PHYTOSANITARY RISKS AND AGRONOMIC PERFORMANCE OF SOYBEANS ASSOCIATED WITH SPATIAL ARRANGEMENTS OF PLANTS

RISCOS FITOSSANITÁRIOS E DESEMPENHO AGRONÔMICO DA SOJA ASSOCIADOS A ARRANJOS ESPACIAIS DE PLANTAS

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ABSTRACT: Soybeans sowing in different plants' spatial distribution can influence the phytosanitary management of this crop and, consequently, impact on grains yield. This study was carried out to evaluate the effect of plants arrangements on infestation and control of caterpillars, the deposition of spray syrup as well as assess the agronomic performance of soybean cultivated in the Brazilian Cerrado. The assay was performed during two consecutive seasons in a randomized complete block design with four replications. Soybean cultivation was implemented in 0.50 m spacing between rows, crossed (0.50 m x 0.50 m), twin rows (0.25 m / 0.75 m), and narrow (0.25 m). In the reproductive stage of plants, both crossed and narrow arrangements showed higher caterpillars' incidence. There was a more evident risk of caterpillar incidence in arrangements that promoted better equidistance among plants. This risk was mitigated when taking into account both control and overlap of syrup, which could be incremented into inferior canopy with the enhancement of application rate. The increase in application rate from 75 to 150 L ha^{-1} promoted superior spray deposition volumes. Increases in grain yield was noted in the narrow arrangement.

KEYWORDS: Application technology. *Glycine max*. Phenotypic plasticity. Sowing systems. Yield components.

INTRODUCTION

Soybean is the most representative agricultural product in Brazil, which production system has evolved significantly. This could be observed in the National Challenge of Maximum yield elaborated by the Strategic Committee of Brazilian Soybean, in which elevated crop yields have been recorded. However, these rates are demanding preeminent input costs (CESB, 2017). Thus, this issue sparked reflection on the tradition system of production by farmers, technicians and researchers. Among the practices employed by the competitors, it is possible to note that certain cultivation techniques are common among the farmers exhibiting higher yield, for instance, the use of different plants arrangements in relation to traditional system, in which the crop is sown in 0.50 m spacing between rows.

The combinations of row spacing and plants density could be defined as plant arrangement; therefore, this represents how the plants are distributed in the area. Theoretically, the best arrangement is the one providing a uniform distribution of plants in the area, enabling better use of water, light and soil nutrients (ASSIS et al., 2014). It should be emphasized that modern soybean cultivars present higher precocity, an indeterminate growth habit and inferior size of trifoliate leaves, which are inserted in at sharper angles in the stem (RICHTER et al., 2014). These traits, distinct from the first lineages introduced in Brazil, are creating the necessity of alterations in plant distributions for soybean crop (SOUZA et al., 2010).

In general, Brazilian farmers, mainly in the Midwest region, adopt a row spacing between 0.40 and 0.50 m and population of 350,000 plants ha^{-1}. However, other types of distribution models have been observed in the field, such as crossed sowing. This was initially used in margins of cultivation areas as a compensatory manner of maneuvering sites failure and sowing outset. Seeds' distribution occurs in parallel rows, and posteriorly, a second sowing is carried out with rows forming angles of 90º in relation to first sowing procedure (LIMA et al., 2012).

Nevertheless, research outcomes obtained to date lead to an understanding that, in most cases, crossed arrangement incorporation does not provide significant increases in soybean yield. Moreover, this distribution denotes several economical and environmental disadvantages, such as increased fuel

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consumption and machinery use. Consequently, it is known that these drawbacks also result in higher levels of soil compaction (BALBINOT JÚNIOR et al., 2013). According to this author, another arrangement that has aroused researchers' interest is twin row sowing, often used in United States. In this method, there are greater light incidence and penetration of phytosanitary products in plants' canopy, enhancing photosynthetic rate, sanity and leaves longevity of the lower third, which can ultimately maximize grains yield (BRUNS, 2011).

Among the distinct plants arrangements, the narrow spacing has also been adopted. In this specific distribution, there is a reduction between row spacing. Moreover, depending on the crop and sowing period, some studies pointed out yield growth (BALBINOT JÚNIOR et al., 2013). Additionally, by having a quick closing between rows, this system enables a diminishment of soil water losses by evaporation (ÇALISKAN et al., 2007) and greater light interception at the beginning of plant development cycle (EDWARDS et al., 2005). Furthermore, this arrangement assists in controlling weeds (BIANCHI et al., 2010). Nonetheless, this may favor increases in crops' diseases severity, such as Asian rust (*Phakopsora pachyrhizi*) (LIMA et al., 2012).

Regardless the employed spatial arrangement, alterations in plants density could lead to an impact on arthropod-plant relation. The variation in the number of plants and distribution in the cultivation area modify the environment in which these are inserted, interfering especially in the intensity of solar rays that reach leaves of middle and lower thirds. As a result, this influence on the microclimate (humidity and temperature), which represents a preponderant fact for the development of a pest population (RODRIGUES, 2011). In this sense, reducing spacing between rows could concern not merely pests' occurrence but also interfere in traits related to application technology (MADALOSSO et al., 2010). Application technology is related to the efficiency in which the application syrup is deposited on the biological target at the time of spraying (BAESSO et al., 2014). Changes in plant distribution may interfere with this process, which may be impaired or maximized as a function of the spatial arrangement adopted in soybean sowing.

Researches focused on plants spatial distribution and their influence on arthropod-pest population as well as phytosanitary syrup deposition are scarce in literature. Thus, there is a need to evaluate the interaction between plants' arrangements, application technology for pest control and soybeans yield. Farmers can use the results of these researches as tools for the crop management, since it can favoring economic sustainability of this agricultural activity.

Therefore, the objective of this work was to assess the effect of soybeans cultivation in different spatial arrangements of plants and their influence on incidence of caterpillars, and application technology.

MATERIAL AND METHODS

The experiments were installed in a field of Rio Verde city, in Goiás State, Brazil, 17°47'53'' S; 51°55'53'' W; at 756 m of altitude in the agricultural period of 2013/14 and 2014/15. According to Köppen classification, the climate for the locality in which the experiments were carried out is considered Aw type, characterized by a tropical climate with dry season and intense rainfall during the summer in relation to the winter. Data of rainfall and mean air temperature during the experiments are shown in Figure 1.

Experimental area was cultivated under no-tillage system with maize as predecessor crop. According to literature, the soil is classified as Red Latosol (Dystroferric) (EMBRAPA, 2013). The analysis of soil collected in depth from 0 to 0.20 m denoted the following physicochemical characteristics: 24.9 g dm^{-3} of organic matter; 5.5 pH in $CaCl_2$; 5.5 mg dm^{-3} of P; 4.95 $cmol_c$ $dm^{-3}$of H+Al; 0.51 $cmol_c$ dm^{-3} of K; 3.18 $cmol_c dm^{-3}$ of Ca; 1.52 $cmol_c$ dm^{-3} of Mg; 51.29% of base saturation and 10.16 $cmol_c$ dm^{-3} of CTC; 69, 10 and 21% of clay, silt and sand respectively (significantly clayey texture).

An experimental design of randomized complete blocks with four replications was utilized in both cultivation periods (2013/14 and 2014/15). Treatments were constituted by the following plant arrangements: wide (traditional with 0.50 m between sowing rows); crossed (0.50 m between rows and 0.50 m between rows perpendicular to the first sowing); twin rows (0.25 m / 0.75 m spacing within and among double rows, respectively) and narrow (0.25 m between rows). Plots were dimensioned at 8.0 m in length and width, denoting equal distance from each other in order to hinder pests' displacement. The useful area was obtained disregarding 1.5 m of rows extremities and 3.0 m from each side of the plot, thus presenting 10 m^2.

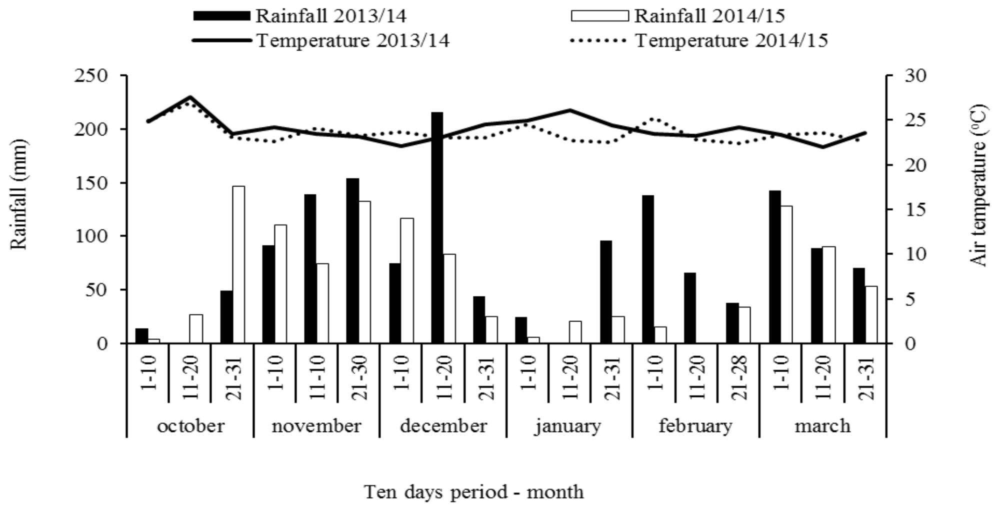


Figure 1. Rainfall and average air temperature during the conduction of the experiments in 2013/14 and 2014/15.

In both experiments, a burndown application was performed to control the weeds ten days before sowing through the utilization of glyphosate herbicide (1,200 g e.a. ha^{-1}). The soybean cultivar used was BMX Potência RR^{TM}, which exhibits indeterminate growth habit and maturation group 6.7 for the region where the assay was performed. Populations of 450.000 and 400.000 plants ha^{-1} were, respectively, employed for 2013/14 and 2014/15 season. Seeds were treated with products containing thiamethoxam, fipronil, pyraclostrobin and thiophanate-methyl (105; 60; 6 and 54 g, correspondingly for each 100 kg of seeds) and liquid inoculants composed of Semia strains 5079 and 5080 in concentration of 6 x 10^{9} colony forming units in the proportion of 50 mL to 50 kg of seeds.

Seeds were sown on November 10, 2013 and October 30, 2014, respectively. For this, a seed-fertilizer of continuous seed distribution was utilized, equipped with seven eccentric double discs, spaced with 0.25 m, regulated to obtain a population of 600.000 plants per hectare. At the occasion, fertilization was performed by applying sine grooves with 450 kg ha^{-1} of formulated fertilizer 02-20-18 (NPK). In the cross-sowing, 225 kg ha^{-1} was applied for each sowing direction. Ten days after seedlings emergence (DAE), manual thinning was carried out to adjust the spacing and plant populations of each treatment.

After plants emergence, a weekly monitoring of caterpillars was started. The cloth strike method with 1.0 m long (one sowing row) at four different points per plot was used. Since both narrow and crossed arrangements exhibit twice as many sowing rows, and consequently half the number of plants per linear meter, a multiplication factor of two was attributed as a manner of not underestimating the insects' quantity per area. In order to adopt caterpillar control measures, the occurrence of these insects was considered in the traditional arrangement with 20 caterpillars larger than 1.5 cm per linear meter of sowing and defoliation of 15% in the reproductive stage (EMBRAPA, 2011). The evaluation of caterpillar infestation was performed only in 2013/14 season due to the insignificant incidence of the pest in the second year of experiment (2014/15).

In the 2013/14 cultivar, the insecticide teflubenzuron (18 g i.a. ha^{-1}) was applied at 57 DAE aiming to monitor caterpillars. At 64, 71 and 78 DAE the following products were incorporated: spinosad (24 g i.a. ha^{-1}), lufenuron + profenofos (25 + 250 g i.a. ha^{-1}) and chlorantraniliprole (16 g i.a. ha^{-1}), respectively. Crops' phytosanitary management related to control of weeds, diseases and other pests that affected the trial area was carried out according to crops technical needs.

In both crops, syrup deposition was evaluated by the application of a tracer (FDC blue bright food coloring), which was dissolved in water at concentration of 3 g L^{-1} (PALLADINI et al., 2005). Syrup was applied at 0.50 m of plants height through the spraying equipment mounted using AXI 11002 flat fan spray tips spaced with 0.50 m, at a working pressure of 275.8 kPa and application rate of 150 L ha^{-1} (2013/14). In the second agricultural period, by changing only the displacement velocity, two application rates were tested: 75 and 150 L ha^{-1} (12 and 6 km h^{-1}, respectively), applied in continuous bands (half of the plot for each) utilizing the same spraying equipment of the prior harvest.

Assessments were performed at the grain filling stage (R5) due to penetration difficulty of phytosanitary syrup in the different plant arrangements. It is noteworthy that this stage was favorable to certain caterpillars' species to attack e.g. *Chrysodeixis includens*. In the application, the minimum operating climatic conditions observed through a portable thermo-hygro-anemometer positioned 0.50 above the crop were: wind speed between 3 and 10 km h^{-1}, air relative humidity above 55% and ambient temperature below 30ºC.

After 30 minutes of application, period for syrup drying, a leaf of each third (lower, middle and higher) was collected in ten plants randomly chosen in a useful area of each plot. Regarding the traits of twin rows arrangement (two spacing between sowing rows), the collection was duplicated in the lower thirds for the leaves inside and between twin rows. Subsequently, mean calculation was performed. For every treatment, leaves were placed in plastic packages previously identified, and forward to laboratory. These samples were washed with 100 mL of distilled water, after 30 seconds a shaking process was executed to remove the dye. Rinse volume was posteriorly analyzed in a spectrophotometer at 630 ηm for absorbance reading.

Absorbance values, when related to different concentrations of Brilliant Blue dye, enabled the establishment of a linear model. In this study, the following model was applied: (y=0.027 + 0.179x; R^2 = 99.6), used to indicate dye concentration (mg L^{-1}) captured by the target during application (SCUDELER et al., 2004). By correlating dye concentration in the sample wash solution with that obtained with the spray solution, it was possible to establish the volume captured through the target by means of the following equation: Vi = (Cf x Vf) / Ci, where:

Vi= volume captured by target (mL);

Cf= dye concentration in the sample, detected by spectrophotometer in absorbance and transformed to mg L^{-1};

Vf= volume of sample dilution (100 mL);

Ci= dye concentration in the sample (3.000 mg L^{-1}).

Foliar area of leaves collected was quantified in each third of the plant by means of a portable laser measuring device. Syrup amount (µL cm^{-2}) was achieved by the division of syrup volume deposited by measured leaf area.

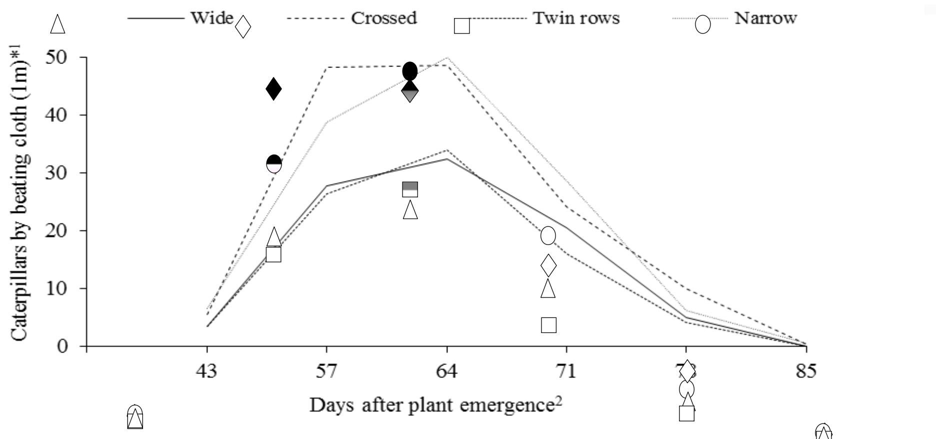
Traits evaluation of syrup deposition in the plants' canopy was carried out at the same time on the following day exclusively in the first year (2013/14). Four stems were fixed with three basal supports; therefore, their positioning represented the thirds evaluated. In the last two, pre-identified moisture-sensitive paper cards were settled. Moreover, after checking the minimum operating climatic conditions, merely water was applied, following the technical procedure of the prior test. Once again, for the twin rows arrangement, this activity was doubled, considering the existence of two different spacing (0.25 m / 0.75 m). Afterwards, the mean calculation was executed. After 30 seconds of application, the cards were collected and packed in absorbent paper. Posteriorly, these were scanned and assessed with the aid of Gotas 2.2 software (CHAIM et al., 2006) for evaluation of droplet density cm^{-2}, deposition coverage (%) and volumetric mean diameter (µm).

The first harvest was performed on February 19, 2014, while the second occurred on February 12, 2015. The following characteristics were evaluated in fifteen continuous plants in plots' useful area: heights of both plants and first pod insertion; measurement from the soil to the end of the last floral raceme and first pod insertion, respectively. Number of both pods per plant and grains per pod; mass of 1000 grains (weighing of thousand grains with moisture correction to 13%); and grains yield (threshing of every plants in the useful area, with posterior grains weighing and moisture correction to 13%).

Data of caterpillar infestation and these insects' control as well as syrup deposition, when needed, were transformed and submitted to analysis of variance. Whether the outcomes denoted statistical significance, treatments' means were compared by Tukey test (P≤0.05). Data related to morphological traits and yield components were submitted to a homogeneity verification of residual variances in individual analyzes. Afterwards, the analysis of joint variance was carried out. Moreover, when significance was found for determined variation source, a Tukey test at 5% of probability was performed to compare treatments means.

RESULTS AND DISCUSSION

In the first agricultural period (2013/14), the narrow and crossed arrangements were more favorable to caterpillar infestation when compared to wide and twin rows distributions at 57 and 64 DAE (Figure 2), which would justify the control anticipation. Probably, the greater number of caterpillars in those arrangements could be attributed to better equidistance of plants, which in turn, provided the fastest interaction between rows at the beginning of the reproductive period. This has caused a microclimate more favorable to Lepidoptera occurrence (SANTOS et al., 2017).



* Means (transformed in $\sqrt{x+0.5}$) represented by markers of equal color and same DAE, were note different according to Tukey test ($P \leq 0.05$). [1] Total caterpillars (%): *Chrysodeixis includens*: 93.6; *Anticarsia gemmatalis*: 4.1; *Spodoptera* sp.:2.1; *Heliothinae* sp.: 0.2. [2] CV (%) in increasing DAE: 43 (4.4); 57 (7.0); 64 (6.4); 71 (9.9); 78 (7.9); 85 (2.1).

Figure 2. Mean number of caterpillars by meter of cloth strike method in different special arrangements of soybean plants.

Thus, this was an outcome opposite to those portrayed by Carvalho (2014), who reported that plants in traditional sowing and in twin rows suffered superior caterpillar infestation, probably due to more significant physiological conditions observed in these distributions compared to crossed and narrow arrangements. It is noteworthy the values were multiplied by factor two for the evaluation of pests in the latter two arrangements. Therefore, attention should be taken to monitor insects when soybean is cultivated in distinct plant distributions in relation to the wide one (0.50 m between rows). Underestimation of pests' quantity may influence the control level, causing damage to rural producers.

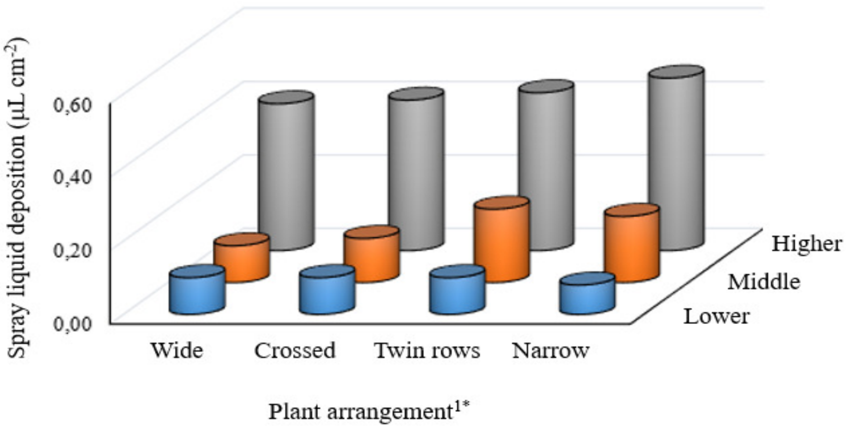
According to Rodrigues (2011), the population dynamics of the following pests, *Aphis gossypii*, *Alabama argillacea*, *Spodoptera eridania*, *Chrysodeixis includens* and *Heliothis virescens,* were not found to be significantly different on cotton crops when cultivated either in denser or traditional arrangements. On the other hand, conventional cotton crops, such as Delta Opal™ suffered more defoliation in the narrow distribution in relation to the traditional cultivation, while the *Bt* (NuOPAL™) crop exhibited none difference in the defoliation percentage independently of the adopted plant arrangement (ROMANO, 2012).

Cultivation of soybean in narrow spacing could have a significant impact on both behavior and control of insects. In this arrangement, there was a faster closure between the rows, with a reduction of sun rays' incidence in plants' inferior thirds, influencing on both microclimate and arthropod-plants relation. Thus, it is essential to assess pests' behavior in this arrangement intending to avoid underestimation of insects' number (WRIGHT et al., 2008). In addition, an important technological tool to minimize the damage caused by Lepidoptera insects in denser soybean arrangements would be the utilization of transgenic materials, which present efficacy to control caterpillars, mainly *C. includens.*

At 57 DAE, the insecticide teflubenzuron was applied due to much of the defoliation observed was resulted from an attack of *A. gemmatalis.* One week later, there was an increase in *C. includens* number. However, the chemical control of this plague in soybean cultivation has been hampered due to this species' trait of being more tolerant to insecticides dosages that are usually recommended for *A. gemmatalis* control. In addition, several active principles currently registered for pest control are being show as inefficient. Moreover, the execution of application operation is also being carried out in an unsatisfactory manner (AVILA; SOUZA, 2015).

Therefore, at 64 DAE a new insecticide application (spinosad) was performed. Consequently, the number of caterpillars in the next evaluation (71 DAE) did not differ significantly between plant arrangements. This outcome suggests that the environments established by distinct distributions were equivalent, regarding phytosanitary control, since *C. includens* has a preference to attack the middle third of plants. This can also be verified in the successive assessment periods, in which treatments denoted similar behavior with lufenuron + profenofos application at 71 DAE and chlorantraniliprole at 78 DAE.

Although there were closures between extemporaneous rows of different plants' arrangements, no significant discrepancies were noted in the syrup volume deposited in canopy extracts (Figure 3). Moreira (2013) perceived similar fact, noting that wide, twin rows, narrow and crossed arrangements as well as the air assistance near to spray bar did not influence on levels of syrup deposition in soybean crop.



* Means represented by cylinders, in equal leaf extract and color did not differ by the Tukey test ($p \leq 0.05$). [1] CV(%): higher (19,2); middle (43,1); lower (31,8).

Figure 3. Mean values of deposited syrup volume in three leaf extracts in different distributions of soybean plants with an application rate of 150 L ha^{-1}.

Once the same plant population was adopted in different distributions, compensation could have occurred in plants development as well as rows closure due to the phenotypic plasticity of soybean plants. Besides this, plant population, row spacing and soil fertility may also influence this trait (VASQUEZ et al., 2008). The absence of significance between treatments could also be justified by the recommended evaluation stage (R5). In this, soybean are presenting the maximum foliar area, independently of treatments.

Moreover, plants distributed in crossed and narrow arrangements probably benefit using the spaces with greater efficiency due to inferior intraspecific competition attributed to major distance of plants in the sowing row. In contrast, the models in which plants are settled in spacing between more distant rows compete in more elevated intensity, because there are more plants in the sowing row. However, soybean leaves exposure to major contact with pulverized volume can be considered an advantage.

Evaluations of spraying syrup deposition were performed at soybeans filling stage, period in which spraying is normally intensified to control pests and diseases. The majority of academic works of syrup deposition are performed in stages of pre and full flowering due to the preventive control of diseases (FARINHA et al., 2009; MOREIRA, 2013). Nonetheless, the phytosanitary control at a more advanced stage is notoriously more complex, since the majority of cultivars present a denser canopy. In addition, higher occurrence of pests can be observed in latter development stages as stated ultimately with *C. includens* in Midwest region. In this context, characteristics related to application technology, such as droplets density, coverage percentage and mean volumetric diameter did not differ for the arrangements of assessed plants and extracts (Table 1).

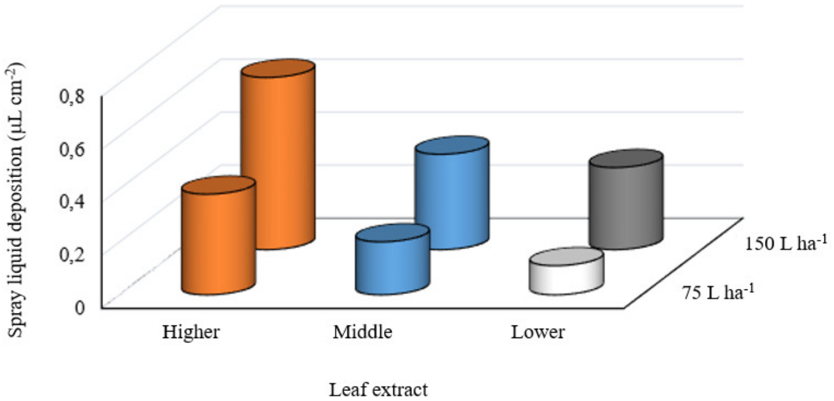
Table 1. Mean values of droplets density, coverage and mean volumetric diameter (MVD) with application rate of 150 L ha^{-1} in different plants arrangements.

Arrangements	Middle extract[1]			Lower extract[a]		
	Droplets (cm^{-2})	Coverage (%)	MVD (μm)	Droplets (cm^{-2})	Coverage (%)[2]	MVD (μm)
Wide	78.3	12.9	345.2	31.5	3.1	250.3
Crossed	81.2	10.4	291.8	39.8	4.4	258.1
Twin rows	106.2	12.2	311.0	37.7	4.6	248.5
Narrow	69.8	10.4	289.4	29.1	2.8	251.3
CV(%)	11.1	22.5	12.1	13.5	26.2	6.5

[a] Data transformed in: $\sqrt{x + 0.5}$x. [2] Means followed by the same letter in the column did not differ according to the Tukey test ($P \leq 0.05$).

As the droplets advanced to the lower leaf extract, a diminishment in their size and quantity could be noted. Consequently, there were inferior coverage of the target, reaching less than 10% in lower extract of soybean plants as observed by Wolf and Daggupati (2009). These authors highlighted that thinner droplet provided better coverings in lower parts of plants, which was also an outcome found in this work. In addition, droplets' spectrum should present a volumetric median diameter sufficient to reach the target, without evaporation of the spray syrup containing the product (YU et al., 2009).

In both foliar extracts, the number of droplets cm^{-2} deposited in different arrangements was superior to 20, being in agreement with values recommended by Matthews (1992). Regardless of plants distribution, application rate variation did not influence on the volume of syrup deposited in higher extracts (Figure 4). However, the minor application rate led to a reduction in the volume of deposited syrup into plants inferior extract. Generally, the increased volume of syrup provides greater depositions in different extracts of soybeans plants (BOSCHINI et al., 2010), as well as common beans (LIMBERGER, 2006) regardless of the spray tip utilized. It is noteworthy that the larger the row spacing is and lower the plant population is, more elevated would be droplets penetration, since the enhancement in spray volume augments the droplets quantity cm^{-2} (FIORIN, 2009).



* Means represented by cylinders, in equal leaf extract and color, were not considered different by Tukey test ($p \leq 0.05$). CV1, 2 and 3 (%) higher extract: 23.8; 55.0 and 24.9 / middle extract: 24.7; 125.8 and 33.7 / lower extract: 32.4; 38.1 and 25.8.

Figure 4. Mean values of syrup deposited volume cm^{-2} with application rates of 75 and 150 L ha^{-1} in three leaf extracts (higher, middle, lower) of soybean plants.

The increasing search for greater autonomy of sprayers in extensive areas of Brazilian Midwest leads producers to adopt minor application rates. Considering the specific target to be controlled, larger areas covered by the increased application rate can provide preeminent operation efficiency, especially for contact products. In contrast, there is less application autonomy and, consequently, more elevated financial costs. However, the application in smaller volumes of syrup requires technical improvement because fewer drops could be produced together with the elevated concentration of active principle. Consequently, this could lead to major environmental risk.

Regarding the agronomic performance of soybean plants, factors' effects (year of plants' arrangement) were verified as well as their interaction with every trait evaluated, except for the number of grains per pod (Table 2). This trait usually concerns to an intrinsic manner for each utilized plant arrangement.

Plants height was not influenced by the effect of arrangements as described in a study developed by Carvalho (2014). Nonetheless, there was interaction between variation sources (year and arrangement). Generally, the plant population effect is observed for the aforementioned trait with absence of significance for the spacing between rows (COSTA, 2013). Moreover, this morphological characteristic is fundamental for the recommendation of crops in a certain region. Considering that, the desirable plant height is from 70 to 80 cm to avoid lodging issues and facilitate mechanized harvest (SEDIYAMA, 2009).

First pod height in the first year was, on average, superior to values achieved in the second year. Probably, this can be justified by the higher plant population adopted in 2013/14 season, resulting in high initial growth and, consequently, higher first pod height as observed by Mauad et al. (2010) in works with plant arrangement. Comparing the distribution models, the narrow provided smaller pod insertion in relation to the traditional one. This could be attributed to a wider distance of plants in the row, which diminishes competition for light, since this trait denotes negative correlation with light incidence in canopy' lower layer (ZABOT, 2009). In the wide arrangement, the auto-shading of plants in the sowing row occurred beforehand in relation to narrow model due to the more elevated quantity of plants in the row.

Table 2. Mean values of morphological traits, yield components and grains productivity in different arrangements of soybean plants.

Harvest	Plant arrangements				Average
	Wide	Crossed	Twin row	Narrow	
	Plant height (cm) - CV(%) = 7.0				
2013/14	75.4 Aa	79.9Aa	73.6 Aa	82.5 Aa	77.9
2014/15	77.6 Aa	77.1Aa	81.5 Aa	71.0 Ab	76.8
Average	76.5	78.5	77.5	76.7	
	The first pod height (cm) - CV(%) = 8.9				
2013/14	18.3	19.0	17.7	16.5	17.9 a
2014/15	15.4	13.8	14.6	13.0	14.2 b
Average	16.8 A	16.4 AB	16.1 AB	14.7 B	
	Number of pods per plant - CV(%) = 10.5				
2013/14	21.9 Ab	19.0 Ab	17.8 Ab	22.3 Aa	20.3 b
2014/15	27.8 Aa	29.7 Aa	26.9 Aa	20.6 Ba	26.3 a
Average	24.9 A	24.4 A	22.3 A	21.5A	
	Number of grains per pod - CV(%) = 5.2				
2013/14	2.5	2.4	2.4	2.5	2.4
2014/15	2.6	2.5	2.5	2.6	2.5
Average	2.5	2.5	2.4	2.5	
	Thousand grain weight (g) - CV(%) = 7.0				
2013/14	117	118	117	116	117 a
2014/15	97	92	98	110	99 b
Average	107	105	107	113	
	Grain yield (kg ha^{-1}) - CV(%) = 8.6				
2013/14	2.685	2.479	2.580	3.025	2.692 a
2014/15	2.544	2.241	2.284	2.609	2.419 b
Average	2.615 AB	2.360 B	2.432 B	2.817 A	

* Means followed by the same letter, lower case and upper case in the column on the line, did not differ by Tukey test ($p \leq 0.05$).

Pods' quantity per plant differed among arrangements in the 2014/15 season with superior values for wide, crossed and twin rows. Among the agricultural years, these distribution models provided greater number of pods in the second year, being resulted from the smaller population of employed plants, fact already highlighted by other authors (RAMBO et al., 2004; VASQUEZ et al., 2008). According to Mauad et al. (2010), the soybean cultivated in inferior plant populations enables higher pod production and increasing branches' quantity, which determines preeminent node production potential, as a result, higher numbers of pods per plant. Moreover, it is believed that the equidistant distribution of BMX Potência RR^{TM} plants in the narrow arrangement had, the lower will be the influence on environment with noticeable uniformity in the growth when compared to other distribution models.

Regarding mass of one thousand grains, it was verified greater volume on the first agricultural year. This can be attributed to more regular distribution of rainfall in the soybean pod filling period, favoring the transport of photoassimilates to grains. It is known that the occurrence of water deficits in this phase leads to a reduction of grain mass and, consequently, a decrease in grain yield (RAMBO et al., 2002). On the other hand, the major number of pods in wide, crossed and twin row arrangements during the second agricultural period resulted in both inferior mass of thousand grains and lower yield. In addition, there was a minor quantity of rainfall during the soybeans filling period, which also compromised the productivity yield.

Narrow distribution model was more productive than both crossed and twin row. In the cultivation conditions of South region, for instance, this model can be executed, considering the spacing regulations of winter crops. Nevertheless, outcomes from other researches registered more elevated productivities when the crossed arrangement was incorporated (LIMA et al., 2012; FIORESE, 2013). This also occurred even considering the need to double the sowing operation and others disadvantages, such as soil compaction. Likewise, studies have shown that twin rows arrangement has not provided significant differences in grains productivity (SCHEREN, 2013; PROCÓPIO et al., 2014), which turns the cultivation unfeasible.

CONCLUSIONS

In equal population, both narrow and crossed arrangements favored caterpillars' infestation. Plants arrangements presented neither influence on caterpillars' control nor on syrup deposition.

Inferior volumes of syrup application led to a decrease in the coverage of soybean crop inferior stratum. Cultivation of soybean in narrow spacing provided higher productivity compared to crossed and twin rows arrangements.

RESUMO: A semeadura da soja em diferentes distribuições espaciais de plantas pode influenciar no manejo fitossanitário da cultura e consequentemente impactar na produtividade de grãos. Este estudo foi conduzido para avaliar o efeito de arranjos de plantas na infestação e controle de lagartas, deposição de calda pulverizada e no desempenho agronômico da soja cultivada no Cerrado brasileiro. Por dois anos agrícolas consecutivos, conduziu-se um ensaio de campo em delineamento de blocos casualizados com quatro repetições, com o cultivo da soja em espaçamento 0,50 m de entrelinhas de semeadura, cruzado (0,50 m x 0,50 m) em fileiras duplas (0,25 m / 0,75 m) e adensado (0,25 m). Em estádio reprodutivo das plantas, arranjos em linhas de semeadura adensadas e cruzadas foram superiores quanto a incidência de lagartas. Em igual população, há maior risco de incidência de lagartas em arranjos que proporcionem melhor equidistância entre plantas. Este risco é minimizado devido a igualdade de controle e sobreposição de calda, a qual pode ser incrementada no dossel inferior com aumento da taxa de aplicação. O aumento da taxa de aplicação de 75 para 150 L ha^{-1} promoveu aumento na deposição no terço inferior das plantas. O arranjo em linhas adensadas mostra-se promissor para cultivo de soja.

PALAVRAS-CHAVE: Tecnologia de aplicação. *Glycine max*. Plasticidade fenotípica. Sistemas de semeadura. Componentes do rendimento.

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