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Seeding quality and soybean yields from using different furrowers and operation speeds

Qualidade de semeadura e produtividade da soja sob diferentes sulcadores e velocidades de operação

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Abstract

The sowing process for annual no-till crops affects the physical soil conditions around the seeds by exposing them to adverse conditions that may limit initial plant development and reduce potential yield. The use of seed drills that are not compatible with field conditions and the use of inappropriate seed drill speeds affect sowing performance. Therefore, this study aims to evaluate the effect of different seed drill types and operating speeds on soybean quality parameters and yield components. Two furrow opener (double disc and chisel) and four operating speed (0.86; 1.22; 1.47 and 1.94 m s^{-1}) treatments were used. The following variables were evaluated: mean number of days until emergence, plant distribution uniformity, sowing depth, area of the soil disturbed, crop stand and grain yield. Overall, the chisel furrow opener provided a greater sowing depth and increased the disturbed soil area more than the double disc furrow opener. Increased operating speeds reduced crop stands and yields and increased the disturbed soil area.
Key words: No-tillage, sowing performance, no-tillage quality

Resumo

Em culturas anuais submetidas ao sistema plantio direto o processo de semeadura afeta o condicionamento físico do solo ao redor das sementes expondo as mesmas a condições adversas, podendo limitar o desenvolvimento inicial das plantas e minimizar o potencial produtivo. O uso de sulcadores não condizentes com a situação de campo e de velocidades inadequadas são fatores que afetam o bom desempenho da semeadura. Nesse contexto, este trabalho teve por objetivo, avaliar o efeito de diferentes sulcadores e velocidades de operação sobre parâmetros de qualidade de semeadura e componentes de produtividade da cultura da soja. Os tratamentos foram compostos pela combinação entre dois sulcadores (disco e haste) e quatro velocidades de operação (0,86; 1,22; 1,47 e 1,94 m s^{-1}). Foram avaliados: o número médio de dias para a emergência, a uniformidade de distribuição de plantas, a profundidade de semeadura, a área de solo mobilizado, o estande de plantas e a produtividade de grãos. De acordo com os resultados, o sulcador tipo haste proporcionou maior profundidade de semeadura e área de solo mobilizada, quando comparado ao disco duplo defasado. O aumento da velocidade reduziu o estande de plantas e a produtividade da cultura e aumentou a área de solo mobilizada.
Palavras-chave: Semeadura direta, desempenho de semeadura, plantio direto com qualidade

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Soybean cultivation is a prominent component of the Brazilian economy due to the large area used by this crop. However, despite the use of new technologies, new concepts and new practices that improve crop stand establishment and increase crop yield are constantly being sought (Moterle et al., 2009).

Many factors interfere with the establishment of crop stands and yields in no-till processes that use precision seeders-fertilisers, including the machine operation speed and the furrower mechanism. Liu et al. (2004) stated that using fast speeds can compromise the sowing quality.

Jasper et al. (2011) concluded that faster sowing speeds increased multiples and reduced the acceptable spacing that affected the longitudinal distribution of the seeds for two different seed-dispensing systems (pneumatic and horizontal disk honeycomb) and five sowing speeds (1.11, 1.66, 2.22, 2.77 and 3.33 m s^{-1}).

Mion and Benez (2008) claim that furrow mechanisms are used to ensure seed and fertiliser deposition in the soil and to provide suitable conditions for germination and crop development. In addition, they state that furrowers are variable and not limited to a single mechanism. Thus, it is necessary to evaluate the best furrow opening mechanisms in the field.

According to Palma et al. (2010), it is possible to use chisel furrowers for soil decompaction in addition to the cultivation of cover crops with a tap root system. The chisel furrowers form deeper seed furrows than the double disc furrowers. Thus, the chisel furrowers increase the soil disturbance and traction forces, which require greater tractor power.

The aim of this study was to evaluate soybean sowing quality parameters and final yields resulting from different furrower mechanisms and seeder-fertiliser travel speeds.

This experiment was conducted at the Experimental Area of the Agronomy Program (“Área Experimental do Curso de Agronomia”) that belongs to the Federal Technological University of Paraná – (“Universidade Tecnológica Federal do Paraná” – UTFPR) and is located in the municipality of Pato Branco – Paraná State. The soil at the experimental area is clayey red latosoil that are rich in aluminium and iron (77.40% clay, 20.31% sand and 2.29% silt). According to the Köppen classification system the climate is humid subtropical (Cfa) with 1,800 mm of annual precipitation. The area is located at 24°16’36” South and 53º30’28” West and has an average elevation of 720 m.

A randomised block experimental design with four replicates in a factorial scheme (2x4) was adopted. The area was divided into four blocks for a total of thirty two plots. Each plot had a total area of 74.0 m^2 (3.7x20 m) and a useful area of 10.0 m^2. Blocks were spaced at 10.0 m for machinery operation and stabilisation. The eight treatments consisted of combinations of two furrowing mechanisms (discs and chisel) and four speeds (0.86, 1.22, 1.47 and 1.94 m s^{-1}).

Sowing took place on November 19, 2009. The cultivar Don Mario 5.8.i was planted at a population of 300,000 plants ha^{-1} with 0.45 m spacing between the rows. During sowing, a 00-20-20 fertiliser was applied at 250 kg ha^{-1}.

The insecticide Methamidophos was applied at a concentration of 750 mL ha^{-1} and the herbicide Glyphosate was applied at a concentration of 2.5 L ha^{-1} 20 days after sowing. Methamidophos, the herbicide Glyphosate and the fungicide Estrobirulin + Triazol were applied at concentrations of 500 mL ha^{-1}, 5.0 L ha^{-1} and 300 mL ha^{-1}, respectively, at an application volume of 200 L ha^{-1} 45 and 60 days after sowing. Mineral oil was used as an adjuvant at a concentration of 0.8 L ha^{-1}.

Average operation speeds of 0.86, 1.22, 1.47 and 1.94 m s^{-1} were determined at the time of sowing and were obtained by shifting gears (1B, 2B, 3B and 4B, respectively) on a New Holland model TL75E, 4x2 FWA (Front Wheel Assist) tractor with a maximum engine power of 57.4 kW (78 hp) at 2,400 rpm. Crops were sown with a "Vence Tudo" brand seeder-fertiliser (model SA 14600) that was equipped with seven sowing units and a compression mechanism consisting of 330 mm (13") diameter and 170 mm wide convex rubber press wheels. For both furrower mechanisms, sowing depth was controlled by using regulator wheels that were located at the rear of the seeder. The seeder-fertiliser mechanisms used for the different treatments included a chisel type with a tube driver, a 14.76 mm wide tip, an attack angle of 30° and a height of 0.45 m and a de-phased double disc type with a 356 mm (14") diameter. The seed furrow opening mechanism consisted of a double disc with a diameter of 356 mm (14"). The seed distributer was a perforated horizontal plate with 90 holes (Model D90/9 and ring number 47R-1). Evaluations were performed using the five central sowing rows. The two outside rows were considered as margins and discarded.

The mean number of days to seedling emergence was determined from daily counts over 10 days that were initiated five days after sowing. Calculations were performed according to the equation shown in Edmond and Drapala (1965).

The seed deposition depth was determined in each experimental plot by sampling the depth of twenty seeds. A spatula was used to remove the soil covering the seeds to avoid removing them from their deposition site. The distance from the furrow border to the uncovered seed was measured.

The seed distribution uniformity was determined by measuring the spacing between twenty seeds in the sowing row of each experimental unit just after sowing. The percentage of normal spacing was derived from this measurement as described by Kurachi et al. (1989).

The disturbed soil area during furrow sowing was determined with a profilometer. The profilometer was constructed of aluminium and had vertical cm scale rulers arranged orthogonally to the row every 0.02 m. The crop stand was evaluated in terms of the number of plants per experimental plot at the time of harvest. This numerical result was extrapolated to determine the number of plants per linear metre.

The soybeans were manually harvested when they reached physiological maturity, and threshing was performed with a stationary thresher. The grain yield was estimated by extrapolating the harvested yield from the usable plot area (10 m^2) to one hectare and correcting for humidity (13%).

Simultaneously, twenty plants were randomly collected within each plot to determine the number of pods per plant and the number of grains per pod. The number of pods per plant were calculated as a ratio of the total number of pods to plants. The number of grains per pod was obtained as a ratio of the total number of grains to pods.

These data were tabulated and subjected to an analysis of variance to determine the effects of the furrower mechanism and speed factors and their interactions with the ASSISTAT 7.5 Beta program (SILVA; AZEVEDO, 2006). We applied Tukey's test when the F test value was significant at a 5% probability level to compare the qualitative factor means (furrower mechanisms). For quantitative factors, the polynomial regression test was applied. For model selection, the significance of the adjusted regression equation coefficients was tested with Student's t-test and with the regression model coefficients of determination (r^2).

Table 1 contains a summary of the analysis of variance. Overall, the operation speed significantly affected the mean number of days to emergence, the sowing depth, the disturbed soil area, the crop stand and the crop yield. The furrower mechanism only influenced the sowing depth and the disturbed soil area. The interaction between furrower mechanism and speed was not significant.

Table 1. Summary of the analysis of variance and the mean number of days to emergence (MNDE), seed distribution uniformity (DU), percentage of acceptable spacing (AS), sowing depth (SD), disturbed soil area (DA), crop stand (CS), number of pods per plant (NP), number of grains per pod (NG) and crop yield (PROD) for different furrow mechanisms.

Furrower	MNDE (days)	DU (cm)	AS (%)	SD (m)	DA (m^2)	CS (pl m^{-1})	NP	NG	PROD (kg ha^{-1})
Disc	6.24 a	7.73 a	65.27 a	0.046 b	0.0037 b	13.49 a	46.26 a	2.25 a	4769.53 a
Chisel	6.23 a	8.34 a	72.22 a	0.050 a	0.0045 a	13.33 a	45.38 a	2.25 a	4695.38 a
F test									
Furrower	0.00^{ns}	2.99^{ns}	385.93^{ns}	0.0002*	0.00001**	0.22^{ns}	6.169^{ns}	0.0005^{ns}	43992.45^{ns}
Speed	0.11*	2.06^{ns}	334.41^{ns}	0.0001^{ns}	0.00000**	1.13**	22.717^{ns}	0.0011^{ns}	356216.85**
F x V	0.03^{ns}	0.31^{ns}	169.73^{ns}	0.0000^{ns}	0.00000^{ns}	0.42^{ns}	26.568^{ns}	0.0014^{ns}	119862.64^{ns}
Residual	0.05	1.26	302.06	0.0000	0.00000	0.20	16.568	0.0034	39898.47
CV(%)	3.52	13.98	25.27	7.60	17.36	3.34	8.96	2.60	4.36

Means followed by the same letter within each column are not significantly different at a 5% probability level according to the Tukey's test.
Source: Elaboration of the authors.

The furrower mechanism did not influence the mean number of days to emergence (MNDE) of 6.2 days (Table 1). The t-test of the linear regression parameters showed that operation speed did not significantly impact the MNDE.

The mean values for seed distribution uniformity and the acceptable spacing percentages are presented in Table 1. Overall, there was no difference between the furrower mechanisms. In addition, the operating speeds did not affect the distribution uniformity or the acceptable spacing percentages. Branquinho et al. (2004) and Celik, Ozturk and Way (2007) obtained similar results from soybean sowing speeds and sunflower cultivation, respectively.

Garcia et al. (2011) concluded that increasing sowing speed negatively affected the uniformity of seed distribution when working with corn sowing rates of 0.69 and 1.2 m s^{-1}. In addition, the authors found that the seeds did not have enough time to fill all of the sowing disc holes at faster travel speeds, which resulted in uneven seed distribution.

With regard to sowing depth, the chisel furrower made deeper furrows than the double disc furrower (Table 1). The greater depth observed from the chisel type furrowers was also observed by Mion and Benez (2008), who claimed that the shape of the chisel furrower made a deeper cut in the soil and provided a greater seeding depth. According to Celik, Ozturk and Way (2007), it is important to maintain and monitor the proper seeding depth when seeds are sown because increasing the sowing depth may delay crop emergence and reduce the crop stand.

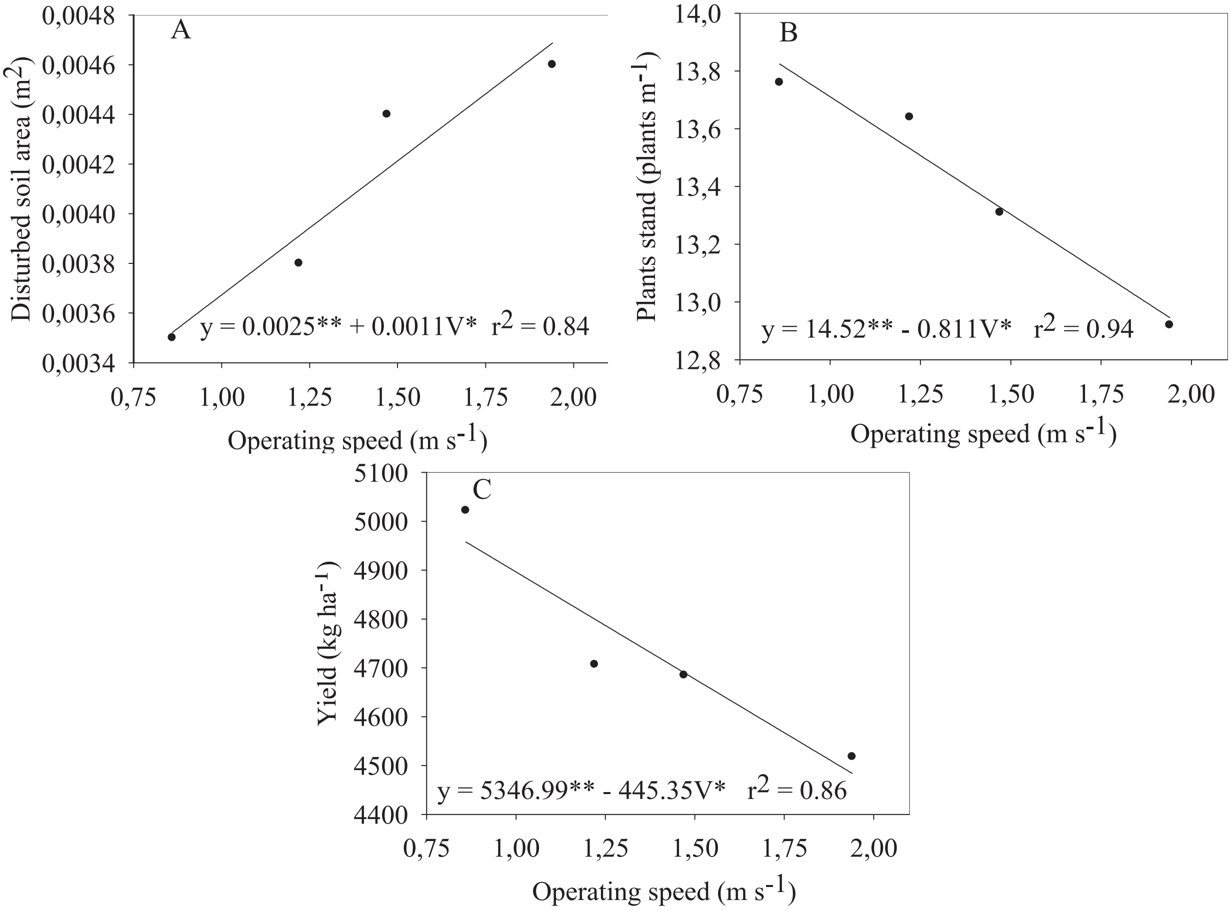
A t-test showed that the linear regression parameters for the operating speed and sowing depths were not significantly different.

Casão Junior et al. (2000) evaluated the performance of a seeder-fertiliser at two operating speeds and found that shallower grooves had faster operating speeds, which is in agreement with the present study. However, Reis et al. (2003) found that operating speed did not significantly affect sowing depth when working with furrower mechanisms (double disc and chisel) at different operating speeds.

The chisel furrower disturbed a greater soil area than the double disc furrower (Table 1). This result can be attributed to the greater depth and tip width of the chisel type mechanism than the double disc type mechanism. Mion and Benez (2008) assessed the required efforts for the seeder-fertilisers soil breaking mechanisms in soils under different vertical loads and found results similar to those obtained in this study.

The regression model fit to the disturbed soil area increased linearly with increasing speed (Figure 1A). For each increasing unit of operational speed, the disturbed soil area increased by 0.00032 m^2. In addition, the disturbed soil area was smallest at an operational speed of 0.86 m s^{-1} and greatest at an operational speed of 1.94 m s^{-1} (0.0035 and 0.0047 m^2, respectively). When the speed increased from 0.86 to 1.94 m s^{-1}, there was a 35.16% increase in the average area of disturbed soil per sowing line.

Figure 1. Disturbed soil area (A), plant stand (B) and soybean crop yield (C) depending on operating speed and type of machinery. * indicates significance at the 5% probability level and ** indicates significance at the 1% probability level according to the Student's "t" test.



Source: Elaboration of the authors.

When working with sowing in soils with different moisture contents at different sowing depths and at two different operating speeds, Cepik, Trein and Levien (2005) observed that the volume of disturbed soil increased by 12% when the sowing speed was increased from 1.25 to 1.80 m s^{-1}. Similarly, the greatest increase in disturbed soil resulted from the greatest increase in sowing speed in the present study.

The crop stand decreased linearly with increasing operating speed (Figure 1B). For example, increasing the velocity from 0.86 to 1.94 m s^{-1} reduced the crop stand by 6.10%. The crop stands were 13.75, 13.60, 13.31 and 12.92 plants m^{-1} for speeds of 0.86, 1.22, 1.47 and 1.94 m^{-1}, respectively.

According to Silva, Kluthcouski and Silveira (2000), the mechanical sowers are less efficient at high speeds because the time to fill the cells of the sowing disc with seeds is less, which impairs seed distribution.

Working with corn seeding rates ranging from 2.0 to 3.1 m s^{-1}, Liu et al. (2004) found no significant differences in the number of final standing plants with increasing speed. In addition, similar results were observed by Mahl, Furlani and Gamero (2008).

Grain yield had a negative linear response to increasing operation speed (Figure 1C). When the speed was increased from 0.86 to 1.94 m s^{-1}, the yield decreased by 505.75 kg ha^{-1}. However, this result was explained by the reduction in crop stand as a result of faster operating speeds, i.e., fewer plants per area significantly influenced the yield. These results differed from those obtained by Branquinho et al. (2004), who found that increased speed did not significantly affect soybean yield.

Working with corn, Silva, Kluthcouski and Silveira (2000) found that increased sowing speed negatively affected yield. In contrast, Mahl, Furlani and Gamero (2008), observed that increasing the sowing speed from 1.22 to 2.72 m s^{-1} did not significantly affect the yield. Based on this unexpected result, the authors concluded that the faster speed did not influence the crop stand.

In conclusion, the use of the chisel furrower provided greater sowing depth and, consequently, a greater area of disturbed soil than the double disc furrower. The operating speed was inversely related to the final crop stand and crop yield and was directly related to the area of soil that was disturbed by the furrower. The furrower mechanisms and operating speeds did not influence the mean number of days to emergence, the uniform distribution of seeds, the percentage of acceptable spacing or the soybean yields.

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