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Doses and Times of Trinexapac-ethyl Application in Soybean Development and Yield

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Abstract

The intense vegetative growth is one of the problems faced by soybean producers, causing the lodging, making difficult and damaging the harvest and, even, the efficiency of the application of agricultural defenses. The use of growth regulators is an important tool in the management of growth, in addition, it can favor the transport of photoassimilates for grain filling. Therefore, the objective was to evaluate the best dose and time of trinexapac-ethyl application in the development and yield of soybean varieties. The experiment was conducted in the Selvíria County, Brazil (20°20′53″ S, 51°24′02″ W). The experimental design was used in randomized blocks with treatments arranged in a factorial scheme 5 x 3 (doses x times), with four replications. The varieties used were the BRS Valiosa RR and the BMX Potência RR, the doses of the growth regulator were 0; 50; 100; 200 and 400 g ha^{-1} of trinexapac-ethyl (Moddus®) and the application times were at the phenological stages V7, V10 and R2. The varieties BRS Valiosa and BMX Potência, respectively, were obtained at the phenological stage V10, with application of 200 g ha^{-1} of trinexapac-ethyl, greater dry matter accumulation of leaves and pods. Nevertheless, the same did not act on the foliar area of the BRS Valiosa RR variety in the same way that it did not induce changes in the production components of the BMX Potência RR variety. Regardless of the application period (V7, V10 and R2) and the dose (up to 400 g ha^{-1}), the application of trinexapac-ethyl was not a management capable of influencing the agronomic characteristics and the lodging of the plants in both varieties.

Keywords: *Glycine max* (L.) Merrill, growth regulator, lodging, agronomic characteristics

1. Introduction

Soybean is a crop that currently occupies a commercially relevant role in the quality of one of the main commodities of the world agribusiness, since, in addition to making it possible to extract oils, it represents an excellent source of protein that, in turn, can be used both in human food and as a meal for animal feed (Fischer, Maier, Rutz, & Bermudez, 2002; Paulino, Moraes, Zervoudaki, Alexandrino, & Figueiredo, 2006; Linzmeyer Junior, Guimarães, Santos, & Bencke, 2008).

According to CONAB (2017), Brazil is the second largest producer of this oilseed with an estimated yield of 3,075 kg ha^{-1}. These values are only possible due to the high technological level acquired and employed by the producers, the incentive to research on crop and genetic improvement in search of varieties resistant to adverse conditions and with desired agronomic characteristics (Dario et al., 2005).

However, even after all the investment provided to the crop aiming at its high performance, there are still factors that can narrow the yield bottleneck of this, such as the lodging of plants. This event causes the rupture of conducting vessels, shading, difficulties and losses in the harvest, among other aspects (Buzzelo, 2010). The same author affirms that lodging is an aggravation in the soybean production system that can be contained through cultural practices on the population of plants, density, spacing and time of sowing, in addition to the use of phytoregulators.

These phytoregulators, according to Castro and Vieira (2001) and Espindula et al. (2011), are substances exogenously synthesized and that, when applied on plants, present similar responses to plant hormones, so that the producer can induce and/or control their development. This tool has great potential, although it is not yet usual in cultures that do not present high technological development (Vieira & Castro, 2002).

Trinexapac-ethyl is a phytoregulator that acts to inhibit the synthesis of highly efficient gibberellin and, as a function of this substance, accumulation and synthesis of biologically less efficient gibberellins occurs, therefore, there is a reduction of the cellular elongation and also a strengthening of the internode, that is, the size of the plant and, finally, the lodging and yield losses related to this aspect (Naqvi, 1994; Taiz & Zeiger, 1998; Witkowicz, 2010).

It should be noted that trinexapac-ethyl is already studied in other crops belonging to the grasses that are registered by the Ministry of Agriculture, Cattle and Supplying, also that the effects of growth regulators have been inconsistent: in some situations, increase in yield and in others, reduction (Alvarez, Crusciol, Trivelin, Rodrigues, & Alvarez, 2007; Nascimento et al., 2009).

Although trinexapac-ethyl is not registered in the Ministry of Agriculture, Cattle and Supplying for soybean cultivation, there is a lack of scientific work on the action of this regulator in the crop, being necessary studies to evaluate the performance of the regulator under the production components. It is also important to evaluate the behavior of the soybean plant, through the application of the regulator, aiming at reducing the size of the plant and consequently the possibility of lodging, as well as improving the conditions for the application of pesticides, facilitating the penetration of the canopy of the plant and providing better efficiency.

2. Material and Methods

The experiment was conducted in the experimental area, located in the municipality of Selvíria (MS), located south of the center-west region of Mato Grosso do Sul State, Brazil (20°20′53″ S, 51°24′02″ W and 340 m). Through survey and using the Brazilian Soil Classification System (EMBRAPA, 2013), the soil of the experimental area is termed as Distroferric RED LATOSOL, corresponding to Typic Haplorthox, according to the international classification (Soil Survey Staff, 2010), which was originally occupied by vegetation of Cerrado and has been explored by annual crops for more than 26 years.

The climate of the region is Aw, defined as tropical humid with rainy season in summer and dry in winter, presenting temperature and average annual precipitation of 25 °C and 1313 mm (average of the last 18 years), respectively (Portugal, Peres, & Rodrigues, 2015). Figure 1 shows the rainfall, minimum and maximum air temperatures occurring during the period of the experiment. The data were obtained from the meteorological station located a few meters from the experimental field.

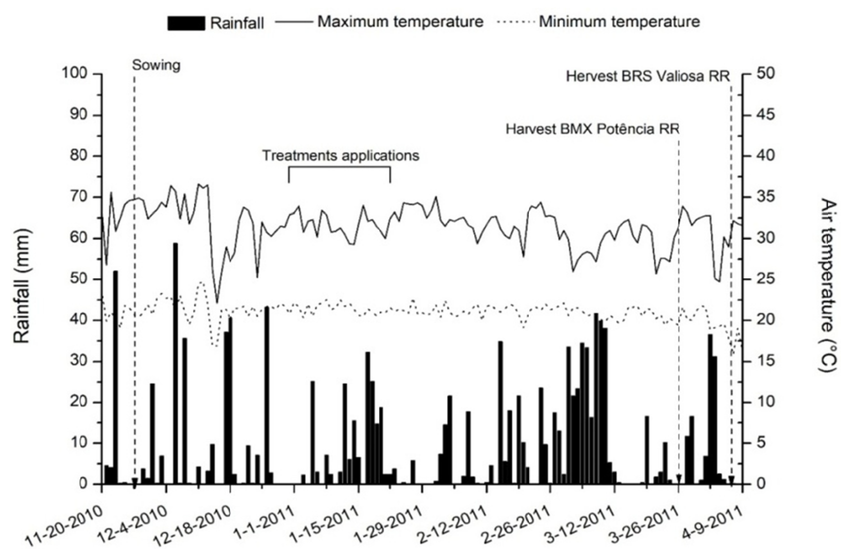

Figure 1. Daily variation of rainfall, relative humidity and maximum and minimum air temperature during the period from November 2010 to April 2011

Before the installation of the field experiment, the soil was sampled in the 0-0.20 m layer for chemical analysis according to the method described by Raij et al. (2001), which results were: pH ($CaCl_2$): 4.9; P (resin): 42 mg dm^{-3};

K (resin): 3.8 mmol dm^{-3}; Ca (resin): 20 mmol dm^{-3}; Mg (resin): 12 mmol dm^{-3}; H + Al (SMP buffer): 38 mmol dm^{-3}; SB: 35.8 mmol dm^{-3}; CTC: 73.8 mmolc dm^{-3}; V (%): 49.

The experimental design was in randomized blocks arranged in a 5 x 3 factorial scheme. The treatments consisted of the combination of five doses of trinexapac-ethyl (0, 50, 100, 200 and 400 g ha^{-1} of a.i.) using the commercial Moddus® product, applied in three phases in the phenological stages (V7, V10 and R2) based on their identification in Fehr et al., (1977), with four replicates.

Two varieties were used, these were the BRS Valiosa RR and the BMX Potência RR. The plots were constituted by seven lines of 10.0 m in length, spaced of 0.45 m. The working area consisted of three central lines, scoring 2.0 m at both ends of each line. The sowing fertilization was calculated according to the soil characteristics, being composed of 250 kg ha^{-1} of formulation 08-28-16. Sowing was carried out on November 27, 2010, in no-tillage system and seed treatment, inoculation, weed management and other plant breeding practices were performed according to EMBRAPA recommendations (2008), using specific products for each case. The sowing density was 16.2 seed m^{-1} furrow for the BRS Valiosa RR and 19.6 seed m^{-1} furrow for the BMX Potência RR. The emergence of most seedlings occurred six days after sowing.

The regulator was applied with bar sprayer, coupled to the tractor, equipped with nozzle tips 110 02 and calibrated for application of 200 L ha^{-1} of mixture. The treatments were always applied between 9:00 a.m. and 10:00 a.m. of each season of application, with favorable conditions for the realization of the applications. Growth regulator applications were performed at the V7 phenological stages (BRS Valiosa RR: 27 DAE, BMX Potência RR: 32 DAE), V10 (BRS Valiosa RR: 39 DAE, BMX Potência RR: 43 DAE) and R2 (BRS Valiosa RR: 49 DAE, BMX Potência RR: 49 DAE). In the BMX Potência RR variety, for the application in stage V7 (32 DAE) it was observed that it was also in stage R1. This variety when it reached the V10 stage (43 DAE) was also in the R2 stage. However, it was decided that the intended application for the R2 stage would be performed later to have in each variety three applications at different times. The simultaneous occurrence of vegetative and reproductive stages is common in indeterminate growing soybean varieties.

The evaluations were: Percentage of inter-row closure at the phenological stages V8, R1, R3 and R4, using a ruler similar in size to the line (0.45 m), the distance between the lines was covered by leaves at three points area and recorded the maximum distance parallel to the incidence of leaves; Dry matter—determined at stages V8, R2 and R6, corresponding to each variety, by counting the number of plants, the weight of the green matter and the dry matter of the plants and their parts (branches, leaves, pods and total); Leaf area—determined at the R6 stage from the leaf area ratio (5.31 cm²) of 15 leaflets, obtained homogeneously throughout the plant (lower, middle and apical third), with their weight, leaflets and number of plants after drying in a forced air circulation oven at 65 ° C; Agronomic characteristics—determined in the R8 stage of the respective varieties from 5 plants followed in the same line of the useful area and measured the characteristics: height of plant, internode in the main stem, pods / plant and grains/pod; Yield—after drying in the sun and mechanical track, the grains obtained were weighed and calculated the yield in kg ha^{-1}, followed by determination of grain moisture for correction of yield at 13% moisture (wet basis), Lodging—obtained by visual observations before harvest to determine grain yield and agronomic characteristics, using the following scales 1-without lodging, 2-up to 25% of bedded plants, 3-from 25 to 50%, 4-from 50 to 75% and 5-above 75%.

The results were submitted to analysis of variance and, later, to the polynomial regression analysis for the quantitative factor (growth regulator doses) and Tukey test for the qualitative factor (application times of the plant regulator). Coefficients of determination (R2) less than 0.70 for the linear and quadratic regression models were considered non-significant (without adjustment). Each variety was individually analyzed using the SISVAR computer application (Ferreira, 2014).

3. Results and Discussion

The application of trinexapac-ethyl did not influence the closure between the lines for both the variety BRS Valiosa RR and the variety BMX Potência RR (Tables 1 and 2) and, although the varieties presented differences regarding the behaviors when compared to their means (Reinhardt & Kuylermeier, 2002). In the present study, it is possible to determine the effect on plant growth

These data do not corroborate results obtained by Costa and Vieira (2001) and Fialho et al. (2009) who stated in works with different species of grass and *Brachiaria brizantha*, that the effect of the application of ethyl-trinexapax resulted in the rearrangement of parenchyma cells and the leaf epidermis, thus, it indirectly influences the closure of the interlining because the leaves had reduced length and increased leaf thickness.

However, when evaluating soybean architecture with different growth regulators, Souza et al., (2013) verified that in soybean plants CD 226 RR variety, trinexapac-ethyl was the regulator that showed little or no effect on this variable, that is, the interlining closure is influenced more by physiological factors intrinsic to the plant, and the applications of regulators do not intervene directly in the leaf structure throughout longitudinal extension of the main stem in soybean plants.

Table 1. Values of F and average values of inter-row closure (%) of BRS Valiosa RR as a function of doses and times of application of trinexapac-ethyl

Treatments	V_8	R_1	R_3	R_4
	------------ % ------------			
Times				
V_7	45.1	58.1	91.2	98.5
V_{10}	-	57.9	94.8	99.3
R_2	-	-	93.8	99.0
Doses				
0	46.3	59.8	90.4	99.3
50	43.3	56.1	94.0	98.4
100	43.5	56.5	93.5	99.4
200	41.6	56.8	95.2	98.6
400	40.8	56.9	93.2	98.9
F Teste				
Times (T)	-	0.97^{NS}	1.74^{NS}	0.51^{NS}
Doses (D)	1.07^{NS}	0.71^{NS}	0.95^{NS}	0.37^{NS}
E × D	-	1.59^{NS}	0.86^{NS}	1.52^{NS}
Average	43	57	93	99
CV (%)	16.47	10.43	6.69	2.56

Note. Averages followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

Table 2. F values and mean values of inter-row closure (%) of the BMX variety RR power as a function of doses and times of application of ethyl-trinexapac

Treatments	V_8	R_1	R_3	R_4
	------------ % ------------			
Times				
V_7	42.0	72,0	91.6	99.2
V_{10}	-	72.6	91.7	99.1
R_2	-	-	88.2	99.2
Doses				
0	45.3	71.3	92.3	98.5
50	39.1	70.8	89.0	99.9
100	40.2	74.1	90.8	98.6
200	41.7	73.9	89.4	99.6
400	42.8	71.8	90.8	99.1
F Test				
Times (T)	-	0.09^{NS}	1.31^{NS}	0.02^{NS}
Doses (D)	1.51^{NS}	0.96^{NS}	0.34^{NS}	0.86^{NS}
T × D	-	1.08^{NS}	0.75^{NS}	0.58^{NS}
Average	42	72	91	99
CV (%)	16.14	7.45	8.69	2.33

Note. Averages followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

For the variable accumulation of dry matter (Tables 3 and 4), in both varieties, in stage V7, no significant differences were detected in any evaluated vegetative part (branches, leaves and total). However, the uniform development of the plants verified in this phase is justified by the precedence to the application of the growth regulator. The same was also verified in the second evaluation (phenological stage R2), similarly to the results verified by Liynzmeyer Junior et al. (2008), when evaluating the effect of different doses of trinexapac-ethyl and of two sowing densities on soybean growth, lodging and yield, whose only influence detected in the dry matter variable came from the sowing density and not from the control regulator growth.

Table 3. Values of F and average values of dry matter of branches, leaves, pods and total (kg ha^{-1}) of the BRS Valiosa RR variety in the different samplings, as a function of doses and times of application of trinexapac-ethyl

Treatments	V_8			R_2			R_6			
	Branches	Leaves	Total	Branches	Leaves	Total	Branches	Leaves	Pods	Total
	kg ha^{-1}									
Timess										
V_7	187.0	378	629	1312	1958	3268	4582	2153	6034	12765
V_{10}	-	-	-	1230	1895	3125	4823	2286	6368	13477
R_2	-	-	-	1187	1918	3100	4565	2309	6347	13221
Doses										
0	182	445	627	1215	1884	3100	4658	2111	5924	12692
50	172	421	593	1258	1910	3168	5065	2570	6726	14360
100	183	428	611	1253	2004	3256	4171	1905	5608	11685
200	152	378	529	1260	1860	3120	4510	2344	6721	13575
400	169	407	576	1230	1948	3178	4880	2317	6269	13466
F Test										
Times (T)	-	-	-	1.22 NS	0.15 NS	0.48 NS	0.31 NS	0.45 NS	0.17 NS	0.23 NS
Doses (D)	0.48 NS	0.31 NS	0.36 NS	0.06 NS	0.29 NS	0.13 NS	1.07 NS	2.40 NS	0.73 NS	1.12 NS
T × D	-	-	-	1.58 NS	1.30 NS	1.51 NS	1.40 NS	2.40 *	0.49 NS	0.84 NS
Average	174	409	594	1243	1921	3164	4657	2249	6250	13156
CV (%)	26.57	27.44	26.62	20.58	18.68	18.3	24.67	25.00	31.80	25.17

Note. Averages followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

Also on dry matter accumulation, now in the third evaluation, which culture was at the phenological stage R6, for the variety BRS Valiosa RR no significant differences were detected between the treatments in any evaluated vegetative part (branches, leaves and total), that is to say, there was also no effect on the mentioned characters independent of the dose and application time of trinexapac-ethyl. Differing from Campos (2005), evaluating soybean (BRS 184 soybean variety) in the Botucatu (SP) region and using plant regulators GA3 (100 mg L^{-1}), BAP (100 mg L^{-1}), IBA (100 + 100 + 100 mg L^{-1}) and ethephon (600 mg L^{-1}), mepiquat chloride (100 mg L^{-1}), mepiquat + BAP + IBA (100 mg L^{-1}), for the total dry matter variable, verified significant differences between the treatment with application of Chloride Mepiquat and the control in soybean, indicating the possibility of increase of dry mass, remembering that mepiquat chloride is a growth regulator with the same principle of trinexapac-ethyl, but interfering more briefly with gibberellin biosynthesis (Shepard & Dipaola, 2000).

In the present study, significant interaction between application time and growth regulator doses was observed (Table 3), corresponding to doses of 50 and 200 g ha^{-1} of a.i. (Table 4). In relation to the dose of 50 g ha^{-1}, although significant difference was detected by the F test, no difference was obtained between the application times by the Tukey test. On the other hand, in the treatment with trinexapac-ethyl in the V10 stage, a dose of 200 g ha^{-1} increased 58.4% and 56.1% over the application times V7 and R2, respectively. In relation to the growth regulator doses, there was no adjustment to a linear or quadratic equation for the data obtained.

The data presented corroborate with Campos (2005) that detected a small increase in leaf dry matter from the application of mepiquat chloride in up to 112 days after sowing. This data can be interpreted in two ways, because according to Zerbe and Wild (1981), some growth regulators indirectly influence the content of chlorophyll and, consequently, the photosynthetic rate of the plant. Therefore, the application of trinexapac-ethyl, at the beginning of the vegetative and reproductive stages (V7 and R2), may induce a slight reduction in the accumulation of carbohydrates and other elements that influence dry matter production. In contrast, Xu and Huang (2012) evaluated the tolerance to the water deficit of *Poa pratensis* by treating them with trinexapac-ethyl and obtained positive responses, among them, by greater assimilation of carbon and the accumulation of essential metabolites for adaptive responses of plants.

Table 4. Unploying of the interaction between doses and application times of trinexapac-ethyl for leaf dry matter (kg ha^{-1}) at the R6 stage of the BRS Valiosa RR variety

Times	Doses of etyl-trinexapac (g ha^{-1})					Equations (R^2)
	0	50	100	200	400	
V7	2189	2844 a	1762	1954 b	2015	No adjustment
V10	1957	1970 a	1967	3095 a	2441	No adjustment
R2	2186	2896 a	1987	1983 b	2494	No adjustment
DMS		966		966		

Note. Average followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

In relation to the accumulation of dry matter of leaves, branches and total referring to the BMX Potência RR variety, there was no influence by the application of trinexapac-ethyl. Only for the dry matter characteristics of pods was observed influence by the interaction between times and doses of application of the regulator (Table 5). This time, only the dose of 200 g ha^{-1} responded significantly to the same, which application in the phenological stage V10 provided an increase of 51.41% compared to the application in R2 (Table 6). The different doses of the growth regulator did not fit a linear or quadratic equation for the obtained data.

This result may be due to the slight redirection of photoassimilates to the pods, similar results were detected by Souza et al. (2013) when testing the influence of growth reducers on plant architecture and soybean yield, and verified the non-influence of trinexapac-ethyl on plant height, but an increase in the diameter of the main stem, suggesting this redirection of photoassimilates. Campos (2005) also verified the increase of dry matter of pods, throughout the cycle of the culture, from the application of mepiquat chloride. In opposition to Lynzmeier Junior et al. (2008) that did not find influence on the reproductive structures and affirm that it does not present more residual in the plant at the time of pod formation when applied in V6. Thus, in a later application as in the present experiment, *i.e.*, in V10 it becomes possible to physiologically maintain the regulator in the plant up to the stage of pod formation.

Table 5. F values and average values of dry matter of branches, leaves, pods and total (kg ha^{-1}) of BMX Potência RR varierty in the different samplings, as a function of doses and times of application of trinexapac-ethyl

Treatments	V_8			R_2			R_6			
	Branches	Leaves	Total	Branches	Leaves	Total	Branches	Leaves	Pods	Total
	kg ha^{-1}									
Times										
V_7	385	771	1156	942	1481	2423	4409	4471	3630	12510
V_{10}	-	-	-	883	1394	2277	4346	4377	4211	12934
R_2	-	-	-	940	1422	2362	3885	3908	3844	11637
Doses										
0	395	806	1201	1012	1586	2599	4322	4301	3990	12613
50	379	820	1199	929	1441	2370	4193	4278	3866	12337
100	361	727	1088	827	1280	2107	4174	4212	4041	12427
200	377	719	1096	882	1352	2234	4613	4627	3873	13113
400	366	718	1084	958	1503	2461	3764	3843	3707	11314
F Teste										
Times (T)	-	-	-	0.60^{NS}	0.45^{NS}	0.45^{NS}	1.79^{NS}	2.75^{NS}	2.51^{NS}	2.15^{NS}
Doses (D)	0.14^{NS}	0.50^{NS}	0.33^{NS}	1.60^{NS}	1.99^{NS}	1.87^{NS}	1.24^{NS}	1.42^{NS}	0.29^{NS}	1.28^{NS}
T × D	-	-	-	0.39^{NS}	0.27^{NS}	0.31^{NS}	0.73^{NS}	0.85^{NS}	2.36^{*}	1.66^{NS}
Average	377	760	1137	922	1432	2354	4213	4252	3895	12361
CV (%)	33.2	33.86	32.6	21.04	20.76	20.66	22.66	19.13	21.29	16.3

Note. Average followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

Table 6. Unploying of the interaction between doses and times of application of trinexapac-ethyl for dry matter of pods (kg ha^{-1}) in the R6 stage of the BMX Potência RR varierty

Times	Doses of etil-trinexapac (g ha^{-1})					Equations (R^2)
	0	50	100	200	400	
V7	3435	3176	4755	3531 ab	3254	No adjustment
V10	4496	3906	3750	4871 a	4035	No adjustment
R2	4039	4515	3619	3217 b	3832	No adjustment
DMS				1425		

Note. Average followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

For both BRS Valiosa RR and BMX Potência RR varieties, growth regulator applications did not provoke direct physiological responses on soybean crop growth in any of the variables evaluated in the following tables: leaf area (AF), plant height (PH), first pod insertion height (AIV), branches per plant (RP), internodes in the main stem (IHP), pods per plant (VP), grains per pod (GV) and yield (P) (Tables 7 and 8). In the literature there are several responses about them, similar data were presented by Kappes et al. (2011), except in relation to plant height and number of branches per plant.

Even though at the phenological stage R2 for dry matter accumulation in both varieties, no responses were observed on the application of trinexapac-ethyl, and in the R6 stage the BRS Valiosa RR variety showed greater accumulation of leaf dry matter, there wasn't a positive effect for leaf area of the plants (Table 7), given that according to Linzmeyer Junior et al. (2008) who verified greater accumulation of dry matter in all organs related to the greater the density of plants, without verifying differences in leaf area between the different densities. In addition, they stressed that the application of trinexapac-ethyl also did not influence the leaf area of soybean plants, and this corroborates with the results obtained in this experiment, indicating that the increase in leaf dry matter does not imply a larger leaf area. Opposite to Campos (2005) that verified increases in the leaf area of soybean plants with the application of IBA + GA3 + kinetin (Stimulate®) or with the application of isolated mepiquat chloride.

As mentioned above, in the BMX Potência RR variety, the evaluation in R6 showed that the application of trinexapac-ethyl provided a greater carry of the photoassimilates to the pods, thus generating a higher dry matter of this organ. However, this yield did not increase the number of pods per plant, nor did it increase yields, for example, the increase in the number of grains per pod (Table 8). Both varieties did not obtain an isolated effect at the time of application or the doses of trinexapac-ethyl, but both were influenced by the interaction doses and times of application of the regulator for the dose 200 g ha^{-1} applied at the phenological stage V10.

Also, no response was verified of the plants in relation to the reproductive traits for the BRS Valiosa RR variety (Table 7) and for the BMX Potência RR variety (Table 8). Thus, the regulator did not influence the number of pods per plant, number of grains per pod and productivity. Results obtained by Linzmeyer Junior et al. (2008) show that the application of trinexapac-ethyl in soybean does not influence soybean production and yield components.

Campos (2005) also verified in the soybean crop that the application of plant regulators did not influence the number of pods per plant as well as the number of grains per pod. According to Fioreze and Guimarães (2015), the application of trinexapac-ethyl in the vegetative period does not affect growth and production components in soybean plants. Buzzelo (2010) found that the application of trinexapac-ethyl did not increase the number of pods per plant and in the grain mass, however the doses 62.5; 187.5 and 312.5 g ha^{-1} promoted an increase in the number of grains per pod and in the yield of the soybean crop in relation to the control, and the doses did not differ from each other.

For all treatments, including controls, of both soybean varieties (BRS Valiosa RR and BMX Potência RR) was assigned a score (1) in relation to lodging, that is, all the plants were standing. Thus, it was observed that the application of trinexapac-ethyl did not influence the lodging of plants, but we can attribute this result to the fact that both soybean varieties used in this experiment had no susceptibility to lodging. Similar results were obtained by Arf et al. (2012) that studying the use of trinexapac-ethyl in upland rice varieties verified that the variety IAC 202 did not require the application of growth regulator because there was no lodging of plants, even in the control treatment.

Linzmeyer Junior et al. (2008) reported that although increasing doses of trinexapac-ethyl had linearly decreased plant height and increased stem diameter, there was no difference between treatments and control in relation to lodging of soybean plants (CD 209 variety). These authors also reported the possibility of a second application of the growth regulator in order to promote an increase in the efficiency of lodging control in susceptible varieties. In contrast, Buzzelo (2010) verified that the application of trinexapac-ethyl at dose 187.5 g ha^{-1}, at stage V5, was efficient in the control of lodging of soybean plants (CD 214 RR variety) in the evaluations carried out after 14, 21 and 28 days after the application of the regulator to the control. The author also found that at the dose 312.5 g ha^{-1}, trinexapac-ethyl promoted a reduction of lodging in the evaluations at 14 and 56 days after the application of the regulator. The same result was found by Zagonel (2002) in the wheat crop.

Table 7. F values and average values of leaf area (LA), plant height (PH), internodes in the main stem (IHP), pods per plant (PP), grains per pod (GP), and yield (YIELD) of the variety BRS Valiosa RR according to the doses and application times of trinexapac-ethyl

Treatments	LA	PH	IHP	PP	GP	YIELD
	cm^2 $plant^{-1}$	cm	----------------------	nº	----------------------	kg ha^{-1}
Times						
V_7	1328	94	16	53	2.0	3829
V_{10}	1383	97	15	53	2.0	4038
R_2	1347	93	15	51	2.0	3931
Doses						
0	1375	96	16	53	2.0	3751
50	1444	95	16	49	2.0	3721
100	1142	90	15	52	2.0	4105
200	1529	93	15	50	2.0	4005
400	1273	99	16	56	2.0	4093
F Test						
Times (T)	0.15^{NS}	2.54^{NS}	0.12^{NS}	0.34^{NS}	1.02^{NS}	0.58^{NS}
Doses (D)	2.43^{NS}	2.46^{NS}	1.13^{NS}	0.92^{NS}	1.12^{NS}	1.18^{NS}
T × D	1.23^{NS}	0.65^{NS}	1.02^{NS}	1.37^{NS}	0.72^{NS}	0.69^{NS}
Average	1353	95	15	52	2.0	3934
CV (%)	24.68	7.47	7.2	18.37	18.14	15.05

Note. Averages followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

Table 8. F values and average values of leaf area (LA), plant height (PH), internodes in the main stem (IHP), pods per plant (PP), grains per pod (GP), and yield (YIELD) of the variety of the varierty BMX Potência RR according to the doses and application times of trinexapac-ethyl

Treatments	LA	PH	IHP	PP	GP	YIELD
	cm^2 $plant^{-1}$	cm	----------------------	nº	----------------------	kg ha^{-1}
Times						
V_7	1404	109	19	33	1.0	3139
V_{10}	1360	108	19	32	2.0	3253
R_2	1413	107	19	32	2.0	3396
Doses						
0	1400	113	19	30	1.0	3101
50	1375	109	19	31	1.0	3268
100	1459	107	19	32	2.0	3154
200	1420	107	19	34	2.0	3374
400	1308	104	18	33	2.0	3423
F Test						
Times (T)	0.13^{NS}	0.38^{NS}	0.24^{NS}	0.08^{NS}	3.22^{NS}	0.97^{NS}
Doses (D)	0.31^{NS}	1.22^{NS}	2.31^{NS}	0.29^{NS}	2.11^{NS}	0.69^{NS}
T × D	0.56^{NS}	0.64^{NS}	2.01^{NS}	0.32^{NS}	1.76^{NS}	0.69^{NS}
Average	1392.5	107.9	18.6	32.1	1.5	3263
CV (%)	25.37	9.63	6.47	27.11	22.34	17.93

Note. Averages followed by distinct letters in the column are statistically different from each other ($p \leq 0.05$) and columns without letters are not statistically different according to the Tukey test ($p \leq 0.05$).

*, ** and NS correspond, respectively, to significant at the probability level of ($p \leq 0.05$), ($p \leq 0.01$) and not significant by the F test.

It is noteworthy that only one study evaluated the use of the trinexapac-ethyl growth regulator in soybean cultivation and presented a positive result in the reduction of plant height, whose experimental environmental conditions were of milder temperatures and higher humidity (Linzmeyer Junior, Guimarães, Santos, & Bencke, 2008; Rodrigues, Didonet, Teixeira, & Roman, 2003), leading to the belief that this lower temperature related to higher humidity can influence the better physiological performance of the molecule in plants, because according to Lamas et al. (2013) temperature is among the environmental factors, which most interferes with the effect of the regulator growth as well as plant growth. In addition to the sowing season, the nutritional and phytosanitary status of the crop. According to Estevo (2013), the effect and duration of the product are associated with the dose and the physiological stage of the crop at the time of application, and that these are more noticeable in winter cereals.

Another important aspect is to consider the active gibberellin at the growth points of soybean plants, as opposed to that of cereal crops, since GA1 is the main gibberellin associated to the caulinar stretching of several species such as turnip, tomato, rice and wheat (Peres & Kerbauy , 2004), and the mechanism of action of trinexapac-ethyl acts by deregulating GA1 active gibberellic acid levels and substantially raising the levels of its GA20 biosynthetic precursor (Nakayama, Kobayashi, Abe, & Akira Sakurai, 1990), so perhaps the results in legumes will not always be efficient , since there are studies that show little or no effect on plant height and reduction in the variables related to yield (Souza, Figueiredo, Coelho, Casa, & Sagoi, 2013).

In view of the great diversification of the results presented by soybean cultivation under the application of trinexapac-ethyl, it was verified that they are still inconsistent. We can also infer that different varieties have different behaviors before this growth regulator, therefore, it is recommended the promotion for further studies in order to know the real effects of trinexapac-ethyl on the vegetative and reproductive development of soybean.

4. Conclusions

1) The application of 200 g ha^{-1} of trinexapac-ethyl a.i. at phenological stage V10, provided greater leaf dry matter accumulation for the BRS Valiosa RR variety and greater accumulation of dry matter of pods for the variety BMX Potência RR.

2)The higher accumulation of leaf dry matter did not increase the leaf area of the BRS Valiosa RR variety, as well as the higher dry matter accumulation of pods did not influence the production components, nor did it increase yield for the BMX Potência RR variety;

3)The application of trinexapac-ethyl, regardless of the application period (V7, V10 and R2) and the dose (up to 400 g ha^{-1}) did not influence the lodging and agronomic characteristics of the soybean BRS Valiosa RR and BMX Potência RR varieties;

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