EFFECT OF WEED COMPETITION ON THE GROWTH OF GLYPHOSATE-RESISTANT TRANSGENIC SOYBEAN

EFEITO DA MATOCOMPETIÇÃO NA CULTURA DA SOJA TRANSGÊNICA RESISTENTE AO HERBICIDA GLYPHOSATE

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Resumo: In order to study the effect of weed interference on soybean under no-tillage system, an experiment was carried out in the northern region of Mato Grosso. The treatments consisted of controls (weeded and infested) and different periods of coexistence and weed control (presence or absence of weeds until 15, 30, 45 days after emergence). The soybean cultivar was M 9056RR, with a spacing of 0.50 m between rows and a population of 280,000 plants ha-1. The results reflected the competitive relationships between the soybean crop and the weed community, which was composed of six species, in which Sorghum halepense was the most important species due to its predominance in the experimental area. The interference imposed by weeds caused etiolation of soybean plants and reduced the number of pods per plant and grain yield, indicating that the crop, under the experimental conditions, suffered irreversible interference from the weed community. Under these conditions, the interference imposed by the weeds caused a change in the average height of the plants and the height of insertion of the first soybean pod and reduced the number of pods per plant, weight of 100 grains and grain yield, which was reduced around 62%.

Keywords: Glycine max. Weeds. Interference.

Resumo: Visando estudar o efeito da interferência das plantas daninhas na cultura da soja sob sistema de semeadura direta, foi realizado experimento na região norte mato-grossense. Os tratamentos constaram de testemunhas (capinada e infestada) e de diferentes períodos de convivência e controle das plantas daninhas (presença ou na ausência das plantas daninhas até os 15, 30, 45 dias após a sua emergência). A cultivar de soja foi M 9056RR, com espaçamento de 0,50 m entre linhas e uma população de 280.000 plantas ha-1. Os resultados refletiram as relações competitivas entre a cultura da soja e a comunidade infestante, que foi composta por seis espécies, em que Sorghum halepense foi a espécie de maior importância devido a sua predominância na área experimental. A interferência imposta pelas plantas daninhas provocou um estiolamento das plantas de soja e reduziu o número de vagens

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por planta e a produtividade de grãos, indicando que a cultura, nas condições experimentais, sofreu interferência irreversível da comunidade infestante. Nestas condições a interferência imposta pelas plantas daninhas causou alteração na altura média das plantas e a altura de inserção da primeira vagem da soja e reduziu o número de vagens por planta, peso de 100 grãos e a produtividade de grãos, que foi reduzida em torno de 62%.

Palavras-chave: Glycine max. Plantas daninhas. Interferência.

Introduction

Soybean (*Glycine max* L.) is the most cultivated oilseed in the world and the agricultural product of greatest economic expression in Brazilian agribusiness, currently being cultivated in all regions of the country (FORBES AGRO, 2022).

The search for increased productivity comes up against the interference caused by weeds, which reduce profits and increase the costs of the production process (FORTE et al., 2017). The presence of these plants in soybean crops can alter the development of the crop due to competition for environmental resources, such as water, light, nutrients and CO_2, reducing their availability for the crop and consequently causing losses in grain yield (TEHULIE et al., 2021).

Due to these problems, over the years, technologies for weed control have been developed, ranging from manual, mechanical and cultural management techniques, as well as the intensive use of herbicides (PEREIRA et al., 2015). Advances in this area have led to the development and cultivation of genetically modified organisms (GMO's), resistant to the herbicide glyphosate, which is the most used herbicide worldwide (LAMBAIS, 2011).

After the official release of transgenic glyphosate-resistant soybeans in Brazil in 2005, changes occurred in the weed management systems in soybean crops, given that several herbicides were replaced by a single active ingredient: glyphosate. These changes in crop management caused selection pressure, altering the composition of the weed flora and the period of coexistence of these with soybean (YAMASHITA; GUIMARÃES, 2013).

The factors that can affect the degree of interference of the weed community on a crop are linked to the weed species, population and distribution, in addition to factors related to the crop itself (cultivating, spacing and sowing population) (ZANINE; SANTOS, 2004). The level of interference also depends on the season and duration for which the crop and the weed community remain together (JANNINK, 2000). The soil and climate conditions and the managements used also influence the level of interference (GUGLIELMINI et al., 2017).

The damage caused by weed interference can be irreversible for the crop, which will not be able to recover, affecting development and productivity after the stress caused by the presence of weeds is removed (SANDERSON; ELWINGER, 2002). Studies carried out on weed interference in crops aim to determine the periods that are critical in the interaction between the crop and the weed community. These periods of interference have been the subject of numerous recent research studies in different crops, such as soybean (ZANDONÁ et al., 2018), beans

(FREITAS et al., 2009), corn (KOZLOWSKI et al., 2009) sugarcane -sugar (MEIRELLES et al., 2009), peanuts (YAMAUTI, 2009), cotton (FREITAS et al., 2002), among others.

The objective of the present work was to evaluate the effects of the weed community on the production of transgenic soybean, in a no-till system, through different periods of coexistence and control of the weed floristic community with the crop.

Metodology

The experiment was carried out under field conditions, on a rural property belonging to the company Agro Norte, located in the municipality of Peixoto de Azevedo - MT, at coordinates 10º02'77" South Latitude and 55º02'36" West Longitude.

The climate of the region is characterized as tropical climate type Awi according to the Köppen classification, with two well-defined seasons. It has an average annual temperature of 25 ºC and an average relative humidity of 85%. The average annual rainfall is 2,750 mm (ALVARES et al., 2014).

The soil of the study area is classified as dystrophic Red-Yellow Latosol (EMBRAPA, 2006). To determine the physical and chemical characteristics of the soil, a sampling was carried out in the experimental area, and its physical and chemical analysis was carried out (Table 1).

The experimental design adopted was randomized blocks, with 8 treatments and four replications, totaling 32 plots. Each plot of the experimental unit consisted of 5 lines of plants. The useful area for the evaluations comprised the three central lines, disregarding 0.50 m at each end of the plot, totaling 6.00 m2 of useful area.

The treatments were divided into two groups of coexistence of the culture with the weeds. In the first group (Group 1), weeds were controlled for increasing periods starting at crop emergence (Table 2). At the end of the initial control periods, weeds were allowed to develop freely in the plots. In the second group (Group 2), the weeds coexisted with the soybean crop for increasing periods, starting with the emergence of the crop. At the end of each coexistence period (Table 2), weed control was carried out in the corresponding plots, which were kept clean until harvest.

Table 1. Results of chemical and physical properties of the soil in the experimental area[1]

Result of chemical analysis										
pH	P	K	K	Ca+Mg	Ca	Mg	Al	H	H+Al	M.O.
$CaCl_2$	--mg dm^{-3}--			---------------------- $cmol_c$ dm^{-3}--------------------------						g dm^{-3}
5,4	7,3	43,0	0,11	3,7	2,5	1,1	0	3,6	3,6	37,6
	SB ($cmol_c$ dm^{-3})					T ($cmol_c$ dm^{-3})			V (%)	
	3,7					7,3			50,6	
Result of physical analysis										
	Sand (g kg^{-1})					Silt (g kg^{-1})			Clay (g kg^{-1})	
	530					110			360	

[1] Analysis performed at the laboratory MT Análises Agronômicas Ltda, Sorriso – MT.
Source: Prepared by the author.

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Table 2. Experimental treatments to determine the coexistence periods for transgenic soybeans in Peixoto de Azevedo – MT

Group 1	Periods
TL	Weeded witness
TL15	Control up to 15 days
TL30	Control up to 30 days
TL45	Control up to 45 days
Group 2	
TM	Infested witness
TM15	Living up to 15 days
TM30	Living up to 30 days
TM45	Living up to 45 days

Source: Prepared by the author.

A management desiccation was carried out with the herbicide glyphosate and 2,4-D (1,440 + 470 g a.i. ha^{-1}, respectively) in a tank mixture, using a 150 L ha^{-1} solution, applied five days before soybean sowing.

In the previous year, the soil of the area was cultivated with soybean and in the off-season with millet, aiming to form straw for soil cover and the implementation of the direct sowing system.

The soybean cultivar used was M 9056RR, whose main characteristics are described in Table 1. Sowing was carried out with a multiple use seeder, spaced 0.50 m apart and 4 cm deep, distributing 14 seeds per linear meter, aiming to obtain 280,000 plants ha^{-1}. Sowing fertilization consisted of the application of 140 kg ha^{-1} of monoammonium phosphate (MAP) fertilizer, and potassium fertilization carried out by broadcast in topdress 25 days after sowing, using 140 kg ha^{-1}.

The seeds were treated with fungicides and insecticide (25 g a.i. pyraclostrobin, 225 g a.i. methyl thiophanate and 250 g a.i. fipronil). Subsequently, the treatment was carried out with a liquid inoculant containing *Bradirhizobium japonicum*.

During the crop cycle, pest and disease infestation was monitored, and control was carried out whenever the level of economic damage was reached, or in a preventive manner, in the case of plant diseases.

The evaluations of the density and identification of the weeds were carried out on a defined date for each coexistence period, both in the infested and weeded plots. The evaluations were carried out with the random launching of the square of wood of 0.25 m^2, twice, in the useful area of each plot, later the average density of the weeds for each treatment was determined.

The variables that compose the evaluated production components were the following: plant height, height of insertion of the first pod, number of pods per plant, mass of 100 grains and grain yield.

The values of the variables of plant height, height of insertion of the first pod and number of pods per plant were obtained from average evaluations of ten plants from each plot, chosen at random.

The results obtained, after meeting the assumptions of homogeneity and homoscedasticity, were subjected to analysis of variance and the means compared by Tukey's test at 5% probability, with the aid of the SISVAR statistical program (FERREIRA, 2014).

Results and Discussion

Through surveys carried out in the weed community, six species of weeds that occurred in the experiment were identified, according to the family to which they belong, scientific names, popular names and international code, were:

Poacea family (Gramineae)
- *Sorghum halepense* L. Pers. (massambará grass) – SORHA
- *Pennisetum americanum* L. Leeke (millet) – PESGL

Commelinaceae family
- *Commelina benghalensis* L. (trapoeraba) – COMBE

Convolvulaceae family
- *Ipomoea grandifolia* (Dammer) O'Donell (viola string) – IAOGR

Fabaceae family (Leguminosae)
- *Desmodium tortuosum* (Sw.) DC. (desmodium) – DEDTO

Asteraceae family
- *Bidens pilosa* L. (black beak) – BIDPI

All weed species present in the experimental area are reported as weeds of agroecosystems (LORENZI, 2000).

The plants found in higher density were *S. halepense* and *C. benghalensis*, and these species had dominance of the weed community for all periods, especially in TM15, with the highest density (41.25 and 15 plants per m^{-2} respectively) focused on the treatment where the culture remained 30 days in the presence of the weed community (TM30). The species density values are shown in Table 3.

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Table 3. Weed density per m² in soybean.

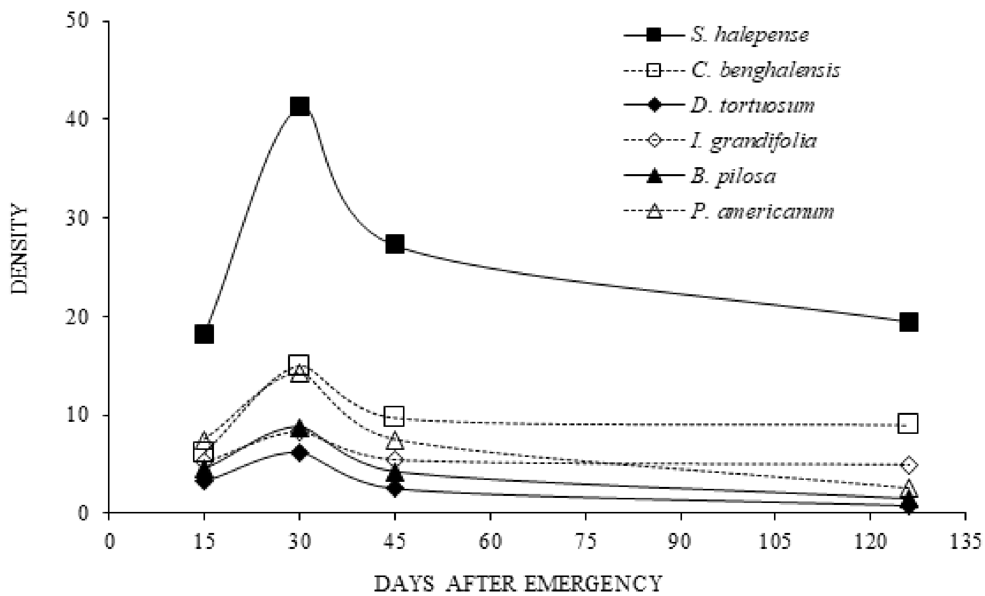
Treatments	Species						
	SORHA	COMBE	IAOGR	DEDTO	BINPI	PENAM	Total
TM	18,25	6,25	3,25	5,25	4,50	7,50	38,25
TM15	41,25	15,00	6,25	8,25	8,75	14,25	45,00
TM30	27,25	9,75	2,50	5,50	4,25	7,50	93,75
TM45	19,50	9,00	0,75	5,00	1,50	2,50	56,75
TL15	18,75	4,00	1,50	3,50	2,75	0,00	30,50
TL30	12,00	4,50	0,75	2,50	1,75	0,00	21,50
TL45	7,75	4,50	0,00	1,75	0,75	0,00	13,25

Source: Prepared by the author.

Analyzing the average density of the weed community (Figure 1), in response to the initial periods of coexistence in the bush (Group 2), it was observed that the density increased until 30 days after emergence (DAE) of the crop, when it reached its maximum number of individuals, decreasing sharply after this period and reaching a minimum at the end of the crop cycle, at 126 days, for all species present in the experimental area.

Radosevich & Holt (1984) report that as the density and development of weeds increases, especially those that emerged at the beginning of a crop cycle, inter and intraspecific competition intensifies, so that the plants with greater larger and more developed ones become dominant, while the smaller ones are suppressed and die. This type of behavior was observed in several studies evaluating coexistence periods in agricultural crops: soybeans (NEPOMUCENO, 2007; DUARTE, 2009), cotton (SALGADO, 2002), peanuts (YAMAUTI, 2009), beans (FREITAS et al., 2009) among others.

Figure 1. Graphic representation of the density values of individuals from the weed community in the soybean crop of Group 2 (initial periods of coexistence in the bush).

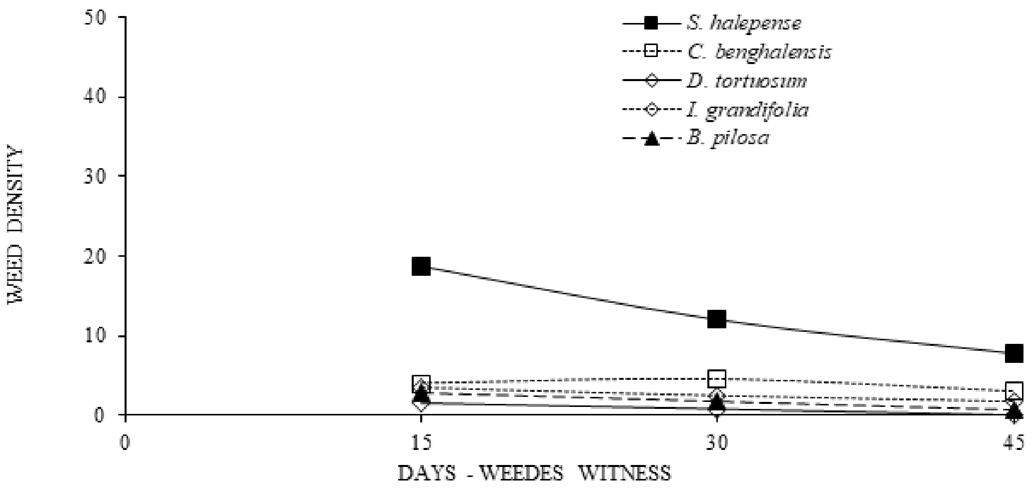


Source: Prepared by the author.

It was found that, at 30 DAE, the *S. halepense* population reached its highest density of 41.25 plants m^{-2}, with the species with the highest density always numerically predominating over the other species that compose the weed community. There was a decline in the density of all species from 30 DAE following this situation until the last evaluations, the data allow us to infer that from 30 DAE there was intense interference within the weed community, promoting a high mortality rate, where the population of *S. halepense* numerically predominated over the other component species of the weed community.

In the periods where the culture remained free of the weed community at the beginning of development (Group 1), the species that predominated the weed community were *S. halepense* and *C. benghalensis*, with a relatively low density (18.75 and 4.00 plants m^{-2} respectively) and there was no presence of *P. americanum* (Figure 2). This occurred because this plant does not support shading and as in these treatments the soybean coexisted with the weed community at a more advanced stage, the culture ended up suppressing the development of this species, the low density of the other weed species may also be due to this factor. competition with the crop, or because most weeds (above 75%) emerge in the first 30 DAE (PEREIRA et al., 2016).

Figure 2. Graphic representation of the density values of the populations present in the weed community in the different treatments of coexistence periods maintained in the clean (group 1).



Source: Prepared by the author.

There were no significant differences in the average height of soybean plants due to the periods of coexistence kept in the clean in the initial periods (Group 1), but the height of the soybean plants that coexisted in the initial periods of development (Group 2) showed significant differences statistically (Table 4). The height of the soybean plants was greater as the period of coexistence of the weed community with the culture was increased, with the control treatment after 45 DAE and the infested control that had the soybean plants with the highest heights (70.13 cm and 70.93 cm, respectively).

In general, soybean height increases the later the weed community control measures are applied. Durigan et al. (1983) reported that this positive relationship between weed competition

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period and soybean plant height, for periods longer than 30 days, occurs due to etiolation in search of light radiation.

These results agree with those observed by Duarte (2009), but contradict the data observed by Nepomuceno et al. (2007), who observed that soybean height was not affected as a result of periods of coexistence or weed control, in the no-till system, probably due to the cultivar, density and composition of the weed community, in addition to soil and climate conditions (work developed in the state of São Paulo).

The height of insertion of the first pod was influenced by the coexistence with weeds (Table 4). The lowest insertion height was observed in the control treatment for 45 DAE (13.80 cm) and this did not differ statistically from the weeded control (14.20 cm), and it was greater as the period of coexistence of the community was increased. with the culture, reaching 21.90 cm in the infested control (Figure 3A).

Table 4. Means of the values of soybean agronomic parameters evaluated at the time of soybean harvest

Treatment	Evaluated parameters				
	Heigh (cm)	**Number of pods/plant**	**1st pod height**	**Weight of 100 grains (g)**	**Productivity (kg ha^{-1})**
			Group 1		
TL0	65,29 a	64,80 a	14,20 bc	13,97 ab	3246,0 a
TL15	63,59 a	47,18 b	14,52 b	13,42 b	2611.6 c
TL30	63,54 a	46,68 b	15,48 a	13,66 ab	2537.3 c
TL45	61,54 a	62,88 a	13,80 c	14,24 a	2933,6 b
CV (%)	7,46	5,07	2,44	2,43	1,45
			Group 2		
TM0	76,93 a	36,20 c	21,90 a	12,61 b	1233,78 d
TM15	64,04 b	59,86 a	14,42 d	13,61 a	2935,26 a
TM30	66,16 b	58,62 a	15,22 c	14,00 a	2832,38 b
TM45	70,13 ab	46,60 b	16,58 b	12,75 b	2356,88 c
CV (%)	5,38	5,47	1,49	2,06	1,26

Means followed by the same letter, within each parameter, do not differ from each other by Tukey's test at the 5% probability level.
Group 1: TL – Control treatments - kept free from the weed community in the initial periods of crop development. Group 2: TM – Treatments maintained with the weed community in the initial periods of crop development.
Source: Prepared by the author.

Durigan et al. (1983) reported that the height of insertion of the first pod is related to the competition for light and the formation of flowers in the lower part of the soybean, since the shading caused by the weeds affects the photosynthetic efficiency of the basal leaves, impairing the transport and distribution. of carbohydrates.

The number of pods per soybean plant was significantly reduced by the interference of the weed community (Table 4). The highest averages were found in the treatment kept clean from

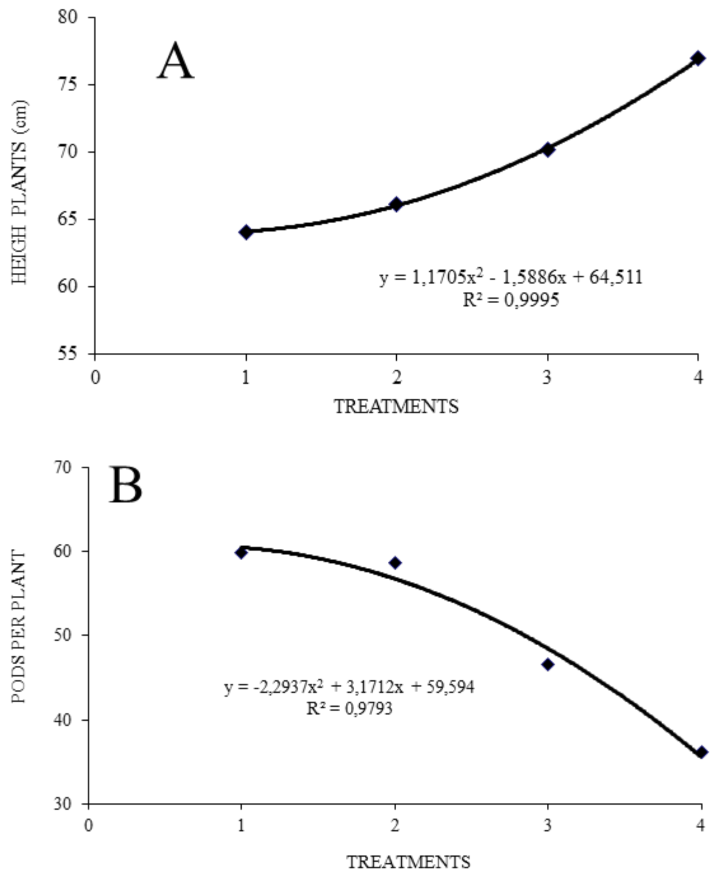
45 DAE and in the weeded control (62.88 and 64.80 pods plant^{-1}, respectively) and there were no significant differences between these two treatments and the most affected was the infested control (36 pods plant^{-1}), comparing the averages, a reduction of around 56% is observed.

It is also observed in Figure 3B that the number of pods decreased as the period of coexistence with the weed community increased, these results are in agreement with those observed by Arns (2007) and Silva et al. (2009).

Velini (1989) and Duarte (2009) consider the reduction in the number of pods per plant as the main component of production affected by the interference of weeds. This component is also considered the most influenced by the modification of management practices (RAMBO et al., 2004).

The weight of 100 grains (Table 4) was not affected when it lived up to 30 DAE with the weed community, a significant effect observed only when the culture lived for 45 DAE and during the entire crop cycle, noting a 10% reduction in this variable. When the culture remained free of the weed community in the initial periods, the best weight was in the LT45 treatment, and there were significant differences only for the LT15 as can be seen in Table 5, these results contradict those obtained by Nepomuceno et al. (2007), Contato (2007) and Duarte (2009) who did not observe significant differences for this variable.

Figure 3. Average value of number of pods per soybean plants, as a function of initial control (A) and initial coexistence (B) periods. 1 - Clean treatment after 15 days (TM15) 2 - Clean treatment after 30 days (TM30) 3 - Clean treatment after 45 days (TM45) 4 - Infested control (TM).



Source: Prepared by the author.

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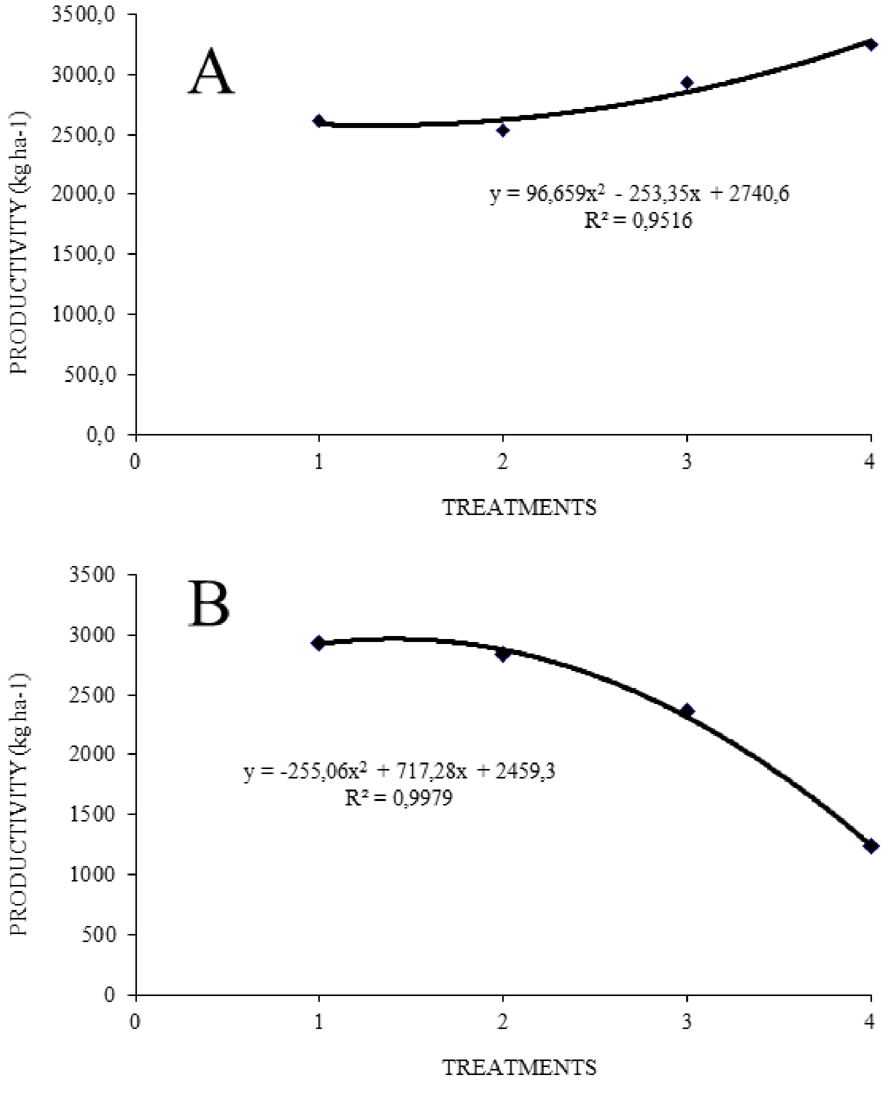
Crop productivity was significantly affected by the coexistence of the weed community. This fact can be observed by analyzing the grain yield data (Table 4). In Figure 4A, it can be observed that the productivity increased significantly as a function of the increase in the period of initial control of the weed community, reaching 3246 kg ha^{-1} in the control maintained in the clean.

Figure 4. Soybean productivity, as a function of initial control (A) and initial coexistence (B) periods.



Source: Prepared by the author.

As for the coexistence of the culture with the weed community in the initial periods of development, there was a decrease in production as the coexistence period was increased (Figure 4B) comparing the average productivity obtained in the weeded control (3246 kg ha^{-1}) with the one obtained in the infested control (1233 kg ha^{-1}) there was a reduction of around 62% in grain production. These data show the high susceptibility of the soybean crop to the interference imposed by weeds in the conditions found at the time of this work. This result corroborates those observed by Martins (1994), Nepomuceno (2007), Contacto (2007) and Duarte (2009).

A significant reduction was observed even in the TM15 treatment (2,935 kg ha^{-1}) where the culture lived only 15 minutes with the weed community, this was explained by Kozlowski et al. (2002), who comments that the effects of interference are irreversible, with no recovery of development or productivity after removal of the stress caused by the presence of weeds.

Final Considerations

Under the conditions in which the experiment was conducted, the results obtained allow us to conclude that:

Living with weeds causes an average increase in the height of soybean plants.

The parameters of number of pods per plant, height of insertion of the first pod and the weight of 100 grains are reduced by the interference of weeds.

Interference with weeds reduces soybean yield in no-tillage system.

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