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Horizontal evaluation of corn seed distribution application in function of dosing mechanisms and operational speed

Avaliação horizontal da distribuição de sementes de milho em função de mecanismos dosadores e velocidade operacional

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ABSTRACT

The type of operation of the seed drill metering mechanism and the operating speed are determinant in the crop's productivity. Thus, the objective was to evaluate the longitudinal distribution of maize seeds with different seed metering mechanisms at different displacement speeds. The study was carried out at the Experimental Farm of Agricultural Sciences - FAECA of the Federal University of Grande Dourados (UFGD), in the municipality of Dourados, Mato Grosso do Sul (MS). The experimental design used was completely randomized in a 2 x 4 factorial scheme, with two seed dosers (pneumatic and mechanical) and four sowing displacement speeds (5, 7, 8 and 10 km^{-1}). The longitudinal distribution of seeds was evaluated by checking the spacing between acceptable, flawed and multiple seedlings. The data were submitted to analysis of variance and the means were compared by the Tukey test at 5%. There was no significant difference up to the speed of 8 km h^{-1} for the mechanical feeder in the analysis of the performance of each mechanism within the different speeds. However, the pneumatic feeder achieved superior performance for faulty and double spacing. In general, for both metering mechanisms, the increase in sowing speed increased the number of faulty and double spacings. Therefore, the pneumatic metering mechanism showed a better response in the number of acceptable spaces with increasing speed.

KEYWORDS: plantability; feed index; mechanical seeding; agronomic enginees.

RESUMO

O tipo de funcionamento do mecanismo dosador das semeadoras e a velocidade de operação são determinantes na produtividade da cultura. Assim, objetivou-se avaliar a distribuição longitudinal de sementes de milho com diferentes mecanismos dosadores de sementes em diferentes velocidades de deslocamento. O estudo foi realizado na Fazenda Experimental de Ciências Agrárias - FAECA da Universidade Federal da Grande Dourados (UFGD), no município de Dourados, Mato Grosso do Sul (MS). O delineamento experimental utilizado foi inteiramente casualizado em esquema fatorial 2 x 4, sendo dois dosadores de sementes (pneumático e mecânico) e quatro velocidades de deslocamento da semeadura (5, 7, 8 e 10 km^{-1}). Foi avaliada a distribuição longitudinal de sementes por meio da verificação do espaçamento entre plântulas em aceitável, falho e múltiplo. Os dados foram submetidos à análise de variação e as médias comparadas pelo teste de Tukey a 5%. Não houve diferença significativa até a velocidade de 8 km h^{-1} para o dosador mecânico na análise do desempenho de cada mecanismo dentro das diferentes velocidades. No entanto, o dosador pneumático obteve desempenho superior para espaçamentos falhos e duplos. De modo geral, para ambos os mecanismos dosadores o aumento da velocidade de semeadura proporcionou acréscimo no número de espaçamentos falhos e duplos. Portanto, o mecanismo dosador pneumático apresentou melhor resposta no número de espaçamento aceitável de distribuição com o incremento da velocidade.

PALAVRAS-CHAVE: plantabilidade; espaços aceitáveis; semeadura mecanizada; colheitadeiras.

INTRODUCTION

Since the 1990s, soybean-corn succession has become the main agricultural production system in Brazil, mainly in the states of Mato Grosso, Paraná, Goiás and Mato Grosso do Sul. In several Brazilian municipalities, 100% of the area planted with soybean in summer is replaced by corn second crop (GARCIA et al. 2018).

The most recent Conab survey indicates that the second crop corn area (formerly called off-season corn) in Brazil reached 16.4 million hectares, 9.7% higher than in the 2020/21 crop, being the largest area ever recorded for cereal cultivation. The expected production is 88.01 million tons, and average productivity of 5,348 kg ha^{-1} (CONAB 2022).

Often, the deadline for sowing the off-season corn established by the Agroclimatic Zoning is exceeded by the producer, either due to the rains in the soybean harvest, which delays the planting of the second crop corn, or the conditions with low water content in the soil at the time of sowing, or even due to a sizing of machines that does not meet its demand.

Faced with this situation, the producer as a way to compensate for the delay in planting corn increases the sowing speed. However, several authors state that the longitudinal distribution of seeds can be affected by the increase in the speed of machine displacement (SANTOS et al. 2011, BOTTEGA et al. 2014, BOTTEGA et al. 2018, MACHADO et al. 2019).

The unevenness in the seed distribution, be it, in greater or lesser quantity, can provide reduction of productivity in the cultivation area. Therefore, obtaining a spatial arrangement that provides adequate plant stand, enabling optimal development and better use of water and nutrients, is paramount (MIALHE 2012). Corn is a species of C4 metabolism, that is, it has better photosynthetic efficiency when compared to C3 plants, so a more uniform plant distribution is of fundamental importance to enhance crop productivity (BERGAMASCHI & MATZENAUER 2014).

Among the factors that can influence the longitudinal distribution of seeds in the soil, the sowing speed and the dosing system should be considered to obtain a stand with the highest number of adequate spacings between plants in the line. A survey conducted by FRANCETTO et al. (2015) indicates that in Brazil, seeders use two main types of seed-dosing mechanisms, the horizontal disc and the tire, the first being used in approximately 79.57% of the machines and the second in 20.43%.

In the literature, some studies are found that indicate the influence on the uniformity of the longitudinal distribution of corn seeds in relation to the seed dosing model and the displacement speed of the seeding-fertilizer adopted (OLIVEIRA et al. 2009, TROGELLO et al. 2013, BOTTEGA et al. 2014, CARPES et al. 2017, BOTTEGA et al. 2018, RINALDI et al. 2019).

In view of the above, the objective of this study was to evaluate the type of dosing mechanism (conventional and pneumatic horizontal disc) and the sowing velocities that can influence the longitudinal distribution of corn seeds.

MATERIAL AND METHODS

The experiment was conducted at the Experimental Farm of Agrarian Sciences of the Federal University of Grande Dourados (UFGD), municipality of Dourados, MS, located at the geographic coordinates of 54° 59' W and 22° 14' S and at 434 m altitude. The climate according to the Köppen classification is type Am - Tropical Mononicic (ALVARES et al. 2013). The soil of the experimental area was classified as dystrophic Red Latosol of very clayey texture (SANTOS et al. 2013) and the granulometric analysis of the soil in the layer 0.0 - 0.20 m presented values of: 644, 203 and 152 gk g^{-1} of clay, silt and sand, respectively.

The experimental area is cultivated in a no-sowing system, in soybean-corn succession for 12 years, and at the time of planting there were cultural remains of soybean cultivated as a summer crop. Corn was sanded in March 2021, in a spacing of 0.9 m between lines and population density of 64,440 plants hectare, that is, 5.8 seeds per meter. The hybrid B2702 VYHR LEPRA (Brevant® Sementes) of super early cycle was used.

The experimental design used was completely randomized, in a 2 x 4 factorial scheme with five replications, two types of dosing mechanism (pneumatic system and mechanical system - traditional alveolate) and four displacement velocities of the seeders during the operation (5, 7, 8 and 10 km h^{-1}). Each experimental unit was composed of five lines of 15 meters long (67.5 m^2 per plot), considering the two lines of each end as surround and the three central lines as useful area, disregarding 1 m at each end, totaling 35.1 m^2 per plot.

The seeders used were a trawler-seeding, Jumil model 2680 TD brand with five sower lines, equipped with pneumatic seed dosing, seeking rod for fertilizer, double disc for seed and compactor wheels of rubberized type, smooth V-shaped. double disc for rubberized, smooth seed and compactor wheels in the form of V. The mechanical seed dosing mechanism is characterized by metal base, with metal seed organizer scraper in the alveolus, a rosette seed ejector and conventional horizontal disc of 28 holes and 11 mm.

For the planting operations, we used a New Holland tractor model 8030 4 x 2 TDA, with nominal potential of 122 hp (89.79 kW) at 1800 rpm, exchange 16 x 4 with 4 (four) gears, h (high) and L (low) and reducer ranges (hare and turtle). Equipped with front wheeled of 14.9-5.8" and rear 23.1-30" with mass of 4510 kg distributed, in static condition, in the proportion of 65% on the rear axle and 35% on the front axle. The average velocities were obtained by recording the time to travel 30 m in the gear combinations according to Table 1.

Table 1. Combination of gears to obtain speeds.

Marches	Ranges	Reducer	Speed (km h^{-1})
1	High	Hare	10
1	High	Turtle	8
4	Low	Turtle	7
3	Low	Turtle	5

The evaluation of longitudinal distribution of seeds in the sowing line was performed at 17 days after sowing, when the emergence of corn seedlings had ceased. The distance between seeds distributed in the line was obtained by the measurement between seedlings contained in 5 m length of the three central lines of each plot, and three measurements were collected per plot with the aid of a 1 mm precision tape measure.

The spacings were classified as acceptable, flawed and double, according to the ABNT standards cited by KURACHI et al. (1989) considering percentages of spacings: "double" (D): <0.5 times Xref. "reference spacing, normal" (A): 0.5< Xref.< 1.5, and "faulty" (F): > 1.5 Xref. The classification is indicated in Table 2, depending on the sowing density adopted and the reference spacing (ref. 17.2 cm) between seeds. The coefficient of variation (CV) was also analyzed according to the type of the dosing mechanism according to COELHO (1996).

Table 2. Classification of spacing between maize seeds by the methodology written by KURACHI et al. (1989).

Classification	Spacing reference (ref)
Acceptable	8.6 cm < ref < 25.8 cm
Failures	ref > 25.8 cm
Double	ref < 8.6 cm

To verify the main effects and interaction of the factors, variance analysis was performed, followed by obtaining the F statistic to analyze the significance of these effects. When significant, the Tukey test was used for multiple comparison between factor levels. In this research, in all hypothesis tests, the level of 5% of significance was adopted.

RESULTS AND DISCUSSION

The results of the analysis of variance of the longitudinal distribution of corn seeds as a function of the dosing mechanism and sowing speed factors are presented in Table 3. According to the F test, significance and interaction between the factors (dosing mechanism x sowing speed) were verified for the variables: double and faulty spacings, while the acceptable spacing variable was not influenced by the MD x V interaction (Table 3).

Table 4 shows that the values of coefficients of variation show homogeneity in the data obtained. According to COELHO (1996), CV values can be adopted as a form of classification, being less than or equal to 50% for horizontal dosing mechanism sowers and for pneumatic dosing mechanism in the order of 30%.

Data from the dosing mechanism interaction and sowing velocity for percentage of double spacings are presented in Figure 1. When analyzing the unfolding of sowing velocity within the dosing mechanism, it was verified that at the sowing speed 5 km h^{-1} there was no significant difference for the percentage of double spacings. However, the measure that increased the sowing speed, there was a significant difference between the types of dosing agent, with the highest percentages of double for the mechanical doser, reaching 12% of double spacings.

Table 3. Analysis of variance of the longitudinal distribution of corn seeds as a function of the factors seed metering mechanism and sowing speed.

Treatments	Valor de F		
	Double	Failures	Acceptable
Dosing mechanism (MD)	65.630**	40.371**	107.07**
Speed (V)	30.157**	2.42**	29.73**
MD x V	5.754**	6.673**	1.45ns
CV (%)	14.6	12.9	8.31

CV: Coefficient of variation; ** significant and ns not significant at the level of 5% probability by the F test. Means followed by the same letter do not differ from each other by the Tukey test at 5% significance.

Table 4. Coefficient of variance as a function of the type of seed dosing mechanism and sowing speed.

Dosing mechanism	CV (%)			
	Speed km h^{-1}			
	5	7	8	10
Mechanic	45.96	48.0	47.3	48.34
Pneumatic	25.23	27.34	26.4	28.13

CV: Coefficient of variation.

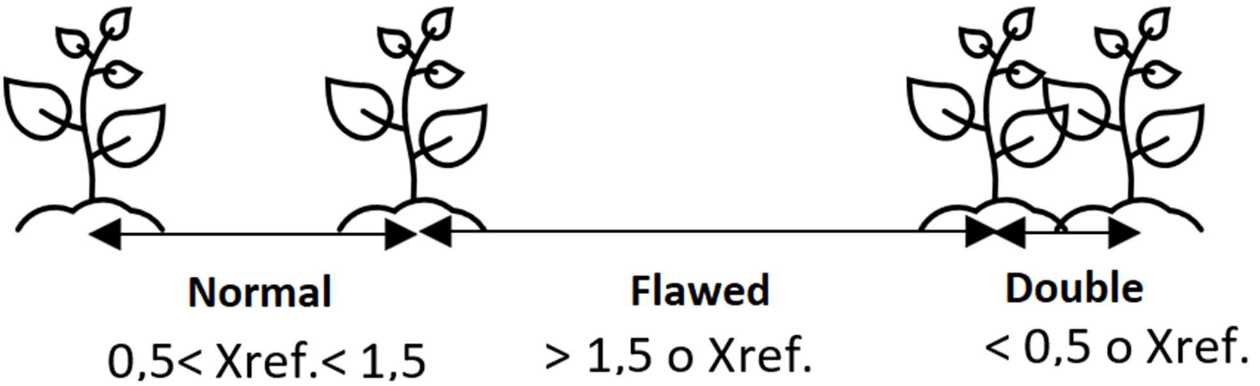

Figure 1. Representation of the longitudinal distribution.

The increase in the sowing speed influenced the longitudinal distribution of seeds, especially when considering the peripheral speed of displacement of the dosing disc, because there is an increase in the number of double spacings (CARPES et al. 2017, BOTTEGA et al. 2018, MACHADO et al. 2019, CORREIA et al. 2020).

By unfolding dosing mechanisms within the sowing speed, it can be observed, as shown in Figure 2, that from 7 km h^{-1} there is a significant increase in the number of failures for the mechanical doser, while for the pneumatic dosing, this difference is observed only at the highest speed 10 km h^{-1}. Thus, better performance is demonstrated to increase speed, corroborating with CORTEZ et al. (2020) and BOTTEGA et al. (2018) in studies conducted on seed dosage systems and tractor-seeder feed speed.

According to CORREIA et al. (2016) the accuracy is directly dependent on aspects of the dosing itself, especially the geometry and dimensions of the alveolus, the lower support of the disc with ring, the ejector mechanism of the seeds and the speed of rotation of the disc. Pneumatic system, presents better performance than the mechanical system in the dosage and distribution of seeds, with greater precision in the range of acceptable spacings and consequently lower double spacings (OLIVEIRA et al. 2009, BOTTEGA et al. 2018, CARPES et al. 2017).

The increase in sowing speed increased the percentage of failure for both dosing mechanisms, presenting statistical differences, except at 10 km h^{-1} (Figure 3). Although the pneumatic dosing has increased the number of faulty spacings with increasing speed, still outnumbered the mechanical doser, demonstrating slightly superior performance up to 8 km h^{-1}.

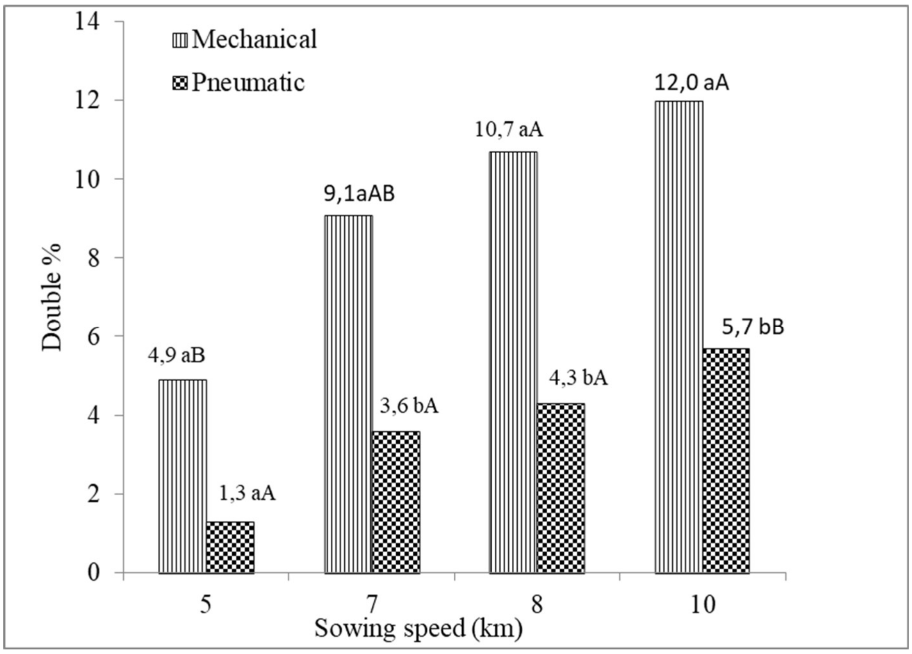

Figure 2. Splitting of double spacings in the longitudinal distribution of corn as a function of dosing mechanism and sowing speed. Equal lowercase letters between column (dosing mechanism) and uppercase letters in columns of the same color (sowing speed) do not differ by Tukey test at 5% ($p \leq 0.05$) of significance.

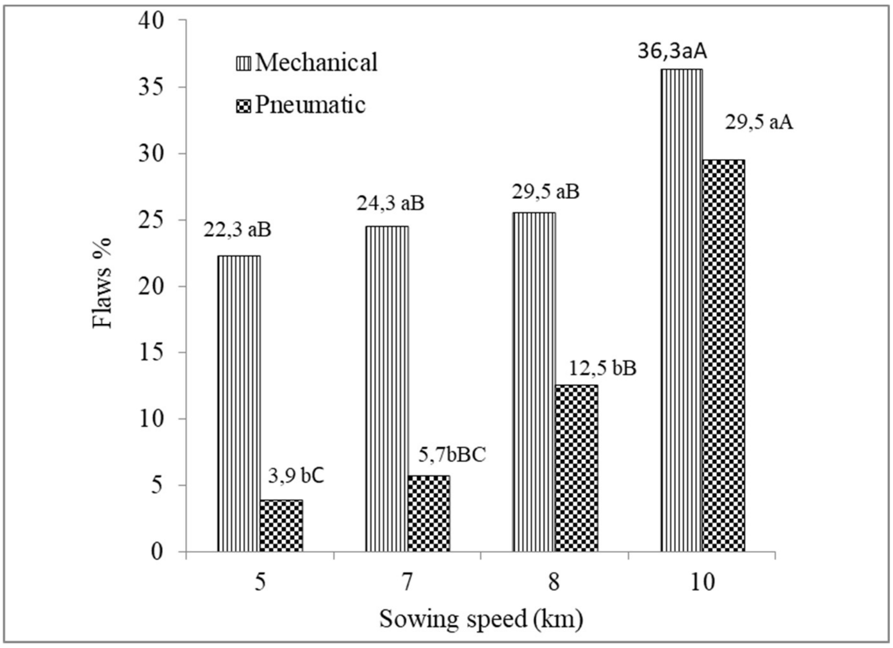

Figure 3. Breakdown of faulty spacings in the longitudinal distribution of corn as a function of the meter and sowing speed. Equal lowercase letters between column (dosing mechanism) and uppercase letters in columns of the same color (seeding speed) do not differ by Tukey test at 5% ($p \leq 0.05$) of significance.

SANTOS et al. (2011), state that the increase in speed during the sowing operation increases the number of failures during sowing. For CARPES et al. (2017), the increase in speed causes reduction of acceptable spacings and increase of doubles and failures between seeds. According to the authors, increases in the peripheral speed of the dosing and displacement of the machine can intensify the horizontal displacement of the seed within the conductive tube, increasing the number of rebounds within it and the loss of travel time to the ground, causing deposition at a fault or double longitudinal distance.

When analyzing the performance of each mechanism within the different velocities (Figure 3) it is possible to observe that there was no significant difference up to the speed of 8 km h^{-1} for the mechanical doser, but with a high percentage of failure, while the pneumatic mechanism presented statistical difference for all tested velocities, but with lower failure values. A possible explanation for the lower percentage of failure of the pneumatic mechanism compared to the mechanical mechanism is due to the fact that the pneumatic dosing mechanism performs the alveolus filling process by means of negative pressure at the time of seed individualization (MIALHE 2012, BOTTEGA et al. 2018), presenting fewer mechanical components when compared to the horizontal disk mechanical system (BOTTEGA et al. 2018).

The data of acceptable spacings depending on the dosing mechanism and sowing speed are presented in Table 5. The pneumatic dosing mechanism showed the highest acceptable spacing numbers, differing statistically in relation to the mechanical dosing mechanism for all speeds studied (Table 5).

Table 5. Acceptable spacings in the longitudinal distribution of corn as a function of the metering mechanism.

Dosing mechanism	Percentage (%)			
	Speed km h^{-1}			
	5	7	8	10
Mechanic	72.30 b	66.22 b	64.28 b	50.71 b
Pneumatic	91.12 a	90.5 a	84.90 a	64.70 a

Averages followed by the same letter do not differ from each other by the Tukey test at 5% ($p \leq 0.05$) of significance.

This behavior is even more evident when we analyze the graph shown in Figure 4. The increase in sowing speed was more harmful for the number of acceptable spacings for sowing of mechanical dosing mechanism in relation to the pneumatic dosing mechanism.

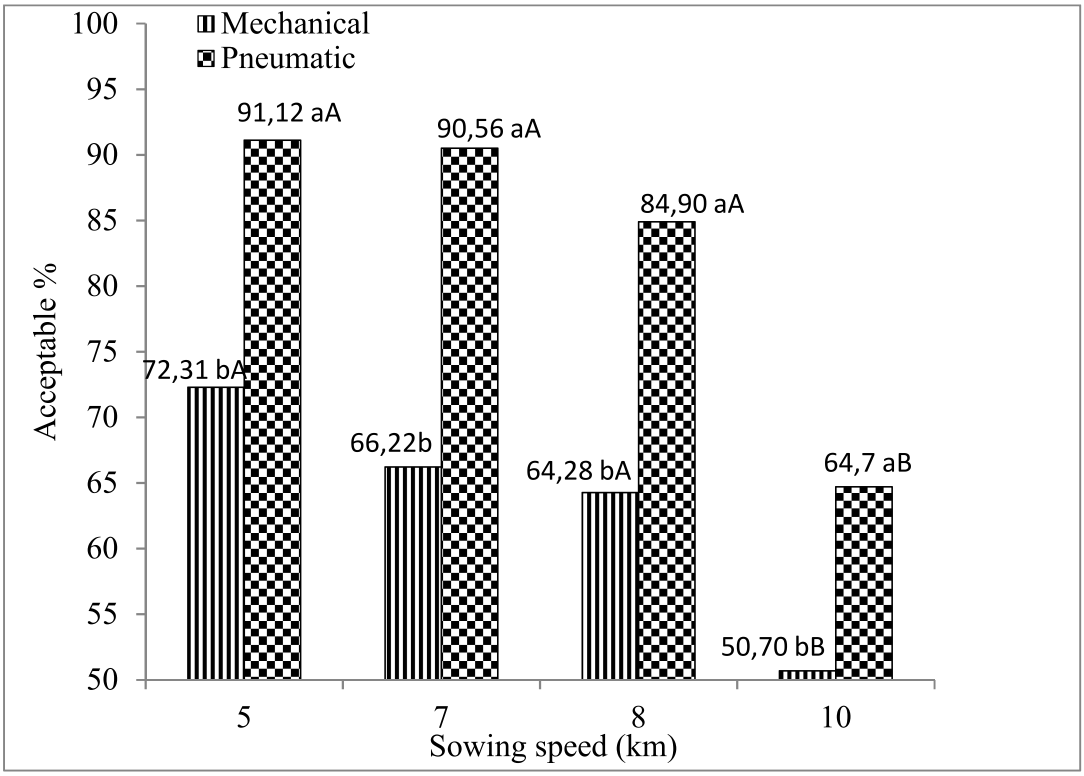

Figure 4. Acceptable spacings in the longitudinal distribution of corn as a function of sowing speed. Equal lowercase letters in the same column do not differ by Tukey test ($p \leq 0.05$).

However, when comparing the two mechanisms and speed increment, it is verified that the mechanical dosing mechanism suffers greater influence as the sowing speed is increased, which can be explained by the fact that it is a more robust mechanical component with a greater number of process to be performed until the seed deposition in the soil. On the other hand, this number of processes is reduced due to the low performance of robust mechanical components integrated into the system, which makes the response time more effective as the speed increase is required (MIALHE 2012).

Thus, it is worth mentioning that the number of acceptable spacing (8.6 cm to 25.8 cm) is between the values of faulty (greater than 25.8 cm) and double (less than 8.6 cm) spacings (Figure 1). As observed in Figures 2 and 3, the pneumatic dosing mechanism obtained a better response to the increase in sowing speed. According to MIALHE (1996), a seeding with pneumatic doser works with distribution efficiency (>90%), while the mechanical distribution has the minimum required in the order of 60% above. Thus, it is verified that both dosing mechanisms obtained longitudinal distribution values above the minimum required for speeds of 5 to 8 km h^{-1} for seeding mechanical dosing mechanism up to 7 km h^{-1} seeding of pneumatic mechanism. However, it is worth mentioning that the reductions in the number of acceptable spacings were more evident for the sower of a mechanical mechanism, which, despite being within the acceptable range for this type of sower up to 8 km h^{-1}, which at the time of harvest may reflect lower productivity.

The pneumatic dosing mechanism showed the highest number of acceptable spacings in relation to the mechanical dosing mechanism up to the speed of 8 km h^{-1} (Table 5), while at the speed of 10 km h^{-1} there was no difference between velocities, observing a sharp decrease for both dosing mechanisms.

CONCLUSION

The increase in sowing speed increased the number of faulty and double spacings for both dosing mechanisms. The pneumatic dosing mechanism obtained the best performance for faulty and double spacings compared to the mechanical doser and also showed better response in the number of acceptable spacing of distribution with the increase of speed.

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