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Agronomic characteristics and oil content of different genotypes of canola (*Brassica napus* L. var. *oleifera*)

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The aim of this study was to evaluate the agronomic performance and oil content of 13 canola genotypes in Western Paraná, Brazil. The experiment was carried out, during the year of 2015, in the municipality of Marechal Cândido Rôndon in the west of the State of Paraná. A Randomized Complete Block Design (RCBD) was utilized with four replications. The genotypes of canola evaluated were Hyola 401, Hyola 76, Hyola 61, Hyola 433, Hyola 50, Hyola 571CL, Hyola 575CL, Hyola 474CL, Hyola 555TT, Hyola 656TT, Hyola 559TT, W8006, and H92002. Sowing was done in plots with four rows, spaced at 0.45 and 5 m in length, on May 8, 2015. The evaluated parameter were phenology, plant height, number of pods per plant, grains per pod, weight of thousand grains, grain yield and oil content. Significant differences were observed where the genotype of canola Hyola 401 and Hyola 559TT reached the physiological maturation in 129 days. No significant differences were observed in the variables analyzed by the Tukey test at 5% probability except the mass of thousand grains in which the Hyola 76 genotype performed better, with 4.11 grams. The average grain yield of tested genotypes was 1518.14 kg ha^{-1} and the average of grain oil content was 42.45%.

Key words: Adaptability, *Brassica napus,* grain yield, Hyola.

INTRODUCTION

Canola (*Brassica napus* L. var. *oleifera*) is an herbaceous plant belonging to the genus *Brassica*. Its origin is linked to the cultivation of oilseeds known as colza. *B. napus*, however, has genotypes with erucic acid content lower than 2% in oil, and less than 30 μmol of glucosinolates per gram of oil-free dry matter (Santos et al., 2001). It is a plant that produces grains with 24 to 27% protein and 34 to 40% oil.

Its bran contains 34 to 38% protein, similar to soy (Galdioli et al., 2002) and can be supplied to the animals, being an excellent protein supplement in the formulation of rations for sheep, cattle, pigs, birds and fish (Bell,

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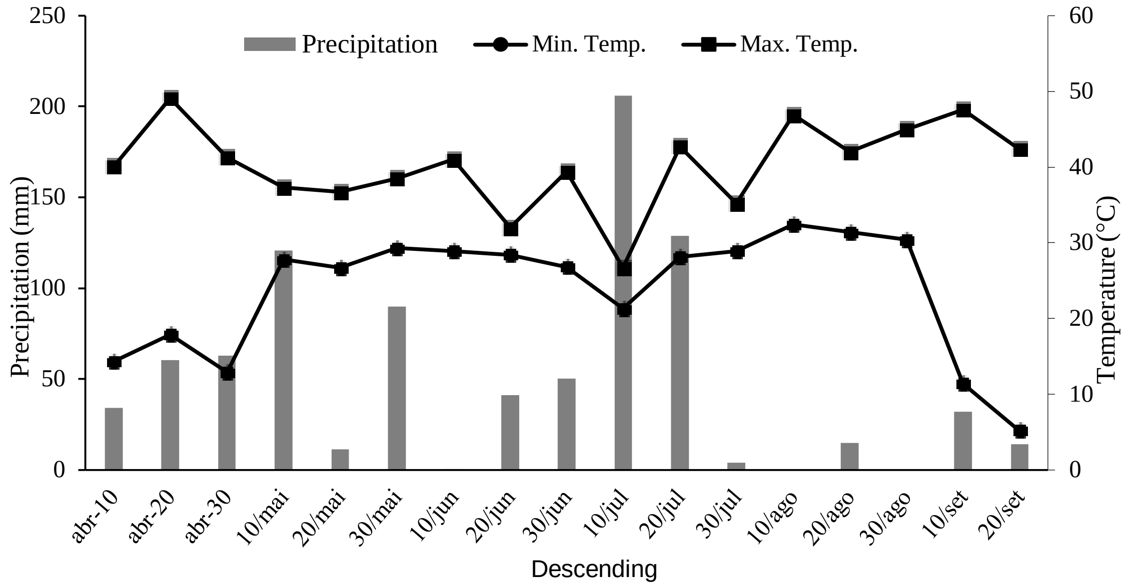

Figure 1. Descending meteorological data for the period from May to August 2015. Precipitation (mm), maximum temperature (Max Temp) and minimum temperature (Min Temp). Source: UNEMET climatological station / Marechal Candido Rondon / PR.

1993; Shurson and Sorrel, 1990). Worldwide, it is the third most produced oilseed and with adaptability characteristics to temperate climate. As for the soil, its best development occurs in frank, medium and high fertility soils and well drained (Tomm, 2000).

The cultivation of canola has great socio-economical value which gives the production of vegetable oils in winter, join the soybean production in summer, and thus, contributes to optimize the means of production (land, equipment and personnel) available. For being a crucifer contributes to the reduction of the occurrence of diseases in succeeding crops, as for example, the wheat sown in the following year, increasing the quality, productivity and minimizing costs (Tomm, 2000). This is due to the fact of not being hostess of the majority of diseases and pests that occur in species of grasses and legumes (Tomm et al., 2009).

In Brazil, the cultivation of canola are concentrated mainly in Rio Grande do Sul and Parana, totaling 44.7 thousand hectares with a production of 61.3 million tonnes (Conab, 2015). However, there is a great availability of land areas suitable for the cultivation of canola in Paraná state, with the possibility of significantly expands these numbers. The choice of more adapted genotypes could allow the increase of oil production for biodiesel formulation, human consumption and its bran destined to the formulation of animal rations.

For the selection of genotypes and/or cultivars, experiments have been conducted in different research centers, having as priority the selection of more productive genotypes in different environments (Coimbra et al., 2004). However, there is a need to broaden the research of the different genotypes, to evaluate the adaptation to new environments, in places where there is still no production tradition of this culture. With the development of the research, the crop recommendation has been particularized in each state, according to the characteristics of soil, climate, relief and altitude.

The objective of this work was to study the agronomic characteristics and oil content of 13 genotypes of canola in the environmental conditions of the West of Paraná.

MATERIALS AND METHODS

The study was conducted at the Experimental Farm "Professor Antonio Carlos dos Santos Person " (latitude 24° 33 ' 22' ' S and longitude 54° 03' 24 ' ' W , with an altitude of approximately 400 m) in the agricultural year 2015, at the Universidade Estadual do Oeste do Paraná - *Campus* Marechal Cândido Rondon in Eutrophic Red Latosol (LVe) (Bhering and Santos, 2008).

The local climate, classified according to Koppen, is Cfa, subtropical humid mesothermal dry winter with rainfall well distributed throughout the year and hot summers. For the average temperatures of the quarter, more cold vary between 17 and 18°C; the quarter more hot between 28 and 29°C, in its turn, the annual temperature ranged between 22 and 23°C. The total average annual precipitation normal pluvial for the region vary from 1600 to 1800 mm. For quarter, more humid presents the totals between 400 and 500 mm (IAPAR, 2002). The climate data of the experimental period were obtained in automatic climatological station of the University of Paraná, with approximately 100 m of the experimental area distance and are presented in Figure 1.

The soil of the experimental area was classified as LVe-1 Deep Eutrophic Red Latosol, with a clayey texture (Bhering and Santos, 2008). The soil was characterized by chemical and physical analysis, the layer of 0 to 10 and 11 to 20 cm of depth being vertically sampled, physically 6% sand, 4% silt and 89% clay by the

Boyoucos decimeter method.

The results of the soil chemical analysis showed mean values of: P = 32.32 mg dm^{-3}; K + = 0.51 $cmol_c.dm^{3}$; Al = 0.24 $cmol_c.dm^3$; pH in water = 5.43; M.W. = 23.06 g dm^{-3}; H + Al = 6.25 $cmol_c$ dm^{-3}; C.T.C. = 12.88 $cmol_c$ dm^{-3}; Al = 4.54%.

The experimental area was under the no-tillage system since 2009, under the succession oats/corn/oats/soybean. The soil acidity was corrected with application of 2.5 $tonne^{-1}$ of dolomitic limestone 30 days before sowing.

The experimental design was a randomized block design with four replications. The canola genotypes evaluated were Hyola 401, Hyola 76, Hyola 61, Hyola 433, Hyola 50CL, Hyola 571CL, Hyola 575CL, Hyola 474CL, Hyola 555TT, Hyola 656TT, Hyola 559TT, W8006 and H92002. The seeds were supplied by Embrapa Trigo.

Sowing of the genotypes was performed manually on April 8, 2015. The stand used was 33.3 seed per square meter. Weed control was performed with manual weeding. Fertilization was based on the interpretations of soil chemical analysis according to the recommendations suggested by EMBRAPA (Tomm et al., 2009).

At the sowing time, 200 kg ha^{-1} of the 10-20-20 formulation (N-P_2O_5-K_2O) applied in the planting line were used. 405 kg ha^{-1} of ammonium sulphate (21% N and 22% S) was applied in the B4 stage, when the plants had four true leaves, to meet the demands of nitrogen and sulfur.

The sowing periods were evaluated until the beginning of emergence, beginning of flowering, duration of flowering and period until harvest. Plant emergence was considered when plots consisted of 50% of emerged plants, the beginning of flowering when plots contained more than 50% of plants with at least one flower.

It was considered the end of flowering when no more flowers were observed in the plants. The date of maturation was considered when at least 50% of the silica had the seeds with the dark brown coloration.

Manual harvesting of canola plants from the experimental area was started on August 15 at the stage of physiological maturation. All plants of the area of each plot were harvested and counted when approximately 50% of the plants were in the G5 phenological stage, that is, they showed a change in the coloration of the grains from green to brown or black. The plants harvested were subjected to sun drying for 5 days.

Plant height was evaluated at the time of harvest, where it was measured from the soil surface to the apex of the plant using a graduated ruler and averaging ten plants of the useful area. The number of pods per plant was evaluated by removing randomly ten plants of the useful area in the phenological stage G5, where there was the count of pods in each plant. The number of grains per pod was determined randomly collecting four plants of useful area in the phenological stage G5, and randomly observed ten pods of each plant, removing three pods on top, four pods in the middle third and three pods from the bottom and quantifying the number of grains per pods. The determination of the weight of 1000 grains was performed according to methodology described in Rules for Seed Analysis (Brasil, 2009) where eight samples containing 100 seeds of each repetition were weighed with analytical balance precision and then calculate the average weight of thousand grains. To assess the productivity, the plants collected from the area of each plot were threshed manually and after removing the impurities. A profiler was used for moisture to standardize the moisture content of the grain and after certain productivity per hectare. The oil content of the seeds was determined in the Laboratory of Animal Nutrition of UNIOESTE. For such samples of uniform seeds were submitted to drying in an oven with forced air ventilation at 65°C for 48 h in order to standardize the moisture. After drying, the seeds were ground. Seed meal was packed in paper cartridges in the amount of 2 g per cartridge, in duplicate per experimental unit. The extraction adopted the methodology described by IUPAC (1979), using the Soxhlet system and petroleum ether extraction solvent, with extraction time of 6 h. After extraction the cartridges were kept in an oven at 60°C for 24 h for complete evaporation of the petroleum ether. The effects of treatments were compared by the F test and then analyzed through the comparison of means by the Scott Knott test (1974) at a nominal value of 5%. The analysis of variance and test of means were performed according to the usual techniques of SISVAR 5.3 software (Ferreira, 2011).

RESULTS AND DISCUSSION

In relation to sowing day until emergence (DAE) of canola, significant differences were observed ($p \leq 0.05$) where the genotype of canola Hyola 401 was the earliest (Table 1). The Hyola 401 is considered very premature in relation to its cycle. There were significant differences ($p \leq 0.05$), in relation to the beginning of flowering (IF) where Hyola 401 started flowering at 52 days after sowing (Table 1). Regarding the flowering days, significant differences were observed ($p \leq 0.05$), where the Hyola 401 genotype had 28 days to complete this cycle (Table 1). Genotypes Hyola 401, 50, 656TT and 559TT completed their cycle in 129 days.

Despite the high rates of flower abortion, flowering for long periods in canola is important for higher yields of grains (Iriarte and Valetti, 2008; Thomas, 2003; Tomm et al., 2009). The importance of the cycles of plant is rooted in that longer periods of flowering to compensate for any thermal conditions or adverse water fertilization of flowers or the formation of grains, when those conditions cease to affect the plant, so the knowledge of growth and development of cultures allows taking appropriate decisions of management.

Regarding plant height, Morceli (2014) evaluating canola genotypes in Campo Grande, MS, observed significant differences in plant height between the Hyola 61, 76 and 413 canola genotypes, in which Hyola 76 obtained higher plant height. However, in the present experiment, although no significant differences were observed, in absolute values, the genotype Hyola 76 obtained the highest plant height, with a mean of 151.76 cm (Table 2).

Ramos (2013), studying plant spacing and population with Hyola 61 hybrid canola, obtained the highest plant height of 119 cm. Turhan et al. (2011) observed that the sowing season was overdue and observed and plant height decreased, perhaps due to less light absorption.

The largest absolute number of pods per plant was observed in the cultivar Hyola 571 CL with an average of 228, and general average in the experiment of 194 pods (Table 2). The number of pods per plant is an important feature in the production components, being directly influenced by factors that affect the growth and branching of the plant, as well as by the climatic conditions during the flowering and beginning the formation of pods (Morcelli, 2014). According to Krüger et al. (2011), the number of pods per plant is a characteristic of quantitative inheritance, and in this way, it is governed by

Table 1. Duration of the subperiods, days until emergence (DUE), beginning of flowering (BOF), days of flowering (DOF) and harvest (HAR) of 13 canola genotypes in Marechal Candido Rondon in the 2015 harvest.

Genotype	DUE	BOF	DOF	HAR
Hyola 401	10[a]	52[a]	28[a]	129[a]
Hyola 76	12[b]	67[d]	40[d]	132[b]
Hyola 61	12[b]	58[c]	39[d]	132[b]
Hyola 433	12[b]	64[d]	43[e]	132[b]
Hyola 50	12[b]	60[c]	36[c]	129 [a]
Hyola 571CL	12[b]	61[c]	48[f]	132[b]
Hyola 575CL	12[b]	59[c]	42[e]	132[b]
Hyola 474CL	12[b]	59[c]	42[e]	136[d]
Hyola 555TT	12[b]	60[c]	37[d]	134[c]
Hyola 656TT	12[b]	58[c]	34[c]	129[a]
Hyola 559TT	12[b]	60[c]	29[b]	129[a]
W8006	16[d]	56[b]	53g	158[f]
H92002	13[c]	60[c]	49[f]	138[e]
Average	12.20	60.00	40.00	133.00
CV (%)	4.00	3.00	3.17	0.20

Means followed by at least one lowercase letter in the column do not differ from each other by the Scott Knott test (p≤0.05).

Table 2. Media for plant height (PH), number of pods per plant (NOP), number of grains per pods (NGP), weight of a thousand grains (WTG) of genotypes of canola in Marechal Cândido Rondon in the harvest of 2015.

Genotype	PH (cm)	NOP	NGP	WTG (g)
Hyola 401	140.85	216.42	18.55	3.46[b]
Hyola 76	151.67	166.71	18.85	4.11[a]
Hyola 61	148.27	193.49	19.40	3.55[b]
Hyola 433	144.92	201.72	16.75	3.26[b]
Hyola 50	146.40	183.54	20.57	3.50[b]
Hyola 571CL	141.35	227.71	19.47	4.01[a]
Hyola 575CL	145.67	186.05	16.80	3.76[a]
Hyola 474CL	137.75	182.77	17.07	3.70[a]
Hyola 555TT	135.02	172.38	16.85	2.97[b]
Hyola 656TT	138.07	207.47	16.02	3.52[b]
Hyola 559TT	149.62	193.15	19.22	3.89[a]
W8006	151.00	198.23	17.27	3.90[a]
H92002	137.20	196.22	18.52	3.80[a]
Average	143.67	194.13	17.90	3.63
F value	1.1[ns]	0.59[ns]	0.68[ns]	3.21*
CV (%)	7.47	22.6	14.20	9.65

Means followed by at least one lowercase letter in the column do not differ from each other by the Scott Knott test (p ≤0.05).

a large number of genes of small cumulative effect to the expression of the character and strongly responsive to changes in the environment.

Although canola presents high phenotypic plasticity, which is the ability of plants to alter their phenotypic expression, through morphological and physiological changes in response to environmental changes, there was no statistically significant difference in the number of grains per pods. In the present study the average number of grains per siliquas was 17.90.

Table 3. Media for productivity (PRO) and oil content (OC) of genotypes of canola in Marechal Cândido Rondon in the harvest of 2015.

Genotype	Productivity (kg ha^{-1})	Oil content (%)
Hyola 401	1755.00	41.89
Hyola 76	1531.87	45.94
Hyola 61	1413.12	42.27
Hyola 433	1358.12	43.59
Hyola 50	1511.87	42.46
Hyola 571CL	1565.62	40.03
Hyola 575CL	1456.62	42.70
Hyola 474CL	1600.00	41.91
Hyola 555TT	1664.37	40.80
Hyola 656TT	1697.50	41.35
Hyola 559TT	1483.12	44.54
W8006	1213.00	44.17
H92002	1485.62	40.25
Average	1518.14	42.45
F value	0.71^{ns}	1.64^{ns}
CV (%)	22.73	6.38

Means followed by at least one lowercase letter in the column do not differ from each other by the Scott Knott test ($p \leq 0.05$).

With respect to weight of 1000 grains, significant differences ($p \leq 0.05$) were observed between the evaluated genotypes (Table 2) where the Hyola 76, Hyola 571CL, Hyola 575CL, Hyola 474CL, Hyola 559TT, W8006 and H92002 obtained the largest mass in grams in relation to the other genotypes studied. Krüger et al. (2011) found that there may be variation in mass of grains, depending on the genotype used and depending on a lesser extent of the environmental conditions of the remaining components of production.

The genotype of canola Hyola 401 presented the highest grain yield among all evaluated with averages of 1755 kg ha^{-1} (Table 3). The average yield of different genotypes was 1518.14 kg ha^{-1}, lower when compared with Brazilian production values of 1728 kg ha^{-1} CONAB (2015). The grain yield in canola is the result of the following components of production: number of plants per square meter, number of pods per plant, number of seeds per pod and average mass of grain (Thomas, 2003). These components are dependent on the genotypes and the climatic conditions. Cycle of canola presented deficit in grain filling and end of cycle, causing losses in yield of grains in the genotypes of the long cycle, favoring the performance of genotypes of short cycle, as verified by Tomm et al. (2003) in the city of Maringa. Rathke et al. (2006) argue that the canola has a high phenotypic plasticity to a large number of variables, but that this plasticity has limited effect on productivity. Cheema et al. (2010) reported that the grain yield of canola is determined mainly by the components number of pods per plant and weight of 1000 grains.

The genotypes did not differ statistically among themselves regarding the content of oil ($p \geq 0.05$) ranging from 40 to 46%. All the evaluated genotypes obtained oil higher to those described in the literature for canola between 34 and 38% (Canola Council of Canada, 1999). Morcelli (2014), observed statistical differences for the oil content in grains; for canola oil, genotype Hyola 411 obtained 38% of the oil. The oil content in grains may vary as a function of climatic factors and nutritional disorders despite being a genetic characteristic of the genotype or species (Morcelli, 2014).

Conclusions

There were no significant differences of the genotypes for the agronomic characteristics and the oil content of the canola in the studied conditions, except for the mass of a thousand grains. Canola genotypes Hyola 401, Hyola 50, Hyola 656TT and Hyola 559TT showed the shortest cycle, with 129 days. The best yield was obtained with the Hyola 401 canola genotype, with an average of 1755 kg ha^{-1} of grains. Genotype Hyola 76 had the highest oil content, approximately 46% oil in the grains.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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