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Article

INTERFERENCE PERIODS IN SOYBEAN CROP AS AFFECTED BY EMERGENCE TIMES OF WEEDS

Períodos de Interferência na Cultura da Soja em Razão da Época de Emergência de Plantas Daninhas

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ABSTRACT - Weeds emergence times modify competition with crops. Thus, the hypothesis was that the increase in weed emergence flow decreases the period prior to interference (PPI) in soybeans and increases the critical period of interference prevention (CPIP). The objective was to determine the PPI and the CPIP of weeds in soybean crops as affected by the preferred time of weeds emergence flow. Three experiments were conducted in the field in a randomized block design with four replications. The treatments were arranged in a factorial design with factor A consisting of coexistence or weed control in soybeans and factor B for eight periods (0, 7, 14, 21, 28, 35, 42 and 135 days after crop emergence (DAE)). The numbers of emerged plants and weed dry mass by genus and crop productivity were evaluated. The weed interference in culture during all the crop cycle reduces the soybean average yield 73, 94 and 89% in the first, second and third sowing times, respectively. Chemical control may be adopted at the end of PPI, which must be done at 14, 15 and 5 DAE crop, for the first, second, third times, respectively. The sowing in advance and intermediate time of recommendation increase the PPI in about 10 days, favoring the weed management in soybean crops.

Keywords: *Glycine max, weed competition, crop yield losses.*

RESUMO - A época de emergência das plantas daninhas modifica a competição com as culturas. Assim, tem-se como hipótese que o aumento do fluxo de emergência de plantas daninhas diminui o período anterior à interferência (PAI) na soja, aumentando o período crítico de prevenção à interferência (PCPI). O objetivo foi determinar o PAI e o PCPI das plantas daninhas na cultura da soja, em função da época preferencial do fluxo de emergência de plantas daninhas. Realizaram-se três experimentos em campo, em delineamento experimental de blocos casualizados, com quatro repetições. Os tratamentos foram arranjados em esquema fatorial, sendo o fator A composto pela convivência ou controle de planta daninha na cultura da soja, e o fator B, por oito períodos (0, 7, 14, 21, 28, 35, 42 e 135 dias após a emergência da cultura –DAE). Avaliou-se o número de plantas emergidas e a massa seca das plantas daninhas por gênero, bem como a produtividade da cultura. A interferência das plantas daninhas na cultura durante todo o ciclo reduz a produtividade de soja, em média, em 73, 94 e 89% na primeira, segunda e terceira época de semeadura, respectivamente. O controle químico deve ser adotado ao final do PAI, o qual deve ser realizado aos 14, 15 e 5 DAE da cultura, para a primeira, segunda e terceira épocas, respectivamente. A semeadura realizada de forma antecipada e na época intermediária de recomendação aumenta o PAI em cerca de 10 dias, favorecendo o manejo das plantas daninhas na cultura da soja.

Palavras-chave: *Glycine max*, competição, perdas de produtividade.

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INTRODUCTION

Soybeans stand out as the most relevant crop of Brazilian agribusiness, being the basis of the economy of the primary sector and the country's balance of trade (BOT). Brazil is the second largest producer and exporter of soybeans worldwide, with 102.1 million tons produced in the 2015/16 agricultural harvest (Conab, 2016). Rio Grande do Sul is the Brazilian state that presents the third largest production, after only Mato Grosso and Paraná states, representing approximately 15% of the national production, with average 2,970 kg ha^{-1} (Conab, 2016).

Soybean yield may be negatively influenced by many abiotic and biotic factors. Among biotic factors, competition with weeds stands out, since they can cause losses of up to 80% in yield (Silva et al., 2009a), considerably increasing production costs. Such losses can be influenced by weeds species and population in the area, their time of emergence and the phenological development stage of the species (Agostinetto et al., 2014), which provide different degrees of competition.

Competition of weeds with crops can generate irreversible losses, with no recovery of development or yield after withdrawal of stress caused by their presence (Agostinetto et al., 2014). Such effects can be expressed in morphophysiological alterations in plants, which compromise the development of reproductive structures, reflecting in reduction of grain production (Adelusi et al., 2006) due to being hosts of insects, pathogens and nematodes (Vasconcelos et al., 2012), hindering operation of crop practices and harvesting and reducing sugar cane yield (Millar et al., 2011).

The period of coexistence between the crop and the weeds defines the level of damage caused to the crop. Thus, the longer this period in which the community is competing for a given resource, the greater the damage to yield. It is known that competition established mainly in the early stages of the cycle causes significant losses in yield (Agostinetto et al., 2014) and weed-free crops should be established to avoid such losses.

Crops may coexist with weeds for a given period. However, there are periods when interference must be avoided and control is essential to maintain high yield levels. At the beginning of the crop development cycle, weeds can coexist without loss of yield, this stage being known as the period prior to interference (PPI) while the stage at which crops should grow free from the presence of weeds so that yield is not affected is known as the total period of interference prevention (TPIP) (Radosevich et al., 2007). From this period, new weeds may emerge, but they shall not cause reduction in crop yield.

The third period, which is known as the critical period of interference prevention (CPIP), corresponds to the difference between TPIP and PPI, being the stage in which management practices must be effectively carried out in order to avoid irreversible yield losses (Radosevich et al., 2007). In general, the ideal moment to adopt the control strategy is the one as close as possible to the PPI since in the CPIP there are already losses in yield.

There are several competition period studies for soybean cultivation (Silva et al., 2009b; Tavares et al., 2012; Agostinetto et al., 2014) but none was performed in order to establish the periods according to weed emergence flow. Studies related to germination beginning and the emergence flow of weeds allow the development of management strategies that provide greater competitive ability to the crop, which can reduce the number of herbicide applications, improve control efficiency and also reduce possible environmental contaminations and/or the emergence of resistant weeds.

From the above, this research hypothesis is that the increase of weed emergence flow decreases the period prior to weed interference in soybeans and increases the critical period of interference prevention. This study objective was to determine the period prior to interference (PPI) and the critical period of interference prevention (CPIP) of weeds in soybean crops due to the weed emergence flow preferential time.

MATERIALS AND METHODS

Three experiments were carried out in the field in the agricultural year of 2014/15 using an experimental randomized block design with four replications. The experimental units consisted of 10.80 m^2 (6 x 1.8 m) plots. Treatments were arranged in a factorial scheme. Factor A consisted of presence (coexistence) and absence (control) of weeds in a soybean crop. And factor B, for eight periods of weed coexistence with the crop, being 0, 7, 14, 21, 28, 35, 42 and 135 days after the emergence (DAE) of the culture. During such periods, soybeans were maintained in the presence of weeds and then controlled until the end of the cycle. In the control periods, the crop was kept free of weeds during the same periods described above. Weeding was carried out and weeds emerged after such intervals were not controlled. The weed population in the experiment came from the seed bank present in the soil.

Soybean cultivar used was NA5909RR, cultivated in a direct seeding system, with spacing between rows of 0.45 m, whose population was of 310 thousand plants ha^{-1}. In the first experiment, sowing was done on October 20, 2014. In the second one, on November 10, 2014. And in the third one, on December 1, 2014. In the three experiments, prior to sowing, seeds were inoculated with strains of *Bradyrhizobium japonicum* (SEMIA 5019) and treated with carboxin + thiram fungicide (50 + 50 g a.i. 100 kg^{-1} seeds) and with insecticide fipronil (50 g a.i. 100 kg^{-1} seeds). Basic fertilization was carried out according to recommendations for the crop, using 350 kg ha^{-1} of fertilizer 05-20-20 (N - P_2O_5 - K_2O), distributed in the sowing row.

Regarding weed control, the area was desiccated 30 days before sowing with glyphosate herbicides and 2,4-Dichlorophenoxyacetic acid in doses of 1,260 and 1,005 g a.e. ha^{-1}, respectively, followed by sequential applications seven days before soybean sowing with glyphosate (1,260 g a.e. ha^{-1}) and clethodim (108 g a.i. ha^{-1}), added of nonionic surfactant adjuvant at 0.5% v/v.

During the conduction of the experiments, water supplements were provided by means of spraying in order to guarantee an adequate development for the culture. Irrigations were done when periods of absence and/or rainfall below 20 mm exceeded 13 days, with approximately 20 mm of water supplied at each operation (Figure 1).

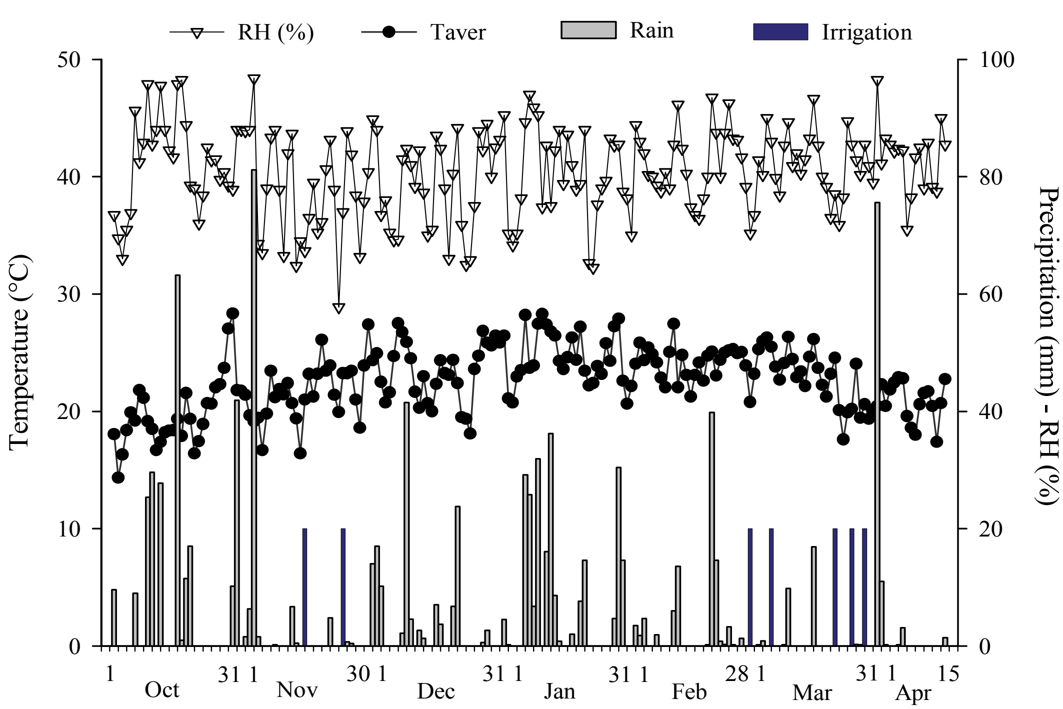


Figure 1 **-** Climatic data observed in the experimental area while carrying out the experiment: air relative humidity (RH), air average temperature (Taver), rainfall (rain) and water supplementation (irrigation) – 2014/15.

At the end of each competition period, the numbers of emerged weeds and shoot dry matter (SDM) were evaluated. For determination of SDM, plants were collected in a 0.25 m^2 area of each plot and samples were then dried in an oven with forced air circulation at 60 °C for 72 hours and then they were weighed. At the time of harvesting, carried out at 135 DAE, crop yield was determined in a floor area of 5.4 m^2 by manually harvesting plants in the two central rows of each plot, building a path and cleaning samples and correcting humidity to 13%.

Data were evaluated for normality (Shapiro-Wilk test) and homoscedasticity (Hartley's test) and afterwards submitted to analysis of variance (p≤0.05). When statistical significance was found, mean values of coexistence and control factors were compared by the t-test (p≤0.05) and Duncan's test (p≤0.05) was used to compare the periods within each factor by means of software R (R Core Team, 2012) scripts. Competition periods were determined by a non-linear regression model (p≤0.05) as described below.

To determine the coexistence period (PPI), a regression equation was used with three parameters, according to Velini (1992):

$$y = a/[1 + (x/x0)^b]$$

where: y = grain yield; a = maximum yield obtained in the clean control; x = number of days after crop emergence; $x0$ = number of days where 50% of maximum yield reduction took place; and b = slope of the curve.

The period prior to interference (PPI) was estimated considering the yield estimated by the mathematical model in the absence of competition from 4,805 kg, 4,450 kg and 3,713 kg ha^{-1} regarding the first, second and third sowing seasons, with a price for a 60 kg sack of soybean, in an average of the last 10 years, of BRL 46.43 (Agrolink, 2016). The other components were the cost of glyphosate herbicide at the dose of 2.5 L ha^{-1} (BRL 70.00 ha^{-1}), of cloransulam-methyl herbicide at the dose of 47.6 g ha^{-1} (BRL 72.00 ha^{-1}) and nonionic surfactant (BRL 27.00 ha^{-1}) and herbicide tractor application (BRL 45,00 ha^{-1}), according to average prices practiced in Rio Grande do Sul during the 2014/15 harvest. From these values, the cost of chemical control totaled BRL 214.00, corresponding to 276.55 kg ha^{-1} of soybean grains. Thus, 5.75, 6.25 and 6.77% were subtracted from the maximum soybean yield estimated by the model, where its value corresponds to the cost of chemical weed control.

Concerning the data regarding the total period of interference prevention (TPIP), the following equation of four parameters was used:

$$y = y0 + a/[1 + (x/x0)^b]$$

where: $y0$ = minimum yield obtained in the treatment infested; a = difference estimated by the model between the maximum yield in the control treatment (without weeds) and the minimum yield in infested treatment. The other parameters are identical to those described for the PPI. To estimate the critical period of interference prevention (CPIP) of weeds, the value of PPI was subtracted from TPIP.

RESULTS AND DISCUSSION

The analysis of the results obtained in the experiments showed that it is not necessary to transform the data, based on the Shapiro-Wilk and Hartley's tests. The analysis of variance indicated an interaction between the factors tested for all the variables analyzed in the three sowing seasons.

The weed community in the experiment area consisted of 11 weed species, the most important ones being *Urochloa plantaginea* (plantain signalgrass), *Digitaria* spp. (cockspur grass), *Raphanus* spp. (turnip), *Bidens pilosa* (beggarticks), *Ipomoea grandifolia* (bindweed), *Sida rhombifolia* (arrowleaf sida), *Richardia brasiliensis* (tropical Mexican clover) and *Amaranthus viridis* (large fruit amaranth) for the three sowing seasons. Weed populations in agricultural crops usually consist of a hierarchy of individuals with one or two dominant species and others of less importance (Werle et al., 2014a).

In the first sowing season, the weed population consisted of 80% liliopsidas and 20% magnoliopsidas (Figures 2A, B), similar to that observed in the second period, with 76% of liliopsidas and 24% of magnoliopsidas (Figures 2C, D). But in terms of species diversity, there was a predominance of magnoliopsidas, with 75%. The occurrence of magnoliopsida species in soybean crops is more harmful, since they have a cycle and root system very similar to those of cultivated plants. It is known that the more morphophysiologically similar two species are, the closer their needs shall be and more intense competition for limiting factors in the environment shall be (Vasconcelos et al., 2012). As for the third season, the proportion of dominant liliopsida weeds decreased by 21.6%, with magnoliopsidas being responsible for an infestation of 41.6% of the area (Figures 2E, F).

Analyzing the weed population in response to the coexistence periods, it was verified that in the first and third sowing times at 14 DAE of the crop the weed population reaches maximum value (1,522 and 363 plants m^{-2}), with a second flow between 35 and 42 DAE of the crop (Figure 2). In the second season, maximum emergence of weeds occurred at 28 DAE, with 873 plants m^{-2} and there were no new emergence flows occurring during the crop cycle. The highest weed population at 14 DAE was also reported in soybeans crops in the Brazilian state of Paraná, but new emergence flows were not observed (Silva et al., 2015).

In the field, weeds usually emerge in discrete and successive flows (Werle et al., 2014b). Non-uniformity in emergence flow is characteristic of weeds, depending on types and conditions of dormancy of each species (Radosevich et al., 2007) and environmental conditions. The weed population established in the area in response to the coexistence periods in the three sowing seasons can be considered high according to Silva et al. (2009a), since more than 150 m^{-2} plants settled and competed with the crop before 10 DAE.

At the beginning of the crop development cycle it was observed that the emergence of weeds tended to increase, allowing better establishment and success in perpetuating the species in all sowing seasons. But with the development of the crop, the population of weeds tends to establish or decrease (Figure 2). In areas of low infestation, linear growth was observed in the weed population. However, in areas of medium and high infestation, a decrease in the weed population was observed in soybean areas from 33 and 28 DAE, respectively (Silva et al., 2009a). This reduction is related to the environment support ability and/or an innate ability to self-thinning in areas with limited resources and conditions (Radosevich et al., 2007), as well as canopy closure by soybeans, which restricts, through shading, germination of new weeds (Tavares et al., 2012).

In the control periods, it was observed that, although weeds were weeded by manual weeding every seven days, there were always new emergences with high weed populations up to 14 DAE and from that period the flow decreased (Figure 2). It is known that agricultural practices can alter the processes leading to the emergence of weeds (Colbach et al., 2005). Thus, the effect of manual weeding control during the control periods may have stimulated germination by soil rotation (Del Monte and Dorado, 2011). Furthermore, it was observed that from 35 DAE no more emergence of liliopsida weeds occurred, but magnoliopsidas continued to emerge. On the other hand, in the periods of coexistence, greater accumulation of weed emergence was observed in comparison with the periods of control.

Weeds showed higher accumulation of SDM in the areas of coexistence, although there was a reduction in population, causing greater interference on the growth and development of the crop at all sowing times (Figures 2A, C, E). The increase in SDM of weeds is more important than the population of individuals per area in terms of the degree of interference imposed on soybeans, presenting an inversely proportional correlation to the yield and phenological components of the crop (Meschede et al., 2004). However, weed control over the soybean crop cycle reduces the number of plants emerged per m^{-2} and prevents SDM production of liliopsida weeds at 135 DAE at both sowing times.

Comparison between the periods of coexistence and control for the SDM variable of liliopsida weeds did not show differences until 7 DAE of the crop in all the sowing seasons. In the other evaluation periods, SDM accumulation was higher in the coexistence period (Figures 2A, C, E). When weeds coexisted with the crop during the whole cycle, the accumulation of SDM was 100% higher than the control performed up to 135 DAE in all sowing seasons. Difference between the periods was expected since the weeds present in the control period had maximum of seven days

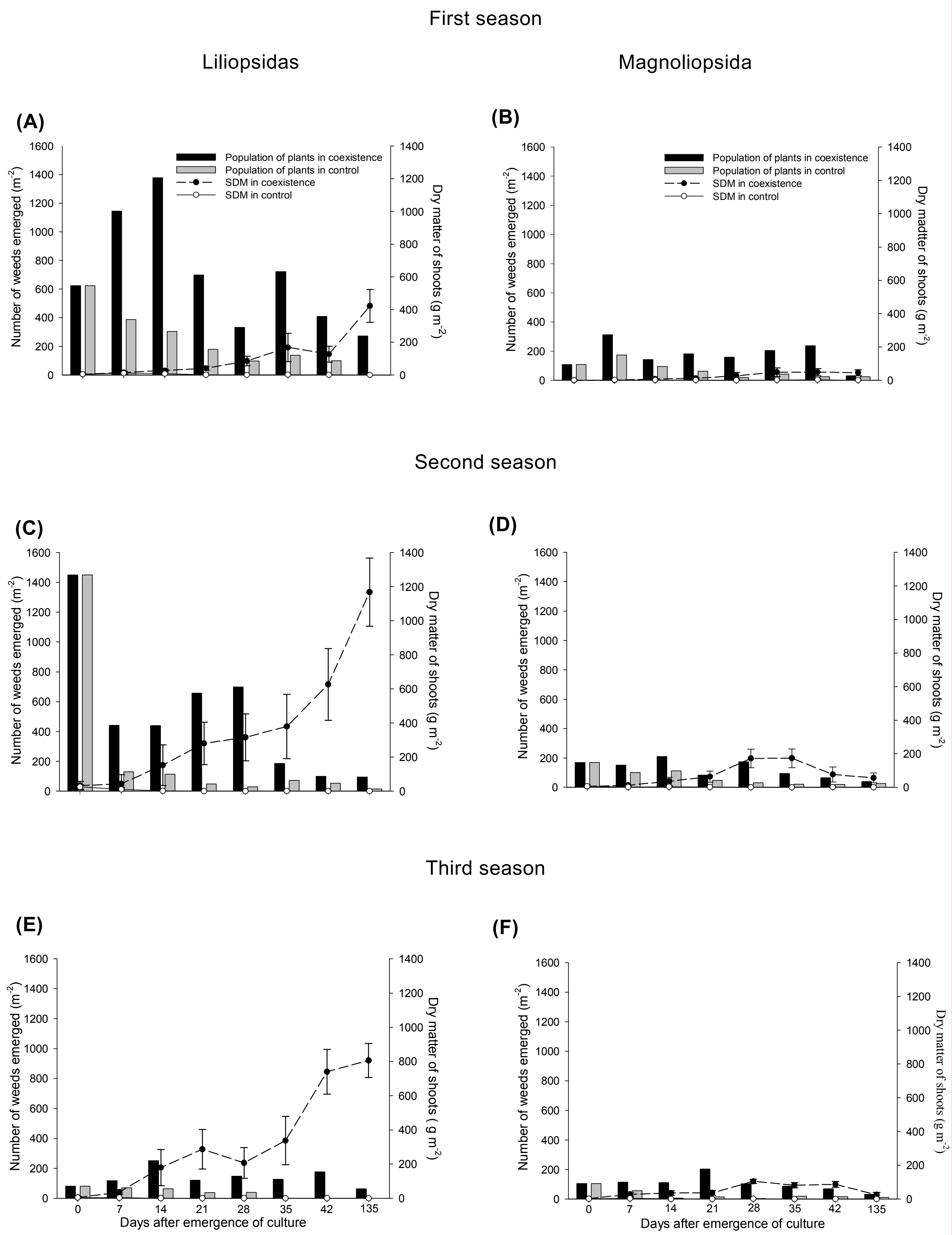


Figure 2 - Number of liliopsida and magnoliopsida weeds emerged (columns) and shoots dry matter (rows) in each period of coexistence or control after emergence of the soybean crop in first (A – B), second (C – D) and third (E – F) sowing seasons in the 2014/15 crop.

from their emergence while the periods of coexistence were in the experimental area from the crop emergence.

For magnoliopsidas, results found for SDM were similar to those presented for liliopsida weeds at all sowing times (Figures 2B, D, F). Thus, there was an increase in their values as the periods of coexistence were extended due to plants growth and the weed emergence new flow. It was observed that SDM remained at low levels for the initial period and after 14 DAE showed large increase. Other authors reported that the accumulation of SDM remained at low levels up to 20 DAE but showed large increase after this period (Silva et al., 2009a, 2015).

SDM of magnoliopsidas in the control periods in the first season presented alteration only at 28 and 42 DAE due to the higher number of weeds emerged (Figure 2B). For the second season, there was no difference in the accumulation of SDM between the control periods due to the low growth and development of weeds in these periods. But for the third period there was a decrease after 35 DAE (Figures 2D, F). This decrease occurs due to the crop suppression exerted on the plants population and stature (Tavares et al., 2012; Pereira et al., 2015).

In the comparison between the periods of coexistence and control for the variable SDM of magnoliopsida weeds there was no difference until 7 DAE of the crop for the first and second sowing seasons and 0 DAE for the third season. In the other times of evaluation the accumulation of SDM was higher in the period of coexistence in both sowing seasons (Figures 2B, D, F). When weed interacted with the crop during the whole cycle, the accumulation of SDM was 98.2, 99.3 and 98.7% higher than the control, carried out up to 135 DAE.

Comparing the two classes of weeds, liliopsidas averaged 82.2, 77.4 and 84.4% dry matter production of all evaluation times for the coexistence periods, higher than those of magnoliopsidas in the first, second and third sowing seasons, respectively, suggesting that there was greater interference of liliopsida species on soybean crop yield. The highest damage caused by liliopsida weeds in the soybean crop was also verified by Fleck and Candemil (1995), who reported that these plants reduced 42% more than magnoliopsida plants because they have high competitive capacity, with high levels of infestation and shading capacity already in the crops initial stages. Other authors claim that magnoliopsida weeds further damage yield by competing for the same nutrients (Bianco et al., 2007). However, since the weed community is formed by a weed complex and under field conditions the species can interact (Guglielmini et al., 2016), total SDM accumulated was 467.8, 1,204.5 and 831.2 g m^{-2} at 135 DAE in the first, second and third sowing seasons, respectively, demonstrating the high interference potential of this community.

Regarding the effects of competition on soybean crop yield in the first sowing season, it was observed that in the periods of coexistence the presence for periods longer than 14 DAE reduced the variable evaluated (Table 1). Weed coexistence during the whole crop cycle reduced yield by 73.2% compared to the average of the first three periods (0, 7 and 14 DAE), where coexistence did not provide changes. In the second and third seasons, the presence of weeds reduced yield at 7 DAE of the crop and the presence of weeds during the whole cycle reduced soybean yield by 94.0 and 88.8%, compared to coexistence at zero day (clean control) (Table 1). In addition, losses were observed in the harvest due to high SDM and because these weeds present a longer cycle than the crop, hindering the harvesting operation, and also by increase in grains moisture. Similar results were presented by Millar et al. (2011) and Pereira et al. (2015), demonstrating that weeds permanently affect agricultural economy, causing direct and indirect losses, and their control considerably increases production costs.

Yield of soybean crop was altered by the time of weed control. Increase in the period when the crop remains free from weed interference reduces losses. When the crop remained clean throughout the cycle, yield was 76.4, 85.7 and 81.9% higher than the control performed only on the day of crop emergence for the first, second and third sowing seasons respectively (Table 1). Such results are in agreement with those by other authors, who observed that competition with weeds always causes damage to soybean yield, which depends on the species present, the weed population and the soybean cultivar used (Silva et al., 2009b; Pereira et al., 2015).

Comparing coexistence and control periods, it was observed that in the first and second seasons there was no difference in yield at 28 and 21 DAE, respectively, which was not verified in the third season (Table 1). Thus, in the initial periods (up to 21, 14 and 7 DAE) yield is higher

Table 1 **-** Grain yield (kg ha^{-1}) due to the effect of the periods of coexistence or weed control with soybean crop, depending on sowing season – 2014/15

Period (DAE[1])	Yield (kg ha^{-1})	
	Coexistence	Control
	First season	
0	4557.0 a*[2]	1177.5 h
7	4889.8 a*	1437.7 g
14	4906.6 a*	2031.3 f
21	4040.1 b*	2717.4 e
28	3264.9 c^{ns}[3]	3244.8 d
35	2246.6 d*	3599.3 c
42	1532.8 e*	4717.1 b
135	1283.1 e*	4983.9 a
VC (%)	9.9	5.5
	Second season	
0	4879.9 a*	665.7 f
7	4059.1 b*	1242.3 e
14	4097.9 b*	2469.2 d
21	3849.5 b^{ns}	3980.8 c
28	3263.8 c*	4311.6 b
35	2511.1 d*	4546.4 ab
42	1193.0 e*	4486.9 ab
135	294.3 f*	4679.1 a
VC (%)	12.1	6.1
	Third season	
0	3751.2 a*	678.1 g
7	3657.7 ab*	1383.4 f
14	3139.8 bc*	2529.6 e
21	2762.2 cd*	2969.6 d
28	2577.6 cd*	3180.9 cd
35	2466.4 d*	3435.6 bc
42	1900.1 e*	3696.5 ab
135	420.4 f*	3738.1 a
VC (%)	12.6	6.3

[1] Days after emergence. [2] Means followed by different letters compared in the column differ by Duncan's test ($p \leq 0.05$). [3] * or ^{ns} compares each variable on the row, significantly differing or not by the t-test ($p \leq 0.05$).

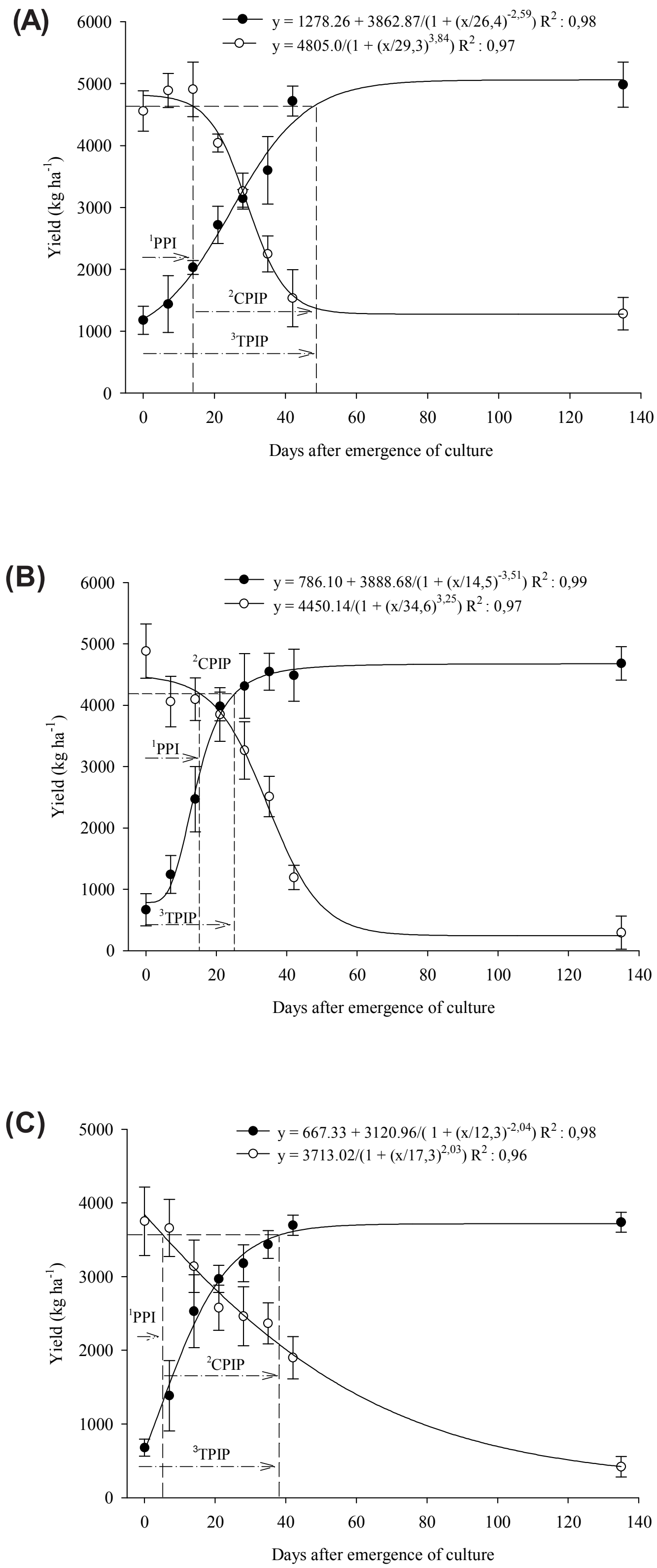
in coexistence while from 35, 28 and 21 DAE yield is higher in the control periods for the first, second and third sowing seasons, respectively. Therefore, control maintained until the end of the crop cycle avoided 74.3, 93.7 and 88.8% of yield losses in relation to the same coexistence period.

Treatments in which soybeans were maintained during the initial growing periods in the absence of weeds allowed to estimate the period in which these plants can emerge and infest soybeans without causing damage to crop yield for each sowing season (Figures 3A, B and C). For the first season, considering 5.76% of the maximum yield estimated by the equation (4,805 kg ha^{-1}) as the cost of chemical control, it was determined that PPI occurred from the emergence until 14 DAE of the crop, whereas TPIP was from 48 DAE (Figure 3A). Thus, the CPIP comprised the period from 14 to 48 DAE of the soybean crop. However, the appropriate time for weed control would be at the end of the PPI, close to 14 DAE, since weeds are in early development and have low dry mass accumulation when control techniques used are generally efficient.

In the second period, the cost of chemical control was estimated to be 6.22% of the maximum yield estimated by the equation (4,450 kg ha^{-1}), being the PPI of 15 DAE, TPIP of 26 DAE and CPIP of 15 to 26 DAE of the soybeans crop (Figure 3B). Results obtained for the PPI in the second season are similar to the one found in the first one, demonstrating that the conditions and degree of weed interference in the initial periods were similar. However, the CPIP was lower in relation to the first season, possibly because at this time the new flow of weed emergence occurred at 28 DAE before flowering and was 5.7% smaller than the first season flow, which may have reflected in lower PTIP. Studies evaluating periods of competition, determined with different weeds in the soybean crop, have shown results similar to those of the present study, with PPI of 11 DAE (Meschede et al., 2004) and 17 DAE (Silva et al., 2009b), CPIP between 28 and 38 DAE (Adelusi et al., 2006) and 23 to 50 (Agostinetto et al., 2014).

In the third season, the cost of chemical control was calculated at 7.45% of the maximum yield estimated by the equation (3,713 kg ha^{-1}), being the PPI of 5 DAE, while the TPIP was of 38 DAE and the CPIP comprised the period from 5 to 38 DAE of the crop (Figure 3C). This value can be considered reduced in relation to the values found in the literature (Meschede et al., 2004; Silva et al., 2009b) and the first two sowing seasons, results being credited to the cultivation season. However, similar results were reported in a study carried out in the Brazilian state of Mato Grosso at sowing carried out in December, with PPI of 7 DAE and TPIP of 42 DAE (Pereira et al., 2015).

Interference of weeds in the crop during the whole cycle reduces soybean yield on average 73% (first season), 94% (second season) and 89% (third season) of sowing. In addition, the highest



[(1)] Period prior to interference; [(2)] Critical period of interference prevention; [(3)] Total period of interference prevention. Vertical bars represent the confidence intervals ($p \leq 0.05$).

Figure 3 - Definition of periods of control (full circle) and coexistence (empty circle) of weeds in soybean culture based on yield in first (A), second (B) and third (C) sowing seasons – 2014/15.

yield was obtained in the first seasons with 4,805 kg ha^{-1}. As for the second and third ones, yield was 7.4 and 22.7% lower than the first sowing season, respectively. Taking into account these results, it is suggested sowing at the beginning of the recommended season to achieve maximum yield and to obtain the smallest losses caused by weeds but control costs shall be higher than in the second season. However, in large areas it is necessary to scale soybean sowing according to machines operational capacity and to provide greater security to farmers to avoid great damage due to climatic problems.

Considering the results obtained in this study and other reports about different research studies carried out in the Brazilian states of Mato Grosso and Paraná with populations of weeds and different soybean cultivars (Pereira et al., 2015; Silva et al., 2015), this study allows to organize management planning for soybean crops based on sowing seasons and the emergence of weeds during the crop cycle (Table 2). Thus, for the first season the recommended chemical control would be performed with postemergence herbicide application with residual effect due to the critical period of interference being from 14 to 48 DAE. For the second season, the application of postemergence herbicide without residual effect would be enough to rid the crop of weed interference as the TPIP is short, of 26 DAE. For the third season, as the PPI is 5 DAE, it is recommended to associate preemergence herbicide together with the herbicide used in the desiccation to guarantee residual and to prolong the PPI, with subsequent postemergence application before closing the crop to allow interference-free establishment.

Lilypsida weeds, during the period of coexistence, presented greater emergence and dry matter production of the shoots compared to magnoliopsidas, regardless of the sowing time of the soybeans. The presence of weeds competing for the medium resources reduces soybean yield, regardless of the sowing season. Thus, weed control measures in soybean crops should be adopted at the end of the PPI, which should be performed at 14, 15 and 5 DAE for first, second and third sowing seasons, respectively. The second sowing season is the most suitable for soybean cultivation since weeds can coexist with the crop during 15 DAE and control can be carried out up to 26 DAE of the crop. Sowing carried out in advance and in the intermediate time of recommendation by

Table 2 - Planning of weed chemical management in soybean crop, according to sowing season and based on weed emergence

Sowing season	Desiccation	Soybean postemergence
October 20	Postemergence	Postemergence**
November 10	Postemergence	Postemergence
December 1	Postemergence + Preemergence*	Postemergence

* Herbicides applied in postemergence and preemergence. ** Postemergence herbicides with residual effect.

agricultural zoning increases the PPI in about 10 days, favoring weed management in soybean crops.

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