EFFICIENCY OF PNEUMATIC AND HORIZONTAL PERFORATED DISK METER MECHANISM IN CORN NO-TILLAGE SEEDERS IN SOIL WITH DIFFERENT MOBILIZATION REPORTS

DENISE MAHL[1], CARLOS E. A. FURLANI[2], CARLOS A. GAMERO[3]

ABSTRACT: This work objectified to evaluate the efficiency of two meter mechanism of corn seeds when submitted to different forward speed and soil management system during the non-tillage seeding. It was used a factorial design in randomized blocks. The factors whose effects were examined were related to the seeders with pneumatic and horizontal disk meter mechanisms for the distribution of the seeds, to the set tractor-seeder forward speeds (4.4; 8.0 and 9.8 km h^{-1}), and to the soil management system considering the corn no-tillage seeding over minimum tillage with chisel plow and the no-tillage system for the seeding of oat culture (*Avena strigosa* Schreb). It was verified that the forward speed didn't influence the initial and final stands of plants but it interfered in the regularity of longitudinal distribution of plants. The smallest speed provided the largest percentile of normal spacing between plants. The pneumatic meter mechanism presented better performance than the horizontal disk perforated in the longitudinal distribution of plants. About corn productivity aspect it’s indifferent the recommendation of use for pneumatic and perforated horizontal disk meter mechanism of seeds.

KEYWORDS: precision of distribution seeds, forward speed, no-tillage system.

EFICIÊNCIA DE DOSADORES PNEUMÁTICOS E DISCO HORIZONTAL PERFURADO NA SEMEADURA DIRETA DE MILHO EM SOLO COM DISTINTOS HISTÓRICOS DE MOBILIZAÇÃO

RESUMO: Este trabalho teve o objetivo de avaliar a eficiência de dois mecanismos dosadores de sementes de milho quando submetidos à variação de velocidade de deslocamento e sistema de cultivo do solo, durante a operação de semeadura direta. O delineamento experimental foi em blocos casualizados, em arranjo fatorial com três fatores: dois mecanismos dosadores de semeadoras-adubadoras de precisão (pneumático e discos horizontais perfurados), três velocidades de deslocamento (4,4; 8,0 e 9,8 km h^{-1}) e dois sistemas de cultivo (semeadura direta de milho sobre aveia-preta em solo preparado com escarificador e no sistema plantio direto). Verificou-se que a velocidade de deslocamento não influenciou nos estandes inicial e final de plantas, mas interferiu na regularidade de distribuição longitudinal de plantas, sendo obtido, na menor velocidade, o maior percentual de espaçamentos normais. O dosador pneumático apresentou melhor desempenho que o disco horizontal perfurado, na distribuição longitudinal de plantas. Sob o aspecto de produtividade da cultura do milho, é indiferente a recomendação de uso dos mecanismos dosadores de sementes pneumático e disco horizontal perfurado.

PALAVRAS-CHAVE: precisão na distribuição de sementes, velocidade, plantio direto.

[1] Agricultural Eng., Prof. Dr., Agricultural Engineering Department, UEM/CAR, Cidade Gaúcha - PR, Brazil, Phone: (0XX44) 3675.1879, dmahl@uem.br
[2] Agronomic Eng., Titular Prof., Rural Engineering Department, FCAV/UNESP, Jaboticabal - SP, Brazil.
[3] Agronomic Eng., Titular Prof., Rural Engineering Department, FCA/UNESP, Botucatu - SP, Brazil.
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INTRODUCTION

Within the productive process, seeding/manuring operation is of decisive importance for the establishment of a yearly cropping for grains production. For conservationist preparing, its importance is increasing, due to the fact soil and covering conditions are generally less favorable to seeds deposition than those verified with the preparing intensive mobilization (PORTELLA et al., 1993).

To improve the efficiency of seeding operation, ENDRES & TEIXEIRA (1997) reported the importance of spatial distribution uniformity of plants in seeding, stating spaces not fulfilled or not compacted will cause greater losses, than spaces not filled or not compacted by the fall of multiple seeds, because of competition among plants. They point out this problem may be softened by a suitable adjustment of seeding-manuring machine regarding to meter discs selection, according to seeds and, mainly, to the seed distributor device used.

PORTELLA (1997) reported high precision doser devices are classified in mechanical and pneumatic devices. Mechanical high precision dosers generally exhibit an alveolate disc shape and are placed on the bottom of seeds reservoir. Pneumatic dosers use air as seeds captation principle, exhibiting bored (vertical) discs, on which air pressurization and suction effects are acting.

Together with seed meter mechanisms, displacement velocity and soil conditions also exhibit a considerable importance for seeding/manurer machines performance regarding to their efficiency. DAMBRÓS (1998) argued plants distribution uniformity was reduced when increasing seeding velocity.

Working with different displacement velocities, MELLO et al. (2001) pointed out seeding machines equipped with pneumatic meter mechanism exhibited a better performance in seeds longitudinal distribution, than bored horizontal discs seeding machines, obtaining, on the average, 85.4 and 77.4% of acceptable spacings for the respective seeding machines. They also verified speed increase from 3.4 to 7.4 km h^{-1} in pneumatic seeding machines, did not cause a significant variation in acceptable spacing percentage, in initial stand and in corn grain production; related to the least tested speed, final stand was reduced at the highest velocity; for both seeding machines, grains production was not affected by seeding velocity.

MAHL et al. (2001) argued displacement velocity increase in seeding operation caused a reduction in the acceptable spacings percentage, and consequently an increase in multiple and failed spacings percentage. Whereas SILVA (2000b), argued seeds distribution uniformity was not influenced by the displacement velocity in corn and soybean culture implantation.

TOURINO (1993) stated non uniform spatial distribution of corn plants can cause losses of 15% or more in grains productivity. On the other hand, RIZZARDI et al. (1994), inquiring about the non uniformity of corn plants distribution on seeding line, considering spacings between 7 and 9 m spacing, under the same seeding density, argued productivity and culture production components, were able to compensate spacings coming from seeds distribution non uniformity. As seeding operation, the initial stage of the process of corn cropping establishment, renders inquiries about seeding-manuring machines performance indispensable to be conducted, because one among the causes of low productivity is the difficulty to establish the ideal conditions in this stage and occasional problems will be only detected after plantules germination and their development, when correction becomes difficult and onerous and production will be already compromised.

Present work intended to analyze the efficiency of the two meter devices of the corn seeds, when submitted to the variation of displacement velocity and soil cropping system, during seeding operation.

The specific purposes consisted in evaluating parameters of seeds longitudinal regularity (the percentage of normal spacings being multiple and failed), initial and final of plants, survival index of plants and corn cropping productivity, when seeding carried out by seeding-manuring machines, joining two seeds meters devices (pneumatic and bored horizontal discs), three displacement velocities (4.4; 8.0 and 9.8 km h^{-1}) and two cropping systems (direct seeding from corn cropping after black oat cropping in soil prepared with scarifier, and in direct seeding.

MATERIAL AND METHODS

Work was conducted on the soil classified as Distroferric Red Nitrosol, in Fazenda Experimental Lageado, of the Agronomic Sciences Faculty, Universidade Estadual Paulista (FCA/UNESP), situated in Botucatu City - SP, Brazil. The experimental area had been cropped with the Direct Cropping System since four years and, to evaluate the influence of soil condition on the performance parameters of seeding-manuring machines, 50% of experimental parcels were kept in direct cropping system and 50% were scarified to implement winter cropping, 120 days before corn cropping. Corn cropping was implemented under black oat vegetation (*Avena strigosa* Schreb) handled with roller knife.

During the carrying out of the experiment were used:

- Tractor, model JD-6600, of 88.3 kW (120 HP), with auxiliary forward driving;

- Scarifier, model Jumbo Matic JMAD-7 with trailing, equipped with seven scarifier rods, pointers 50 mm wide and 430 mm long, 18” cutting discs, serrated survey roller, adjusted for a 0.3 m working depth;

- Combined Roller Knife (ten and seven knives), model Dobruski, 2 m wide, ballasted with water;

- High precision seeding-manuring machine, model PST^3 - Suprema, with trailing, with a pneumatic seed meter device (vertical discs), with 32 holes;

- High precision Seeding-manuring machine, model PST^2, with trailing, with a seed meter mechanism provided with bored horizontal discs, with 28 holes.

Both seeding-manurer machines were equipped with four 0.80 m spaced seeding rows, cutting stubble ploughers, set smooth discs, as much as for seeds, as for fertilizers, double discs dephased type, with seeds and fertilizers reservoirs supplied at 50% of their capacity. Seeding-manuring machines were adjusted for seeds distribution according to characteristics (purity and germinating power) and cultigen recommendations implanted, at a depth of 60 mm.

To perform the experiment, corn seeds (*Zea mays* L.) were used, whose cultigen was the variety of São Paulo State Agricultural Secretary, AL-30 (without the use of lubricant), with the germinating power of 91%, minimum germination of 85% and 99% of purity. With the purpose to get a final population of 60 thousand corn plants per hectare, seeding-manurer machines PST^3-Suprema and PST^2 were adjusted according to the possibility of gear combinations, to distribute 5.88 and 6.05 seeds per meter, respectively.

Fertilizer used followed 8-28-16 (N-P-K) formulation, and seeding-manuring machines were adjusted to distribute 230 kg ha^{-1} (in accordance with soil chemical analysis).

The variables monitored and evaluated in the present inquiry were displacement velocity, normal, multiple and failed spacing percentage among normal plants, initial and final plants stands, plants survival index and corn cropping grains production.

The displacement velocity monitoring during the corn crop seeding was carried out by means of the ratio between the traveled distance for every experimental parcel and the time spent to pass through it.

Velocities making up inquiry treatments were defined as a function of the gearing ratio (1B, 3B e 2C) of tractor used (John Deere 6600), which worked with the motor steady rotation of

2,100 rpm (540 rpm at TDP), due to the use of the seeding-manuring machine with vacuum meter system for seeds distribution.

The regularity of the longitudinal distribution or the spacing uniformity among plants in seeding line was determined by measuring the distance among every corn plants existing on 3 m of seeded row, in the four central lines of every experimental parcel. A 3 m graduated wood ruler was used, to measure spacing among plants.

Spacings among plants (X_i) were analyzed by means of a classification adapted from KURACHI et al. (1989) to evaluate spacing among seeds, determining the percentage of spacings corresponding to the acceptable or normal classes ($0.5\ X_{ref} < X_i < 1.5\ X_{ref}$), multiple ($X_i < 0.5\ X_{ref}$) and failed ($X_i > 1.5\ X_{ref}$), based upon reference spacing (X_{ref}), according to the adjustment of every seeding-manuring machine (X_{ref} of 17.01 and 16.53 cm, respectively, for seeding machines with pneumatic meter and bored horizontal disc), as exhibited in Table 1.

TABLE 1. Limits values of spacing among plants (cm) in agreement with the classes for the meter mechanisms used.

Spacing Class	Pneumatic Meter	Horizontal Disc Meter
Normal	$8.50 \leq X_i \leq 25.50$	$8.26 \leq X_i \leq 24.79$
Multiple	$X_i < 8.50$	$X_i < 8.26$
Failed	$X_i > 25.50$	$X_i > 24.79$

The average corn plants initial stand was obtained by means of a counting of plants existing in 3 m of seeded line, when data collecting of plants longitudinal distribution was carried out, in the four central rows of every experimental parcel. The average final stand was obtained by means of a counting of plants existing in 5 m of seeded row, in the four central rows of every experimental parcel, when culture was cropped (152 days after seeding). Average values obtained were transformed and expressed in number of plants per hectare.

The average survival index corresponded to the average proportion (in percentage) of plants which reached their maturation, related to the corn plants average stand.

To quantify the average corner cropping grains productivity, the spikes of the four central lines were harvested by hand, in 5 m of seeded row, for every parcel, during the period when culture reached the point of physiologic maturation. Samples collected were processed by a grain stationary thrashing-machine of trade-mark NUX Maquinagricola, model BC-30 Junior, and afterward weighed on digital balance, with a 0.01 g accuracy. From every sample a subsample was withdrawn to determine the grain water contents, carried out by the stove method at 105 ºC, during 24 h. Average productivity was calculated correcting grains water contents to 13% and obtained by means of the ratio between parcel (kg) grain production and the area collected in every parcel (m^2), converting results to kg ha^{-1} unit.

The experimental delineation was carried out in casualized blocks, in a factorial arrange with three factors: two doser devices of high precision seeding-manuring machines (pneumatic doser and bored horizontal discs), three displacement velocities (4.4; 8.0 and 9.8 km h^{-1}), and two conditions of soil (previous black oak seeding on soil prepared with scarifier at a 30 cm depth and direct cropping system. So, the sampled universe was made up of 48 experimental units, 20 m long and with a width equivalent to two paces of seeding-manuring machine, with 15 m between them, for maneuvers and stabilization of the tractor-seeding-manuring machine set.

Data were submitted to the variance analysis as for the significance variation ($P<0.05$) Tukey’s test was applied, for the comparison of the contrasts between averages. The values of the variation coefficient of the parameters under inquiry were also determined.

RESULTS AND DISCUSSION

The result of plants longitudinal distribution regularity expressed by the normal, multiple and failed spacings percentages, is exhibited in Table 2.

TABLE 2. Test of the averages for the variables normal, multiple and failed percentage of spacing among plants.

Factor	Normal (%)	Multiple (%)	Failed (%)
	Seed Meter		
Pneumatic	70.33 a	11.50 a	18.17 b
Horizontal disc	57.74 b	12.01 a	30.25 a
	Velocity		
4.4 km h^{-1}	75.37 a	6.95 b	17.68 b
8.0 km h^{-1}	59.21 b	12.70 a	28.08 a
9.8 km h^{-1}	57.52 b	15.61 a	26.87 a
	Cropping System		
Direct cropping	62.48 a	11.67 a	25.85 a
Scarified	65.59 a	11.84 a	22.57 b
C.V. (%)	10.78	34.68	21.57

* Averages followed by different small letters in every column and for every factor differ among themselves, by the 5% probability Tukey test. C.V. variation coefficient.

A significant effect of the velocity and the interaction between meter device and soil cropping system, on the percentage of normal spacing among corn plants, was verified. The difference favorable to the pneumatic meter referred to the bored horizontal discs, when related to the obtention of normal spacings among corn plants became evident. Seeding machine with pneumatic doser device allowed 70.33% of spacings stayed within the desirable limit, whereas in the seeding machine equipped with bored horizontal seed meter, only 57.74% of values were found within this limit. Similar results were found by DAMBRÓS (1998) and by MELLO et al. (2001), however, these authors obtained values of 85 and 77% of normal spacings between plants for the pneumatic meters and horizontal disc, respectively.

With velocity increase, a reduction of the percentage of normal spacings among plants was verified, obtaining better regularity in plants distribution at a velocity of 4.4 km h^{-1} with 75.37% of normal spacings, what statistically differed from remaining velocities, which did not differ among themselves. Similar results were found by DAMBRÓS (1998). ARAÚJO et al. (1999), when inquiring velocities of de 4.5 and 8.0 km h^{-1}, found normal spacings percentage values greater than 60%.

In Table 3, the interaction effect between factors meter device and cropping system is exhibited. It was verified pneumatic meter did not differ statistically among soil cropping systems, whereas horizontal disc meter exhibited a greater percentage of normal spacings with scarified soil. Taking into account that, between scarification carrying out and the seeding period, four months elapsed, (whose purpose of time gap was verifying performance of seeding machine in soils with residual effect of probable unthickening operations in direct cropping areas) and that, in this period, pluvimetric distribution was regular, what contributed to the occurrence of natural and uniform soil compacting during the time, possibly the least occurrence of normal spacings among plants, obtained by horizontal disc meter in soil submitted to direct cropping, was due to the possible impacts of compacted layer, or terrain irregularities on the seeds meter device.

Its would be desirable multiple and failed spacing were zero or near to zero, however, several factors of machine and soil contribute to the occurrence of irregularity in the plants longitudinal distribution. These irregularities mainly happen as a function of meter discs angular velocity, as the probability of holes being suitably fulfilled diminishes with velocity, causing failed and multiple spacings.

TABLE 3. Averages of the interaction between the factors meter mechanism of seeds and soil management system for the variable percentile of spacing among plants normal (%).

Seed Meter	Cropping System	
	Direct Cropping	Scarifier
Pneumatic	70.81 aA	69.86 aA
Horizontal disc	54.15 bB	61.33 bA

* Averages followed by different small letters in every column and for every factor do not differ among themselves, by the 5% probability Tukey test. C.V. variation coefficient.

According to Table 2, only displacement velocity interfered on the multiple spacings percentage. At the least seeding velocity, the least multiple spacings percentage (6.95%) was obtained. What differed statistically from the remaining (12.70 and 15.61%, respectively, at the velocities of 8.0 and 9.8 km h^{-1}) and these spacings were similar among themselves. This effect was also verified by ANDERSSON (2001), but diverged from the results obtained by DAMBRÓS (1998).

Failed spacings were influenced by soil cropping system (Table 2), and in direct cropping soil a greater percentage of the failed spacings among plants (25.85%) occurred. On the other hand, bored horizontal discs doser caused an increase of 66.5% on the failed spacings percentage, in relation to pneumatic meter.

In relation to velocity variation, failed spacings had the same statistical behavior of multiple ones, being inverted to normal spacings among plants. The least values of failed and multiple spacings were found for the least displacement velocity. Increasing velocity, the increase of multiple and failed failings spacing was greater than 80 and 50%, respectively. However, in the average, there were 106% more failed spacings than multiple. Similar results were obtained by ARAÚJO et al. (1999) and MAHL et al. (2001). In Table 4, results of corn plants population and grain productivity are exhibited.

TABLE 4. Test of averages for the variables initial stand, final stand, survival plants index - IS and corn grains productivity - PROD.

Factor	Initial stand (plants ha^{-1})	Final stand (plants ha^{-1})	IS (%)	PROD (kg ha^{-1})
	Seeds meter			
Pneumatic	69,618 a	55,521 a	80.11 a	6,237 a
Horizontal disc	61,892 b	51,302 b	83.11 a	6,583 a
	Velocity			
4.4 km h^{-1}	66,537 a	54,063 a	81.53 a	6,240 a
8.0 km h^{-1}	64,974 a	53,242 a	82.60 a	6,490 a
9.8 km h^{-1}	65,755 a	52,930 a	80.71 a	6,499 a
	Cropping system			
Direct cropping	65,365 a	53,490 a	82.12 a	6,364 a
Scarified	66,146 a	53,333 a	81.10 a	6,455 a
C.V. (%)	5.55	7.26	10.09	12.80

* Averages followed by different small letters in every column and for every factor differ among themselves, by the 5% probability Tukey test. C.V. variation coefficient.

TABLE 5. Averages of the interaction between the factors meter mechanism of seeds and soil management system for the variable corn grains productivity (kg ha^{-1}).

Seeds Meter	Cropping System	
	Direct Cropping	Scarifier
Pneumatic	6,437 aA	6,037 bA
Horizontal disc	6,291 aA	6,874 aA

* Averages followed by different small letters in every column and for every factor do not differ among themselves, by the 5% probability Tukey test. C.V. variation coefficient.

It was verified initial and final plant stands were influenced by the seeding-manuring machine dosers, and for the seeding-manuring machines of pneumatic doser type, initial and final stand values, respectively 12% and 8% higher than those of bored horizontal disc type, were obtained. This increase in initial and final stands can be explained by the higher occurrence of fails in bored horizontal disc doser, related to pneumatic one (30.25 and 18.17%, respectively, of failed spacings between plants, according to Table 2). However, seeding machine meter mechanisms did not interfere in the survival index of corn plants.

On the contrary of results found out by ANDERSSON (2001) e MELLO et al. (2001), there was no variation of stand when related to the variation of displacement velocity and cropping system. OLIVEIRA et al. (2000) also verified initial and final stands were not influenced by displacement velocity.

The average cropping grains productivity was not affected by the variation of velocity and soil cropping system. By means of the significant interaction between doser device and cropping system, as shown in Table 5, it was verified for soil previously prepared with scarifier, grains productivity was higher for seeder machine equipped with bored horizontal discs. The absence of velocity effect on corn productivity was found by MELLO et al. (2001), whereas the absence of the soil preparing effect was found by SILVA (2000a).

It was observed that, even existing a significant difference between initial and final plants stans, no variation of grain productivity occurred, what probably occurred due to the greater concurrence among the plants where stand was greater.

On the contrary of TOURINO's (1993) observations, losses due to plants distribution irregularities were not verified, in accordance with RIZZARDI et al. (1994), who observed corn cropping achieved a compensation of not uniformities of seeds distribution.

Before the results obtained with corn productivity, an additional cost for the purchase of a pneumatic meter device seeding machine is not justified.

CONCLUSIONS

Displacement velocity did not influence plants initial and final stands, but interfered in the plants longitudinal distribution regularity and, at the lower velocity, a higher normal spacings and a lower multiple spacings percentage were obtained.

Pneumatic meter exhibited a better performance than the bored horizontal disc in the plants longitudinal distribution, and a greater percentage of normal spacings and a reduction in the fail spacings.

The productivity of the corn grains was not influenced by velocity variation, soil cropping system, the use of different seed meters, stands difference irregularities, and by spatial plant distribution as a function of seeding line longitudinal distribution.

Under the aspect of the corn cropping, recommendation about using pneumatic doser devices or bored horizontal disc is indifferent.

REFERENCES

ANDERSSON, C. Avaliação técnica de semeadoras-adubadoras para plantio direto. *Plantio Direto*, Passo Fundo, n.66, p.28-32, 2001.

ARAÚJO, A.G.; CASÃO JÚNIOR, R.; RALISCH, R.; SILVA, A.L.; LADEIRA, A.S.; ROSSETTO, R.; SILVA, J.C.; MACHADO, P. *Desempenho da semeadora-adubadora direta PST2 - Marchesan em solos argilosos*. Londrina: IAPAR, 1999. 44 p. 1999. (Circular Técnica, 107)

DAMBRÓS, R.M. *Avaliação do desempenho de semeadoras-adubadoras de milho com diferentes mecanismos dosadores*. 1998. 86 f. Dissertação (Mestrado em Máquinas Agrícolas) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, 1998.

ENDRES, V.C.; TEIXEIRA, M.R.O. População de plantas e arranjo entre fileiras. In: EMBRAPA - Centro de Pesquisa Agropecuária do Oeste. *Milho*: informações técnicas. Dourados, 1997. cap. 6, p.108-10.

KURACHI, S.A.H.; COSTA, J.A.S.; BERNARDI, J.A.; COELHO, J.L.O.; SILVEIRA, G.M. Avaliação tecnológica de semeadoras e/ou adubadoras: tratamento de dados de ensaios e regularidade de distribuição longitudinal de sementes. *Bragantia*, Campinas, v.48, n.2, p.249-62, 1989.

MAHL, D.; GAMERO, C.A.; BENEZ, S.H.; LEITE, M.A.S.; SILVA, A.R.B.; PONTES, J.R.V.; MARQUES, J.P.; GREGO, C.R.; COSTA, A.M. Distribuição longitudinal e profundidade de deposição de sementes de uma semeadora-adubadora de plantio direto em função da velocidade e mecanismo sulcador. In: CONGRESSO BRASILEIRO DE ENGENHARIA AGRÍCOLA, 30., 2001, Foz do Iguaçu. *Anais*... Cascavel: Sociedade Brasileira de Engenharia Agrícola, 2001. 1 CD-ROM.

MELLO, L.M.M.; PINTO, E.R.; YANO, E.H. Velocidade de semeadura na cultura do milho (Zea mays L.): distribuição de sementes e produtividade. In: CONGRESSO BRASILEIRO DE ENGENHARIA AGRÍCOLA, 30., 2001, Foz do Iguaçu. *Anais*... Cascavel: Sociedade Brasileira de Engenharia Agrícola, 2001. 1 CD-ROM.

OLIVEIRA M.L.; VIEIRA, L.B.; MANTOVANI, E.C.; SOUZA, C.M.; DIAS, G.P. Desempenho de uma semeadora-adubadora para plantio direto, em dois solos com diferentes tipos de cobertura vegetal. *Pesquisa Agropecuária Brasileira*, Brasília, v.35, n.7, p.1455-63, 2000.

PORTELLA, J.A. *Mecanismos dosadores de sementes e de fertilizantes em máquinas agrícolas*. Passo Fundo: EMBRABA/CNPT, 1997. 40 p. (Documentos, 41).

PORTELA, J.A.; FAGANELLO, A.; SATTLER, A. Máquinas e implementos para plantio direto. In: CNPT/EMBRAPA, FECOTRIGO, FUNDAÇÃO ABC. *Plantio direto no Brasil*. Passo Fundo: Aldeia Norte, 1993. p.29-36.

RIZZARDI, M.A.; BOLLER, W.; DALLOGLIO, R. Distribuição de plantas de milho, na linha de semeadura e seus efeitos nos componentes de produção. *Pesquisa Agropecuária Brasileira*, Brasília, v.29, p.1231-6, 1994.

SILVA, A.R.B. *Comportamento de variedades/híbridos de milho* (Zea mays *L.*) *em diferentes tipos de preparo do solo. 2000*. 96 f. Dissertação (Mestrado em Energia na Agricultura) - Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Botucatu, 2000a.

SILVA, S.L. *Avaliação de semeadoras para plantio direto: demanda energética, distribuição longitudinal e profundidade de deposição de sementes em diferentes velocidades de deslocamento*. 2000. 123 f. Tese (Doutorado em Energia na Agricultura) - Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Botucatu, 2000b.

TOURINO, M.C.C. *Influência da velocidade tangencial dos discos de distribuição e dos condutores de sementes de soja na precisão de semeadura*. 1993. 98 f. Dissertação (Mestrado em Máquinas Agrícolas) - Faculdade de Engenharia Agrícola, Universidade Estadual de Campinas, Campinas, 1993.