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Article

Weed incidence and sowing time affect soybean development

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Abstract

Despite the economic importance of the effects of weeds on the plastochron and emission of nodes of soybean plants, it has not been studied in detail. The aim of this study was to provide information about the effects of weeds on the development of soybean plants by determining the plastochron and number of nodes of soybean plants of different cultivars sown at different times in soils with presence and absence of weeds. A field study was conducted during the 2013/2014 crop season including a phytosociological survey to identify the occurring weeds, and the determination of the plastochron and final number of nodes of soybean plants. Four botanical families of weeds were found infesting the soybean crops. The plastochron and final number of nodes of soybean were influenced by the cultivar, sowing time, and presence of weeds. The plastochron was higher when the plants were grown in the presence weeds due to the higher relative frequency, relative density, relative abundance, and importance value index of the Euphorbia heterophyla, Ipomoea purpurea, and Urochloa plantaginea species, which resulted in a slower development of the soybean plants, and lower number of nodes per plant.

Keywords: *Glycine max*, interspecific competition, phytosociological survey, plastochron, thermal sum

Introduction

Soybean (*Glycine max* (L.) Merril) is one of the world's most important oilseed plant due to its high protein and oil contents (Yang et al., 2016) and its general use for human and animal consumption. In Brazil, 114.07 million Mg of soybeans were produced in the 2016/2017 crop season, and the estimate production for 2017/2018 is 108.6 million Mg (Conab, 2017).

The yield of soybean plants is affected by several factors during its development; one of the main factor is its competition with weeds (Rezvani et al., 2013; Knezevic, 2014; Datta et al., 2017; Gharde et al., 2018). Prolonged interference of weeds in soybean production areas may result in significant yield and quality losses, which depend on the infestation degree, seed bank quality, climatic conditions, and cultural practices used, such as the sowing time (Silva et al., 2008; Matsuo et al., 2015; Zanon et al., 2015).

Weed management in crops depends on the weed species found in the crop, and their density and phenological stages (Korres, 2018). Therefore, phytosociological studies are needed to assess the weed populations in the area of interest. However, soybean crops are sensitive to weed interference, thus, an appropriate manage of weeds is necessary to the development of this crop (Ulloa et al., 2010; Datta et al., 2017).

The growth rate of soybean crops can

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be estimated by the speed of appearance of nodes in the main stem of the plants during their vegetative phase. The time interval between the appearance of nodes on the stem of dicot species is called plastochron, with units of °C day node^{-1} (Streck et al., 2005). According to Streck et al. (2008), the plastochron of soybean plants is dependent on the cultivar. Moreover, the final number of nodes is dependent on the cultivars, sowing time, and photoperiod, and is related to the duration of the crop cycle of the cultivar (Setiyono et al., 2007; Zanon et al., 2016).

Characterizing the development of soybean cultivars in different sowing times and under competition with weeds is important to improve the efficiency of the soybean production. However, the plastochron of some cultivars available in the market, and the weed interference in this variable is unknown due to the introduction of new cultivars that are adapted to the different edaphoclimatic regions.

Therefore, the aim of this study was to provide information about the effects of weeds on the development of soybean plants by determining the plastochron and number of nodes of soybean cultivars sown at different times in the presence or absence of weeds.

Material and Methods

A field study was conducted during the 2013/2014 crop season in Frederico Westphalen RS, Brazil (27°23'48''S, 53°25'45''W, and altitude of 490 m). The climate of the region is Cfa, subtropical humid, according to the Köppen classification, with an average annual temperature of 19.1 °C, varying from 0 °C to 38 °C (Alvares et al., 2013).

The soil of the experimental area was classified as typical dystrophic Red Latosol (Oxisol) and its physicochemical analysis showed pH in water of 6.0, 3.0 mg dm^{-3} of P (Mehlich), 160 mg dm^{-3} of K, 6.2 cmol$_c$ dm^{-3} of Ca, 3.3 cmol$_c$ dm^{-3} of Mg, 0.0 cmol$_c$ dm^{-3} of Al, CEC of 9.9 cmol$_c$ dm^{-3}; base saturation of 76%, and 3.1% of organic matter. The soil was fertilized according to the soil analysis with 45 kg ha^{-1} of potassium chloride and 85 kg ha^{-1} of triple superphosphate at sowing.

The experiment was conducted in a randomized complete block design, in a 3×5×2 factorial arrangement with three replicates, consisting of three sowing times (October 15, November 15, and December 15), five soybean cultivars (BMX-TornadoRR, BMX-AlvoRR, BMX-VelozRR, TEC-7849IPRO, and TEC-5718IPRO), and two weed conditions (presence and absence of weeds).

All cultivars used are resistant to glyphosate herbicide (RR). The seeds used were from the Central Gaúcha cooperative, and Brasmax Genética company. These soybean cultivars were selected because they are recommended to the study region, have high yield potential, and present different maturation times and growth habits (Table 1).

Table 1. Characteristics of the soybean cultivars used in the experiment.

Cultivar	Maturation Group	Recomendation	Growth Habit
BMX Tornado RR	6.2	RS, SC, PR, SP, MS	Indeterminate
BMX Alvo RR	5.9	RS, SC, PR, SP	Indeterminate
BMX Veloz RR	5.0	RS, SC, PR	Indeterminate
TEC 7849 IPRO	7.8	RS, SC, PR, SP, MS	Indeterminate
TEC 5718 IPRO	5.7	RS, SC, PR	Determinate

The experimental units consisted of five 3-meter rows spaced 45 cm apart, with central evaluation area of 4.5 m^2. The weeds in the area were controlled with glyphosate herbicide at 15 days before sowing. The seeds were sowed manually using depths of 3 cm and density of 20 seed m^{-1}. The seedling emergence was defined as the time that 50% of the seedlings were visible above the ground. The seedlings were thinned seven days after emergence, leaving 11 plants per meter to obtain a final density that represented 250,000 plants ha^{-1}.

The weeds were quantified and identified at 42 days after the emergence of the soybean plants using the square inventory method, which consists in subjectively finding patterns within the community to be sampled, with sampling not favoring a certain pattern (Braun-Blanquet, 1979). A 0.5×0.5 m frame (0.25 m²) was randomly launched twice, making a total sampling area of

0.50 m² per plot.

The class, family, and genus of the weeds in the frame were identified and described. This identification and number of plants was used to calculate the phytosociological variables-relative density (RD% =100 × density of the species ÷ total density of all species), relative frequency (RF% = 100 × frequency of the species ÷ total frequency of all species), relative abundance (RA% = 100 × abundance of the species ÷ total abundance of all species), and importance value index (IVI = RF% + RD% + RA%). Thus, the RF%, RD%, and RA% showed the correlations of a species with the other species found in the area (Mueller-Dombois & Ellenberg, 1974).

Four seedlings of the central row of each plot were marked with colored wires at five days after emergence, and their number of visible nodes (when the related leaf had unrolled the edges of at least one leaf limb) in the main stem was counted every two days (Johnson, 1997).

Air temperature and precipitation during the crop cycle were collected from a meteorological station of the Brazilian National Institute of Meteorology that is connected to the an agroclimatology laboratory at approximately 300 m from the experiment area.

The temperatures at sowing times varied, but they were above the base temperature of the crop (10 °C), and within its optimum temperature range (20 °C to 33 °C) (Setiyono et al., 2007). The precipitation in the first two sowing times was higher than that in the third due to the low precipitation occurred in February (Figure 1).

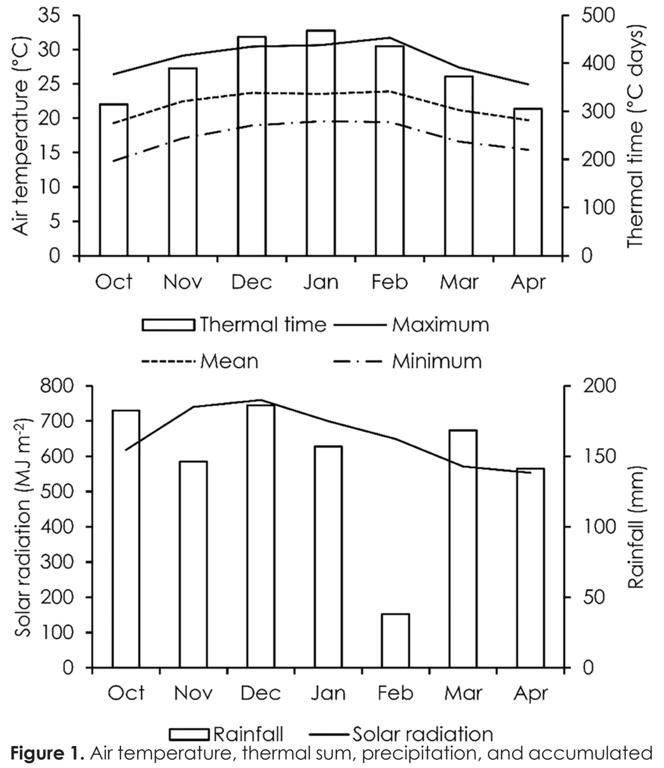

Figure 1. Air temperature, thermal sum, precipitation, and accumulated global solar radiation during the soybean crop cycle. Frederico Westphalen RS, Brazil, 2014.

The arithmetic means of the maximum and minimum air temperatures were used to obtain the average daily temperature (ADT). The daily thermal sum (DTS, °C day) was calculated from the emergency, considering the base temperature (BT) of the crop of 10 °C (Piper et al., 1996), using the equation proposed by Gilmore & Rogers (1958) ($DTS = (ADT - BT)\ 1\ day$). The accumulated thermal sum (ATS, °C day) was the sum of the DTS, ($ATS = \Sigma DTS$).

The marked plants were subjected to linear regression analysis considering the ATS, and number of nodes in their main stems. Thus, the plastochron was the inverse of the angular coefficient of the linear regression equation (XUE et al., 2004). At the end of the experiment, the final number of nodes in the main stem of the marked plants was evaluated.

The plastochron and final number of nodes were subjected to analysis of variance using the Genes program (Cruz, 2013) and the parameters that presented a significant difference at 5% probability of error were compared by the Tukey's test.

Results and Discussions

The phytosociological survey showed 385 weed plants infesting the soybean crops; they were from two Liliopsida, and three Magnoliopsida orders, and four botanical families (Table 2). Oliveira & Freitas (2008) found similar results, with Poaceae and Asteraceae as the two main families of weeds existing in Brazil, which are found in areas with soybean, sunflower, and sugarcane crops.

The weeds found varied according to the soybean cultivars, with higher RF% of *Euphorbia heterophyla,* and *Urochloa plantaginea* species with the BMX-AlvoRR cultivar, and *Ipomoea purpurea,* and *Digitaria horizontalis* with the TEC-7849IPRO cultivar in the first sowing time. The highest RF% of weeds in the second and third sowing times was found with the BMX-TornadoRR cultivar (Table 3).

Table 2. Phytosociological survey of weeds in soybean crop areas. Frederico Westphalen RS, Brazil, 2014.

Common name	Scientific name	Family	Class
Papuã	*Urochloa plantaginea* (L.) Hitch.	Poaceae	Liliopsida
Milhã	*Digitaria horizontalis* Willd. (Digho)	Poaceae	Liliopsida
Leiteiro	*Euphorbia heterophylla* (L.)	Euphorbiaceae	Magnoliopsida
Corriola	*Ipomoea purpurea*(L.) Roth	Convolvulaceae	Magnoliopsida
Picão preto	*Bidens pilosa* (L.) Hook	Asteraceae	Magnoliopsida

Table 3. Relative frequency (RF%) and relative density (RD%) of weeds as a function of sowing time of different soybean cultivars. Frederico Westphalen RS, Brazil, 2014.

Cultivar		Weed				
		E. heterophyla	*I. purpurea*	*U. plantaginea*	*D. horizontalis*	*B. pilosa*
		Sowing time 10/15				
BMX Tornado RR	RF	21.4	21.4	21.4	21.4	14.3
	RD	29.0	29.0	19.4	12.9	9.7
TEC 7849 IPRO	RF	16.7	25.0	16.7	25.0	16.7
	RD	20.7	27.6	17.2	24.1	10.3
TEC 5718 IPRO	RF	20.0	20.0	20.0	20.0	20.0
	RD	25.0	31.3	15.6	18.8	9.4
BMX Alvo RR	RF	25.0	16.7	25.0	16.7	16.7
	RD	28.6	25.0	17.9	17.9	10.7
BMX Veloz RR	RF	21.4	14.3	21.4	21.4	21.4
	RD	25.0	21.9	21.9	18.8	12.5
		Sowing time 11/15				
BMX Tornado RR	RF	25.0	25.0	25.0	25.0	0.0
	RD	25.9	25.9	29.6	18.5	0.0
TEC 7849 IPRO	RF	23.1	23.1	23.1	23.1	7.7
	RD	25.9	22.2	25.9	22.2	3.7
TEC 5718 IPRO	RF	23.1	23.1	23.1	23.1	7.7
	RD	29.0	16.1	29.0	22.6	3.2
BMX Alvo RR	RF	21.4	21.4	21.4	21.4	14.3
	RD	29.0	19.4	29.0	12.9	9.7
BMX Veloz RR	RF	23.1	23.1	23.1	23.1	7.7
	RD	20.0	23.3	33.3	16.7	6.7
		Sowing time 12/15				
BMX Tornado RR	RF	10.0	30.0	30.0	20.0	10.0
	RD	5.9	29.4	47.1	11.8	5.9
TEC 7849 IPRO	RF	23.1	23.1	23.1	23.1	7.7
	RD	15.0	20.0	40.0	20.0	5.0
TEC 5718 IPRO	RF	18.2	27.3	27.3	18.2	9.1
	RD	17.6	23.5	41.2	11.8	5.9
BMX Alvo RR	RF	25.0	25.0	25.0	25.0	0.0
	RD	23.1	23.1	38.5	15.4	0.0
BMX Veloz RR	RF	18.2	27.3	27.3	18.2	9.1
	RD	16.7	22.2	44.4	11.1	5.6

Silva et al. (2008) evaluated areas with low, medium, and high weed infestations in soybean crops and found similar species: *I. purpurea*, *D. horizontalis*, *U. plantaginea*, *Euphorbia heterophyla,* and *Cyperus rotundus*.

I. purpurea presented the highest RD% (31.3%), and *Bidens pilosa* presented the lowest RD% (9.4%) with the cultivar TEC-5718IPRO in the first sowing time (Table 3). However, in the second and third sowing time, *U. plantaginea* showed RD% of 33.3% (BMX-VelozRR), and 47.1% (BMX-TornadoRR).

According to Constantin et al. (2007), RD% is the phytosociological parameter that better show the importance of a species in a given area; they found a weed community infesting soybean crops consisting mainly of *U. plantaginea*, *E. heterophyla,* and *B. Pilosa*, which have competitive potential with soybean plants.

I. purpurea presented the highest RA% in the first sowing time, with similar distribution in the areas with the TEC-5718IPRO (29.9%), and BMX-AlvoRR (29.6%) cultivars (Table 4).

Table 4. Relative abundance (RA%) and importance value index (IVI) of weeds as a function of sowing time of different soybean cultivars. Frederico Westphalen RS, Brazil, 2014.

Cultivar		Weed				
		E. heterophyla	*I. purpurea*	*U. plantaginea*	*D. horizontalis*	*B. Pilosa*
		Sowing time 10/15				
BMX Tornado RR	RA	27.7	27.7	18.5	12.3	13.8
	IVI	78.2	78.2	59.2	46.6	37.8
TEC 7849 IPRO	RA	25.0	22.2	20.8	19.4	12.5
	IVI	62.4	74.8	54.7	68.6	39.5
TEC 5718 IPRO	RA	23.9	29.9	14.9	17.9	13.4
	IVI	68.9	81.1	50.6	56.7	42.8
BMX Alvo RR	RA	22.5	29.6	21.1	14.1	12.7
	IVI	76.1	71.2	64.0	48.6	40.1
BMX Veloz RR	RA	21.3	28.0	18.7	16.0	16.0
	IVI	67.8	64.2	62.0	56.2	49.9
		Sowing time 11/15				
BMX Tornado RR	RA	25.9	25.9	29.6	18.5	0.0
	IVI	76.9	76.9	84.3	62.0	0.0
TEC 7849 IPRO	RA	32.3	18.5	21.5	18.5	9.2
	IVI	81.3	63.8	70.5	63.8	20.6
TEC 5718 IPRO	RA	27.3	15.2	27.3	21.2	9.1
	IVI	76.3	60.5	76.3	66.5	20.5
BMX Alvo RR	RA	25.4	25.4	25.4	11.3	12.7
	IVI	75.8	63.1	75.8	55.3	30.2
BMX Veloz RR	RA	17.6	20.6	29.4	14.7	17.6
	IVI	69.8	63.0	81.5	50.7	35.0
		Sowing time 12/15				
BMX Tornado RR	RA	13.6	22.7	36.4	13.6	13.6
	IVI	29.5	82.1	113.4	45.4	29.5
TEC 7849 IPRO	RA	19.1	17.0	34.0	17.0	12.8
	IVI	57.2	60.1	97.1	60.1	25.5
TEC 5718 IPRO	RA	20.9	18.6	32.6	14.0	14.0
	IVI	56.8	69.4	101.0	43.9	28.9
BMX Alvo RR	RA	23.1	23.1	38.5	15.4	0.0
	IVI	71.2	71.2	101.9	55.8	0.0
BMX Veloz RR	RA	21.4	19.0	38.1	14.3	7.1
	IVI	56.3	68.5	109.8	43.6	21.8

E. heterophylla presented the highest RA% (32.3%) in the second sowing time for the TEC-7849IPRO cultivar. *U. plantaginea* was the most abundant species in all soybean cultivars in the third sowing time, with 10% to 15%. This result may be due to the high prolificity of the *U. plantaginea*; a single plant of this species can replenish the soil seed bank of an area, increasing the relative abundance of this weed (Agostinetto et al., 2009).

B. pilosa presented the lowest IVI for the cultivar BMX-TornadoRR in the first (37.8%) and second sowing times (0%) (Table 4). *U. plantaginea* presented the highest IVI for the BMX-TornadoRR (113.4%), and BMX-VelozRR (109.8%) cultivars in the third sowing time. Santi et al. (2014) found similar results when evaluating the phytosociological variability of weeds in soybean crops, with IVI of 51.92% for *U. plantaginea*.

Information on phytosociological parameters of weeds for different cultivars and sowing times is essential for planning a weed management program. Evaluating the presence of weeds and their populations during the crop cycle is important, especially at the critical period of control to prevent interference with the crop (Kamoshita et al., 2014; Pinke et al., 2016; Rauber et al., 2018).

The analysis of variance showed a significant difference in plastochron due to the interaction between cultivar, sowing time, and weed conditions. The highest plastochron (73.86 °C day node^{-1}) (Table 5) was found in the first sowing time of the cultivar BMX-AlvoRR, in the presence of weeds. This can be related to the high RF% (Table 3), and IVI (Table 4) of the *E. heterophyla,* and *U. plantaginea* species, which competed with this soybean cultivar.

Table 5. Effect of the interaction between cultivars, sowing times, and presence of weeds on the plastochron of soybean plants. Frederico Westphalen RS, Brazil, 2014.

Cultivar	Weed	Sowing times		
		10/15	11/15	12/15
BMX Tornado RR	Presence	67.47 bc C α	86.02 a A α	70.57 a B α
	Absence	65.01 b B β	75.30 c A β	66.29 b B β
TEC 7849 IPRO	Presence	65.76 c B β	85.08 ab A α	61.71 d C α
	Absence	70.43 a A α	70.14 d A β	61.56 c B α
TEC 5718 IPRO	Presence	60.97 d C β	86.41 a A α	64.70 c B α
	Absence	65.85 b B α	83.47 a A β	61.22 c C β
BMX Alvo RR	Presence	73.86 a B α	83.32 b A α	68.50 b C α
	Absence	70.95 a B β	78.50 b A β	66.77 ab C α
BMX Veloz RR	Presence	69.17 b B β	75.44 c A α	65.60 c C β
	Absence	71.05 a A α	70.42 d A β	68.12 a B α

Means followed by the same lowercase letter in the columns (comparing cultivars at each sowing time in the presence or absence of weeds), uppercase letters in the rows (comparing sowing times of each cultivar in the presence or absence of weeds) and Greek letters in the columns (comparing presence or absence of weeds for each cultivar and sowing time) are not different by the Tukey's test at 5% probability of error.

A high plastochron indicates that a greater accumulated thermal sum is required for the plant to emit the next node on the main stem. This explains the higher plastochron found in treatments with presence of weeds.

The highest plastochron in the second sowing time were found for the cultivars BMX-TornadoRR (86.02 °C day node^{-1}), TEC-7849IPRO (85.08 °C day node^{-1}), and TEC-5718IPRO (86.41 °C day node^{-1}), in the presence of weeds (Table 5). This result may be related to the greater competition between crop and weed plants, and favorable meteorological conditions, which promoted the development of weeds, resulting in greater competition for space and solar radiation, hindering the development of soybean plants and increasing their plastochron.

The highest plastochron in the third sowing time were found for the BMX-TornadoRR (70.57 °C day node^{-1}) cultivar, in the presence of weeds. This was probably due to the high RF%, RD%, and IVI of the *I. purpurea* and *U. plantaginea* species. Moreover, the highest plastochron of soybean in third sowing time was due to a greater competition for natural resources, especially solar radiation. Procópio et al. (2004) evaluated physiological aspects of soybean crops in competition with weeds and found the weeds presenting greater efficiency in the use of light per unit area of leaf, and in the use of water, despite their lower biomass production and lower leaf emission than the crop.

The TEC-7849IPRO cultivar presented the lowest plastochron (61.71 °C day node^{-1}) in the third sowing time, probably due to the genetic characteristics of this cultivar (late-maturing, and larger plant size), which are more suitable for sowing in winter crops. Generally, plants of larger sizes have greater competitive ability.

The competitive ability of the cultivars differed due to canopy characteristics of the crops. According to Drews et al. (2009), plants with high plant size and leaf area index, and rapid canopy formation frequently result in crops with high competitive ability. However, the different competitive ability of the cultivars may not be related to morphological characteristics that affect light interception but are specific to the cultivar (Paynter & Hills, 2009).

The plastochron of the cultivars grown in the absence of weeds presented no significant differences, since the sowing time presented a greater effect than the weeds. This was probably because of the development conditions of the soybean plants; when they are grown in a weed-free environment, the cultivar factor, mainly the development cycle, has lower effect on the plastochron than other factors, such as sowing time, and meteorological conditions.

The plastochron of all cultivars in the second sowing time was higher in the presence of weeds (Table 5), probably due to the higher water availability and average temperatures during the period of node emission (Figure 1) that caused a greater competition due to the weed biomass increment.

The higher plastochron generated by the competition with weeds represent a lower development of the crop plants. According to Silva et al. (2008), weeds affect, irreversibly, the development and growth of soybean crops by generating competition for resources, and shading on the canopy of the crop. Heldwein et al. (2010) evaluated the plastochron of common bean plants grown under protected environment conditions and found a higher plastochron with the lower solar radiation availability because the plants produced less photoassimilates than they needed for their maintenance.

According to Silva et al. (2008), decreases in growth and development of crops grown with weeds vary according to the crop plant size, duration of the competition period, edaphoclimatic conditions, and biomass produced by the weed community.

The number of nodes depended on the presence or absence of weeds. The TEC-7849IPRO cultivar presented the highest number of nodes (23.67 nodes plant^{-1}), and the TEC-5718IPRO cultivar presented the lowest (12 nodes plant^{-1}) when grown in the presence of weeds, considering the three sowing times (Table 6). The final number of nodes in the first sowing time was higher (24 nodes plant^{-1}) for the TEC-7849IPRO cultivar grown in the absence of weeds.

Table 6. Effect of the interaction between cultivars, sowing times, and presence of weeds on the final number of nodes (plant^{-1} nodes) of soybean plants. Frederico Westphalen RS, Brazil, 2014.

Cultivar	Weed	Sowing times					
		10/15		11/15			
BMX Tornado RR	Presence	19.00	b A α	16.50	b B β	14.50	b C β
	Absence	19.00	b A α	16.83	b B α	16.00	b C α
TEC 7849 IPRO	Presence	23.67	a A β	18.92	a B β	18.42	a B β
	Absence	24.00	a A α	19.83	a B α	18.58	a C α
TEC 5718 IPRO	Presence	12.00	d A α	12.00	d A α	12.00	d A α
	Absence	12.00	e A α	12.00	c A α	12.00	e A α
BMX Alvo RR	Presence	17.67	c A α	15.08	c B β	13.00	c C β
	Absence	16.67	d A β	16.92	b A α	13.83	c B α
BMX Veloz RR	Presence	17.50	c A β	15.00	c B β	12.75	c C β
	Absence	18.00	c A α	17.00	b B α	13.33	d C α

Means followed by the same lowercase letter in the columns (comparing cultivars at each sowing time in the presence or absence of weeds), uppercase letters in the rows (comparing sowing times of each cultivar in the presence or absence of weeds) and Greek letters in the columns (comparing presence or absence of weeds for each cultivar and sowing time) are not different by the Tukey's test at 5% probability of error.

The third sowing time caused a reduction in the final number of nodes in four cultivars; however, the final number of nodes of the TEC-5718IPRO cultivar in all sowing times presented no difference due to its determined growth habit (Table 6). In the third sowing time, BMX-VelozRR presented the lowest number of nodes among the cultivars that had indeterminate growth habit, in the presence of weeds (Table 6), reducing 4.75 nodes plant^{-1} from the first to the last sowing time.

Reductions in plastochron and final number of nodes due to the delay of the sowing time can be a response to the photoperiod and presence of weeds, which significantly affect the development rate and duration cycle of the crop.

The sensitivity to photoperiod of soybean varies according to the cultivar; each cultivar needs a specific accumulated photothermal index for its vegetative and reproductive stages (Toledo et al., 2010). Late-maturing cultivars require a higher degree-day accumulation than early-maturing cultivars. Moreover, unfavorable temperatures (below 20 °C or above 30 °C), low availability of solar radiation, and short photoperiod (low thermal time) are the most common abiotic factors occurring in late sowing times and determine the growth and development of the crops (Zanon et al., 2015; Schwerz et al., 2016).

Similarly, Martins et al. (2011) found a reduction of 4.3 nodes plant^{-1} for the BRS247 cultivar by delaying the sowing from November 9 to January 28. Setiyono et al. (2007) found a decrease in the final number of nodes in 12 soybean cultivars by delaying sowing and attributed this result to the decreasing photoperiod in which the plants were grown. Thus, the higher the reduction in the final number of nodes, the greater the response of the cultivar to photoperiod.

The results found in this study can assist producers in choosing the appropriate sowing time, between October and November, and the cultivars to be used, since delaying the sowing, combined with the presence of weeds, reduced the development of the evaluated cultivars. This information may be useful to producers and assist them in planning the crops and defining management strategies for weed control.

Conclusion

The plastochron and final number of nodes of soybean were influenced by the cultivar, sowing time, and presence of weeds.

The plastochron was higher when the plants were grown in the presence weeds due to the higher relative frequency, relative density, relative abundance, and importance value index of the *Euphorbia heterophyla*, *Ipomoea purpurea,* and *Urochloa plantaginea* species, which resulted in a slower development of the soybean plants, and lower number of nodes per plant.

The soybean cultivars of undetermined growth habit (BMX-TornadoRR, BMX-AlvoRR, BMX-VelozRR and TEC-7849IPRO) presented lower final number of nodes when their sowing time was delayed, and when they were grown in the presence of weeds.

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