TECHNICAL PAPER

LONGITUDINAL DISTRIBUTION OF BEAN SEEDS IN HORIZONTAL PLATE METER OPERATING WITH ONE OR TWO SEED OUTLETS

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ABSTRACT: This study aimed to evaluate the effect of horizontal plate meter with oblong holes operating with one or two seed outlets at different speeds over the accuracy of longitudinal distribution of common bean seeds (*Phaseolus vulgaris* L.). The experiment was performed in laboratory using the meter with one and two seed outlet points in relation to ten tangential disk plate speeds (0.03 to 0.30 m s^{-1}). It was used a complete randomized design with four replications, summing up 80 experimental treatments. Tangential speed quantitative factor was estimated through a 2nd order polynomial regression. There was no significant difference in the behavior of the seed meter operating with one or two outlets in the metering of bean seeds in all tested speeds, with percentage of single seeds spacing over 60% in tangential speeds below of 0.24 m s^{-1}.

KEY WORDS: agricultural mechanization, precision planters, percentage of single.

DISTRIBUIÇÃO LONGITUDINAL DE SEMENTES DE FEIJÃO (*Phaseolus vulgaris L.*) COM DOSADOR DE DISCO HORIZONTAL OPERANDO COM UMA OU DUAS SAÍDAS DE SEMENTES

RESUMO: Este trabalho objetiva comparar os efeitos da utilização do dosador de sementes do tipo disco horizontal com orifícios oblongos, operando com uma e duas saídas de sementes, sobre a uniformidade de distribuição longitudinal de sementes de feijão comum (*Phaseolus vulgaris* L.). O experimento foi realizado em laboratório, utilizando-se de dosador com uma e duas saídas de sementes, em relação a dez velocidades periféricas do disco horizontal, variando de 0,03 a 0,30 m s^{-1}. O delineamento experimental foi o inteiramente casualizado, com quatro repetições, totalizando 80 tratamentos. O fator quantitativo referente à velocidade periférica do disco dosador foi estimado por meio de regressão polinomial de segunda ordem. Os resultados demonstraram não haver diferença significativa na distribuição de sementes de feijão pelo disco dosador operando com uma ou duas saídas, em todas as velocidades periféricas testadas, sendo que, abaixo da velocidade de 0,24 m s^{-1}, o dosador apresentou porcentagem de espaçamentos aceitáveis acima de 60%.

PALAVRAS-CHAVE: máquinas agrícolas, semeadora de precisão, espaçamentos aceitáveis.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.), accounts for about 95% of world production of beans, being grown in about 100 countries, especially in India, Brazil, China, Mexico and United States, being these countries responsible for approximately 48.4% of total production. Brazil is the largest per capita consumer of beans with 16.5 kg inhabitant year (CONAB, 2011).

Small holder farmers are responsible for about 70% of the Brazilian beans production (FRANÇA et al., 2009). These farms are characterized by having small areas, use family labor force with profit income arising from the farm itself and the management of the activities performed by the family (according to Brazilian Law 11,326 of July 24, 2006).

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Precision planters with horizontal plate meter are used mainly for seeding large size grains. This mechanism represents 77.3% of all meters used in mechanical traction planters of domestic manufacturers (SILVA, 2003). Although it is common for these machines to have just one seed meter for each row of seeding, it is observed that in some planter/drill arrangements the horizontal plate has two outlets of seeds for sowing of winter crops (wheat and oats). For the sowing of summer crops such as soybeans and corn, for only one of the seeds is enabled. TEIXEIRA et al. (2009) tested in laboratory the use of a horizontal plate meter using two outlets for corn seeds. There were no significant differences in the uniformity of longitudinal distribution of seeds in relation to the operation speed with only one outlet enabled. According to these authors, it is therefore possible to use only one meter for every two rows of corn, thereby reducing the production cost of planters for the small holder farmers.

The horizontal plate seed meter is used in all types of planters available in the domestic market (TEIXEIRA, 2008). The same author, analyzing the concepts of precision planters with mechanical (walking tractor) or animal traction oriented to family farmers, noted that all models used a single meter for each row.

Several studies indicate that increasing the tangential speed of the horizontal disk plate, which is directly related to the speed of the planter on the field, negatively affects the longitudinal distribution of seeds (GARCIA et al., 2006; MELLO et al., 2007; MAHL et al., 2008). Seeking to test alternative concepts for planter design of lower cost for small holder farms, this study aimed to evaluate the longitudinal distribution of bean seeds by horizontal plate meter using one or two seed outlets in relation to various tangential speeds of the disc plate.

MATERIAL AND METHODS

The experiment was conducted in the Laboratory of Agricultural Machinery, Department of Agricultural Engineering, Faculty of Agronomy ‘Eliseu Maciel’, Federal University of Pelotas. A horizontal plate meter commercially available that works with one or two outlets of seeds was used. The variation of the tangential speed of the disc plate was calculated over the mean diameter between two row of holes and it was obtained through a test bench for seed meters developed by REIS et al. (2007), which meets the requirements of laboratory evaluations of meters recommended by the Brazilian Association of Technical Standards (ABNT, 1994).

Another important factor is the selection of the disk’s hole in relation to the size and shape of the seeds. Due to it, seeds were classified by size using sieves with circular holes having diameters of 6.0, 6.5 and 7.0 mm, being used in the experiment the seeds which were retained on sieve 6.5 mm, since their size were approximately 10% smaller than the disk plate holes and its depth was equal to the diameter or thickness of the seed. The dimensions of the seeds (length, width and thickness) were assessed using a caliper with a resolution of 0.05 mm. The number of seeds measures was enough that the coefficients of variation and the average dimensions were stabilized which happened with 20 samples. The disc plate had 90 oblong holes with dimensions of 7 x 12 mm and 4 mm thick, arranged in two rows.

A randomized experimental design was applied with two experimental factors: number of outlets of the meter, with two levels (one and two) and tangential speed of the disc plate, with ten levels (0.03; 0.06; 0.09; 0.12; 0.15; 0.18; 0.21; 0.24; 0.27 and 0.30 m s^{-1}), resulting in a 2 x 10 factorial design with four replications for each treatment, totalizing 80 treatments. Speed levels were chosen in decreasing order with an interval of 0.03 m s^{-1} and they were the same used by TEIXEIRA et al. (2009). Assuming a bean row spacing of 0.5 m and a stand of 250,000 plants ha^{-1}, these peripheral speeds in the disc plate correspond to speeds from 1.08 to 10.8 km h^{-1} of the planter on the field.

The seed hopper was kept leveled with half the capacity for conducting the tests. The number of seeds metered in each test was 250, as recommended by ABNT (1994).

To enable the measurement of time between the passage of the seeds was used an electronic system composed of a photoelectric sensor unit (plus one unit analog-digital microprocessor PIC16F876 microcontroller, five LM358 integrated circuits, a power supply, filters to prevent the electrical network noise and other discrete components) connected to the computer via serial port EIA-232. The passage of a seed through the seed tube generates an output voltage on the LED receiver, which is compared in the integrated circuit LM358, where there is a reference voltage. If the voltage coming from the receiver is larger, it indicates to the microcontroller that there was the passage of a seed. The signal from the LM358 is interpreted by the microcontroller, which does the processing and sends it to the computer. The counting of the number of seeds and the relative time between them is done using an internal timer with a resolution of ± 0.001 s.

The software RcomSerial v. 1.2 was used for acquiring and recording data on file for later analysis in a spreadsheet.

The sensor unit was adjusted at the exit of the metering device in place of the seed tube. The system showed an average error of 0.93% in the counting of bean seeds to the disc plate peripheral speeds between 0.03 and 0.30 m s^{-1}. This peripheral speed was calculated considering the medium diameter between two lines of holes.

For each peripheral speed of the disc plate, a reference time (t_{ref}) corresponding to the transit time between two consecutive holes was established. This time was calculated in seconds, based on the average diameter, the peripheral speed of the horizontal plate and the number of holes in the disk, according to eq.(1):

$$t_{ref} = \frac{\text{Ø}_m \times \pi}{no \times vp} \qquad (1)$$

where:

Ø_m - mean diameter between the two rows of holes in the disc plate (m);
no - number of holes in disc plate;
vp - peripheral speed of the disc plate (m s^{-1}).

Thus, the reference time, which are directly proportional to the reference spacing for each peripheral speed of the disc plate were calculated. Later, the single time, representing the single spacings, according to the ABNT (1994) were established. Multiple time and missed seeds were also determined by equation 1, considering the multiple as being smaller than 0.5 t_{ref} and the missed seeds the time greater than 1.5 t_{ref}.

As one of the factors is qualitative (output) and has only two levels, for analysis of effects, a paired comparison using the F test was performed. In the quantitative factor (peripheral speed), it was necessary to perform a polynomial regression in order to enable the analysis of its effect on the response characteristic. The mean comparison was performed through the t test. In all statistical tests was adopted a significance level of 5%.

RESULTS AND DISCUSSION

Seed dimensional data (Table 1) indicate that the coefficient of variation (CV) relative to its length was greater than its height and width. This variation can be explained by the use of sieves with circular holes for the grading of seeds.

TABLE 1. Dimensions of bean seeds samples used in the experiment.

Parameters	Length	Width	Height
Average (mm)	10.1	6.6	4.9
Standard deviation (mm)	0.7	0.3	0.3
C.V. (%)	7.2	4.6	6.3
Confidence interval – p=0,95 (mm)	±0.5	±0.2	±0.2

In relation to the metering of beans, both the simple effect of the number of outlets as the interaction between the number of outlets and peripheral speed did not affect the accuracy of the metering according to the F test, with a significance level of 5%. However, the variations in peripheral speed of the disc plate significantly affect the accuracy of the longitudinal distribution of bean seeds.

The mean percentage of multiple seeds, single and missed seeds are showed in Table 2. The sum of three values for each speed is not 100% because each value presented is the average of four trials. It may be noted that, with increasing peripheral speed of the disc plate, the average percentage of single seeds decreases, increasing the average of multiples and missed seeds. This effect was expected because as the disk speed increase, the shorter is the time available for the singulation of seeds by the orifices of the disc plate, resulting in an increase in the number of missed seeds (empty holes), which is consistent with the results described by GARCIA et al. (2006) and TEIXEIRA et al. (2009). Likewise, the increase in peripheral speed has probably hindered the removal of excess seeds by the cutoff pawls causing the increase in the percentage of multiple spacings.

TABLE 2. Mean percentage of multiple, single and missed seeds in relation to peripheral speed of the disc plate in the metering of beans.

Average Spacings (%)		Peripheral Speed of the Disc Plate (m s^{-1}) 0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.30
one outlet	Multiple	5.9	4.9	5.8	5.6	7.9	16.6	24.2	27.8	35.7	37.2
	Single	92.6a	93.4a	93.1a	92.5a	86.8a	73.8a	64.4a	57.0a	40.7a	42.6a
	Missed	1.5	1.7	1.1	1.9	5.3	9.57	11.4	15.1	23.6	20.3
two outlets	Multiple	5.2	3.4	4.9	6.0	6.9	12.0	19.6	22.9	30.9	32.2
	Single	94.0a	95.0a	91.2a	88.6a	84.9a	77.1a	65.4a	63.2a	41.9a	45.4a
	Missed	0.8	1.6	3.9	5.7	8.2	10.8	15.0	13.6	27.2	22.4

Means followed by same letter in column do not differ by F test at 5% level of significance.

It was also observed that the percentage of multiple seeds is greater than the percentage of missed seeds at all speeds examined both for the condition of one or two seed outlets. This could indicate excessive clearance between the hole and the seed, allowing the accommodation of more than one seed in the hole, which would hinder the function of cutoff pawls. However, as the percentage of acceptable distance between seeds was high throughout the experiment, it is likely that this characteristic is due to the irregular shape of common seeds, which were only classified by size.

FEY et al. (1999) analyzed the effect of peripheral speed (between 0.10 and 0.36 m s^{-1}) of a horizontal plate meter commercially recommended on the longitudinal distribution of two sets of bean seeds and found percentages of maximum single spacing approximately 52% below the data presented in Table 2 for speeds less than 0.27 m s^{-1}. These researchers concluded that it is needed a more severe classification of bean seeds and a better adequacy of the discs available on the market in relation to seeds to be metered.

COELHO (1996) established the minimum value of 60% for single distances between seeds and maximum allowable 50% for the coefficient of variation of the distances for the certification of horizontal plate-type meters. The minimum value of 60% can be considered low for single distance, since other factors affect the regularity of the distances between plants, in addition to metering errors, as errors of deposition, depth and covering (MACHADO et al., 2005). In the case of the metering of beans, the disc plate tested reached near 60% of single spacing to 0.24 m s^{-1} of peripheral speed. But because of other errors that affect the accuracy of planting it is advisable to use the disc plate in peripheral speeds lower than this value. At the speed of 0.15 m s^{-1}, which corresponds, in this case, a planter forward speed of 5.4 km h^{-1}, which it is typical for this operation, the percentage of a single seed each time reached a value of 85.7%.

The effect of varying the peripheral speed of the disc plate on the percentage of single seeds of bean is shown in Figure 1.

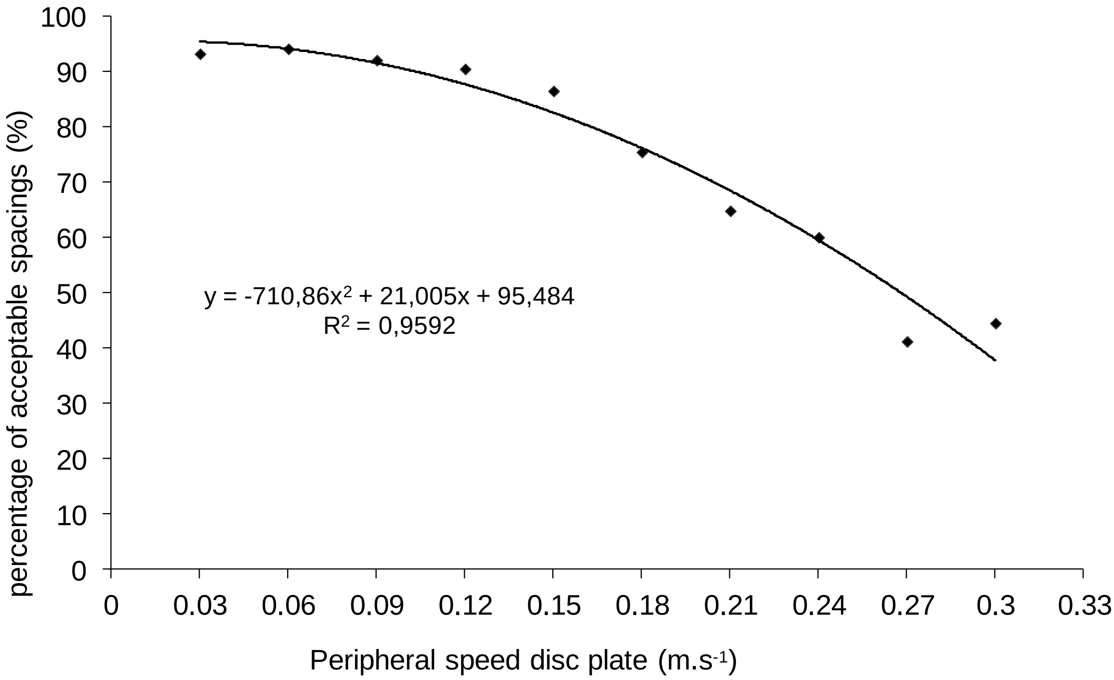

FIGURE 1. Regression curve of the effect of the peripheral speed disc plate for bean seeds in relation to the percentage of acceptable distances between seeds.

CONCLUSIONS

The number of outlets (one or two) did not affect the uniformity of the longitudinal distribution of bean seeds classified by size.

The horizontal plate meter tested showed longitudinal distribution, measured by the single spacing, exceeding 60% when tested under of the tangential speed of 0.24 m s^{-1}.

In typical speed, using animal draft or walking tractors for the planting of beans, the longitudinal distribution of the disc plate, operating with one or two seed outlets, was over 85% of single spacing.

It is possible to use a single horizontal plate meter with oblong holes for seeding two rows of bean seeds and observed that the lower the tangential speed of the disc plate, the greater the uniformity of a single seed each time.

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