

## SPATIAL VARIABILITY OF LONGITUDINAL DISTRIBUTION OF CORN SEEDS IN FUNCTION OF THE DISPLACEMENT SPEED

ELIVÂNIA MARIA SOUSA NASCIMENTO<sup>1</sup>, CARLOS ALESSANDRO CHIODEROLI<sup>2</sup>,  
MARCELO QUEIROZ AMORIM<sup>3</sup>, JEAN LUCAS PEREIRA OLIVEIRA<sup>4</sup>, JOSÉ  
EVANALDO LIMA LOPES<sup>5</sup>

<sup>1</sup> Departamento de Engenharia Agrícola, Universidade Federal do Ceará, Avenida Mister Hull, Bloco 804, s/n, Pici, 60455-760, Fortaleza, Ceará, Brasil, elivania\_sousa@yahoo.com.br.

<sup>2</sup> Curso de Agronomia, Universidade Federal do Triângulo Mineiro, Avenida Rio Paranaíba, 1229, 38280-000, Iturama, Minas Gerais, Brasil, ca.chioderoli@gmail.com.

<sup>3</sup> Departamento de Engenharia Agrícola, Universidade Federal do Ceará, Avenida Mister Hull, Bloco 804, s/n, Pici, 60455-760, Fortaleza, Ceará, Brasil, mqueirozamorim@yahoo.com.

<sup>4</sup> Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Via de Acesso Professor Paulo Donato Castellane, s/n, Jaboticabal São Paulo, 14884-900, jean07lucasagro@gmail.com.

<sup>5</sup> Empresa de Assistência Técnica e Extensão Rural do Ceará, Avenida Bezerra de Menezes, 1900, São Gerardo, 60325-105, Fortaleza, Ceará, Brasil. evanaldolopes@yahoo.com.br.

**ABSTRACT:** In the seeding process, factors many interfere in the plants stand, among them, the longitudinal distribution of seeds as a function of displacement speed. So, objective of this study is to assess the spatial variability of the longitudinal distribution of corn seeds as a function of the displacement speed of the tractor seed-fertilizer. The experiment had conducted at the Federal University of Ceara, Fortaleza, Ceara, Brazil in an area 0.19 ha. The speeds were 4.59; 6.86 and 8.16 km h<sup>-1</sup>. The regularity of plants longitudinal distribution was determined 21 days after seeding, and within each point the distance between the corn plants in the central line of ten meters in length was measured, percentage of spacing between plants considered as acceptable, multiples and failures. The results showed that the displacement speed negatively influenced the longitudinal distribution of seeds for the normal spacing and positively of failures spacing. The spatial dependence analysis proved to be a useful tool to represent the behavior of the longitudinal distribution of seeds evaluated in sowing operation as a function of the displacement speed.

**Keywords:** geostatistic, mechanization. production.

## VARIABILIDADE ESPACIAL DA DISTRIBUIÇÃO LONGITUDINAL DE SEMENTES DE MILHO EM FUNÇÃO DA VELOCIDADE DE DESLOCAMENTO

**RESUMO:** No processo de semeadura, para se obter produtividades elevadas, inúmeros fatores interferem no estande de plantas, dentre estes, a distribuição longitudinal das sementes em função da velocidade de deslocamento. Assim objetivou-se com este trabalho estudar a variabilidade espacial da distribuição longitudinal de sementes de milho em função da velocidade de deslocamento do conjunto trator semeadora-adubadora. O experimento foi conduzido na Universidade Federal do Ceará, Fortaleza/CE em uma área de 0,19 ha. As velocidades de deslocamento utilizadas foram 4,59; 6,86 e 8,16 km h<sup>-1</sup>. A regularidade da distribuição longitudinal de plantas foi determinada 21 dias após a semeadura, sendo que, dentro de cada ponto procedeu-se a mensuração da distância entre as plantas de milho existentes na linha central de dez metros de comprimento, calculando o percentual de espaçamentos entre plantas, considerado em aceitáveis, múltiplos e falhos. Os resultados mostraram a velocidade de deslocamento influenciou negativamente na distribuição longitudinal de sementes para a classe de espaçamentos normal e positivamente na classe de espaçamentos falhos. A análise da dependência espacial demonstrou ser ferramenta útil para representar o comportamento da distribuição longitudinal de sementes avaliadas em operação de semeadura em função da velocidade de deslocamento.

**Palavras-chave:** geoestatística, mecanização, produtividade.

## 1 INTRODUCTION

Seeding is one of the most important cultural practices associated with crop productivity (ALONÇO et al., 2015). In the corn seeding process, the displacement speed may directly interfere with crop productivity (GARCIA et al., 2011).

The speed is one of the main factors that interfere with quality and operational performance during seeding, due to these obstacles, the authors commented that seed-fertilizer have undergone modifications in order to improve the efficiency of longitudinal distribution (CASTELA JÚNIOR et al., 2014). To Bertelli et al. (2016) the identification of limit speed to realize the seeding is important to take advantage of the machines with pneumatic system and necessary to maintain suitable plantability.

The ideal speed during seeding process is which the groove is opened and closed allowing distributing the seeds in the appropriate spacing and depth. Mahl et al. (2004) found that the longitudinal distribution in seeds can be affected by increasing the displacement speed of the machine, especially when taking into account the peripheral speed of the displacement metering disc, since occurs a decrease in the number of acceptable spacing between seeds.

Santos et al. (2011) affirm that the increase of speed in seeding is a factor that interferes in the establishment of plants negatively influencing the reduction of the percentage of acceptable spacing, increasing the number of failures during seeding. Cortez et al. (2006) verified that speed during seeding operations may directly interfere at longitudinal distribution in seeds.

The study of the spatial variability of plant attributes is fundamental for the understanding of the factors that determine the expression of the productive potential of the crop and its variability in an agricultural area (VIAN et al., 2016).

The geostatistical analysis can act as an alternative or complementation of traditional statistical analyzes, since this tool incorporates the spatial dependence (AQUINO et al., 2016), besides indicating management alternatives,

not only to reduce the effects of spatial variability on the production of the crops, as well as to estimate plant responses to certain management practices (MATTIONI et al., 2013). The objective of this study is evaluate the spatial variability longitudinal distribution of seeds corn in function of the displacement speed of the tractor seed-fertilizer.

## 2 MATERIAL AND METHODS

The experiment was conducted in the experimental area from University Federal of Ceara, in the city of Fortaleza, state of Ceara, situated in the geographic coordinates 3° 44'45" S and 38° 34'55" W and with 19.5 m above of the medium level of the sea. The climate is part of the second classification by Koppen as Aw', wet tropical, with average annual temperature of 28 °C and precipitation of 900 mm. The soil of the area was classified as Red Yellow Acrisol (EMBRAPA, 2013). The experimental area was conventionally prepared with plowing and seeding at a depth of 0.20 m for seeding.

As power source, a tractor BM 120 4x2 TDA (Front Wheel Drive), nominal power 88.26 kW, 2,000 rpm, diagonal tires, front axle 14,9-24 R1 with inflation pressure of 12 psi (83,73 kPa) and rear 18.4-34 R1 with inflation pressure of 22 psi (110.31 kPa), total mass of 6117.5 kg, distributed 41.96% and 58.03% on the front and rear axles, respectively. To seeding process had used, seeder-fertilizer model JM 2090, with 3 planting rows, deposit with a volumetric capacity of 39 L to fertilizer and seed, supplied in 50% of its capacity (fertilizer density of 1.081 g mL<sup>-1</sup> and corn seed 0.781 g mL<sup>-1</sup>). Displacement speeds were 4.59; 6.86 and 8.16 km h<sup>-1</sup>, the spacing between planting was 0.60 m and between rows in the 0.25 m.

The experiment was conducted in randomized blocks, with treatments three (V1- 4.59; V2 - 6.86 and V3 - 8.16 km h<sup>-1</sup>), with five replications. The total area was constituted of sixteen parcels (6 x 20 m) and two points were marked in each parcel. A sample mesh was made with 32 points, distance of 6 m (direction X) and 10 m (direction Y), in an area of 0.19 ha.

The regularity of the longitudinal distribution of seeds in the seeding line were determined 21 days after seeding, and within each point were measured the distance between corn existing in the central line of the meter ten of the long calculating spacing between plants following the methodology Kurachi et al. (1989) correspondents acceptable spacing ( $X_{ref} < X_i < 1.5X_{ref}$ ), multiples ( $X_i \leq 0.5 X_{ref}$ ) and failures ( $X_i \geq 1.5 X_{ref}$ ), based on reference spacing ( $X_{ref}$ ) according to the regulation of the seeder-fertilizer.

The variability of the longitudinal distribution of seeds was initially evaluated through the descriptive analysis of the data, calculating the average, median, variance, coefficient of variation, asymmetry and kurtosis coefficient, the normality analyzes by the Shapiro-Wilks test. In order to verify the spatial dependence of the variables and to interpolate the data, the geostatistical analysis had used (VIEIRA, 2000), from which variogram had constructed starting from the assumptions of the stationary of the intrinsic hypothesis and the calculation of the estimated semi variance in Equation 1.

$$\gamma^*(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \quad (1)$$

Where:  $\gamma^*(h)$  is the number of experimental pairs of (observations;  $N(h)$  is the number of pairs of variables;  $Z(x_i)$  and  $Z(x_i + h)$  separated by a distance  $h$ .

For the determination of the spatial dependence index (SDI), which is the percentage ratio of the nugget effect ( $C_0$ ) to the plateau ( $C_0 + C$ ), the equation ( $C_0 / C_0 + C$ ) proposed by Cambardella et al. (1994) that considers strong dependence <25%; moderate dependence of 25 to 75%; weak dependency >75%. Geostatistical analyzes were carried out using the GS+ program (GAMMA DESIGN SOFTWARE, 2000) and the interpolation of the data made by the kriging method to the mapping through Surfer 9 (GOLDEN SOFTWARE, 2010).

### 3 RESULTS AND DISCUSSION

The descriptive statistic (Table 1) presents the longitudinal distribution of seeds at the displacement speed of 4.59; 6.86 and 8.16 km h<sup>-1</sup> for acceptable, multiple and failures row spacing. The multiple rows spacing at the speed of 4.59 km h<sup>-1</sup> presented a high kurtosis of the coefficient, not passing the normality test. The other classes of row spacing did not present high values for the asymmetry and kurtosis coefficients, the distribution of the data was considered close to the normal distribution and the geostatistical analysis was performed.

The acceptable row spacing presented a distribution with negative asymmetry at all speeds analyzed. In these cases, it was observed that the median is higher than the average, showing a tendency for the concentration of values greater than this. The kurtosis coefficients presented a variation between leptokurtic behaviors with a higher concentration of the data surrounding the medium and platykurtic with a higher level of flattening of the distribution. As described by Oliveira (2010) the asymmetry and kurtosis data demonstrated that the mean values for all variables were between the ranges of -3 and 3, except for the multiple row spacing, at the speed of 4.59 km h<sup>-1</sup>, the other variables were normal distribution by Shapiro-Wilk (SW) test.

To obtain a coefficient of variation, it used methodology proposed by Pimentel-Gomes and Garcia (2002) that classifies CV as low (<10%), medium (between 10 and 20%), high (20-30%) and very high (>30%). The acceptable row spacing presented a medium CV in all displacement speed the normal spacing, while the other spacing presented high CV. Result already expected since when the number of acceptable spacing increases, there is an increase in multiple and failures spacing, since these variables are dependent on each other. The multiple spacing presented a high CV and did not present normality in the data, this was due to the dispersion of the data that was large very. High CVs in agricultural experiments are common, since it is not always possible to control the intrinsic conditions of

the process, among them: poor machine regulation, soil and area conditions.

**Table 1.** Descriptive analysis of the longitudinal distribution of seeds at the displacement speed of 4.59; 6.86 and 8.16 km h<sup>-1</sup> for the row spacing: normal, multiple and failures.

Variable	Mean	Me	$\sigma$	$\sigma^2$	CV	$\mu$	K	S-W*
Speed 4.59 km h <sup>-1</sup>								
N	83.54	87.74	12.11	167.79	14.49	-0.85	0.44	Yes
M	5.43	3.13	7.04	49.56	129.65	2.23	5.56	No
F	11.02	10.06	7.92	62.87	71.86	0.00	-1.67	Yes
Speed 6.86 km h <sup>-1</sup>								
N	75.89	77.78	9.08	82.51	11.96	-0.66	0.73	Yes
M	11.61	11.11	6.73	45.33	57.97	-1.83	0.79	Yes
F	12.48	13.13	9.30	86.58	74.51	0.55	0.56	Yes
Speed 8.16 km h <sup>-1</sup>								
N	71.17	74.59	10.62	114.94	15.06	-0.53	-1.00	Yes
M	12.23	12.06	6.34	40.29	51.90	0.01	-1.86	Yes
F	16.59	16.45	9.15	83.90	55.18	0.45	-0.91	Yes

**Source:** Row spacing: N - normal, M - multiple, F - failures, Me - Median;  $\sigma$  - Standard deviation;  $\sigma^2$  -variance,  $\mu$  - Asymmetry, K - Kurtosis, \* Normality test at 5% probability, CV- Coefficient of Variation.

The longitudinal distribution of plants was influenced by the displacement speed, the higher the speed, the smaller the number of normal row spacing, and the greater the amount of multiple and failures row spacing, due to the speed of the mechanized assembly influencing the speed of the seeds inside the reservoir and the spinning of the seeding speeds that were not evaluated in the work, causing alterations in the uniformity of distribution and the adequate placement of the seed in the soil, interfering in the ideal density of planting. These results corroborate with Dias et al. (2009) when evaluating the influence of speed on longitudinal distribution in maize crop. The same authors verified

acceptable row spacing reduction with the elevation from 3.5 to 7.0 km h<sup>-1</sup>, a fact confirmed in this study.

In Table 2, it is possible to observe through the semivariogram analysis that all variables studied presented weak spatial dependence index (SDI). The range is an important parameter in the study of the semivariogram, since it represents the distance in which there is no spatial correlation between the points of the same variable. The range for the normal spacing was higher (71 m) at speeds of 5.59 and 8.16 km h<sup>-1</sup> and the lowest value (15.12 m) at 6.86 km h<sup>-1</sup>.

**Table 2.** Models and parameters estimated to the experimental semivariogram at the displacement speed of 4.59; 6.86 and 8.16 km h<sup>-1</sup> for the row spacing normal, multiple and failures.

Attributes	Model	Co	Co+C	A	SDI	R <sup>2</sup>
Speed – 4.59 km h <sup>-1</sup>						
N	Spherical	0.38	1.24	71.00	68	91
M	PPE	-	-	-	-	-
F	PPE	-	-	-	-	-
Speed – 6.86 km h <sup>-1</sup>						
N	Spherical	0.00	2.51	15,12	100	90
M	PPE	--	--	--	--	--
F	Spherical	0.01	19.93	20,43	99	96
Speed – 8.16 km h <sup>-1</sup>						
N	Spherical	6.07	22.95	71.00	73	93
M	PPE	--	--	-	--	--
F	Spherical	0.27	3.06	59.40	91	97

**Source:** Row spacing: N - normal, M - multiple, F - failures, Co - effect nugget; C0+C1 - threshold; A - range of spatial dependence (m), SDI - spatial dependency index; R<sup>2</sup> – determination of the coefficient, PPE – pure nugget effect.

The multiple spacing in the speed evaluated and spacing failures in the speed of 4.59 km h<sup>-1</sup> presented EPP, that is, it was not possible to fit a theoretical model experimental semivariogram since this shows that the spatial distribution in this area is random and samples with distance of 10 m are independent.

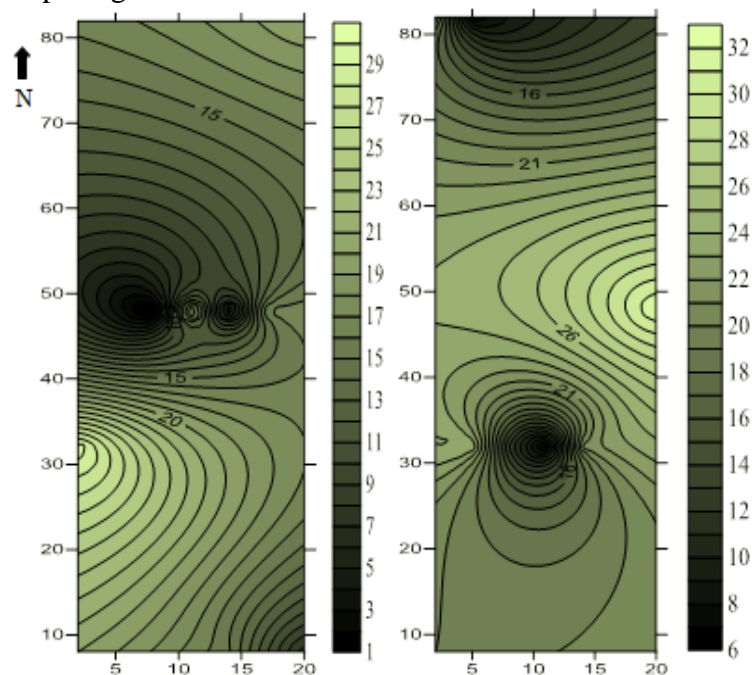
The factors that may have contributed to this absence of spatial dependence were the number of observations by points, the distance between the sampling points, the regularity of distribution of the seeder-fertilizer, showing that the error is random in the operation, regardless of the speeds used. According to Cambardella et al. (1994), the nugget effect

constitutes an important measure of the semivariogram and indicates the unexplained variability, which may be due to undetected measurement error and micro variation, considering the sampling distance used.

The kriging maps of the longitudinal distribution seed at 4.59; 6.86 and 8.16 km h<sup>-1</sup> displacement speed for the acceptable row spacing are shown in Figure 1. It is noted that the longitudinal distribution in seed decreased as the displacement speed increased. Santos et al. (2011) found that the increase of the displacement speed reduced the acceptable row spacing, reflecting the performance of the seeding machine, influencing crop yield.



**Figure 2.** Kriging maps of the longitudinal distribution of seeds at speed 6.86 and 8.16 km h<sup>-1</sup> for the failure row spacing.



#### 4 CONCLUSIONS

The longitudinal distribution of seeds for the normal row spacing presented a weak spatial dependence index at all speeds evaluated.

The displacement speed influenced negatively the longitudinal distribution of

seeds to the normal row spacing, and positively at the multiples and failures row spacing.

The spatial dependence analysis proved to be a useful tool to represent the behavior of the longitudinal distribution of seeds evaluated in seeding operation as a function of the displacement speed.

#### 5 REFERENCES

- ALONÇO, A. S.; SILVEIRA, H. A. T.; CARDINAL, K. M.; RIST, G. P. Distribuição longitudinal de sementes de algodão e girassol com diferentes velocidades e inclinações em dosadores pneumáticos. *Scientia Agraria*, Curitiba, v. 16, n. 3, p. 63-70, 2015.
- AQUINO, R. E.; CAMPOS, M. C. C.; MARQUES JÚNIOR, J.; OLIVEIRA, I. A.; TEIXEIRA, D. B.; CUNHA, J. M. Uso de semivariogramas escalonados no planejamento amostral de atributos físicos do solo em ambientes na região sul do Amazonas. *Revista Brasileira de Ciência do Solo*, Viçosa, v. 39, n. 1, p. 21-30, 2015.
- BERTELLI, G. A.; JADOSKI, S. O.; DOLATO, M. L.; RAMPIM, L.; MAGGI, M. F. Desempenho da plantabilidade de semeadoras pneumática na implantação da cultura da soja no cerrado piauiense – Brasil. *Brazilian Journal of Applied Technology for Agricultural Science*, Guarapuava, v. 9, n. 1, p. 91-103, 2016.
- CAMBARDELLA, C. A.; MOORMAN, T. B.; NOVAK, J. M.; PARKIN, T. B.; KARLEN, D. L.; TURCO, R. F.; KONOPKA, A. E. Field-scale variability of soil properties in central Iowa soils. *Soil Science Society Amsterdam Journal*, Madison, v. 58, n. 5, p. 1501-1511, 1994.

CORTEZ, J. W.; FURLANI, C. E. A.; SILVA, R. P.; LOPES, A. Distribuição longitudinal de sementes de soja e características físicas do solo no plantio direto. **Engenharia Agrícola**, Jaboticabal, v. 26, n. 2, p. 502-510, 2006.

CASTELA JÚNIOR, M. A.; OLIVEIRA, T. C.; FIGUEIREDO, Z. N.; SAMOGIM, E. M.; CALDEIRA, D. S. A. Influência da velocidade da semeadora na semeadura direta da soja. **Enciclopédia Biosfera**, Goiânia, v. 10, n. 19, p. 1199-1207, 2014.

DIAS, O. V.; ALONÇO, A. S.; BAUMHARDT, U. B.; BONOTTO, G. J. Distribuição de sementes de milho e soja em função da velocidade e densidade de semeadura. **Ciência Rural**, Santa Maria, v. 39, n. 6, p. 721-1728, 2009.

EMBRAPA. **Sistema Brasileiro de Classificação de Solos**. 3. ed. ampl. Brasília, DF: Embrapa Produção da Informação; Rio de Janeiro: Embrapa Solos, 2013.

GAMMA DESIGN SOFTWARE. **GS+ for Windows**. Demonstration version. Michigan: Gamma Design Software, 2000.

GARCIA, R. F.; VALE, W. G.; OLIVEIRA, M. T. R.; PEREIRA, E. M.; AMIN, R. T.; BRAGA, T. C. Influência da velocidade de deslocamento no desempenho de uma semeadora-adubadora de precisão no Norte Fluminense. **Acta Scientiarum Agronomy**, Maringá, v. 33, n. 3, p. 417-422, 2011.

GOLDEN SOFTWARE. **Surfer for Windows**. Version 9.0. Colorado: Golden, 2010.

KURACHI, S. A. H.; COSTA, J. A. S.; BERNARDI, J. A.; COELHO, J. L. D.; SILVEIRA, G. 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. 249-262, 1989.

MAHL, D.; GAMERO, C. A.; BENEZ, S. H.; FURLANI, C. E. A.; SILVA, A. R. B. Demanda energética e eficiência da distribuição de sementes milho sob variação de velocidade e condição de solo. **Engenharia Agrícola**, Jaboticabal, v. 24, n. 1, p. 150-157, 2004.

MATTIONI, N. M.; SCHUCH, O. B.; VILLELA, F. A. Variabilidade espacial e efeito de atributos químicos de um latossolo na população de plantas e produtividade da cultura da soja. **Revista da FZVA**, Uruguaiana, v. 19, n. 1, p. 20-32, 2013.

OLIVEIRA, J. U. C. **Estatística**: uma nova abordagem. Rio de Janeiro: Ciência Moderna Ltda, 2010.

SANTOS, A. J. M.; GAMERO, C. A.; OLIVEIRA, R. B.; VILLEN, A.C. Análise espacial da distribuição longitudinal de sementes de milho em uma semeadora-adubadora de precisão. **Bioscience Journal**, Uberlândia, v. 27, n. 1, p. 16-23, 2011.

PIMENTEL-GOMES, F.; GARCIA, C. H. **Estatística aplicada a experimentos agrônômicos e florestais**: exposição com exemplos e orientações para uso de aplicativos. Piracicaba: FEALQ, 2002.



VIAN, A.; SANTI, A. L.; AMADO, T. J.; CHERUBIN, M. R.; SIMON, D. H.; DAMIAN, J. M.; BREDEMEIER, C. Variabilidade espacial da distribuição de milho irrigado e sua correlação com variáveis explicativas de planta. **Ciência Rural**, Santa Maria, v. 46, n. 2, p. 464-471, 2016.

VIEIRA, S. R. Geoestatística em estudos de variabilidade espacial do solo. *In*: NOVAIS, R. F.; ALVARES, V. V. H.; SCHAEFFER, C. E. G. R. (ed.). **Tópicos em ciência do solo**. Viçosa: Sociedade Brasileira de Ciência do Solo, 2000. p. 54.

WEIRICH NETO, P. H.; FORNARI, A. J.; JUSTINO, A.; GARCIA, L. C. Qualidade na semeadura do milho. **Engenharia Agrícola**, Jaboticabal, v. 35, n. 1, p. 171-179, 2015.