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Weed Competition on Soybean Varieties from Different Relative Maturity Groups

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Abstract: One factor limiting the achievement of high yields in the soybean crop is weed interference. The level of weed interference can vary according to the specificities of the weed community but also due to the agronomic characteristics of the soybean varieties. The objective of this work was to evaluate the effects of weed interference on soybean varieties of different relative maturity groups (RMG). A field experiment was implemented in a randomized complete block design, in a 3 × 4 factorial scheme, with five replications. The treatments were composed of the varieties BMX Flecha® (RMG 6.6), BMX Power® (RMG 7.3), and BMX Bônus® (RMG 7.9), associated with the following four weed managements: weeding throughout the cycle; weeded up to 20 days after emergence (DAE); weeded after 20 DAE until the end of soybean cycle; not weeded throughout the entire cycle. There was no interaction between the effects of the varieties and the weed management for emergence speed index, plant height, chlorophyll, first pod height insertion, plant population, thousand-grain weight and yield. The initial weed management caused changes in the composition of the weed community. The managements weeded throughout the cycle and weeded up until 20 DAE provided higher levels of chlorophyll and grain yield. The management without weeding during the entire cycle negatively influenced yield components. Late interventions in weed control, regardless of the soybean variety, result in yield losses.

Keywords: cycle; *Glycine max*; interference; weeds

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1. Introduction

Soybean is an oleaginous crop with a wide array of commercial varieties adapted for growing in different latitudes worldwide. This crop has gained more and more space on the world stage, being a fundamental commodity for the growth of Brazil's gross domestic product and one of the main items exported by the country [1]. This high market potential, combined with the excellent adaptation of the crop in practically the entire Brazilian territory, means that its cultivation is increasingly disseminated throughout all country regions, contributing significantly to the national economy [1,2].

This positive scenario has driven farmers to search for technologies and varieties that provide higher yields to meet the growing market demand. In this context, the search for early-cycle varieties is one of the points most explored by researchers and one of the requirements of the farmers when choosing a soybean variety. This is justified by the fact that these varieties reduce production costs and less exposure to biotic and abiotic stresses, in addition to contributing to the cultivation of second-season crops. The duration of the soybean development cycle is determined by the relative maturity groups (RMG) [2], which range from 0000 to 10, where the RMG near 0000 represents varieties adapted to regions where summer days are very long, and the RMG 10 includes varieties adapted for cultivation close to the equator latitude [3], where the photoperiod is shorter (≈12 h of light). Each of the 14 RMGs can be subdivided at a decimal level (e.g., RMG 6.1; RMG 6.2; RMG 6.3; etc.), where each decimal increase in the RMG represents an extra day in the soybean variety cycle [4].

In soybean cultivation, several factors harm the development of the crop, with weeds being listed among the main agents that cause yield losses [5,6]. Mainly, these yield losses are due to the weed competition for space, water, light and nutrients, besides other effects such as allelopathy and the weeds serving as hosts for pests and diseases [7]. The intensity of weed competition may vary according to the density and composition of weed species present in the agricultural area, as well as the competitive ability of the variety used, soil and crop management practices, and the period of coexistence between the crop and weed community [5,8–10]. Thus, the interference of weeds in the crop can cause reductions of up to 80% in grain yield [9].

In general, the longer the period of coexistence between the crop and the weeds, the higher the damage to production. Another important point to be mentioned is probably the more significant influence that weed competition exerts on early-cycle varieties, where the period of coexistence and the time of coexistence can affect the yield potential of the crop [5,10,11]. Thus, the damage caused by weed competition in the soybean crop may vary according to the variety and the relative maturity group. The technical-scientific literature shows different results regarding the critical period of interference prevention in the soybean crop [12–14]. Considering the wide variation in terms of the cycle extension of soybean varieties available for cultivation, it is hypothesized that they may have a distinct competitive potential with weeds, as well as different levels of sensitivity to the interference imposed by the weed community [5,6,10].

Given the above scenario, it is important to carry out local research involving varieties most relevant to the study region. In this sense, the objective of the present work was to evaluate the effects of weed interference on soybean varieties of different relative maturity groups.

2. Materials and Methods

The experiment was carried out in the field in the municipality of Rio Verde (Goiás State), Brazil (17°47′209″ S; 51°00′376″ W; 767 m altitude) from 29 November 2019 to 7 April 2020. The experimental area in question has been conducted with 8 agricultural years in the crop succession system soybean/maize, with soybean being implemented in summer cultivation and maize in second-crop.

For the physic-chemical characterization of the soil in the experimental area, representative samples were collected from the site, which presented the following characteristics: pH in $CaCl_2$: 5.2; O.M.: 32.1 and O.C.: 18.6 g dm^{-3}; P: 5.4 mg dm^{-3}; K: 0.35; Ca: 1.42; Mg: 0.88; Al: 0.03; H + Al: 1.90; CEC: 4.55 and SB: 2.65 cmolc dm^{-3}; sand, silt and clay: 470, 80 and 450 g kg^{-1}, respectively.

According to Köppen's classification, the climate at the location where the experiment was conducted is classified as Aw type, which stands for a tropical climate with a dry season. This climate condition typically has more intense summer rainfall than winter [15]. The temperature, precipitation and relative humidity data during the experiment are presented in Figure 1.

The treatments were arranged in a randomized complete block design based on a 3 × 4 factorial scheme with five replications. The first factor (Factor A) consisted of the following three soybean varieties with indeterminate growth habits: BMX Flecha® (FLX 6266 IPRO; RMG: 6.6), BMX Power® (73I70 RSF IPRO; RMG: 7.3) and BMX Bônus® (8579 RSF IPRO; RMG: 7.9). The second factor (Factor B) was composed of the following four periods of intervention in the weed management: weeded throughout the cycle, weeded up to 20 days after emergence (DAE), weeded after 20 DAE until the end of soybean cycle and without weeding during the entire crop cycle. Each experimental unit comprised 16.0 m^2, consisting of four 8.0 m long sowing lines spaced 0.50 m between rows. The useful area was formed by the two central lines, disregarding 1.0 m from each end, totaling 6.0 m^2.

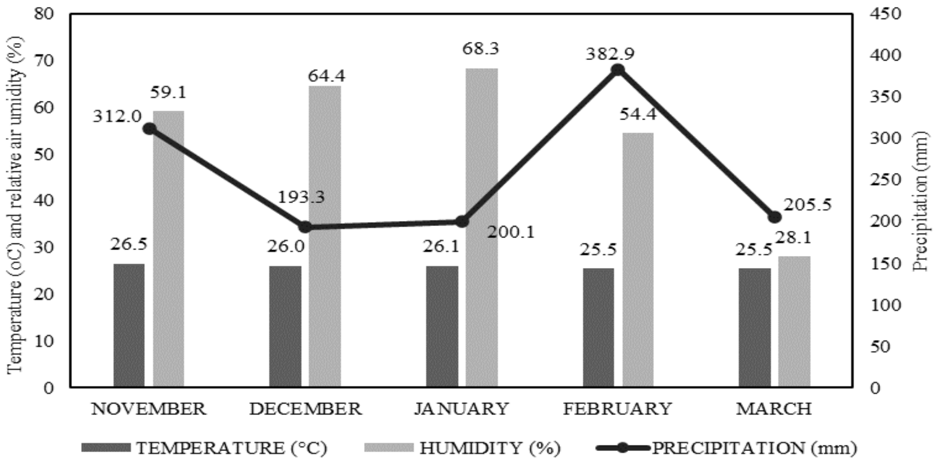

Figure 1. Monthly averages of air temperature (°C), relative air humidity (%) and precipitation (mm) throughout the experimental period. Source: National Institute of Meteorology (INMET)—Climatological Station of the University of Rio Verde.

Before installing the experiment, a burndown herbicide application was performed in the area. The first application was carried out 20 days before soybean sowing, using the herbicide glyphosate (1440 g a.i. ha^{-1}) associated with the herbicide clethodim (108 g a.i. ha^{-1}). The second application was performed 7 days before sowing, using the herbicide paraquat (400 g a.i. ha^{-1}). The applications were carried out with a land sprayer of bars, using an application volume equivalent to 150 L ha^{-1}.

The sowing of soybean varieties was carried out on 29 November 2019 at 2 cm depth. The sowing density adopted was 16, 17 and 12 seeds per linear meter for the varieties BMX Flecha®, BMX Power® and BMX Bônus®, respectively, to obtain a final population of 280, 300 and 200 thousand plants ha^{-1}. A liquid inoculant (*Bradyrhizobium elkanii*; concentration of 5 × 109 viable cells mL^{-1}) was applied in 0.15 L c.p. 100 kg^{-1} of seeds. Fertilization was carried out according to the chemical analysis of the soil, with 300 kg ha^{-1} of the formulated fertilizer 00-20-20 being applied at the base, which corresponded to 60 kg of P_2O_5 and 60 kg of K_2O per hectare. After the experiment was set up, the weeds that emerged were eliminated as proposed in each treatment by hand weeding. The management of pests and diseases was carried out following the technical recommendations of cultivation for the soybean crop [16].

To evaluate the effect of treatments on the development of soybean plants, the following evaluations were performed: emergence speed index (ESI—Equation (1)) [17] from 1 to 10 DAE (until the number of emerged plants was constant); plant height at 7, 14, 28 and 35 DAE (measurement of five plants from the soil surface to the insertion of the last fully developed trifoliate); chlorophyll *a* and *b* indices at 14, 21, 28 and 35 DAE (measurement of the last fully developed trifoliate in five plants per plot), using the ClorofiLOG® sensor.

$$ESI = (E\_1/N\_1) + (E\_2/N\_2) + \ldots\ (E\_n/N\_n) \quad (1)$$

where: ESI: emergence speed index;

E: Number of plants that emerged each day;

N: Number of days elapsed since sowing.

At the soybean maturity (7 April 2020), the following evaluations were carried out in the useful area of the plots: identification and quantification of weeds (using a hollow square measuring 0.5 × 0.5 m, evaluating two samples per plot), first pod height insertion (measurement in five plants, based on the distance from the soil surface to the insertion of the first pod), number of pods per plant (counting the number of pods in five plants), plant population (counting the number of plants harvested); thousand-grain weight (thousand-grain weighing with humidity correction to 13%); grain yield (weighing the grains of the plants harvested with humidity correction to 13%).

The statistical program SISVAR [18] was used in the data analysis. Initially, the hypothesis of normality was tested by the Shapiro-Wilk test. Data that did not meet the normality assumption were transformed into $\sqrt{(x + 0.5)}$ (plant population, chlorophyll *a* and *b* indices and the total amount of weeds). Once the assumption was met, the data were subjected to analysis of variance using the F test ($p < 0.05$) and when significance was found, the means were compared using the Tukey test ($p < 0.05$).

3. Results and Discussion

The results obtained showed significant effects on the emergence speed index for the varieties and weed management as isolated factors. The emergence speed index values obtained with the treatments weeded throughout the cycle and weeded up to 20 DAE were higher than those observed in the treatments weeded after 20 DAE and without weeding (Table 1).

Table 1. Mean values of emergence speed index and height of soybean plants as a function of different soybean varieties and weed competition management.

Varities	Weeded	Weeded until 20 DAE	Weeded after 20 DAE	Non Weeded	Averages
			Emergence Speed Index		
BMX Flecha®	49.19	50.70	47.69	48.80	49.09 a
BMX Power®	51.18	54.15	48.13	48.37	50.46 a
BMX Bônus®	39.40	39.89	34.37	35.60	37.32 b
Averages	46.59 A	48.25 A	43.40 B	44.26 B	
CV (%)			9.76		
			Plant height 7 DAE (cm)		
BMX Flecha®	9.48	10.32	10.52	10.96	10.32 a
BMX Power®	7.92	8.36	9.76	8.56	8.65 b
BMX Bônus®	8.84	8.84	8.84	9.16	8.92 b
Averages	8.74 A	9.17 A	9.70 A	9.56 A	
CV (%)			13.38		
			Plant height 14 DAE (cm)		
BMX Flecha®	14.04	15.00	18.44	15.88	15.84 a
BMX Power®	13.04	12.84	16.92	15.00	14.45 b
BMX Bônus®	13.28	13.28	16.52	15.76	14.71 b
Averages	13.45 C	13.70 C	17.29 A	15.54 B	
CV (%)			8.47		
			Plant height 28 DAE (cm)		
BMX Flecha®	29.52	29.96	29.04	31.80	30.08 a
BMX Power®	24.76	26.48	25.08	26.24	25.64 b
BMX Bônus®	26.48	25.00	25.20	25.88	25.64 b
Averages	26.92 A	27.14 A	26.44 A	27.97 A	
CV (%)			5.75		
			Plant height 35 DAE (cm)		
BMX Flecha®	47.64	47.76	41.56	46.24	45.80 a
BMX Power®	41.28	41.16	34.76	44.36	40.39 b
BMX Bônus®	41.36	41.76	36.28	44.12	40.88 b
Averages	43.42 A	43.56 A	37.53 B	44.90 A	
CV (%)			6.68		

CV = coefficient of variation. Means followed by distinct letters, lowercase in the column and uppercase in the row, differ significantly from each other by Tukey test ($p < 0.05$).

This evidences that the interference of the weed community can delay the emergence of soybean seedlings, as observed by Conti et al. [14], considering the high density of weeds found in the experimental area. Regarding soybean varieties, significant differences were observed regarding the emergence speed index, with the BMX Flecha® and BMX Power® varieties showing the highest emergence speed compared to BMX Bônus®, a fact that may be related to the longer cycle of this variety.

There was no interaction between the factors evaluated for plant height, only isolated effects for weed management at 14 and 35 DAE and soybean varieties at 7, 14, 28 and 35 DAE (Table 1). No significant differences were found in evaluating plant height at 7 DAE between the different weed management. The weed density was still low at this time, and the emerged seedlings were small, not favoring competition with soybean plants. In contrast, the more significant growth of soybean plants, verified in the evaluation performed at 14 DAE in the treatments weeded after 20 DAE and without weeding, about the treatments weeded throughout the entire cycle and weeded up to 20 DAE, is a result of competition for light. This provoked the etiolation of the plants due to the shading imposed by the weeds, as reported in previous research [9,19].

At 28 DAE, no differences were detected between weed management and soybean plant height (Table 1). In this case, the soybean plants with no interference already had a height equivalent to the plants that were etiolated due to weed competition. It is noteworthy that, in this evaluation, the soybean plants present in the weeding treatment after 20 DAE were no longer exposed to weed interference. In the last evaluation (35 DAE), weeding after 20 DAE resulted in a lower soybean plant height than the other treatments evaluated (Table 1). This is attributed to the etiolation that the density of weed community caused to soybean varieties until the beginning of the control period. After removing the weeds with weeding, the lodging of the soybean plants was observed. This caused a new direction in the growth, thus affecting the internode elongation and, consequently, the height of the plants.

To compare the plant height among the soybean varieties, it was found that BMX Flecha® presented the highest size in all evaluation periods, regardless of the weed management used (Table 1). It is known that early-cycle soybean varieties have been gaining more and more space in agricultural production systems since they generally have satisfactory agronomic characteristics, such as higher emergence speed and better use of soil nutrients [20].

In the evaluation of the chlorophyll indices, it was possible to verify the absence of significant interaction between the factors of weed management and soybean varieties (Table 2), demonstrating similar effects of weed competition on the varieties, regardless of the management performed.

Moreover, no significant difference was found in soybean varieties in terms of chlorophyll indices. This result may be related to the fact that all varieties evaluated are derived from the same genetic improvement company [21] and may have an analogous genetic matrix. The treatments weeded throughout the cycle and weeded up to 20 DAE, providing higher values of chlorophyll *a* and *b* indices at 14 DAE (Table 2).

The absence of weeds provided initial development of the crop free of competition, which resulted in greater use of environmental resources (e.g., water, light, etc.) and more significant absorption of nutrients. This may have contributed to the increased production of chlorophyll pigments in plant tissues, mainly chlorophyll *a* [22]. At 21 DAE, there was no significant difference for any of the characteristics evaluated about chlorophyll indices (data not shown).

This fact may be associated with the etiolation of the plants verified in the treatments without weeding and weeding after 20 DAE. It is known that soybean seedlings in the early stages of development tend to show etiolation when exposed to weed competition [23]. When etiolating, the light capture was enough so that the chlorophyll values did not present a discrepancy at the time evaluated in relation to the treatments weeded and weeded up to 20 DAE.

Table 2. Mean values of chlorophyll *a* and *b* as a function of different soybean varieties and weed competition management.

Varieties	Weeded	Weeded until 20 DAE	Weeded after 20 DAE	Non Weeded	Averages
			Chlorophyll *a* Index 14 DAE		
BMX Flecha®	26.72	27.67	20.25	20.36	23.75 a
BMX Power®	27.75	25.94	21.52	20.34	23.89 a
BMX Bônus®	26.90	27.60	18.23	19.14	22.89 a
Averages	27.13 A	26.97 A	20.00 B	19.95 B	
CV (%)			4.22		
			Chlorophyll *b* index 14 DAE		
BMX Flecha®	8.03	8.47	5.10	5.40	6.75 a
BMX Power®	8.84	8.54	5.33	5.46	7.04 a
BMX Bônus®	8.25	8.42	4.72	5.24	6.66 a
Averages	8.37 A	8.48 A	5.05 B	5.37 B	
CV (%)			6.48		
			Chlorophyll *a* index 28 DAE		
BMX Flecha®	28.02	26.68	25.04	26.39	26.53 a
BMX Power®	26.98	27.81	25.31	25.27	26.34 a
BMX Bônus®	26.79	27.40	26.30	26.44	26.73 a
Averages	27.26 A	27.30 A	25.55 B	26.03 B	
CV (%)			3.26		
			Chlorophyll *b* index 28 DAE		
BMX Flecha®	9.56	8.19	8.05	7.98	8.44 a
BMX Power®	8.57	9.56	7.62	7.66	8.35 a
BMX Bônus®	8.44	8.58	8.05	8.04	8.28 a
Averages	8.86 A	8.78 A	7.91 B	7.89 B	
CV (%)			6.05		
			Chlorophyll *a* index 35 DAE		
BMX Flecha®	31.30	32.71	29.39	28.62	30.50 a
BMX Power®	30.14	31.06	28.23	27.08	29.13 a
BMX Bônus®	30.36	30.46	29.47	28.76	29.76 a
Averages	30.60 A	31.41 A	29.03 AB	28.15 B	
CV (%)			4.00		
			Chlorophyll *b* index 35 DAE		
BMX Flecha®	12.48	11.91	9.56	9.02	10.74 a
BMX Power®	10.59	10.76	9.08	8.38	9.70 a
BMX Bônus®	10.41	9.70	9.82	9.17	9.77 a
Averages	11.16 A	10.79 A	9.49 AB	8.85 B	
CV (%)			9.74		

CV = coefficient of variation. Means followed by distinct letters, lowercase in the column and uppercase in the row, differ significantly from each other by Tukey test ($p < 0.05$). Data that did not meet the normality assumption were transformed into $\sqrt{x+0.5}$.

Similar to what was observed at 14 DAE, treatments weeded throughout the cycle and up to 20 DAE provided higher chlorophyll contents than treatments weeded after 20 DAE and without weeding at 28 DAE (Table 2). Weed shading on soybean plants during critical competition periods can result in greater plant elongation, causing lower production of photoassimilates for leaf formation, thus decreasing the number of chlorophyll pigments [24].

In the last evaluation, performed at 35 DAE, the treatments weeded throughout the cycle and up to 20 DAE provided higher chlorophyll contents than the treatment without weeding. These pieces of evidence show the significant impact of weed interference on chlorophyll production by soybean plants. In addition, when a cultivated plant is under the effects of weed competition, it can be negatively impacted by the release of allelopathic substances secreted by weeds [25], directly influencing its vegetative and reproductive development. Still, in this evaluation, it was observed that the weeding treatment after 20 DAE did not differ from the others in terms of chlorophyll *a* and *b* contents. This evidences that the effects of interference in relation to competition for light were reduced after weeding.

Soybean varieties did not influence the number of weeds at harvest (Table 3). This implies the absence of effects of the relative maturity group of soybean varieties on weed population reduction. The experimental units under treatment without weeding had the highest number of weeds at harvest (average of 48 plants m^{-2}) in the weed management evaluated. This result can be explained because these experimental units were maintained without carrying out any weed community control operation during the experiment.

Table 3. Mean values of number of weeds as a function of different soybean varieties and weed competition management.

Varieties	Weeded	Weeded until 20 DAE	Weeded after 20 DAE	Non Weeded	Averages
	Weed Density at Harvest (Plants m^{-2})				
BMX Flecha®	0.00	28.80	0.00	48.80	19.40 a
BMX Power®	0.00	20.80	0.00	48.80	17.40 a
BMX Bônus®	0.00	32.00	0.00	46.40	19.60 a
Averages	0.00 A	27.20 B	0.00 A	48.00 C	
CV (%)			34.93		

CV = coefficient of variation. Means followed by distinct letters, lowercase in the column and uppercase in the row, differ significantly from each other by Tukey test ($p < 0.05$). Data that did not meet the normality assumption were transformed into $\sqrt{x + 0.5}$.

In the weeded management up to 20 DAE, the number of weeds at harvest was lower than in the treatment without weeding (Table 3). As predicted in the experimental design, the other treatments (weeded and weeded after 20 DAE) showed no weeds at harvest time. Thus, it can be seen that weed control in the initial period of soybean development resulted in a reduction of approximately 43% in the number of weeds recorded at harvest. This fact demonstrates the importance of using pre-emergence herbicides to reduce the number of individuals competing with the crop [26,27]. Furthermore, these weeds were suppressed by soybean, with very small size, showing a low competitive capacity with the crop.

The weed community was formed by the joyweed (*Alternanthera tenella*), hairy spurge (*Euphorbia hirta*) and goosegrass (*Eleusine indica*) species (Table 4). In smaller numbers, the presence of purslane (*Portulaca oleracea*), morning-glory (*Ipomoea* spp.), Benghal dayflower (*Commelina benghalensis*) and beggarticks (*Bidens pilosa*). Therefore, the survey made it possible to verify the predominance in the experimental area of dicotyledonous species. For the weeded treatment up to 20 DAE, the *A. tenella* species was the one that showed the most significant predominance at the time of harvest (≈52% of the total weeds present), followed by *E. indica* (34%). The highest densities observed for the treatment without weeding were for *E. hirta* (42%) and *A. tenella* (33%). These data demonstrate that the initial weeding enhanced the representation of *A. tenella* and *E. indica*, reducing the participation of *E. hirta* in the composition of the weed community.

Table 4. Floristic composition of weeds evaluated at harvest as a function of different soybean varieties and weed competition management.

Weed Management	**Weed Species**			
	Alternanthera tenella	***Euphorbia hirta***	***Eleusine indica***	**Others**
	% in Relation to the Total Weeds			
Weeded	0.00	0.00	0.00	0.00
Weeded until 20 DAE	52.37	7.14	34.08	6.41
Weeded after 20 DAE	0.00	0.00	0.00	0.00
Non weeded	32.59	42.40	8.86	16.15

It is important to highlight that among the species found, *A. tenella* is among the most present weeds in Brazilian crop fields, mainly in the *Cerrado* region [28], and its principal characteristic is rapid dissemination. The species *E. indica* is characterized as an autogamous plant with an annual cycle with a high capacity to produce seeds, which can remain in the soil for long periods in dormancy [29]. Hence the importance of managing the species in question to avoid possible damage to the soybean crop.

In the analysis of the agronomic characteristics of soybean, it can be seen for the variables first pod insertion height, the number of pods per plant, plant population at harvest, thousand-grain weight and grain yield, no significant interaction between the factors of weed management and soybean varieties (Table 5). Among the managements employed, the treatments weeded throughout the cycle and weeded up to 20 DAE, providing a higher height of the first pod insertion, regardless of the soybean variety, compared to the treatment without weeding. The weeded treatment after 20 DAE did not differ from the other managements. According to [30], taller soybean plants tend to have a higher height of first pod insertion, which differs from the results found. Soybean varieties did not vary during the first pod height insertion. This variable is significant because when very close to the ground, there may be an increase in pods not harvested by the cutting platform during mechanized soybean harvesting [31] and reduced operational efficiency. Therefore, early weed control is essential so that pods, whose insertion in the plant is closer to the ground, are harvested by the harvester's cutting platform.

Weed management influenced the soybean plant population at harvest (Table 5). Weed competition throughout the soybean cycle (treatment without weeding) caused the highest level of reduction in the plant population (56%) with reference to the weeded treatment throughout the cycle, followed by the weeded treatment after 20 DAE (33% of reduction). These results are justified because crop competition with weeds is more significant in the early stages of development, affecting obtaining resources such as water, light, nutrients and space [7]. The smaller population of plants in the harvest of BMX Bônus® was an expected fact because, for this variety, a lower density of seeds was used due to its leaf architecture and the larger relative maturity group [21].

The yield component number of pods per plant was influenced both by the varieties and the weed management, but without interaction between them (Table 5). Soybean plants of the BMX Bônus® variety showed higher value for the trait in question when compared to BMX Power® and BMX Flecha®, the latter being of lower value. Thus, the results show that varieties with a later cycle tend to produce a more significant number of pods per plant. Usually, these varieties are implanted with a smaller population of plants than the earlier cycle's ones, which justifies their higher number of pods per plant.

Regarding weed management, the highest number of pods per plant was verified using the weeded treatment after 20 DAE (Table 5). This result may have been attributed to reducing the population of soybean plants observed in this treatment. This resulted in less intraspecific competition, providing greater targeting of photoassimilates for vegetative growth in the form of branches. Therefore, this fact contributed to the increase in pods per plant. Similar results were reported by [19,32], who also verified the relationship between a lower population and a higher number of pods per plant. The treatments weeded throughout the cycle and up to 20 DAE resulted in a lower number of pods per plant compared to the weeded treatment after 20 DAE, but with higher numbers than the non-weeded treatment. In evaluating this yield component, it is important to point out that the lack of weed control can lead to flower and pod abortion in soybean plants [33].

Table 5. Mean values of first pod height insertion, plant population, number of pods per plant, thousand-grain weight and grain yield as a function of different soybean varieties and weed competition management.

Varieties	Weeded	Weeded until 20 DAE	Weeded after 20 DAE	Non Weeded	Averages
			First Pod Height Insertion (cm)		
BMX Flecha®	15.36	14.88	10.64	9.56	12.61 a
BMX Power®	13.08	14.96	11.80	6.40	11.56 a
BMX Bônus®	16.96	15.84	15.08	9.04	14.23 a
Averages	15.13 A	15.22 A	12.50 AB	8.33 B	
CV (%)			34.20		
			Plant population at harvest (thousand plants ha^{-1})		
BMX Flecha®	254.00	247.00	210.00	128.20	209.80 a
BMX Power®	280.00	283.00	170.00	126.40	214.85 a
BMX Bônus®	189.00	185.00	107.00	63.20	136.05 b
Averages	241.00 A	238.33 A	162.33 B	105.93 C	
CV (%)			21.11		
			Number of pods per plant		
BMX Flecha®	40.48	39.04	47.88	19.20	36.65 c
BMX Power®	53.56	51.56	69.48	23.16	49.44 b
BMX Bônus®	59.00	63.84	87.16	41.80	62.95 a
Averages	51.01 B	51.48 B	68.17 A	28.05 C	
CV (%)			31.93		
			Thousand-grain weight (g)		
BMX Flecha®	211.77	207.08	197.38	171.92	197.04 a
BMX Power®	193.20	198.10	181.12	158.77	182.79 b
BMX Bônus®	202.34	206.99	217.14	179.24	202.17 a
Averages	202.44 A	204.05 A	198.54 A	169.98 B	
CV (%)			5.75		
			Grain yield (kg ha^{-1})		
BMX Flecha®	5.357	5.055	4.600	1.494	4.126 a
BMX Power®	5.274	5.000	3.995	1.666	3.984 a
BMX Bônus®	4.898	4.971	4.310	2.011	4.047 a
Averages	5.176 A	5.009 A	4.302 B	1.723 C	
CV (%)			16.31		

CV = coefficient of variation. Means followed by distinct letters, lowercase in the column and uppercase in the row, differ significantly from each other by Tukey test ($p < 0.05$).

As for the thousand-grain yield component, it is noted that the BMX Bônus® and BMX Flecha® varieties had higher values than BMX Power® (Table 5), which can be attributed to the intrinsic characteristics of the evaluated varieties. Regarding weed management, the highest weight of a thousand grains was observed in the treatments weeded up to 20 DAE and weeded after 20 DAE. Even though it is considered a yield component little influenced by the interference of weeds, soybeans produced in experimental units with the presence of these species throughout the cycle (non-weeded treatment) showed a significant reduction in weight that demonstrates a level of competition high intensity by weeds. Invasive species are usually more efficient in absorbing water and nutrients than soybean plants [34]. Thus, when subjected to a highly competitive density of weeds, the crop can be subjected to nutritional deficits, negatively impacting grain filling [35].

Regardless of the weed management used, no differences were observed in grain yield between soybean varieties with all materials showing an average yield close to 4000 kg ha^{-1} (Table 5). The absence of effects for the variety factor may be because even if the material has a superior genetic yield potential since agronomic performance is influenced by the environment in which the variety is inserted [36], the edaphoclimatic component may have a decisive influence on the response of the variation in yield potential. Therefore, when the environment does not present favorable characteristics for gene expression, grain yield ends up being limited.

The treatments weeded throughout the cycle and weeded up to 20 DAE promoting higher grain yields (Table 5). This fact shows that weed control until 20 DAE was sufficient to guarantee the yield of the evaluated soybean varieties, regardless of the relative maturity group. Therefore, it can be inferred that the total period of interference prevention found at work was equal to or less than 20 DAE. This highlights the importance of control interventions that provide the initial growth of soybeans free from weeds, such as pre-emergence herbicides or even pre-planting herbicide applications closer to sowing [37].

Late intervention in weed control is harmful to the soybean crop. This can be evidenced by the beginning of manual weeding at 20 DAE promoted an average reduction in the soybean yield varieties of about 17% compared to the weeded treatment throughout the cycle (Table 5). The treatment without weeding promoted an average decrease of 67%, corroborating the adverse effects of weed competition in the soybean crop reported in the literature [19,38].

Differences in yield among treatments related to weed management confirm the need to control the weed community in soybean. It is known that yield reduction caused by weed competition in the crop is dependent on several factors, such as the density of the weed community, distribution and the species present in the area. In this work, competition between the *A. tenella*, *E. hirta* and *E. indica* species with the soybean crop was evident, regardless of the variety. This competition caused reductions in grain yield, mainly in the weeded treatment after 20 DAE, besides the treatment without weed management practices throughout the entire cycle. In this way, weed competition needs to be prevented from the early stages of crop development, regardless of the relative maturity group of the soybean variety.

4. Conclusions

Based on the results obtained according to the edaphoclimatic conditions of the local where the experiment was installed, it can be concluded that there was no interaction between the effects of the relative maturity groups of the soybean varieties and weed management.

The initial management of weeds in soybean crops causes changes in the composition of the weed community. The managements weeded throughout the cycle, and up to 20 DAE provides higher levels of chlorophyll and grain yield in all soybean varieties.

Management without weeding throughout the cycle negatively influences soybean yield components such as plant population, number of pods per plant, thousand-grain weight and grain yield.

Late interventions in weed control, regardless of the maturation group of the soybean variety, will result in yield losses.

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