 b
CASOB	8,50 b	29,75 b	49,00 from	20,00 a
DRINK	9,00 b	32,75 b	52,25 from	18,00 from
TEST	14,75 a	54,25 a	65,25 a	20,25 a

Means followed by the same letter did not differ from each other by Tukey's test ($p<0.05$).

For VA, the witness had a lower mean than CYPRO. Corroborating this data, Pagnoncelli et al. (2017) and Diesel et al. (2020) observed an increase in the VA of coexisting soybeans, and the values reached were higher than these.

The AF of the witness was higher than that of CYPRO. Pagnoncelli et al. (2017) and Diesel et al. (2020) also found a decrease in soybean leaf area due to weed interference. And Oliveira et al. (2018) found similar results in beans.

The decrease in leaf area results in a lower capture of solar radiation, which negatively impacts photosynthesis and consequently productivity. And for the other treatments, the competition for light must have had a physiological cost that led to the drop in PG (Sujinah et al., 2022).

Living with ERIBO, TRCIN, EPHHL, CASOB and BOIVE decreased MSPA. Reductions like these were also described by Fialho et al. (2016) and Diesel et al. (2020) at 60 days and in harvest maturation, respectively.

For NV, NG and M100, the control differed from the treatments with lower means. Living with IPOTR led to a decrease in these three characteristics. NV is reduced for all

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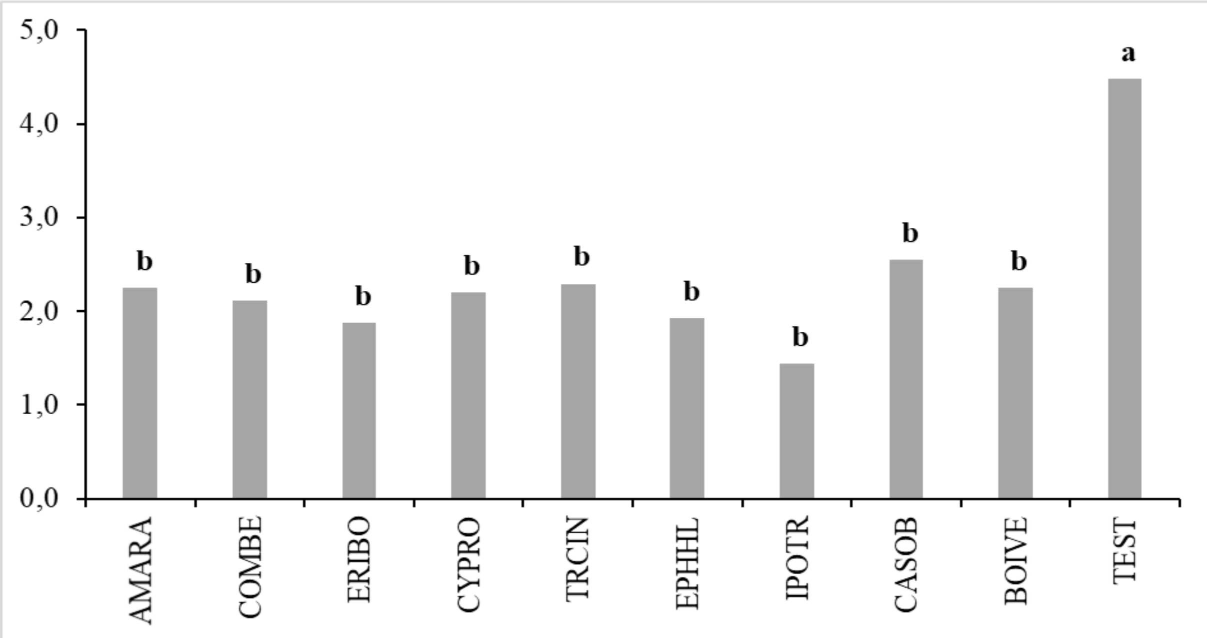
weeds studied. NG values were lower than those found by Vitorino et al. (2017), but for LB the decrease in this study was greater. Schneider et al. (2020) also found a decrease in soybean M100 in coexistence with weeds.

Soybean yield (Figure 2) was reduced by coexistence with weeds. The drops in yield ranged from 32.19% to 56.90%, thus evidencing the interference of weeds in the development of soybean crop. These reductions were greater than those found by Vitorino et al. (2017) and Souza et al. (2019), which were 27.15% and 32.39% for coexistence throughout the cycle.

Figure 2. Grain yield (Mg $^{ha-1}$) of soybean cv. 8579RSF IPRO in coexistence with weeds. Gurupi – TO, Brazil, 2024.



Means followed by the same letter did not differ statistically by Tukey's test ($p<0.05$).

As in the study by Diesel et al. (2020) with *Borreria latifolia* and *Richardia brasiliensis*, the reduction in PG occurred due to the decrease in NG, NV, and M100. Because these characteristics have a high correlation with productivity (Zuffo et al., 2018).

CONCLUSION

The weeds *Amaranthus spp., Commelina benghalensis, Conyza bonariensis, Cyperus rotundus, Digitaria insularis, Euphorbia heterophylla, Ipomoea triloba, Senna obtusifolia* and *Spermacoce verticillata* interfere negatively with the soybean crop.

The straw of weeds on the soil, in the proportions used, did not cause a deleterious effect on the soybean crop.

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The coexistence of weeds with soybean crop causes a decrease in plant height, first pod insertion height, shoot dry mass, number of pods per plant, number of grains per plant, weight of one hundred grains and productivity.

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