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Capacidad de interferencia de las malezas en la productividad de la soya

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ABSTRACT

Keywords:
Coexistence
Control
Glycine max
Productivity
Suppression

Among biological factors, weeds are the most important limiting factor for crop yields, as well as increasing production costs. The aim was to determine the influence of control and coexistence of weed community on soybean crop yield and to define the period before interference, the critical period of interference prevention and the total period of interference prevention, with the comparative use of chemical and mechanical methods for weed eradication. The study was conducted in an experimental field in the 2018/2019 harvest. A randomized block with four replications was implemented as experimental design, using two methods for control. The evaluated periods were 0-10, 0-20, 0-30, 0-40, 0-50, 0-60 and 130 days after crop emergence. It was possible to observe that the use of the chemical method generated a higher yield compared to mechanical method. The period before the interference in both chemical and mechanical management was similar, approaching 20 days after crop emergence. The critical period of interference prevention was between 20-50 and 40.5 days after crop emergence in chemical and mechanical methods, respectively. The total period of interference prevention was extended to 50 and 40.5 days after crop emergence in chemical and mechanical methods, respectively. The reduction in productivity due to weed interference was 1639 kg ha^{-1} (55%) and 947 kg ha^{-1} (34.6%) in chemical and mechanical methods, respectively.

RESUMEN

Palabras clave:
Coexistencia
Control
Glycine max
Productividad
Supresión

Entre los factores biológicos, la maleza es el factor restrictivo más importante del rendimiento de los cultivos, además de aumentar los costos de producción. El objetivo fue determinar la influencia del control y la coexistencia de la comunidad de malezas en el rendimiento del cultivo de soya y definir el período anterior a la interferencia, el período crítico de prevención de las interferencias y el período total de prevención de las interferencias, con el uso comparativo de métodos químicos y mecánicos para la erradicación de las malezas. El estudio se realizó en un campo experimental en la cosecha de 2018/2019. Se implementó un diseño experimental de bloque aleatorio con cuatro réplicas, utilizando dos métodos para el control. Los períodos evaluados fueron 0-10, 0-20, 0-30, 0-40, 0-50, 0-60 y 130 días después de la aparición de las plantas. Se pudo observar que el uso del método químico generó un mayor rendimiento en comparación con el método mecánico. El período anterior a la interferencia tanto en el manejo químico como mecánico fue similar, acercándose a los 20 días después de la aparición de las plantas. El período crítico de prevención de la interferencia fue entre 20-50 y 40,5 días después de la aparición de las plantas en los métodos químico y mecánico, respectivamente. El período total de prevención de la interferencia se extendió hasta los 50 y 40,5 días después de la aparición de las plantas según método químico y mecánico, respectivamente. La reducción de la productividad debida a la interferencia de las malezas fue de 1639 kg ha^{-1} para el método químico (55%) y 947 kg ha^{-1} (34,6%) para el mecánico.

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The quality of the soybean crop can be affected by several factors, being the competition of the crop with weeds one of the most important elements when a higher yield is the target. The interference in soybean crop performance by weeds can result in losses of up to 90%, if effective control methods are not used (Silva *et al.,* 2009; Almarie, 2017). The dispute for the same resources, essential for the growth and development of weed and the crop of interest, when limited in quantity to satisfy the individual requirements present in the environment causes interference, resulting in productivity reduction of the crop of interest, in the final quality of the harvested product and impacting the economic result of the crop (Balbinot *et al.,* 2016).

According to Vargas *et. al.,* (2016), by considering only the state of Rio Grande do Sul, the presence of areas with resistant weeds and the additional cost of using alternative herbicides for their control, combined with the production losses due to competition between crops and weeds estimated at 10 to 20% of production, exceed $1 billion in each crop. In the national scenario, the total cost of weed resistance to herbicides with an average productive interference in soybean crop of 5% may exceed $2 billion each year (Adegas *et. al.,* 2017).

According to Radosevich *et al.* (2007), the competition between weeds and the crop of interest is divided into three periods, period before to interference (PBI), critical period of interference (CPIP) and total period of interference prevention (TPIP). PBI is the period in which weeds occurrence does not cause yield losses, starting at the emergence of the crop and extending to the beginning of the CPIP, which is the most relevant phase of the competition because it comprises the most critical period in which the crop is more susceptible to the damage caused by the presence of plants in the area and the coexistence between the two species causes yield losses and grain quality in greater evidence (Radosevich *et al.,* 2007; Agostinetto *et al.,* 2014; Zandoná *et al.,* 2018). The CPIP starts at the end of the PBI and extends until not causing any more significant damage to the crop (Radosevich *et al.,* 2007). TPIP covers the two periods aforementioned, encompassing the sum of both.

To determine each period, to evaluate the effect of different times of weed management on phytosociological indices and to determine the periods of weed interference on crop yield, controlling the intensity of weed interference on the crops of interest, is extremely important regarding strategies for weed management.

Thus, the aim of this study was to determine the influence of control and coexistence of the infesting weed community on soybean crop productivity and to define the PBI, the CPIP and the TPIP with the comparative use of chemical and manual methods for weed eradication, as well as the loss of productivity caused by intraspecific competition.

MATERIALS AND METHODS

The research was conducted in the experimental area of the Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul during 2018/2019, with 705 m of altitude. The soil of the experimental area is classified as typical dystrophic Red Nitosol (Streck *et al.,* 2018). The climate is hot and temperate (Cfa in the Köeppen and Geiger classification) with average annual rainfall of 1971 mm and average annual temperature of 17.8 °C.

The design of the experiment was in randomized blocks. The presence (coexistence) and absence (control) of weeds in soybean crop were evaluated for seven periods of weed coexistence with the crop: 0-10, 0-20, 0-30, 0-40, 0-50, 0-60 and 130 days after crop emergence (DAE). During these periods, the coexistence management consisted of keeping soybean in the presence of weeds and then controlled until the end of the cycle. During the control periods, the crop remained weed-free in the same periods.

The experiment area was planted with black oat during the previous season. The soybean cultivar used was BMX Lança IPRO 58i60 RSF, which presents an indeterminate growth habit and maturation group 5.8, with average plant size and undetermined growth habit, requiring high soil fertility and presenting a total development cycle of 142 days in the region. The local management of the cultivated straw was a no-tillage system with fertilization in the sowing line using the formulation 20-30-20 N-P-K, at a dose of 380 kg ha^{-1}, as being adjusted according to the soil analysis and the crop productivity expectations.

The experimental area was managed under the consolidated no-tillage system, where the previous used crop was black oat for the purpose of soil coverage. The management was carried out 30 days before soybean sowing, using a sequential application of herbicides Cletodim (144 g ai (active ingredient) ha^{-1})+Glyphosate (854.4 g ai ha^{-1}) and in pre-sowing the herbicide Paraquat (400 g ai ha^{-1}).

The counting and identification of weed population were performed in the interval of 10 days, coinciding with the periods of coexistence and interference. Weed control was based on the use of a chemical method (herbicides), since it is the most used, and also, the use of the mechanical method, pulling out weed present in the sowing line and weeding between the rows of the crop.

For the chemical control of weeds, chlorimuron or Cletodim associated with glyphosate were applied, according to the predominant population at the time of application, performing an association of glyphosate herbicides (854.4 g ai ha^{-1}), and Cletodim (108 g ai ha^{-1}) in the predominance of monocotyledon weeds, or the combination of glyphosate herbicides (854.4 g ai ha^{-1}) and clorimuron (20 g ai ha^{-1}) when dicotyledons were predominated.

In order to determine the PBI, a regression equation with three parameters was used, according to Velini *et al.* (1997):

$$Y = a / [1+ (x / x_0)^b] \quad (1)$$

where: Y=grain yield; a=maximum yield obtained in the clean control; x=number of days after crop emergence; x_0=number of days in which 50% of maximum yield reduction occurred; and b=curve slope.

Regarding the data referring to the control period, the following equation of four parameters was used:

$$Y = y_0 + c / [1 + (x/x_0)^b] \quad (2)$$

where: y_0=minimum yield obtained in the infested treatment; c=difference estimated by the model between the maximum yield in the control treatment (without weeds) and the minimum yield in the infested treatment. The other parameters are similar to those of the previous equation. To determine the critical period of interference prevention, the value of the coexistence period was subtracted from the total period of interference.

PBI was estimated considering a 5% reduction in crop maximum productivity in each of the management, being defined as the average cost to control the weed community present (Silva *et al.,* 2015; Silva *et al.,* 2016; Agostinetto *et al.,* 2020).

The harvesting process was carried out in a useful area of 4.05 m², manually. After tracking the material, impurities were removed, moisture determination and weighing of each sample was performed. The data were compared by Tukey's test at 5% significance using the ASSISTAT statistical program (v.7.7). The regression curves were constructed by Sigmaplot software (v.12.5).

RESULTS AND DISCUSSION

The weed-infesting community covered several species, of which stand out *Conyza* spp. (horseweed), *Bidens pilosa* (black-jack), *Euphorbia heterophylla* (milkweed), *Raphanus sativus* (radish), *Lolium multiflorum* (ryegrass), *Amaranthus hybridus* (green amaranth), *Digitaria horizontalis* (crabgrass), *Urochloa plantaginea* (alexandergrass), *Ipomoea purpurea* (morning-glory), and *Eleusine indica* (indian goosegrass).

The presence of these weeds, predominantly those of the Magnoliopsida family in the considered area, is related to the record of the management of the area. Heterogeneity of weeds causes different flows during the development of the crop of interest, which makes weed management more complex and requires a management of a wide control spectrum during a considerable period of time. Furthermore, species of the Magnoliopsida family can be considered to be potentially more harmful to the soybean cultivation, given that they present characteristic cycles, root system and nutritional needs similar to the crop (Rizzardi *et al.,* 2004).

The use of chemical management for weed control was selective, not causing phytotoxicity to the crop and thus not affecting productivity, as well as allowing a satisfactory weed control. This fact is explained by the use of herbicides at 10-day intervals, ensuring weed control in its initial stages, where they have high sensitivity (Oliveira and Brighenti, 2018), as well as in early stages of the crop, allowing the herbicide to reach effectively the weed (Souza *et al,* 2018).

By considering the evaluated data, there was no interaction between the factors. There was interaction between chemical and mechanical management with the 7 periods evaluated at 5% level of significance. When the singular factors were evaluated, a statistical difference was observed between the initially clean period and initially dirty period at 1% level of significance.

Regarding the period of coexistence of the crop with weeds (coexistence), it was possible to observe that even when sowing of the crop without the presence of weeds, the propagules developed very early and as soon as the competition began, as well as they interfered in the productive potential of the crop (Figure 1). However, when considering the cost of herbicide use and the use of machines corresponding to 5% of productivity to define the period prior to interference, there are no productive losses of the crop due to the effect of coexistence with weeds until 20 DAE.

Thus, it is possible to affirm that when the crop and weeds are in early stages of development, there is no harmful competition for these individuals (Zandoná *et al.,* 2018), which can be considered the period before interference. However, monitoring the crop since the emergence, through weed control in early stages, ensures better control of the infesting population (Agostinetto *et al.,* 2009), considering that the increase of density of these plants, especially those of that develop at the beginning of the crop cycle, accentuate the competition for water, light and nutrients (Souza *et al.,* 2019).

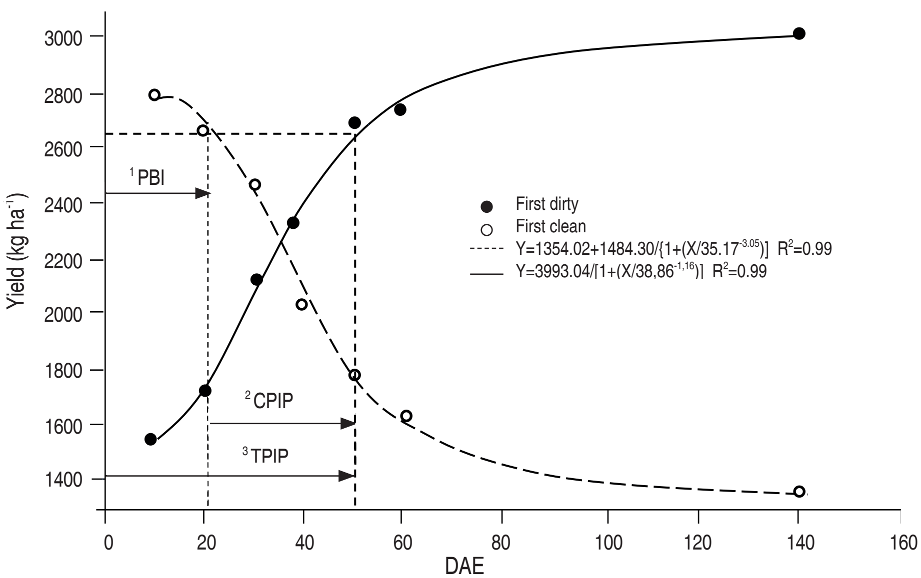

Figure 1. Period of coexistence and interference of soybean crop with weeds through chemical management. Sertão-RS/Brazil, 2019. PPI: period before interference; CPIP: critical period of interference; TPIP: total period of interference prevention; DAE: days after crop emergence.

The critical period of interference extended from 20 to 50 days. During this period, there was a reduction in productivity higher than 33% where no weed management was used, highlighting the loss of productive potential that weed interference causes in soybean crop. However, the study conducted by Nonemacher *et al.,* (2017) showed that the application of post-emergent herbicides when the crop was in the V3 stage (three fully developed trifoils) ensured that there was no significant interference of weeds in productivity, reinforcing the relevance of the initial period of crop development.

Thus, it is important to emphasize that each weed species as well as each cultivar have unique characteristics in relation to the interference and/or competition capacity. According to Danilussi *et al.* (2019), a plant m^{-2} of *Digitaria insularis* has the capacity to reduce 22.98%

of crop productivity. Moreover, according to Zandoná *et al.* (2018), productivity losses due to weed interference reached 93.7%, which emphasizes that the evaluated crop shows good competitive characteristics.

When weed control was performed mechanically (Figure 2), a pulling out weed was implemented in the sowing line and weeding between the rows of the crop. At each moment of mechanical management, a higher weed population was observed because of the higher regrowth rate in the periods of higher soil moisture. In contrast, the chemical method was more effective in the control of weed population. The use of the mechanical method when performed in periods of higher soil moisture, allows a higher rate of regrowth compared to the chemical method and propitiates the propagation of species that reproduce vegetatively (Jakelaitis *et al.,* 2003).

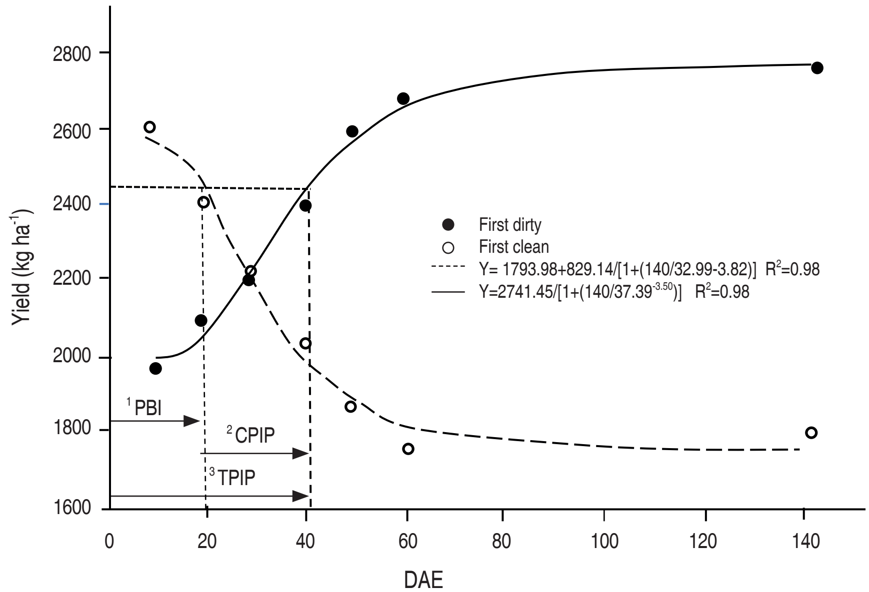

Figure 2. Period of coexistence and interference of soybean crop with weeds through mechanical management. Sertão-RS/Brazil, 2019. PBI: period before interference; CPIP: critical period of interference; TPIP: total period of interference prevention; DAE: days after crop emergence

When comparing the maximum crop yield between Figure 1 and 2, it is possible to observe that there was a lower productivity (8.4%) when the mechanical management of weeds was used. This difference may be related to the turnover of the surface soil layer, which can cause mechanical damage to roots of the crop, affecting productivity directly (Stall and Dusky, 2006). Besides, the rate of weed emergence increases, since the no-tillage system, by not turning over the soil, allows to accumulate most of the propagules of these species at 0-5 cm layer (Scherner *et al.,* 2016). Thus, the turnover of this soil layer exposes the seeds to light and variations in temperature, moisture and oxygenation and stimulates the emergence of dormant viable propagules (Vivian *et al.,* 2008).

During crop development, when reaching a size that closes the space between the sowing lines, a shadow on the soil is produced. According to Oliveira and Briguenti, (2018), this condition hinders the emergence of new weed flows reducing the amount of radiation incident in the most low-level populations (Maciel *et al.,* 2004). This condition prevents the need for weed management, both for reducing the emergency flow and for the inability of this population to interfere in crop productivity. This period takes place after the total period of interference until the physiological maturation of the crop.

The use of weed management, regardless of the method used, ensures a satisfactory crop productivity. The loss of productivity due to the competition of crops with weeds without chemical or mechanical management was 1639 kg ha^{-1} (55%) and 947 kg ha^{-1} (34.6%), respectively. These data show the importance of using efficient management, which allows the development of the crop without competition for space, water, sunlight and nutrients.

It is also noteworthy that the competition may vary according to the intrinsic morphological characteristics of each cultivar, depending on the planting season and density, the initial development, phytomass production, leaf area index, size and architecture of the aerial parts and the adaptability to the growing region (Oliveira and Briguenti, 2018; Brighenti and Oliveira, 2011). In addition to direct interference in the productive parameters of the crop, other problems observed are interference in the harvest, contamination of the harvested product with seeds and other plant parts, an increase in the moisture of the harvested product, impairing its processing and reducing its commercial value (Brighenti and Oliveira, 2011).

Weed management is essential to ensure good crop yield, mainly managing the propagation of emerging weeds until the gap between the sowing lines is closed. Therefore, chemical control is the most efficient method evaluated in weed control, reducing the impacts of interspecific interferences. It is essential to carry out good crop management and the use of rotation, in addition to using both methods interchangeably to ensure the economic success of the activity and the sustainability of the agricultural system.

CONCLUSION

The use of the chemical method ensures a higher crop productivity compared to the mechanical method. The period before the interference in both chemical and mechanical managements was similar, approaching 20 DAE. The critical period of interference prevention was from 20 DAE to 50 and 40.5 DAE in chemical and mechanical methods, respectively, in a total of 30 and 20.5 days. The reduction in productivity due to weed interference was 55 and 34.6% in chemical and mechanical methods, respectively.

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