Middle-East Journal of Scientific Research 13 (9): 1202-1212, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.13.9.895

Effect of Sowing Date on Some Phenological Stages and Oil Contents in Spring Canola (*Brassica napus*, L.) Cultivars

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Abstract: In order to investigate the effect of sowing date on phenological stages, yield and oil content in canola varieties, an experiment was conducted at Ardabil (Iran) in 2009. The experimental was evaluated at factorial in randomized completely block design with three replication. The first factor was sowing dates including 30th March, 14th April, 29th April and 14th May second factor was three varieties of canola including Hayola-410, RDF-003 and Sarigol. Results indicated that the stage of 50% greening, complete green, bolting stage, branch development stage, flowering stage, 50% flowering stage, 50% pod development stage, length of flowering period, length of reproductive period, growth period, seed yield, biological yield, Oil yield and oil content were obtained in the first sowing date (30th March). Also in interaction of sowing date and cultivar, the highest stage of 50% greening, 50% flowering stage and 50% pod development stage were obtained in Sarigol×first sowing date. In interaction of Hayola410×first sowing, the highest seed and biological yield were obtained. Lowest seed and biological yield were detected in sarigol×fourth sowing date (14th May). Results showed that Hayola410 cultivar was superior in many traits except seed and biological yield. Therefore cultivar of Hayola410 has more potential for many traits. Thus, it can be suggested that use Hayola410 cultivar and first sowing date (30th March).

Key words: Canola cultivars · Oil content · Phenological traits · Seed yield and Sowing date

INTRODUCTION

Canola (*Brassica napus* L.), is an important oil crop growing in many part of the world [1]. Canola lines have become more important to the western world, through breeding for better oil quality and improved processing techniques [2]. Edible oil was first extracted in Canada in 1956 [3]. Canola has some good characteristics such as suiTable placement in crop rotation, desirable quality, high value of oil (40 - 45%) and protein (39%) that has changed it to an important crop [4]. Canola cultivars appear to be best adapted to the conditions of Iran; however, some cultivars are less tolerant to environmental conditions [1]. There are wide variations among the cultivated canola cultivars with respect to seed and oil yields per unit area at different planting dates as well as irrigation regimes [1]. The canola seed contains 40-50 percent oil. Iran is not on a high level in terms of producing the oil seeds; about 80% of Iran's necessary oil is imported from foreign countries. Therefore the country gives priority to the production of oil products [5].

Sowing dates is an important factor that determines the length of growing season and hence yields. Sowing dates obviously affect canola yield and yield components [1]. Early spring sowing of oil canola delayed flowering and reduced reflection of radiation during flowering which were important factors leading to the highest yields achieved by late sowing. Effect of sowing dates on yield, yield components and quality was studied by many investigators [6-8], Who reported that the early Sowing increase oil yield and oil percentage. Horton [9] found that highest yield of canola was observed from earlier

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sowings. A number of studies have shown yield decline in canola with delay in sowing [10]. In addition, canola oil content has been found to decline with later sowing [10]. Also, Hocking and Stapper [11] concluded that oil concentration reduced by 3% per month of sowing delay. Early seeding is recommended, but seeding should be late enough to avoid damage from spring frost just after emergence [6].

Ideal sowing date for one or more variety allows for availability of a set of environmental factors that favor a desirable greening, establishment and survival of the plantlet which as a result the plant encounters favorable environmental conditions and avoid unfavorable ones during each stage of its growth [11]. Studies have shown that low and high temperatures during flowering stage are the main factors decreasing grain crops through inoculating pollens [12]. Johnson *et al*. [13] argued that high yield production in canola follows a long pod development and flowering period under the low daily mean temperature. Asgari and Moradie-Dalini [14] after an investigation on sowing date reported that sowing date had a significant effect on traits such as day number to flowering, length of flowering period and length of vegetative growth. Diepenbrock [15] after reviewing studies conducted on canola found that traits such as length of flowering stage and length of growth period play a significant role in improvement of grain yield of canola. In addition, report by Vaezi *et al*. [16] suggests a decreased grain yield following a short reproductive growth. Gross [17], after an investigation on the effect of sowing date on phenological stages of canola reported that a delayed sowing had a decreasing effect on grain yield through shortening time required for vegetative and reproductive growth. The experiment conducted by Mendham *et al*. [18] revealed that a delayed sowing accelerate growth and decrease day number from sowing to flowering by 50%. Khan *et al*. [19] reported that delayed sowing led to decreased day number to flowering and maturity as well as grain yield. These results are in line with those reported by Mandal *et al*. [20]. Miralles *et al*. [21] reported that late sowing of canola led to decreased grain yield and decreased growth. Si and Walton [22] reported that every two weeks of delay in canola sowing resulted in decrease of roughly 1.1% oil and of 309 Kg/ha grain yield. Robertson *et al*. [23] reported that delayed sowing shortened the time to flowering and maturity by 50%.

The present study was undertaken to assess the effect of sowing dates on phenological stages, yield and oil content of three cultivars of canola.

MATERIALS AND METHODS

To study the effects of sowing date on phenological stages and oil contents of canola, 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.

Following traits were identified in order to measure phenological traits: 50% greening: once approximately 50% of plants in a given plot are green. Complete green: once approximately all the plants in a given plot are green. Bolting: outgrowth of stems from the plant and elongation of first internode in 50% of the plants. Day number to flowering: number of days from germination to start of flowering. Start of flowering: appearance of first flower in 50% of plants in a given plot. Length of flowering period: the length between start and end of flowering was calculated in days. The start of flowering is when at least 10% of the plants have flowered, whereas the end of flowering is when 95% of flowering has happened. Length of reproductive period: time length from the start of flowering to physiological maturity. Physiological maturity: when the plants are getting yellow colored and grains are hard enough not to be crushed when compressed between fingers. Total growth period: the time between germination and maturity after at least 45 to 50% of grains are incased with browned capsule, which is calculated in day. In order to measure the oil percentage of the grains, certain part of the samples was analyzed using Seed-Analysis-Device and then calculated in percent. Oil yield also was estimated using oil percentage obtained from seed analysis device and following equation, which can be generalized to oil yield per hectare.

Oil Yield = oil percentage × dry weight of sampled grains

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

Properties		(EC) ds/m	(PH)	(PaVa) (sp) %	(KaVa) (TNV) %	(OC) %	(Zn) (N) %	(Fe) PPM	(Mn) PPM	(Cu) (C) %	(Si) %	(S)%	Tex	PPM	PPM	PPM	PPM
Sampling depth	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
(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

The obtained data were first subjected to normal test and data converting was used for the traits that did not follow the normal test. Data were analyzed as factorial design based on randomized complete blocks using SAS software. Excel and Word software were used to draw Tables and diagrams.

RESULTS AND DISCUSSION

Phenological Stages: Stage of 50% greening: based on results from analysis of variance the effect of sowing date and variety and interaction between them on 50% greening stage were significant at 1 and 5% probability levels, respectively (Table 3). Sowing date of March 30th had the highest effect on reaching to stage of 50% greening (17.77 days), followed by April 14th and April 29th and then by May 14th (4.33 days), which had the lowest time to stage of 50% greening (Table 4). Asgari and Moradie-Dalini [14] also argued that by delayed sowing the length of vegetative stage decreases. This can be due to low temperature at first sowing date and to gradual warming of weather during spring season. Among the varieties, Sarigol had the longest period (13.58 days) of reaching the stage of 50% greening (Table 4). Asgari and Moradie-Dalini [14] also characterized the effect of vegetative growth as significant. Sarigol is a late-maturing variety and has had the longest of all phenological stages. In the study on interaction of "sowing date × variety", also it was categorized as group A in sowing dates of March 30th and April 14th, whereas in sowing date of March 30th it was in the same place as RDF003. In addition, Hayola-401 along with RDF003 was categorized as the lowest group at sowing date of May 14th. Hayola-401 was an early-maturing cultivar so that it had the lowest times required for most phenological stages, particularly in last sowing date (Fig. 1).

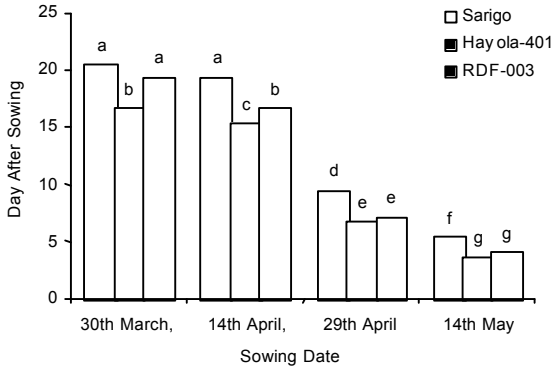

Fig. 1: Interaction effect of sowing date and cultivar on 50 percentage of greening

Complete Green: based on Table of analysis of variance (Table 3), the main effect of sowing date and variety on complete greening stage was significant at 1% probability level. In addition, based on Table of mean comparisons (Table 4), the first sowing date had the longest time (31.11 days) for complete greening, which is significantly different from other sowing dates, so much as there is a difference as high as 400% between first (March 30th) and last (May 14th) sowing dates. This can be due to warming of weather during spring season. Asgari and Moradie-Dalini [14] argued that delayed sowing leads to shortening of various vegetative stages. Sarigol, characterized as a late-maturing cultivar, had the longest time required for complete greening (19.16 days) and was significantly different from two other varieties namely Hayola-401 and RDF003 (Table 4). It shows a difference as high as 24% with early-maturing Hayola-410, which reached its complete greening stage in 15.41 days. Sarigol had the longest time in most of the phenological stages, as it is a late-maturing cultivar, whereas Hayola-401 as an early-maturing cultivar had the shortest time required for

Table 3: Analysis of variance for phenological stages of canola genotypes at different sowing date

		MS									
S.O.V	df	Stage of 50% greening	Complete green	Bolting stage	Branch development stage	Flowering stage	50% flowering stage	50% pod development stage	Length of flowering period	Length of reproductive period	Growth period
Block	2	19/1	11/0	58/28 **	36/13 **	86/4 *	58/5 *	58/1	25/5	11/10	75/27 *
Sowing Date (SD)	3	84/448 **	69/1138 **	43/233 **	87/487 **	77/660 **	37/885 **	51/1296 **	21/277 **	95/1553 **	65/4093 **
Cultivar (C)	2	44/27 **	02/43 **	08/115 **	86/83 **	11/88 **	25/102 **	00/247 **	58/3	86/1018 **	58/1608 **
C ×SD	6	48/1 *	13/2	37/10 *	*15/2	22/4	39/2 *	18/24 **	87/6 *	78/10	54/16
Error	22	46/0	14/1	94/4	75/0	52/2	12/1	28/1	18/3	92/10	44/8
C.V. (%)	-	70/5	23/6	57/5	92/1	22/3	03/2	77/1	24/12	82/6	97/2

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

Table 4: Mean comparison for phenological stages of canola genotypes at different sowing date

		MS									
Treatment		Stage of 50 % greening (day after sowing)	Complete green (day after sowing)	Bolting stage (day after sowing)	Branch devel--opment stage (day after sowing)	flowering stage (day after sowing)	50% flowering stage (day after sowing)	50% pod develo--pment stage (day after sowing)	Length of flowering period (day)	Length of reproductive period (day)	Growth period (day)
Genotypes	30-March	77/18 a	11/31 a	66/42 a	77/50 a	33/58 a	88/62 a	44/75 a	44/19 a	66/61 a	22/120 a
	14-April	11/17 b	11/21 b	11/44 a	22/51 a	11/53 b	55/56 b	55/69 b	66/17 b	77/57 b	88/110 b
	19-April	66/7 c	11/10 c	22/40 b	11/43 b	33/47 c	44/49 c	00/62 c	33/14 c	66/38 c	00/86 c
Sowing date	14-May	33/4 d	22/6 d	66/32 c	66/35 c	33/38 d	77/39 d	66/47 d	88/6 d	77/35 c	77/74 d
	Sarigol	58/13 a	16/19 a	83/42 a	00/48 a	33/52 a	33/55 a	83/67 a	16/15 a	91/55 a	25/108 a
	Hayola410	58/10 c	41/15 c	66/36 c	75/42 c	16/47 b	58/49 c	83/58 c	08/14 a	/38 c	33/85 c
	RDF003	75/11 b	83/16 b	25/40 b	83/44 b	33/48 b	58/51 b	33/64 b	50/14 a	33/51 b	66/99 b

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

various phenological stages. It is known that varieties carry differences with each other in terms of growth period and various phenological stages. Notably, Razmi [24] argues that there is a significant difference between the varieties in terms of day number from greening to flowering and length of growth period. Maralian *et al*. [25] also stated that the traits being studied such as length of growth period are influenced by the cultivar at 1% probability level.

Bolting Stage: Based on Table of analysis of variance (Table 3) the main effect of sowing date and variety and their interaction on bolting stage were significant at 1% and 5% probability levels, respectively. results showed that sowing dates of March 30th and April 14th jointly were in the highest group and had the longest time before reaching bolting stage, whereas May 14th was the last sowing date, which had the shortest time (32.66 days) before reaching bolting stage (Table 4). Razmi [25] reported that the effect of sowing date on vegetative growth stages of canola genotypes was significant. Hocking and Stapper [10], reported that late sowing had a shortening effect on vegetative growth period (before flowering) of canola. In late sowings during spring season, plant tends to cut short various phenological stages to avoid environmental stresses such as heat, drought etc. as it is evident in this experiment that late sowing dates terminated various phenological stages in a shorter time than early sowing dates. Sarigol experienced the longest vegetative growth stages including the time to reach bolting (42.83 days) and was in the highest group, whereas Hayola-401(36.66 days) as an early-maturing cultivar was in the lowest group (Table 4). Asgari and Moradie-Dalini [14] also reported that variety had a significant effect on various vegetative growth stages in canola. As mentioned before, Sarigol is a late-maturing variety and terminate other phenological stages later than two other varieties, as well. Investigation on interaction of sowing date and variety on day number to bolting put Sarigol planted on April 14th along with RDF003 planted on March 30th on the highest group. In contrast, the early-maturing variety of Hayola-401 planted on May 14th along with RDF003 planted on the same date was placed on the lowest group (Fig. 2). Late-maturity and early sowing date actually were two factors that contributed to longest bolting stage of Sarigol, which ended on March 30.

Branch Development Stage: based on results from Table of analysis of variance the main effect of sowing date and variety and their interaction on branch development stage were significant at 1% and 5% probability levels, respectively (Table 3). Based on Table of mean comparisons, sowing date of April 14th (51.22 days) had the longest time to reach branch development stage and along with March 30th was placed at highest group, whereas May 14th (35.66 days) had the shortest time to reach this stage (Table 4). Maralian *et al*. [25] stated that delayed sowing had a shortening effect on vegetative growth period and subsequently growth period of canola.

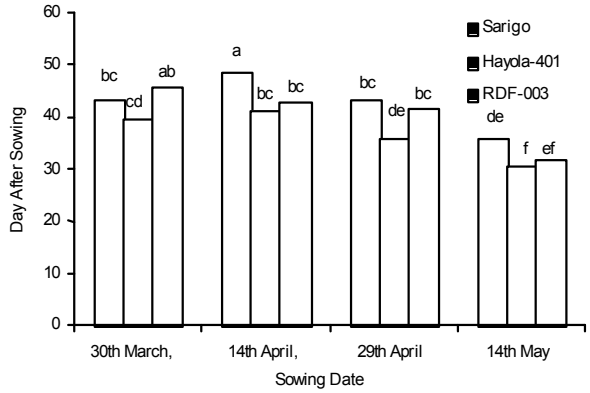

Fig. 2: Interaction effect of sowing date and cultivar on bolting stage

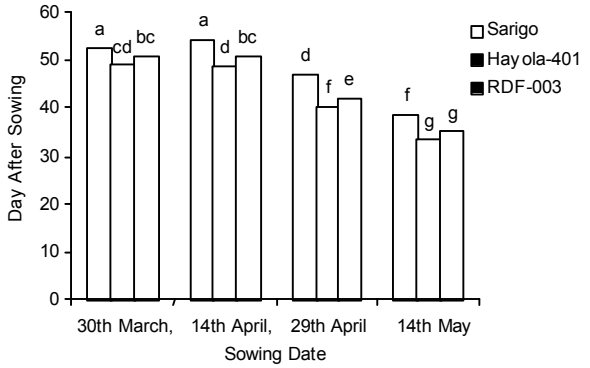

Fig. 3: Interaction effect of sowing date and cultivar on branching stage

Gross [17] argued that delayed sowing, had a limiting effect on the vegetative growth of the plant and in the regions with short growth season led to remarkable decrease in yield. As mentioned previously, in late sowing plant tends to cut short various phenological stages to avoid environmental stresses, even at the expense of dramatic yield loss. The late-maturing variety of Sarigol reached to branch development stage within 48 days as of sowing, whereas the late maturing variety of Hayola-401 reached this stage earlier than two other varieties and within 42.75 days as of sowing (Table 4). This is the genetic characteristics that make Sarigol a late maturing variety and Hayola-401 an early maturing one, which in turn leads to this difference. In the study on interaction of sowing date and variety, late maturing variety of Sarigol had the highest values in sowing dates of March 30th and April 14th and was the last to reach branch development stage, whereas early maturing variety of Hayola-40, with last sowing date that is May 14th, along with RDF003was placed at lowest group (Fig. 3).

Flowering Stage: results from Table of analysis of variance showed that the main effect of sowing date and variety on flowering stage was significant at 1% probability level (Table 3). Based on Table of mean comparisons (Table 4), sowing date of March 30th (58.33 days) had the longest time before entering flowering stage. The shortest time (38.33 days) before the start of flowering stage belonged to last sowing date that was May 14th. According to Razmi [24] the effect of sowing date on flowering stage was significant. Nanda *et al*. [26] argued that as the day length increases, the flowering of canola happens earlier. Khan *et al*. [19] after studying the effect of sowing date on canola concluded that delayed sowing led to decreased day number to flowering. This is so because in early and on timely sowings during spring season as the environmental conditions for growth are favorable for plant, it has more time for various activities and consequently can complete various phenological stages. However, in delayed sowing, due to unfavorable environmental conditions plant tends to reach reproductive and seed production stage earlier. In the study on main effect of variety, Sarigol had the longest time (52.33 days) for this reaching this stage, which was placed at highest group, whereas early-maturing variety of Hayola-401 was placed at lowest group (Table 4). Vaezi *et al*. [16] stated that there is a significant difference between various experimental lines in terms of some of the important agronomical traits such as days to flowering, at 1% probability level, representing genetic variation among the cultivars. Asgari and Moradie-Dalini [14] also reported that variety had a significant effect on days to flowering.

50% Flowering Stage: results indicated that the main effect of sowing date and variety and their interaction on 50% flowering stage was significant at 1 and 5% probability levels, respectively (Table 3). Based on Table of mean comparisons, the highest time to reach 50% flowering stage belonged to the first sowing date (62.88 days), which was placed at the highest group and was significantly different from others, so much that the earliest sowing date (March 30th) reached 50% flowering stage 58% more extendedly than last one (May 14th). The last sowing date reached this stage within 39.77 days (Table 4). Delayed sowing tends to cut short, however little it may be, various growth stages in order to avoid unfavorable environmental conditions and to be able to produce seeds. Mendham *et al*. [18] reported that delayed sowing leads to accelerated growth and consequently to

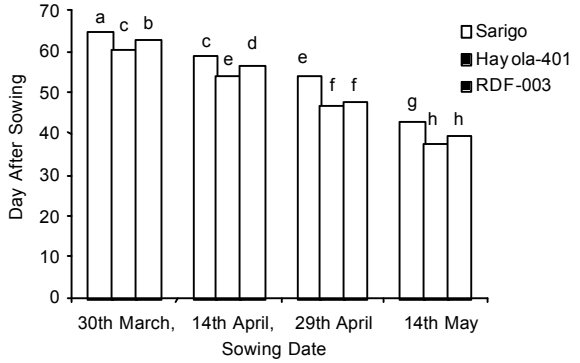

Fig. 4: Interaction effect of sowing date and cultivar on 50 percentage of flowering

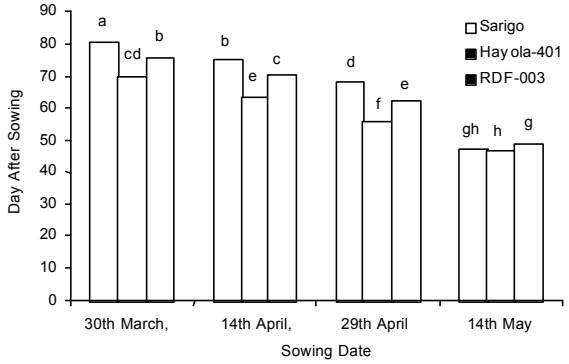

Fig. 5: Interaction effect of sowing date and cultivar on 50 percentage of pod development

decreased number of days to 50% flowering as of sowing. Robertson *et al*. [23] during a study on response of canola and Indian mustard to sowing date reported that the more delayed the sowing, the shorter was time to reach 50% flowering and maturity. Similarly, delayed sowing appears to have led to accelerated growth and faster phenological stages to avoid stress. In addition, investigating the main effect of variety revealed that the highest time (55.33 days) to reach 50% flowering stage belonged to late-maturing Sarigol cultivar, which was placed at the highest group. Hayola-401 cultivar was placed at the lowest group that was C group (Table 4). Based on the Diagram for interaction of sowing date and variety (Fig. 4), one can see that Sarigol cultivar planted in first sowing date (March 30th) was placed at highest group. In addition, Hayola-401 and RDF003 cultivars shared the lowest group in May 14th sowing date. Characteristic late-maturity combined with early sowing date caused Sarigol cultivar to enter 50% flowering stage after a more extended period. In contrast, Hayola-401 cultivar is an early maturing, with the lowest time for most of the phenological stages and in its case, the characteristic early-maturity combined with late sowing has caused early entry of the cultivar to this stage.

50% Pod Development Stage: based on Table of analysis of variance (Table 3) the main effect of sowing date and variety and their interaction was significant on 50% pod development stage at 1% probability level. The longest time (75.44 days) to reach 50% pod development stage belonged to first sowing, whereas the shortest time (47.66 days) belonged to last sowing date, which there was a difference as high as 58% between the first and last sowing dates (Table 4). Here as well, we can see with early sowing the 50% pod development stage came late because of favorable environmental conditions. In addition, investigating the main effect of variety revealed that Sarigol (67.83 days) ranked first among three cultivars, followed by RDF003 and then by early-maturing Hayola-401 (58.38 days) (Table 4). This is due to genetic characteristics of early- and late-maturity of the varieties [5]. Diagram for interaction of sowing date and variety (Fig. 5) shows that late-maturing Sarigol with sowing date of March 30th is well above other groups, whereas late-maturing Hayola-401 with sowing date of May 14th was at the lowest group.

Length of Flowering Period: based on Table of analysis of variance (Table 3) both sowing date and interaction of sowing date and variety were significantly effective on length of flowering period at 1 and 5% probability levels, respectively. Based on Table of mean comparisons, the first sowing date (19.44 days) had the longest flowering period and took its place at highest group, followed by second and then third sowing dates. There was a difference as high as 182% between the first and last sowing dates (Table 4). As mentioned before, in early and not to mention, on-timely sowing dates, spring plant could grow naturally due to favorable environmental conditions and it has enough time for phenological stages. Maralian *et al*. [26] reported that sowing date is significantly effective on length of flowering period and growth period. Asgari and Moradie-Dalini [14] also reported that the effect of sowing date on length of flowering period is significant. Investigation on the interaction of sowing date and variety revealed that in first sowing date RDF003 had the longest flowering period followed by Hayola-401. All three varieties had the shortest flowering period in last sowing date that is May 14th (Fig. 6).

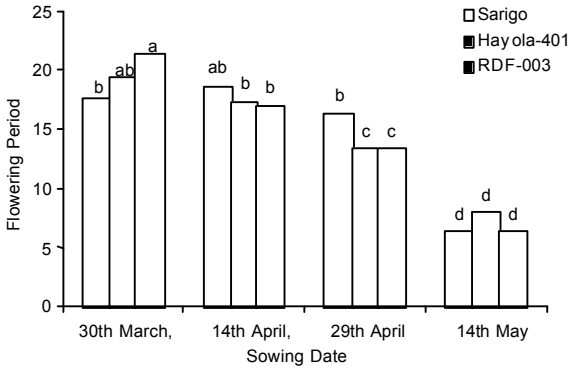

Fig. 6: Interaction effect of sowing date and cultivar on flowerin period of canola

Length of Reproductive Period: based on Table of analysis of variance, sowing date and variety both had a significant effect on length of reproductive period, at 1% probability level (Table 3). Sowing date of March 30th (61.66 days) led to longest reproductive period and was placed at highest group, whereas the last sowing date (35.77 days) had the shortest reproductive period and shared the lowest group with third sowing date (Table 4). Johnson *et al*. [13] argued that canola produces high yields after a long flowering and pod development periods under lower daily temperature. Gross [17] in an investigation on the effect of sowing date on growth stages of vernal canola reported that delayed sowing had a shortening effect on time required for vegetative and reproductive growth. Consequently, in a delayed sowing, all growth stages including reproductive period get shortened and this in turn leads to yield loss. In addition, investigation on the main effect of variety revealed that late-maturing Sarigol (55.91 days) and early-maturing Hayola-401 (38 days) had the highest and lowest number of days in reproductive period (Table 6). Ozer [27] reported that the time to maturity is influenced by sowing date and varies from one cultivar to another. In fact, different cultivars vary in their reproductive periods and times of maturity based on their genetic characteristics.

Growth Period: based on Table of analysis of variance (Table 3) the main effect of sowing date and variety on growth period was significant at 1% probability level. Based on Table of mean comparisons (Table 4), the first sowing date (120.22 days) had the highest and significantly different growth period from others (with a difference of as high as 60% from the last sowing date) and was placed at the highest group followed by second sowing date and so forth. Maralian *et al*. [25] argued that the effect of sowing date on growth period was significant. They maintained that delayed sowing had a shortening effect on vegetative period and growth period in canola. Ozer [28] concluded that the time to maturity is influenced by sowing date and varies by the varieties of the canola. Thus, late sowing dates lead to delayed vegetative growth as well as reproductive growth and subsequently these varieties could be harvested later than in early sowing. Hocking and Stapper [10] reported that late sowing in canola had a shortening effect on vegetative growth period (pre-flowering period) and as a result, the time between flowering and maturity decreases. Based on Table of mean comparisons (Table 4), late-maturing Sarigol variety (108.25 days) had the longest growth period followed by RDF003 and then Hayola-401 (85.33 days), which was placed at the lowest group. Ozer [28] associates the time to maturity and growth period with not only the sowing date, but also with variety. Asgari and Moradie-Dalini [14] also reported the effect of variety on growth period as significant.

Seed and Biological Yield: Results showed that seed yield was markedly affected by main and interaction effects of sowing date and cultivars (Table 5). Hyola410 (1423.39 kg/ha), RDF003 (1289.28 kg/ha) and Sarigol (1040.92 kg/ha) significantly had maximum seed yield, respectively (Table 6). Also first (2432 kg/ha), second (1943 kg/ha), third (619 kg/ha) and fourth (9.43 kg/ha) sowing date significantly had maximum seed yield, respectively. In case of interaction effect, highest seed yield (2766 Kg/ha) was obtained in Hayola410×first sowing date. Lowest seed yield (5.3 kg/ha) was obtained in Sarigol×fourth sowing date (Fig. 7). The yield reductions in canola at later sowings can be explained by fewer pods per plant and lower 1000- seed weight [27]. This reduction in seed yield with delaying sowing has been verified in early field studies [28, 13]. The late sowing usually causes a decline in growth, leaf area and a faster maturation [29] thus, decreasing seed yield. Si and Walton [22] reported that whit delayed in sowing date yield and yield component of canola was decrease. Similar results reported by Miralles *et al*. [21], Lunn *et al*. [30] and Hocking and stapper [10]. As can be seen from Table 5, there were statistically differences between canola cultivars, sowing dates and interaction of sowing date and cultivars, for biological yield. Hyola410 (4759 kg/ha), RDF003 (4280 kg/ha) and Sarigol (3628 kg/ha) significantly had highest biological yield, respectively (Table 6).

Table 5: Analysis of variance for some traits of canola genotypes at different sowing date

	MS				
S.O.V	df	Biological Yield	Grain Yield	Oil yield	Oil content
Block	2	1112621	140223 *	1871.0*	4.05
Sowing Date (SD)	3	116695145 **	11445905 **	1946569.9**	91.96**
Cultivar (C)	2	4067282 **	451916 **	115530.0**	45.32**
C × SD	6	1014463 *	135937 **	30984.9**	2.401
Error	22	452119	29351	6105.2	4.81
C.V. (%)	-	88/15	69/13	15.60	5.82

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

Table 6: Mean comparison of some traits of canola genotypes at different sowing date

	MS				
	Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Oil yield (kg/ha)	Oil content (%)
Sowing date	30-March	2432.07a	7449.4a	00.1015 a	53.41 a
	14-April	1943.8b	6432.2b	79.753 b	70.38 b
	19-April	619.44c	2446.6c	67.230 c	46.36 c
	14-May	9.43d	102.8d	33.3 d	03.34 d
Genotypes	Sarigol	1040.92b	3628.0b	34.401 c	31.36 b
	Hayola410	1423.39a	4759.3a	53.597 a	83.36 b
	RDF003	1289.28a	4280.9a	21.503 b	90.39 a

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

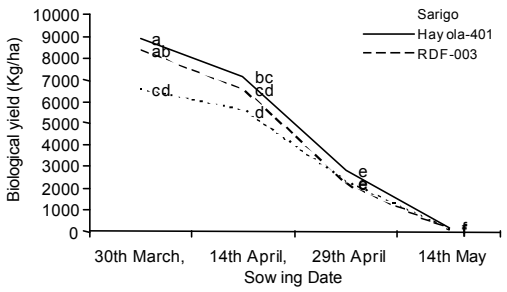

Fig. 7: Interaction effect of sowing date and cultivar on biological yield of canola

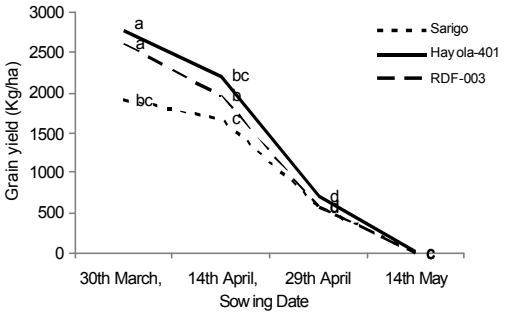

Fig. 8: Interaction effect of sowing date and cultivar on grain yield of canola

Also first (7449 kg/ha), second (6432 kg/ha), third (2446 kg/ha) and fourth (102 kg/ha) sowing date significantly had maximum biological yield, respectively. In case of interaction effect, highest biological yield (8954 Kg/ha) was obtained in Hayola410×first sowing date. Lowest seed yield (66 kg/ha) was obtained in Sarigol×fourth sowing date (Fig. 8).

Oil Yield and Oil Content: Results from analysis of variance show that the main effect of sowing date and variety on traits such as oil percentage and oil yield is significant, whereas their interaction on oil yield proves significant as well (Table 5). Mean comparisons (Table 6) showed that first sowing date produced the highest percentage (41.53%). Numerous experiments have found that delayed sowing and rising environmental temperature tend to decrease oil percentage. Scarisbric *et al*. [31] concluded that delayed sowing not only decreases the grain yield and other traits effective on the yield, but also the oil content of the grain. Rajport *et al*. [32] observed that delayed sowing of canola led to increased protein and decreased oil content of the grain. These results are consistent with those reported by Si and Elton [22]. Based on studies conducted by Hocking and Stopper [10], Robertson *et al*. [23] every 1°C increase in temperature during flowering and grain filling increases the oil percentage by 1.7. Based on Table of mean comparisons (Table 6) the highest mean oil percentage of RDF003 (39.9%) put it at the highest group, while it carried statistic difference with two other varieties. The two other varieties had no significant statistic difference with each other and so shared one group. Kazerani and Ahmadi [33]

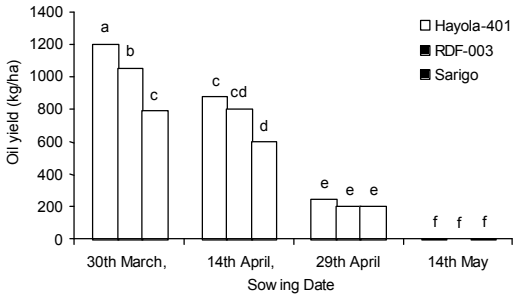

Fig. 9: Interaction effect of sowing date and cultivar on oil yield of canola

and Fanaei *et al*. [34] in their experiments found that the effect of variety on oil percentage trait was significant. Based on results from Table of mean comparisons (Table 6) the first sowing date (1015.00 kg/ha) had the highest oil yield. Mackinon and Fatel [35] reported that sowing date and variety had a significant effect on oil yield and delayed sowing led to decreased oil yield. Investigation on the effect of variety revealed that Hayola-401 (with a mean yield of 597.53 kg/ha) had the highest oil yield. Sarigol (401.34 kg/ha) had the lowest oil yield and was placed at the lowest group (Table 6). Hayola-401 had a higher grain yield with an optimum oil percentage and consequently higher oil yield, representing superior genetic characteristics of the variety (Fig. 9). Numerous experiments suggest that oil yield in canola is influenced by the variety, as Motlabipour *et al*. [36] found after an experiment on 12 canola lines, which lasted for two cropping years, that there was a significant difference between the studied cultivars in terms of oil percentage trait. Mackinon and Fatel [35] also argued that higher oil yield in canola is not only influenced by sowing date, but also by the variety. Based on Fig. 9 and investigation on interaction of sowing date and variety, Hayola-401 (1229.93 kg/ha) had the highest oil yield and was significantly different from other varieties, whereas all three varieties had the lowest oil yield in last sowing date.

CONCLUSIONS

Results showed that the Stage of 50% greening, Complete green, Bolting stage, Branch development stage, Flowering stage, 50% flowering stage, 50% pod development stage, Length of flowering period, Length of reproductive period, growth period, Seed yield, biological yield, Oil yield and oil content were obtained in the first sowing date (30th March). Also in interaction of sowing date and cultivar, the highest Stage of 50% greening, 50% flowering stage and 50% pod development stage were obtained in Sarigol×first sowing date.

In interaction of sowing data and cultivar, the highest seed and biological yield were obtained in Hayola 410 × first sowing date (30 March). Lowest seed and biological yield were detected in sarigol × fourth sowing date (14 May). In general, sowing canola at 30 March was optimal for Meshkin region. Sowings after this time usually resulted in substantial seed yield reductions. Results showed that Hayola410 cultivar was superior in many traits. Therefore cultivar of Hayola 410 has more potential for many traits. Thus, it can be suggested that use Hayola410 cultivar and first sowing date (30th March).

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