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Effect of Sowing Date and Humic Acid Foliar Application on Yield and Yield Components of Canola Cultivars

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ABSTRACT

In order to investigate the effects of different sowing dates and humic acid foliar application on some agronomic traits of six canola cultivars a two-year experiment was carried out in 2015 and 2016 growing seasons. The experiments were laid out in a randomized complete block design arranged in factorial split plot with three replicates. The factorial combination of three sowing dates (7th, 17th and 27th October) and two humic acid levels (0 and 0.2%) were allocated to the main plots and six canola cultivars (HW118, WPN6, HL3721, L14, Tassilo and Natali) were randomized in sub-plots. The results indicated that the main effects of experimental factors were significant on all studied traits, except for harvest index. Interaction between sowing date and cultivar was also significant on all traits except for branch number and harvest index. In general, early seed sowing caused the highest yield and yield component as well as oil percentage and yield. Similarly, humic acid foliar application could increase agronomic traits in canola cultivars. In sum, early seed sowing and humic acid foliar application are highly recommended in canola production.

Keywords: Canola; Humic acid; Oil content; Sowing date; Yield

1. Introduction

Canola (*Brassica napus* L.) is one of the most important oilseed crops grown extensively in Iran. The crop has been taken into account to reduce vegetable oil import dependence. Among oilseed crops, canola has become the second largest oil crop behind soybean in the world (USDA 2013) and is widely grown for its high quality oil for human consumption. Canola seeds contain about 40 to 42% oil and its meal is also great protein supplement in cattle rations and averages approximately 35% crude protein. Agronomic practices such as tillage, planting density, nitrogen fertilizer rate, and cultivar selection have received attention to improve survival and yield of canola (Holman et al 2011). Among these crop management practices, optimum sowing date plays key role in determining final crop yields and should be considered for the germination, seedling establishment and vegetative and reproductive stages not to be affected by unfavourable conditions (Usman et al 2016). Generally, canola should be sown before soil temperature falls under -4 °C as canola is highly cold tolerant at eight leaf stage or rosette stage. In winter cropping, early sowing in autumn increases water and nutrients uptakes and vegetative growth resulting in the risk of cold tolerance loss. On the other hand, late sowing reduces total growth period and increases the risk of freezing. It has been reported that late sowing decreases biomass production, yield and yield components through increasing the risk that the crop is affected by late season drought stress (Wang et al 2012). Late sowing reduces canola vegetative growth period resulting in reduced assimilates production. In addition, late sowing increases the risk heat and drought stress during reproductive stages resulting in poor pollination, flower abortion and low seed set (Farre et al 2002). Optimum sowing date results in better seedling establishment and improved cold tolerance, which prevent cold injury and yield loss (Begna & Angadi 2016). Reduction in oil content due to late sowing has been reported in canola by (Robertson et al 2004; Turhan et al 2011). Oil content is a trait with high heritability in canola. Oil content depends on genotype, region, soil fertility and seed age. Among environmental factors temperature is the most important factor affecting oil synthesis so that oil percentage dramatically decreases with increasing temperature (Wang et al 2012). Siliques as an active photosynthetic organ play a key role in determining seed yield. In addition, increase in silique length means more photosynthetic area and more photosynthates transfer into the seeds (Gammelvind et al 1996). Furthermore, it has been documented that seed number in siliques increases with increasing plant dry weight (Gan et al 2008). In this regard, it has been stated that canola genotypes differ to each other in terms of seed number in siliques, a trait that plays a crucial role in final seed yield (Iqbal et al 2008). However, seed number in silique is more controlled by genetic than environmental factors.

In addition to organic and mineral fertilizers, application of humic acid is getting popular in improving the crops growth and yield. Humic compounds or humus are products of decomposing plants that have complex structures and large molecular weights (Lee et al 2004). It can be extracted from any material containing well-decomposed organic matter soil, coal, composts, etc. (Sani 2014). Humic acid as the most important component of soil humus (Sparks 2003) can be applied in liquid or powder form in soil or one plant leaves (Ulukan 2008) to reduce the negative effect of environmental stresses. Humic acid has numerous benefits and all farmers across the world have come to this conclusion that humic acid is considered as an inseparable and integral part of fertilization program and soil fertility (El-Ghamry et al 2009). It has been reported that humic acid application significantly increases soil organic matter which in turn improves plant growth and development (Erik et al 2000; Hafez 2003; Abd El-Aal et al 2005). In a study, humic acid application could significantly affect initial growth stages of wheat (Mirzamasoumzadeh et al 2012). Humic acid application has been advised to diminish drought stress effects, especially after flowering (Bassoa et al 2013). It has been reported that humic acid has limited promoting effect on growth, yield and quality of wheat (Delfine et al 2005). Application of 2% humic acid could increase grain and straw yield in wheat (Brunetti et al 2007).

As a result, there have been several studies on the effect of sowing date on the agronomic traits of numerous crops; however, studies on the effect of sowing date and humic acid on canola growth and production using different cultivars are still limited. Therefore, the objective of this research was to determine the effects of sowing dates and humic acid on some agronomic of six canola cultivars.

Therefore, the current study was aimed to evaluate the effects of sowing dates and humic acid foliar application on canola cultivars seed yield and yield components.

2. Material and Methods

In this study, the effects of different sowing date and humic acid foliar application were evaluated on plant height, branch number, seed yield and yield components, biological yield, harvest index, oil percentage and oil yield of six canola cultivars using a two-year experiment carried out in Seed and Plant Improvement Institute, Karaj, Iran, in 2015 and 2016 growing seasons. Meteorological data during growing season are given in Table 1. The experiments were laid out in a randomized complete block design arranged in factorial split plot with three replicates. The factorial combination of three sowing dates (7th, 17th and 27th October) and two humic acid levels (0 and 0.2%) were allocated to the main plots and six canola cultivars (HW118, WPN6, HL3721, L14, Tassilo and Natali) were randomized in sub-plots. Soil samples were collected at the depth of 0-30 and 30-60 before seed sowing, the soil physicochemical properties are presented in Table 2. According to the soil analysis results 150 kg ha^{-1} ammonium phosphate and 150 kg ha^{-1} potassium sulphate were applied into the soil before seed sowing. In addition, 350 kg ha^{-1} urea was applied at three separate times (100 kg ha^{-1} at sowing time, 150 kg ha^{-1} at stem elongation and 100 kg ha^{-1} at flowering stage). Each plot consisted of 6 ridges, 60 cm apart and distance between seeds on each row was 5 cm (70,000 plant ha^{-1}). Seeds were sown using a drill sower on both side of a ridge (30 cm apart) and at 25 mm depth. Irrigation was perfumed immediately after seed sowing. Weeds were manually controlled from 4 to 8 leaf stage. Humic acid was sprayed on plants at 4 leaf stage and stem elongation stage using backpack sprayer. Control plants were sprayed with distilled water. In order to determine plant height, branch number, silique number per plant, seed number per silique, 1000-seed weight, four central rows were manually harvested at maturity stage. Silique number in plants was determined using 10 harvested plants and average values were recorded. To determine seed number in silique, 30 siliques were randomly detached from the plants and seed number was determined. The seeds were counted and weighted using laboratory scale. Finally seed

Table 1- Meteorological data during growing season

Growing season months											
Year	*Parameter*	*October*	*November*	*December*	*January*	*February*	*March*	*April*	*May*	*June*	*July*
2015	Rainfall (mm)	13.4	13.7	31.6	6	47.8	21.3	45.4	2.2	6.6	0
	Temperature (°C)	18.31	18.2	6.3	5.2	7.3	6.7	13.8	20	26.4	30.9
2016	Rainfall (mm)	3.5	77.4	28.6	15.6	8.7	17.8	75.5	13	0	0
	Temperature (°C)	19.4	10.5	4.6	5.1	4.9	11.8	11.7	19.9	24.2	28.9

Table 2- Soil physicochemical properties

	2015		*2016*	
Parameter	*Depth (0-30 cm)*	*Depth (30-60 cm)*	*Depth (0-30 cm)*	*Depth (30-60 cm)*
Electrical conductivity (dS m^{-1})	1.45	1.24	1.33	1.15
pH	7.9	7.2	7.8	7.4
Total neutralizing value (%)	8.56	6.68	8.25	8.46
Moisture content (%)	36	38	35	37
Organic carbon (%)	0.91	0.99	0.83	0.96
Total N (%)	0.09	0.07	0.08	0.06
Available P (mg kh^{-1})	14.7	15.8	14.2	15.3
Available K (mg kh^{-1})	197	155	165	148
Clay (%)	28	25	29	27
Silt (%)	47	49	45	46
Sand (%)	25	26	26	27
Soil texture	Clay loam	Clay loam	Clay loam	Clay loam

yield was calculated using yield components date. Oil percentage was measured using NMR (Mq20) and oil yield was calculated through multiplying oil percentage by seed yield. In order to determine biological yield, harvested plants were sun dried, weighed and converted into kg per hectare. Harvest index was calculated as the ratio of seed yield to biological yield (Kutcher et al 2010). The data were analysed using SAS 9.0 software program. Bartlett's test showed the homogeneity of variance in all traits in both years. Therefore, combined anlaysis of variance was carried out. The Duncan's multiple range test (DMRT) was used to compare means within the combined analysis of variance.

3. Results

The analysis of variance indicated that the main effects of year, sowing date, humic acid foliar application and cultivar were significant on all studied traits, except for harvest index (Table 3). In addition, the results revealed that interaction between sowing date and cultivars was significant for all traits except for branch number and harvest index (Table 3). No significant interaction between sowing date and humic acid or between cultivar and humic acid were detected; therefore, only main effects are discussed. According to Table 4, sowing date significantly affected canola plant height. The highest plants were observed when seed sowing was performed on 7th October (Table 4). The shortest plants were related to late sowing date (27th October) (Table 4). Similar results were found as to branch number (Table 4). The branch number decreased when late seed sowing was practiced (Table 4). The minimum and maximum silique number was found when seed sowing was done on 27th and 7th October, respectively (Table 4). Seed number in silique followed a similar trend and decreased when seed sowing delayed (Table 4). 1000-seed weight decreased when seed sowing was done later than 7th October (Table 4). In other words, the maximum 1000-seed weight was found when seed sowing was done on 7th October. In case of biological yield, delay in seed sowing caused a significant reduction in biological yield so that the minimum and maximum biological yield was observed when canola seeds were sown on 7th and 27th October, respectively (Table 4). Since seed yield is a function of interaction among yield components that are affected by sowing date, then delay in seed sowing could reduce final seed yield too (Table 4). Oil percentage and oil yield decreased as seed sowing was delayed (Table 4). As shown in Table 4, humic acid application could significantly increase plant height, branch number, yield components, biological yield, final seed yield as well as oil percentage and yield. Harvest index was the only trait that was not affected by humic acid foliar application (Table 4). The results indicated that there are significant differences among canola cultivars in terms of height, branch number yield and yield components as well as oil percentage and yield but not in terms of harvest index (Table 4). However, some cultivars were the same in terms of above mentioned traits. For example, no significant difference was found between WPN6 and Natali in terms of plant height or there was no significant difference among HW118, WPN6 and Natali cultivars in terms of final seed yield (Table 4). As mentioned before, interaction between cultivar and sowing date was found to be significant on all studied traits except for branch number and harvest index (Table 3). Comparison of means indicated that the maximum plant height was related to WPN6 and Natali cultivars when planted on 7th October (Table 5). The highest plant height was observed in HW118, WPN6 and Natali cultivars at the 17th October (Table 5). Similar results were found when seed sowing delayed and seeds were sown on 27th October (Table 5). In case of silique number per plant, when WPN6 and Natali cultivars were sown on 7th October, the maximum silique umber per plant was obtained (Table 5). On 17th October, the maximum silique number was related to HW118 cultivar (Table 5). The maximum silique number per plant was related to HW118 and WPN6 cultivars when sown on 27th October (Table 5). The maximum seed number in silique was related to WPN6 and Natali cultivars sown on 7th October (Table 5), however, when seed sowing was performed 17th or 27th October, the maximum seed number was observed in HW118, WPN6 and Natali cultivars (Table 5). Almost in all sowing dates, the maximum 1000-seed weight was related to HW118, WPN6 and Natali cultivars (Table 5). The maximum biological yield was related to WPN6 and Natali cultivars when sown on 7th October (Table 5). Seed sowing on 17th October caused the maximum biological yield in HW118, WPN6 and Natali cultivars (Table 5). Late sowing date (27th October) decreased biological yield in all the cultivars (Table 5). Almost in all sowing dates, the maximum seed

Table 3- Analysis of variance on yield and yield components of canola cultivars as affected by sowing date and humic acid application

S.O.V	*Df*	*Plant height*	*Branch number*	*Silique number*	*Seed number in silique*	*1000-seed weight*	*Biological yield*	*Seed yield*	*Harvest index*	*Oil percentage*	*Oil yield*
Y	1	**	**	**	**	**	**	**	ns	**	**
E	4	23.66	0.69	356.49	1.81	0.38	2076708	1497597.80	33.97	0.26	291703.43
S	2	**	**	**	**	**	**	**	ns	**	**
Y×S	2	ns	ns	*	*	**	ns	ns	ns	ns	ns
H	1	**	**	**	**	**	**	**	ns	**	**
Y×H	1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
S×H	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y×S×H	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
E	20	38.14	0.82	112.84	1.32	0.28	912493	255431.20	12.30	0.26	50708.73
C	5	**	**	**	**	**	**	**	ns	**	**
Y×C	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
S×C	10	**	ns	**	**	**	**	**	ns	**	**
Y×S×C	10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
H×C	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y×H×C	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
S×H×C	10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Y×S×H×C	10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
E	120	51.80	1.39	110.09	1.30	0.17	1122770	235235.30	12.12	0.13	40811.81
C.V (%)		4.94	18.18	6.77	6.87	9.51	6.27	11.98	14.55	0.89	11.92

S.O.V, source of variation; df, degree of freedom; Y, year; E, error; P, sowing date; H, humic acid; C, cultivar; C.V, coefficient of variation; *, ** and ns indicate significance at P<0.05, 0.01 and not significant, respectively

Table 4- Main effects of sowing date, humic acid and cultivar on yield and yield components

Factors	*Levels*	*Plant height (cm)*	*Branch number*	*Silique number*	*Seed number in silique*	*1000-seed weight (g)*	*Biological yield (kg ha^{-1})*	*Seed yield (kg ha^{-1})*	*Harvest index (%)*	*Oil percentage*	*Oil yield (kg ha^{-1})*
Sowing date	October 7th	173.92a	8.63a	215.41a	19.80a	5.47a	21835a	5243a	24.06a	42.87a	2250a
	October 17th	144.43b	6.40b	151.09b	16.62b	4.41b	16689b	4069b	24.41a	41.57b	1694b
	October 27th	118.19c	4.42c	98.24c	13.40c	3.30c	12148c	2826c	23.29a	40.25c	1140c
Humic acid	-	142.12b	6.21b	147.21b	16.21b	4.26b	16229b	3894b	23.93a	41.38b	1624b
	+	148.90a	6.75a	162.62a	17.00a	4.53a	17553a	4199a	23.91a	41.75a	1765a
Cultivars	HW118	148.21b	6.76a	159.75b	17.02a	4.53a	17261b	4198a	24.36a	41.75b	1759a
	WPN6	152.42a	7.03a	170.1a	17.46a	4.68a	18353a	4355a	23.79a	41.94a	1840a
	HL3721	140.65c	6.08b	144.37c	16.01b	4.216b	15924c	3832b	24.00a	41.318c	1595b
	L14	141.08c	6.09b	145.6c	16.03b	4.217b	16069c	3834b	23.74a	41.311c	1598b
	Tassilo	138.94c	5.93b	140.72c	15.78b	4.12b	15608c	3736b	23.76a	41.19c	1554b
	Natali	151.76a	7.00a	168.95a	17.34a	4.62a	18130a	4321a	23.87a	41.88ab	1823a

In each column same letters show that there are no significantly difference according to DMRT

Table 5- Interaction between sowing date and cultivar on some agronomic traits of canola

	Plant height (cm)			*Silique number per plant*			*Seed number in silique*			*1000-seed weight (g)*		
	7th	*17th*	*27th*	*7th*	*17th*	*27th*	*7th*	*17th*	*27th*	*7th*	*17th*	*27th*
HW118	165.05c	154.07a	125.51a	194.99d	170.31a	113.95a	18.89b	17.73a	14.45a	5.14b	4.72a	3.72a
WPN6	184.51a	149.33a	123.42a	240.57a	160.24b	109.50ab	21.12a	17.11a	14.15a	5.87a	4.55ab	361a
HL3721	167.81bc	139.68b	114.46b	231.87cd	141.35c	90.84c	19.11b	16.04b	12.87b	5.27b	4.25bc	3.12b
L14	173.03b	137.45b	112.78b	206.37b	136.40cd	86.55cd	19.63b	15.83b	12.62b	5.34b	4.21c	3.00b
Tassilo	170.70bc	134.57b	111.54b	200.92bc	132.90d	82.90d	19.38b	15.56b	12.40b	5.34b	4.12c	2.91b
Natali	182.40a	151.47a	121.40a	235.76a	165.35b	105.72b	20.70a	17.45a	13.89a	5.80a	4.61a	3.46a
	Biological yield (kg ha-1)			*Seed yield (kg ha-1)*			*Oil percentage*			*Oil yield (kg ha-1)*		
	7th	*17th*	*27th*	*7th*	*17th*	*27th*	*7th*	*17th*	*27th*	*7th*	*17th*	*27th*
HW118	19943.20d	18189.30a	13649.80a	4892.90b	4452.90a	3249.20a	42.48c	42.00a	40.75a	2080.40b	1871.80a	1324.70a
WPN6	24321.30a	17534.80a	13201.60ab	5672.10a	4284.10a	3110.10a	43.41a	41.77a	40.63ab	2464.00a	1790.70a	1264.70a
HL3721	20487.50cd	15897.50b	11387.90c	5003.70b	3870.50b	2622.80b	42.58bc	41.35b	40.01c	2132.08b	1601.70b	1051.08b
L14	21536.90b	15556.40bc	11115.00c	5186.70b	3786.70b	2527.30b	42.78b	41.26b	39.88c	2219.30b	1565.08b	1008.90b
Tassilo	20982.20bc	15120.80c	10720.30c	5117.10b	3674.90b	2415.50b	42.68bc	41.14b	39.76c	2184.90b	1513.80b	962.50b
Natali	23740.90a	17834.30a	12813.50b	5584.20a	4344.30a	3033.30a	43.28a	41.90a	40.46b	2417.50a	1821.10a	1228.80a

In each column same letters show that there are no significantly difference according to DMRT

yield was obtained from HW118, WPN6 and Natali cultivars (Table 5). When canola seeds were sown on 7th October, WPN6 and Natali cultivars showed the maximum oil percentage (Table 5). When seed sowing was performed on 17th October, HW118, WPN6 and Natali cultivars showed the maximum oil percentage and in late sowing date (27th October) HW118 and WPN6 cultivars indicated maximum oil percentage (Table 5). Almost in all sowing dates, the maximum oil yield, was obtained from HW118, WPN6 and Natali cultivars (Table 5).

4. Discussion

The results indicated that sowing date has a significant effect on yield and yield components, biological yield, oil percentage and oil yield in canola cultivars. These results agree with previous reports on canola yield (Farre et al 2002; Kutcher et al 2010). A similar experiment carried out in the United State (Holman et al 2011), documented the advantage of optimum sowing date in canola, and showed that optimum sowing date can vary across a relatively short geographical distance, largely driven by substantial differences in annual precipitation and elevation. In another study it has also been reported that sowing date significantly affects winter survival, suggesting early sowing can assure sufficient canola plant growth to survive the winter (Holman et al 2011; Darby et al 2013), but sowing too early also can have negative effects on plant. The reduction in canola seed yield due to delay in seed sowing has been reported by several authors (Robertson et al 2004; Faraji et al 2009). The increase in canola seed yield due to early sowing date might be attributed to more light, water and nutrients absorption by plants thus, increasing photosynthetic capacity. These results are in agreement with those of Chauhan et al (1993). Sowing date is a critical factor that controls growing season length and hence, final seed yield. Early sowing postpones flowering which is an important factor leading to the highest yields (Jenkins & Leitch 1986). Jansinka et al (1989) indicated that seed and oil yields decreased with delay in sowing date. The differences between canola cultivars in terms of seed yield might be attributed to their differences in growth traits such as branches number that mirrored differences in yield components and hence, increased seed yield. Sharief & Keshta (2000) have found similar results. According to the results, the effect of humic acid foliar application was significant on plant height, branch number, seed yield and yield components as well as biological yield, oil percentage and yield. It has been reported that humic acid application reduces the requirement of other fertilizers (Sani 2014). For instance, previous findings have shown that total chemical contents percentage in leaves of cucumber plants due to humic acid application (El-Nemr et al 2012).

The increase in plant height on account of humic acid application may be due to enhanced shoot growth. The results are in line with (Salwa & Eisa 2011) who stated that maximum plant height was recorded when 15 kg ha^{-1} humic acid was applied. Increase in branch number due to humic acid can also be attributed to increased plant growth as reported by Sani (2014). Regarding increase in silique number on account of humic acid application, similar results have been reported with regard to the increased number of pod in soya bush (Farnia 2006). Furthermore, in a study carried out by Hagh-Parast et al (2012), humic acid application caused noticeable increase in number of pod in chickpea. Since humic acid causes remarkable increase in photosynthesis activity (Saadati & Baghi 2014), therefore, more flowers will be formed in canola plant which is effective on formation of fertile silique and seed production. It has been documented that humic acid application leads to increased photosynthesis rate and consequently, assimilates. In the same direction, assimilates retransfer rate would increase and seed weight will be increased (Farnia & Nasrollahi 2010). Similar results were reported by Wang et al (2015) that humic acid application increases 1000-seed weight and biological yield. Rao et al (2000) also reported such results in case of increased dry matter yields of mustard due to humic acid application. In this study, humic acid application caused an increase in oil percentage and oil yield in comparison with control plants. These results are in agreement with the report of Rajpar et al (2011) which showed that application of humic acid had significant effect on oil percentage and yield. Similarly, it has been reported that foliar application of humic acid improved seed yield and oil content in mustard (Chris et al 2005). Generally, humates enhance nutrient uptake and increase the yield and quality of various oilseed crops (MacCarthy et al 2001; Salt et al 2001).

5. Conclusions

The canola cultivars responded to different sowing dates. Growth, seed yield and oil yield decreased with delayed sowing date. By contrast, early seed sowing could improve canola yield and oil production. In this experiment, application of humic acid could significantly increase yield and yield components of canola as well as oil percentage and oil yield. Therefore, choosing a suitable sowing date (as early as possible) is essential depending upon growing conditions and cultivar. According to this experiment, it can be suggested that the most appropriate sowing time for a desire seed yield in the experimental region is early October and humic acid foliar application as a way to increase canola yield and production is recommended.

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