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Soybean performance in grouped and conventional sowing with pneumatic seeder at different operational speeds

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ABSTRACT

Conventionally, soybean sowing is carried out by distributing the seeds individually and equidistantly along the sowing furrow. An alternative is the grouped dosage and distribution of seeds, just rearranging them. The aim of this work was to evaluate the agronomic characteristics of soybean sown with a grouped and conventional seed metering disc in a pneumatic seeder at different operating speeds. The experimental design adopted was completely randomized (CRD) under a 2 x 3 factorial scheme, with two spatial sowing arrangements, grouped and conventional, and three sowing speeds, 4.5; 5.2 e 6 km h^{-1}, resulting in six treatments with four repetitions each. The results show a productive increase between 20.7% and 39.9% for the grouped arrangement at speeds of 5.2 and 4.5 km h^{-1}, respectively. The higher sowing speed, limits the grouping of seeds to the grouped arrangement.

Keywords: *Glycine max*, Spatial arrangement, Agronomic characteristics.

Desempenho de soja em plantio agrupado e convencional com dosadores pneumáticos

RESUMO

Convencionalmente a semeadura da soja é realizada distribuindo as sementes de forma individualizada e equidistante ao longo do sulco de semeadura. Uma alternativa é a dosagem e distribuição agrupada de sementes, apenas rearranjando-as. O objetivo do trabalho foi avaliar as características agronômicas da soja semeada com disco dosador de sementes agrupado e convencional em uma semeadora pneumática sob diferentes velocidades operacionais. O delineamento experimental adotado foi o inteiramente casualizado (DIC) sob esquema fatorial 2 x 3, sendo dois arranjos espaciais de semeadura, agrupado e convencional, e três velocidades de semeadura, 4,5; 5,2 e 6 km h^{-1}, perfazendo seis tratamentos com quatro repetições cada. Os resultados evidenciam incremento produtivo entre 20,7% e 39,9% para o arranjo agrupado nas velocidades de 5,2 e 4,5 km h^{-1}, respectivamente. A maior velocidade de semeadura limita o agrupamento de sementes para o arranjo agrupado.

Palavras-chave: *Glycine max*, Arranjo espacial, Características agronômicas

1. Introduction

According to Bertelli et al. (2016), the success of the operation depends on specific knowledge related to plantability, a concept described by the authors as the deposition of seeds at the correct depth and spacing along the seed furrow, including knowledge of the seeder, soil preparation, culture, human resources and information technology. For the authors, ignoring any of these factors can compromise the crop's productive potential.

The spatial arrangement of grain crops is basically obtained in the sowing operation, and may vary depending on the density of deposited seeds, distance between lines and geometric arrangement between lines, such factors contribute to the arrangement and development of plants during growth, and may alter productive performance (SILVA et al., 2015). Correia et al. (2020) state that for soybean sowing the speed of 4.5 km h^{-1} provides a higher index of acceptable spacing and a lower index of faulty and double spacing, when compared to the speeds of 6.2 and 8.2 km h^{-1}.

Balbinot Junior et al. (2015) and Werner et al. (2016) mention that different sowing arrangements can interfere in the competition for available natural resources, which can alter the development of soybeans and the closing of spaces between rows, height and bracing, incidence of weeds, pests and diseases, penetration of spray droplets with pesticides, plant lodging and quality of grains harvested.

According to Balbinot Junior et al., (2018), grouped sowing of soybean is an alternative spatial arrangement for the crop. The technique consists of the longitudinal distribution of groups of seeds in the furrow together, with the possibility of varying the number of seeds per group and the distance between the groups. One of the ways of grouping plants described by Santos et al. (2018) is the linear increase in the spacing between seeds for each seed added to the group, that is, the distance between groups depends on the number of seeds present in each group.

The grouped sowing method aims, according to Balbinot Junior et al. (2018), to increase yield, induce lateral branching, increase the penetration of pesticides in the canopy and facilitate the emergence of seedlings, especially in conditions of surface sealing and soil compaction. The aim of this work was to evaluate the agronomic characteristics of soybean sown with a grouped and conventional seed metering disc in a pneumatic seeder at different operating speeds.

2. Material and Methods

The experiment was conducted during the agricultural year 2019/2020, in a soybean production area, located in the municipality of Unaí/MG under the coordinates (16°34’43.8” S; 47°10’02.7” W). According to Köppen's classification, the region's climate is of the Aw type, characterized as tropical with a hot and rainy season between months of October and April, and dry between May and September. The soil in the region is classified as Dystrophic Red Latosol, according to EMBRAPA (2013).

The experiment was sown in strips, in which each strip was composed of a random speed and sowing arrangement, making up a completely randomized design (CRD) under a 2 x 3 factorial scheme, with two spatial sowing arrangements (conventional and grouped) and three sowing speeds (4.5, 5.2 and 6 km h^{-1}), accounting for six treatments with four repetitions each, resulting in 24 experimental plots. In each experimental plot, a useful area of 25m^2 was defined, where all data collection and evaluations were carried out.

The treatments were identified as T1: conventional sowing at 4.5 km h^{-1}; T2: conventional sowing at 5.2 km h^{-1}; T3: conventional sowing at 6 km h^{-1}; T4: grouped sowing at 4.5 km h^{-1}; T5: grouped sowing at 5.2 km h^{-1}; T6: grouped sowing at 6 km h^{-1}. For sowing, a John Deere® seeder-fertilizer, model JD2122 CCS was used, configured with 20 sowing units spaced 0.5 m apart, equipped with pneumatic-type metering mechanisms, rod-type fertilizer furrower mechanisms and furrower mechanisms for seeds, double disc type in “V” – Walking SystemTM. A John Deere® tractor, model 7225J, 4x2 TDA, with nominal power of 165.6 kW (225hp) was used to drive the seeder-fertilizer.

The experiment was sown in a no-tillage system, with the spontaneous vegetation and residual straw from the previous soybean crop being dried 30 days before sowing with the herbicides DMA (2,4-D, dimethylamine salt 806 g L^{-1}), Zethamaxx (Imazetapir 212 g L^{-1} + Flumioxazine 100 g L^{-1}) and Roundup Original DI (Glyphosate 445 g L^{-1}), at recommended doses: 1.5; 0.4 and 2.5 L ha^{-1}, respectively.

The fertilizer used was monoammonium phosphate (MAP), at a dosage of 150 kg ha^{-1}. Soybean seeds used were cultivar BRS 7980, sown with a distance between rows of 0.5 m, sowing density of 12 seeds per meter. For both arrangements, the seeder was previously set to deposit the same number of seeds, changing only their conformation. Seeds were treated before sowing with a specific fungicide and insecticide for the crop, biological agents: *Trichoderma asperellum, Bacillus subtilis, Azospirillum brasiliense*, *Bradyrhizobium japonicum* and micronutrients: cobalt, molybdenum and nickel.

After treated and dried, 7 g of graphite kg^{-1} seed was added. Treatments T1, T2 and T3 were sown using conventional seed metering discs (Figure 1A), with 36 holes of 4.7 mm in diameter each, arranged one by one, near the edge of the disc, making a sequence (row) of holes. Treatments T4, T5 and T6 were sown using Scherer® seed metering discs, model JDS-SA3645 "grouped soy" (Figure 1B), with 36 holes of 4.5 mm in diameter each, separated into groups of holes arranged radially from the center to end of the disk, making a total of nine groups with four holes each per disk, explaining the fact that groups with four seeds were used.

The "grouped soy" disc allows the dosage of four seeds simultaneously, placing the plants in the field as shown in Figure 2. The response variables of the experiment were: longitudinal distribution of seeds, longitudinal distribution of seed groups, emergence speed index, number of pods per plant, mass of a thousand grains, grain yield.

The evaluation of the longitudinal distribution of seeds was carried out exclusively for the conventional arrangement, according to the ABNT (1994) standard, measuring the spacing between the plants contained in the useful area of each plot. From this, the distances between plants were classified, being considered acceptable when the seeds were between 0.5 and 1.5 times the desired reference spacing for sowing (Xref), spacing smaller than 0.5 Xref were considered double and those greater than 1.5 Xref were considered faulty. The distance between plants adopted was 8.3 cm between plants.

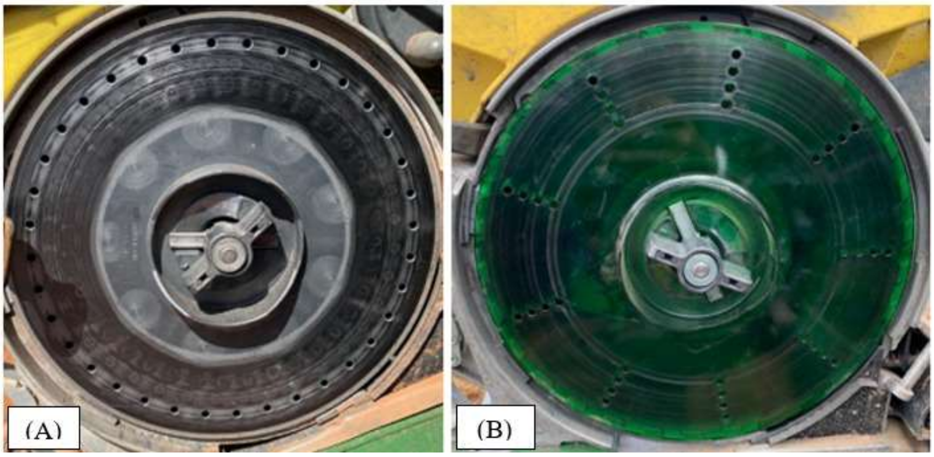

Figure 1. Conventional (A) and grouped (B) seed metering disks. Source: Author, 2020.

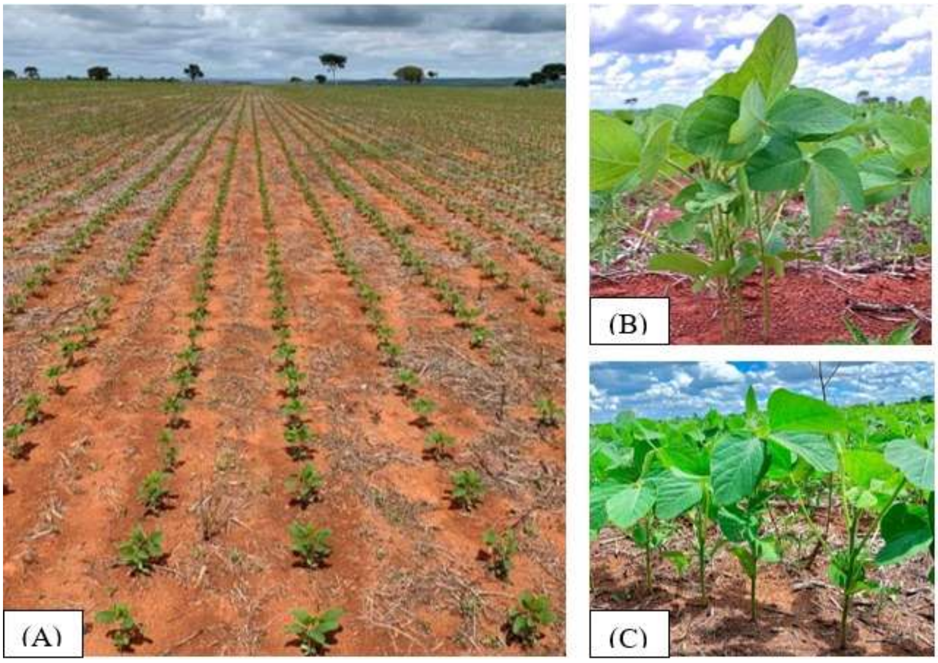

Figure 2. Soybean plants in grouped sowing arrangement (A), close-up photo of grouped plants (B) and in the conventional arrangement (C). Source: Author, 2020.

To evaluate the quality of the longitudinal distribution between groups of seeds in the grouped arrangement, an adaptation was carried out, as to this date there is no record in the scientific literature of evaluating criteria for the distribution of seeds under this sowing arrangement. Thus, based on the methodology described by Kurachi et al. (1989) in which they evaluate sowing in the conventional arrangement, in this work a criterion for the evaluation of coefficients of variation in grouped sowing was adapted. Data collection was based on measuring the distances between groups of plants within 10 meters of the five central lines of each plot, considering the distances between the last plant of one group and the first plant of the next group. In this arrangement, the adjustment for the reference distance between groups of four seeds was 33.3 cm. The collected data were submitted to the determination of the coefficient of variation of the spacings.

$$\mathrm{CV_{GS}}\ (\%) = \frac{S}{X}\ x\ 100$$

Em que:

CV_{GS} = coefficient of variation of the spacing between groups of seeds (%);

S = standard deviation of all spacings between plants or between groups of plants (cm);

X = average of all spacings between plants or between plant groups (cm).

For the variables longitudinal distribution of seeds in the conventional and grouped arrangements, the analysis was carried out following a completely randomized design (CRD), without considering the arrangement factor, which, in this case, was isolated. The analyzes took into account only the speed factor, with no comparison of interactions between the arrangements.

The seedling emergence speed index (ESI) was obtained by counting the soybean seedlings contained in the useful area of each experimental plot for seven consecutive days from the beginning of emergence. For counting, seedlings with the cotyledons above the soil surface were considered. The evaluation was interrupted when the number of counted cotyledons was repeated for two consecutive days.

To determine the ESI, the data obtained were submitted to the equation proposed by Maguire (1962).

$$ESI = \frac{G1}{NI} + \frac{G2}{N2} + \cdots + \frac{Gn}{Nn}$$

Em que:

ESI. = emergence speed index;

G = number of normal seedlings computed in counts;

N = number of days from sowing to 1st, 2nd... umpteenth evaluation.

The number of pods was obtained by manually counting all the pods contained in each of the plants present in the useful plot, with each plant being considered a repetition. The evaluation was carried out after harvesting and manual threshing of the pods contained in the useful area of each plot, when the crop reached maturity stage R5.

Grain yield, as well as the mass of a thousand grains of the different treatments were determined after harvesting and manual threshing of the plants contained in the useful area of each plot. The obtained grain mass was measured on a 0.001 g precision scale and the mass moisture corrected to 13% according to the RAS methodology (BRASIL/MAPA, 2009).

The data obtained were subjected to analysis of variance and unfolding all interactions, and the means were compared by Tukey's test at the level of 5% probability ($p \leq 0.05$). Statistical analysis was performed using the statistical software RStudio, version 1.4.1106 (R CORE TEAM, 2016).

3. Results and Discussion

The data presented in Table 1 refer to the summary of the ANOVA (analysis of variance) for the variables related to the agronomic characteristics of the soybean crop and the operational performance of the sowing operation, respectively. Observing the interaction effect between the factors sowing speed and sowing arrangement, a significant interaction was verified for emergence speed index and a thousand grain mass at the 5% probability level, and for the number of pods per plant at the level of 1% significance.

The interaction indicates that there is a direct relationship between speed and arrangement, indicating that the variation in the levels of these factors directly influences the behavior of the plant, whether beneficial or not, thus directly impacting the value of the response variable.

The factors, longitudinal distribution of seeds in the conventional arrangement and coefficient of variation of the spacing between groups of seeds do not present values for the sowing arrangement factor and interaction between the sowing arrangement and sowing speed factors because they were analyzed individually taking into account only the sowing speed factor (A).

Data referring to the classification of spacing for the conventional sowing arrangement are presented in Figure 3.

Table 1. Summary of analysis of variance (ANOVA) for: longitudinal distribution of seeds in the conventional arrangement (LDS), coefficient of variation of spacing between groups of seed (CVGS), emergence velocity index (ESI), number of pods per plant (NPP), grain yield (GY), mass of a thousand grains (MTG) for the variables of agronomic characteristics of soybean and sowing operational performance.

ANOVA					
Factor	SS (A)	SA (B)	A x B	Mean	CV (%)
LDS	0.01^{NS}	-	-	33.42	16.01
CVGS	6.07^{*}	-	-	8.06	13.9
ESI	0.49^{NS}	48.90^{**}	4.79^{*}	60.02	5.12
NPP	30.08^{**}	0.09^{NS}	12.01^{**}	50.88	35.60
GY	2.56^{NS}	42.60^{**}	8.02^{**}	3731.82	9.60
MTG	6.29^{**}	15.98^{**}	5.56^{*}	187.10	2.36

*significant by Test F at 5% probability level. **significant by Test F at the 1% probability level. NS not significant by Test F at 5% probability. SS: sowing speed. SA: seeding arrangement. CV: coefficient of variation.

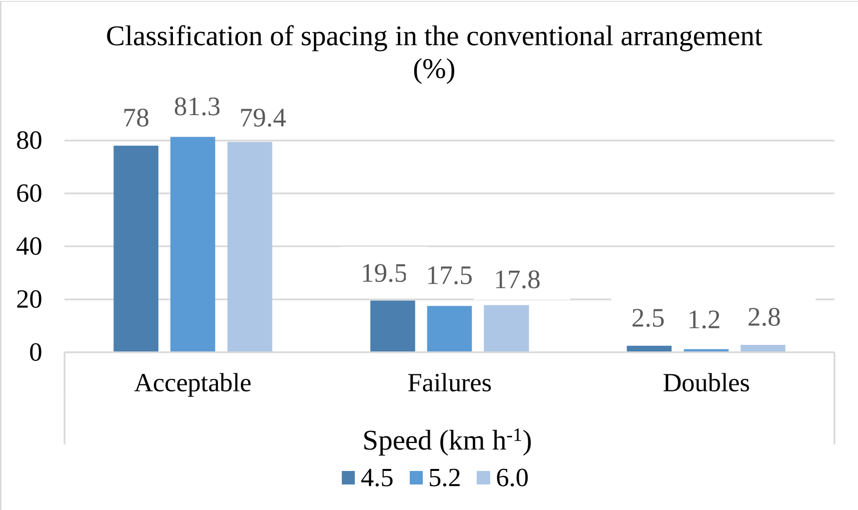

Figure 3. Longitudinal distribution of soybean seeds in the conventional arrangement as a function of sowing speed.

According to Figure 3, in none of the items referring to the classification of spacing, both for acceptable and for faults and doubles, there was a significant difference for the three speeds studied. The acceptable spacing indices at the three speeds qualify sowing as heterogeneous in relation to the idealized indices, because according to Coelho (1996), when the acceptable spacing index for a pneumatic precision seeder is less than 90%, it means that the desired levels of accuracy were not reached.

It was observed that the increase in the operational speed of sowing up to the speed of 6 km h^{-1} did not impact the fault spacing index in the equidistant distribution, a result that diverges from the statement made by Pereira et al. (2021) that the increase in speed, from 4 to 6 and 8 km h^{-1}, promoted a higher index of faulty spacing, potentially caused by the greater turbulence suffered by the seeds inside the conductor tube.

With values ranging from 1.25 to 1.75% for double or multiple spacing, an increase of 40% between the highest and the lowest index was observed, a behavior similar to that observed by Correia et al. (2020), who evaluated two mechanical precision metering mechanisms and three work speeds, and found that when increasing the speed from 4.5 to 6.2 and 8.2 km h^{-1}, there were significant increases in faulty spacings, from 35 and 33.3% for the respective speed.

In general, the results obtained corroborate, in part, with those found by Matos et al. (2021) when the authors tested the effect of speed and fertilizer furrowing mechanisms on the longitudinal distribution of seeds at speeds of 4, 6, 8 and 10 km h^{-1}, did not measure significant differences between the speeds for faulty and normal spacing up to 8 km h^{-1}, only at the highest speed there was a reduction in normal spacing.

The coefficient of variation of the spacing between seeds aims to indicate the regularity of the distribution, however, for the grouped arrangement there is no described evaluation methodology in the scientific literature. The data presented in this work can become parameters for the new distribution method and are presented in Table 2.

Table 2. Coefficient of variation of the spacing between groups of soybean seeds (CVGS) in the spatial arrangement of grouped sowing as a function of operational speed.

Speed (km h^{-1})	CVGS (%)	MSD
4.5	6.67 b	
5.2	7.09 b	2.2
6.0	9.43 a	

Means followed by the same lowercase letter in the column indicate that there is no significant difference by the Tukey test at the 5% probability level. MSD: minimum significant difference.

The coefficient of variation for the spacing between groups of seeds can be used as an indicator of deposition quality. According to Table 3, the increase in sowing speed negatively influences the coefficient of variation, showing that speed is a limiting factor for the grouped arrangement as described by Balbinot Junior et al. (2018), speeds above 4 km h^{-1} do not favor the distribution of seeds in groups.

When increasing the speed from 4.5 and 5.2 to 6 km h^{-1} there is a consequent increase in the coefficient of variation of the spacing, showing that the increase in speed undoes the groups, causing the distribution of plants to approximate the conventional or equidistant arrangement. The emergence speed index (ESI) results are shown in Table 3 and indicate significant differences for the spatial arrangement factor and sowing speeds.

Higher emergence speed indices (ESI) were observed in the grouped arrangement compared to the conventional one, except for the speed of 6 km h^{-1}. The remaining 4.5 and 5.2 km h^{-1} showed increases of 25.8 and 14.4% compared to the conventional arrangement, respectively. One of the reasons that can explain such differences is the greater ease of soil disruption in the grouped arrangement, as in this arrangement the soil rupture capacity was maximized compared to the conventional arrangement, as four seeds emerged simultaneously in the same place, breaking the soil together instead of one.

The results confirm the assertion of Knebel et al, (2006), that the grouping of seeds positively influences the emergence of seedlings, because the closer the seeds, the easier it is for the cotyledons to break through the upper soil layer. The results for the number of pods per plant are shown in Figure 4, demonstrating that in the grouped arrangement, except at the speed of 6 km h ^{1}, more pods are produced per plant.

Table 3. Soybean plant emergence speed index (ESI) as a function of the sowing spatial arrangement and sowing speed factors.

Sowing spatial arrangement	Emergence speed index			
	Speed (km h^{-1})			F^2
	4.5	5.2	6	
Grouped	67.8 aA	63.4 aAB	62.0 aB	3.88*
Conventional	53.9 bA	55.4 bA	57.6 aA	1.4^{NS}
F^1	40.85^{**}	13.37^{**}	4.26^{NS}	-
CV (%)		5.13		-

Means followed by the same lowercase letter in the column and uppercase in the row indicate that there is no significant difference by the Tukey test at the 5% probability level. *significant at the 5% probability level. **significant at the 1% probability level. NS not significant. F1 refers to the interaction between factors in the column and F2 refers to the interaction between factors in the row.

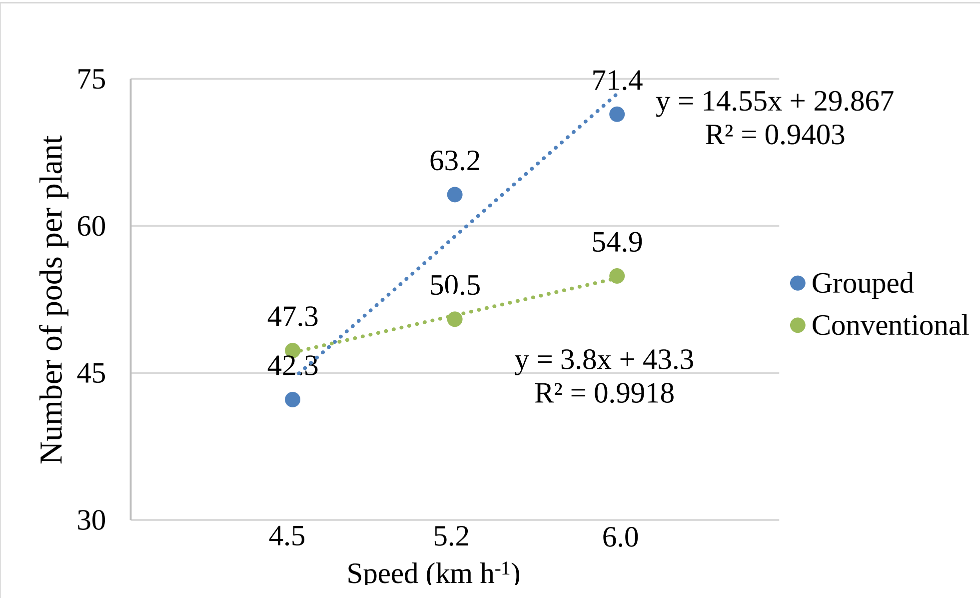

Figure 4. Number of pods per soybean plant as a function of the sowing spatial arrangement and sowing speed.

According to Dan et al, (2010) ESI can be associated with seed vigor. The higher the ESI, the greater the capacity of the plants to resist climatic stresses, especially in the initial phase of growth. In addition, the faster emergence of seedlings and consequent stabilization of the initial plant stand, anticipates the shading of the soil by the crop, favoring the control of weeds, which may be an advantage for the grouped arrangement, which under the conditions studied may have increased the seed vigor, as they had higher emergence speed indices.

The variable number of pods per plant showed different behavior between the arrangements. Considering the speeds in each arrangement, differences were found only in the grouped arrangement. With the increase in speed, there was a decrease in the total number of pods of 40.8 and 33.1% when increasing the sowing speed from 4.5 and 5.2 to 6 km h^{-1}, respectively.

It was observed that the sowing method grouped in the two lower speeds, presented the highest averages for the number of total pods among those studied, and in an equivalent comparison for the conventional arrangement, it was observed a 30.1 and 25.1% higher production for 4.5 and 5.2 km h^{-1}, demonstrating an advantage for this sowing method. The results can be justified by the potential higher conversion of photoassimilates in the production of pods, resulting from a superior photosynthetic use provided by the new arrangement.

The results disagree, in part, with those found by Serraglio and Simonetti (2017), in which, when studying the effect of grouped and traditional sowing in three soybean cultivars and three spacing between holes for grouped sowing, the authors demonstrate that there is greater pod production in the grouped sowing method for only one of the cultivars. In the others there was no significant difference for the cultivar and spacing interaction, as well as for the factors evaluated separately. The 4.5 km h^{-1} speed in the grouped arrangement produced more pods than in the conventional treatment, characterizing the speed as a primordial factor for the execution of grouped sowing.

As shown in Table 5, except for 6 km h^{-1}, the grouped sowing method presented a higher average yield than the conventional arrangement. The productive performance of the grouped arrangement differed between the speeds of 4.5 and 5.2 km h^{-1} when compared to 6 km h^{-1}, and at the lower and intermediate speed this arrangement presented significant productive gains in relation to the equidistant distribution of the conventional arrangement, being 39.9 and 20.7% higher, respectively. This increase in productivity can be explained by some factors, including number of total pods and mass of a thousand grains, which in the grouped arrangement presented statistically superior results.

With an average yield of 3254 kg ha^{-1} in the conventional arrangement, no significant differences were found between the adopted sowing speeds. The results disagree with those found by Reynaldo et al. (2016), who identified a reduction in productivity with a gradual increase in sowing speed, ranging from 2 km h^{-1} to 10 km h^{-1}, with production losses of 4, being identified 75% between the highest and lowest grain yield. As it is recent, this sowing method lacks information available in scientific research. The few published researches differ on the viability of the grouped arrangement with regard to grain yield. Works already published such as Serraglio and Simonetti (2017); Balbinot Junior et al. (2018) and Santos et al. (2018) state that there are no advantages in using this arrangement.

On the other hand, Bisinella and Simonetti (2017), analyzing the agronomic performance of two cultivars with indeterminate growth habits, these opposite to the present work, obtained similar conclusions, in which the grouping proved to be a viable practice for presenting productive gains between 10 and 20% higher than equidistant sowing of soybean seeds. The use of a cultivar with indeterminate habit was not, in this case, a limiting factor for the use of the new arrangement, indicating a potential use of the technique in different cultivars. Table 6 presents the data referring to the mass of a thousand grains for the different sowing speeds and arrangements.

Table 5. Soybean grain yield as a function of the sowing spatial arrangement and sowing speed factors.

Sowing spatial arrangement	Grain yield (kg ha^{-1}) Speed (km h^{-1}) 4.5	5.2	6	F2
Grouped	4198 aA	3972 aA	3499 aB	5.25*
Conventional	3000 bA	3300 bA	3462 aA	0.44^{NS}
F1	19.52**	6.54*	0.08NS	-
CV (%)		18.2		-

Means followed by the same lowercase letter in the column and uppercase in the row indicate that there is no significant difference by the Tukey test at the 5% probability level. *significant at the 5% probability level. **significant at the 1% probability level. NS not significant. F1 refers to the interaction between factors in the column and F2 refers to the interaction between factors in the row.

Table 6. Mass of a thousand grains as a function of the sowing spatial arrangement and sowing speed factors.

Sowing spatial arrangement	Mass of Thousand grains (g)			
	Speed (km h^{-1})			F^2
	4.5	5.2	6	
Grouped	195.9 aA	193.8 aA	183.5 aB	11.32**
Conventional	185.1 bA	181.9 bA	182.2 aA	0.53^{NS}
F^1	12.24^{**}	14.70^{**}	0.17^{NS}	-
CV (%)		2.36		-

Means followed by the same lowercase letter in the column and uppercase in the row indicate that there is no significant difference by the Tukey test at the 5% probability level. *significant at the 5% probability level. **significant at the 1% probability level. NS not significant. F1 refers to the interaction between factors in the column and F2 refers to the interaction between factors in the row.

Differences were identified between the arrangements and between the velocities in the grouped arrangement for the variable mass of one thousand grains. In the case of the grouped arrangement, the speeds of 4.5 and 5.2 km h^{-1} are significantly equal and differ only from the highest speed, which in turn had a mass, on average, 5.8% lower than the others. The same behavior was not observed for the conventional arrangement since the speed did not influence the variable results.

The grouped arrangement presented a mass of a thousand grains 5.8 and 6.5% higher than the conventional one for the speeds of 4.5 and 5.2 km h^{-1}, respectively, a fact that can be correlated by the higher phytomass production due to the possible greater interception of sunlight that provides greater photosynthetic use of plants. Similar results were published by Bisinella and Simonetti (2017), in which study the authors evaluated two cultivars submitted to the conventional arrangement and grouped with a density of 12 seeds per linear meter, finding superior results for a thousand grain mass with the grouped arrangement in one of these cultivars, while the other presented the same results for the arrangements.

4. Conclusions

The emergence speed indices were 25.8 and 14.4% higher in the grouped arrangement at speeds 4.5 and 5.2 km h^{-1} respectively.The grouped sowing of soybean provided an increase of 39.9 and 20.7% in grain yield for the speeds of 4.5 and 5.2 km h^{-1} in relation to the equidistant arrangement. The higher sowing speed increases the coefficient of variation between seed groups by 2.76 and 2.34% compared to the speeds of 4.5 and 5.2 km h^{-1}, respectively, and causes disarrangement of the seeds in the groups.

Authors' Contribution

Arthur Gabriel Caldas Lopes contributed to the planning, work implementation, evaluations, data acquisition and statistical analysis. Tiago Pereira da Silva Correia contributed to the planning, implementation of the work and statistical analysis. Wesley Matheus Cordeiro Fulgêncio Taveira, Gabriela Greice Pereira and Alyne Ayla Rodrigues de Souza contributed to the assessments and data acquisition.

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