Quality of sunflower seeds in function of thickness classification and sowing under speed variation of the seeder-fertilizer[1]

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ABSTRACT

The objective was to evaluate the quality of sunflower seeds classified according to their thickness and passed through the seeder-fertilizer dosing system under variation of the travel speed. A lot of M734 was classified by thickness passing the seeds through a set of oblong-hole sieves and two thicknesses were selected. A portion of the seeds with only the commercial classification was also reserved, named as non-classified. The biometric evaluation was done and the sowing was carried out at 5.0, 6.5, 8.0, 9.5 and 11.0 km h^{-1}. The quality of the seeds was evaluated through: germination and first germination count, average time and percentage of emergence in sand, accelerated aging and tetrazolium test. The classification by thickness reduce the coefficient of variation of the length, width, thickness, and mass but seeds classification does not affect seed vigor and viability after sowing under speed variation. In the higher studied speed, the passage of seeds through the dosing mechanism reduces germination. The vigor is affected at 6.5 km h^{-1} speed by the accelerated aging test. According to the emergence in sand and tetrazolium test, speed variation does not affect the vigor and viability of sunflower seeds.

Keywords: biometry; *Helianthus annuus L.*; mechanical damage; sowing damage.

INTRODUCTION

Sunflower is a second crop option in Brazil in replacement to maize, contributing to crop rotation/succession. However, there are still obstacles to be overcome in its management, such as unevenness in the size of commercial seeds and low seeding uniformity. Seed distribution in the row in sunflower cultivation is still irregular and may be associated with low seed uniformity, damage during sowing, and the travel speed of the seeder-fertilizer.

Seed classification by size is a tool adopted during seed processing meant to standardize the seed lot (Nunes *et al.*, 2016), generating a standardized product for mechanized sowing. Bottega *et al.* (2014a) justified that variations in seed size affect the longitudinal distribution of maize. For peanuts, seed size influences damage occurrence during sowing (Yutao *et al.*, 2012). According to Albiero *et al.* (2012), seed damage at sowing may be related to the dosage and the geometric and positioning aspects of the seeds in the dosing system.

Regarding the travel speed, there is still controversy about damage occurrence to the seeds during sowing. The displacement speed can influence the operational capacity, the rotation of the metering mechanism, the distance and depth of seed deposition, the occurrence of mechanical damage, the opening and closing of the furrow, among others (Garcia *et al.*, 2011; Jasper *et al.*, 2011; Vazquez *et al.*, 2012).

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Vale *et al.* (2010), studying the influence of displacement speed on the performance of a seeder-fertilizer, reiterate that the disc metering mechanism generates damage to the embryo during sowing, decreasing the germination of corn seeds compared to those that did not pass through the dosing mechanism.

The increase in speed can reduce seed quality, as already observed in canola (Harker *et al.*, 2012), maize (Garcia *et al.*, 2011), wheat (Vasconcellos *et al.*, 2018), and sorghum (Correia *et al.*, 2016). Seeds of several species can be damaged during sowing, and the dosage mechanism can act as a harmful agent reducing the seed viability and vigor (Almeida *et al.*, 2003). However, there is still little information for sunflower.

Therefore, this study aimed to evaluate the quality of sunflower seeds classified according to their thickness and passed through the seeder-fertilizer dosing system under variation of the travel speed.

MATERIAL AND METHODS

A commercial seed lot of sunflower M734 was classified according to the thickness by passing the seeds through a set of oblong-hole sieves. Thus, in addition to the original (industrial) classification performed at the seed processing unit, a new classification was performed to separate the seeds by thickness. The size of the sieve holes was 22 mm in length and 5.00, 4.50, 4.00, 3.50, 3.00, 2.50, 2.00, and 1.75 mm in width and bottom (< 1.17 mm).

Subsequently, two thicknesses were selected for sowing based on the size difference between them, namely C1 (seeds retained in the 3.50 mm sieve) and C2 (seeds retained in the 2.50 mm sieve). A portion of the seeds with only the commercial classification was also reserved, named as non-classified (NC).

After thickness classification and selection, the seeds were subjected to biometric analysis by measuring the length, thickness, width, and unit mass of 30 seeds (Fava, 2014) using a digital caliper (accurate to 0.01 mm) and an analytical balance (accurate to 0.0001 g). These data were analyzed by descriptive statistics determining the mean, standard deviation, coefficient of variation, and maximum and minimum values.

The travel speeds of the tractor-seeder-fertilizer set were 5.0, 6.5, 8.0, 9.5, and 11.0 km h^{-1}. For the comparison regarding damage occurrence at sowing, the classified and non-classified seeds that did not pass through the dosing mechanism of the seeder-fertilizer were adopted as a control.

A two-wheel drive Case® MX 270 tractor with front-wheel drive (FWD), powershift transmission, maximum power of 270 hp, dual rear wheels, hydraulic system, and a multifunctional control station with electronic speed control was used in the experiment. The Semeato® *Quadra 9* seeder-fertilizer had a mechanical distribution system with a horizontal disk meter.

To evaluate the physiological quality and damage occurrence after sowing, the seeds were put into the respective containers, and the end of the conducting tubes of the seed distribution system was sealed with sponges. Subsequently, the tractor-seeder set ran through 50 m at each pre-established speed, and the seeds retained in the tubes were collected and put into pre-identified paper bags. The experiment was conducted in a completely randomized design in a 2 x 5 + 1 factorial arrangement (classifications x speeds + control) with four replications.

Afterward, in the analysis laboratory, the seeds were evaluated regarding the first germination count (FGC) and germination percentage (G) on the 4^{th} and 10^{th} days after sowing (DAS), respectively, by counting the number of normal seedlings (Brasil, 2009). Also, the sand emergence percentage (SE) was evaluated by considering as emerged the seedlings with a visible shoot until the 10^{th} DAS; the mean germination time (MGT), by daily counting the emerged seedlings and applying Labouriau's equation (1983); finally, the accelerated aging test (AA) was performed with incubation in Gerbox® germination boxes for 48 hours at 42 ºC and germination count on the 4^{th} DAS (Marcos Filho, 1999).

Seed evaluation by the tetrazolium test was performed by pre-moistening the samples in distilled water for 18 hours at 20 °C to manually remove the pericarp and the seed coat. Subsequently, the seeds were stained with a 1% 2,3,5-triphenyl tetrazolium chloride solution at 30 °C and in the dark, for three hours, for classification as: viable and high vigor (class I), viable and medium vigor (class II), viable and non-vigorous (class III), non-viable (class IV), and dead (class V). Classes I and II were summed to obtain the vigor; classes I, II, and III were summed for the percentage of viable seeds; and classes IV and V were summed to obtain the non-viable seeds (Nobre *et al.*, 2014).

The data collected were subjected to the normality test (Shapiro-Wilk: $p < 0.05$) and to the analysis of variance by the F-test ($p < 0.05$). The means of the quantitative factor (speed) were analyzed by regression ($p < 0.05$) considering the first and second-degree equations, not using the control at this stage. Subsequently, the means referring to each speed were compared to the control (0.0 km h^{-1}) by Dunnett's test ($p < 0.05$). The Tukey-Kramer test ($p < 0.05$) was used for the qualitative factor (classification) when significant. The statistical software SAS Studio version 9.4. was used in all statistical analyses.

RESULTS AND DISCUSSION

The highest retention percentage occurred in the first sieve, with 3.00 mm thickness (Table 1), which retained 43% of the total, with seed thickness in this lot varying from 4.00 to 2.00 mm (Table 1). Lots composed by seeds with different thicknesses (heterogeneous) make difficult to choose the disk/ring set to be used in sowing since the producer considers the accommodation and passage of the seeds through the disk holes, with thickness being the parameter used to choose the ring

When the seeds are heterogeneous or the classification is insufficient, disks with larger holes are usually chosen as they can be used for both large and small seeds. However, this may result in an increased occurrence of double spaces as the disk holes may be filled by two smaller seeds simultaneously. According to Aguiar *et al.* (2001) and Celik *et al.* (2007), the tapered shape of sunflower seeds and the intrinsic unevenness of the species complicate seed processing and favor seed heterogeneity.

Table 1: Percentage of sunflower seeds (*Helianthus annuus L.*) retained in the sieves used for classification as a function of thickness.

Thickness (mm)	Retained seeds (%)
5.00	0.00
4.50	0.00
4.00	4.30
3.50	39.20
3.00	43.50
2.50	12.20
2.00	0.70
1.75	0.00
Bottom*	0.00

* Bottom: seed thickness < 1.75 mm.

Table 2: Length (L), width (W), thickness (T), and mass (M) of sunflower seeds (*Helianthus annuus L.*), cultivar M734, classified (C1 and C2) or not (NC) as a function of thickness.

Classification	Characters	L (mm)	W (mm)	T (mm)	M (g)
Class 1 (3.5 mm)	Mean	10.51	5.34	3.52	0.0771
	Min. value	9.35	4.91	2.48	0.0597
	Max. value	11.62	6.15	3.95	0.1003
	S	1.88	1.10	1.20	0.0300
	CV (%)	4.77	5.47	9.11	11.5800
Class 2 (2.5 mm)	Mean	9.81	4.73	2.70	0.0557
	Min. value	8.84	4.06	2.41	0.0440
	Max. value	10.93	5.30	2.94	0.0663
	S	2.05	1.22	0.48	0.0200
	CV (%)	5.57	6.90	4.75	11.3600
Non-classified	Mean	10.33	5.09	3.26	0.0677
	Min. value	9.34	4.21	2.61	0.0492
	Max. value	11.28	5.60	4.04	0.0960
	S	1.92	1.31	1.62	0.0400
	CV (%)	4.95	6.88	13.23	17.4800

*S: standard deviation; CV: coefficient of variation.

Comparing the biometric data of the classified (C1 and C2) with non-classified (NC) seeds, the classification by thickness reduced the coefficient of variation of the length, width, thickness, and mass variables (Table 2), with mass and thickness being the attributes with greater variation. As expected, classification by thickness reduced the range (maximum and minimum values) of the data, minimizing the dimensional variation of the seeds (Table 2). Jasper *et al.* (2006) stated that variation in seed size is inversely proportional to distribution quality.

In the evaluation of seed physiological quality, the interaction between sowing speeds and classifications (thicknesses) was not significant for all analyzed variables, with the factors being discussed separately. For the classification factor, only in the first germination count did the classes differ, while seed classification as a function of thickness did not influence the physiological quality of the seeds after sowing under variation of the seeder-fertilizer in the remaining evaluations. Regarding germination, the increase in speed resulted in a 1.1% reduction in the germination mean per speed unit, ranging from 93% in the sowing at 5.0 km h^{-1} to 86% at 11.0 km h^{-1}, with a coefficient of regression of 98% (Figure 1A).

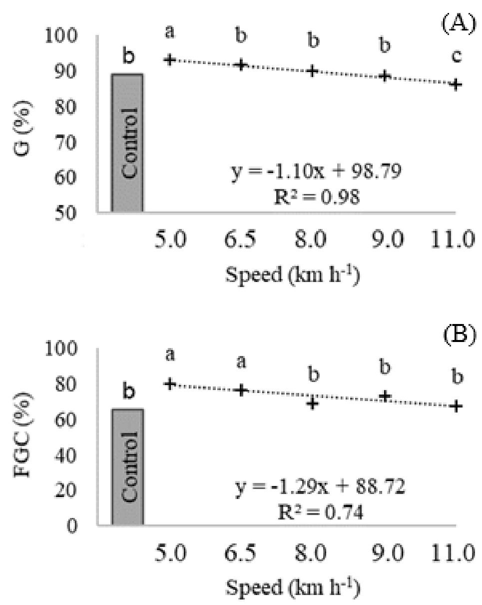

Figure 1: Seed classes average in the germination (A) and first germination count (B) of sunflower (*Helianthus annuus L.*), cultivar M734, subjected to sowing at different travel speeds.

*Speeds means followed by the same letter do not differ to the control by Dunnett's test at 5% significance level; control: seeds that did not pass through the dosing mechanism of the seeder-fertilizer.

When comparing the highest travel speed (11.0 km h^{-1}) with the control (seeds that did not pass through the seeder), a reduction in the germination potential is highlighted, possibly due to the occurrence of damage during the passage through the dosing system of the seeder-fertilizer (Figure 1A). According to Correia *et al.* (2016), the friction between the seed and the dosing system components may damage the seeds. Bottega *et al.* (2014b) also stated that the greater the friction and abrasion at dosing, the greater the mechanical damage.

However, when comparing the lowest speed (5.0 km h^{-1}) with the control, it is possible to note a significant increase in the germination percentage (Figure 1A). This fact may be related to the occurrence of small injuries caused to the pericarp, which may have facilitated the germination.

Dormancy in sunflower seeds has been reported by several authors, such as Santos *et al.* (2013), Szemruch *et al.* (2014) and Nobre *et al.* (2015), may be associated with the pericarp and the different seed maturation stages in the capitulum (Vigliocco *et al.*, 2017). In this species, the pericarp and the seed coat influence the dormancy level, restricting gas exchange and imbibition, while the removal of these structures provides performance improvements (Szemruch *et al.*, 2014).

In the evaluation of the first germination count, the seeds that passed through the dousing mechanism at 5.0 and 6.5 km h^{-1} obtained a higher performance compared to the control (0.0 km h^{-1}) (Figure 1B), ratifying the possibility of dormancy occurrence. Studying dormancy in sunflower seeds, Szemruch *et al.* (2014) observed that the removal of the pericarp and/or the seed coat resulted in increased germination. The authors also stated that these structures influence dormancy in sunflower seeds; thus, their removal improves the performance by overcoming dormancy.

There was no reduction in germination in the first germination count in the remaining travel speeds (8.0, 9.5, and 11.0 km h^{-1}) compared to the control (Figure 1B). Therefore, seed passage through the dosing mechanism did not damage their performance at these speeds. Regarding the effect of speed variation, linear regression was significant as the increase in the travel speed reduced the first germination count by 1.92%, with a high regression coefficient (Figure 1A).

Higher sowing speeds increased the rotation of the disk/ring set, leading to possible damage to the seeds due to the reduction in the time for their accommodation in the alveoli of the dosing disk. However, even in the treatments with higher speeds, the physiological quality of sunflower seeds was little affected compared to the control. This may occur since the sowing density used for the crop is low (40,000 plants ha^{-1}); thus, the seed accommodation time is longer compared to other crops, such as soybean.

Silva *et al.* (2000) did not observe significant differences regarding damage to maize seeds after passing through the dosing mechanism of the seeder at different operation speeds that varied from 3 to 11.2 km h^{-1}. When evaluating sorghum seeds (*Sorghum* spp.), no mechanical damage was verified when increasing the seeder speed from 4 to 7 km h^{-1} (Correia *et al.*, 2015). On the other hand, during sowing, the travel speed increase reduced the emergence in canola (*Brassica napus*) (Harker *et al.*, 2012). In maize, Vale *et al.* (2010), Garcia *et al.* (2011) and Bottega *et al.* (2018), observed the occurrence of damage in the sowing process, with a reduction in vigor and viability.

For the classification factor, the classified seeds (C1 and C2) were superior compared to non-classified seeds (NC) in the first germination count (Figure 2). There was no significant difference in the remaining evaluations, and thus the classification had little influence on the physiological quality of sunflower seeds after passing through the dosing mechanism and the conducting tube during sowing.

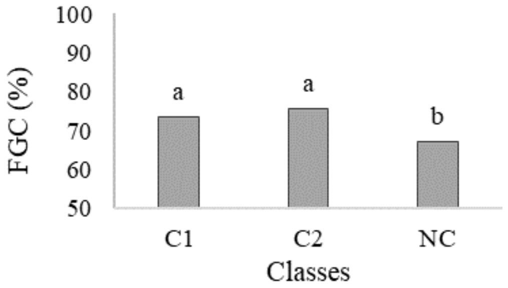

Figure 2: Speed average in the first germination count (FGC) of sunflower seeds (*Helianthus annuus L.*), cultivar M734, classified as a function of thickness.

*Means followed by the same letter do not differ by the Tukey-Kramer test at 5% significance level.

Regarding the emergence in sand, there was no difference between the studied classifications and travel speeds, and the overall seedling emergence mean was 96%. For the mean emergence time, the sowing speed increase reduced the period between sowing and seedling emergence. However, in absolute values, this difference was lower than 0.5 days (Figure 3A).

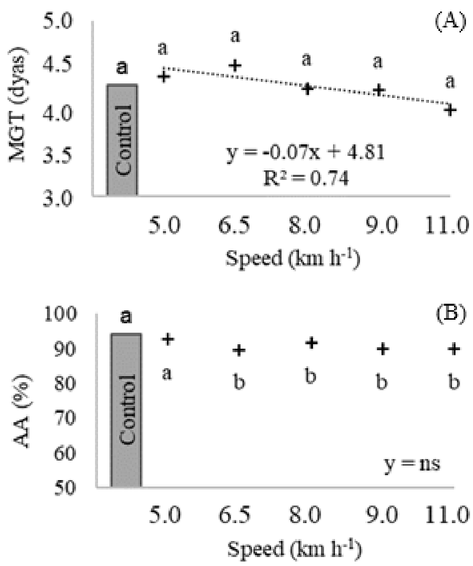

Figure 3: Seed classes average in the emergence time (A) and vigor by accelerated aging (B) of sunflower (*Helianthus annuus L.*), cultivar M734, subjected to sowing at different travel speeds.

*Speeds means followed by the same letter do not differ to the control by Dunnett's test at 5% significance level; control: seeds that did not pass through the dosing mechanism of the seeder-fertilizer.

According to the accelerated aging test, there was a reduction in seed vigor from the travel speed of 6.5 km h^{-1} compared to the control (Figure 3B). Thus, seed passage through the dosing system caused damage to the sunflower seeds at higher speeds. Studying maize sowing, Bottega *et al.* (2018) stated that the seeds are damaged at sowing, losing vigor and reducing the emergence speed.

Regarding the percentage of viable, vigorous, and non-viable seeds by the tetrazolium test, the regressions were not significant, and the overall means corresponded to 97, 93, and 3%, respectively. Therefore, the variations in the sowing speed did not affect seed physiological quality. The presence of a thick and resistant pericarp in the seeds possibly acts by protecting the embryo, avoiding or minimizing damage. According to Hernandez & Belles (2007) and Gonçalves (2012), the sunflower seed is composed of an embryo covered by the seed coat and the pericarp, and the latter acts as a physical barrier to impacts, protecting the embryo and regulating seed dormancy and germination (Gonçalves, 2012).

Thus, in general, seed passage through the dosing mechanism of the seeder-fertilizer under speed variation had little influence on their physiological quality, affecting germination only at the highest travel speed (11 km h^{-1}) (Figure 1A). Regarding vigor, this attribute was affected by speeds from 6.5 km h^{-1} according to the accelerated aging test, while there was no influence in the remaining evaluations.

The morphological condition of the seed, composed of a thick and resistant pericarp, probably protects the embryo, reducing the occurrence of significant mechanical damage to the seeds at lower speeds. It is highlighted that the plant population used in sunflower cultivation is low (40,000 plants ha^{-1}); thus, even at faster travel conditions, the tangential speed of the dosing disk is low as the number of seeds laid on the soil per time unit is reduced, minimizing the mechanical damage.

CONCLUSIONS

The classification of sunflower seeds by thickness reduce the coefficient of variation of the length, width, thickness, and mass attributes. More or less thick seeds are similar in physiological quality after passing through the dosing mechanism under speed variation.

In the higher study speed (11.0 km h^{-1}), the passage of the seeds through the dosing mechanism causes damage that reduces sunflower germination. Seed vigor is affected at speeds higher than 6.5 km h^{-1} by the accelerated aging test however, according to the emergence in sand and tetrazolium and test, speed variation does not affect the emergence, vigor, and viability of sunflower.

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REFERENCES

Aguiar RH, Fantinatti JB, Groth D & Usberti R (2001) Qualidade física, fisiológica e sanitária de sementes de girassol de diferentes tamanhos. Revista Brasileira de Sementes, 23:134-139.

Albiero D, Maciel AJS, Lanças KP, Monteiro LA, Viliotti CA & Mion RL (2012) Gráficos de probabilidade normal para avaliação de mecanismos de distribuição de sementes em semeadoras. Semina, 33:507-518.

Almeida RA, Barcellos LC & Ximenes PA (2003) Danos mecânicos ocasionados por sistemas dosadores de sementes. Pesquisa Agropecuária Tropical, 33:17-22.

Bottega EL, Braido R, Piazzetta HVL, Oliveira Neto AM & Guerra N (2014a) Efeitos da profundidade e velocidade de semeadura na implantação da cultura do milho. Pesquisa Agropecuária, 19:74-78.

Bottega EL, Rosolem DH, Neto AMO, Piazzetta HVL & Guerra N (2014b) Qualidade da semeadura do milho em função do sistema dosador de semente e velocidade de operação. Global Science and Technology, 7:107-114.

Bottega EL, Vian T, Guerra N & Oliveira Neto AM (2018) Diferentes dosadores de sementes e velocidades de deslocamento na semeadura do milho em plantio direto. Pesquisa Agropecuária Pernambucana, 22:01-05.

Brasil - Ministério da Agricultura, Pecuária e Abastecimento (2009) Regras para análise de sementes. Brasília, MAPA/DAS. 395p.

Celik A, Ozturk I & Way TR (2007) Effects of various planters on emergence and seed distribution uniformity of sunflower. Applied Engineering in Agriculture, 23:57-61.

Correia TPS, Kato LH, Gomes ARA, Souza SFG & Silva PRA (2015) Influência da inclinação do terreno e velocidade de operação na semeadura de sorgo por semeadora de fluxo contínuo. Energia na Agricultura, 30:331-337.

Correia TPS, Sousa SFG, Silva PRA, Dias PP & Gomes ARA (2016) Sowing performance by a metering mechanism of continuous flow in different slope conditions. Engenharia Agrícola, 36:839-845.

Fava CLF (2014) Aspectos morfológicos e fisiológicos de diásporos e plântulas de 24 espécies do Cerrado. Doctoral Thesis. Universidade Federal de Mato Grosso, Cuiabá. 130p.

Garcia RF, Vale WG, Oliveira MTR, Pereira EM, Amim RT & Braga TC (2011) Influência da velocidade de deslocamento no desempenho de uma semeadora-adubadora de precisão no Norte Fluminense. Acta Scientiarum. Agronomy, 33:417-422.

Gonçalves NR (2012) Qualidade de sementes de girassol no beneficiamento. Master Dissertation. Universidade Federal de Lavras, Lavras. 67p.

Harker KN, O’donovan TJ, Blackshaw RE, Johnson EN, Lafond GP & May WE (2012) Seeding depth and seeding speed effects on no-till canola emergence, maturity, yield and seed quality. Canadian Journal of Plant Science, 92:795-802.

Hernandez LF & Belles PM (2007) A 3-D finite element analysis of the sunflower (*Helianthus annuus L.*) fruit: biomechanical approach for the improvement of its hullability. Journal of Food Engineering, 78:861-869.

Jasper R, Jasper M, Assumpção PSM, Rocil J & Garcia ALC (2011) Velocidade de semeadura da soja. Engenharia Agrícola, 31:102-110.

Jasper R, Jasper M & Garcia LC (2006) Seleção de sementes de milho durante a simulação da semeadura com disco perfurado horizontal. Engenharia Agrícola, 26:434-441.

Laboriau LG (1983) A germinação das sementes. Washington, Secretaria Geral da Organização dos Estados Americanos. 174p.

Marcos Filho J (1999) Testes de envelhecimento acelerado. In: Krzyzanowski FC, Vieira RD & França Neto JB (Eds.) Vigor de sementes: conceitos e testes. Londrina, Abrates. p.3.01-3.21.

Nobre DAC, Brandão Junior DS, Salazar AH & Cardoso RR (2014) Vigor e viabilidade em aquênios de girassol determinados pelo teste de tetrazólio. Pesquisa Agropecuária Pernambucana, 19:89-93.

Nobre DAC, Costa CA, Brandão Junior DS, Resende JCF & Flávio NSDS (2015) Qualidade das sementes de girassol de diferentes genótipos. Ciência Rural, 45:1729-1735.

Nunes RTC, Cangussu ACV, Oliveira CC, Santos APS & Morais OM (2016) Qualidade fisiológica de sementes de girassol classificadas pelo tamanho. Agropecuária Científica no Semiárido, 12:153-161.

Santos CAC, Peixoto CP, Vieira EL, Carvalho EV & Peixoto VAB (2013) Stimulate na germinação de sementes, emergência e vigor de plântulas de girassol. Bioscience Journal, 29:605-616.

Silva JG, Kluthcouski J & Silveira PM (2000) Desempenho de uma semeadora-adubadora no estabelecimento e na produtividade da cultura do milho sob plantio direto. Scientia Agricola, 57:07-12.

Szemruch CL, Renteria SJ, Moreira F, Cantamutto MA, Ferrari L & Rondanini DP (2014) Germination, vigour and dormancy of sunflower seeds following chemical desiccation of female plants. Seed Science & Technology, 42:454-460.

Vale WG, Garcia RF, Corrêa Júnior D, Gravina GA, Klaver PPC & Vasconcelos Júnior JFS (2010) Influência da velocidade de deslocamento no desempenho de uma semeadora-adubadora direta. Global Science and Technology, 3:67-74.

Vasconcellos JPR, Reis RB, Rezende RM, Rezende RALS & Carvalho AFS (2018) Influência da velocidade de semeadura na produtividade do trigo. Revista da Universidade Vale do Rio Verde, 16:01-07.

Vazquez GH, Arf O, Sargi BA & Pessoa ACO (2012) Influência do tamanho e da forma da semente de milho sobre o desenvolvimento da planta e a produtividade de grãos. Bioscience Journal, 28:16-24.

Vigliocco AE, Andrade AM, Lindström LI & Alemano SG (2017) Dormancy in sunflower line A-3: the role of the pericarp. Botany, 95:853-858.

Yutao S, Lizhong T, Shuqi S, Ranbing1 Y, Yanyao W & Jianliang Z (2012) Experimental research on inside-filling metering device for peanut seeder. Transactions of the Chinese Society of Agricultural Engineering, 28:84-89.