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The Effect of Planting Date on Phenologic, Physiologic Characteristics, Correlation Grain Yield Traits and the Percentage Changes Compared to the Characteristics of Canola Genotypes in the South West of Iran

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ABSTRACT

In southwest regions of Iran the conditions of alternative cropping in some cases have a negative effect on yield after summer cropping, because of Canola delay planting. By analyzing the growth process, planting date and effective variables on grain yield, Canola can be managed according to its needs. Therefore a split plot experiment in Randomized Complete Block Design (CRBD) with three replications was conducted. 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. Planting date (November 6th) was more effective according to the traits mentioned above. Genotypes which were under experiment also had a significant difference according to grain yield, yield components and other traits. The maximum grain yield was that of Hyola401 hybrid with 2.61 (ton ha^{-1}) and the minimum grain yield was that of Option 500 variety with 1.51 (ton ha^{-1}). Correlation coefficients indicated that traits of total dry matter (r=0.932**), Harvest index (r=0.810**), 1000 Grain weight (r= 0.909**), grains per pod (r= 0.575*), pod per plant (r=0.955**), plant height (r= 0.715**), maturity time (r= 0.67**) and flowering duration (r= 0.824**) had a positive and significant correlation with the grain yield. In general the first planting date was superior in physiological index comparing with the other planting dates. Also Hyola401 hybrid, due to the fact that it had a higher leaf area index (3.51), Total dry matter (1248.91 gm^{-2}), crop growth rate (21 gm^{-2}.day^{-1}), net assimilation rate (7 g m^{-2}.day^{-1}), relative growth rate (0.064 g g^{-1}.day^{-1}) and maximum grain yield, was seen to be the most adaptable genotype.
KEY WORDS: Canola, genotype, planting date, Correlation, Phenology, Physiology.

INTRODUCTION

Delayed planting, inappropriate weather conditions during the flowering period, fertilization and pod formation can cause a decrease in duration of maturity period, affect the number of pods per plant, affect the number and weight of grains and finally can lead to decrease in grain yield [17]. Delayed planting causes a decrease in duration from time of planting to flowering or maturity. Therefore the decrease in yield, which occurs because of delayed planting, is basically as a result of decrease of biomass during the maturity period. In order to choose a genotype, we have to consider its adaptation with climate of the region, and we need to determine a suitable genotype for each region [21, 19]. According to the results about average yield in dry regions, Hyola308 and Hyola401 hybrids, also Pf 7045.91 and Taporo varieties, respectively with yielding of 2996, 2783, 2231, and 2191 Kg. ha^{-1}, was superior over other genotypes and are advised to be planted in dry climate of southwest regions [16]. Growth analysis is a precious method which was first conducted in quantitative growth analysis of plants and their yield by [4]. Crop growth rate, net assimilation rate and leaf area index in unadoptable 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 maturity varieties with high-potentiality have more proper yield, comparing with serotinal varieties [10, 11]. Because planting date in comparison with other agronomic factors has more influence on phenologic and physiological characteristics of the plant, determining a proper planting date makes the maximum conformity between plant growth process and climate conditions. This research was conducted to study the phenological and physiological characteristics of Canola genotypes in different planting dates and to determine the most suitable planting date from the aspect of conformity with climate condition of regions and achieving the best yield.

MATERIAL AND METHODS

This research has been fulfilled in the 2008-2009 agronomic season in Randomized Complete Block Designs (CRBD) with three replications, which was conducted in the experimental field of Science and Research

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Branch, Islamic Azad University, south west of Iran (32°20' N, 40°20' E and altitude 22.5m) with moderate winters and hot summers. Planting dates were (November 6th and 21st. December 6th and 21st) in the main plots and the subplots were with four Genotypes (Hyola401, PP401, RGS003 and Option500). The texture of the soil in this region was silty clay loam; electricity conductivity of condensed saturation was 3.5 $ds.m^{-1}$ and acidity of the soil was 7.3. The average annual precipitation was 248 mm, long-term daily temperature (in 30 years) was 24-45 degrees centigrade, the average precipitation in agronomic year was 68-136 mm and the average temperature of the agronomic year was 20 degrees centigrade. Each plot consisted of 8 rows with 30 cm distance from each other and each plot was 6 meters long. The average distance between plants was considered to be 3 to 4 cm. using fertilizers in this land was according to information which was gained about the soil. Therefore manure the land using 100 kilogram urea fertilizer per hectare, 100 kilogram triple super phosphate fertilizer and 200 kilogram potassium sulfate per hectare as the basic fertilization, and during the growth period of stem, was 200 kilograms of urea fertilizer per hectare utilized. In order to determine the growth process from January 1st 2008 to April 4th 2009, samples were collected for seven times with interval duration of twice a week, and in each sampling, the leaf layer index and total dry weight were estimated in plots. Daily growth degree was calculated by the following formula (23):

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

Formula 1. Growing Degree Days

In this formula $\mathbf{T_{max}}$ is: maximum daily temperature, $\mathbf{T_{min}}$ is: minimum daily temperature, $\mathbf{T_b}$ is: the basic temperature and **n** is: the number of days in a particular period.

The basic temperature in this research was considered $+5^0$c [1, 15 and 22]. In order to determine grain yield components during physiologic maturity, 10 plants were chosen randomly from each plot. Then the traits of pods per plant, the number of grain per pod 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. 9.1) software and average comparisons were fulfilled according to Duncan multiple rang test at 5 percent probability. All of the charts were drawn by Excel 2003 software.

RESULTS AND DISCUSSIONS

Grain Yield and Yield components

The effect of planting date and genotype on the number of pods per plant trait was significant (Table 1). The maximum number of pods per plant was seen in the first planting date (November 6th) which contained nearly 98.8 pods per plant. Second, the third and fourth planting dates afterward, had respectively average pods of 82.3, 70.1 and 62.4 per plant, which were categorized in the next groups (Table 2). Delayed planting and end-season heat would lead to physiologic limitations in the flowering period. This status occurs due to poor growth of the plant or limited leaf expansion. Therefore nourished ingredients are limited to the end of flowering and as a result the number of pods per plant decreased [14, 8]. Hyola401 hybrid with 91.2 pods, and Option 500 variety with 67.8 pods, respectively generated the maximum and minimum number of pods per plant (Table 3). The mutual effect of planting date and genotype on the mentioned trait was significant (Table 4). The maximum number of pods per plant was that of Hyola401 hybrid with 118.5 pods at the first planting date. Some scientists have proclaimed excellence of Hyola401 hybrid to other varieties because of the reason mentioned above [8, 6]. The effect of planting date and genotype on trait of the number of grain per pod was significant (Table 1). The first planting date (with 18.8 grains) had the maximum, and the fourth planting date (with 13.7 grains) had the minimum number of grains per pod (Table 2). Hyola401 hybrid (with generating 20.2 grains per pod), had excellence over the other varieties. The mutual effect of planting date and genotype on this trait was significant. In the first planting date, Hyola401 hybrid (with 21.3 the grains), devoted the maximum number of grains per pod to itself (Table 3). Decrease in this component of yielding (because of delayed planting), had conformity with the findings of some researchers [3, 9, and 17]. The effect of planting date and genotype was significant on 1000- grain weight, to the extent that, observed 2.93 g at the first planting date decreased to 2.17 g in the fourth planting date as a result of delayed planting (Tables 1 and 2). In delayed plantings, the grain filling period meets high temperature of the environment, and heat prevents optimized grain filling. Hyola401 hybrid (with 3.04 g), involved the maximum 1000 grain weight among the varieties. The mentioned points above had conformity with the results of other researchers [17, 18]. As we can see in Table (1), the mutual effect of genotype and planting date on above trait was significant. The maximum 1000 grain weight was that of Hyola401 hybrid in the first planting date (the amount of that was 2.98 g) (Table 4). The effect of different planting dates was significant on grain yield. Other researchers have reported the same findings [3, 5 and 17]. Grain yield from the first planting date to the fourth one decreased from 2611.6 $Kgha^{-1}$, to 1515.3. The first planting date, benefiting from environmental conditions and extreme photosynthesis, had the maximum yield (Table 2). Hyola401 hybrid, by having 2608.5

$Kgha^{-1}$ yields, had the maximum yield, and RGS003, Pp401 and Option500 varieties respectively with yield of 1948, 1874 and 1747 $Kgha^{-1}$, were categorized in the next stages (Table 3). The Mutual effects of planting date and genotype on grain yield was significant. The maximum grain yield was observed in Hyola401 hybrid at the first planting date, and the minimum grain yield was in Option 500 at the fourth planting date (Table 4).

Harvest index

The harvest index was decreased with delayed planting (Table 2). The significant difference which was observed between experimental areas indicated that a change in planting date can seriously affect dry matter distribution, in plant sinks. By 15, 30 or 45 days of delay in planting date, the harvest index which was 20.72 % in the first planting date, decreased to 19.14 % in the second planting date, 16.48 % in the third and 14.7 % in the fourth planting date (Table 2). Choosing a proper planting date can cause an increase in the harvest index, and finally can lead to a better transmission of photosynthesis materials to grains. Genotypes which were studied in this experiment had totally different potentialities according to their plant dry matter distributions and their Economic crop components. It was to the extent that, Hyola401 hybrid [by reaching to 20.03 % harvest index], had appropriate conditions for these potentialities comparing with other varieties (Table 3). The reason why this hybrid has excellence to other varieties is that this genotype makes a better use of environmental conditions.

Physiological traits

Total dry matter

According to diagram 1, slow growth period in all genotypes continued to the middle of January, and maximum dry weight in the plants was because of the increase in the weight of dry leaves. This occurred as a 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 create total dry matter. It was because of its adaptability to environmental conditions and its early maturity. Hence creating a large amount of dry matter during the flowering period can guarantee the increase of grain yield. Hyola401 hybrid [with 1248.91 gm^{-2}] had the maximum, and Option 500 [with 1046 gm^{-2}] had the minimum outputting dry matter and grain yield. In delayed plantings, the plant can not pass the whole vegetable period; therefore it may have a reduction in the number of pods, flower formation, sink's capacity and productive potentiality of the source [3]. The first planting date [with total dry matter of 1271.25 gm^{-2}], had excellence comparing with the other planting dates (diagram 2). These results had conformity with the findings of other researchers [2, 3].

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 (diagram 3 and 4). After that, the leaf area index eventually decreased, to the extent that in the time of harvest it reached zero. This had conformity with the findings of other researchers [2, 3, and 14]. Hyola401 hybrid, (with amount of 3.51) contained the maximum leaf area index (diagram 3). The maximum leaf area index was conducted for all genotypes during their flowering period. It was because in this period, sufficient photosynthesis materials can have positive effects on the number of pods 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, owning the minimum leaf area index, devoted minimum grain yield to itself. 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. 45 days delay in planting, caused 2.83 decreases in leaf area (diagram 4). The other researchers have mentioned the same results [9, 14].

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 (diagram 5). At the beginning of the growth period, all of the cells are involved in photosynthesis function and assimilates 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 assimilates production [2]. Diagram5 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 in delayed plantings was lower than 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 a result of the increase in structural texture and decrease in production efficiency. Other researchers have reported the same findings [9, 10, and 15].

Crop growth rate

This trait is an index dealing with production potentiality of plant and it is utilized in order to determine yield among different varieties and to operate agronomic activities [13]. Crop growth rate was observed to be low in the initial growing process, yet it was increased by the passage of time, so much so that during the flowering period of plant, it reaches the maximum amount simultaneously with leaf area index (diagram 6). The maximum and minimum crop growth rates were respectively those of Hyola401 hybrid [21 $gm^{-2}day^{-1}$] and Option500 [17.08 gm^{-2} days-^{1}]. They also contained the maximum and minimum total dry matter (diagram 6). Delayed plantings [because of insufficient vegetation cover, low amount of sunlight absorption and heat during end of the season] own a slow growth rate. The findings of other researchers verify this viewpoint [2, 14]. The first planting date [with 22.34 $g.m^{-2}.day^{-1}$], had the maximum relative growth rate, and the fourth planting date [with 16.5 $g.m^{-2}.day^{-1}$], had the minimum relative growth rate (diagram 7).

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 [7, 13]. By having delayed planting, observed an extreme decrease in net assimilation rate during November cultivation. Hyola401 hybrid (7 $gm^{-2}day^{-1}$), from this aspect, had excellence to other varieties, while Option 500 variety (5.6 $gm^{-2}day^{-1}$), had the pure absorption rate (diagram 8).

Phenological traits

The results achieved from variance analysis indicated that differences between planting dates and genotypes according to their germination period, duration of flowering period and stem height were significant (Table 1). The maximum and minimum lengths of germinating time were respectively related to the first planting date on November 6th (with average of 6.8 days), and fourth planting date on December 21st (with average of 11.6 days). Hence by separation from proper environmental conditions (humidity and temperature), germinating duration of plant would increase. Hyola401 hybrid (with average duration of 7.9 days), had the minimum germinating duration (Table 3). Excellence of this hybrid was because of its superior potentiality and higher germination strength. This results had conformity with the findings of other researchers [5, 16 and 17]. The first planting date (with average of 22.5 days) had the maximum flowering duration and the fourth planting date, (with average of 15.9 days) had the minimum flowering duration (Table 2). The flowering period is the most important period which affects Canola yield. As the flowering period in plants commences, the photosynthesis process decreases drastically and within this period, the plant shows extreme sensitivities to environmental tensions [14]. In delayed plantings, the average temperature during flowering period increases and causes a decrease in the leaf area index, intense competition among leaves and flowers, and finally leads to a decrease in the length of flowering period. Hyola401 hybrid (with 21.3 days), had the maximum flowering duration, after that varieties of RGS003, PP401 and Option500, respectively (with 20, 19.2 and 17.7 days), devoted the minimum flowering duration to themselves (Table 3). Because of delayed planting, length of maturity period from the first to the fourth planting date decreased from 155.6 days to 127.9 days. In delayed plantings, heat caused by the end of the season leads to early maturity, decrease in length of the grain- filling period and preventing transmission of photosynthesis materials to the grain [16, 21]. RGS003 variety (with average of 140.8 days), had the maximum duration from planting date to the harvest, while Hyola401 hybrid (with 187.4 days) embraced the minimum duration of that sort. Similar results have been reported by other researchers about this point [5, 17]. The first planting date (with 181.3 Cm), and the fourth planting date (with 111.9 Cm), respectively had the maximum and minimum plant height. By having a delayed planting, the plant loses the chance of saving photosynthesis materials. This finding was confirmed by some researchers [17, 18]. RGS003 variety, [with 158.7 average stem height], had excellence over other genotypes (Table 3). Planting date and genotype effects on phenological traits of Canola such as flowering initiation, the length of the flowering period and duration from planting date to maturity, were significant (Table 1). The length of the flowering period was affected by planting date and genotype and the maximum amount of that was related to PP401 varieties (with 24.5 days) at the first planting date. The maximum length of maturity period was that of Option500 variety, (with average of 155.8 days) at the first planting date (Table 4). Despite the significant effects of planting date and genotype on the length of flowering or the maturity period, still intensity of these effects is in a degree that, even early-matured genotypes can not embrace these effects on their grain yield. The following results mentioned above, had conformity with the findings of other researchers [2, 14, and 16].

Simple Correlation coefficients between traits

These coefficients were figured out by means of Pearson coefficient. The maximum positive and significant correlation was observed in; dry matter trait ($r=0.932^{**}$), harvest index ($r=0.810^{**}$), pod 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 ($r= 0.67^{**}$). The traits of grain per pod ($r=0.575^{*}$) and days to grow ($r=0.656^{*}$) had correlation with the grain yield.

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 pods [20, 21]. In serotinal varieties or delayed-growing plants, the decrease of length in the growing period, poor environmental conditions (temperature and humidity) during the flowering period and fertilization and pod formation, decreases number of pods per plant, the number and weight of the grain finally lead to the a decrease in the of Canola yield [17]. Earning maximum correlation coefficient in grain yield by the number of pods per plant ($r= 0.955^{**}$) because it is assimilates supplier for the grains, therefore, there was a positive and significant correlation of grain per pod with grain yield, a natural thing. As a result, the more this trait is observed, the bigger sink plant would have for metabolic materials. The other researchers have mentioned the same results [9, 12].

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 varieties which gained more profit of the production factors according to growth conditions and they keep more photosynthesis materials in their sinks, had more efficiency. This status was in conformity with the other researchers have mentioned the same results [15, 21]. The significant and positive correlation between the harvest index and grain yield ($r=0.810^{**}$) indicates efficiency and kind of photosynthesis materials distribution in different parts of plant, especially in grain. The other researchers have mentioned the same results [17, 18].

Y = - 3507 + 25.1 GD + 12.8 GP + 17.6 FI - 15.6 EF + 30.5 FD + 0.39 MD- 1.52 PH + 1.89 PPP - 8.02 GPP + 108 SW + 131 HI + 1.07 TDM

Formula 2. Grain yield formula according to regression relations among all identified traits.

MD: maturity date, PPP: Pod per plant, SPP: grain per pod, SW: 1000 seed weight, TDM: Total Dry Matter, HI: harvest index, GD: growing duration, GP: germination percentage, FI: flowering initiation, EF: end of flowering, FD: flowering duration, PH: plant height

A survey on the changes in the measured traits, comparing with time

In order to identify the degree of changes in the measured traits and comparing them with each other, the degree of changes in them was estimated and then diagrams were drawn for them indicating changes percentage in ratio to time. The horizontal axis included first to fourth planting dates, and the vertical axis encompassed changes percentage of traits which measured. In diagram (9), the biological yield reaction rarely decreased by the passage of time, in comparison with grain yield. Also the harvest index was affected more which led to a decrease of that and delay in planting time. Among yield components, 1000 -grain weight, the number of grain per pod, and the number of pods per plant respectively had fewer changes in ratio of delayed planting (diagram 10).

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 are 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 indicates. According to the findings of this research, in order to achieve maximum yield, planting Hyola401 hybrid in the middle of November in southwest regions of Iran is suggested.

Table 1 - Summary results of analysis variance of traits

S.O.V	df	Days to emergence	Flowering duration	Days to ripening	Plant heights	Pod per plant	Grain per pod	1000 grain weight	Total dry matter	Harvest index	Grain yield
Replication	2	0.1	4.1	4.2	695.2	235.9	2.8	0.16	227.02	71.12	36548.1
Planting date	3	68.4**	122.9**	2440.1**	13702.5**	3596.4**	82.0**	1.75**	174453**	86.95**	377812.7**
Error	9	1.6	5.6	18.0	65.3	28.5	0.7	0.03	33.43	0.0108	89643.1
Genotype	9	51.9**	35.7**	20.5**	2379.6**	1517.2**	105.9**	1.16**	91498**	30.16**	237854.3**
Planting date × Genotype	27	1.8*	3.8*	4.3*	374.7*	105.3*	5.9**	0.07*	6533.2**	11.47**	331796.9**
Error	72	0.7	1.8	1.6	180.8	47.1	1.7	0.03	26.1	0.0503	20513.8
CV (%)	-	9.3	6.9	1.0	9.1	8.8	7.8	6.8	3.65	4.08	7.0

ns, * and **: No significant and Significant at 5 and 1% Level of Probability, Respectively

Table 2- Mean Comparison of Effect of planting date on yield, Yield Components, Total Dry Matter and Harvest index traits.

Treatment	Days to emergence	Flowering duration	Days to ripening	Plant heights	Pod per plant	Seed per pod	1000 grain weight (g)	Grain yield ($kgha^{-1}$)	Harvest index (%)	Total dry matter (gm^{-2})
Planting date										
6.11	6.8 ^{c}	22.5 ^{a}	155.6 ^{a}	181.3 ^{a}	96.7 ^{a*}	18.8 ^{d}	2.93 ^{a}	2611.6 ^{a}	22.72 ^{a}	1271.25 ^{a}
21.11	8.8 ^{b}	20.4 ^{b}	142.4 ^{b}	157.5 ^{b}	82.3 ^{b}	18.0 ^{a}	2.78 ^{a}	2252.6 ^{b}	19.4 ^{b}	1165.91 ^{b}
6.12	8.0 ^{b}	19.3 ^{b}	131.9 ^{c}	139.7 ^{c}	70.1 ^{c}	16.3 ^{b}	2.70 ^{b}	1792.4 ^{c}	16.48 ^{c}	1068.5 ^{c}
21.12	11.6 ^{a}	15.9 ^{c}	127.9 ^{c}	111.9 ^{d}	62.4 ^{d}	13.7 ^{c}	2.17 ^{c}	1515.3 ^{c}	14.7 ^{d}	1025.1 ^{c}

*: Similar Letters in each column show non-significant difference according to 5% Level in Duncan Multiple Rang Test.

Table 3 - Mean Comparison of Effect of Genotype on Yield, Yield Components, Total Dry Matter and Harvest index traits.

Treatment	Days to emergence	Flowering duration	Days to ripening	Plant heights	Pod per plant	Seed per pod	1000 grain weight (g)	Grain yield ($kgha^{-1}$)	Harvest index (%)	Total Dry Matter (gm^{-2})
Genotypes										
HYOLA401	7.9 ^{bc}	21.3 ^{a}	1381.1 ^{c}	157.5 ^{a}	91.2 ^{a*}	20.3 ^{a}	3.04 ^{a}	2608.5 ^{a}	20.03 ^{a}	1248.91 ^{a}
PP401	7.4 ^{c}	20.0 ^{b}	139.1 ^{b}	137.5 ^{b}	76.5 ^{b}	16.9 ^{b}	2.55 ^{b}	1874.4 ^{b}	16.97 ^{c}	1091.5 ^{b}
RGS 003	8.4 ^{b}	19.2 ^{b}	140.8 ^{a}	158.8 ^{a}	76.2 ^{b}	15.0 ^{c}	2.47 ^{b}	1942.0 ^{b}	17.61 ^{b}	1112.5 ^{b}
OPTION 500	11.4 ^{a}	17.7 ^{c}	139.8 ^{b}	136.6 ^{b}	67.8 ^{c}	14.6 ^{c}	2.51 ^{b}	1747.1 ^{c}	16.44 ^{c}	1046.0 ^{c}

*: Similar Letters in each column show non-significant difference according to 5% Level in Duncan Multiple Rang Test.

Table 4 - Mean Comparison of interaction effect of traits by Duncan test

	Treatment	Day to emergence	Flowering duration	Days to ripening	Plant heights (cm)	Pod per plant	Seed per pod	1000 grain Weight (g)	Grain yield ($kgha^{-1}$)	Total dry matter (gm^{-2})	Harvest index (%)
6.11	**Hyola401**	5.8 ^{gh*}	24.0 ^{ab}	154.0 ^{b}	175.0 ^{b}	118.5 ^{a}	21.3 ^{ab}	3.75 ^{a}	3603.5 ^{a}	1225.95 ^{a}	**26.5** ^{a}
	PP401.15E	5.5 ^{h}	24.5 ^{a}	157.0 ^{a}	167.5 ^{bc}	86.8 ^{bc}	19.5 ^{bd}	2.98 ^{cd}	2387.9 ^{c}	1210.35 ^{bc}	**21.6** ^{b}
	RGS003	5.5 ^{h}	22.5 ^{bc}	155.5 ^{ab}	201.3 ^{a}	95.8 ^{b}	16.5 $^{f-i}$	2.63 ^{ef}	2480.3 ^{c}	1205.45 ^{b}	**23.3** ^{ab}
	Option500	10.3 ^{c}	19.0 ^{eg}	155.8 ^{ab}	181.3 ^{b}	86.0 ^{bc}	18.0 $^{c-f}$	2.78 ^{de}	1974.6 $^{d-f}$	1195.0 ^{b}	**19.5** ^{b}
21.11	**Hyola401**	7.3 ^{ef}	22.3 ^{bc}	141.0 ^{d}	168.8 ^{bc}	93.5 ^{df}	21.5 ^{a}	3.25 ^{bc}	3030.9 ^{b}	1185.25 ^{df}	**22.1** ^{ab}
	Pp401.15E	7.5 ^{ef}	20.8 ^{ce}	141.8 ^{d}	150.0 ^{cd}	80.5 ^{cd}	16.8 $^{e-h}$	2.55 ^{de}	1974.5 $^{d-f}$	1125.16 ^{cd}	**18.2** ^{c}
	RGS003	8.5 ^{d}	19.8 ^{df}	144.3 ^{c}	167.5 ^{bc}	82.3 ^{cd}	17.8 $^{d-g}$	2.75 ^{de}	2116.9 ^{d}	1160.15 ^{bc}	**20.4** ^{bc}
	Option500	12.0 ^{b}	19.0 ^{eg}	142.8 ^{cd}	143.8 ^{de}	73.0 ^{b}	26.0 $^{g-i}$	2.55 ^{ef}	1888.2 ^{ef}	1110.11 ^{de}	**17.1** ^{d}
6.12	**Hypola401**	7.3 ^{ef}	21.0 ^{cd}	130.3 ^{f}	168.8 ^{bc}	78.5 ^{cd}	19.8 $^{a-c}$	3.03 ^{bc}	20209.0 ^{de}	1080.96 ^{ef}	17.9 ^{d}
	PP401.15E	6.8 ^{fg}	18.5 ^{fg}	131.0 ^{f}	127.5 ^{ef}	75.3 ^{de}	16.5 ^{fi}	2.73 ^{e}	1868.3 $^{e-g}$	1041.9 ^{de}	16.3 ^{de}
	RGS003	8.0 ^{de}	19.3 ^{dg}	133.3 ^{e}	141.3 ^{df}	66.0 ^{eg}	14.8 ^{ig}	2.43 ^{f}	1664.7 $^{g-i}$	1063.65 ^{ef}	16.5 ^{de}
	Option500	10.0 ^{c}	18.5 ^{fg}	133.3 ^{e}	126.3 ^{ef}	60.8 ^{gh}	14.3 ^{j}	2.63 ^{f}	1607.7 ^{hi}	1015.3 ^{gh}	15.2 ^{e}
21.12	**Hyola401**	11.5 ^{b}	17.8 ^{gh}	127.3 ^{g}	122.5 ^{fg}	74.3 ^{de}	18.5 ^{ce}	2.5 ^{ef}	1170.6 $^{f-h}$	1049.30 ^{fg}	15.9 ^{e}
	Pp401.15E	10.0 ^{c}	16.3 ^{hi}	126.8 ^{g}	105.0 ^{gh}	63.5 ^{fg}	15.0 ^{kj}	2.1 ^{g}	1266.8 ^{j}	1015.42 ^{ef}	14.6 ^{f}
	RGS003	11.5 ^{b}	15.3 ^{ij}	130.3 ^{f}	125.0 ^{ef}	60.8 ^{gh}	11.0 ^{k}	2.2 ^{g}	1506.2 ^{i}	1022.66 ^{de}	14.8 ^{f}
	Option500	13.5 ^{b}	14.3 ^{j}	127.5 ^{g}	95.0 ^{h}	51.3 ^{h}	10.3 ^{k}	1.9 ^{g}	1517.9 ^{i}	1009.74 ^{h}	13.8 ^{g}

*: Similar Letters in each column show non-significant difference according to 5% Level in Duncan Multiple Rang Test.

Table 5 - 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 (Cm)	Pod per plant	Seed per pod	1000 grain weight (g)	Harvest index (%)	Total dry matter (gm^{-2})
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 (Cm)	-0.690**	0.400 ns	0.572*	0.682**	0.823**	0.849**						
Pod per plant	-0.723**	00.321 ns	0.400 ns	0.41 ns	0.855**	0.764**	0.822**					
Seed per pod	-0.316 ns	0.206 ns	0.87 ns	0.75 ns	0.637**	0.65 ns	0.526*	0.620*				
1000 grain weight (g)	-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*	00.157 ns	0.431 ns	0.45 ns	0.786**	0.653**	0.689**	0.907**	0.568*	0.886**		
Total dry matter (gm^{-2})	-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 ($Kgha^{-1}$)	-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.

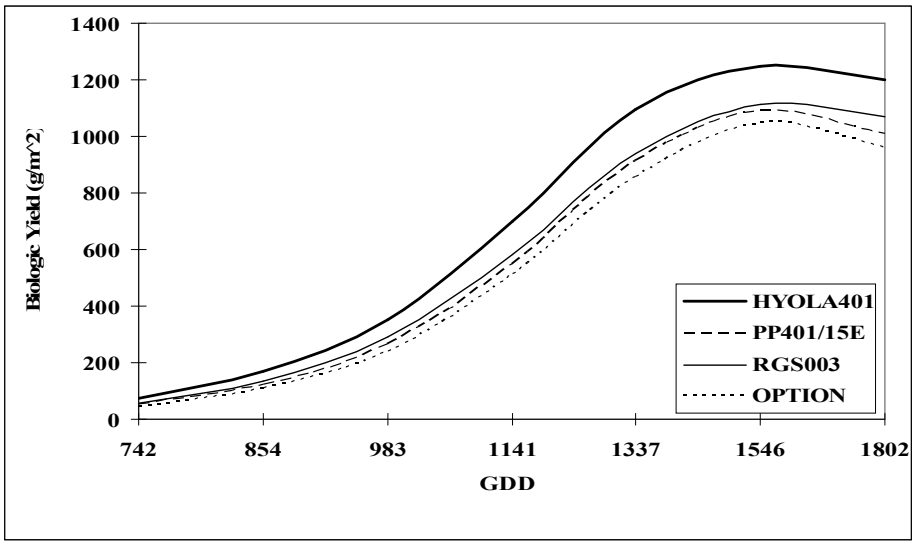

Diagram 1. Effect of genotype on total dry matter

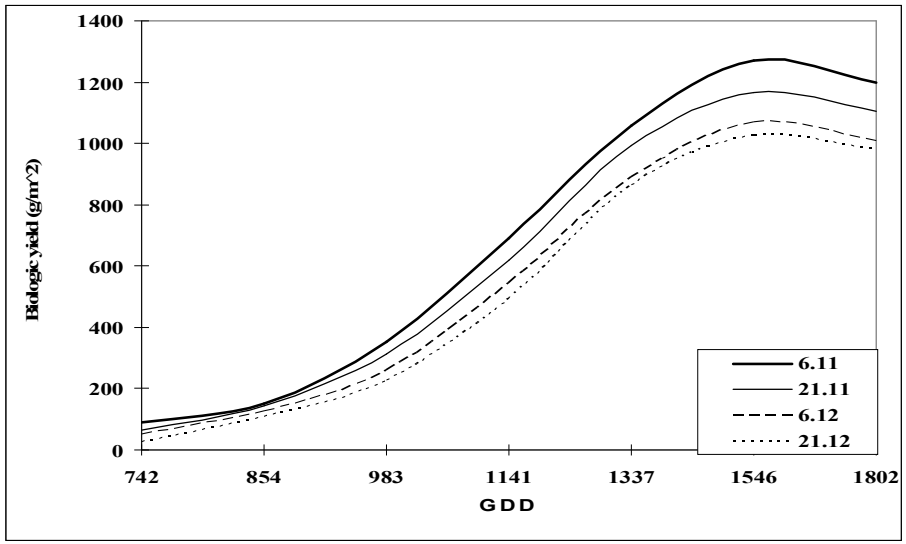

Diagram 2. Effect of planting date on total dry matter

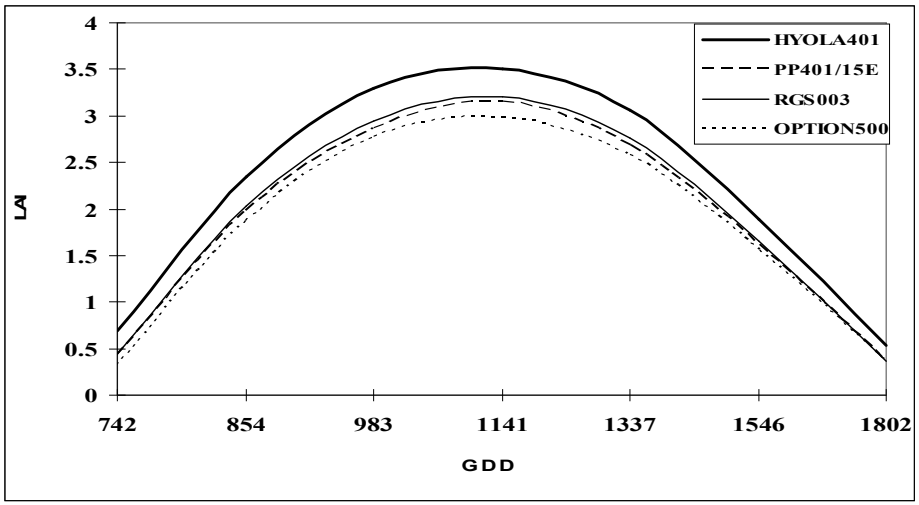

Diagram 3. Effect of genotype on leaf area index

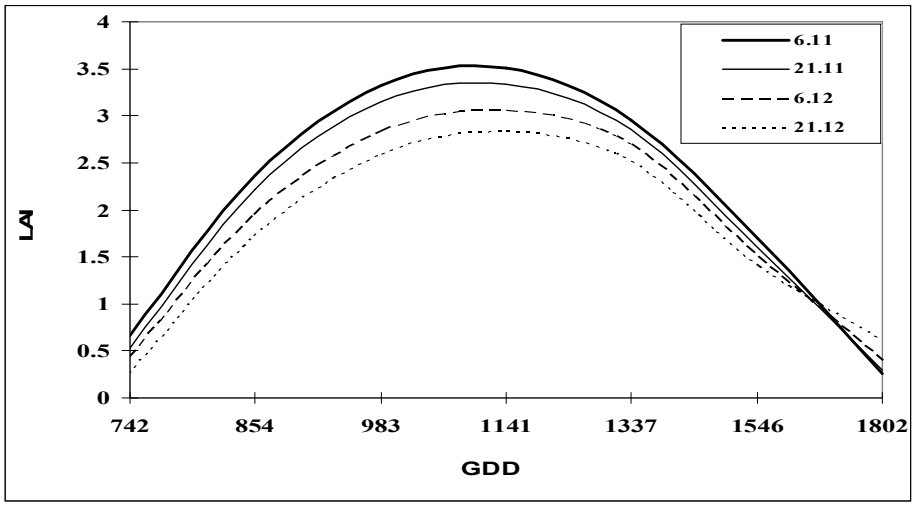

Diagram 4. Effect of planting date on leaf area index

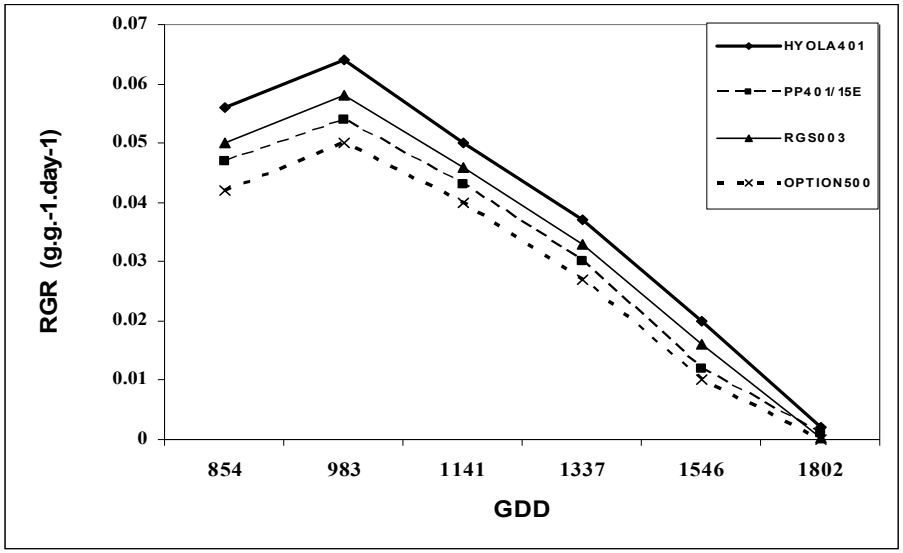

Diagram 5. Effect of genotype on relative growth rate

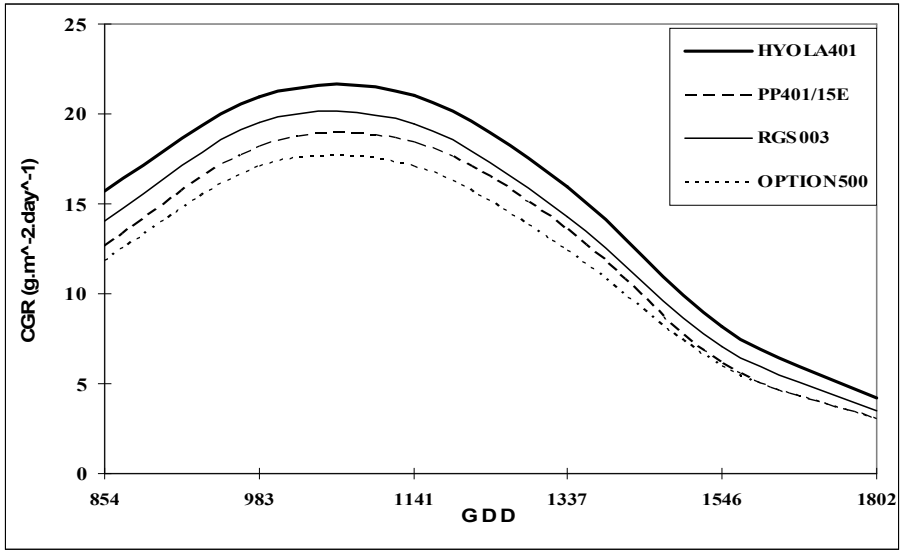

Diagram 6. Effect of genotype on crop growth rate

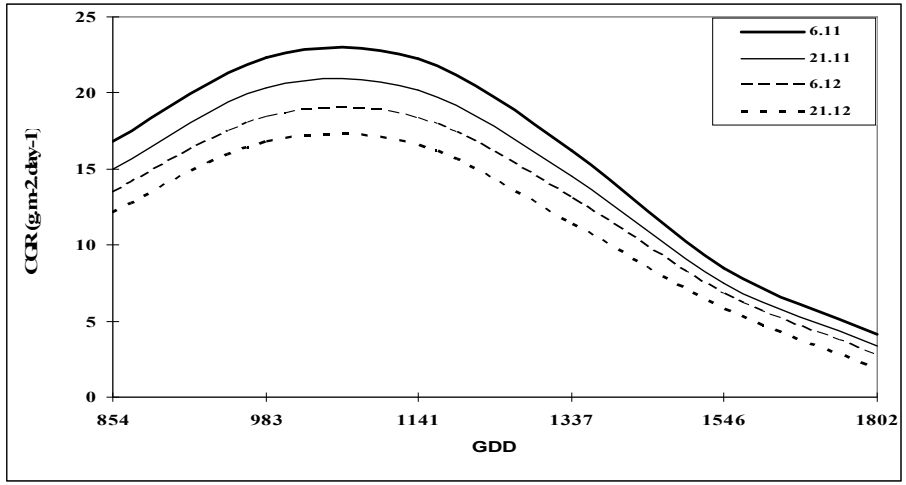

Diagram 7. Effect of planting date on crop growth rate

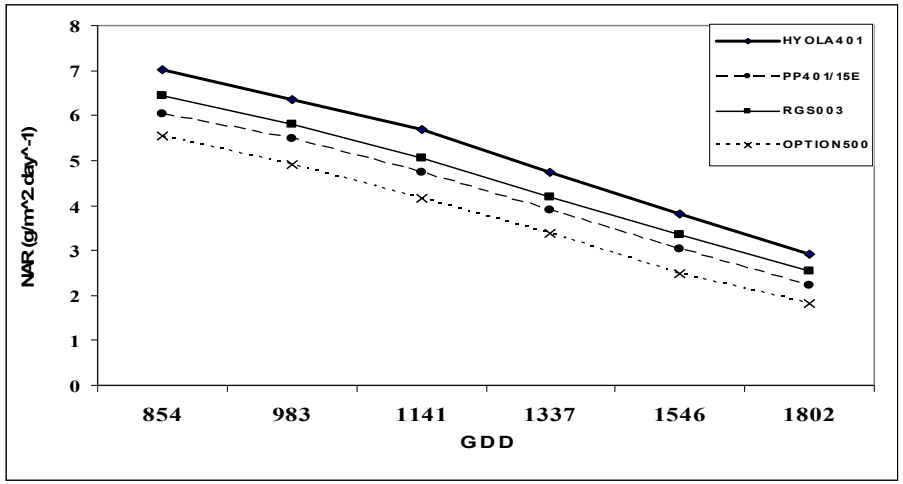

Diagram 8. Effect of genotype net assimilation rate

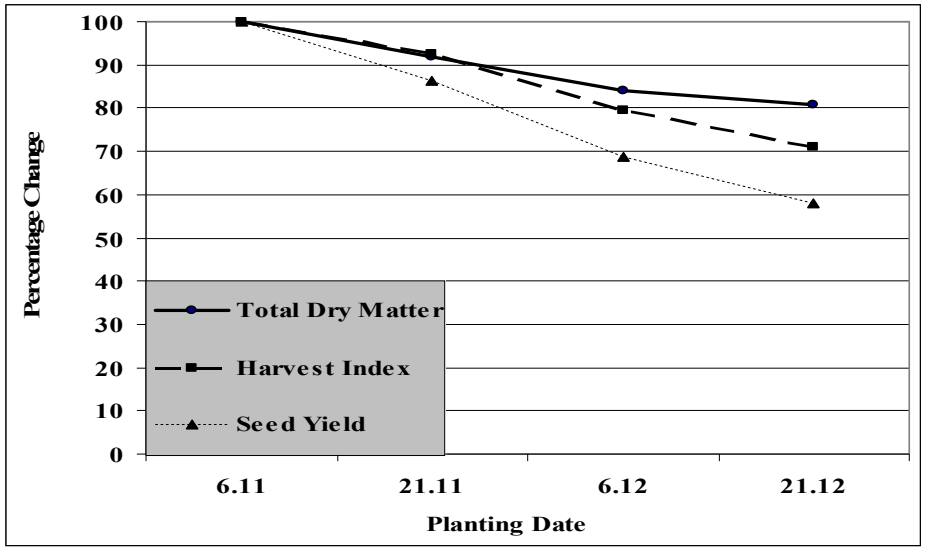

Diagram 9- Percentage change in total dry matter, harvest index and grain yield than the first planting date

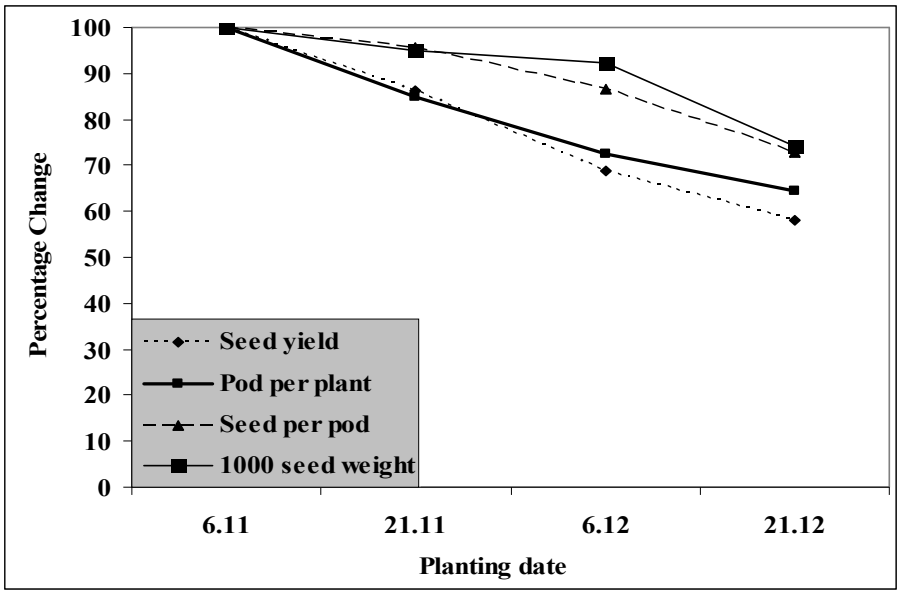

Diagram 10 - Percentage change traits of pods per plant, seed per pod, seed weight and seed yield than the first planting date

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