

Physiological Indices, Phenological Characteristics and Trait Evaluation of Canola Genotypes Response to Different Planting Dates

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Abstract To manage planting date based on optimal compatibility to the environmental condition a split plot experiment based Randomized Complete Block Design with three replications was carried out. Four planting dates (November 6th and 21st, December 6th and 21st) in main plots and four genotypes (Hyola401, PP401, RGS003 and Option500) in subplots were studied. According to analysis of variance results, grain yield, yield components and biological yield were significantly affected by planting date, genotypes and interaction effect. The first planting date (November 6th) had maximum grain yield (2611.6 t ha^{-1}) and after it another planting date showed decrease in amount (13.74, 31.36 and 41.97 % respectively). First planting date was superior in physiological index as compared to the other planting dates. Hyola401 hybrid, due to the fact that it had a higher leaf area index (3.51), total dry matter (1248.91 g m^{-2}), crop growth rate ($21 \text{ g m}^{-2} \text{ day}^{-1}$), net assimilation rate ($7 \text{ g m}^{-2} \text{ day}^{-1}$), relative growth rate ($0.064 \text{ g g}^{-1} \text{ day}^{-1}$) and maximum grain yield, was seen to be the most adaptable genotype. Hyola401 hybrid at first planting date germinated in shortest time (5.8 day) had the highest flowering duration (24.0 day) and long days to ripening (154.0 day). Finally

according to the results of the present work, sowing of Hyola401 hybrid on 6th November was recommended as suitable planting date.

Keywords Phenology · Physiological indexes · Rapeseed · Sowing date · Yield

Introduction

Canola is a valuable oil seed that has attracted the attention of many people in recent years. This plant has been given a great importance in the plan for oil seed import reduction. The canola plant, on account of enjoying high percentage of oil and protein, was ranked third and second, respectively among oil seeds. This plant grows annually in the favorable weather conditions. The meal and oil are two products extracted from this plant. The canola seed contains 40–50 % oil [1]. Canola oil contains a desirable profile of saturated fatty acids (7 %) and high level of unsaturated fatty oleic acids (about 61 %) and medium level of unsaturated fatty linoleic acids (21 %) and linolenic acid (11 %) [2]. The average yield of oil crops in Iran is 245,000 ton (area harvested 521,000 ha), whereas the world average yield of oil crops is 261,099,000 tons (area harvested 157,382,000 ha) as stated by FAO [3].

Canola cultivars appear to be best adapted to the conditions of Iran; however, some cultivars are less tolerant to environmental conditions [4]. Knowing the relationship among these processes and investigating other quantitative traits make breeding programs and their success more optimistic and secure [5]. Seed yield is a quantitative trait, which is the expression of the result of genotype, environmental effect and genotype-environment interaction [6–9]. Assessment of relationship using correlation

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coefficient analyses help breeders to distinguish significant relation between traits. Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield, as well as to examine direct and indirect contributions to yield variables [10, 11]. Emphasis has been given on the importance of 1000-seed weight and number of seed/plant as efficient indirect selection criteria for genetic improvement of seed yield in canola cultivars [12]. It has been reported that there is a positive and significant correlation between crop height traits, grains per silique and 1000-grain weight with grain yield [13]. Early spring sowing of oil canola delayed flowering and reduced reflection of radiation during flowering which were important factors leading to the high yield achieved by late sowing. Effect of sowing dates on yield, yield components and quality was studied by many investigators [14, 15], who reported that the early sowing increases oil yield and oil percentage. According to the results about average yield in dry regions, Hyola308, Hyola401, Pf 7045.91 and Taporo varieties, with yield of 2996, 2783, 2231, and 2191 kg ha⁻¹, respectively were superior over other genotypes hence advised to be planted in dry climate of southwest regions [16]. The early maturing varieties with high potentiality have higher yield as compared with serotinal varieties [7, 17]. Delayed planting, inappropriate weather conditions during the flowering period, fertilization and silique formation can cause a decrease in duration of maturity period, affect the number of siliques per plant, the number and weight of grains and finally can lead to decrease in grain yield [2]. Delayed planting causes a decrease in period from planting time to flowering or maturity. Therefore, the decrease in yield, which occurs because of planting delay, is basically a result of decrease of biomass during the maturity period. In order to choose a genotype, it is needed to determine adaptability of a genotype for each region [18]. Because planting date in comparison with other agronomic factors has more influence on phenologic and physiologic characteristics of the plant, determining a proper planting date makes the maximum coordination between plant growth process and climatic conditions [19–21]. It was found that highest yield of canola was observed from earlier sowings [22]. A number of studies have shown yield decline in canola with delay in sowing [23]. Ideal sowing date for one or more varieties allows for availability of a set of environmental factors that favor a desirable greening, establishment and survival of the plantlet, as the result the plant encounters favorable environmental conditions and avoids unfavorable ones during each stage of its growth [24].

Studies have shown that low and high temperatures during flowering stage are the main factors decreasing grain crops through inoculating pollens [25]. Some workers argued that high yield production in canola follows a long

silique development and flowering period under low daily mean temperature [26]. The experiment conducted by Mendham et al. revealed that delayed sowing accelerates growth and decreases day number from sowing to flowering by 50 % [27]. Delayed sowing led to decreased day number to flowering and maturity as well as grain yield [28]. Late sowing of canola led to decreased grain yield and decreased growth [29]. Every 2 weeks of delay in canola sowing resulted in decrease of roughly 1.1 % oil and of 309 kg ha⁻¹ grain yield [30]. Delayed sowing shortened the time to flowering and maturity by 50 % [31]. Growth analysis is a precious method which was first conducted in quantitative growth analysis of plants and their yield [32]. Plant growth analysis is considered to be a standard approach to study of plant growth and productivity [33]. Growth and yield are functions of a large number of metabolic processes, which are affected by environmental and genetic factors. Studies of growth pattern and its understanding not only tell us how plant accumulates dry matter, but also reveals the events which can make a plant more or less productive singly or in population. In a crop the growth parameters like optimum LAI and CGR at flowering have been identified as the major determinants of yield [34]. A combination of these growth parameters explain different yields better than any individual growth variable [35]. CGR, RGR and NAR directly influence the economic yield of lentil. Dry matter production, LAI, LAD, CGR, NAR and RGR are ultimately reflected in higher grain yield [36]. Crop growth rate (CGR) is slow at early growth stages because the plant cover is incomplete and the plants absorb just a part of the solar radiation. As the plants develop, their growth rate is quickly increased because of the expansion of leaf area and the penetration of less radiation through plant cover to the soil surface. Maximum CGR (the steepest slope in total biomass variations graph) is realized when the plants are tall and dense enough to be able to maximally utilize all environmental parameters. The ecological advantage of high RGR is very clear. Due to high RGR, a plant will rapidly increase in size and is able to occupy a large space, both below and above ground. A high RGR may also facilitate rapid completion of life cycle of a plant [37]. The seed yield, total dry matter and harvest index in some genotype of *Brassica napus* and *Brassica juncea* has been found to improve with higher rate of N [38, 39]. LAI was recorded more during linear growth stage and during flowering stage. During grain filling stage, there was decrease in leaf area and consequently in LAI [40]. Crop growth rate, net assimilation rate and leaf area index in inadaptable or serotinal genotypes (mainly in low tension conditions), are lower than early maturity genotypes. Due to the fact that the amount of photosynthesis is enhanced by an increase in daily photosynthesis time or

by an increase in leaf area duration in grain filling period. Early maturing varieties with high-potentiality have more proper yield as compared with serotinal varieties [41, 42]. Increase in CGR and dry-matter accumulation irrespective to decrease in LAI in the corresponding phase is more likely because of the new actively photosynthesizing tissues of siliques which might be responsible for increase in dry weight as well as CGR during these phases [43]. This research was conducted to study the phenological, physiological characteristics and to analyze the correlation between seed yield and related traits of canola genotypes in different planting dates to determine most suitable planting date according to the climatic condition to achieve best yield.

Material and Methods

The experiment was carried out in Randomized Complete Block Designs (CRBD) with three replications at experimental field of Khouzestan Agricultural Research and Natural Recourses Organization in south west Iran with moderate winters and hot summers (32°20'N, 40°20'E and altitude 22.5 m). Planting dates were (November 6th and 21st, December 6th and 21st) in the main plots and the subplots were with four genotypes [Hyola401 (Hybrid), PP401 (Cultivar), RGS003 (Cultivar) and Option500 (Cultivar)]. The texture of the soil in this region was silty clay loam; electrical conductivity of condensed saturation was 3.5 dsm⁻¹ and soil pH was 7.3. The average annual precipitation was 248 mm, long-term daily temperature (in 30 years) was 24–45 °C, the average precipitation in agronomic year was 68–136 mm and the average temperature of the agronomic year was 20 °C. Each plot was 6 m long consisting of 8 rows with 30 cm distance from each other. The average distance between plants was considered to be 3 to 4 cm. Use of fertilizers was according to the information gained about the soil. The land was manured by using 50 kg ha⁻¹ nitrogen, 46 kg ha⁻¹ phosphate, 104 kg ha⁻¹ potassium and 36 kg ha⁻¹ sulfate as the basic component. During the growth period 100 kg ha⁻¹ nitrogen fertilizer was utilized. In order to determine the growth process from January 1st to April 4th, samples were collected seven times with an interval of two weeks. In each sampling, the leaf layer index and total dry weight were estimated in plots. Daily growth degree was calculated by the following formula [44]:

$$\sum GDD = \sum_{j=1}^n [(T_{\max} + T_{\min})/2] - T_b \quad (1)$$

where GDD is growing degree days,

T_{\max} is maximum daily temperature, T_{\min} is minimum daily temperature, T_b is the basic temperature and n is the number of days in a particular period.

The basic temperature during the experiment was +5 °C [16, 45]. In order to determine grain yield components during physiologic maturity, 10 plants were chosen randomly from each plot and the traits of siliques per plant, the number of grain per silique and 1000 grain weight were assessed in them. In the final harvest, from each (one-squared meter land) plot, grain and biological yields were calculated. Data analysis was performed by the SAS (Ver. 8) software and average comparisons were fulfilled according to Duncan multiple rang test at 5 % probability. All of the charts were drawn by Excel 2003 software.

Results and Discussion

Physiological Indices

Total Dry Matter

The data presented in Fig. 1 showed that the plant growth was slow during early growth period till January in all genotypes, and maximum dry weight in the plants was because of the increase in the weight of dry leaves [12]. This occurred as the result of the increase in the number of leaves and the leaf area index. From the middle of January fast growth period began, and total dry weight increased rapidly. Comparing with other genotypes, Hyola401 hybrid had more potentiality to generate total dry matter. It was because of its adaptability to environmental conditions and its early maturity. Hence increase in accumulation of dry matter during flowering stage resulted in high grain yield. Hyola401 hybrid (with 1248.91 g m⁻²) had the maximum, and Option500 (with 1046 g m⁻²) had the minimum outputting of dry matter and grain yield. In delayed plantings, it may have a reduction in the number of siliques, flower formation, sink's capacity and productive potentiality of the source [46, 47]. The first planting date showed maximum total dry matter (1271.25 g m⁻²) and subsequent three planting dates showed decrease in the amount by 8.28, 15.94 and 19.36 %, respectively (Fig. 2). These results had conformity with the findings of other researchers [26, 48].

Leaf Area Index

Canola in its initial growth period had the lowest number of leaves, while it had the maximum number of leaves in its flowering period. After that, the leaf area index eventually decreased, to the extent that at the time of harvest it

Fig. 1 Effect of genotype on total dry matter

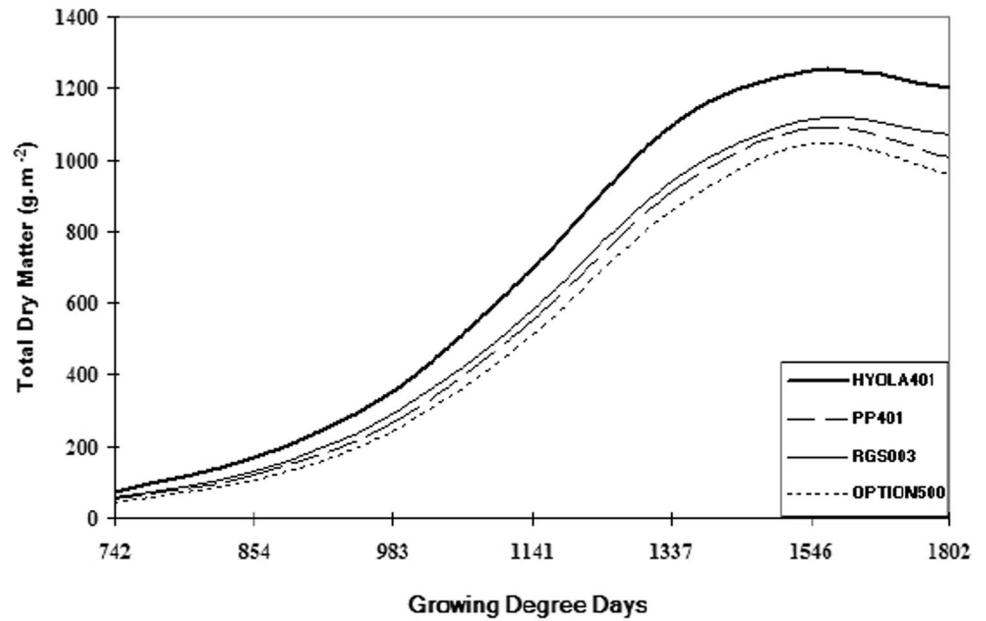
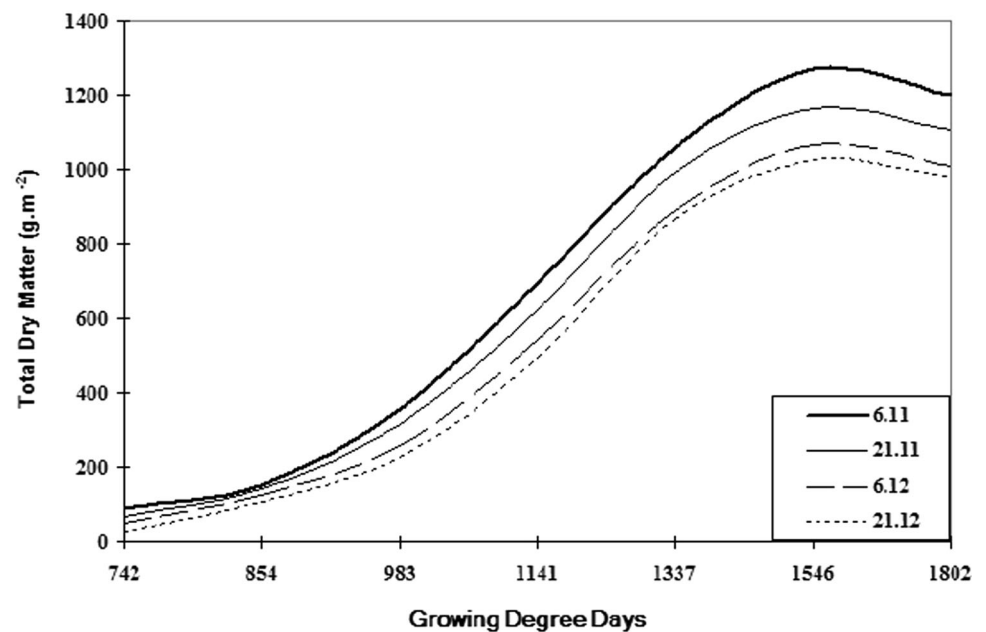


Fig. 2 Effect of planting date on total dry matter



reached zero. Hyola401 hybrid, (with amount of 3.51) contained the maximum leaf area index (Fig. 3). The maximum leaf area index was recorded for all genotypes during flowering period. It was because in this period, sufficient photosynthetic material can have positive effects on the number of siliques and grain yield. In serotinal genotypes, the leaf area index (because of meeting uncomfortable environmental conditions), is considered to

be a preventive element for yielding. Therefore; Option500 variety, owing to the minimum leaf area index, gave minimum grain yield. Yet Hyola401 hybrid, not only had the maximum leaf area index, but also because of having more leaf area duration, had the maximum dry matter. Delay in planting by 45 days, caused decrease in leaf area index (2.83) (Fig. 4). It agrees with the result of Gabrielle et al. [48].

Fig. 3 Effect of genotype on leaf area index

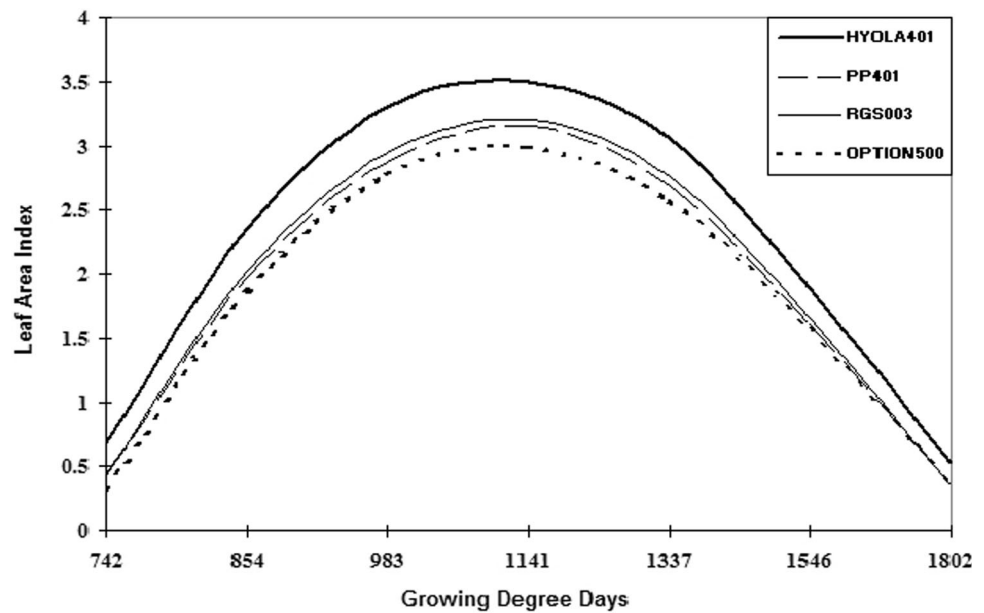
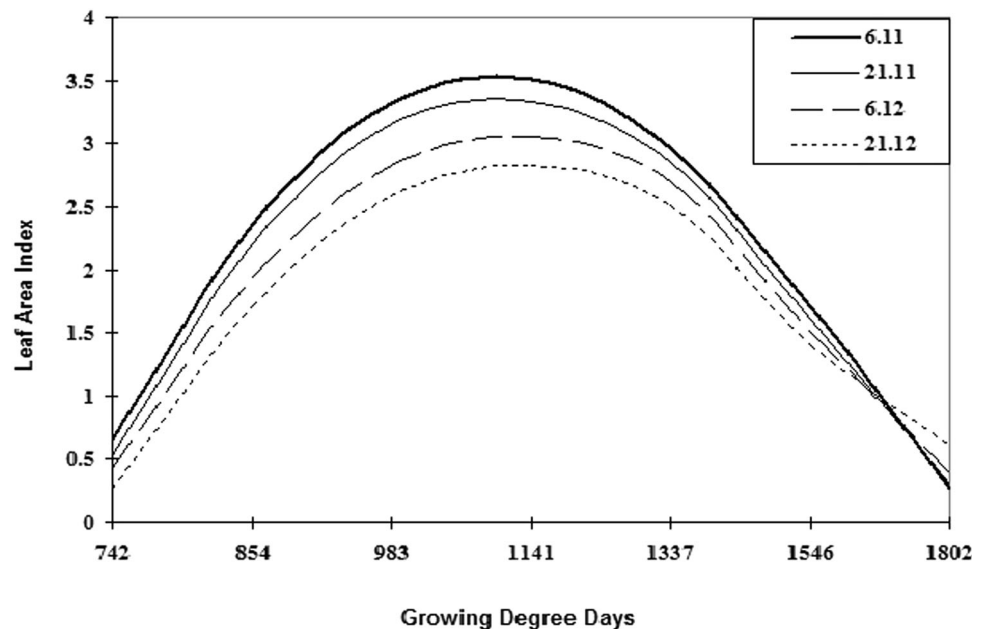


Fig. 4 Effect of planting date on leaf area index

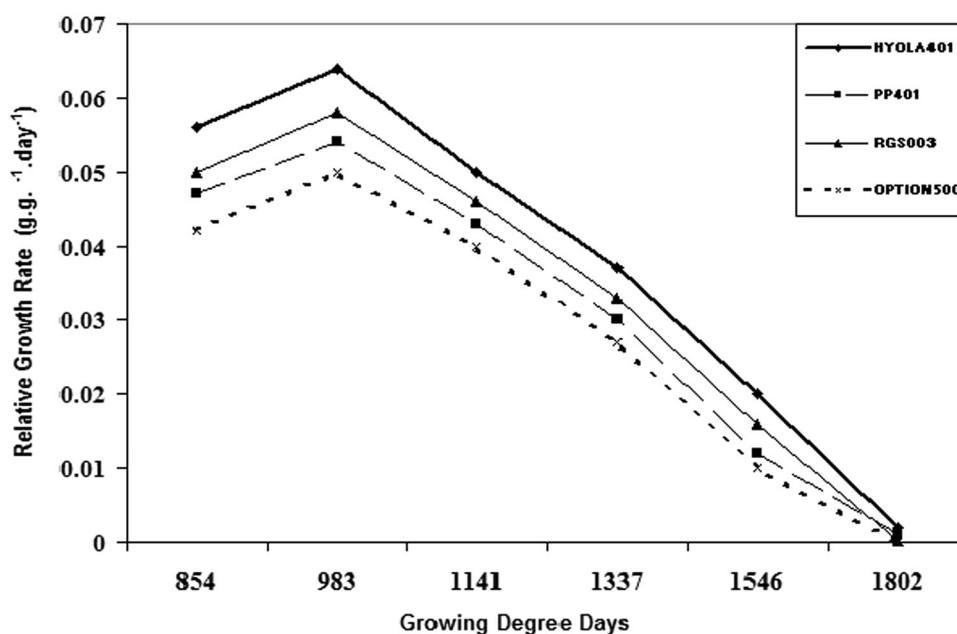


Relative Growth Rate

In Canola genotypes, by the passage of time relative growth rate decreases, and at the end of the season it reaches zero. At the beginning of the growth period, all the cells are involved in photosynthesis and assimilate production. But by the passage of time, the lower leaves (because of being old) are not able to make appropriate photosynthesis; therefore the proportion of assimilates to total dry weight would decrease. This process occurs because old leaves are involved in measuring dry weight,

but they have no function in assimilate production [49]. Figure 5 indicates the similarities between different genotypes according to their relative growth rate changes. Hyola401 hybrid had the maximum and Option500 variety had the minimum amount of this index. Delay in planting had an influence on this index, and in plantings which were conducted after the middle of November, relative growth rate was lower than those of the first planting date. At the beginning of the growth period, in all varieties, this index was in maximum amount, but as the plant grew older this amount decreased. This happened as the result of the

Fig. 5 Effect of genotype on relative growth rate



increase in structural texture and decrease in production efficiency.

Crop Growth Rate

This trait is an index dealing with production potentiality of the plant and it is utilized in order to determine yield among different varieties and to operate agronomic activities [17, 50]. Crop growth rate was observed to be low in the initial growth process, yet it was increased by the passage of time, so much so that during the flowering period of the plant, it reaches the maximum simultaneously with leaf area index. Delayed plantings (because of insufficient vegetation cover, low amount of sunlight absorption and heat during end of the season) show a slow growth rate. The first planting date (with $22.34 \text{ g m}^{-2} \text{ day}^{-1}$), had the maximum relative growth rate, and the fourth planting date (with $16.5 \text{ g m}^{-2} \text{ day}^{-1}$), had the minimum relative growth rate (Fig. 6).

Net Assimilation Rate

The purpose of measuring this parameter is to determine the amount of dry matter, produced by the leaves. As plant's growth carries on, due to the fact that leaves cast shadow on each other and older leaves have lower photosynthesis efficiency, net assimilation rate decreases [51]. Delayed planting observed an extreme decrease in net assimilation rate during November cultivation. Hyola401 hybrid ($7 \text{ g m}^{-2} \text{ day}^{-1}$), from this aspect, had excellence to other varieties, while Option500 variety ($5.6 \text{ g m}^{-2} \text{ day}^{-1}$), showed the pure absorption rate (Fig. 7).

Grain Yield and Yield Components

Siliques Per Plant

The effect of planting date and genotype on the number of siliques per plant was significant at 1 % probability level (Table 1). Delayed planting and end-season heat had led to physiological limitations in the flowering period. This status occurs due to poor growth of the plant or limited leaf expansion. Therefore, nutrient ingredients are limited to the end of flowering and as the result, the number of siliques per plant decreased [2, 52].

The interaction effect of planting date and genotype on the mentioned trait was significant at 5 % probability level (Table 1). The maximum number of siliques per plant was obtained from Hyola401 hybrid with 118.5 siliques at the first planting date (Table 2). Some workers have pro-claimed superiority of Hyola401 hybrid to other varieties because of the reason mentioned above [27].

Grain Per Silique

The effect of planting date, genotype and interaction effect of treatments on number of grain per silique was significant at 1 % probability level (Table 1). In the first planting date, Hyola401 hybrid (with 21.3 grains), devoted the maximum number of grains per silique to itself (Table 2). Decrease in this yield component (because of delayed planting), was similar to the findings of Ozer [52] and Siose-Mardeh et al. [53].

Fig. 6 Effect of planting date on crop growth rate

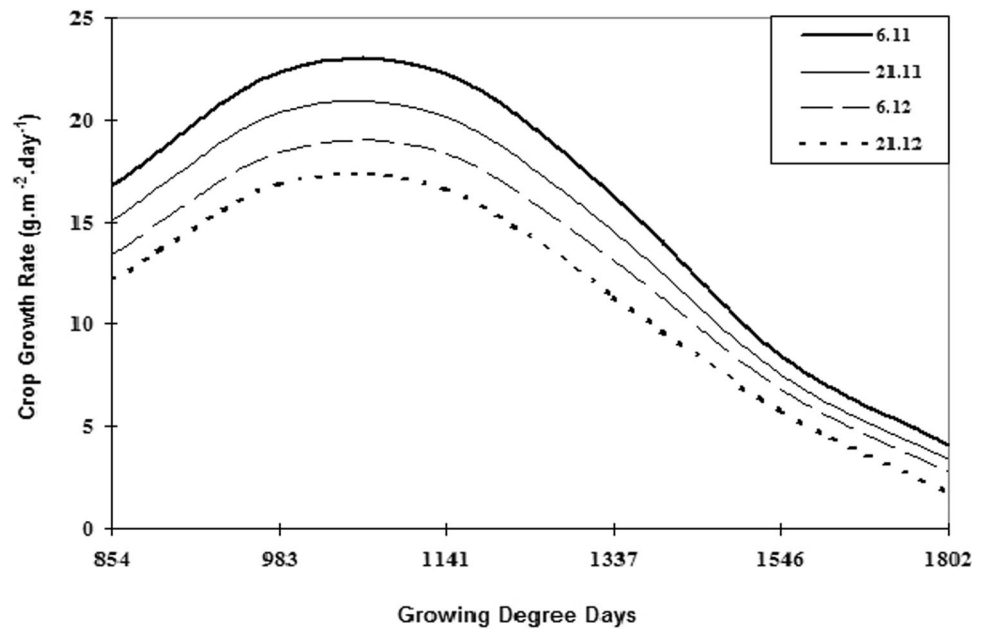
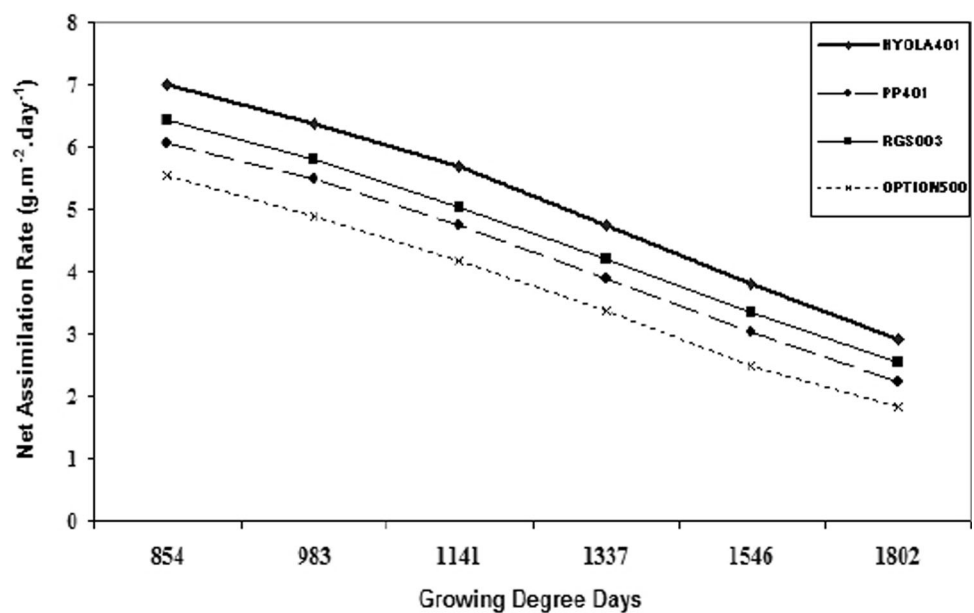


Fig. 7 Effect of genotype on net assimilation rate



Thousand Grain Weight

The effect of planting date and genotype on 1000 grain weight was significant at 1 % probability level (Table 1). In delayed plantings, the grain filling period meets high temperature of the environment, and heat prevents optimized grain filling. As one can be seen in Table 1, the interaction effect of genotype by planting date on grain weight trait was significant at 5 % probability level (Table 1). The maximum 1000 grain weight (2.98 g) was obtained from Hyola401 hybrid in the first planting date

(Table 2). These results are in agreement with those of Angadi et al. [41].

Grain Yield

The interaction effects of planting date and genotype on grain yield was significant at 1 % probability level (Table 1). Maximum grain yield was observed in Hyola401 hybrid at first planting date, while minimum grain yield was in Option500 at the fourth planting date (Table 2). Verma et al. [54] have reported the same findings.

Table 1 Analysis of variance for tested traits

S.O.V	df	Siliques per plant	Grains per silique	1000 grain weight	Grain yield	Total dry weight	Harvest index	Days to emergence	Flowering duration	Days to ripening
Replication	2	235.9	2.8	0.16	36,548.1	227.02	71.12	0.1	4.1	4.2
Planting date	3	3596.4**	82.0**	1.75**	377,812.7**	174,453**	86.95**	68.4**	122.9**	2440.1**
Error a	6	47.5	1.7	0.05	89,643.1	33.43	0.0508	1.6	5.6	18.0
Genotype	3	1517.2**	105.9**	1.16**	237,854.3**	91,498**	30.16**	51.9**	35.7**	20.5**
Planting date × genotype	9	105.3*	5.9**	0.07*	331,796.9**	6533.2**	11.47**	1.8*	3.8*	4.3*
Error b	24	25.1	0.7	0.03	20,513.8	26.1	0.0103	0.7	1.8	1.6
CV (%)		8.8	7.8	6.8	7.0	3.65	4.08	9.3	6.9	1.0

* ns and **: not significant, significant at 5 and 1 % level of probability, respectively

Table 2 Mean comparisons of interaction effect of traits by Duncan's test

Treatment	Siliques per plant	Grains per silique	1000 grain weight (g)	Grain yield (kg ha ⁻¹)	Harvest index (%)	Total dry weight (g m ⁻²)	Day to emergence	Flowering duration	Days to ripening
6.11									
Hyola401	118.5 ^a	21.3 ^{ab}	3.75 ^a	3603.5 ^a	26.5 ^a	1225.95 ^a	5.8 ^{gh}	24.0 ^{ab}	154.0 ^b
PP401	86.8 ^{bc}	19.5 ^{bd}	2.98 ^{cd}	2387.9 ^c	21.6 ^b	1210.35 ^{bc}	5.5 ^h	24.5 ^a	157.0 ^a
RGS003	95.8 ^b	16.5 ^{f-i}	2.63 ^{ef}	2480.3 ^c	23.3 ^{ab}	1205.45 ^b	5.5 ^h	22.5 ^{bc}	155.5 ^{ab}
Option500	86.0 ^{bc}	18.0 ^{c-f}	2.78 ^{de}	1974.6 ^{d-f}	19.5 ^b	1195.0 ^b	10.3 ^c	19.0 ^{eg}	155.8 ^{ab}
21.11									
Hyola401	93.5 ^{df}	21.5 ^a	3.25 ^{bc}	3030.9 ^b	22.1 ^{ab}	1185.25 ^{df}	7.3 ^{ef}	22.3 ^{bc}	141.0 ^d
PP401	80.5 ^{cd}	16.8 ^{e-h}	2.55 ^{de}	1974.5 ^{d-f}	18.2 ^c	1125.16 ^{cd}	7.5 ^{ef}	20.8 ^{ce}	141.8 ^d
RGS003	82.3 ^{cd}	17.8 ^{d-g}	2.75 ^{de}	2116.9 ^d	20.4 ^{bc}	1160.15 ^{bc}	8.5 ^d	19.8 ^{df}	144.3 ^c
Option500	73.0 ^b	26.0 ^{g-i}	2.55 ^{ef}	1888.2 ^{ef}	17.1 ^d	1110.11 ^{de}	12.0 ^b	19.0 ^{eg}	142.8 ^{cd}
6.12									
Hyola401	78.5 ^{cd}	19.8 ^{a-c}	3.03 ^{bc}	20,209.0 ^{de}	17.9 ^d	1080.96 ^{ef}	7.3 ^{ef}	21.0 ^{cd}	130.3 ^f
PP401	75.3 ^{de}	16.5 ^{fi}	2.73 ^e	1868.3 ^{e-g}	16.3 ^{de}	1041.9 ^{de}	6.8 ^{fg}	18.5 ^{fg}	131.0 ^f
RGS003	66.0 ^{eg}	14.8 ^{ig}	2.43 ^f	1664.7 ^{g-i}	16.5 ^{de}	1063.65 ^{ef}	8.0 ^{de}	19.3 ^{dg}	133.3 ^e
Option500	60.8 ^{gh}	14.3 ^j	2.63 ^f	1607.7 ^{hi}	15.2 ^e	1015.3 ^{gh}	10.0 ^c	18.5 ^{fg}	133.3 ^e
21.12									
Hyola401	74.3 ^{de}	18.5 ^{ce}	2.5 ^{ef}	1170.6 ^{f-h}	15.9 ^e	1049.30 ^{fg}	11.5 ^b	17.8 ^{gh}	127.3 ^g
PP401	63.5 ^{fg}	15.0 ^{kj}	2.1 ^g	1266.8 ^j	14.6 ^f	1015.42 ^{ef}	10.0 ^c	16.3 ^{hi}	126.8 ^g
RGS003	60.8 ^{gh}	11.0 ^k	2.2 ^g	1506.2 ⁱ	14.8 ^f	1022.66 ^{de}	11.5 ^b	15.3 ^{ij}	130.3 ^f
Option500	51.3 ^h	10.3 ^k	1.9 ^g	1517.9 ⁱ	13.8 ^g	1009.74 ^h	13.5 ^a	14.3 ^j	127.5 ^g

Similar letters in each column show non-significant difference according to 5 % level in Duncan's Multiple Rang Test

Harvest Index

The effect of different planting dates, genotypes and interaction effect of treatment on that trait were significant at 1 % probability level (Table 1). Maximum harvest index was shown by hybrid Hyola401 at first planting date (26.5 %) while minimum was shown by Option500 at fourth planting date (13.8 %) (Table 2).

Phenological Characteristics

The results achieved from variance analysis indicated that differences between planting dates, genotypes and interaction effect according to the days to emergence, duration of flowering period and days to ripening were significant at 1 % probability level (Table 1). Maximum and minimum length of days to emergence respectively belonged to

Table 3 Correlation coefficients of agronomic traits of canola genotypes

Traits	Day to emergence	Percent of emergence	Initiation of flowering	End of flowering	Flowering duration	Days to ripening	Plant heights	Silique per plant	Seed per silique	1000 grain weight	Harvest index	Total dry matter
Percent of emergence	-0.686**											
Initiation of flowering	-0.197 ^{ns}	-0.88 ^{ns}										
End of flowering	-0.336 ^{ns}	-0.184 ^{ns}	0.962**									
Flowering duration	-0.861**	0.513*	0.81 ^{ns}	0.523*								
Days to ripening	-0.544*	0.130 ^{ns}	0.697**	0.755**	0.753**							
Plant Heights	-0.690**	0.400 ^{ns}	0.572*	0.682**	0.823**	0.849**						
Silique per plant	-0.723**	0.321 ^{ns}	0.400 ^{ns}	0.41 ^{ns}	0.855**	0.764**	0.822**					
Seed per silique	-0.316 ^{ns}	0.206 ^{ns}	0.87 ^{ns}	0.75 ^{ns}	0.637**	0.65*	0.526*	0.620*				
1000 grain weight	-0.655**	0.195 ^{ns}	0.25 ^{ns}	0.66 ^{ns}	0.831**	0.581*	0.683**	0.863**	0.652**			
Harvest index	-0.617*	0.1570 ^{ns}	0.431 ^{ns}	0.45 ^{ns}	0.786**	0.653**	0.689**	0.907**	0.568*	0.886**		
Total dry matter	-0.720**	0.294 ^{ns}	0.414 ^{ns}	0.485*	0.888**	0.729**	0.819**	0.943**	0.602*	0.886**	0.929**	
Grain yield	-0.656**	0.202 ^{ns}	0.407 ^{ns}	0.430 ^{ns}	0.824**	0.670**	0.715**	0.955**	0.575*	0.909**	0.810**	0.932**

ns, ** and *: no significant and significant at 5 and 1 % level of probability, respectively

variety Option500 at first planting date on November 6th (average of 6.8 days) and varieties of RGS003 and PP401 at fourth planting date on December 21st (average of 5.5 days) (Table 2). The hybrid Hyola401 at first planting date (average of 24.5 days) had the maximum flowering duration and the variety Option500 at fourth planting date (average of 14.3 days) had the minimum flowering duration. Flowering period is most important period which affects Canola yield. When flowering period in plants commences, photosynthesis process decreases drastically and within this period, plant shows extreme sensitivities to environmental tensions [17]. Because of delayed planting, length of maturity period in all genotypes along first to the fourth planting date decreased. In delayed plantings, heat caused by the end of the season leads to early maturity, decrease in length of the seed filling period and preventing transmission of photosynthetic materials to the seed [47]. Length of flowering period was affected by planting date and genotype. Maximum amount of that was related to PP401 varieties (24.5 days) at first planting date (Table 2). Maximum days to ripening period were shown by Option500 variety, (average of 155.8 days) at first planting date (Table 2).

Correlation Between Traits

These coefficients were determined by means of Pearson coefficient. The maximum positive and significant correlation was observed in dry matter trait ($r = 0.932^{**}$), harvest index ($r = 0.810^{**}$), silique per plant ($r = 0.955^{**}$), 1000-grain weight ($r = 0.909^{**}$), flowering duration ($r = 0.824^{**}$), plant height ($r = 0.715^{**}$) and maturity time trait ($r = 0.67^{**}$) (Table 3). The number of grains per silique ($r = 0.575^{*}$) and days to emergence ($r = -0.656^{*}$) had positive and negative correlation (5 % probability level) with the grain yield (Table 3). Traits of days to flowering and days to maturity have a significant and positive correlation with grain yield of Canola varieties, therefore varieties with longer flowering duration would have a better chance for fertilizing flowers and turning them to siliques [13]. In serotinal varieties or delayed-growing plants, the decrease in the duration of growth period, poor environmental conditions (temperature and humidity) during the flowering and fertilization period and silique formation, decreases the number of siliques per plant. The number and weight of the grain finally lead to the decrease in Canola yield [10]. Earning maximum

correlation coefficient in grain yield, by the number of siliques per plant ($r = 0.955^{**}$) there was a positive and significant correlation of grain per silique with grain yield. As the result, the more this trait is observed, the plant would have bigger sink for metabolic materials. Other workers have mentioned similar results [12, 19]. The increase of total dry matter and its direct relation with grain yield show the relations between photosynthesis efficiency of plant and grain yield. Therefore, the varieties which gained more profit of the production keep more photosynthetic material in their sink. This status was in conformity with the work of Leilah and AL-Khateeb [45]. The significant and positive correlation between the harvest index and grain yield ($r = 0.810^{**}$) indicates efficiency and the kind of photosynthetic material distribution in different parts of the plant, especially in grains.

Conclusion

Hyola401 hybrid due to its genetic characteristics such as better yield potentialities, early maturity and optimum usage of environmental conditions, has excellence over other varieties. Delayed planting, especially among serotinal varieties, is seen to encounter an increase of temperature and some humidity tensions during March and April, which is the most sensitive time of its growing process (flowering and grain filling). This can cause some negative effects on grain yield, yield components and physiological indicators. According to the findings of this work, in order to achieve maximum yield, planting Hyola401 hybrid in the middle of November in southwest regions of Iran is suggested.

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Compliance with Ethical Standards

Conflict of interest There exist no conflict of interest among the authors.

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