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# Planter speed and plant establishment in corn hybrids seeding

## Velocidade da semeadora e estabelecimento de plantas em semeadura de híbridos de milho

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**Abstract**

Corn (*Zea mays* L.) crop productivity is directly related to the plants establishment which results from the planting operation in the field. The objective of this study was to evaluate two displacement speeds of the tractor seeder set when used to sow seeds of three corn hybrids. The completely randomized design with three repetitions per treatment was used. The following variables were evaluated: power requirement in the drawbar, operational field capacity, fuel consumption, mean number of days for seedling emergence, initial plant stand, and seedling longitudinal distribution. The resulting data were submitted to the analysis of variance and the means compared by the test of Tukey (5%). The results showed that the three hybrids performance was not influenced by the speeds of displacement. Drawbar power and fuel consumption increased with speed of displacement whereas gain in operational field capacity was little.

**Additional keywords:** *Zea mays* L., agricultural engineering, agricultural machines.

**Resumo**

A produtividade da cultura do milho (*Zea mays* L.) está diretamente relacionada com o estabelecimento de plantas na operação de semeadura. O objetivo deste trabalho foi analisar três híbridos de milho e duas velocidades de deslocamento do conjunto trator-semeadora. Conduziu-se o estudo em área experimental da FCAV, UNESP - Jaboticabal-SP, Brasil. Utilizou-se de delineamento inteiramente casualizado, com três repetições por tratamento. Analisaram-se a potência demandada na barra de tração, a capacidade de campo operacional, o consumo de combustível, o número médio de dias para emergência, o estande inicial das plantas e a distribuição longitudinal de plântulas. Realizou-se a análise de variância dos dados e, quando significativos, as médias foram comparadas pelo teste de Tukey, a 5% de probabilidade. Os híbridos não sofreram nenhuma influência sobre as variáveis avaliadas, enquanto o aumento na velocidade de deslocamento do conjunto proporcionou maior potência na barra de tração. O consumo horário de combustível apresentou pequeno aumento na capacidade de campo operacional.

**Palavras-chave adicionais:** engenharia agrícola, máquinas agrícolas, *Zea mays* L.

## Introduction

The ideal speed to the planting is that the groove is opened and closed, not too much disturbed, allowing the seed distribution in constants spaces and depths (RODRIGUES et al., 2011).

The relation between costs of machinery and total costs of operating a farm usually indicate whether their use is being made right or wrong. The selected machinery must be able to complete all operations suitable within the critical periods of available time.

Corn is a major worldwide cultivated grain providing products widely used for food, feed, raw materials for industry and ethanol, mainly due to the quantity and nature of reserves accumulated in the grains. Planting-fertilization operation is crucial in the establishment of this annual crop for better yield, being essential up to date studies on performance of seeder-fertilizers machines.

Machines used together should be appropriate to each other, for instance, a tractor should be able to provide the exact amount of power to pull or move the full range of selected machines or implements to work in combination at the best possible operational velocity so that the seeds are adequately distributed in its depth, row position and ideal plant density. In addition, the fertilizer is distributed in the right amount, position and depth providing effective nutrition for crop sown. The draft force required for the operation of large grain seeders (precision seeders) in the horizontal travel direction, including the machine's rolling resistance, in a good seedbed, ranges from 0.9 kN ± 25% per row, for planting only, and 3.4 kN ± 35% per row, for planting, fertilizer and herbicide application (ASABE, 1999).

All these features may be lost due to the misuse of equipment and machines or according to operational performance of the equipment. In nearly all cultivation systems, the quality of sowing decreases when the speed of work increases. Accuracy (exactness of an operation) and precision (regularity in the execution) at sowing contribute to increase rates of production and reduce the amount of seed and fertilizer used.

According to MAHL et al. (2004) and FURLANI et al. (2007), there could be an average increase of up to 12% in the hourly fuel consumption for each km $h^{-1}$ increase in the forward speed. Planting operation velocity also has a direct influence on the coverage of seeds, regardless the type and brand of seeder.

BONINI et al. (2008) studying the physical soil attributes and power requirement for corn planting operation in an Oxisol concluded that with speed increment, the traction force also increase.

SANTOS et al. (2008) concluded that not only the increase in the forward speed had reduced the planting distribution uniformity, but also mechanically damaged the seeds.

Thus, the present work evaluated the performance of a tractor-seeder set in corn sowing operation according to two forward speeds and its quality using three corn hybrids.

## Material e methods

The experiment was conducted in experimental area from the Department of Rural Engineering, São Paulo State University - UNESP/FCAV, Jaboticabal-SP-Brazil, in the season of 2010/2011. The average slope of the area is 4%, with Aw climate (subtropical), according to the Köppen classification and the soil texture is classified as Eutroferric Red Latosol (ANDRIOLI & CENTURION, 1999) with 469 g $kg^{-1}$ of clay, 307 g $kg^{-1}$ of silt and 224 g $kg^{-1}$ of sand. A total area of 1 ha was divided into plots of 30 m long and 7.2 m wide, with 10 m within plots for maneuvering and stabilization of machines. It was used standard spacing of 0.90 m between corn rows, where plots were made of eight planting rows. Tillage was done using moldboard plow (0.3 m deep) and leveling harrow. The experiment was arranged into 6 treatments, randomized block design with a 3 x 2 factorial scheme, and 4 replications. Treatments were: three corn hybrids (BM2202, BM3061 and BRS3003) and 2 forward speeds of the tractor-seeder set (6.0 and 8.0 km $h^{-1}$), adjusted to 6.9 seeds per meter allowing stand of 76700 plants $ha^{-1}$. Corn hybrids characteristics were: BM2202 double hybrid (18 L sieve – 4.3 mm discs), BM3061 triple hybrid (20 L sieve – 4 mm discs) and BRS3003 triple hybrid (22RM sieve – 4 mm discs). A 04-14-08 N-P-K fertilizer was used at the recommended rate of 320 kg $ha^{-1}$ and 80 kg $ha^{-1}$ of ammonium sulfate for coverage fertilization. The experiment was performed with a Tatu Marchesan PST Plus trailing seeder-fertilizer machine (working width of 3.6 m), double discs (15"x15") for seed and fertilizer distribution and aligned dual-angled press wheels. The tractor used to pull the planter was a AGCO-Valtra, model BM 100, 4x2, with front wheel assist (FWA), 73.6 kW (100 hp) engine power at 2300 rpm, front axle with 14.9-24 R1 and rear axle with 23.1-26 R1 tires.

The values of operating parameters for the tractor-seeder set were stored with a "CR23X micrologger, Campbell Scientific Company." The speed values were obtained by the radar unit located on the right side of the tractor, with an angle of 45° to the ground, RVS type II. The traction force average was measured by a load cell connected to the data acquisition system. The parameter average drawbar power was obtained as a function of the force in the drawbar and the operating speed (SALVADOR et al., 2009).

The operational field capacity was calculated by the working width of the seeder and displacement speed, according to MIALHE (1996). The volumetric and operational fuel consumption of the tractor was determined by flowmeter, i.e. the difference between the measured amount of fuel in the input and return fuel injection pump.

For monitoring the crop were evaluated, seedling longitudinal uniformity (KURACHI et al., 1989), average number of days to seedling emergence (EDMOND & DRAPALA, 1958) and initial stand of plants.

The statistical programs used were the SISVAR (FERREIRA, 2011), resulting in analysis of variance by F test of Snedecor and, when significant, applied the Tukey test at 5% of probability ($p<0.05$).

## Results and discussion

Mean number of days for seedling emergency (Table 1) was not statistically significant to the hybrids and speeds treatments, it maybe caused by the same sowing depth regulation of the seeder machine. Tractor-seeder set forward speed increment also caused no effect over the sower machine.

**Table 1 -** Variance analysis of average number of days for seedlings emergence (NDE) and initial stand of plants.

| Factors | NDE (day) | Initial Stand (plants ha$^{-1}$) |
|---|---|---|
| Hybrids (H) | | |
| BM 2202 | 4.9 | 51851 |
| BM 3061 | 4.9 | 62962 |
| BRS 3003 | 5.1 | 51851 |
| Speed (S) | | |
| 6.0 km h$^{-1}$ | 5.0 | 58024 |
| 8.0 km h$^{-1}$ | 4.9 | 53085 |
| F Test | | |
| H | 1.8 $^{ns}$ | 1.8 $^{ns}$ |
| S | 0.0 $^{ns}$ | 0.8 $^{ns}$ |
| H x S | 1.5 $^{ns}$ | 0.1 $^{ns}$ |
| C.V. (%) | 3.7 | 21.0 |

Means followed by same lowercase letters in columns do not differ by Tukey test at 5% of probability. ns: non-significant; *: significant (P<0.05); **: significant (P<0.01), C.V.: coefficient of variation.

MELLO et al. (2007), working with forward speeds of 5.4, 6.8 e 9.8 km h$^{-1}$, also verified no influence on corn hybrids nor speeds of the seeder machine over average number of days to seedlings.

A possibility for no initial corn plants stand variation is due to the seeder machine regulations and adjustments that were the same for all hybrids and speed treatments (Table 1). SILVEIRA et al. (2005) studying initial corn crop stand, did not find differences ranging forward speed from 3.0, 4.5 and 7.0 km h$^{-1}$.

There were no relevant differences between percentage of normal, flawed and multiple spacing in the treatments and interactions evaluated (Table 2). Nevertheless, it is notable at the 8.0 km h$^{-1}$ speed a 16% lower normal spacing than at the 6.0 km h$^{-1}$ treatment, whereas flawed spacing was nearly double, respectively. MELLO et al. (2007) verified that only for the 9.8 km h$^{-1}$ speed there was a 25% decrease in normal spacing, reflecting the underperformance of the seeder machine at that speed, and speeds of 5.4 e 6.8 km h$^{-1}$ provided around 76% of normal spacing, similar to the present results.

DIAS et al. (2009) developed similar work, where the forward speed increment from 3.5 to 7.0 km$^{-1}$ reduced the percentage of acceptable spacing between corn seeds. It may be linked to the efficiency of the planter feeder mechanism. Some seeders have difficult to lay the seed in the correct place, i.e. acceptable spacing, due to the vibration of the seed supply mechanism, causing a long period of travel of the seed since seed feeder, conductor pipe until arrival in the furrow.

**Table 2 -** Variance analysis for planting longitudinal uniformity (normal, flawed and multiple).

| Factors | Seedling longitudinal uniformity | | |
|---|---|---|---|
| | Normal (%) | Flawed (%) | Multiple (%) |
| Hybrids (H) | | | |
| BM 2202 | 78.8 | 9.0 | 12.2 |
| BM 3061 | 75.6 | 6.6 | 17.8 |
| BRS 3003 | 73.1 | 16.4 | 10.4 |
| Speed (S) | | | |
| 6.0 km h$^{-1}$ | 81.6 | 6.6 | 11.8 |
| 8.0 km h$^{-1}$ | 70.0 | 14.7 | 15.2 |
| F Test | | | |
| H | 0.1 $^{ns}$ | 1.1 $^{ns}$ | 0.5 $^{ns}$ |
| S | 2.1 $^{ns}$ | 2.0 $^{ns}$ | 0.3 $^{ns}$ |
| H x S | 1.5 $^{ns}$ | 1.8 $^{ns}$ | 0.1 $^{ns}$ |
| C.V. (%) | 21.9 | 111.9 | 95.9 |

Means followed by same lowercase letters in columns do not differ by Tukey test at 5% of probability. ns: non-significant; *: significant (P<0.05); **: significant (P<0.01), C.V.: coefficient of variation.

The values for mean and peak power, which are directly proportional to the values of ‘mean force and displacement speed’, presented significant difference between speeds tested. The 8.0 km h$^{-1}$ speed sustained the highest values for Mean and Peak Power, 29.5 kW and 32.7 kW respectively (Table 3), consequently at the expense of higher fuel consumptions, and likewise

'Power', the fuel consumption decreased with the forward speed reduction, in other words, the use of lower speeds led to a lower fuel consumption, and higher speeds led to greater power demand and consequently higher fuel consumption.

**Table 3 -** Variance analysis and F Test for mean and peak traction force, mean and peak drawbar power.

| Factors | Traction force (kN) | | Power (kW) | |
|---|---|---|---|---|
| | Mean | Peak | Mean | Peak |
| Hybrids (H) | | | | |
| BM 2202 | 13.0 | 14.5 | 25.3 | 28.2 |
| BM 3061 | 13.1 | 14.6 | 23.5 | 28.4 |
| BRS 3003 | 12.9 | 14.0 | 25.1 | 27.2 |
| Speed (S) | | | | |
| 6.0 km $h^{-1}$ | 12.8 | 14.0 | 21.3 b | 23.3 b |
| 8.0 km $h^{-1}$ | 13.3 | 14.7 | 29.5 a | 32.7 a |
| F Test | | | | |
| H | $0.1^{ns}$ | $0.1^{ns}$ | $0.1^{ns}$ | $0.4^{ns}$ |
| S | $0.3^{ns}$ | $0.6^{ns}$ | $29.9^{**}$ | $38.7^{**}$ |
| H x S | $0.1^{ns}$ | $0.2^{ns}$ | $0.2^{ns}$ | $0.3^{ns}$ |
| C.V. (%) | 14.6 | 13.2 | 12.5 | 11.4 |

Means followed by same lowercase letters in columns do not differ by Tukey test at 5% of probability. ns: non-significant; *: significant (P<0.05); **: significant (P<0.01), C.V.: coefficient of variation.

RODRIGUES et al. (2011) found an increase of mean power of 32.2% between speeds 6.0 and 9.0 km $h^{-1}$, working with different methods of soil management and a tractor with 89 kW. The same fact happened to the present study, with an increase of 27.8% from 6.0 to 8.0 km $h^{-1}$.

ANDREOLLA & GABRIEL FILHO (2006) noted that the energy demand of drawbar force is lower in the reduced cultivation than conventional tillage and no-tillage with chisel plow or disc.

With 8.0 km $h^{-1}$ speed of tractor-seeder set, the operational field capacity, hourly fuel consumption are significantly higher than 6.0 km $h^{-1}$ (Table 4). For RODRIGUES et al. (2011) the hourly fuel consumption was not influenced by the management systems and was inversely proportional to the increase of the working speed. GARCIA et al. (2011) concluded that with increasing speeds, the effective field capacity also increased since it is directly proportional to the seeder-machine work width and speed.

Operational fuel consumption values from both speeds were similar to each other, showing no statistical differences, which may be explained by the ratio between fuel consumption and operational capacity.

**Table 4 -** Variance analysis for speed, operational field capacity (OFC) and fuel consumption (hourly and operational).

| Factors | Speed | OFC | Hourly consumption | Operational consumption |
|---|---|---|---|---|
| Hybrids (H) | (km $h^{-1}$) | (ha $h^{-1}$) | (L $h^{-1}$) | (L $ha^{-1}$) |
| BM 2202 | 6.9 | 1.6 | 11.9 | 7.3 |
| BM 3061 | 7.1 | 1.6 | 12.5 | 7.6 |
| BRS 3003 | 6.9 | 1.6 | 12.9 | 8.1 |
| Speed (S) | | | | |
| 6.0 km $h^{-1}$ | 6.0 b | 1.4 b | 10.9 b | 7.8 |
| 8.0 km $h^{-1}$ | 8.0 a | 1.8 a | 13.9 a | 7.7 |
| F Test | | | | |
| H | $1.3^{ns}$ | $0.6^{ns}$ | $2.6^{ns}$ | $2.6^{ns}$ |
| S | $833.8^{**}$ | $275.6^{**}$ | $58.4^{**}$ | $2.5^{ns}$ |
| H x S | $0.1^{ns}$ | $0.1^{ns}$ | $0.2^{ns}$ | $0.4^{ns}$ |
| C.V. (%) | 2.1 | 3.6 | 6.5 | 7.3 |

Means followed by same lowercase letters in columns do not differ by Tukey test at 5% of probability. ns: not-significant; *: significant (P<0.05); **: significant (P<0.01), C.V.: coefficient of variation.

## Conclusions

Hybrids tested in the experiment were not influenced on the variables: number of days for seedling emergence, initial stand of plants and seedling longitudinal uniformity.

Forward speed increase to 8.0 km $h^{-1}$ provided significantly greater power at the draw bar, hourly fuel consumption and operational field capacity.

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