Original Article: Agronomic performance of soybean under the application of 2,4-D amine subdoses

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ABSTRACT

The search for cultivation practices that provide increased soybean yield has been recurrent. From this context, the objective of this study was to evaluate the agronomic performance of soybeans with the application of phytosanitary products, as well as the effect of 2,4-D amine subdoses on this crop. Two field experiments were conducted in a randomized block design (RCBD), in a factorial arrangement, with four replications. In the first experiment, one factor corresponded to the soybean post-emergence application of propiconazole, 2,4-D amine, lactofen, imazethapyr and Grainset®, while the other factor corresponded to the single or sequential application of these products. For the second experiment, one factor corresponded to the application of 2,4-D amine at two phenological stages of soybeans: V4 or V8 (4 and 8 fully expanded trifoliate leaves, respectively), while in the other factor the subdoses of this herbicide were evaluated: 4.03, 8.06, 12.09, 16.12, 20, 15 and 24.18 g a.i. ha^{-1}. In both experiments, the additional treatment consisted of the control without application. 2,4-D amine applied in subdoses has potential for use in soybeans. The application of 2,4-D amine subdoses promotes changes in morphological parameters of this crop. Increase in the yield of this crop can be obtained with the application of 2,4-D amine in subdoses varying between 16.12 and 20.15 g a.i. ha^{-1}.

Introduction

Brazilian agriculture plays a prominent role in national economic sustainability and Brazil is among the largest food producers in the world and routinely appointed as the world's breadbasket for food production for the next generations. Proof of this refers to the level reached for soybean (*Glycine max* L.) in the 2019/2020 harvest, since Brazil has become the world's largest producer of this oilseed.

This fact deserves to be highlighted, especially when considering the center of origin of the species, which is located in the Asian continent, and in less than half a century, Brazil has become one of the world exponents in soybean production. In order to maximize the yield of this crop, through changes in the architecture of the plants, some cultivation practices have been evaluated. In this sense, the use of different sowing arrangements stands out, such as spacing and denser populations (Carmo et al. 2018; Carmo et al. 2019), use of cultivars with greater capacity in producing branches (Souza et al. 2010), as well as the application of phytosanitary products that regulate the growth of soybean plants (Basuchaudhuri, 2016).

With respect to this last practice, the application of phytosanitary products that act as growth regulators, can provide better architecture to plants, leading to higher soybean grain yields (Buzzello et al. 2013; Rios, 2016). From the use of these phytosanitary products in the vegetative phase of the crop, it is expected that they can promote physiological changes in the plants, optimizing the partition of photoassimilates, reducing the expenses in vegetative parts and redistributing them to the reproductive parts. Despite the great potential of this practice, few phytosanitary products are registered in the class of growth regulators for use in soybean crops.

In this context, herbicides, fungicides and biostimulants are among the product classes tested to promote hormonal stimuli or other physiological changes that influence plant morphology, distribution of photoassimilates and consequently grain yield (Buzzello et al. 2013; Rios, 2016; Beam et al. 2018; Alridiwirsah et al. 2020). These products can reduce the impacts caused by chemical or environmental stresses on the development of the crop, which can sometimes result in increased soybean yield (Gilley and Fletcher, 1997; Carvalho et al. 2014).

To certify the performance of phytosanitary products in modulating soybean growth, it is necessary to evaluate each active ingredient, determining which is the best application stage, as well as the most appropriate dose for use in this crop. In this context, the goal of the present study was to evaluate the agronomic performance of soybean subjected to the application of phytosanitary products of different classes, as well as to determine the effect of increasing subdoses of 2,4-D amine applied in different phenological stages of this crop.

Materials and Methods

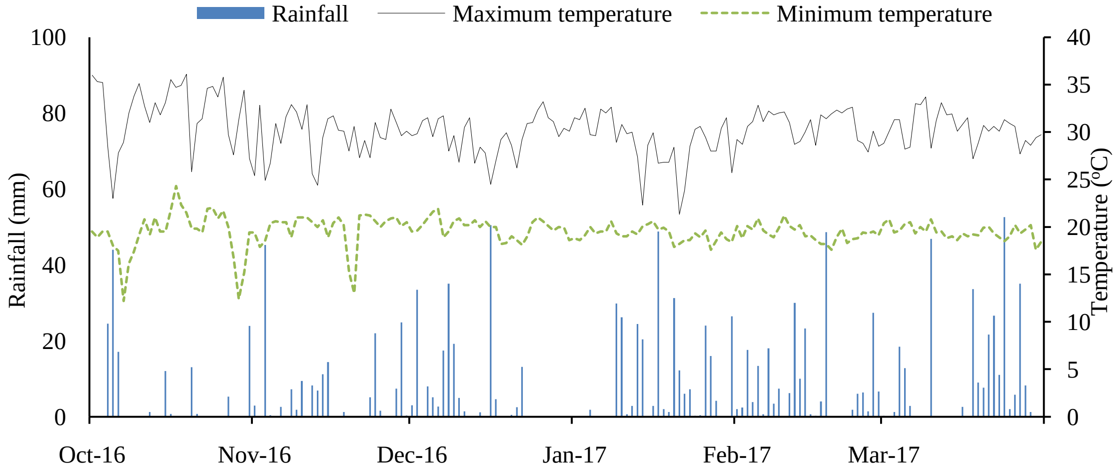
Two experiments were conducted in field conditions; the first evaluated the effect of phytosanitary products of different classes on the agronomic performance of soybeans. This experiment was set up in an area located in the municipality of Montividiu, state of Goiás, Brazil (17°19'35.11"S, 51°19'26.91"W, and 790 m altitude), in the 2016/2017 growing season. The second experiment was carried out with the objective of evaluating the effects of the application of subdoses of 2,4-D amine on the development of soybean plants, which was installed in the municipality of Rio Verde, state of Goiás, Brazil (17°52'04.93"S, 50°55'34.14"W, and 740 m altitude), in the 2017/2018 growing season.

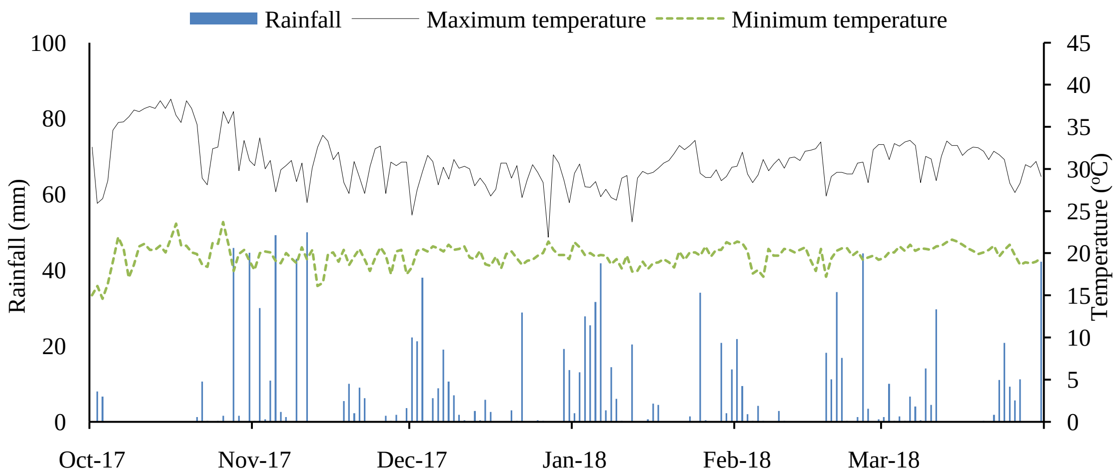
The climate in the experimental area, according to the classification proposed by Köppen-Geiger, is Aw, which is identified as a tropical climate with a dry season, with more intense rains in summer compared to winter. For this location, the annual average of rainfall and air temperature is 1,663 mm and 23.3ºC, respectively. Figure 1 illustrates data of rainfall and maximum and minimum air temperature during the experimental period.

The soil of both experimental areas was classified as eutrophic Red Latosol (EMBRAPA, 2018). Prior to the installation of the experiments, soil samples were taken in the 0-20 cm layer, in both experimental areas. The physical and chemical properties of the soil, as well as the crop planting data are listed in Table 1. In both experiments, the soybean cultivar used was M7739 IPRO®, belonging to the MONSOY® portfolio. This cultivar presents a semi-determinate growth habit, maturity group 7.7 and high capacity to produces branching (MONSOY, 2021). The criterion for selecting this cultivar in the experiments considered the economic relevance of the material in terms of planting area in Central Brazil, as well as its morphological aspects.

In both experiments, the experimental units were 6 meters in length and 3 meters in width (18 m^2), and the useful area was composed by the two central rows of the plot with 5 meters in length. The phytosanitary management of the crop was carried out to ensure that soybean yield was not affected by weeds, pests and diseases, carrying out weekly monitoring of plants present in the experimental area. When the occurrence of any of these agents was detected, management was carried out according to the strategies proposed by EMBRAPA (2013).

Furthermore, in both experiments, a CO_2 pressurized backpack sprayer was used to apply the treatments, which was equipped with an application bar containing five nozzles spaced 0.5 m apart. Sprayer adjustments, as well as speed when performing this operation, provided an application rate of 150 L ha^{-1}. Climatic conditions (air temperature and humidity, and wind speed) at the time of application were within the standards indicated for agricultural spraying (Silva et al. 2018).





Source: Climatological Station of the University of Rio Verde.

Figure 1- Maximum and minimum air temperature and rainfall during the conduction of the experiments. Rio Verde (Brazil), 2016/2017 and 2017/2018.

Table 1- Soil physical and chemical properties in the experimental areas and soybean crop information.

	Montividiu (2016/17)	Rio Verde (2017/18)
	Soil physical and chemical properties	
pH (H_2O)	5.5	6.2
Organic matter (g kg^{-1})	44.7	28.6
Clay (g kg^{-1})	460	400
Silt (g kg^{-1})	50	75
Sand (g kg^{-1})	490	525
	Crop information	
Planting date	11/05/2016	11/05/2017
Emergence date	11/12/2016	11/12/2017
Row spacing (m)	0,5	0,5
Soybean density	280,000 plants ha^{-1}	280,000 plants ha^{-1}
Fertilization (kg ha^{-1})	180 + 140 kg ha^{-1} of MAP + KCl	400 + 150 kg ha^{-1} of MAP + KCl
Harvest date	03/05/2017	03/05/2018

Selection of products for regulating soybean growth

The experiment was a randomized block design, with treatments in a 5x2+1 factorial arrangement, with four replications. The first factor corresponded to the post-emergence application of different phytosanitary products, evaluating: propiconazole (125 g a.i. ha^{-1}, fungicide), 2,4-D amine (8.06 g a.i. ha^{-1}, herbicide), lactofen (120 g a.i. ha^{-1}, herbicide), imazethapyr (42.4 g a.i. ha^{-1}, herbicide) and Grainset® (500 mL c.p. ha^{-1}, biostimulant). The second factor corresponded to the single application (V4: 4 fully expanded trifoliate leaves) or sequential application of these products (V4 and V8: 4 and 8 fully expanded trifoliate leaves, respectively), using the doses described above, regardless of the number of applications performed. The additional treatment corresponded to the control without the application of phytosanitary products to regulate the growth of soybeans.

To evaluate the effect of treatments on soybean agronomic performance, the following response variables were evaluated when the plants were at the R6 stage: plant height, distance between the 5^{th} and 10^{th} reproductive nodes and number of branches and reproductive nodes per plant. For these variables, 5 plants were sampled per experimental unit, averaging the values obtained for each treatment. In addition, to determine yield, the plants in the useful area of each experimental unit were manually harvested, threshed, packaged, identified, weighed and the grain moisture corrected to 13%.

Performance of subdoses of 2,4-D amine applied at different stages of soybean

The experiment was a randomized block design, with treatments in a 2x6+1 factorial arrangement, with four replications. The first factor corresponded to the application of 2,4-D amine in two phenological stages: V4 or V8, while in the second factor six subdoses of this herbicide were evaluated, comprising: 4.03, 8.06, 12.09, 16.12, 20.15 and 24.18 g a.i. ha^{-1}. The additional treatment consisted of the control without herbicide application.

To assess the effect of applying 2,4-D amine different subdoses on soybean, plants at the R6 stage were evaluated for: plant height, lodging index, chlorophyll relative index, root dry mass, number of branches and number of reproductive nodes per plant. To check the lodging scores, we used the scale proposed by Bernard et al. (1966). In measuring the relative chlorophyll index, the Minolta SPAD-502 chlorophyll meter was used, measuring in the second fully expanded trifoliate from the apex to the base of the plant. Excluding the lodging index, for which the score of the experimental unit was considered, for all other variables mentioned above, 5 plants per experimental unit were sampled.

At the time of soybean harvest, the following response variables were evaluated: number of pods per plant and grains per pod, number of pods with 2 and 3 grains, mass of 100 grains and yield, both with moisture correction to 13%. For the variables related to the number of pods/grains, 5 plants were evaluated per experimental unit, while to determine the yield, all plants in the useful area were harvested.

Statistical analysis

Statistical analyses of both experiments were run using the ASSISTAT® software (Silva and Azevedo, 2016). Data were tested by analysis of variance and when there was significance between the factors or between the levels of each factor, Tukey's test ($p \leq 0.05$) and regression analysis ($p \leq 0.05$) were applied to the qualitative and quantitative factors, respectively. The comparison between the control without application and the other treatments was performed by Dunnett's test ($p \leq 0.05$).

Results and Discussion

Selection of products for regulating soybean growth

Table 2 lists the summary of the analysis of variance of the first experiment, which evaluated the effect of phytosanitary products of different classes on soybean agronomic performance. A significant effect was detected of the interaction between product and number of applications on plant height and soybean yield. Furthermore, for these variables, a significant effect was also found in the comparison between the factorial and the additional treatment, composed of the control without the application of phytosanitary products.

Table 2- Summary of the analysis of variance for the response variables: distance between the 5th and 10th reproductive nodes (DBRN), number of branches (NB) and reproductive nodes (NRN), plant height (PH) and grain yield (YIELD). Montividiu (Brazil), 2016/17.

Sources of variation	DF	Mean squares				
		DBRN	NB	NRN	PH	YIELD
Product	4	95.73**	0.12^{ns}	0.12^{ns}	136.41**	106.18**
Number of applications	1	34.68^{ns}	0.14^{ns}	0.01^{ns}	100.80**	1428.02**
Product *vs* number of applications	4	9.75^{ns}	0.06^{ns}	0.22^{ns}	86.88**	59.96**
Factorial *vs* additional	1	21.71^{ns}	0.08^{ns}	0.67^{ns}	242.27**	211.42**
CV (%)		10.13	14.54	4.77	3.29	4.71

**, *, ^{ns}, significant at 1 and 5% probability and non-significant, respectively, by F-test.

For the response variables, number of branches and reproductive nodes per plant, no significant effect was found for any of the isolated factors, nor interaction between them (Table 2). Regarding the distance between the 5th and 10th reproductive node of soybean plants, the behavior was only significantly affected by the product. For this variable, there was a reduction in the distance between 5th and 10th reproductive node of soybean plants when they were treated with propiconazole or lactofen, when compared to the values observed in treatments with application of imazethapyr or Grainset® (Table 3).

Table 3- Distance between the 5th and 10th reproductive nodes (DBRN), plant height and soybean grain yield depending on the application of different phytosanitary products in the crop. Montividiu (Brazil), 2016/17.

Treatments	Dose (g a.i. ha^{-1})	DBRN	Plant height (cm)		Yield (kg ha^{-1})	
			V4	V4/V8	V4	V4/V8
Propiconazole	125	38.2 b	79.38 Aa	68.25 Bc$^{(-)}$	3,195 Abc	2.280 Bb$^{(-)}$
2,4-D amina	8.06	41.7 ab	73.50 Ac$^{(-)}$	74.38 Ab$^{(-)}$	3,555 Aa$^{(+)}$	2.415 Bb$^{(-)}$
Lactofen	120	37.4 b	74.25 Abc$^{(-)}$	65.00 Bc$^{(-)}$	2,970 Ac$^{(-)}$	2.280 Bb$^{(-)}$
Imazethapyr	42.4	44.8 a	78.63 Bab	82.38 Aa	2,940 Ac$^{(-)}$	2.385 Bb$^{(-)}$
Grainset®	500[1/]	44.5 a	77.63 Aabc$^{(-)}$	77.50 Aab$^{(-)}$	3,270 Ab	2.985 Ba$^{(-)}$
Control	-	38.9	83.25		3.285	

DNR: Distance between the 5th and 10th reproductive node. Means with negative and positive values are significantly different from the control, being inferior and superior, respectively, by Dunnet's test (*p≤0,05*). Means followed by different lowercase letters, in the same column, and uppercase letters, in the same row, are significantly different by Tukey's test (*p≤0,05*). [1/] Dose in mL of commercial product ha^{-1}.

Similar results have already been reported in the literature for fungicides from the chemical group of triazoles (e.g. propiconazole), as well as for the herbicide lactofen with regard to the effect of these products on the architecture of soybean plants (Rios, 2016; Pacentchuk et al. 2018). The shortening of the distance between the reproductive nodes of soybean is related to the physiological stress that these products provide to plants, also causing a reduction in size. Under severe stress, effects can be damaging to yield. Despite this, when there is recovery of the plants from intoxication imposed by these products, these morphological changes can result in advantages for the agronomic performance of the crop, such as less susceptibility to lodging (Rios, 2016).

Lactofen, 2,4-D amine and Grainset® provided a reduction in the size of soybean plants when compared to those in the control, regardless of whether they were applied at once or sequentially (Table 3). For propiconazole, reductions in plant height compared to the control without application were only observed when this product was used sequentially. In numerical terms, the greatest reductions in height of soybean plants were observed with the sequential application of lactofen and propiconazole.

In treatments containing imazethapyr, no differences in plant size were observed in relation to the control. Despite this, when comparing the effect of the single or sequential application of this herbicide, it appears that the plants that were subjected to two applications of this herbicide, had a taller size. The treatments with application of 2,4-D amine provided a reduction in the size of soybean plants in relation to the control, in the order of 11.70% and 10.65%, when applied at once or sequentially, respectively (Table 3).

The application of subdoses of 2,4-D amine in post-emergence of soybeans can increase the balance between auxin-cytokinin, since 2,4-D amine has the mechanism of action to mimic the phytohormone auxin. In this case, auxin is transported in a basipetal direction, and redistributed from the shoots to the roots of the plants through the phloem tissue (Taiz et al. 2017). In this sense, it is hypothesized that the plant may have invested in this phase in the development of its root system, and to a lesser extent in the aerial part, a fact that caused the reduction in the canopy growth of soybean plants treated with 2,4- D amine.

Some authors mention that certain products have a dose limit for use in the crop cycle, and that sequential applications, when exceeding these values, can cause irreversible damage to plants, which compromises soybean yield (Velini et al. 2010; Robinson et al. 2013). In this context, all the phytosanitary products evaluated, when used in sequential applications, provided a reduction in yield in relation to the control and also to the respective treatments in which they were applied only in the culture cycle. It is worth mentioning that in sequential applications. It is worth mentioning that Grainset® consisted of the treatment that showed the highest yield in relation to the other phytosanitary products used, when comparing their yields in sequential applications.

In this context, all the phytosanitary products evaluated, when used in sequential applications, provided a reduction in yield in relation to the control and, also to the respective treatments in which they were applied at once in the crop cycle. It is worth mentioning that Grainset® consisted of the treatment that showed the highest yield in relation to the other phytosanitary products used, when comparing their yields in sequential applications.

For propiconazole, reductions in yield compared to the control without application were only observed when this fungicide was used sequentially. It is inferred that this reduction in yield provided by propiconazole in sequential applications may be motivated by the fact that triazoles have a cumulative effect when sprayed on soybean plants, causing inhibition in the synthesis of gibberellin, which may negatively impact the yield of this crop (Pacentchuk et al. 2018).

For imazethapyr and lactofen, a reduction in yield was found in comparison with the control, even when these products were used in a single application in the soybean cycle. Possibly, this factor may be related to a greater sensitivity of the cultivar used in the experiment to these herbicides, since in the literature the selectivity of these herbicides for soybean crops has already been attested (Alonso et al. 2011; Alonso et al. 2013). The use of Grainset®, in a single application, did not show differences in grain yield when compared to the control.

Only the 2,4-D amine product, applied at the phenological stage V4, provided an increase in yield in relation to the control (Table 3). The increase in grain yield obtained with the single application of 2,4-D amine, compared to the control, was of the order of 8.21%. Possibly, the single application of 2,4-D amine in subdoses, provided morphological changes to soybean plants, favoring its architecture, a fact that consequently led to an increase in crop yield. Based on these results, the need for a study to better understand the effects of 2,4-D amine subdoses on soybean agronomic performance was seen.

Performance of subdoses of 2,4-D amine applied at different of soybean crop

For the response variables lodging, SPAD index, number of grains and pods per plant and mass of 100 grains, no significant effects of the evaluated factors were detected, demonstrating that the application of increasing subdoses of 2,4-D amine at different stages of soybean does not affect these morphological parameters (Table 4). Furthermore, it is noteworthy that none of the response variables analyzed had a significant effect on the interaction between the subdoses and application stages of 2,4-D amine.

Table 4- Summary of analysis of variance for response variables lodging (LOD), plant height (PH), relative chlorophyll index (RCI), number of branches per plant (NBP), root dry mass (RDM), number of reproductive nodes per plant (NRNP), number of pods with two (NP2) and three (NP3) grains, number of grains per plant (NGP), number of pods per plant (NPP), mass of 100 grains (M100G) and yield (YIELD). Rio Verde (Brazil), 2017/18.

Source of variation	DF	LOD	PH	RCI	NBP	RDM	NRNP
Stage	1	2.08^{ns}	206.6**	7.20^{ns}	2.80**	0.00000^{ns}	5.10**
Dose	5	1.48^{ns}	40.6^{ns}	2.79^{ns}	0.95*	0.00020*	1.27^{ns}
Stage *vs* Dose	5	1.73^{ns}	34.8^{ns}	2.88^{ns}	0.20^{ns}	0.00001^{ns}	0.20^{ns}
Factorial *vs* additional	1	0.10^{ns}	313.3**	4.00^{ns}	0.87^{ns}	0.00010**	0.12^{ns}
CV (%)		41.31	6.28	4.02	10.27	14.92	5.96
Source of variation	**DF**	**NP2**	**NP3**	**NGP**	**NPP**	**M100G**	**YIELD**
Stage	1	67.3^{ns}	22.0^{ns}	14.2^{ns}	22.6^{ns}	1.100^{ns}	410331^{ns}
Dose	5	67.6**	25.5*	555.9^{ns}	110.0^{ns}	0.700^{ns}	674278**
Stage *vs* Dose	5	26.4^{ns}	8.54^{ns}	240.4^{ns}	40.4^{ns}	1.081^{ns}	98342^{ns}
Factorial *vs* additional	1	60.3^{ns}	18.4^{ns}	818.1^{ns}	147.2^{ns}	0.872^{ns}	1058543**
CV (%)		13.50	17.44	13.03	13.68	3.63	9.37

**, *, ^{ns}, significant at 1 and 5% probability and non-significant, respectively, by F-test.

The application of increasing sub-doses of 2,4-D amine had a significant effect on root dry mass, number of side branches, number of pods with two and three grains and soybean yield (Table 4). In contrast, plant height, number of branches and number of reproductive nodes per plant, were influenced by the phenological stage of the plant at the time it received the application of 2,4-D amine. Finally, an effect was detected between the factorial and the additional treatment, composed of the control without application, for the response-variables of plant height, dry root mass and grain yield.

The application of 2,4-D amine, in almost all doses, interfered with plant height when applied at the V8 stage (Tables 5 and 6). Possibly because the application to plants at the stage V4 is carried out earlier, plants had a longer period to metabolize the product before reaching the reproductive phase, which may have contributed to the lack of differences in size at the time of harvest.

Table 5- Plant height, number of branches and reproductive nodes per plant depending on the stages of application in the soybean crop. Rio Verde (Brazil), 2017/18.

Stage	Plant height (cm)	Number of branches	Number of reproductive nodes
V4	82.2 a	6.1 a	13.9 a
V8	79.0 b	5.6 b	12.9 b

Means followed by different lowercase letters, in the same column, are significantly different by Tukey's test ($p \leq 0.05$).

The application of 2,4-D amine at the phenological stage V4, promoted an increase in the number of branches and reproductive nodes per plant, when compared to those that received application of this herbicide at the V8 stage (Table 5). Possibly, the application of this herbicide at an earlier stage may have provided a better redistribution of photoassimilates for the formation of reproductive nodes. This is common in experiments with the use of growth regulators (Buzzello et al. 2013; Rios, 2016). Furthermore, a hypothesis to explain the fact that at the V8 stage there were inferior results for these variables, it is stated that in late applications, there may not be enough time for the plants to change morphologically, because the influence of the preparation of the reproductive components (flowers) is more important for the direction of photoassimilates, in the source-sink relationship (Taiz et al. 2017).

The application of subdoses of 2,4-D amine provides an increase in the dry root mass in relation to the control, especially when the herbicide was used at the V8 stage (Table 6; Figure 2). The result can be explained by the mechanism of action that this product has (auxin mimic), since in subdoses, the herbicide can have a *hormesis* effect, in which auxin is a phytohormone responsible for stimulating root production, among other functions (Taiz et al.

2017). In general, more dense root systems can, in a second moment, promote an increase in the production of cytokinin, a hormone involved in the cellular differentiation of the aerial part (Muller and Leyser, 2011), which may contribute to greater formation of buds in lateral branches.

Table 6- Plant height, root dry mass and grain yield of soybean as a function of the application of subdoses of 2,4-D amine in two crop stages. Rio Verde (Brazil), 2017/18.

2,4-D amine (g a.i. ha^{-1})	Plant height (cm)		Root dry mass (g plant^{-1})		Yield (kg ha^{-1})	
	V4	V8	V4	V8	V4	V8
4.03	88.4	77.9$^{(-)}$	2.0	2.0	3,847	3,825
8.06	79.1	79.4	1.8	1.7	3,828	3,854
12.09	79.1	76.3$^{(-)}$	1.8	2.3$^{(+)}$	3,710	3,916
16.12	82.0	77.8$^{(-)}$	2.0	1.8	4,191$^{(+)}$	4,188$^{(+)}$
20.15	78.3	76.4$^{(-)}$	2.0	2.1$^{(+)}$	3,995	4,418$^{(+)}$
24.18	80.7	74.1$^{(-)}$	2.4$^{(+)}$	2.3$^{(+)}$	3,181	3,659
Control	88.5		1.5		3,349	

Means with negative and positive values are significantly different from the control, being inferior and superior, respectively, by Dunnet's test (*p≤0,05*).

The number of reproductive branches shows significant differences between treatments for dose and a quadratic behavior, reaching its maximum point at the dose 17.5 g a.i. ha^{-1} of 2,4-D amine (Figure 2). A higher number of branches allow greater points of bud insertion and, consequently, a better distribution of photoassimilates. This adjustment in the plant morphology allows better use of environmental resources, mainly light, enabling the increase in the photosynthetic rate, even when the light is not sufficient (Schwerz et al. 2019).

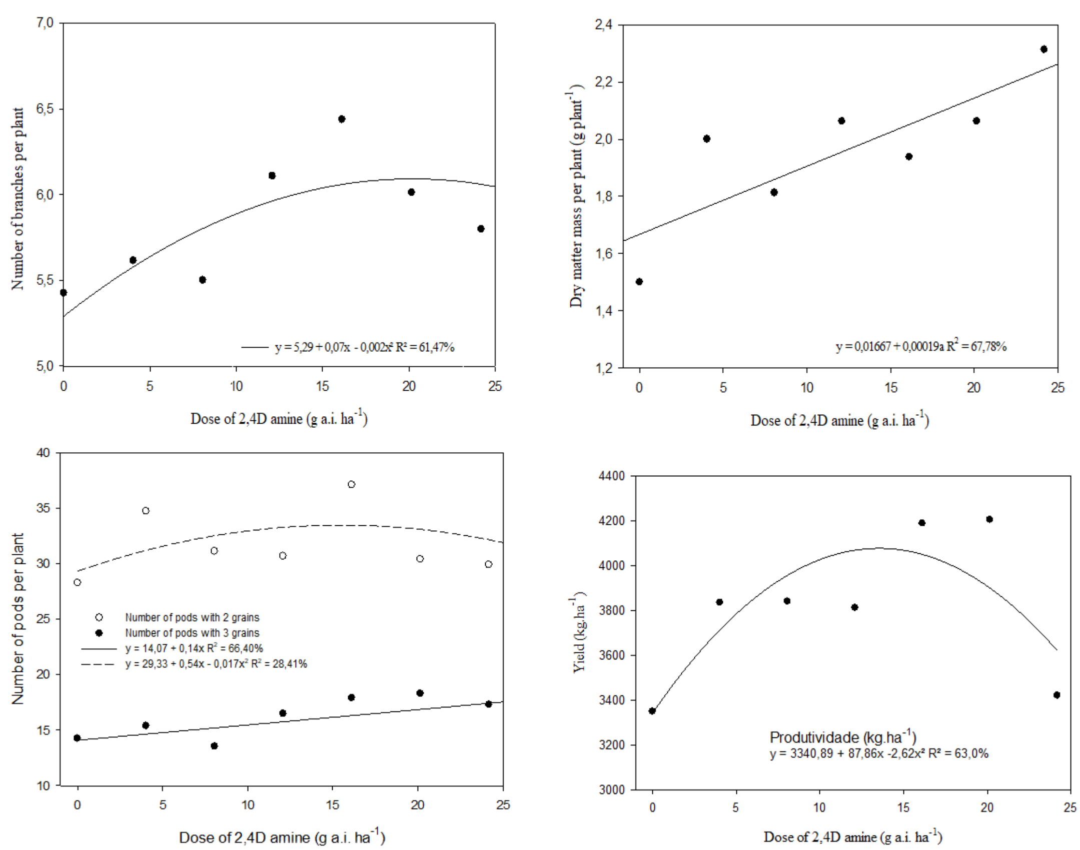


Figure 2- Variation in the number of branches, root dry mass per plant, number of pods with 2 and 3 grains per plant and yield according to the doses of 2,4-D amine in soybean. Rio Verde (Brazil), 2017/18.

For the evaluation of root dry mass, a linear response to the dose increase was found, providing significant increases in root growth (Figure 2). It is observed that the dose that resulted in the highest number of pods with two grains was 15.88 g a.i. ha^{-1} while the number of pods with three grains increased linearly with increasing dose.

The yield was not influenced by the stage of application and presented a quadratic behavior in relation to the dose of 2,4D amine, being the point of maximum yield reached when the dose of 16.78 g a.i. ha^{-1} was used (Figure 2). In addition, doses 16.08 g a.i. ha^{-1} (both stages) and the dose 20.15 g a.i. ha^{-1} (V8) showed higher yield than the control without application (Table 6).

According to results of experiments conducted by Johnson et al. (2012), there were also no injuries or impacts on yield at doses of up to 5 g a.i. ha^{-1} of 2,4-D amine, while this occurred only when doses higher than 78 g a.i. ha^{-1} were applied. In the results of Robinson et al. (2013), yield reductions were observed only in applications of doses above 70 g a.i. ha^{-1}, and doses like 35 g a.i. ha^{-1} did not affect soybean yield.

Conclusion

Among the phytosanitary products evaluated, 2,4-D amine had the greatest potential for use in soybean crops in order to obtain changes in plant architecture.

The reduction in the size of soybean plants was more pronounced with the application of 2,4-D amine at the V8 phenological stage. The application of 2,4-D amine at the V4 phenological stage produced a greater number of lateral branches and number of reproductive nodes than application at the V8 stage.

The application of increasing subdoses of 2,4-D amine, up to 24 g a.i. ha^{-1}, provides a linear increase in the root dry mass of soybean plants.

The application of 2,4-D amine increases the yield of soybeans, especially when doses varying between 16.12 and 20.15 g a.i. ha^{-1} are applied.

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Conflicts of Interest

All authors declare that they have no conflict of interest.

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