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SOWING PERFORMANCE BY A METERING MECHANISM OF CONTINUOUS FLOW IN DIFFERENT SLOPE CONDITIONS

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ABSTRACT: One of the reasons for the success of a productive culture is the correct sowing. Therefore, the seeds must be properly dosed, deposited and not damaged by the metering mechanism of the seed drill. So, the aim of this study was to evaluate in a simulator the sorghum seed deposition by a metering mechanism with continuous flow in different conditions of slope and sowing speed, and evaluate the quality of the deposited seeds assessing mechanical damage and germination. The experiment was carried out at the College of Agricultural Sciences, UNESP in Botucatu-SP, being used a simulator equipped with seed metering mechanism of helical channelled rotor type. The experimental design was randomized in a 3 x 2 factorial arrangement with six replications. The factors were three lateral slopes drill, 3%, 8% and 16%, and two sowing speed, 4 and 10 km h^{-1}. For the damage and germination variables we added a control treatment whose seeds were evaluated without being distributed by the metering mechanism. The results indicate that increasing the lateral slope and working speed reduce the rate of seed deposition. The metering mechanism provides mechanical damage and contributes to the reduction of seed germination.

KEY WORDS: deposition, germination, mechanical damage, sowing.

INTRODUCTION

According to MERCANTE et al. (2005) the correct sowing process consists, among others, the effective dosage and uniform deposition of the seed, according to the standards recommended for the crop. Researches realized by SANTOS et al. (2011), MELO et al. (2013), and TEIXEIRA et al. (2013), demonstrate the longitudinal deposition uniformity of seeds as one of the most important characteristics that contribute to an adequate population of plants and the improve of crop productivity. However, these advantages can be annulled due to the improper use of the seed drills by the producer, for example, incorrect selection of the gear ratio, no adjustment of the length and opening of the rotors, and high working speed (MATTAR, 2010).

The seed drills are classified according to the form of seed deposition, and the continuous flow machines that distribute the seeds in the soil continuously, mainly small seeds that require smaller spacing. The precision sowing machines distribute large seeds, one by one on line and at regular intervals in accordance with the established sowing density, as defined by the ABNT 04: 015.06-004 standard (1996).

The most common continuous flow seed drills are equipped with seeds metering mechanism of helical channelled rotor type, toothed rotor and distribution cup. These mechanisms are responsible for the seeds deposition at the desired dosage, keeping the physical quality of the seeds, causing no injury and mechanical damage (SILVA et al., 2000).SILVA & GAMERO (2010) point out that the efficiency of the seed drills and their metering mechanism is related, also, to the displacement speed in the operation.

VALE et al. (2010) reported that increasing the operation speed of the seed drill and not changing the rotor exposure in the adjustment, the rotation speed of the seed metering also increases, causing failures in the seeds deposition. The opposite occurs when the speed is decreased. GARCIA et al. (2011) identified the decrease in the number of seeds distributed due to the increase

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of sowing speed, as they noted higher percentage of mechanical damage in seeds, with consequent reduction in germination.

In addition to speed operation, other factors can contribute to poor deposition of seeds, including land conditions that can cause variations in the levelling of the seed drill and their metering (FERREIRA et al. 2010). Evaluating a helical metering mechanism for fertilizer, the authors concluded that in uphill (+ 10 °) the applied dose of fertilizer was 8.1% higher and in slope (-10 °) 7.8% lower than the expected dose.

Contrary to the results obtained by FERREIRA et al. (2010), REIS & FORCELLINI (2009) performing functional tests in precision mechanical metering, concluded that the seed level in the tank and the longitudinal slope of the seed drill did not affect significantly the seeds dosage.

The study aimed to evaluate the seeds deposition by a metering mechanism of continuous flow through simulation under different conditions of side slope of the metering and sowing speeds, as well as to evaluate the quality of the deposited seeds for mechanical damage and germination.

MATERIAL AND METHODS

The experiment was carried out using a simulator (test bench), belonging to the Agricultural Foundation of Agricultural Research - FAPA, located in the colony Entre Rios in Guarapuava – PR, Brazil.

The experimental design of the trial was randomized in a 3 x 2 factorial arrangement with six repetitions. The factors studied were three side slopes, 3%, 8% and 16%, and two working speeds for sowing, 4 and 10 km h^{-1}.

For the execution of the treatments, we used the seed deposition simulator (Figure 1), consisting of tank, electric motor with frequency inverter and Semeato® seed metering mechanism of continuous flow of helical channelled rotor type, Figure 1 (B).

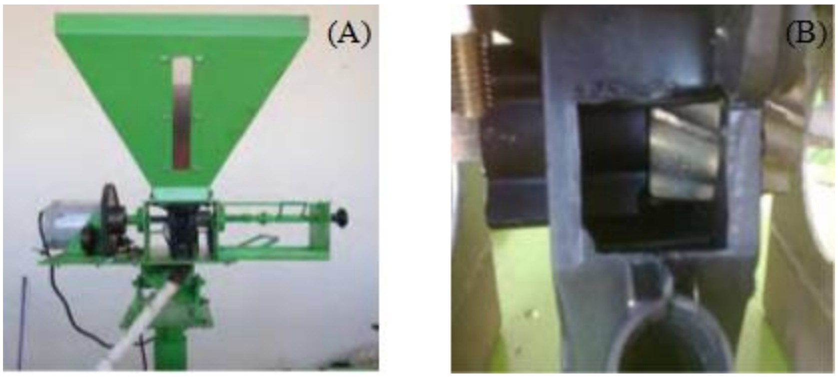

FIGURE 1. Seed deposition simulator (A), with continuous flow seed metering mechanism of channelled helical rotor type (B).

For the measurement of the metering mechanism slope we fixed two analogue magnetic inclinometers, Magnetic Base®, one in the longitudinal axis of the simulator and the other in the transverse axis.

The seeds used were of sorghum Agroceres Qualimax AG1040 hybrid, with minimum germination information of 80% and purity of 98%. The dosage of seeds was 20 kg ha^{-1}, corresponding to the recommended adjustment of deposition by the simulator of 0.90 g m^{-1} of seed, for a row spacing of 0.45 m.

Before each collection the simulator was put into full operation to promote the stability of the dosing system, later we carried out the collection of seeds in plastic cups for a period of one minute of deposition by the simulator. The samples were individually weighed in analytical balance with an accuracy of 0.0001 g.

To determine the water content of the seed at the time of the assay we used the greenhouse method at 105 ± 3 ° C for 24 hours, using six samples of 50 g of seeds, on an analytical balance with an accuracy of 0.001 g, with data expressed as percentage (BRASIL, 2009).

To understand the flowability of the seeds characteristic that influences the flow capacity within the metering system, we determined the sorghum seeds angle of repose according to the methodology described by NUNES et al. (2014). The angle was determined using a rectangular box constructed of glass and wood (Figure 2). The sorghum seeds were drained at a constant speed through a funnel fixed in a lateral opening of the box, forming a pile. With the aid of metrics rules placed in the vertical and horizontal in the box, we measured the height of the seeds in the X axes and flow length in the Y axis.

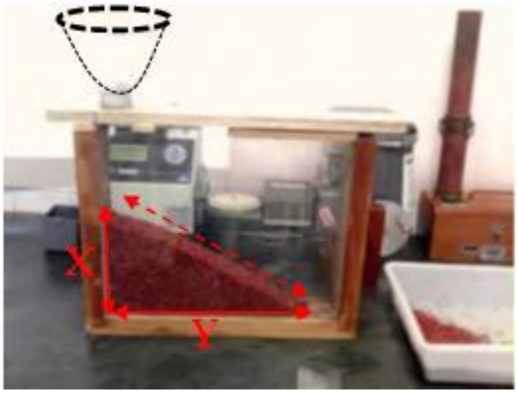

FIGURE 2. Wooden framework for measuring the seed angle of repose.

From the obtained values of X and Y we used the trigonometric tangent equation (Equation 1) to determine the calculation of the seed angle of repose.

$$tg\alpha = \frac{Co}{Ca} \tag{1}$$

That:

$tg\alpha$ = angle of repose

Co = opposite cathetus

Cα = adjacent cathetus

For the evaluation of mechanical damage to the seeds, they were subjected to the fast green test, immersed in a solution of fast green (0.1%) for five minutes and then washed in water and dried in the shade, according to the procedure recommended by CHOWDHURY (1977).The fast green solution in this procedure was used as a dye to identify the regions damaged in the seeds and to quantify them. The criterion for classification of the seed mechanical damage was: absence of damage (uncoloured) and the presence of damages (coloured).

For the germination test, we used as substrate the Germitest paper in roll system previously moistened with water at a ratio of 2.5 times the paper weight. The seeds were placed on paper and placed in a germinator with constant temperature of 20 ° C for ten days. The evaluations were made in the fourth and tenth day by counting the germinated seeds, according to the criteria set out in the Rules for Seed Analysis – RSA (BRASIL, 2009).

For the evaluation of mechanical damage and seed germination, we used a control treatment, which the evaluated seeds were not deposited by the metering mechanism, corresponding to the quality as they were packed by the manufacturer.

Statistical analyses were carried out using the SAS program. We applied the variance homogeneity analysis and subsequently proceeded the processing of data to obtain the homogeneity of variance. The results were submitted to analysis of variance by F test, the averages were compared by Tukey test at 5% of error probability.

RESULTS AND DISCUSSION

The average angle of repose of the sorghum seeds was 32.57 °. According to MILAN & GADANHA JÚNIOR (1996), materials with angle of repose smaller than 40 ° showed good flow characteristics and above 50 ° a low flowability index. Thus, the sorghum seed used has good flowability, facilitating its fluidity in the metering mechanism.

The seeds had average water content of 12.92% and they are in conformity with the 29/2011 normative ruling of the Ministry of Agriculture, Livestock, and Supply, which determines maximum value of water content of 13% for sorghum seeds. According to ANDRADE et al. (1999), the seed water content has an important influence on the mechanical damage; dry seeds are more susceptible to crack and break than the wet seeds and can be understood as an effect of lower plasticity to the speed impact with the rotor of metering mechanism.

The seed deposition by the evaluated metering mechanism of continuous flow showed a significant difference between the lateral slope and working speed factors (Table 1).

TABLE 1. Sorghum seeds deposition (g) due to slope (%) and working speed (km h^{-1}).

Speed	**Slope**		
(km h^{-1})	**3%**	**8%**	**16%**
4	5.4 aA	4.2 bA	3.9 bA
10	4.1 aB	4.0 aA	3.4 bA
Speed x slope			3.99*
C.V (%)			6.57
M.S.D			0.33

C.V.: coefficient of variation; M.S.D: minor significant difference; *Significant ($p \leq 0.05$).Averages followed by the same letter horizontally and capital letter vertically do not differ from each other by Tukey test ($p \leq 0.05$).

In the general context, the deposition of seeds is reduced as higher the lateral slope is, as well as the increased speed in the lower slope also decreases the deposition of the seed by the studied metering mechanism.

At the speed of 4 km h^{-1} the seed deposition on side slopes of 8 and 16% were significantly lower than the slope of 3%, corresponding to 22.2% and 27.7% less of deposited seeds. At the speed of 10 km h^{-1} the seed deposition reduced in the higher slope of the metering mechanism, 17% less than the amount deposited in the lower slope. The difference between the highest and the lowest deposition rate verified in the test, achieved respectively in the relief of 3% with speed of 4 km h^{-1}, and in the relief of 16% at 10 km h^{-1}, it was 37.03%, difference that confirms the interaction of slope and speed factors in the efficiency with which the metering mechanism of continuous flow performs the seeds deposition.

The increase of the slope and the working speed reduces the seeds deposition by the metering mechanism.

The results are consistent with the studies by CORRÊA JÚNIOR et al. (2010), wherein the speed increase influenced in the minor amount of deposited corn seeds. DIAS et al. (2009), in a study with seed drills, found an increase in acceptable spacing between one soybean seed and other, concluding that the deposition has changed due to the increase of speed in sowing.

Using soybean seeds to evaluate the influence of cross slope on the performance of three pneumatic metering under different working speeds, ALONÇO et al. (2014) concluded that the slope negatively affected the performance of the metering mechanism, significantly impacting the average results of acceptable and flawed spacing.

The slope and working speed showed no significant interaction between them, but alone the two factors showed significant results compared to the control, for mechanical damage and for germination (Table 2).

TABLE 2. Sorghum speed deposition due to slope and working speed.

FACTOR	Mechanical damage (%)	Germination (%)
Slope		
Control	5.8 a	99.5 a
3%	9.5 b	94.3 b
8%	10.4 b	92.4 c
16%	10.3 b	90.5 d
Speed		
Control	5.8 a	99.5 a
4 km h^{-1}	10.1 b	92.5 b
10 km h^{-1}	9.8 b	92.3 b
Relief	13.46*	64.12*
Speed	12.65*	43.26*
Relief x Speed	1.04^{NS}	1.10^{NS}
C.V (%)	12.06	1.09
M.S.D	1.87	1.64

C.V.: coefficient of variation; M.S.D: minor significant difference; *Significant ($p \leq 0.05$); ^{NS} not significant. Averages followed by the same letter horizontally and capital letter vertically does not differ from each other by Tukey test ($p \leq 0.05$).

The slope and working speed showed no significant interaction between them, but alone the two factors showed significant results compared to the control, for mechanical damage and for germination.

The speeds studied showed significantly higher percentage of mechanical damage when compared to the control. The damage to the seeds in function of the speed factor increased 42.5%. The friction between the seed and the rotary movement of the rotor can justify this result. Another aspect is the rotor opening length and the output fin. Due to the low sorghum seed density, less than 1 g m^{-1}, the adjustment of the rotor and the fin are only possible with short opening length, making the seeds accommodation space tight, increasing friction and the compression between them and the parts of the metering. According to BOTTEGA et al. (2014), the greater the friction and abrasion of the seeds are in the metering, the higher will be the mechanical damage to the seed.

Although differentiated from the control, among them the speeds did not differ the percentage of mechanical damage in the seeds, being permissible that sow in greater speed, leading to a possibility of higher sowing operating income, without loss of mechanical damage in the seeds.

The germination was different between all the slopes and control. As increases the inclination of the metering mechanism the germination is reduced, in relief of 3%, the percentage of germination decreased 5.2%, from 99.5% in the control to 94.3%. In the average slope the reduction was 7.1% and in the higher slope was 9%. These results would likely be associated with the occurrence of mechanical damage in seeds caused by the metering mechanism; however, the damage was not statistically different between the slopes. Among the working speeds studied there are no significant differences for the seeds germination.

The results are similar to COSTA et al. (1996), reporting that mechanical damages contribute to water and microorganisms penetrate through cracks in the husk of the seeds, broken or damaged during mechanical processes, bringing as consequences reduction of germination and its force.

Carrying out tests on seeds obtained in the output conducting tube, and in this study, REIS & FORCELLINI (2009) found that the increase in the metering speed reduced the average level of damage to the rice seeds. In the tangential velocities of 0.36; 0.79 and 1.08 km h^{-1}, the average damages were 4.2; 3.3 and 2.9%, respectively.

CONCLUSIONS

The slope of the metering mechanism of continuous flow at 3% was the best condition for deposition of sorghum seeds, being the worst condition in the slope of 16%.

The sowing speed of 10 km h^{-1} reduces the deposition of sorghum seeds by the continuous flow metering.

The metering mechanism of continuous flow causes mechanical damage to the deposited seeds, regardless of the studied slope and sowing speed. The germination is reduced with the increase of the metering slope and of the sowing speed.

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