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Effect of Sowing Date on Physiological Growth Indices in Canola (*Brassica napus* L.) Cultivars in Meshkin Region

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Abstract: In order to evaluate the effect of sowing date on physiological growth indices in canola cultivars in Meshkin Region, an experiment was carried out in Agricultural Research Institute of Meshkin, Iran during the growing season in 2009. This investigation was arranged as factorial experiment based on the randomized complete block design with three replications. Factors were 1) sowing date including 30th March, 14th April, 29th April and 14th May and 2) genotype including three cultivars of canola (Hayola410, RDF003 and Sarigol). The results showed that, the total dry matter, the crop growth rate, the relative growth rate, the seed yield and the biological yield were affected by canola cultivars and sowing date. The highest quantities of total dry matter, crop growth rate, seed yield and biological yield were obtained in the first sowing date. Also in interaction of sowing data with cultivars, the highest seed yield was obtained in Hayola410×first sowing date (30 March). The lowest seed yield was observed in A-+A-Sarigol×fourth sowing date (14 May).The results showed that Hayola410 cultivar was superior in many traits except the seed yield and biological yield. Therefore cultivar of Hayola410 has more potential for many traits. Thus, we can suggest using Hayola410 cultivar and the first sowing date.

Key words: Canola varieties · Crop Growth rate · Relative Growth rate · Seed yield · Sowing Date · Total dry matter · Biological yield

INTRODUCTION

Canola (*Brassica napus* L.) is one of two cultivars of rapeseed or *Brassica campestris* (*Brassica napus L.* and *B. campestris L.*). Their seeds are used to produce edible oil that is fit for human consumption because it has lower levels of erucic acid than traditional rapeseed oils and to produce livestock feed because it has reduced levels of the toxic glucosinolates. Canola is one of the main oil seed crops in the world. Canola has a high adaptability under the different environmental conditions. Canola oil is expanding its market share due to its placement as one of the healthiest of vegetable oils [1, 2]. Canola oil has achieved worldwide commodity status and it is used extensively in Japan, Canada and Europe [3]. Planting date is critical ¡since if canola is planted too early or late and the acceptable planting dates are based upon location and elevation [4, 5] stated that planting date is one of the most important production decisions. Sowing date is an important factor that determines the length of growing season and hence yields. Timely sowing of canola has proven a key to maximize yield potential and by default reduce risk. Spring varieties of canola are sown in Asia. These varieties have a shorter growing season than winter varieties which are grown in Europe.

The plant growth is a complex and dynamic process. Growth analysis is a way to assess what events occurs during plant growth. Growth analysis is a suitable method for plant response to different environmental conditions during plants life [6]. It can be expressed as interaction between genetic [internal] and environment [external] factors. Plant growth analysis is considered to be a standard approach to study of plant growth and

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productivity [7]. 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 [8]. In a crop the growth parameters like optimum LAI and CGR at flowering have been identified as the major determinants of yield [9]. A combination of these growth parameters explain different yields better than any individual growth variable [10]. Several workers reported that the improvement in physiological parameters is associated with higher grain yield in pulses. Total dry matter (TDM), Crop growth rate (CGR) and relative growth rate are, the most important traits in plant growth analysis. Srivastava and Singh [11] reported that growth process i.e. CGR, RGR and NAR directly influenced the economic yield of lentil. Similarly, Thakur and Patel [12] reported that dry matter production, LAI, LAD, CGR, NAR and RGR are ultimately reflected in higher grain yield. Khan *et al*., [13] studied twenty-two genetically diverse chickpea genotypes for their physiological efficiency to select the most desirable genotype/genotypes. Significant difference was found in grain and biological yield of different genotypes. Jasinska *et al.* [14] reported that seed yield decreased with delay in sowing date. Also Taylor and Smith [15] concluded that seed yield declined when sowing date is delayed. Johnson, *et al.* [16] evaluated three canola cultivars at four sowing dates and found that seed yield was the highest at the first two sowing dates. Shafique *et al.* [17] in Pakistan on ten canola varieties found that delaying sowing date significantly decreased plant growth and consequently low yield. Kirkland and Johnson [18] stated that seed yield was greater in the early sowing dates and smaller in the later sowing dates. Horton [19] found that highest yield of canola was observed from earlier sowings.

The present study was, therefore, undertaken to determine effects of different sowing dates on the physiological growth indices in canola (*Brassica napus*, L.) cultivars in Meshkin Region, so that recommendation for optimum sowing date could be made for achieving higher productivity.

MATERIALS AND METHODS

In order to evaluate the effects of sowing date on physiological growth indices in canola cultivars, a field experiment in the year 2009 was conducted in the Agriculture Research Station at western Meshkin (47°29′N and 38°22′E; 1244 elevation) Ardabil, Iran. This investigation was arranged as a factorial experiment based on the randomized complete block design with three replications. The factors were 1) sowing date including 30th March, 14th April, 29th April and 14th May 2) genotypes including three cultivars of canola (Hayola410, RDF003 and Sarigol). According to on the soil test, pH was about 8.15, soil texture was Silt-loam and the depth of top soil was 70 cm (Table 1). The maximum and minimum temperature and precipitation rates at growth season are available in table 2. The experimental unit included six ridges of 25 cm in width and 4 m in length, (i.e.6 m^2). The plant density was 150 plants per m^2. The seeds of three cultivars were sown at the depth of 3 to 4 cm. In order to measure the total dry matter, crop growth rate and relative growth rate, 40-50 days after planting and at 10 days intervals. Some plants were selected randomly from each row of the main plots to be placed in electric ovens of 75°C for 72 hours or more until they reached a constant weight and then the dry weight was weighed. The total dry matter (TDM), crop growth rate and relative growth rate, were calculated by the formulas given by Karimi and siddiqe [20] (Eq 1, 2 and 3). In order to calculate the "growth degree day" of canola during the growth stages we used the formula given by Wall *et al*. [21] (Eq 4).

$$TDM = e^{a+bt+ct2+dt3} \quad \text{(Eq 1)}$$

$$CGR = (b+2ct+3dt^2)\, e^{(a+bt+ct2+dt3)} \quad \text{(Eq 2)}$$

$$RGR = b+2ct+3dt^2 \quad \text{(Eq 3)}$$

$$GDD = \sum \left[\frac{T\max + T\min}{2} \right] - Tb \quad \text{(Eq 4)}$$

Tmax= maximum of temperature
Tmin= minimum of temperature
Tb= base temperature of canola (2°C)

Table 1: The analysis of Physico-chemical properties of the soil

properties		(EC) ds/m	(PH)	(sp) %	(TNV) %	(OC) %	(N) %	(PaVa) PPM	(KaVa) PPM	(C) %	(Si) %	(S) %	Tex	(Zn) PPM	(Fe) PPM	(Mn) PPM	(Cu) PPM
Sampling	0-30	0.5	8.15	48	14.35	1.31	0.1	6	340	18	50	32	Silty-loam	0.86	2	3.5	1.4
depth (cm)	30-60	0.42	8.15	45	22.5	1.2	0.1	7	224	18	45	37	loam	0.85	2	3.5	1.4

Table 2: Meteorological data for Meshkin Agricultural Resources Research during the growth period of canola in cropping seasons (2009)

	temperature (°C)			Relative humidity (%)			Precipitation (mm)	
Months	Max. mean	mean	Min.mean	Max. mean	mean	Min.mean	Max	Sum
April	10.7	6.3	1.9	83.8	63.7	43.6	9.2	43.44
May	16.9	12.1	7.3	43.5	86.0	64.9	14.6	48.8
June	21.7	16.6	11.4	85.2	63.0	40.7	18.4	58.6
July	26.5	21.1	15.7	51.2	70.6	31.7	3.8	9.2
August	23.6	19.0	14.4	83.8	63.8	43.9	8.5	22.9
September	21.4	16.2	11.6	88.0	67.6	47.3	16.4	46.9
October	18.8	13.9	9.0	76	55	35	8.0	10.8

RESULTS AND DISCUSSION

Total Dry Matter: According to the trend in the accumulation of the dry matter (Figure 1-a), at the first sowing date (30th March) up to the flowering stage, the most amount of the accumulation was in Hayola410 while the least amount was in Sarigol. This high rate of the accumulation of dry matter in Hayola410 can be attributed to one or so factors of the yield improvement existing in Hayola410. Some of these factors existing in Hayola410 are faster maturation, better use of suitable environmental conditions and preferable genetic properties. After the flowering stage, on account of the intense fall of the leaves and seeds, the entire accumulation of the dry matter decreases tremendously in these three studied genotypes; this is a genetic trait of rape. I must say that in the next sowing dates (14th April, 29th April, 14th May), Hayola410 was superior to other two genotypes- Sarigol, Hayola410- in terms of the entire accumulated dry mater (Figure 2-a, 3-a and 4-a). Dehdashti *et al.* [22].

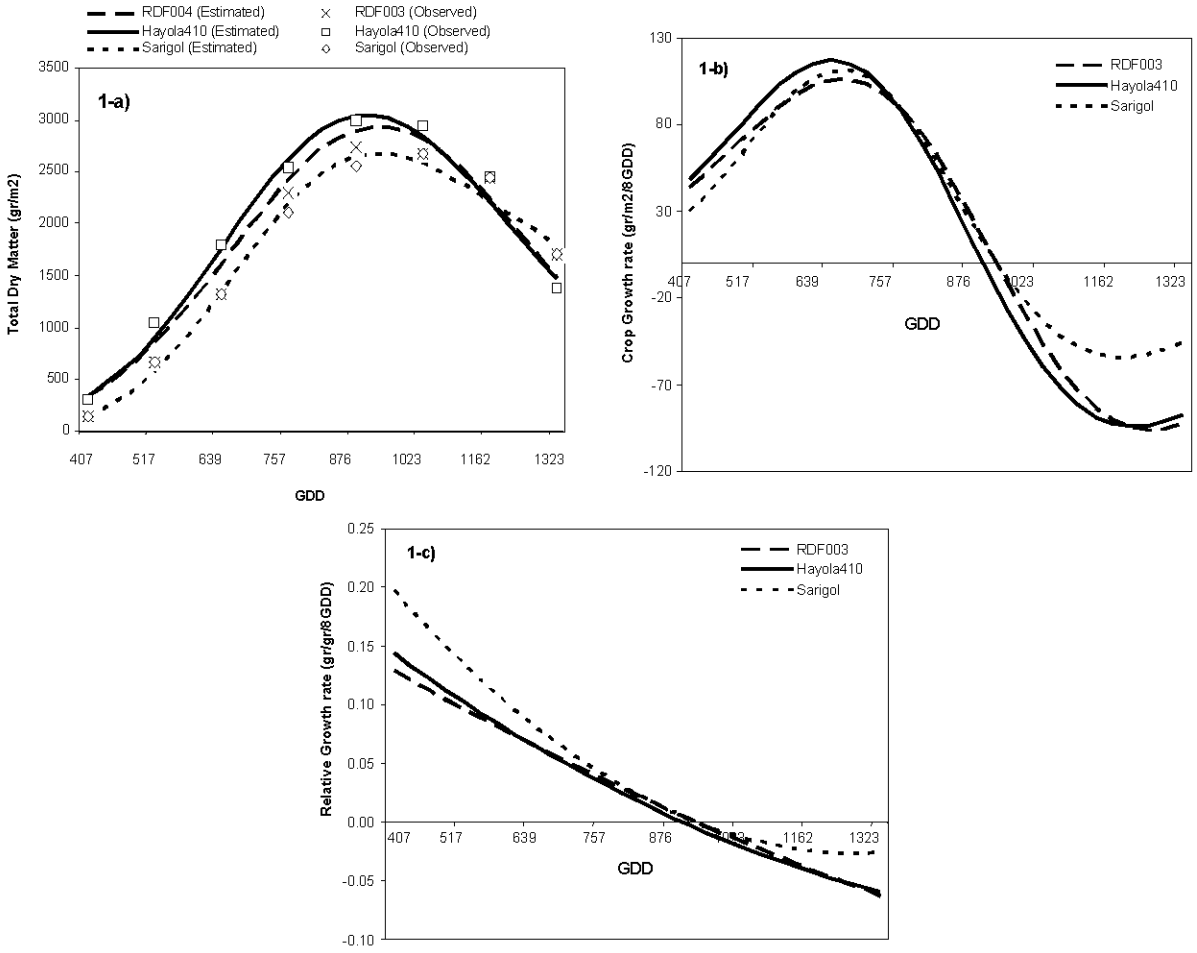

Fig. 1: Trend changes 1-a) total dry matter, 1-b) Crop Growth Rate and 1-c) Relative Growth Rate, at first sowing date.

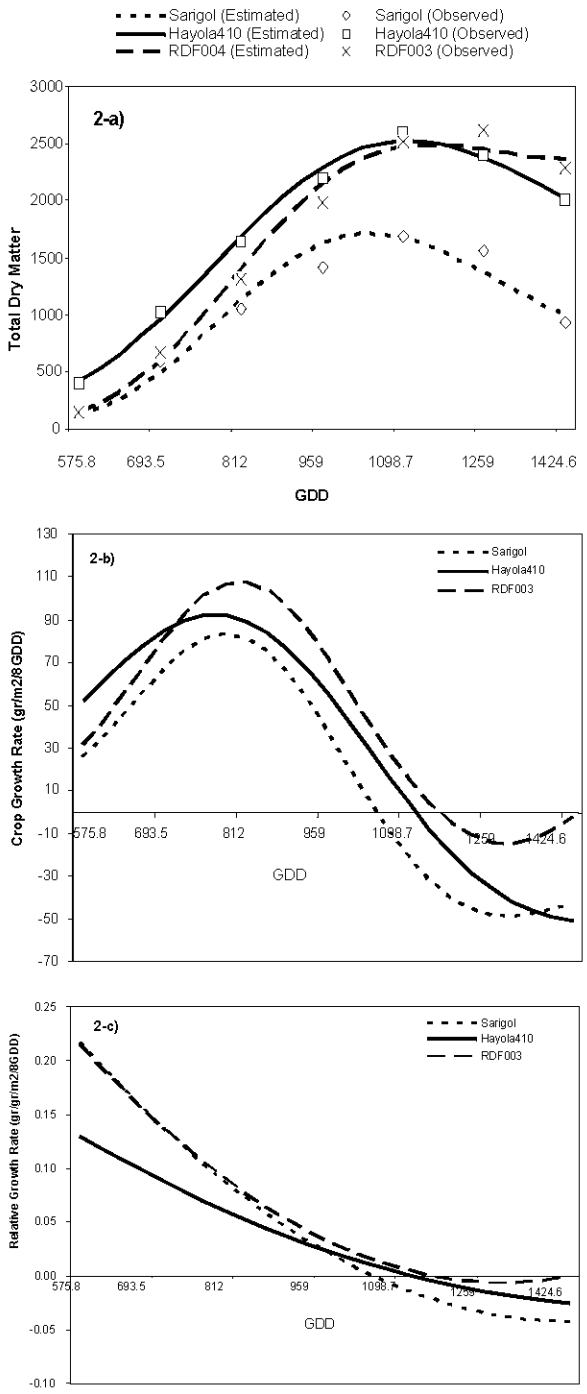

Fig. 2: Trend changes 2-a) total dry matter, 2-b) Crop Growth Rate and 2-c) Relative Growth Rate, at second sowing date.

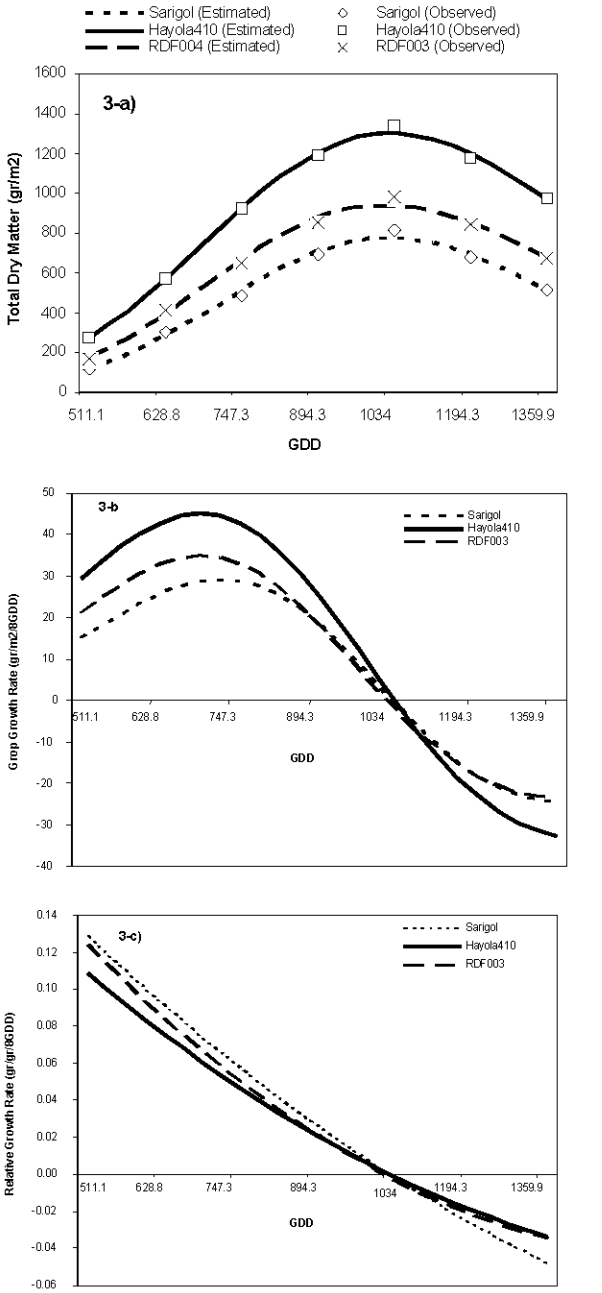

Fig. 3: Trend changes 3-a) total dry matter, 3-b) Crop Growth Rate and 3-c) Relative Growth Rate, at third sowing date.

investigated the physiological reactions of 9 genotypes of rape to the sowing delay. They stated that the studied genotypes were dissimilar in terms of the amount of the accumulated dry matter. In an investigation, Arveen *et al.* [23] studied and compared the yield and physiological indices of growth concerning different genotypes of spring rape. They observed that the rape genotypes significantly differ with each other in terms of the entire yield of dry matter. They announced that Hayola 330 had the largest amount of the dry matter and Goldroush had the least amount.

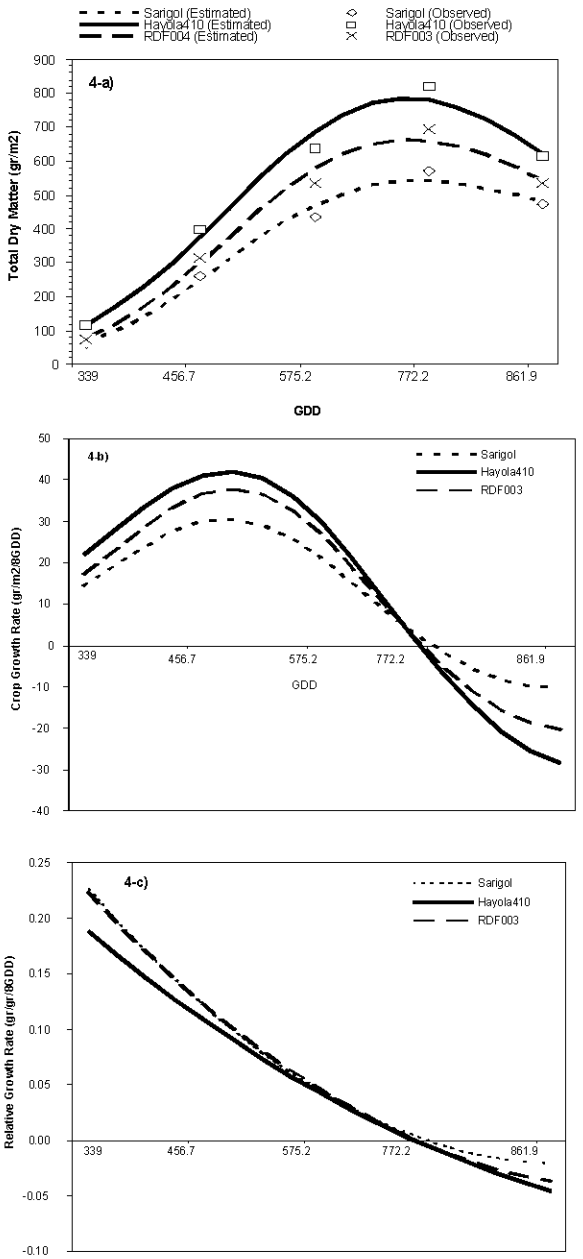

Fig. 4: Trend changes 4-a) total dry matter, 4-b) Crop Growth Rate and 4-c) Relative Growth Rate, at fourth sowing date.

Crop Growth Rate: Based on the findings, at different sowing dates, Hayola410 has more "crop growth rate" than those of other two kinds; after 639 growth degree days, however, the "crop growth rate" of all three genotypes deceases and this goes on until the flowering stage. Afterwards the "crop growth rate" numbers become negative for the reason that there occurs an increase in their respiration, leaf falling, ochrea falling and seed falling. Dehdashty *et al.* [22]. Announce that the genotype of ochrea has a meaningful effect on the "crop growth rate" of it. Concerning the second sowing date, at the beginning of the growth, Hayola410 has had the highest "crop growth rate" but later DRF003 has overtaken Hayola410. In this respect, after 812 growth-degree days all three genotypes declined and, as it was the case with the first sowing date, the "crop growth rate" became negative after the flowering stage. As it was the case with the first sowing date, the reason for this can be the ageing of lower leaves, the respiration increase and finally the fall of leaves, ochreas and seeds. Also the results indicated that at the third sowing dates) 29th April, 14th May), Hayola410 is the best of three in terms of the crop growth rate.

Relative Growth Rate: According to the changes in the trend of the "relative growth rate" of the studied genotypes (Figures 1-c, 2-c, 3-c and 4-c), it is apparent that at the first sowing date 30th March the relative growth rate of Sarigol is the highest of all; however after the flowering stage the relative growth rate of all three genotypes becomes negative. At the second and third sowing dates (29th April and 14th May), Sarigol and RDF003 jointly bear higher relative growth rates than that of Hayola410 while at the last sowing date (14th May) Sarigol has the highest relative growth rate. At the end of the growth stage, the relative growth rate of all three genotype has become negative; this can be attributed to the leaves ageing and consequently the increase in the respiration area as compared to the photosynthetic area. Tesar [6] announces that the "relative growth rate" index is subordinate to the photosynthetic and respirational areas of the plant; that is why as the respiration increases at the end of the growth stage, the relative growth rate becomes negative.

Seed Yield: As shown in Table 4 the results showed that the seed yield was markedly affected by the main and interactional effects of sowing date and cultivars. Hyola410 (1423.39 kg/ha), RDF003 (1289.28 kg/ha) and Sarigol (1040.92 kg/ha) significantly had the maximum seed yields, respectively (Table4). Also the first (2432 kg/ha), second (1943 kg/ha), third (619 kg/ha) and fourth (9.43 kg/ha) sowing dates obviously had the maximum seed yield, respectively. In case of interactional effect, the highest seed yield (2766 Kg/ha) was obtained in Hayola410×first sowing date. The lowest seed yield (5.3 kg/ ha) was obtained in Sarigol×fourth sowing date. The yield reductions in canola at later sowings can be explained by fewer pods per plant and lower 1000-seed

Table 3: Regression equations fitted between the studied parameters and experimental treatment

Treatment*	Total Dry Matter	Crop Growth Rate	Relative Growth Rate	R^2
D1V1	$e^{-7.4994+0.38x-0.0027x2+0.0000043x3}$	$(0.38-0.0054x+0.0000129x2)e^{(-7.4994+0.38x-0.0027x2+0.0000043x3)}$	0.38-0.0054x+0.0000129x2	0.99
D1V2	$e^{-21.1794+0.86x-0.00824x2+0.000024x3}$	$(0.86-0.16x+0.000078x2)e^{(-21.1794+0.86x-0.00824x2+0.000024x3)}$	0.86-0.16x+0.000078x2	0.99
D1V3	$e^{-10.7494+0.51x-0.0042x2+0.000001x3}$	$(0.51-0.0084x+0.000003x2)e^{(-10.7494+0.51x-0.0042x2+0.000001x3)}$	0.51-0.0084x+0.000003x2	0.98
D2V1	$e^{-11.7994+0.57x-0.003x2+0.00014x3}$	$(0.57-0.01x+0.000048x2)e^{(-11.7994+0.57x-0.003x2+0.00014x3)}$	0.57-0.01x+0.000048x2	0.99
D2V2	$e^{-28.434+1.13x-0.012x2+0.00042x3}$	$(1.15-0.024x+0.00126x2)e^{(-28.434+1.13x-0.012x2+0.00042x3)}$	1.15-0.024x+0.00126x2	0.99
D2V3	$e^{-28.684+1.12x-0.011x2+0.000037x3}$	$(1.12-0.022x+0.000111x2)e^{(-28.684+1.12x-0.011x2+0.000037x3)}$	1.12-0.022x+0.000111x2	0.98
D3V1	$e^{-2.694+0.32x-0.0032x2+0.0000093x3}$	$(0.32-0.0064x-0.0000285x2)e^{(-2.694+0.32x-0.0032x2+0.0000093x3)}$	0.32-0.0064x-0.0000285x2	0.99
D3V2	$e^{-4.334+0.39x-0.0042x2+0.000013x3}$	$(0.39-0.0084x+0.000039x2)e^{(-4.334+0.39x-0.0042x2+0.000013x3)}$	0.39-0.0084x+0.000039x2	0.99
D3V3	$e^{-4.44+0.33x-0.003x2+0.000008x3}$	$(0.35-0.0068x+0.0000249x2)e^{(-3.284+0.311x-0.008x2+0.000034x3)}$	0.35-0.0068x+0.0000249x2	0.99
D4V1	$e^{-3.284+0.311x-0.008x2+0.000034x3}$	$(0.51-0.016x+0.000108x2)e^{(-3.284+0.311x-0.008x2+0.000034x3)}$	0.51-0.016x+0.000108x2	0.99
D4V2	$e^{-5.894+0.444x-0.011x2+0.000048x3}$	$(0.66-0.022x+0.00018x2)e^{(-5.894+0.444x-0.011x2+0.000048x3)}$	0.66-0.022x+0.00018x2	0.99
D4V3	$e^{-1.4794+0.71x-0.0129x2+0.000073x3}$	$(0.71-0.0258x+0.000225x2)e^{(-1.4794+0.71x-0.0129x2+0.000073x3)}$	0.71-0.0258x+0.000225x2	0.99

* D1, D2, D3 and D4 are first, second, third and fourth sowing date respectively. V1, V2 and V3 are Hayola410, RDF003 and Sarigol respectively

Table 4: Analysis of variance for seed yield, biological yield and harvest index of canola genotypes at different sowing dates

		MS		
S.O.V.	df	Seed yield	Biological yield	Harvest index
Block	2	140223*	1112621	3.87
Sowing date (SD)	3	11445905**	116695145**	743.14**
Genotype (G)	2	451916**	4067282**	0.0608
SD × G	6	135937**	1014463*	6.775
Error	22	29351	452119	31.396
C.V. (%)	-	13.69	15.88	22.91

*, ** significant at the 0.05 and 0.01 level, respectively.

Table 5: Mean comparison for seed yield, biological yield and harvest index of canola genotypes at different sowing date

		MS		
Treatment		Seed yield ($Kgha^{-1}$)	Biological yield ($Kgha^{-1}$)	Harvest index (%)
Sowing date	30-March	2432.07a	7449.4a	30.587 a
	14-April	1943.8b	6432.2b	30.222a
	19-April	619.44c	2446.6c	25.678a
	14-May	9.43d	102.8d	11.322b
Genotypes	Sarigol	1040.92b	3628.0b	24.525a
	Hayola410	1423.39a	4759.3a	24.442a
	RDF003	1289.28a	4280.9a	24.383a

*Means, in each column and for each factor, followed by similar letter(s) are not significantly different

weight [24]. This reduction in seed yield with delaying sowing has been verified in the early field studies [25, 26 and 27]. The late sowing usually causes a decline in the growth and the leaf area as well as a faster maturation [28]. Thus Si and Walton [29] reported that with the delay of sowing date, the yield and yield component of canola decreased. Similar results were reported by Miralles *et al.* [30], Lunn *et al.* [31] and Hocking and Stapper [32].

Biological Yield: The main effect of sowing date and the main effect of the genotype on biological yield are meaningful at 1% probability while their interactional effect on biological yield is meaningful at 5% probability (table 4). The largest quantity of biological yield (7949.4kg/ha) was obtained at the first sowing date (30th March) and the next sowing dates (14th April, 29th April and 14th May) ranked the next ones respectively. The least quantity of biological yield (102.8kg/ha on average) concerns the last sowing date -14th May. According to the Table of Mean Comparisons, Hayola410 has had the most quantity (4789.3kg/ha) of biological yield which does not differ statistically with that of RDF003 and the two kinds both are classified in group A. Moreover Sarigol has had the least (3628kg/ha) biological yield (3628kg/ha) (Table 5). Taking into account the Figure concerning the interactional effect of sowing date on genotype, indicates that Hayola410 sown at 30th March has had the best biological yield and was grouped in the same group as RDF003 sown at the very date. All three genotypes (Sarigol¡ Hayola410æ RDF003) had the least biological yield at the last sowing date (Figure 6).

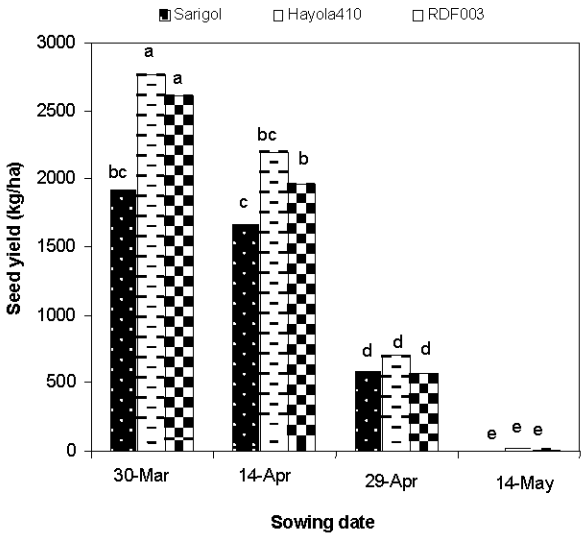

Fig. 5: Seed yield changes as affected by interaction of sowing date and genotype

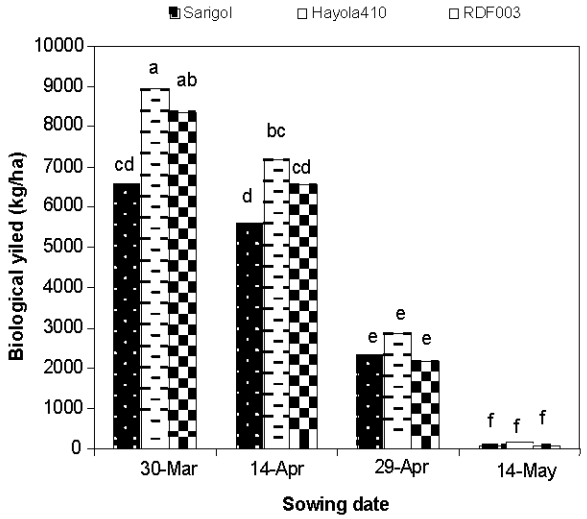

Fig. 6: Biological yield changes as affected by interaction of sowing date and genotype

Harvest Index: According to the analysis of variances (Table 4), only the main effect of sowing date on the harvest index is meaningful and neither the main effect of genotype nor the interactional effect between the sowing date and genotype affect the "harvest index" meaningfully. The highest "harvest index" concerns the sowing date of 30th March (30.587) although this number does not statistically differ with the harvest indexes of 14th April and 29th April and all quantities are classified in the same group. The least quantity of harvest index (11.322 percent) concerned the last sowing date (Table 5). Johnson *et al.* [16] by comparing different dates of rape sowing concluded that through the delay in sowing, the "harvest index" noticeably decreases. These results correspond with findings of Song *et al.* [33] and Mc Key *et al.* [34].

CONCLUSION

The results obtained from this research proved that the optimum seed yield of the studied genotypes occurred at the first sowing date (30th March) and at the next sowing dates there was a significant decline in the yield of the studied genotypes, as at the last sowing (14th May) the obtained yield was very few- a few killograms approximately. Hayola410 revealed higher seed yield than other genotypes did. The increase in the seed yield of the investigated genotypes at different sowing dates and the difference between theses genotypes can be attributed to their various genetic powers to apply the ecological agents during their growth. As it was mentioned earlier, Hayola410 had higher "relative growth rate" than other genotypes had; this enables hayola410 to produce more dry matter and consequently to have better seed yield as compared to other genotypes. Thus, in order to attain the optimal seed yield in any region which is under investigation, we advise cultivating Hayola410 at the first sowing date (30th March).

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