academicJournals

Vol. 9(32), pp. 2488-2494, 7 August, 2014
DOI: 10.5897/AJAR2014.8876
Article Number: 975D15B46484
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Evaluation of some hybrids of canola in function of sowing dates in Viçosa, MG, Brazil

Luís Eduardo Panozzo[1]*, Jacson Zuchi[2], Fred Denilson da Silva[3], Luciana Barros Pinto[1], Denise Cunha Fernandes dos Santos Dias[3], Willian Silva Barros[1] and Gilberto Omar Tomm[4]

[1]Department of Statistics, Federal University of Pelotas, CEP: 96.160-000, Pelotas, RS - Brazil.
[2]Breeding Section, FEPAGRO, CEP: 95.200-970, Vacaria, RS - Brazil.
[3]Seed Science and Technology Department, Federal University of Viçosa, CEP: 36.571-000, Viçosa, MG - Brazil.
[4]Agriculture Section, EMBRAPA, CEP: 99.001-970, Passo Fundo, RS - Brazil.

Received 27 May, 2014; Accepted 26 June, 2014

The canola constitutes an excellent option for cultivation in winter in Brazil, besides being an alternative for the production of biodiesel. The aim of this study was to evaluate the phenological characteristics of hybrid canola sown at different dates in Viçosa, MG. The experiment was conducted in the experimental area of Horta Velha, belonging to the Federal University of Viçosa (UFV). Seeds of four hybrids of canola: Hyola 432, 433, 401 and 61 were used. From 26 May, 2009 was held the first sowing date and the other every 15 days, a total of four sowing dates. Seedling emergence (%), duration of the vegetative phase (days), duration of flowering stage (days), number of days to the end of flowering, number of days from emergence to maturity (total cycle), bedding plants (%) and disease reaction (%) were evaluated. The experimental design was a randomized block in factorial arrangement with four replications. Data were subjected to analysis of variance and means were compared by Tukey test ($p<0.01$). The results showed that Viçosa (MG) have promising characteristics for growing canola. The most suitable time for sowing canola corresponds to the month of May. Hyola 61 is the hybrid that, presents faster seedling emergence and uniform, is the material that showed greater adaptation to the region of Viçosa, based on all traits, regardless of sowing dates. The delay of sowing decreased the duration of the vegetative and reproductive phases, the days to the end of flowering and duration of emergence to maturity (total cycle) for all hybrids. Variables lodging and disease reaction of canola plants were not affected by local conditions and factors considered in this experiment.

Key words: *Brassica napus* L., development cycle, phenology, management, tropicalization, adaptability, Viçosa (MG).

INTRODUCTION

The canola crop (*Brassica napus* L. var. Oleifera Moench.) in Brazil has been assuming a role for importance of its products, mainly for human consumption and agro-energetic purposes, due to its oil quality, and high levels of protein in bran and its derivatives. Brazilian research on this crop beginning in

*Corresponding author. E-mail: lepanozzo@gmail.com

1974 with varieties obtained from the breeding of rapeseed (Marchiori et al., 2002; Figueiredo et al., 2003).

The commercial cultivation of canola in the world is concentrated in regions with temperate latitudes between 35 to 55°; it is a plant adapted to cold regions (Tomm et al., 2008; Mcclinchey and Kott, 2008). In Brazil, these thermal conditions are found mostly in the south during the fall, winter and early spring, corresponding to the period of the year when canola is grown in these regions (Dalmago et al., 2010). However, there are several studies reporting that this culture has the potential for your tropicalization, or for growing in warmer climates, such as Brazilian Northeast, for both diversification and crop rotation (Souza et al., 2008, 2010).

In regions with tropical or subtropical climate, environmental factors have a great influence on the phenological development of plants, mainly due to the availability of solar radiation. Phenology can be defined as the study of periodic events of the plant cycle depending on their response to environmental conditions such as light, temperature, humidity and other (De Fina and Ravelo, 1973). Through knowledge of phenological stages, we can obtain more details of the development cycle of plants, since many times the elapsed time between two distinct phases can be quite variable depending on the environmental conditions (Bergamaschi, 2012).

Among the applications of phenology, are the possibility of subdividing the cycle, determining requirements eco-climatic and critical periods, classification of precocious cultivars, the development of agricultural zoning and proper management of crops, such as the determination of irrigation and in other cultural practices, such as in pest management and fertilizer applications (Bergamaschi, 2012). Furthermore, the prediction of the growth stages of the

plants helps in the planning of the most suitable sowing times in studies of adaptation of new materials under different environments (Matzenauer, 1997), providing better choice, planning and development of crops.

Studies indicate that the best sowing times for crop canola in southern RS is between May 15 and June 15 and between August 15 and September 15 (Dias, 1992), and the north between April 14 and 20 June (Tomm, 2007). However, canola has a higher potential yield when sown in mid-April, where your income potential decreases each day of delay in sowing after this season (Tomm, 2007).

The air temperature is one of the most important environmental variables in regulating the growth and development of canola (Thomas, 2003; Light et al., 2012), as there is a minimum temperature below which plants interrupt their physiological activities, a track satisfactory temperature suitable for its development and an effective maximum temperature above which the respiratory rate exceeds the production of photo-assimilates (Barbano et al., 2001). For canola, the optimal temperature for its full development is about 20°C, with extreme limits between 12 and 30°C (Robertson et al., 2002; Thomas, 2003).

Studies report that for their growth and development, canola requires cold weather, high brightness and at least 500 mm of water during itself cycle (Tomm, 2006). Also, it can be grown in various soil types, except in waterlogged soils, but its best development occurs on loamy soils, medium and high fertility and well drained (Tomm, 2000).

The genetic and physiological quality of the seeds of canola hybrids available for planting also has great importance for the improvement and adaptation of culture in new regions. The seeds of canola hybrids available in the Brazilian market are certified and mostly imported, so, with high yield, they are produced under management and provide favorable conditions for disease-free seed, avoiding the introduction of pathogen inoculum, beyond its high physiological quality, which avoids the need to re-sow crops and delay the next crop, but also enables an emergency vigorous and uniform, reducing the losses caused by desuniform maturation (Tomm, 2007).

The canola due to these features shows with great potential to become an option for the Zona da Mata of Minas Gerais and other regions. In this context, in order to generate information to support the choice of hybrid canola that most adapted the conditions of Viçosa, the aim of this work was to define the phenological periods of four hybrids of canola sown at different dates, in addition to quantifying and establishing parameters to help in the management of the cultivation of this crop under the environmental conditions of Viçosa.

MATERIALS AND METHODS

This research was accomplished in the year 2009 in the experimental area of Horta Velha, belonging to the Federal University of Viçosa (UFV), located in Viçosa, MG. Viçosa is located at latitude 20°75'S, longitude 42°85'W and with an elevation of 690 m (INMET, 2012). Climatic data daily precipitation and maximum temperature, average and minimum daily, for the duration of the test, were collected daily with the help of a weather station located at a distance of 10 m from the experiment (Figure 1).

The soil of the experimental area was prepared with plowing, disking and rotary hoe operation, to reduce the presence of lumps and impediments to emergency. For chemical analysis, soil was collected from seven points (single sample) to form the composite sample in advance of 30 days of culture. The basic fertilizer coverage was performed according to the chemical analysis of the soil and the technical recommendations for culture, performing the correct levels of the nutrients nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) at the base, and also placed 120 kg of nitrogen in the form of urea, when the canola plants had four leaves (Tomm, 2007).

The seeds were sown in four seasons spaced from 15 to 15 days, and the first season sown on 05/26/2009 and the other on 06/10/2009, 06/25/2009 and 07/10/2009 of the same year. Around 50% more seeds amount were used than that indicated by the literature, seeking suitable seedling establishment. Two weeks after seedling emergence, thinning was carried out for the establishment of a population of 40 plants m^{-2} (Tomm, 2007).

The experiment consisted of sixteen treatments involving two

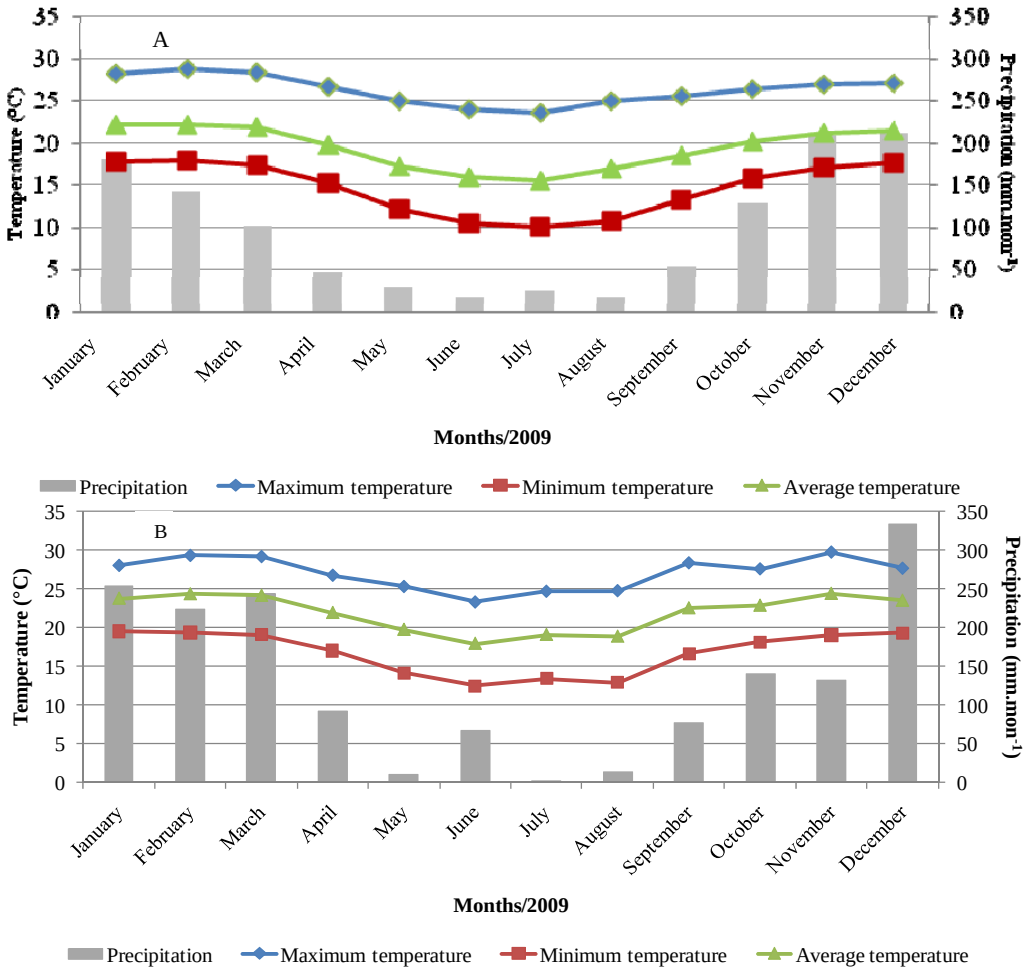

Figure 1. Data about precipitation and maximum temperature, average and minimum climatological normal of Viçosa (A) and a meteorological station located in the area experience the Horta Velha (B) in Viçosa-MG in 2009.

factors: Factor A - 4 sowing dates (05/26/2009, 06/10/2009, 06/25/2009 and 07/10/2009) and factor B - 4 commercial hybrids canola (Hyola 432, Hyola 433, Hyola 401 and Hyola 61). The experimental design was a randomized block factorial (4x4), with four replications. Each plot consisted of 17 rows, 3 m long and 2.89 m wide, spaced at 17 cm between rows, with two lines serving each end of edging.

Cultivation techniques and pest control were carried out according to the recommendation for the crop (Tomm, 2007). Applications of the insecticide Decis 25 EC (Deltamethrin - pyrethroid group) at doses of 160 and 300 ml ha^{-1}, were used for controlling kitty (*Diabrotica speciosa*), after emergence, and green peach aphid (*Myzus persicae*) in early flowering, respectively. Weeds that emerged during the development of culture were controlled by hand weeding. Sprinkler irrigations were performed whenever necessary throughout the development of culture.

Phenological observations were made based on criteria adopted in Canada and Australia (Tomm et al., 2007), according to the following definitions:

Emergence of seedlings: Period (days) required for 50% of the seedlings plot that emerged.

Length of the vegetative phase: Period (days) between emergence and one in which 50% of plants showing at least one flower.

Duration of flowering stage (flowering): Period (days) between the onset of flowering until no more flowers remained, except in atypical plants.

Days to the end of flowering: Period (days) obtained by the sum of the duration of the vegetative phase to the reproductive.

Cycle total: Period (days) between seedling emergence and harvest, which was performed when at least 50% of pods located in the middle third of the main raceme plants had seeds with dark-brown characterizing its physiological maturity (MF).

Lodging: was determined by assigning a scale to all plants in each plot, ranging from 1 to 9, considering the fractional parts as described below: 1 = 100% of lodged plants and 9 = 100% of plants erect; and.

Reaction to disease: was determined by assigning a rating scale to all plants in each plot, ranging from 1 to 9, whereas the fractional parts as described below: 1 = 100% dead plants and 9 = 100% disease free plants.

Table 1. Number of days to seedling emergence due to canola hybrids and sowing dates. Viçosa / MG, UFV (2009).

Hybrids	Sowing dates			
	05/26/2009	06/10/2009	06/25/2009	07/10/2009
Hyola 432	6^{Ba}	6^{Ba}	7^{Aa}	7^{Aa}
Hyola 433	6^{Ba}	6^{Ba}	7^{Aa}	7^{Aa}
Hyola 401	6^{Ba}	6^{Ba}	7^{Aa}	7^{Aa}
Hyola 61	5^{Ab}	5^{Ab}	5^{Ab}	5^{Ab}
C.V. (%) 1.0				

Means with the same uppercase letter in the same row and lowercase letter in the column do not differ significantly by Tukey test ($p \leq 0.01$).

Table 2. Duration (days) of the vegetative phase of canola plants due to hybrids and sowing dates. Viçosa / MG, UFV (2009).

Hybrids	Sowing dates			
	05/26/2009	06/10/2009	06/25/2009	07/10/2009
Hyola 432	55^{Bc}	60^{Ab}	48^{Cb}	54^{Bb}
Hyola 433	51^{Ab}	49^{Bc}	47^{Cb}	52^{Ac}
Hyola 401	59^{Aa}	48^{Bc}	45^{Cc}	49^{Bd}
Hyola 61	59^{Ba}	65^{Aa}	56^{Ca}	60^{Ba}
C.V. (%) 1.6				

Means with the same uppercase letter in the same row and lowercase letter in the column do not differ significantly by Tukey test ($p \leq 0.01$).

Statistical design

Data were subjected to analysis of variance and the means when significant, were compared by Tukey test at 1% probability. Data processing was performed with SAS software (Delwiche and Slaughter, 2003).

RESULTS AND DISCUSSION

There was significant interaction between hybrids and planting dates for variable seedling emergence in the field (Table 1). It can be observed that for all times of sowing, seedlings of the hybrid Hyola 61 emerged in five days after sowing, resulting in an emergency faster than the other genotypes.

In comparing each hybrid between sowing times, it was noted that for the first two seasons (05/26/2009 and 06/10/2009), the emergence for all hybrids was faster than the past two seasons (06/25/2009 and 07/10/2009) (Table 1). Similar results were found for different genotypes of canola in Rio Grande do Sul (RS), where the interaction of sowing dates with genotypes resulted in emergency 7-day average (Tomm et al., 2003). These authors reported that the emergency time is not a factor of agronomic relevance, due to the small variation among genotypes. However, it is noteworthy that this small variation occurs when using lots with similar levels of force. This variable can be considered an indicator of seed vigor, because, in general, vigorous seeds for other crops, have greater capacity remobilizing reserves for the embryo, enabling faster emergency and greater initial seedling growth (Schuch et al., 1999, 2000; Argenta et al., 2001; Vanzolini and Carvalho, 2002; Hofs et al., 2004; Scheeren et al., 2010), which can result in greater leaf area, dry matter accumulation (Schuch et al., 2009) and productivity (Panozzo et al., 2009).

For variable duration of the vegetative phase of hybrid canola, significant interaction was observed among treatments (Table 2). For all hybrids, there was a reduction in the duration of the vegetative stage when the seeds were sown in the third season (06/25/2009). With delay in sowing, it is found that the hybrid Hyola 401 showed a decrease of 12 days in the duration of the vegetative stage for the last three seasons (06/10/2009, 06/25/2009 and 07/10/2009) compared to the first sowing date (05/26). This fact may be explained as the fact that it is the most sensitive to high temperatures compared to other hybrids (Figure 1 and Table 2). The greater availability of thermal conditions influences directly the canola crop cycle, where local or warmer periods accelerate its development due to thermal (Kerber et al., 2009; Light et al., 2012), because the materials canola grown in Brazil has low sensitivity to photoperiod and greater response to air temperature (thermal) (Kerber et al., 2009). In this regard, Light et al. (2012) concluded that there is a negative linear relationship between the air

Table 3. Duration of reproductive stage (flowering, days) of canola plants due to hybrids and sowing dates. Viçosa/MG, UFV (2009).

Hybrids	Sowing dates			
	05/26/2009	06/10/2009	06/25/2009	07/10/2009
Hyola 432	36^{Ab}	26^{Cd}	26^{Cb}	27^{Bb}
Hyola 433	36^{Ab}	34^{Ba}	26^{Db}	27^{Cb}
Hyola 401	37^{Aa}	33^{Bb}	27Da	29^{Ca}
Hyola 61	36^{Ab}	28^{Cc}	27Da	29^{Ba}
C.V. (%) 1.0				

Means with the same uppercase letter in the same row and lowercase letter in the column do not differ significantly by Tukey test ($p \leq 0.01$).

Table 4. Days to the end of flowering in canola plants due to hybrids and sowing dates. Viçosa / MG, UFV (2009).

Hybrids	Sowing dates			
	05/26/2009	06/10/2009	06/25/2009	07/10/2009
Hyola 432	91^{Ab}	86^{Bb}	74^{Db}	81^{Cb}
Hyola 433	87^{Ac}	83^{Bc}	72^{Dc}	79^{Cc}
Hyola 401	96^{Aa}	81^{Bd}	72^{Dc}	78^{Cc}
Hyola 61	95^{Aa}	93^{Ba}	83Da	89^{Ca}
C.V. (%) 2.53				

Means with the same uppercase letter in the same row and lowercase letter in the column do not differ significantly by Tukey test ($p \leq 0.01$).

temperature and duration of phenological phases for hybrid canola Hyola 61 and 433.

When comparing hybrids within each sowing date, it appears there was longer vegetative stage to Hyola 61, regardless of sowing date (Table 2). In general, for the last three seasons (06/10/2009, 06/25/2009 and 07/10/2009) sowing, hybrids Hyola 433 and 401 had the lowest durations vegetative phase within each sowing date. The vegetative growth stage of the plants ranged from 65 to 45 days, an amplitude corresponding to 20 days, however, changes in plant development due to this amplitude was not observed. In the same way, Tomm et al. (2008) reported that these same hybrids when planted in the Brazilian Northeast presented a variation of the vegetative cycle 37 and 55 days, range 18 days; this period was considered sufficient for proper plant development before the reproductive stage.

The duration of the reproductive phase (flowering) plants was significantly affected by canola hybrids and by the different sowing dates (Table 3). It can be observed that the delay of sowing decreases the time of flowering from eight days to an average of the last three times in relation to the first, regardless of the sown hybrid. It was observed that for the first sowing date (05/26/2009) the duration of the reproductive stage (flowering period) was on average 36 days, varying only one day among the genotypes tested. This same period was also observed in a study with 15 genotypes of canola in the state of Paraná (Tomm et al., 2003).

In general, for all seeding seasons Hyola 401 hybrid had the highest duration of reproductive stage compared to the other materials (Table 3). The hybrid Hyola 432 was the material with the lowest reproductive period length and the material most affected especially in the second sowing date (06/10/2009) compared to the others. Moreover, some plants that suffer heat stress for some period of time showed an increase in the rate of flowering, besides a prolongation of the flowering period (Cross et al., 2003).

A significant interaction between hybrids and planting dates for variable end of flowering canola plants was observed (Table 4). Similar to what happened with the variable duration of the flowering period, the delay of sowing interfered in decreasing the total time to the end of flowering from emergence. For all hybrids, it can be seen that there was an effect of the treatments where the average of the last three sowing dates (06/10/2009, 06/25/2009 and 07/10/2009) was a decrease of 11 days for this variable, comparing with the first sowing date (05/26/2009) (Table 4).

The hybrid Hyola 61 again showed lower treatment effect compared to other hybrids, because it got a lower range for this variable between sowing dates, 7 days difference between the first season and the average of

Table 5. Cycle of the crop of canola due to hybrids and sowing dates. Viçosa / MG, UFV (2009).

Hybrids	Sowing dates			
	05/26/2009	06/10/2009	06/25/2009	07/10/2009
Hyola 432	110^{Aa}	107^{Bb}	95^{Dc}	101^{Cb}
Hyola 433	104^{Ab}	104^{Ac}	96^{Dbc}	99^{Bc}
Hyola 401	109^{Aa}	104^{Bc}	97^{Cb}	95^{Dd}
Hyola 61	109^{Aa}	110^{Aa}	106^{Ba}	107^{Ba}
C.V. (%) 1.93				

Means with the same uppercase letter in the same row and lowercase letter in the column do not differ significantly by Tukey test ($p \leq 0.01$).

the other seasons (Table 4). This same material showed significantly higher values for the variable, days to the end of flowering, in all sowing dates. In general, hybrids 433 and 401 for all sowing dates had lower durations of this variable. As had happened with the duration of the cycle (Table 2), the material Hyola 401 was the hybrid with the highest reduction of the first sowing date compared to other seasons.

The cycle of the crop of canola showed significant interaction between different hybrids tested sowing dates (Table 5). Comparing the sowing dates for all hybrids in general, it was observed that there was a reduction of the cycle in the last two seasons (06/25/2009 and 07/10/2009) compared to the first two (05/26/2009, 06/10/2009), giving an average difference of around 8 days. In general, smaller cycles were observed for hybrid Hyola 433 and 401. Similar results were found for these two same hybrids in a study conducted in the state of Paraíba, where development cycles of 92 and 90 days, were observed respectively (Tomm et al., 2008). In the same vein, studies have concluded that delay in sowing causes significant reduction in total cycle of hybrid canola Hyola 433 and 61, as both materials experienced decrease in cycle from 162 to 100 days (Light et al., 2012).

As for all other variables, the Hyola 61 was the hybrid that had the less influence by sowing time, presenting a range of variation in the cycle, a maximum of four days between the second and third sowing date may be considered, therefore, as the material with greater genetic stability.

There was no significant difference between treatments in bedding plants and in the reaction of plants to diseases. The absence of bedding plants can be explained by the nutritional status of the plants and suitability for local weather conditions, where there was no incidence of high winds. It was found that practically no disease incidence was observed in the plants of all tested hybrids, which can be explained by the fact that it is the first crop, rapeseed in place. Important though, was the presence of other cultures of the same genus (*Brassica* spp.) where the experiment was conducted. Therefore, even if there may be some initial inoculum source of diseases, it can be seen that the hybrid canola tested had adequate tolerance to potential pathogens from the environment. Tomm et al. (2008) did not observe the occurrence of diseases in farming with hybrid canola in the northeast region of the country, claiming that there were unfavorable climatic conditions to the development of pathogens.

Conclusions

The results showed that Viçosa (MG) have promising characteristics for growing canola. The most suitable time for sowing canola corresponds to the month of May. Hyola 61 is the hybrid that presents faster seedling emergence and uniform, and it is the material that showed greater adaptation to the region of Viçosa, based on all traits evaluated, regardless of sowing dates. The delay in sowing decreased the duration of the vegetative and reproductive phases, days to the end of flowering and duration of emergence to maturity (full cycle) for all hybrids. Variables lodging and reaction to disease canola plants were not affected by local conditions and factors considered in this experiment.

Conflict of Interest

The author(s) have not declared any conflict of interest.

ACKNOWLEDGMENTS

The authors are grateful to CNPq - Conselho Nacional de Desenvolvimento Científico e Tecnológico for scholarship granted and financial support; and also to the Federal University of Viçosa, for assistance during this research.

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