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Performance of disks and rings for seeders subjected to increasing temperatures

Abstract – The objective of this work was to evaluate the effect of temperature on disks and rings for seeders and the consequences for the performance of seed distribution. The treatments consisted of the heating of three types of disks and rings for seeders at 30, 40, 50, 60, 70, 80, 90, and 100°C, with four replicates. The evaluated variables were: fitting to the base of the seeder, thickness, diameter, and quality of seed distribution (failed, multiple, and acceptable spacings). There is no significant deformation in the disks and rings for the analyzed variables, and the performance of the longitudinal seed distribution is maintained at all temperatures.

Index terms: disk diameter, disk thickness, horizontal seed plate, seed distribution quality.

Desempenho de discos e anéis de semeadoras submetidos a temperaturas crescentes

Resumo – O objetivo deste trabalho foi avaliar o efeito da temperatura sobre discos e anéis de semeadoras e as consequências sobre o desempenho de distribuição de sementes. Os tratamentos consistiram do aquecimento de três tipos de discos e anéis perfurados de semeadoras a 30, 40, 50, 60, 70, 80, 90 e 100°C, com quatro repetições. As variáveis avaliadas foram: adaptação à base da semeadora, espessura, diâmetro e qualidade da distribuição das sementes (espaçamentos falhados, múltiplos e aceitáveis). Não há deformação significativa nos discos e nos anéis quanto às variáveis avaliadas, e o desempenho da distribuição longitudinal das sementes é mantido em todas as temperaturas.

Termos para indexação: diâmetro do disco, espessura do disco, disco perfurado horizontal, qualidade de distribuição de semente.

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Seeders are machines that distribute seeds into the ground in the following ways: randomly, scattering over the soil surface; in continuous flow, in fillets inside sowing furrows; individually, in determined spaces within the grooves; and in groups in regular spaces within the sowing furrows (Garcia et al., 2022; Woo et al., 2017). Precision seeders are machines that bury seeds in furrows, one by one or in groups, at regular distances, according to the pre-established sowing density (Singh et al., 2019). Most seeders use the horizontal seed plate type, corresponding to 80% of the market (Francetto et al., 2012).

The perforated disk metering mechanism consists of a metering disk with round, oblong, or specially shaped holes located on the edges of the disks. These perforated disks can be vertical, inclined, or horizontal. In general, the mechanical metering systems of horizontal disks consist of a cast base that supports an axle equipped with a small gear, a large one, and a driving gear. The small gear mobilizes the large one that has pins on both sides, which displaces the dosing disk. The horizontal seed plate has holes to house and dose the seeds aligned together with the ring, between the base and the seed box. When the disk rotates, the seeds enter the holes and are led to the exit by the distributor box, directed to the ground by the conductive tube (Weirich Neto et al., 2015).

The disks and seed metering rings are mostly made of polyamide, more specifically nylon 6.6, which is an engineering plastic obtained from modified copolyimide 6.6/6. Their main characteristics are: a greater resistance compared with other materials; a high melting point of 215 to 265°C; a high tensile strength, with a compression and bending tensile strength of 100 and 120 MPa, respectively; chemical resistance to hydrocarbons; and a high rigidity (Mano & Mendes, 2004; Datta et al., 2018).

In a study on corn (*Zea mays* L.) sowing in a no-tillage system, in four farms and two crop seasons, the recorded average fail spacing was determined at 5.5%, multiple spacing at 2.6%, and acceptable spacing at 91.6% (Weirich Neto et al., 2012). Working with different tangential speeds of corn and soybean [*Glycine max* (L.) Merr.] seed metering disks on a carpeted belt, Dias et al. (2014) obtained the best distribution of about 5.0% of fails and multiple spacings, and 90% of acceptable spacings. Checking the space between the base and intermediate base, the lowest values were observed for corn as 1.0% for fails, 1.8% for multiples, and 97.2% for acceptable spacings; and for soybean, the values were 4.1% for fails, 5.1 for multiples, and 90.8% for acceptable spacings (Garcia et al., 2017).

The distribution of seeds occurs with the disk in movement that reaches 0.30 m s^{-1} tangential velocity, which causes the system to heat due to friction which can deform nylon parts (Teixeira et al., 2013).

The objective of this work was to evaluate the effect of temperature on disks and rings for seeders and the consequences for the performance of seed distribution

The experiment was carried out in 2021, in the Department of Soil Sciences and Agricultural Engineering of Universidade Estadual de Ponta Grossa, in the municipality of Ponta Grossa, in the state of Paraná, Brazil. A completely randomized experimental design was applied with eight treatments and four replicates. The treatments consisted of heating (up to 30, 40, 50, 60, 70, 80, 90 and 100°C) the disks and rings for seeders used for sowing the bean (*Phaseolus vulgaris* L.), corn, and soybean crops. Four pieces of each disk and ring model were considered as a replicate (Table 1).

The disks and rings were heated with dry heat in the 400 ND oven (Ethik Technology, Vargem Grande Paulista, SP, Brazil) for 60 min; the temperature stabilization, they were removed for evaluation.

The variables fitting to the base of the seeder, thickness, diameter, and quality of the longitudinal distribution of seeds (failed, multiple, and acceptable spacings) were evaluated. A universal standard base was used to check the deformation, before placing and after removing the materials from the dry heat, for each treatment. Then, the pieces were measured using the 330 mm 100178BL caliper (Digimess Instrumentos de Precisão Ltda., São Paulo, SP, Brazil). The pieces had their evaluations completed in maximum 60 s after removal from the dry heat. Thus, it was possible to observe whether the piece suffered deformation due to heating and if it did not fit into the seed distribution base of the seeder.

The evaluation of the seed distribution was based on the standard project of Associação Brasileira de Normas Técnicas (ABNT, 1996), which considers as acceptable all spacing between seeds from 0.5 to 1.5 times the average spacing. Values obtained beyond this limit are considered as fault spacing (above 1.5 times) or multiples (below 0.5 times). The solid graphite lubricant was added to the seeds at 2.0 g kg^{-1} of seeds. A seeding simulator bench with 9.1 m carpeted mat was used, and scientifically validated at sowing speed was 4.5 km h^{-1} (Jasper et al., 2009). The measurement of the distance between seeds in the length of the mat for each piece subjected to heating (treatment) was considered as a replicate. The evaluations were performed after heating the disks when they returned to environment temperature (20°C).

Recorded values were subjected to Hartley's test, to verify the homoscedasticity of the variances, and to Shapiro-Wilk's test, for data normality. Variables were analyzed by Fisher-Snedecor's test and to polynomial regression with a confidence degree higher than 95%.

Hartley's test indicated the homoscedasticity of variances and Shapiro-Wilk's confirmed the normality of the data for all studied variables. Therefore, there was no need to transform the values to apply the analysis of variance.

The applied temperatures were not sufficient to deform the pieces and did not affect their fit. These results corroborate the findings by Mano & Mendes (2004) and Datta et al. (2018), for the quality of raw material and pieces used in seed distribution.

There was no significant effect of increasing temperatures on the diameters and thickness of the disks and rings tested (Figure 1). The disks and seed metering rings made of nylon 6.6 withstood temperatures up to 100°C without significant changes. Such simplicity of the properties (physical, mechanical, electrical, and chemical) of the material support the option of 80% of Brazilian farmers to use the system of horizontal seed disks for sowing crops, as highlighted by Francetto et al. (2012) and Weirich Neto et al. (2015).

Regarding the distribution quality, the temperature increase did not significantly alter the values collected on a simulating bench of the seeding process (Figure 2). For seed distribution of bean, the averages for faulty, multiple, and acceptable spacings were respectively 3.5, 5.5, and 91.0%. For seed distribution of corn, such spacing averages were respectively: 1.5, 1.0, and 97.5%. For seed distribution of soybean, the spacing averages were respectively: 1.9, 2.7, and 95.4%.

The quality of seed distribution was attained for corn cultivation in a no-tillage system, recording at the time 5.5% average of faulty spacing, 2.6% multiple spacing, and 91.6% acceptable spacing, according to Weirich Neto et al. (2012). These values are lower than those presented by Dias et al. (2014) for soybean distributed in a sowing carpeted mat, with about 5.0% of faulty and multiple spacings, and 90% of acceptable spacings. The trend was kept in comparison with simulated seeding of several cultures on a carpeted mat performed by Garcia et al. (2017), from which the authors attained the following results: for corn, 1.0% of faulty spacings, 1.8% of multiple spacings, and 97.2% of acceptable spacings; and for soybean, 4.1% for faulty spacing, 5.1 multiple ones, and 90.8% for acceptable ones.

As there were no significant changes for dimensions, which made it possible to fit into the universal seed distribution system with horizontal seed disks, seeds were positioned in regular spaces. Thus, the sowing process established by Garcia et al. (2022) and Woo et al. (2017) fitted within the parameters that define precision seedling according to Singh et al. (2019).

Even if there is heating in the seed distribution system – due to the friction generated between the horizontal seed plate, ring, base, and seeds with a treatment that is often abrasive (Teixeira et al., 2013) – the disks and rings made of nylon should not deform and affect the distribution quality up to 100°C, as occurred under the experimental conditions. In the experimental conditions, there was no significant deformation for the analyzed variables, and the quality of the longitudinal seed distribution was maintained in disks and rings that were heated up to 100°C.

Table 1. Characteristics of the horizontal seed disk models and rings, measured at 20°C, used in the seed distribution of the bean (*Phaseolus vulgaris*), corn (*Zea mays*), and soybean (*Glycine max*) crops.

Crop	Piece[(1)]	Thickness (mm)	Diameter (mm)
Bean	Disk with 62 holes (12.5×9.5 mm)	5.3	189.4
Bean	Ring	3.0	189.5
Corn	Disk with 28 holes (12.0 mm)	4.3	189.4
Corn	Ring	4.0	189.4
Soybean	Disk with 90 holes (6.5 mm)	5.3	189.5
Soybean	Ring	3.0	189.5

[(1)]The disks and rings used to sow the bean, corn, and soybean crops are from, respectively: Socidisco (Ponta Grossa, PR, Brazil), Apollo (J.Assay, Caldas Nova, GO, Brazil), and Scherer (Cascavel, PR, Brazil).

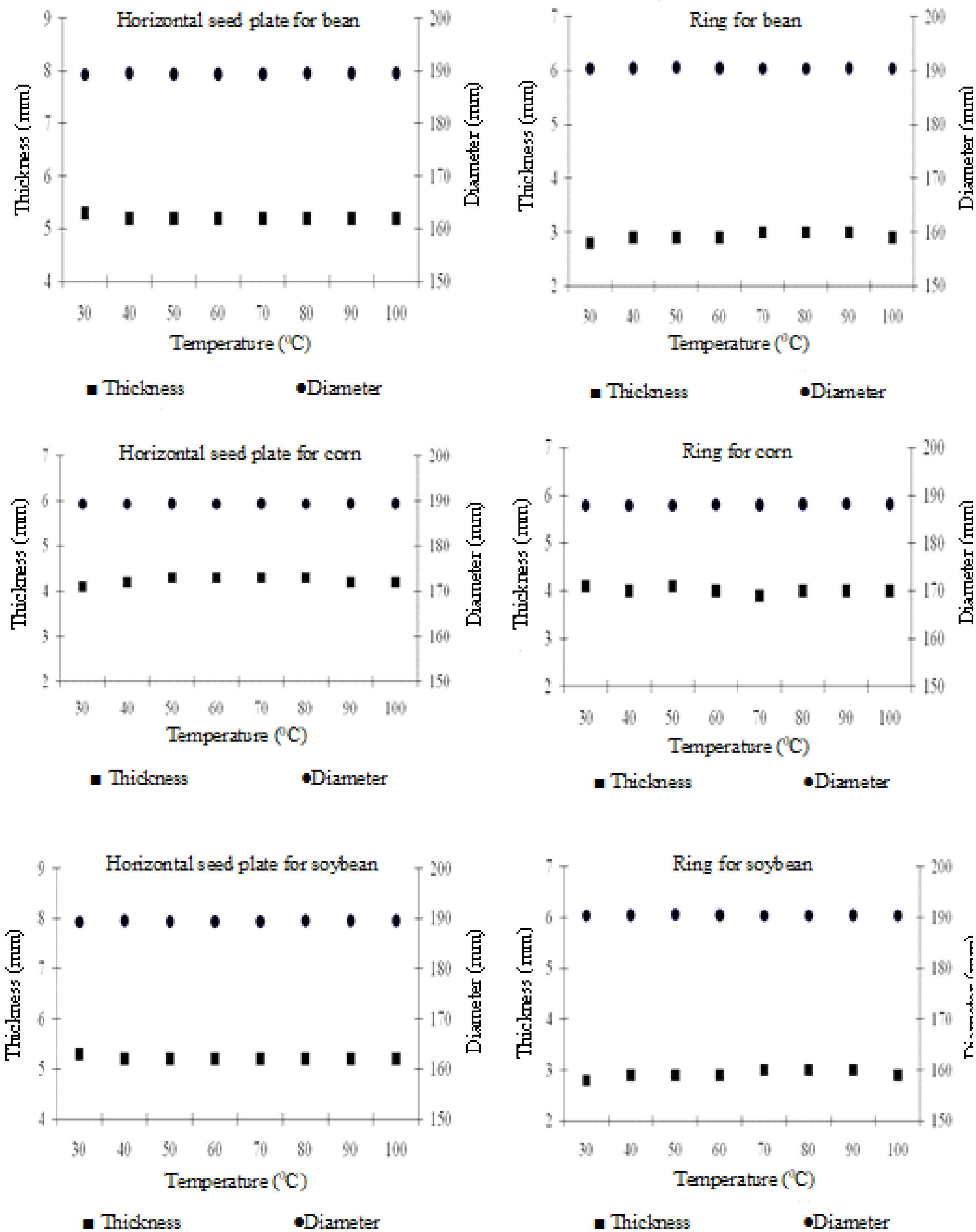

Figure 1. Thickness and diameter of the horizontal seed disks used for seed distribution of the bean (*Phaseolus vulgaris*), corn (*Zea mays*), and soybean (*Glycine max*) crops, at increasing temperatures, by Fisher-Snedecor's test and polynomial regression, at 5% probability.

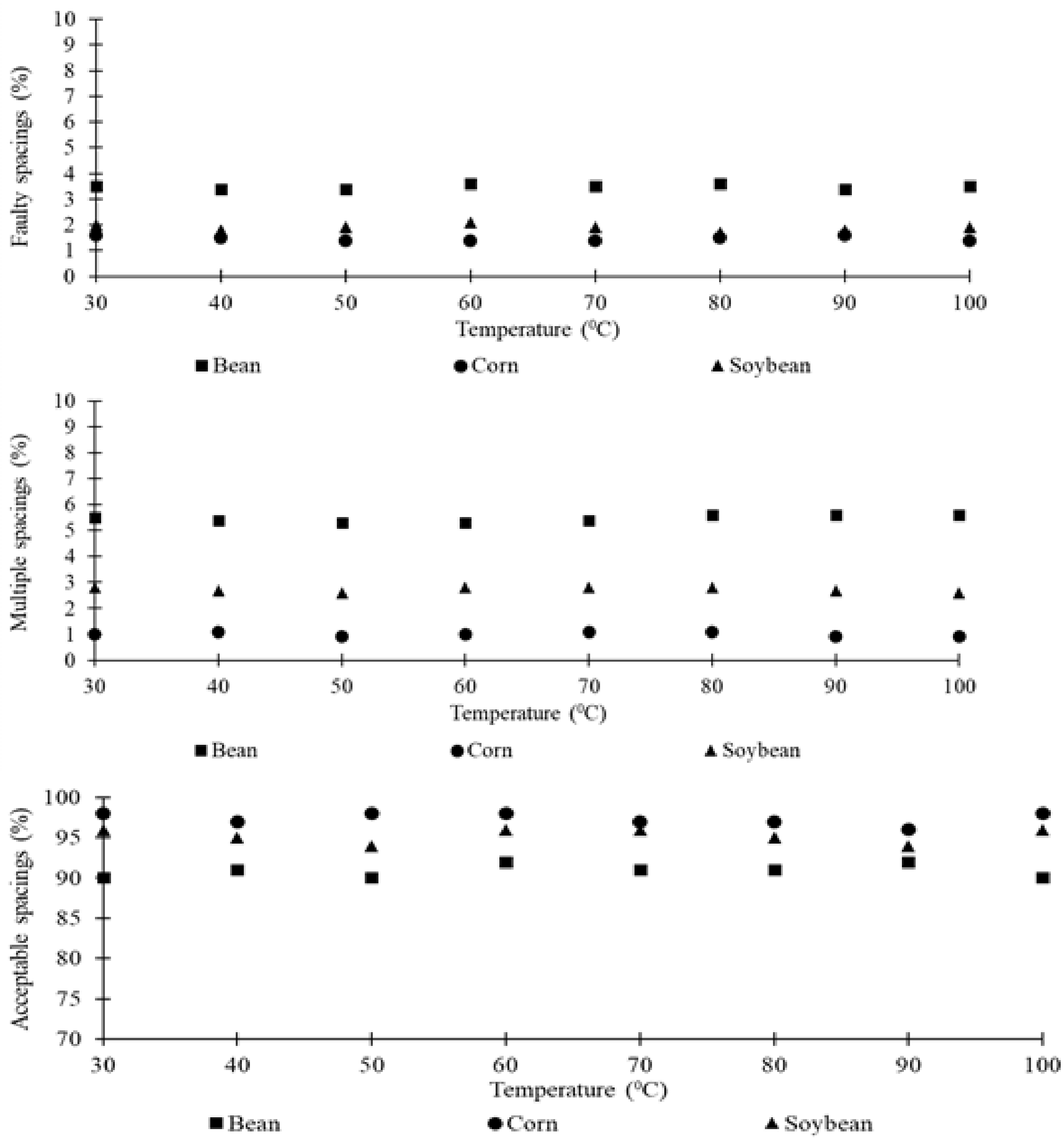

Figure 2. Longitudinal distribution of bean (*Phaseolus vulgaris*), corn (*Zea mays*), and soybean (*Glycine max*), using horizontal seed disks and rings at the base of the seeder with a universal system (Socidisco, Ponta Grossa, PR, Brazil), at increasing temperatures, according to Fisher-Snedecor's test and polynomial regression, at 5% probability.

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