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Effects of different sowing dates and row spacing on physiological quality of canola seed

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Abstract

The aim of this study was to evaluate the seed physiological quality of four canola hybrids (Hyola 76, Hyola 61, Hyola 433 and Hyola 411), subjected to two sowing dates (April 08 and May 10) in two different spacings (0.17 and 0.45 m) in Maringá, Paraná state, Brazil, during 2011 and 2012 crop seasons. The experimental design was setup as a randomized complete block design with treatments in a split-split plot arrangement with four replications. Seed physiological quality was evaluated through first and final count of germination test, accelerated aging and electrical conductivity. For 2011 crop season, Hyola 433 had the highest percentage of normal seedlings for both first and final germination counts. Hybrids Hyola 76 and Hyola 433 can be considered for sowing in early May, as it showed higher vigour level in accelerated aging. For 2012 crop season, sowing in early April presented higher percentage of normal seedlings for accelerated aging and first and final count of germination test. Hybrid Hyola 433 showed higher values of electrical conductivity; therefore, lower vigour, when sown in early April at 0.45 m spacing and when sown in early May in 0.17 or 0.45 m spacing, in 2012 crop season. Hyola 411 presented lower electrical conductivity when sown in 0.17 m spacing in 2012 crop season, exhibiting a higher vigour.

Keywords: accelerated aging; *Brassica napus*; electrical conductivity; germination; rapeseed; vigour.

Introduction

Canola (*Brassica napus* L. var. Oleifera) belongs to the Brassicaceae family (such as collard greens, mustard, cabbage and radish) and was created through genetic breeding of rapeseed (Chavarria et al., 2011; Kandil and Gad, 2012). In Brazil, canola seeds are used as raw material for food and industrial products, such as edible oil, animal feed, biodiesel and lubricants (Rempel and Scanlon, 2012; MacWilliam et al., 2016). In Paraná state, the crop's second largest national producer (Conab, 2016), canola has emerged as an excellent cost-effective alternative for winter cultivation, with potential to replace wheat (Árrua et al., 2014) because of its advantageous prices and climate conditions. The southern region is considered to be the coldest in the country (Krüger et al., 2011). Besides being an adequate succession with soybean cultivation, canola can also be use as mulching (Kaefer et al., 2014).

Modifying plants arrangement is an alternative to achieve higher productivity and quality of canola grains. It can be achieved by variations in spacing. The crop will express its maximum yield potential only in conditions with maximum interception of solar radiation and absence of stress factors. Information on spacing arrangements between lines that can promote both yield and canola seeds' quality in the northwest region of Paraná state is scarce. Farmers have adopted other species' cultivation practices (Krüger et al., 2011; Jacob Junior et al., 2012; Bandeira et al., 2013).

Sowing date is a key point in canola cultivation because of its influence on yield and grain quality. According to Árrua et al. (2014) early sowing provides greater productivity for hybrids Hyola 61 and 433 in the western region of the State. Meanwhile, Lima (2015) tested sowing dates in the northwest of the same State and found that hybrids 411 and 433 can be sown without date restriction. In other countries, late sowing has resulted in low yields (Ozer, 2003; Robertson and Holland, 2004; Uzun et al., 2009; Tobe et al., 2013; Shirani Rad et al., 2014; Neely et al., 2015; Kirkegaard et al., 2016).

Physiological potential of seeds is directly responsible for field performance and is routinely evaluated through laboratory tests (Kikuti and Marcos Filho, 2007). Seeds can express their maximum germination capacity through germination test because it is conducted in crop's optimal conditions. However, this test does not subsidize information about seed vigour. In field situations, circumstances are not always favourable (Bewley and Black, 1994; Hilhorst et al., 2001). Thus, to avoid discrepancy between results of germination test with those observed in the field and to identify lots with better performance, Byrum and Copeland (1995) suggested the vigour tests, such as accelerated aging and electrical conductivity in parallel with germination test.

In Brazil, agronomic studies with canola are scarce, particularly for yield and seed quality, when conducted at different sowing dates and spacing. Thus, it is desirable to obtain information about production of hybrids adapted to the climate of region and considering the best production techniques available. In this sense, the aim of present study was to evaluate physiological seed quality of four canola hybrids in two sowing dates and two spacings in Maringá, northwest of Paraná.

Results and Discussion

First and final count of germination test

Main effect of Hybrid for first and final count of germination test for 2011 (Table 2) and 2012 crop season (Table 3) was significant. This was regardless of spacing and sowing dates adopted, differences arise between canola hybrids for variables in question. The results demonstrated that all tested hybrids showed high normal seedlings percentages, more than 85%, for both response variables, first and final count of germination (Table 2). Hybrids Hyola 76, Hyola 61 and Hyola 411 showed similar behaviour, surpassing Hyola 433.

Response variables, final count of germination test for 2011 (Table 4) and first and final count of germination test for 2012 (Table 5) showed significant differences in main effect "sowing date". This is regardless of hybrids and spacings, and differences are between sowing dates used. Results of final count of germination test for main effect of sowing date (Table 4) shows that sowing on 05/10/2011 promoted percentage of normal seedlings (94.89%) compared to 04/08/2011 (90.70%). These results can be directly related to low rainfall (Table 1) which affected especially seedlings in May, as they were in early stages of plant growth (Shirani Rad et al., 2014).

Results of first and final count of seed germination test in 2012 are shown in Table 5. Higher germination percentage on 04/08/2012 sowing date is observed. Hybrids sown on 05/10/2012 suffered greater influence of drought from half to the end of plant cycle, which significantly influenced the physiological potential. Although seed germination is influenced by both genetic and environmental factors, it is still unknown if well-performing seeds under ideal environmental conditions have advantages when cultivated under stress conditions (Hatzig et al., 2015).

Often, seed quality is evaluated through germination test. However, to supplement results of germination tests, other vigour tests are necessary. It is not ideal to take only first count of germination into consideration, since vigour identification depends on a number of features that can positively or negatively influence the results (Koornneef et al., 2002; Martins et al., 2002; Bentsink and Koornneef, 2008; Rajjou et al., 2012).

Accelerated aging

The accelerated aging test is a vigour test determined under unfavourable conditions. Seeds are subjected to high temperature and humidity for a short period of time, and then put to germination (Copeland and McDonald, 1999; Halmer, 2000). High vigour seed lots will maintain its viability (having high percentage of normal seedlings) when subjected to such conditions, while low vigour seeds will have reduced viability. For year 2011, interaction of first order Hybrid × Sowing date was observed significant, indicating statistical differences between hybrids and sowing dates regardless of tested spacings.

Partition of first order interaction (2011 crop season) is shown in Table 6. In the 04/08/2011 sowing date, superiority of hybrids Hyola 411 and Hyola 61 was noted. These hybrids showed higher percentages of normal seedlings compared to other hybrids and; therefore, higher seed vigour. Hybrid Hyola 433 presented lower percentage of normal seedlings than Hyola 76 and; therefore, lower vigour. These results demonstrate that the short-cycle hybrid Hyola 433 presented a lower performance compared to others in the first sowing date. This can be explained by low water availability observed in May (7.5 mm) and in the second ten days of June (0.0 mm), which may have affected flowering and also grain filling (Faraji, 2012).

For 05/10/2011 sowing date (Table 6), superiority of hybrid Hyola 411 was noted over Hyola 433. The first hybrid had a higher percentage of normal seedlings in the accelerated aging test. The hybrids Hyola 76 and Hyola 433, when sown on 05/10/2011, had superior performance compared to sowing on 04/08/2011 (comparing the sowing dates). According to Dalmago (2010) and Zhang et al. (2015), it is plausible to suggest that these results are due to conditions of lower temperature occurred since the start of cycle until harvest (Table 1).

Results obtained in accelerated aging test for 2011 crop season (Table 6), corroborate the results for first and final count of germination test in the same year (Table 2). According to Avila et al. (2005), besides first and final count of germination test, accelerated aging is efficient in estimating the emergence potential of seedlings of canola in field condition because it is a vigour test determined under unfavourable conditions.

In Table 3, the result of first and final count of germination test and accelerated aging for 2012 crop season is presented. In this case, low germination percentage of seeds was observed for all hybrids analyzed. Data of the three aforementioned tests demonstrated that seeds of hybrids Hyola 61 and Hyola 411 differed and outperformed over other hybrids, using LSD test ($p < 0.05$). Although hybrids 411 and 433 belong to the same maturity cycle, Hyola 433 is considered among the tested hybrids as the most sensitive to water deficit (Tomm et al., 2009; Marco et al., 2014). Therefore, higher percentage of normal seedlings of Hyola 411 emphasizes the influence of climatic factors on seed quality in hybrids more suited to harsh conditions. For 2012, in the accelerated aging test, seeds presented higher percentages of normal seedlings at the 04/08/2012 sowing date (Table 5). Canola hybrids sown on 05/10/2012 suffered greater influence of drought from half to the end of cycle, which significantly influenced physiological potential.

In the present study, the accelerated aging test contributed decisively to detect important differences between hybrids and provide greater safety in decision-making, since there is a positive correlation between accelerated aging and seedling emergence in the field (Avila et al., 2005; Braz and Rossetto, 2009; Boligon et al., 2011; Mambrinet al., 2015; Martins et al., 2016).

Electrical conductivity

The essence of electrical conductivity test is to assess seed quality by the amount of leakages present in the soaking solution. Lower electrical conductivity values indicate greater vigour seeds, since they correspond to greater integrity of the cytoplasmic membrane, and consequently, lower release of exudates (Marchiori Júnior et al. 2002).

The results of second significant interaction (Hybrid × Sowing Date × Spacing) for variable electrical conductivity, are presented in Tables 7 and 8, for 2011 and 2012, respectively. In 2011 (Table 7), hybrid Hyola 433 differed and positively surpassed over hybrids Hyola 76 and Hyola 61, when sown on 04/08/2011 on 0.45 m spacing.

In 2011, the lowest amount of rainfall was observed at the beginning of flowering, only 7.5 mm in total for May.

Table 1. Climatic data of maximum and minimum temperature, relative humidity and rainfall of Iguatemi Experimental Farm, from April to September, 2011 and 2012, in Maringá-PR.

Month	Ten-day period	Temperature (ºC)				Relative Humidity (%)		Rainfall (mm)	
		Maximum		Minimum					
		2011	2012	2011	2012	2011	2012	2011	2012
April	1º	28.3	30.0	17.9	18.6	66.0	55.6	15.0	17.2
	2º	27.2	29.0	18.5	19.8	64.0	65.7	72.8	14.4
	3º	26.8	24.2	16.9	16.1	67.0	71.1	23.3	65.6
May	1º	26.0	24.6	14.4	14.6	63.5	57.2	7.5	0.0
	2º	24.3	23.0	13.8	16.0	65.8	73.7	0.0	3.7
	3º	24.9	23.2	13.0	16.7	59.1	75.0	0.0	5.9
June	1º	21.7	19.0	10.2	13.4	59.0	84.2	82.0	55.4
	2º	23.4	23.7	12.0	16.7	53.5	76.1	0.0	221.6
	3º	21.9	21.3	8.9	15.4	74.5	64.4	54.8	2.0
July	1º	18.8	23.9	10.6	14.2	65.4	53.8	22.0	14.2
	2º	26.9	18.8	16.6	11.6	52.7	60.6	46.0	2.2
	3º	24.9	23.8	14.9	18.0	65.1	58.9	69.8	2.0
August	1º	24.8	28.0	10.6	17.6	52.7	46.6	17.0	0.0
	2º	26.9	29.0	17.0	17.9	56.3	43.4	15.8	0.0
	3º	25.0	28.2	14.8	16.8	52.6	49.0	1.0	4.8
September	1º	26.4	33.5	14.5	20.2	50.8	60.8	20.2	27.5
	2º	28.7	34.0	15.3	21.7	45.2	42.6	0.0	0.0
	3º	29.8	25.3	16.2	12.8	45.4	59.8	7.8	0.0
Mean/Total Total		25.4	25.7	14.2	16.6	58.8	61.0	455.0	436.5

Source: Iguatemi Experimental Farm's Weather Station (UEM. Maringá – PR).

Table 2. Means of main effect hybrid for response variables first (GER) and final count of germination test (GERF) in Maringá-PR, in 2011 crop year.

Hybrid	GER (%)[1]	GERF (%)[1]
Hyola 76	89.78 A	93.28 A
Hyola 61	90.75 A	93.47 A
Hyola 411	92.09 A	94.13 A
Hyola 433	85.38 B	90.31 B

[1]Means followed by same uppercase letter on the column do not differ significantly at 5% probability, by LSD test.

Table 3. Means of main effect hybrid for response variables first (GER) and, final count of germination (GERF) and accelerated aging (ACA), in Maringá-PR, in 2012 crop year.

Hybrid	GER (%)[1]	GERF (%)[1]	ACA (%)[1]
Hyola 76	60.63 B	67.56 B	56.65 B
Hyola 61	66.40 A	72.68 A	61.84 A
Hyola 411	65.33 A	72.40 A	61.39 A
Hyola 433	62.19 B	69.15 B	57.41 B

[1]Means followed by same letter on the column do not differ significantly at 5% probability, by LSD test.

Table 4. Means of main effect sowing date for variable final count of germination test (GERF) in Maringá-PR, in 2011crop year.

Date	GERF (%)[1]
04/08/2011	90.70 B
05/10/2011	94.89 A

[1]Means followed by same letter on the column do not differ significantly at 5% probability, by F test.

Table 5. Means of main effect sowing date, for response variables first (GER) and final count of germination (GERF) and accelerated aging (ACA) in Maringá-PR, in 2012 crop year.

Date	GER (%)[1]	GERF (%)[1]	ACA (%)[1]
04/08/2012	67.06 A	74.27 A	62.97 A
05/10/2012	60.21 B	66.63 B	55.67 B

[1]Means followed by same letter on the column do not differ significantly at 5% probability, by F test.

Table 6. Partition of first order interaction (Hybrid x Sowing Date) for variable accelerated aging in Maringá-PR, in 2011crop year.

Hybrid	Date[1]	
	Accelerated aging(%)	
	04/08/2011	05/10/2011
Hyola 76	67.59 bB	76.75 aAB
Hyola 61	75.69 aA	75.31 aAB
Hyola 411	81.00 aA	82.56 aA
Hyola 433	56.75 bC	70.38 aB

[1]Means followed by equal letters uppercase in column and lowercase in line do not differ significantly at 5% probability by LSD test and F test, respectively.

Table 7. Partition of second order interaction (Hybrid x Sowing Date x Spacing) for variable electrical conductivity (μS cm^{-1} g^{-1}) in Maringá-PR in 2011 crop year.

Date and Spacing	Hybrid[1]			
	Hyola 76	Hyola 61	Hyola 411	Hyola 433
04/08/2011 and 0.17 m	187.59 a	190.18 a	241.40 a	175.12 a
04/08/2011 and 0.45 m	147.41 b	144.48 b	207.57 ab	241.19 a
05/10/2011 and 0.17 m	141.24 a	139.62 a	155.02 a	181.88 a
05/10/2011 and 0.45 m	125.32 a	140.30 a	167.18 a	121.43 a

[1]Means followed by same letter on line do not differ significantly at 5% probability, by LSD test.

Table 8. Partition of second order interaction (Hybrid x Sowing Date x Spacing) for variable electrical conductivity (μS cm^{-1} g^{-1}) in Maringá-PR, in 2012 crop year

Date and Spacing	Hybrid[1]			
	Hyola 76	Hyola 61	Hyola 411	Hyola 433
04/08/2012 and 0.17 m	347.85 b	393.23 a	228.67 c	401.25 a
04/08/2012 and 0.45 m	251.87 c	356.44 a	230.90 c	303.60 b
05/10/2012 and 0.17 m	306.46 a	228.70 c	203.96 d	262.85 b
05/10/2012 and 0.45 m	167.77 c	203.47 b	166.64 c	296.73 a

[1]Means followed by same letter on line do not differ significantly at 5% probability, by LSD test.

The water deficit, especially in the flowering period can affect grain development (Avila et al., 2004; Gunasekera et al., 2006; Tesfamariam et al., 2010) preventing early maturing hybrids to express its maximum physiological potential. According to Pavlista et al. (2016), water availability needs to be constant, without interruption and throughout the crop cycle, to achieve high yield and obtain high physiological quality seeds.

Mean values for the second crop season is verified in Table 8. The lowest vigour is noted in hybrid Hyola 61, compared to others, when sown on 04/08/2012 and subjected to 0.45 m spacing. In the same sowing date, hybrids Hyola 61 and 433 showed lower vigour in the 0.17 m spacing; however they did not differ at 5% probability by the t-test (LSD).

Hybrid Hyola 76 showed higher solute leaching values when sown on 05/10/2012 and 0.17 m spacing; thus, higher electrical conductivity values. Seeds of early maturing material Hyola 433 showed the highest electrical conductivity values for the same sowing date under 0.45m spacing. Therefore, response of seed vigour from plants under different densities is dependent to the hybrid genotype.

Results of electrical conductivity test demonstrated that sowing dates and spacings have significant effect on the physiological quality of canola seed. Based on Rossetto and Nakagawa (2000) and Estevez et al. (2012), the influence of low temperature and water deficit, especially at flowering stage, results in vigour reduction.

According to Araujo et al. (2011), electrical conductivity test is used as a vigour test with promising results, mainly for peanut (Vanzolini and Nakagawa, 2005), cowpea (Dutra et al., 2006) and some vegetable crops like pumpkin (Vieira and Dutra, 2006) and pepper seeds (Oliveira and Novembre, 2005). For more studied crops such as cauliflower, radish, and turnip, immersion period of seeds in conductivity test can be reduced because the amount of released solute is very high as the imbibition starts and decreases as the reorganization system of membranes occurs.

Unlike the above mentioned crops, radicle protrusion for canola occurs quickly in conductivity test, when it is in direct contact with water. Thus, more leaching solutes in the medium are verified, overestimating test results. For canola, there is still a need to standardize the test, since there are divergences in literature in relation to parameters, such as amount of seeds, time and volume of water imbibition.

For example, Avila et al. (2005) used 50 canola seeds immersed in 25 mL of deionized water for a 24 hours period. Milani et al. (2012) used 50 canola seeds soaked in 25 mL of deionized water for 8 hours. Kaefer et al. (2014) suggested 50 canola seeds, soaked in 75 mL of deionized water for a 4 hour period. The lack of standardisation for electrical conductivity test makes it difficult to compare results obtained in this experiment with those of other authors. However, the methodology that we used allowed distinguishing the vigour level of hybrids with consistency.

Materials and Methods

Experimental conditions

The experiment was carried out during crop years of 2011 and 2012 at Iguatemi Research Station (FEI) of the State University of Maringá (UEM), in Maringá in northwest Paraná State, located at latitude 23°25’ south and longitude 51°57’ west of Greenwich and with an average altitude of 540 m. Climate of region is Cfa (humid mesothermal, with abundant rains in warm summer and dry winter), according to Köppen classification (McKnight and Hess 2000). Weather data registered over the crop cycle is in Table 1.

Experiments were installed in a soil classified as dystrophic Red Argisol, medium texture according to Brazilian Classification System (Embrapa, 2013). Values of chemical properties in the 0-20 cm layer were as follows: pH (water) – 5.5; P – 7.0 mg dm^{-3}; exchangeable Al^{3+} - 0.1 $cmol_c$ dm^{-3}; K^+ - 0.54 $cmol_c$ dm^{-3}; Ca^{2+} - 2.82 $cmol_c$ dm^{-3}; Mg^{2+} - 1.01 $cmol_c$ dm^{-3}; S – 6.54 mg dm^{-3}; CTC – 7.79$cmol_c$ dm^{-3}; V – 56.10%.

Fertilization was carried out with 270 kg ha^{-1} of 8-16-16 fertilizer, containing 9.2% of sulfur. Dolomitic limestone top-dressing was applied three months before sowing in order to raise base saturation to 70%. Sowing was carried out with a higher plant stand than necessary. However, at the two-to-three true leaf stage (Meier, 2001), thinning was performed to obtain a uniform density of 40 plants m^{-2}. Seeds were treated with Tetramethylthiuram disulfide (Thiram®) at dosage of 2 g of active ingredient for kg^{-1} of seed.

Manual or chemical methods were carried out to control weeds and, later on, to control *Diabrotica speciosa* and *Brevicoryne brassicae* infestations, as stated in Tomm et al. (2009) and updated in Sanches et al. (2014). Experimental units consisted of six rows of five meters long, spaced 0.45 m apart and of sixteen rows of five meters long, spaced 0.17 m apart. As useful area, 3.6 m^2 of the central portion from each experimental unit were used and lateral rows and ends of central rows as borders disregarded.

When main stem of plants had around 60% of seeds with a brown or black colour, harvest was manually done, as recommended by Portella and Tomm (2007). Then, plants of the useful area of each plot were arranged in identified raffia bags, taken to a protected environment, with air circulation, where they remained for five days to dry out. At that point, seeds were subjected to manual threshing and cleaned with aid of screens and a digital picker impurities, ME-06 model, MEDIZA brand.

Later, seeds were placed in multiwall *Kraft* paper bags and stored in cold chamber at the Applied Research Center for Agriculture (Nupagri) of UEM in Maringá, PR, where they stayed for a week in order to standardize humidity before being subjected to physiological quality evaluation.

Treatments and experimental design

In both crop years, the first sowing date took place on April 8 and the second sowing date on May 10. The tested hybrids were: Hyola 76, Hyola 61, Hyola 411 and Hyola 433. Regarding maturity cycles, these hybrids are classified as late, medium and early (for the last two), respectively. All of them have polygenic resistance to blackleg (*Phoma lingam*). The hybrids were sown in 0.17 and 0.45 m spacing between rows.

Experimental design was a randomized complete block design with four blocks and arrangement of treatments was done in split-split plots. Sixteen treatments were used, which consisted of two sowing dates (April 8 and May 10) in whole plots, two spacings (0.17 and 0.45 m between rows) allocated in subplots and four hybrids (Hyola 76, Hyola 61, Hyola 411 and Hyola 433) allocated in sub-subplots.

Variables measured

Final count of germination test: it was conducted with four sub-samples of 50 seeds for each experimental unit, germinated in "Gerbox" type plastic boxes on three paper towel sheets "Germitest", moistened with distilled water in the proportion of 2.5 times the dry substrate weight. Later, seeds were taken to germinator Mangelsdorf type set to maintain at a constant temperature 20±1 ºC. Evaluations were performed seven days after sowing, computing seedlings considered normal, according to the criteria of the National Rules for Seed Analysis (Brasil, 2009).

First count of germination: it was performed similar to the above procedure, using same methodology considering normal only seedlings obtained in the fifth day after initiating the test (Brasil, 2009).

Accelerated Aging: seed samples of each lot were distributed in a single layer on a plastic screen placed inside plastic boxes, "gerbox" type, containing 40 mL of distilled water. Distance between water level and seeds were approximately 2 cm. Then, boxes were closed and taken to a water jacketed chamber (model 3015, VWR/ USA) and maintained at a temperature of 42°C for 24 hours (Marcos Filho, 1999). After the aging period, 200 seeds were randomly chosen and divided into four subsamples of 50 seeds, which were subjected to the germination test as described above. Evaluation was performed on the fifth day after transferring to the germinator.

Electrical conductivity: test was performed according to methodology described by Vieira and Krzyzanowski (1999). Four replications of 50 seeds for each lot were weighted in an analytical scale with an accuracy of one milligram and placed in plastic cups (cup system or mass conductivity or bulk conductivity) containing 25 mL of demineralized water, remaining in an incubator set for 25°C over 24 hours. Evaluation was performed after contents of cups were gently stirred with a glass rod, and electrical conductivity was measured in a conductivity digital bench microprocessor (Alpax). The electrode was washed in demineralized water and dried with a paper towel before each measurement. Mean values of electrical conductivity of each lot were expressed in $\mu S\ cm^{-1}\ g^{-1}$ of seed.

Statistical analysis

Basic assumptions for analysis of variance were analyzed and met. Subsequently, data for all variables were subjected to analysis of variance at 5% probability and, in presence of significant interaction; partitions were proceeded as recommended by Banzatto and Kronka (2006). Mean comparisons of hybrids was done by Fisher's LSD test (Least Significant Difference) ($p \leq 0.05$). The F test is conclusive when comparing averages of sowing dates and spacings. Software used in analysis was SISVAR (Ferreira, 2011).

Conclusion

For the crop year 2011: Hybrid Hyola 433 had the highest values of normal seedlings for variables first and final count of germination tests. Canola hybrids Hyola 76 and Hyola 433 can be considered for sowing in early May as both presented high-vigorous seeds according to the accelerated aging test.

For the crop year 2012: Sowing in early April resulted in higher percentages of normal seedlings for variables germination test's first and final counts, as well as for accelerated aging. Hybrid Hyola 433 showed higher electrical conductivity and; therefore, lower seed vigour when sown in early April using the row spacing of 0.45 m or when sown in early May in both tested spacings. Regardless of sowing date, hybrid Hyola 411 presented lower values of electrical conductivity and; thus, greater vigour, under row-spacing of 0.17 m.

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