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QUALITY OF SOWING AND DEVELOPMENT OF MAIZE AS A FUNCTION OF BLACK OAT MANAGEMENT METHODS APPLIED IN DIFFERENT PERIODS BEFORE MAIZE SOWING

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Abstract – The correct straw management in no-tillage system is necessary and has demonstrated to be an excellent alternative to improve sowing quality. Cover crop management periods may compromise the performance of planters and the productivity of the successor crop. The objective of this study was to evaluate the effect of black oat management methods, carried out in different periods before maize planting, on the quality of sowing and development of the crop. Two experiments were conducted in the municipality of Coimbra, MG: the first in 2013 and the second in 2016. Randomized block design was used in both experiments, in split-plot arrangement (4x3), with four replications. The plots consisted of four black oat management periods (21, 14, 7 and 0 days before sowing) and the subplots consisted of three black oat management methods (desiccated, rolled and cleared). The plants were managed in the flowering stage. The characteristics evaluated were: average, faulty, double and normal spacing between plants; sowing depth; emergence speed index; plant stand; and uniformity of plant development in V5 stage. In both experiments, the desiccated black oat presented lower emergence speed index, plant stand and uniformity of plant development. The mechanical managements of black oat, regardless of the period before maize planting, improve the quality of maize sowing, with significant reduction of faulty and double spacing, and promote proper plant development.

Keywords: *Avena strigosa* Schreb, soil cover, no-tillage, *Zea mays* L.

QUALIDADE DA SEMEADURA E DESENVOLVIMENTO DO MILHO EM FUNÇÃO DE MÉTODOS DE MANEJO DA AVEIA PRETA EM DIFERENTES ÉPOCAS ANTECEDENDO A SEMEADURA

Resumo - O manejo correto da palhada no sistema plantio direto faz-se necessário e tem-se mostrado excelente alternativa para melhorar a qualidade da semeadura. As épocas utilizadas nos manejos de plantas de cobertura de solo podem prejudicar o desempenho das semeadoras e a produtividade da cultura sucessora. Objetivou-se avaliar o efeito de métodos de manejo da aveia preta realizados em diferentes épocas antecedendo a semeadura do milho sobre a qualidade da semeadura e o desenvolvimento da cultura. Foram realizados dois experimentos no município de Coimbra, MG, o primeiro em 2013 e o segundo em 2016. Nos dois experimentos, adotou-se o delineamento experimental em blocos ao acaso, no esquema de parcelas subdivididas (4x3), com quatro repetições. As parcelas foram constituídas por quatro épocas de manejo da aveia preta (21, 14, 7 e 0 dias antes da semeadura) e as subparcelas por três métodos de manejo da aveia preta (dessecada, rolada e roçada). As plantas foram manejadas no florescimento. Características avaliadas: espaçamento médio, falho, duplo e normal entre plantas, profundidade de semeadura, índice de velocidade de emergência, estande de plantas e uniformidade de desenvolvimento das plantas no estádio V5. Nos dois experimentos, a aveia preta dessecada apresentou menor índice de velocidade de emergência, estande de plantas e uniformidade de desenvolvimento das plantas. Os manejos mecânicos da aveia preta, independente da época antes da semeadura do milho, melhoram a qualidade da semeadura do milho com expressiva redução dos espaçamentos falhos e duplos e promovem desenvolvimento adequado das plantas.

Palavras-chave: *Avena strigosa* Schreb, cobertura do solo, plantio direto, *Zea mays* L.

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Maize (*Zea mays* L.) crop is one of the most important crops in the world (Silva et al., 2008), being cultivated in several regions and in different production systems (Silva et al., 2011). Maize is a grain used for direct feeding or in the formulation of feed to be supplied to cattle, poultry and pig farming, in addition to being widely used for human consumption and as raw material in different segments and products (Môro & Fritsche-Neto, 2015).

The increment in maize yield also depends on the quality of crop implantation at sowing time (Bottega et al., 2014). In the maize crop, there is no compensation of the lack of plants with tillering or flower production (Ros et al., 2011; Embrapa, 2012), with the plant density being one of the cultivation practices that most interfere with the grain yield of the crop (Melo et al., 2011).

The sowing process is an important activity in the crop implantation, thus special attention shall be given to the obtainment of suitable populations, at the recommended depth, with plants spaced equidistantly (Silva et al., 2017) and more uniformly developed (Weirich Neto et al., 2015). Otherwise, the total investment made will not translate into productivity gains (Silva et al., 2017) and may compromise the profitability of the maize crop (Ros et al., 2011).

Problems such as double and faulty spacing are detected through irregularity in the longitudinal seed distribution in the row. In the case of multiple seeds, the productivity loss results from the intraspecific competition. In the case of sowing failures, the crop will compete with spontaneous plants for production factors, thus creating interspecific competition (Pinheiro Neto et al., 2008). That increases the number of plants with delayed phenological development and fragile stems, which are dominated in the crop, with production of small ears (Sangoi et al., 2012).

In order for the sowing to be done efficiently, there must be straw cutting and soil breaking operations in the sowing row, opening and closing of furrows, uniform distribution of seeds and fertilizer on the soil, with the seeds being deposited at the correct depth in the furrow to ensure that the germination occurs and to obtain a proper and uniform plant stand (Santos et al., 2008; Vale et al., 2009; Almeida et al., 2010; Jasper et al., 2011).

The management of soil cover crop directly affects the maize sowing process, since the high or irregular straw deposition on the soil may limit the crop sowing and establishment (Trogello et al., 2013). Therefore, the correct management of straw in no-tillage system is necessary and has demonstrated to be an excellent alternative to improve the sowing quality (Cortez et al., 2009). Besides, the implementation period for the cover crop management, in relation to the maize crop sowing, may cause differences in the conditions of the crop sowing and development environment.

The cover crop management period also affects the efficiency of the cutting mechanism of the planter. It is believed that both the anticipation

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of 30 to 40 days and the black oat management carried out on the day of sowing facilitate the straw cutting operation. When the management occurs in an intermediate period of time between those aforementioned, the black oat residues may be withered, which causes clogging and reduction of cutting efficiency (Modolo et al., 2019).

Consequently, information is required to clarify about the correct moment to perform the cover crop management, so that it does not negatively influence the successor crop (Nunes et al., 2009).

Kaefer et al. (2012) did not detect significant difference concerning the grain yield of maize planted in the agricultural year of 2009/2010 in succession to the chemical management of black oat carried out 0, 7, 14, 21 and 28 days before sowing. Weirich Neto et al. (2012) also noted that the crop yield was not significantly influenced when maize was planted on desiccated black oat straw, with no mechanical management and rolled 20 days before maize sowing. Modolo et al. (2019) observed that the anticipation of black oat desiccation done 0, 15, 30 and 45 days before maize sowing improves the plantability conditions, but it does not promote increment in grain yield or significant difference in the initial and final plant stand.

Among the soil cover crops for no-tillage system, the black oat (*Avena strigosa* Schreb) stands out due to the facility regarding seed acquisition and implantation, its rusticity and quick soil cover formation, allelopathic suppressive effect on many spontaneous plants, and low residue decomposition rate if compared to the Fabaceae (Silva et al., 2009; Wutke et al., 2014). It presents nutrient concentration in the plant tissue (aerial part + roots) in the following order: K>N>Ca>Mg>P (Wolschick et al., 2016), due to its recycling capacity, releasing them gradually in the surface layers for the successor crop (Crusciol et al., 2008).

In this context, the objective of this work was to evaluate the effect of black oat management methods, carried out in different periods before maize planting, on the quality of sowing and development of the crop.

Material and Methods

The experiments were conducted in 2013 (Experiment I) and 2016 (Experiment II) at the São João Experimental Station, a property of the Federal University of Viçosa, located in the municipality of Coimbra, MG, with an altitude of 719 m. The climate data for the municipality of Viçosa-MG, collected during the experimental periods, are shown in Figure 1. Viçosa is located 20 km away from Coimbra-MG, where the research was carried out, thus presenting similar climate.

The soil was classified as Cambic Red-Yellow Argisol, terrace phase, with very clayey texture (Embrapa, 2013). For many years in the area, conventional maize cultivation was practiced for grain production in the summer, with bean cultivation in winter. Therefore, maize was cultivated in the previous seasons and, after

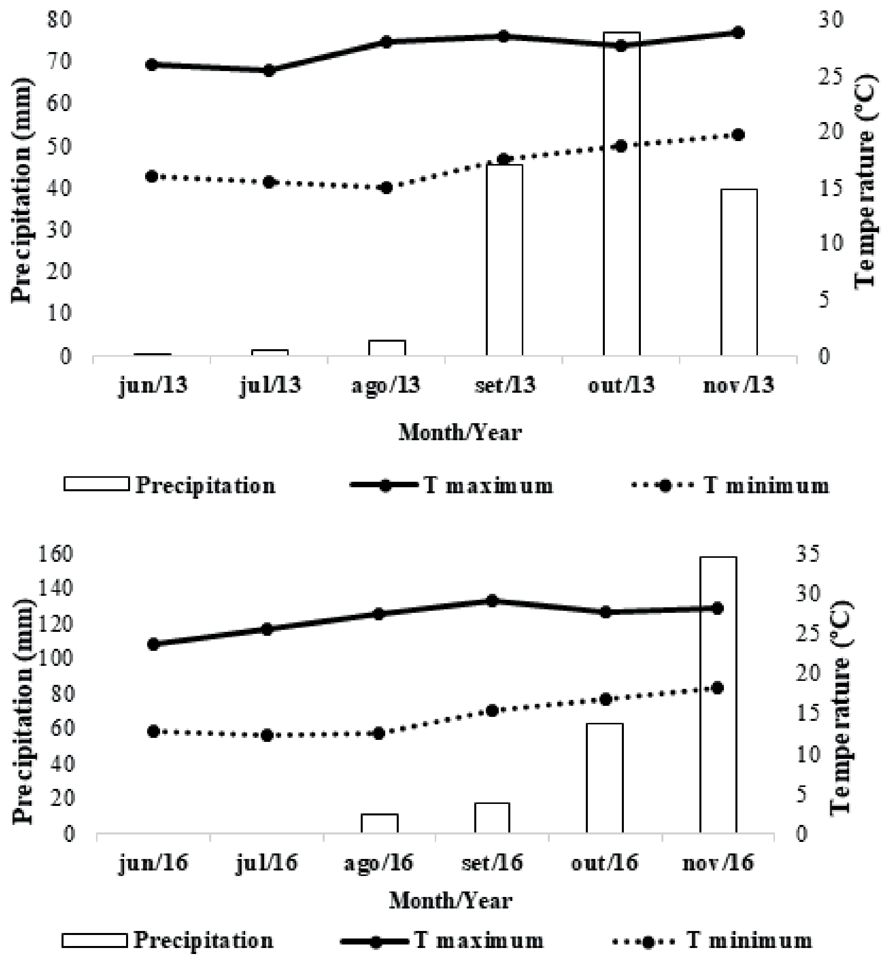

Figure 1. Data for precipitation (mm) and maximum and minimum temperature (ºC) recorded in the municipality of Viçosa, MG, during the period when experiments I (2013) and II (2016) were conducted.

harvesting, the crop residues were kept on the soil surface. By the time of black oat sowing, those crop residues were partially incorporated into the soil, during the area preparation by means of plowing and light harrowing operations.

Randomized block design was used, in a split-plot arrangement (4x3), with four replications. The plots consisted of four management periods of black oat as soil cover plant (0, 7, 14 and 21 days before maize sowing) and the subplots consisted of three management methods for formation of black oat straw (desiccated, rolled and cleared).

The Embrapa 139 black oat cultivar was planted by way of broadcasting, at the density of 80 kg ha^{-1} (Fontanetti, 2008), with the use of irrigation but no fertilizer application. Sowing was done every 7 days, on the following dates:

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June 24, July 01, 08 and 15 in 2013 and 2016. The aim was the management of plants in the same phenological stage (flowering). Therefore, the managements of black oat for soil cover were carried out 21, 14, 7 and 0 days before sowing (DBS) of maize, with the use of brush cutter (black oat cleared), knife roller filled with water and pulled by tractor (black oat rolled), and 20 L manual backpack sprayer, with application of Roundup Original® in the dose of 2.5 L ha^{-1} (black oat desiccated, with no mechanical management).

Right after the managements, the dry mass of the aerial part of the plants was assessed by means of two samples of 0.25 m^2 (0.50 x 0.50 m) collected from each subplot. The material was dried in oven at 65 ºC for 72 hours and weighed to obtain dry mass in kg ha^{-1}.

The DKB 390 maize was sown on 10/15/2013, with 450 kg ha^{-1} of the 08-28-16 (NPK) formulation being used at sowing. The LG 6036 maize was sown on 10/17/2016, with 300 kg ha^{-1} of the 08-28-16 (NPK) formulation being applied at sowing. In the phenological stage V4, 120 kg ha^{-1} of N, in the form of urea, were manually applied in the row. Those single cross hybrids present early cycle, high yield potential and VT PRO2™ technology for resistance to glyphosate-based herbicide and to some insect pest species. They were sown with 0.50 m spacing between rows and a density of 70,000 seeds ha^{-1}. The sowing was done with the use of a planter proper for no-tillage, manufactured by Vence Tudo Company, regulated for sowing at 5.0 cm depth and pulled by tractor at the speed of 5 km h^{-1}.

The dimensions were 5 m x 10 m (50 m^2) for each plot, which consisted of five and eight plant rows in experiment I (2013) and in experiment II (2016), respectively. Each subplot measured 6.0 m^2 in experiment I and 6.9 m^2 in experiment II.

The plants received supplemental irrigation during the vegetative stage. The control of spontaneous plants was performed with one application of 4 L ha^{-1} of glyphosate, using volume of 200 L ha^{-1} of spray solution, in the phenological stage V3 of maize plant with three leaves developed.

The quality parameters assessed for maize sowing were: sowing depth; seedling emergence speed index; average spacing between plants; uniformity of plant distribution in the row; uniformity of phenological development of plants in V5 stage; plant stand; and dry mass production of the aerial part of maize plants in the phenological stages V4 and V8, with four and eight leaves developed.

The sowing depth was determined in 10 plants in the subplot useful area, which were in the phenological stage when three maize leaves were developed. The aerial part of the maize plant was cut low to the ground with pruning shears and, with the use of a garden trowel, the part buried in the soil was removed. The distance between the coleoptile and the seed was measured with the use of digital caliper in mm, with the data being converted to cm (Trogello et al., 2012).

The seedling emergence speed index (ESI)

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was determined by the sum of the ratio between the number of emerged plants (first, second, up to the last counting) by the number of sowing days (first, second, up to the last counting), according to the methodology by Maguire (1962), (Equation 1): ESI = (E1/T1) + (E2/T2) + ... + (En/Tn), where ESI = emergence speed index; $E_{1...n}$ = number of emerged seedlings in the first, second, until the last counting; and $T_{1...n}$ = number of sowing days in the first, second, until the last counting. The counting was finalized when the number of emerged seedlings remained constant during three days of consecutive counting.

The uniformity of plant distribution was obtained by measuring the spacing between 30 plants in the subplot useful area. Afterwards, the spacing was classified as normal (0.5*Xref < Xi < 1.5*Xref), double (Xi < 0.5*Xref) and faulty (Xi > 1.5*Xref), according to Kurachi et al. (1989). The reference average spacing (Xref) was calculated by dividing the linear useful area by the number of plants observed in the same area. Xi corresponds to the actual spacing obtained in the evaluation.

For evaluation of the uniformity of phenological development of maize plants in the stage when five leaves were developed, the development stage of 20 maize plants in the subplot useful area was identified when these plants had between three and six leaves developed.

The plant stand was assessed as from the moment when a constant number of emerged seedlings was obtained. All seedlings in the subplot useful area were counted, with the value being extrapolated to plants per hectare.

In each experiment, the percentage data were submitted to the Shapiro–Wilk normality test at 5% significance, being changed when required and statistically analyzed. The means of original data were presented in the tables to facilitate the understanding. The other data were submitted to analysis of variance, and when the F-test was significant at 5% probability, the means were compared by Tukey's test. The black oat management periods before maize sowing were submitted to regression analysis. The Assistat 9.0 statistical software was used (Silva & Azevedo, 2009).

Results and Discussion

In both experiments, there was no effect of significant interaction between the factors on the studied parameters (Tables 1 & 2).

In experiment I (2013), the black oat managements did not influence average, faulty, double and normal spacing of maize crop (Table 1). That correct plant distribution in the row was demonstrated by the proper operation of the planter, appropriate to no-tillage system. The treatments presented the following means for dry matter of black oat: 6,833 kg ha^{-1} - 21 DBS; 9,832 kg ha^{-1} - 14 DBS; 7,160 kg ha^{-1} - 7 DBS; and 8,465 kg ha^{-1} - 0 DBS of maize. Those amounts of straw did not compromise the machinery set operation, similarly to experiment II (2016), when the dry

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Table 1. Average spacing (AS) and faulty, double and normal spacing between maize plants as a function of methods of black oat management carried out in different periods, preceding maize sowing, in experiments I (2013) and II (2016) in Coimbra, MG.

Factors	AS (cm)	Uniformity of plant distribution (%)		
		Faulty	Double	Normal
		Experiment I (2013)		
F-test				
Period	1.2^{*}	4.6^{*}	2.1^{ns}	4.1^{*}
Management	0.2^{ns}	0.3^{ns}	2.9^{ns}	1.7^{ns}
Period x Management	0.9^{ns}	0.6^{ns}	0.1^{ns}	0.2^{ns}
Period				
0 DBS	-	-	15.00	-
7 DBS	-	-	15.00	-
14 DBS	-	-	14.72	-
21 DBS	-	-	13.05	-
Management				
Desiccated oat	31.77	6.87	17.50	75.62
Rolled oat	31.62	5.83	12.92	81.25
Cleared oat	30.81	6.67	12.92	80.42
CV (%) Period	13.8	38.5	41.1	8.3
CV (%) Management	13.1	64.8	43.3	11.7
		Experiment II (2016)		
F-test				
Period	0.1^{ns}	0.7^{ns}	0.2^{ns}	1.4^{ns}
Management	70.2^{*}	17.1^{*}	5.9^{*}	14.5^{*}
Period x Management	0.3^{ns}	0.4^{ns}	0.4^{ns}	0.4^{ns}
Period				
0 DBS	29.9	7.0	5.8	87.1
7 DBS	29.9	8.7	6.5	84.8
14 DBS	30.0	7.9	6.5	85.4
21 DBS	30.0	7.5	6.1	86.4
Management				
Desiccated oat	34.5 a	12.3 a	8.6 a	79.0 b
Rolled oat	28.7 b	5.3 b	4.7 b	89.8 a
Cleared oat	29.3 b	5.7 b	5.3 b	88.8 a
CV (%) Period	2.5	35.7	38.1	4.7
CV (%) Management	3.5	48.1	54.2	7.0

Where, DBS: days before sowing; CV: coefficient of variation; ns: F not significant at 5%; * F significant at 5%. Means followed by different letters in the column differ among one another at 5% probability as per Tukey's test.

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Table 2. Sowing depth (SD), emergence speed index (ESI), plant stand (ST) and plants in the phenological stage V5 as a function of methods of black oat management carried out in different periods preceding maize sowing, in experiments I (2013) and II (2016). Coimbra, MG.

Factors	SD (cm)	ESI	ST (plants ha^{-1})	V5 (%)
	Experiment I (2013)			
F-test				
Period	1.7*	1.9*	3.0^{ns}	0.9^{ns}
Management	1.8^{ns}	4.5*	4.7*	4.0*
Period x Management	1.0^{ns}	1.0^{ns}	0.9^{ns}	1.1^{ns}
Period				
0 DBS	-	-	57,380	68.3
7 DBS	-	-	54,190	57.2
14 DBS	-	-	59,047	66.1
21 DBS	-	-	61,761	67.2
Management				
Desiccated oat	2.9	1.8 b	52,928 b	56.2 b
Rolled oat	2.5	2.0 ab	60,642 a	65.8 ab
Cleared oat	2.6	2.2 a	60,714 a	72.0 a
CV (%) Period	31.4	17.5	10.9	33.4
CV (%) Management	21.6	20.5	14.1	24.5
	Experiment II (2016)			
F-test				
Period	1.7^{ns}	1.4^{ns}	0.3^{ns}	0.1^{ns}
Management	1.8^{ns}	4.3*	10.2*	21.2*
Period x Management	1.2^{ns}	0.8^{ns}	0.7^{ns}	0.2^{ns}
Period				
0 DBS	2.4	2.0	65,338	88.4
7 DBS	2.7	1.8	65,217	88.5
14 DBS	2.9	1.7	65,942	88.1
21 DBS	3.1	1.9	65,097	88.4
Management				
Desiccated oat	3.0	1.6 b	58,243 b	69.2 b
Rolled oat	2.6	2.0 a	69,022 a	98.3 a
Cleared oat	2.8	2.2 a	68,931 a	97.6 a
CV (%) Period	28.2	18.9	3.3	2.3
CV (%) Management	20.6	21.9	3.7	5.1

Where, DBS: days before sowing; CV: coefficient of variation; ^{ns}: F not significant at 5%; * F significant at 5%. Means followed by different letters in the column differ among one another at 5% probability as per Tukey's test.

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mass production of black oat was: 9,680 kg ha^{-1} - 21 DBS; 7,390 kg ha^{-1} - 14 DBS; 6,650 kg ha^{-1} - 7 DBS; and 6,093 kg ha^{-1} - 0 DBS of maize.

Black oat management periods before maize sowing presented significance for the quadratic regression model in average (Figure 2A), faulty (Figure 2B), and normal spacing (Figure 2C), in experiment I (2013).

The management carried out on the day of maize sowing (0 DBS) presented smaller average spacing between plants of 29.73 cm, lower percentage of faulty spacing of 4.72%, and higher percentage of normal spacing of 84.44%. This management period indicates better straw condition to the proper performance of the planter since the straw is greener, which facilitates its cutting and the seed distribution in the row. The black oat managements carried out 7 and 14 DBS of maize caused the straw to desiccate and wither, which makes its cutting by the planter disc difficult. That affects the proper performance of the planter in the sowing row, thus resulting in worse results for these variables.

In experiment I (2013), the management carried out 21 DBS of maize presented average spacing between plants of 30.87 cm (Figure 2A), percentage of faulty spacing of 5.83% (Figure 2B), and percentage of normal spacing of 78.61% (Figure 2C). These values are close to those obtained when the management was carried out on the day of maize sowing. The straw that is managed beforehand is at a more advanced degradation stage, breaking more easily and being susceptible to the proper cutting by the planter disc.

The uniformity of space distribution between maize plants in the sowing row enables minimum competition between these plants and maximum competitiveness between maize and spontaneous plants. A uniform crop tends to present higher yield (Sangoi et al., 2012).

With regard to the normal spacing observed in experiment I (2013), the percentage was higher than 75%, being classified as a good performance of the planter. In pursuit of precision agriculture and the best use of the potential of the single cross hybrid selected, a better sowing condition was expected, with values close to the optimal performance, that is, higher than 90% of normal spacing. Such result was verified in experiment II (2016) (Table 1) when the rolled and cleared black oat managements presented normal spacing of 89.8% and 88.8%, respectively, close to the recommended percentage.

Therefore, the inferior result achieved in 2013 is justified by the conditions found at the moment of sowing, since it was a month with relatively more rainfall when compared with 2016 (Figure 1). It was noted that the moisture conditions on the day of sowing (10/15/2013) were not ideal. High moisture of the soil and, consequently, of the straw on the soil can compromise the proper performance of the planter (Trogello et al., 2013).

It is recommended that the normal spacing percentage is above 90%, being acceptable faulty and multiple spacing up to 5% (Weirich Neto et al., 2015). The maize grain yield

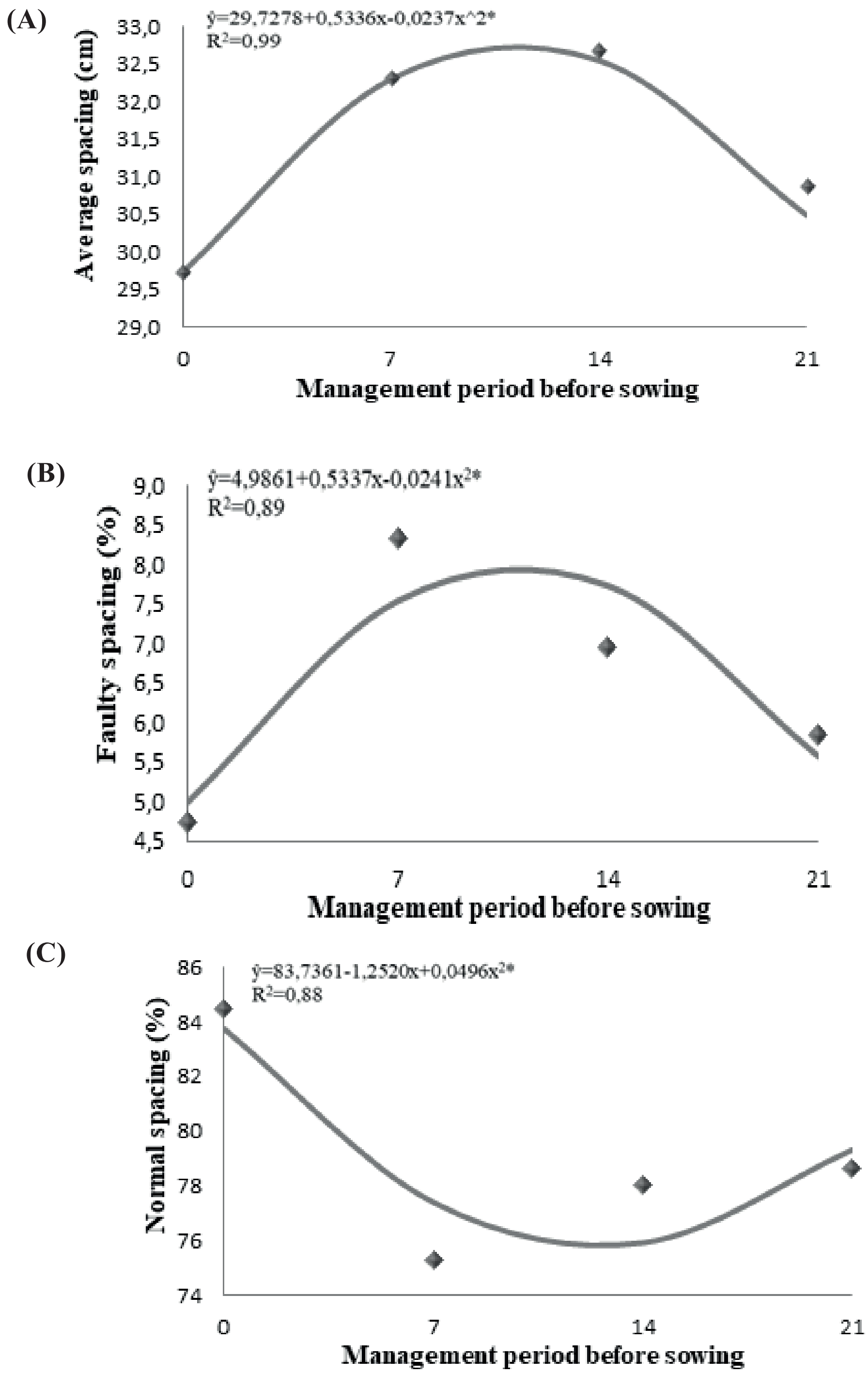

Figure 2. Quadratic regression model for average spacing between plants (A), percentage of faulty (B) and normal spacing (C) as a function of black oat management periods preceding maize sowing. Coimbra, MG. Experiment I (2013).

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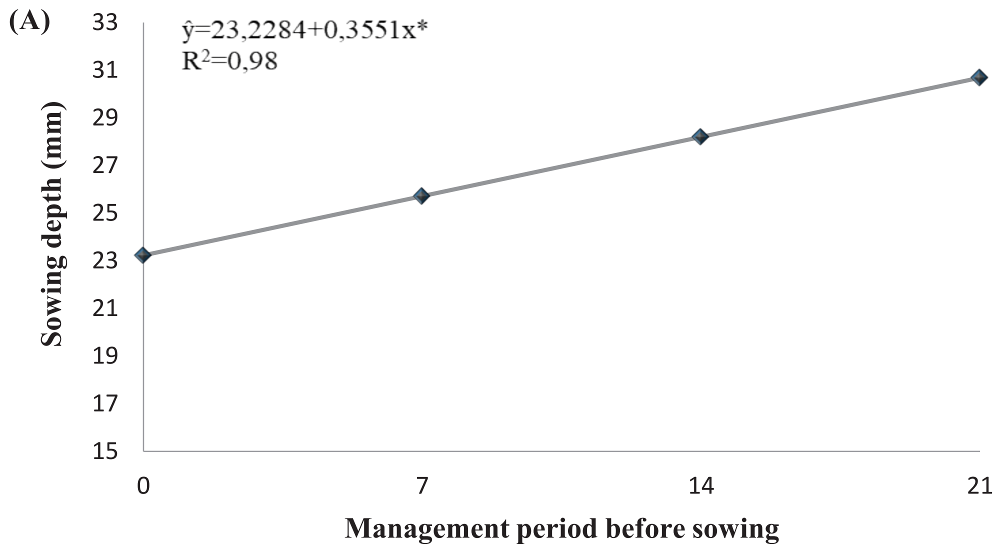
diminishes with the increase of non-uniformity of plant spacing in the row, which may occur even when the desired plant stand is attained (Sangoi et al., 2012). The non-uniform distribution of the plants can reduce the yield by up to 20% (Cortez et al., 2009).

In experiment II (2016), the different black oat management periods, preceding maize sowing, did not interfere with the variables studied (Tables 1 & 2), which can be justified by the climate conditions verified (Figure 1). At sowing time, the straw was green in the plots corresponding to 0 DBS, and sufficiently dry and breakable to allow a good cutting operation by the planter disc in the plots where the managements were performed 7, 14 and 21 days before maize sowing. This is a result of the low precipitation of 45.4 mm, irregularly distributed, and the high average temperature recorded during the period when managements were carried out (September 26 to October 17, 2016). The highest precipitation levels were registered in October 2016, as from the 17th day, which was the date of maize planting and end of black oat managements, and in November 2016. For a proper straw cutting operation, the cover plants must be green or dry (Copetti, 2015), as verified in this experiment.

In experiment II (2016), the black oat managements affected the uniformity of plant distribution in the maize planting row, result not observed in experiment I (2013), with identification of higher percentage of average, faulty and double spacing, and lower percentage of normal spacing in the desiccated black oat management (Table 1). That occurs due to difficulty concerning the shank operation to open furrows and the restoration of soil to cover the seed (Trogello et al., 2013). The desiccated black oat management presented larger average spacing due to the smaller number of plants in the area.

The black oat management periods, preceding maize sowing, promoted linear increase of the maize sowing depth in experiment I (2013), with the management carried out 21 DBS of maize presenting the greatest sowing depth of 30.59 mm (Figure 3A). This fact may be related to a higher straw decomposition, as well as its closer contact with the soil, as the management is anticipated. The sowing depth varied from 2.3 cm to 3.0 cm and had no influence on the emergence speed index (Figure 3B) and plant stand composition (Table 2). The prior regulation of the planter was performed targeting a sowing depth of 5.0 cm, which indicates that the cover straw ends up lifting the planter set, thus reducing the regulated depth. For no-tillage system, the sowing depth must be established at field condition.

In experiment II (2016), similarly to experiment I (2013), the maize sowing depth was not influenced by the black oat management methods (Table 2). There was a reduction in this parameter that varied from 2.6 cm to 3.0 cm, given that the planter was also regulated for a sowing depth of 5.0 cm. Both in experiment I (2013) and in experiment II (2016), the black oat straw managed on the day of maize sowing (0



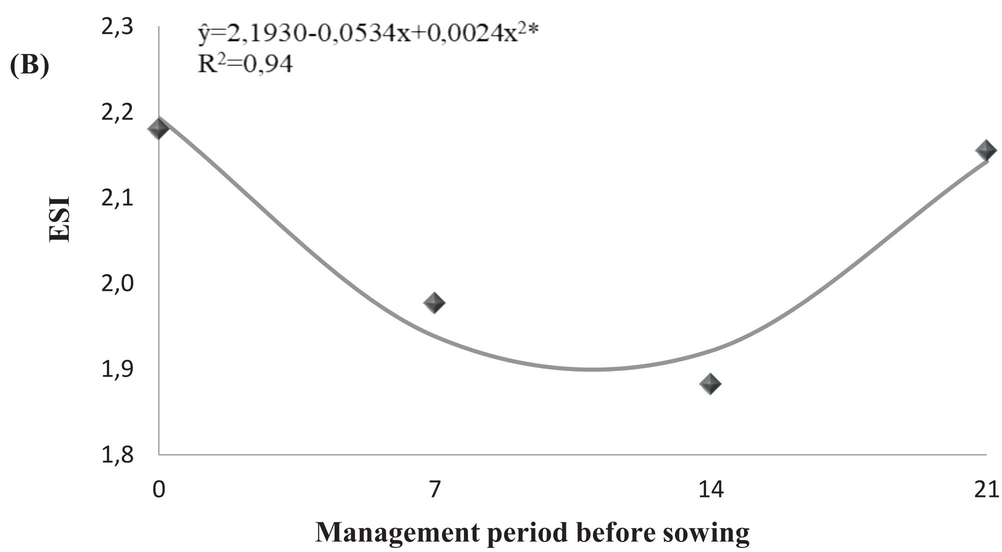


Figure 3. Linear regression model for sowing depth (A) and quadratic regression model for emergence speed index (B) as a function of black oat management periods preceding maize sowing. Coimbra, MG. Experiment I (2013).

DBS) was green and not decomposed, which may have prevented the shank from reaching deeper into the soil, thus resulting in a more superficial sowing depth (Modolo et al., 2019).

When studying the black oat managements (harrowed, rolled, ground and desiccated) carried out 15 DBS of maize, Trogello et al. (2013) did not find effect of the black oat managements on the seed deposition depth or the percentage of double and normal spacing between plants. Those authors verified that the desiccated black oat presented higher percentage of faulty spacing when compared with the ground black oat. The rolled black oat reduced plant stand in relation to the ground black oat.

In both years of evaluation, the desiccated black oat management negatively influenced the emergence speed index. In experiment I (2013) and in experiment II (2016), that index was 20% and 27% lower, respectively, when compared with the index verified for the cleared black oat (Table 2).

The intact straw ends up inhibiting the light penetration into the mulch canopy, thus hampering the maize seedling emergence, which results in lower index. Clearing promotes better straw uniformity on the soil surface and greater straw fragmentation, in comparison with the desiccated straw, and promotes better sowing environment, performance of the machinery set and condition for seedling emergence. In experiment II (2016), the cleared black oat management did not statistically differ from the rolled black oat in respect to that variable.

Only in experiment I (2013) the emergence speed index, as a function of black oat management periods before maize sowing, presented quadratic behavior. Managements carried out on the day of sowing (0 DBS) and 21 DBS of maize were the ones that presented the highest indices (Figure 3B). That, associated with the results observed for average (Figure 2A), faulty (Figure 2B) and normal spacing (Figure 2C), demonstrates that the management must be carried out at a prior period of at least 21 days. In case this is not possible, the management on the day of maize sowing can be recommended. The management of black oat 7 or 14 DBS of maize results in withered straw, which limits the quality of sowing and development of the crop.

Kaefer et al. (2012), in the two-year period when the experiment was conducted, noted that the periods for chemical management of black oat (0, 7, 14, 21 and 28 DBS of maize), and the consequent amount of straw on the soil surface, did not affect the percentage of emerged maize plants.

In experiment I (2013), the maize sowing on desiccated black oat presented reduction in the plant stand by 12.82% in relation to the cleared black oat (Table 2). The reduction in plant stand on desiccated straw may be related to the unsuitable sowing environment and the reduction of light penetration into the mulch canopy. The greatest difference regarding plant stand of 15.51%, between desiccated black oat and cleared black oat, was observed in experiment II (2016), when a higher percentage of faulty spacing found in

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desiccated black oat (12.3%) contributed to the reduction of this variable.

The establishment of the initial population is a critical factor to attain higher productivity and profitability for maize crop (Ros et al., 2011; Embrapa, 2012), as it presents low plasticity (Ikeda et al., 2013). Therefore, for maize crop sowing on desiccated black oat with no mechanical operation, it is recommended to use 5% more seeds because of the losses in the crop establishment. In addition to that, it is necessary to develop further works that can provide more scientific basis in regard to the significant reduction in maize plant stand on desiccated black oat straw.

Cortez et al. (2009) verified that the plant stand and the number of days for maize seedling emergence, as well as normal, faulty and double spacing, were not affected by sorghum managements with knife roller, straw grinder and herbicide.

In both experiments, the maize plants cultivated on desiccated black oat presented higher non-uniformity of vertical growth, demonstrated by the percentage of plants in the same phenological stage V5, in relation to cleared black oat (Table 2). It is highly desirable that the plants distributed in the sowing row present uniformity as to the phenological stage. Plants with delayed development tend to be dominated by neighboring plants, which generates loss of production per plant (Sangoi et al., 2012). The ideal condition is that 95% of the maize plants are in the same phenological stage and that a maximum of 5% of the plants present phenological delay of one leaf.

In experiment II (2016), the cleared black oat did not significantly differ from the rolled black oat as to the number of plants in the same phenological stage V5 (Table 2). It was also observed that 22% of the maize plants cultivated on desiccated black oat presented phenological delay of one leaf (V4) and 8.8% of the plants presented phenological delay of two leaves (V3). Besides, the lower emergence speed index obtained in this management method may have contributed to those results.

Conclusions

Mechanical managements of black oat, regardless of the period before maize planting, improve the quality of maize sowing, with significant reduction of faulty and double spacing, and promote the proper development of the plants.

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