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Yield of Five Canola Hybrids Under Plant Densities and Chemical Dissection

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Abstract

BACKGROUND: There are many challenges to be overcome in order to enlarge canola cultivation in Brazil. Cultural aspects such as lack of knowledge of crop potential, logistics aspects due to the lack of companies that receive and process crop production, establishment frustrations, phytosanitary problems, lack of efficient management strategies, natural dehiscence and crop losses stand out among these challenges. Thus, optimal plant density is required to improve plant phenological traits and maximize seed yield in field crops. OBJECTIVE: Evaluate the response of hybrid canola (Hyola 433, Hyola 571, Hyola 575, Hyola 61 and Hyola 50) to tree plant densities (25, 30 and 35 plants m^{-2}) and a chemical ripening called "Clockker" at rates of 4 and 6 L ha^{-1} plus a control treatment. RESULTS: There was difference on plant density, as expected, with final plant density of 20, 26 and 32 plants m^2. Treatments showed similar number of branches per plant. There was difference on the number of pods per plant between cv. Hyola 61 and Hyola 50, which had 289 and203 pods per plant respectively. Cultivars Hyola 60 and Hyola 51 showed a higher thousand grain weight (4.08 g) when compared to Hyola 433 (3.73 g).Canola cv. Hyola 50 started flowering 57 days after its emergence (DAE) (June 3, 2017), nine days after cv. Hyola 433 (May 25, 2017), which showed the shorten cycle. Hyola 51 showed the longest flowering period, with 61 days on flower and also the longest cycle, however, there was no effect of plant density on length of flowering. In general, canola hybrids spent an average of 44% of their life cycle in flower, and another 25% of the time filling seed post-flowering. There was no significant yield difference between seeding rates, with average yield among treatments of 1,847 kg ha^{-1}. Chemical ripening showed negative influence over canola yield in relation to the control (1607 versus 2,316 kg ha^{-1}) probably because it was applied to early on the crop cycle. CONCLUSION: Canola showed similar yield among hybrids and plant densities. Length of flowering was not affect by plant densities; however, there was difference on days to flower and days to maturity among hybrids. The use of chemical ripening 15 days before cut-windrowing negatively affected canola yield.

Key words: Length of flowering, days to maturity, Brassica napus.

INTRODUCTION

Canola (*Brassica napus*) is a major oilseed crop in the world, however, is not usual cultivated in Brazil. Of the 19.4 million hectares cultivated with soybeans and maize in the southern at the 2015/16 summer crop, wheat occupied an area of 2.1 million hectares, with canola occupying a much smaller area with only 47 thousand hectares cultivated (Conab, 2017).

Canola stands out as the main wheat rotation option, being popularly known as "winter soybeans " because of its potential for producing better nutritional oil quality. In addition to the available market, canola crop have a lower level of investment and production risk in relation to wheat and can be cultivated using the same structure with small adaptations in seeders, trucks and harvesters.

Also, the viability of cultivation is increased by the current average yield (1,500 kg ha^{-1}), which can and should be improved, especially in the current context, with the availability of new hybrids of canola in the market. These materials present resistance to the main disease of canola (*Leptosphaeria maculans*) (West *et al*., 2001) and Clearfield® technology (CL), which greatly facilitate disease and weed management problem. However, these hybrids still present uneven ripening of seedpods, which feature natural dehiscence, causing excessive grain losses during ripening and harvesting times, serious problems to be overcome in canola cultivation.

In this way, the present study aims to investigate two strategies to reduce harvest losses by studying the effect of plant density and a chemical ripening on canola better uniform plant maturity. Thus, the optimum plant density for a particular crop varies depending on many factors, such as crop type, cultivar, soil fertility, water availability, and environmental factors and due to it, must be evaluated by local researches. In principle, optimum plant density is the small rate that allows higher yield.

Canola chemical ripening is aimed to uniform plant maturity and reduce harvest loss, however, this can impact grain yield. Due to it, new products need to be evaluated aiming to find out management strategies to avoid these problems. In this context, the study aimed to evaluate the effect of different sowing densities on the flowering uniformity and yield of different canola hybrids, and also the use of a physiological ripening to improve maturation uniformity and reduce seed harvest losses. The objectives of this work were: 1) determine the effect of the low plant population on the yield potential of different canola hybrids; 2) evaluate the viability of physiological ripening on the yield potential of canola; 3) verify if the maturation stages of canola are affected by the different populations and canola hybrids.

MATERIAL AND METHODS

The experiment was carried out at the Federal Technologic University of Paraná – UTFPR, campus of Dois Vizinhos, Agricultural Research Station, at 540 m above sea level. According to the Köppen classification, the climate is Cfa (Alvares *et al.*, 2013) with mean annual rainfall of 2000 mm (Iapar, 2017). Soil at the experimental site is classified as a Clayey Oxisol, according to Embrapa (2006).

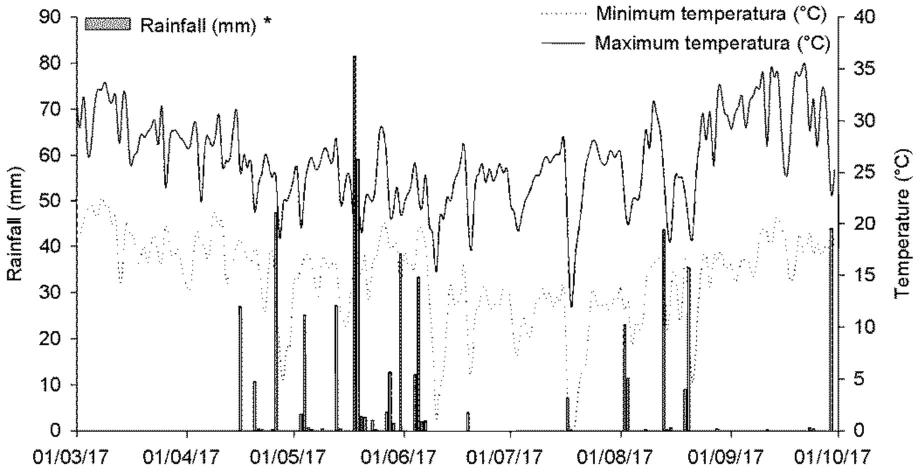

Fig. 1: Rainfall (mm), Maximum temperature (°C) and minimum temperature (°C) and recorded during the study period (03/26/2017 to 02/09/2017) at Dois Vizinhos - PR, 2017.
Source: Inmet, (2017) - National Institute of Meteorology, Automatic Station of Dois Vizinhos - PR. * Rainfall information not recorded during the month of March 2017.

Detailed soil properties were measured at 0-20 cm (Table 1).

Table 1: Soil analyses at 0-20 cm depth. Dois Vizinhos – PR, 2017.

MO	K	Ca	Mg	Al^{+3}	P	CTC	H+Al	pH	V
g dm³	------- $Cmol_c$ dm³ -------				mg dm³	$Cmol_c$	$Cmol_c$	$CaCl_2$	(%)
41,55	0,18	4,60	2,30	0,00	11,30	12,04	4,96	5,10	58,80

Experiment was laid out as a randomized block design with four replications in a 5x3 factorial scheme. Five canola hybrids (Hyola 433, Hyola 571, Hyola 575, Hyola 61 and Hyola 50) were cultivated in the main plots (2.25 m × 15 m) and three plant densities (250, 300 and 350 thousand plants ha^{-1}) established at the sub-plots.

The sowing of the canola hybrids took place on April 03, 2017, 25 days after soybean harvest. A seeder-fertilizer was used with a mechanic seed dispenser that contained five sowing rows with inter rows spaced 0.45 m apart at 0,015 m depth. The average sowing speed was 5.0 km h^{-1}. Considering a typical seed rate survival of 50%, seeder was regulated to sow 200 seeds per m^{-2}, which translates to a emergence rate of 100 plants m^{-2}. A higher seeding rate was used to get a good and uniform population density. At the 2 to 4 leaf stage seedlings (04/18/2017) were thinned to uniform plant stands of 35, 30, 25 plants m^{-2}.

As a starter fertilizer, was applied 350 kg ha^{-1} of chemical fertilizer 05-20-10 (N-P_20_5-K_2O). Nitrogen was broadcast applied at 38 days after sowing, using 133 kg of uréia ha^{-1}. Ten days before seeding, glyphosate was applied in the area at a rate of 1000 g i.a ha^{-1}. Later on, weeds were handpicked and fungicide was not used. At the 2 to 4 leaves, imidacloprid (250 mL ha^{-1}) was applied to control *Diabrotica speciosa.*

Data collection included plant density, plant height, days to start and end of flowering, days to maturity, branching, pods per plant, thousand grain weight and grain yield.

Plant population was determined at the harvest day counting de number of plants per plot and then extrapolated to hectare. Plant height was measured on 10 plants per plot and was measured at the top portion of the main stem where pods are developed. These evaluations were carried out in five plants per sub-plot, calculating the arithmetic mean between the values found and this value was used in the statistical analysis of the data.

The beginning of flowering was defined as the date when flowers appeared on 10% of the plants in a plot, and the end of flowering as the date when 90% of the plants in a plot finished flowering. The period from the beginning to the end of flowering was defined as the “duration of flowering.” In addition, the post-flowering period was recorded, which was the duration from the end of flowering to pod maturity because this period is critical for seed filling and seed weight (Angadi *et al.*, 2003). Under field conditions, when 50 to 60% of the pods on a canola plant (main stem) turn brown the crop is usually swathed to facilitate dry-down for combining (Anonymous, 2011). In the present study, we defined days to maturity as the time when 60% of the pods in the superior part of the plant had turned brown.

Grain yield was measured collecting tree center rows of each plot 5 m length. Plants were cut down to the ground and about 7–10 d after, dry-down was sufficient to allow samples was cleaned and weighed. Plants were placed in bags, with a capacity of 1,000 kg, and a wooden stick was used to beat the sample and to thresh the pods. After it, plants were checked and when closed pods was observed, they were manually opened to obtain the grains. Impurities present in the sample were removed and the grain sample was weighed in a precision 1 g scale. Plant survival was calculated considering the initial plant density after pruning and final stand.

Canola hybrids showed different cycles resulting in harvest management with cut-windrowing at different dates: Hyola 433 (08/09/2017), Hyola 571 (08/07/2017), Hyola 575 (08/07/2017), Hyola 61 (08/19/2017) and Hyola 50 (08/25/2017).

Additional plots of Hyola 50 was carried out just as mentioned before to evaluated a chemical ripening (Magnesium salt) called ‘‘Clockker’’ at rates of 4 and 6 L ha^{-1} plus a control treatment. Cultivar Hyola 50 was set at the main plots and chemical ripening applied at the sub-plotcarried out in a randomized block design with for replication.

Chemical ripening was applied when plants showed a 40% of mature pods on 08/11/2017. Five and ten days (16 and 21 August/2017) after product application, phytotoxicity degree on canola leaves (Table 2) was evaluated in 10 plants per plot. For each plant a note was assigned rating chemical ripening injury on a visual scale of 1 (no crop injury) to 5 (complete necrosis and superbursting) relative to untreated control plants. Plant were harvest on 08/25/2017.

A grain sample was taken to the Seeds Lab of the Federal Technological University of Paraná, Campus Dois Vizinhos (UTFPR-DV), to determine the moisture of the canola grains in a Universal Humidity Determiner. Final yield was corrected for percent moisture of 13%.

Thousand-seed weights from each plot were determined by weighing 4 samples of 250 seeds.

Table 2: Scale of phytotoxicity notes with respective denominations.

Score	Description of symptoms
1	Absence of phytotoxicity symptoms - no damage
2	Chlorotic Injury in leaves of the periphery of the plant
3	Chlorotic and necrotic symptoms (leaf edges)
4	Chlorotic Injury and Superbursting
5	Chlorotic, necrotic and superbursting

Adaped from Ewrc, (1964).

The data regarding the beginning and end of the flowering are presented in tables. The data of canola yield components were submitted to the Shapiro-Wilk normality test and, according to the assumptions, analysis of variance (ANOVA). When this presented significance, the averages were compared by Tukey's test, at 5% probability with the aid of Software Assistat 7.7 (Silva and Azevedo, 2016).

RESULTS AND DISCUSSION

Canola establishment is one of the most critical stages in the crop cultivation due to reduced seed size and little seed reserve. Less than half of the 200 seeds m^2 sowed emerged as seedling and there were plots with less than 70 seedlings, even with good wheatear condition after sowing (Rainfall of 20 mm 5 days after sowing).

It is usually assumed that a lower proportion of planted canola seed will become seedlings. Harker *et al*. (2003) studies suggests that 50% emergence is a representative average of canola emergence under field conditions. Furthermore, differences between target and actual densities demonstrated that percent germination (greater than 90% for the seed used in this study) greatly overestimates the number of plants that actually emerge under field conditions. According to Harker *et al*. (2003), typical seeding rates for canola in Western Canada would be close to 100 seeds m^{-2} (5.5 kg ha^{-1}). In this study, higher density was sowed, and lower plant density was noticed.

There was no interaction between canola hybrids versus plant density (Table 3). However, there was difference on plant density, as expected, with final plant density of 20, 26 and 32 plants m^2. It is noteworthy to report the plant loss between canola thinning and final density was of 20, 13.3 and 8.5% respectively to the treatments with 250, 300 and 350 thousand plants ha^{-1}. Intra-specific competition and self-thinning may explain these results (Linde, 2001).

Table 3: Plant population (POP) (plants ha^{-1}), number of branches (NB), plant height (PH) (m), number of pods per plant (PODS), Thousand grain weight (TGW) and grain yield (kg ha^{-1}) of different canola cultivars grown at different densities at Dois Vizinhos – PR, 2017.

	POP	NB	PH	PODS	TGW	YIELD
Hyola 433	240.329 b	4,96	1,25 b	273,15 ab	3,73 b	1.753
Hyola 571	299.039 a	5,56	1,27 b	248,04 ab	3,89 ab	1.695
Hyola 575	266.666 b	4,81	1,28 ab	242,67 ab	3,83 ab	2.010
Hyola 61	268.779 ab	5,19	1,25 b	289,33 a	4,08 a	1.934
Hyola 50	257.887 b	5,04	1,36 a	203,52 b	4,08 a	1.842
Dms	31.088	0,91	0,08	80,79	0,34	350
250.000	209.580 c	4,98	1,28	248,55	3,88	1.801
300.000	262.222 b	5,33	1,28	261,71	3,97	1.807
350.000	327.818 a	5,02	1,29	243,76	3,91	1.932
Dms	20.388	0,60	0,06	52,99	0,22	229
Mean	266.540	5,11	1,28	251,34	3,92	1.847
CV (%)	8,48	12,91	4,79	23,37	6,38	13,78
F Hybr.	8,03 **	$1,64^{NS}$	5,05 **	2,79 *	3,35 *	$2,28^{NS}$
F Dens.	103,07 **	$1,29^{NS}$	$0,07^{NS}$	$0,37^{NS}$	$0,39^{NS}$	$1,26^{NS}$
Hybr. X Dens.	$2,02^{NS}$	$1,24^{NS}$	$0,48^{NS}$	$0,49^{NS}$	$1,65^{NS}$	$1,01^{NS}$

^{NS}, * e ** correspond respectively not significant, significant at 5% and significant at 1% probability. Means followed by different letters in the column, differ statistically by the Tukey test at 5% probability.

There was no significant yield difference between seeding rates, with average yield among treatments of 1,847 kg ha^{-1} (Table 3). This yield is higher than the national and Paraná state average reported in the 2016 growing season, which was of 1,515 and 1,479 kg ha^{-1}, respectively (Conab, 2017). It is also higher than expected survey of Conab at September 2017, which estimates national and state yield of 1,289 and 1,316 kg ha^{-1} for the 2017 season. Thus, same survey estimates wheat crop season average production of 3,000 kg ha^{-1} at the Paraná.

Plant density in canola governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock, 2000). Al-Barzinjy *et al.* (1999) investigated the effects of different plant densities ranging from 20 to 130 plants m^2 in canola and concluded that pods per plant, seed weights and dry matter per plant decreased as plant density increased.

Morrison *et al.* (1990) reported that plants at the lower seeding rates compensated for available space and produced larger plants with greater leaf area index per plant, while the higher degree of competition beginning at an early growth stage that occurred at the higher seeding rates, resulted in smaller plants. Furthermore, canola was able to compensate yield potential by increasing the number of branches and pods per plant. Although, the effect of non-uniform plant stand on fertile branches was more evident at lower population densities.

The shorter difference between plant stand of the present study resulted in similar number of branches. There was only diference on the number of pods per plant between cv. Hyola 61 (289.33) and Hyola 50, which had 203.52 pods per plant (Table 3).

According to Angadi *et al.* (2003), because of the plasticity of the canola plant, yields were maintained over a wide range of populations before yields began to decline. Authors suggest that the primary response of canola to lower plant population is increased branching and pods per branch. Thus, 80 or 40 plants m^2 produced similar yields. Moreover, a lower plant population of 20 plants m^2 of canola can produce seed yields only slightly lower (11% lower) than that of 80 plant m^2. When canola populations are reduced from 86 to 3 plants m^{-2}, the number of pods per plant increases from 20 to 600 and branching per plant increased from 3 to more than 40 branches, thus evidencing the high plasticity capacity of canola.

Furthermore, Angadi *et al.* (2003) reported that along 9 site years, 90 and 80% of maximum yield was achieved at plant densities of 18 and 12 plants m^{-2}, respectively. As plant density increased yield reached a plateau at 28 plants m^{-2}.

Thus, it is thought that the newer hybrids of canola cultivars have a higher degree of phenotypic plasticity than open pollinated cultivars and are able to compensate for reduced densities with increased plant size. In a meta-analysis of canola seeding rate and plant population trials, Shirtliffe (2009) found hybrid and open pollinated canola cultivars to respond differently to low plant populations. Hybrid canola achieved 90 percent of its yield potential at 45 plants m^{-2} compared to 90 plants m^2 for open pollinated canola (Shirtliffe, 2009).

It is also important to consider environmental conditions when interpreting these results. Off course, in order for yield compensation at low plant densities to occur, plants must have adequate soil moisture and nutrient availability. Compared to years of normal precipitation, Angadi *et al.* (2003) found that there are greater reductions in seed yield at low plant populations in stressful environments.

Canola reaches a higher development of plants and the best yield results with N levels around 60 to 80 kg ha^{-1} (Ceolin *et al.*, 2017), (Kaefer *et al.*, 2014). These values of N are similar to the one used in this study (60 kg ha^{-1}), and this factor may have interfered in the results of plant height and canola yield components, collaborating so that there was no interaction among the evaluated factors.

Kirk *et al.* (2014) after three years of evaluation reported an average yield of 2,628 and 2,714 kg ha^{-1} respectively for the density of plants of 21 and 39 plants m^2. Yield differences between studies may be explained by hybrids, soil and weather conditions.

It is observed in Table 3 that canola densities did not affect plant height, but that, cv. Hyola 50, with plant height of 1.36 meters, differed statistically from cvs. Hyola 433, Hyola 571 and Hyola 61, which presented plant height of 1.25, 1.27 and 1.25 meters respectively. These values are similar as those reported by Embrapa. Kaefer *et al.* (2014), evaluating sources and rates of nitrogen (N) in canola cv. Hyola 61 observed plant height between 91 and 116 cm, values slightly lower than that observed in this study.

Cultivars Hyola 60 and Hyola 51 showed a higher thousand grain weight (4.08 g) when compared to Hyola 433 (3.73 g) (Table 3).

There were a few days of differences between beginning and end of flowering (Table 4). Canola cv. Hyola 50 started flowering 57 days after emergence (DAE) (June 3, 2017), nine days after cv. Hyola 433 (May 25, 2017), which showed the shorten cycle. Hyola 51 showed the longest flowering period, with 61 days on flower and also the longest cycle.

There was no diference to the plant density and days on flowering. A reduction in plant density from 70 plants m^{-2} to the density at which 90% of maximum yield was achieved (approximately 21 plants m^{-2}) results in a 3 day increase in days to maturity (Angadi *et al.*, 2003). The increase in flowering period and days to maturity at lower plant densities was likely a result of increased branching.

Table 4: Start, finish and length of flowering of different hybrids of canola cultivated in Dois Vizinhos - PR, 2017.

Hibrids	Start of flowering		End of flowering		Length of flowering	Days to Maturity
	Day	DAE	Day	DAE		
Hyola 433	25 May, 2017	48	21 July, 2017	105	57	129
Hyola 571	27 May, 2017	50	22 July, 2017	106	56	127
Hyola 575	28 May, 2017	51	24 July, 2017	108	57	127
Hyola 61	29 May, 2017	52	24 July, 2017	108	56	139
Hyola 50	03 June, 2017	57	07 August, 2017	118	61	145

DAE = Days after emergence.

There were small differences among canola hybrids for the length of flowering being the Hyola 50 the one with the longest period on flower and the longest cycle (Days to maturity). Canola hybrids spent an average of 44% of their life cycle in flower, and another 25% of the time filling seed post-flowering. This data is important once Gan*et al.* (2016) reported that seed yield was negatively associated with duration of flowering and was positively associated with days post-flower. Thus, seed yield was not associated with the total number of days from seeding to maturity.

Gunasekera *et al.* (2009) reported that longer post-flower period has been demonstrated to enhance the rate of photoassimilate remobilization from vegetative organs to the pods, significantly increasing harvest index in canola.

Hyola 50 showed a slightly longer cycle in relation to the other cultivars evaluated. However, for the population densities, there were no differences in the cycle. These data differ from Kirk et al. (2014), who report that increased plant density significantly reduced days to maturity and that increasing plant density from 5 to 70 plants m^{-2} resulted in a reduction from 5 to 19 days until maturity.

Angadi *et al.* (2003) also reported that the length of flowering period was significantly longer for canola plants in low-density stands (e.g., 20 plants m^{-2}) compared with those in high-density stands (e.g., 80 plants m^{-2}). According to the authors, this phenomenon held true regardless of the overall seed yield. They observed that canola plants in a low-density stand had more branches, with some of them emerging later in the flowering period. The initiation of flowering on the racemes at late-emerged branches was delayed, and those branches were still in the progress of flowering by the time the early-emerged branches had completed flowering. This traits were not observed in the present study mainly explained by the shorten diference among plant final density and good soil traits.

Canola stand establishment is depend upon factors such as soil moisture, soil temperature, disease, insects and other climatic factors (Hanson *et al.*, 2008), therefore, it is expected that varying conditions in the fall will lead to differences in plant density when canola is seeded on different dates.

It noteworthy to report that the period (from 06/11 to 07/29/2017) of canola flowering (Table 4) coincided with a prolonged period of abnormally low rainfall (only 10 mm). This lack of rainfall may have affected flowering and consequently yield components and canola yield of all evaluated densities and cultivars.

In two-year studies, Kaefer *et al.* (2014) observed differences in averages of dry matter, number of pods, plant height and number of plants per square meter, and attributed these results to climatic factors. Thus, Sanches *et al.* (2014) concluded that yield components and grain yield of cv. Hyola 61 responds significantly with the presence of irrigation.

Chemical ripening with clockker showed negative influence over canola yield probably because it was applied to early on the crop cycle. Canola yield of 1,586 and 1,629 kg ha^{-1} was observed to the treatment with 6 and 4 L ha^{-1} of Clockker, values lower than the control treatment, which yield was of 2,316 kg ha^{-1} of canola(Table 5).

In the other hand, Pizolotto *et al*. (2017) reported that harvest management with cut-windrowing or with previous chemical desiccation (diquat and glufosinato de amônio applied when 60 to 75% of the pods on a canola plant turn brown) are excellent strategies to reduce crop losses, once these treatments showed higher grain yields (in the order of 31% and 66%) when compared to the traditional systems used. The management with cut-windrowing before natural maturation carried out in this study was important to avoid grain losses at the harvest time.

Pre-harvest desiccation or ripening application may allow growers who decide to straight combine some of their canola field, particularly in fields with uneven maturity. While these products can hasten dry down of mature plants, they will kill any immature ones. It is also important to understand that these products are not designed to seal the pods against pod shattering, and in some cases may make the crop more vulnerable to shattering if harvest is delayed. It is important to be prepared to harvest as soon as the crop is ready, because the more rapid dry down will leave the crop vulnerable to shattering sooner than if it is left to mature on its own.

Table 5: Population of plants (POP) (plants ha^{-1}), degree of phytotoxicity in leaves on 08/16/2017 (Fit1) and 08/21/2017 (Fit2), number of pods per plant (PODS), thousand grains weight (TGW) (g) and yield (kg ha^{-1}) of canola cv. Hyola 50 with application of physiological ripening at Dois Vizinhos - PR, 2017.

	POP	Fit1	Fit2	PODS	TGW	YIELD
6 L ha^{-1}	292.604	2,31 A	2,55 A	272,91	4,02	1.586 B
4 L ha^{-1}	290.061	1,90 B	2,47 A	274,42	4,06	1.629 B
0 L ha^{-1}	292.716	1,00 C	1,00 B	265,75	4,15	2.316 A
Mean	291.460	1,73	2,01	271,02	4,08	1.844
Dms	48.136	0,37	0,37	90,40	0,36	338,92
CV (%)	7,61	9,99	8,50	16,17	4,13	8,47
Valor F	0,01^{NS}	59,11**	104,77**	1,76^{NS}	0,69^{NS}	27,51**

^{NS} and ** correspond respectively non-significant and significant at 1% probability. Means followed by different letters in the column, differ statistically by the Tukey test at 5% probability.

Conclusion:

Canola hybrids showed to have a higher degree of phenotypic plasticity once there were no yield difference among hybrids and plant densities. Canola hybrids showed mean yield potential very close to 2.000 kg ha^{-1}which makes the canola crop a very interesting option to the winter crop rotation. Plant densities did not affect the length of flowering; however, there were difference among hybrids to the length of flowering and days to maturity, which should be considered when choosing the hybrid to be sowed. Canola cv. Hyola 50 started flowering 57 days after its emergence (DAE) (June 3, 2017), nine days after cv. Hyola 433 (May 25, 2017), which showed the shorten cycle (129 days from emergence to maturity). Hyola 51 showed the longest flowering period, with 61 days on flower and also the longest cycle with 145 days from emergence to maturity. The use of chemical ripening 15 days before cut-windrowing affected canola yield and shorter periods between product application and harvest should be tested.

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