Asian Journal of Chemistry Vol. 21, No. 3 (2009), 1957-1965

Sowing Date Effects on Growth, Flowering, Oil Content and Seed Yield of Canola Cultivars

BÜLENT UZUN*, ÜMRAN ZENGIN, SEYMUS FURAT and ÖZGÜR AKDESIR†
Department of Field Crops, Faculty of Agriculture, Akdeniz University, TR-07058 Antalya, Turkey
Fax: (90)(242)2274564; Tel: (90)(242)3102424
E-mail: bulentuzun@akdeniz.edu.tr

A comprehensive analysis of response to sowing date in canola has been studied under true Mediterranean type environment. The field research were conducted to investigate the influence of sowing dates on growth and flowering patterns and seed yield of canola cultivars during 2004-05 and 2005-06 growing seasons. Six sowing dates were established at about 20 days intervals from 1st October to 10th January. The responses of growth, flowering, oil content, seed yield and components of yield were consistent in both years. Cultivars tended to respond similarly to sowing date for the characters studied. The results apparently showed that late sowings caused to decline in seed yield of canola cultivars. The decline of seed yield with delay in sowing date could be explained by shortening the length of the reproductive period and consequently the potential grain-filling period. Practically, later planted plants reached both pre-flowering and post-flowering period sooner compared to those planted earlier. The present study highlights the practical importance of sowing date in growing and flowering patterns, yield formation and oil content of canola cultivars.

Key Words: *Brassica napus* L., Canola, Growth, Oil content, Seed yield, Sowing date.

INTRODUCTION

Canola (*Brassica napus* L.) is an important oilseed crop in the world. It is globally recognized as an alternative to temperate cereals in the winter-spring growing season of most temperate agricultural regions and is the single most important winter oilseed crop[1]. With this characteristic, canola can be rotated with wheat when sown in winter.

Canola is a new and promising oilseed crop for south part of Turkey. It has a quite limited acreage but its production is recently expanding in this region by replacing wheat growing areas. Traditional practice in the southern is to sow wheat in mid-November to mid-December. Same practice is now being applied to canola by cultivators. Nevertheless, considerable amount of seed yield reduction in canola has been observed when planting dates delay.

†Atatürk Central Horticultural Research Institute, P.O. Box 15, Yalova, Turkey.

Indeed, there is an urgent need to grow canola as a winter rotational crop because most of vegetable oil and oilseeds consumed in Turkey is imported from abroad with a value of about one billion dollars annually[2,3]. Canola has the potential to fill the gap as a winter oilseed without sacrificing any other oilseed crop harvested area. Moreover, it is harvested at least 15 days earlier than wheat that can be useful for second crop farming in the southern parts.

A better understanding of development in canola would help in devising strategies for managing the crop in traditional cereal production areas. An important management factor in the production of all crops is sowing date[4]. To date, a detailed management practices for canola development and seed yield have not been described for the southern part as a true Mediterranean type environment. A typical Mediterranean environment characterised by short, mild and wet winters and long, hot and dry summers[5]. There is high rainfall in winter and a long drought period and high temperatures after May. High rainfall and relatively low temperature in vegetative growth period and high temperature and drought during grain filling period should take into consideration for determining optimum sowing time. Otherwise delayed sowings in this environment may result in more seed yield reduction than in other canola growing areas. Accordingly, the aim of this study was to determine the effects of sowing dates on growth, flowering, oil content, seed yield and its components in four canola cultivars under Mediterranean environment conditions.

EXPERIMENTAL

The study was conducted in the experimental field of West Mediterranean Agricultural Research Institute of Antalya (36°52'N, 30°50'E, 15 m elevation) during the 2004-2005 and 2005-2006 growing seasons. The soil was an alkaline (8.60) clay with low organic matter (1.90 %). The previous crop for the plots planted in both years was wheat. Temperature, rainfall and relative humidity of the experimental site during the crop growing period was presented in Table-1.

The study consisted of the factorial combination of 6 sowing dates and 4 cultivars in both years. Treatments were arranged in a split-plot design with sowing dates as main plots and cultivars as sub-plots completely randomized in 3 blocks. Each sub-plot had four rows, 0.30 m apart and 4 m long. Four canola cultivars used in the study were Bristol, Capitol, Licord and Licrown. Plots were over-seeded and hand-thinned shortly after seedling emergence.

Cultivars were sown on 6 dates each year: 1 October, 20 October, 11 November, 1 December, 24 December and 10 January of 2004-2005 growing season; and 30 September, 20 October, 11 November, 6 December, 24 December and 17 January of 2005-2006 growing season. Fourth and last sowings were delayed by 5 and 7 d, respectively in the second year when compared with the first year of the study because of rainfall and excessive wet soil conditions. Data were not taken from 5th and 6th sowings since there were almost no flowering plants due to vernalization

TABLE-1
MONTHLY AND GROWING SEASON PRECIPITATION, TEMPERATURE AND RELATIVE HUMIDITY IN ANTALYA IN 2004-2005 AND 2005-2006 GROWING SEASONS

Months	Temperature (°C)			Relative humidity (%)			Precipitation (mm)		
	2004-2005	2005-2006	Long-term averages*	2004-2005	2005-2006	Long-term averages*	2004-2005	2005-2006	Long-term averages*
October	21.8	19.0	19.4	59.1	54.9	62.0	15.5	17.2	77.4
November	15.2	13.8	14.0	57.4	56.0	66.0	146.9	142.2	179.4
December	11.2	11.7	10.8	60.0	63.1	67.0	176.8	129.6	241.3
January	10.8	9.0	9.2	63.5	55.1	68.0	428.9	319.0	195.5
February	10.2	11.1	9.6	59.8	63.3	68.0	126.8	84.5	138.8
March	13.4	13.3	11.7	62.0	71.4	66.0	29.9	78.2	117.1
April	16.7	17.2	15.6	59.5	63.7	67.0	7.4	87.3	52.8
May	21.1	21.0	20.1	58.8	64.2	68.0	74.7	12.3	29.9
June	25.4	25.9	25.1	58.7	57.9	61.0	5.5	21.9	9.7

*60 years

requirements of cultivars. Hereafter, sowing dates in each year will also be referred to as first, second, third and fourth.

Nitrogen, phosphorus and potassium were applied at a rate of 80 kg per hectare at sowing in both years as a complete fertilizer. Weeds were controlled by hand. Recommended insecticides were applied to the plots to prevent aphid damage. The plots were irrigated once for stand establishment immediately after sowing and thereafter the plants were grown under rainfed conditions.

Seed yields were taken by hand-harvesting in central two rows of each plot for seed yield determination that was recorded in g per plot and then converted hectare basis. Plant height, number of branches, number of pods per plant, number of seeds per pod, stem height to the first pod were measured from randomly selected plants from central two rows of each plot. One thousand, clean, mature seed were hand counted and weighed to determine 1000 seed weights. The seeds obtained from each genotype in different sowing times in a given year were subjected to oil extraction using Soxhlet apparatus with gravimetric method. For every accession, seeds were bulked and 5 g clean and mature seed samples taken for oil content analysis. The data obtained were analyzed using MSTAT-C software package program[6].

RESULTS AND DISCUSSION

Growth and development: Developmental and flowering patterns were greatly influenced by sowing time. A delay in sowing shortened both development and flowering times of all the cultivars. The period from sowing to stem elongation ranged from 106 to 156 days in Bristol, 106 to 157 days in Capitol, 108 to 162 in Licord and 105 to 157 days in Licrown (Table-2). Similarly, days to first flower and to 100 % flowering gradually shortened in all the cultivars in both years when sowing dates were delay (Table-2). In the fifth and sixth sowing times, there were only 1 or 2 flowering plants in all the plots because of vernalization requirements of the plants (data not shown). Apparently, warmer temperatures inhibited the growth of canola cultivars from fifth and sixth sowing dates.

Changes in sowing dates produced statistically significant differences in time to emergence in the second growing year (Table-2). In the first sowing date, the period from sowing to emergence ranged from 5 to 6.7 in all the cultivars. This period had longer in the subsequent sowing dates with a range of 6.7 to 13.3. Relatively cold temperatures in the late sowings caused to longer emergence times.

As shown in Table-2, the means of two growing seasons, 2004/05 and 2005/06, revealed progressive and statistically significant decreases in the number of branches when sowing dates were delay. The number of pods per plant showed a similar trend of decrease with delayed sowing. The pod distribution per branch, including the terminal raceme, was the same (data not shown) in agreement with the findings of Momoh and Zhou[7]. Number of pods per plant is a major determinant of the canola yield and it is dependent on the number of flowers produced by plant[2].

Seed yield, yield components and oil content: Seed yield, stem height to the first pod, plant height, number of pods per plant and number of branches were significantly influenced by sowing dates (Tables 2 and 3). Average plant heights of cultivars indicated a significant decrease with delaying sowing dates in both years. The cultivars had a lower means for stem height to the first pod and plant height characters in the first growing season compared to second one. The trend was the same for seed yield and 1000-seed weight. The differences in sowing dates had significant effects to seed yield. The cultivars, Bristol, Capitol, Licord and Licrown, produced the highest seed yields in the first sowing date in both years. In the subsequent sowing dates, their means exhibited progressive and statistically significant decreases in the two growing seasons. The highest seed yield values in both years were obtained from Licrown. In parallel to seed yield trend, there were progressive and significant decline for number of pods per plant. This decline was sharper in 2005/06 compared to 2004/05 growing season (Table 2). Total number of pods per plant was significantly lower in late sowings in both years.

Surprisingly, there was not statistically significant change for number of seeds per pod depending on sowing dates in both years while significant differences were observed for 1000-seed weight only in the first year of the experiment as well as oil content (Table-3). There were statistically differences among the canola cultivars for 1000-seed weight. Apparently, the means of cultivars for 1000-seed weight in the second year had higher than the first year of the experiment. Generally, this was reverse for number of seeds per pod. There was no direct relation between oil content and sowing dates. While there was a significant decrease for all the agronomic traits with delaying sowing dates, oil content was not influenced by the different sowing dates (Table-3).

TABLE-2
INFLUENCE OF SOWING DATES ON GROWTH AND FLOWERING OF FOUR CANOLA CULTIVARS GROWN IN 2004-05 AND 2005-06 GROWING SEASONS

Cultivars	SD	Number of pods per plant		Number of branches		Days to emergence		Days to stem elongation		Days to first flower		Days to 100% flowering	
		2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006
Bristol	1	273.0	245.3	8.1	8.3	5.0	5.0	151.0	156.7	158.7	165.3	167.7	175.3
	2	222.8	174.7	5.9	6.3	6.3	7.7	141.0	143.0	147.7	154.3	167.3	164.0
	3	259.2	93.0	5.3	3.0	11.3	7.7	118.0	136.7	127.3	146.3	147.7	158.0
	4	258.0	80.7	5.3	3.0	9.0	8.0	112.3	106.3	123.7	118.0	142.0	132.3
Capitol	1	292.4	220.0	9.0	7.3	5.0	5.0	153.7	157.3	162.7	167.0	174.7	178.0
	2	280.8	154.7	7.2	5.7	12.3	6.7	145.7	142.0	157.0	154.7	174.0	165.7
	3	235.8	120.0	5.4	4.0	11.0	9.0	120.7	137.7	132.0	150.3	150.3	162.0
	4	192.3	79.7	4.9	3.0	9.0	8.7	117.0	106.0	128.0	118.3	148.0	132.0
Licord	1	287.1	222.7	8.1	8.0	5.7	6.7	153.7	162.3	162.7	170.3	179.7	180.7
	2	294.3	150.3	8.7	5.0	8.0	7.7	146.3	144.0	155.3	155.0	178.7	166.0
	3	222.8	119.0	4.9	3.7	12.7	9.0	123.0	139.3	133.0	150.3	154.7	161.7
	4	282.3	78.3	5.3	3.0	10.7	9.0	115.0	108.3	126.0	120.3	150.0	134.7
Licrown	1	333.1	215.0	9.3	8.3	6.0	6.7	154.0	157.7	162.0	166.3	172.7	175.3
	2	270.6	159.0	7.4	5.7	12.7	7.3	147.0	141.7	158.0	154.0	174.3	163.0
	3	221.3	147.7	5.8	4.0	13.3	7.7	121.3	137.0	131.3	146.7	149.3	158.7
	4	255.8	77.3	6.1	3.7	11.0	9.3	112.0	105.7	123.0	118.0	144.0	132.7
$LSD_{S.D.}$		37.2*	47.9**	0.4**	1.0**	ns	1.71*	3.8**	2.6**	4.6**	3.0**	2.7**	4.4**
$LSD_{Cultivar}$		ns	ns	0.5**	ns	2.6*	ns	1.5**	0.6**	2.0**	1.4**	2.1**	1.1**
$LSD_{S.D. x Cultivar}$		ns	ns	1.1**	ns	ns	ns	ns	1.2**	ns	ns	ns	ns

*, **: Statistically significant at 0.05 and 0.01 significance level, respectively, ns = not significant, SD = Sowing dates.

TABLE-3
INFLUENCE OF SOWING DATES ON YIELD, YIELD COMPONENTS AND OIL CONTENTS OF FOUR CANOLA CULTIVARS GROWN IN 2004-05 AND 2005-06 GROWING SEASONS

Cultivars	SD	Seed yield (kg/ha)		Stem height to the first pod (cm)		Plant height (cm)		Number of seeds per pod		1000-Seed weight (g)		Oil content (%)	
		2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006	2004-2005	2005-2006
Bristol	1	2415.0	2933.3	94.4	129.3	144.6	183.3	24.2	21.7	3.0	3.1	27.7	34.8
	2	382.5	2316.7	65.1	138.0	109.2	184.0	21.1	22.0	2.3	3.0	33.9	32.4
	3	390.1	1061.1	57.6	101.3	102.9	143.7	23.4	20.3	2.4	2.9	25.3	28.2
	4	516.8	916.7	62.2	72.0	108.7	120.0	23.8	19.7	2.4	2.8	34.3	28.7
Capitol	1	1806.3	2355.5	117.8	129.3	169.4	180.7	22.8	17.7	3.2	3.8	36.8	30.9
	2	363.5	1927.8	88.8	144.3	122.9	185.3	16.9	17.3	2.7	3.9	34.6	29.1
	3	490.8	877.8	82.6	107.3	118.4	150.7	20.7	24.7	2.8	3.9	39.3	31.5
	4	476.3	122.2	94.6	72.0	132.7	124.3	22.1	19.3	2.9	3.7	45.0	31.5
Licord	1	1165.6	2061.1	99.5	138.7	151.7	192.0	23.5	18.3	2.6	3.5	41.4	26.1
	2	622.8	1872.2	69.1	134.0	104.9	177.7	21.9	18.3	2.0	3.1	41.1	27.1
	3	385.7	1638.9	67.1	97.7	106.2	148.0	21.9	20.7	2.4	3.5	39.9	26.2
	4	326.6	650.0	43.8	70.7	109.8	120.7	25.0	20.0	2.6	3.2	35.7	24.9
Licrown	1	2702.2	3166.7	124.2	147.3	172.8	187.7	24.3	17.7	3.1	3.6	33.2	32.8
	2	257.9	2366.7	98.3	136.7	136.9	176.3	20.7	18.0	2.6	3.3	29.4	26.2
	3	226.9	1238.9	72.3	97.3	112.4	147.3	23.0	22.3	2.5	3.7	32.8	32.5
	4	434.8	750.0	83.2	73.0	124.0	122.7	25.6	19.0	2.7	3.7	32.4	28.6
$LSD_{S.D.}$		502.8**	711.0**	10.3**	16.8**	18.1**	14.4**	ns	ns	0.3*	ns	1.6**	ns
$LSD_{Cultivar}$		ns	310.8**	10.9**	ns	13.0**	ns	1.8*	ns	0.2**	0.2**	ns	ns
$LSD_{S.D. x Cultivar}$		1106**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

*, ** = Statistically significant at 0.05 and 0.01 significance level, respectively, ns = not significant, SD = Sowing dates

The results reported here underline the faster growth and development of canola when sowing dates were delay. This had the consequence of shortening the length of the reproductive period and consequently the potential grain-filling period. The results are consistent with the study of Robertson *et al.*[8]. In parallel, Hocking and Stapper[9] reported that late sowing resulted in a shortening of the pre-flowering period and that the duration between flowering and maturity. A similar response occurred among the cultivars studied at changing sowing dates. Later planted plants reached flowering sooner compared to those planted earlier.

Late sowings caused delayed plant establishment and decrease in stem elongation and flowering times. Especially, stem elongation occurs very early but the stem tends to be weaker, leading to increased incidence of lodging at late sowings. This effect was also observed by Momoh and Zhou[7] and Bilgili *et al.*[10] when the crop was grown at higher seeding rate. However, there were no lodging problem occurred in this study since plant height was also importantly decreased at late sowings.

The results in this study showed that early sowings had a great advantage to obtain high yields by allowing plants to long duration of pre-flowering, flowering and grain filling periods. According to Mendham *et al.*[11] and Hocking[12], late sowings shorten the vegetative and reproductive phases of canola development through temperature and photoperiod effects and increase yield losses because of water deficit during flowering and seed filling. Water deficits during flowering and maturity have a great effect on seed yield[13-15]. Meteorological data in Table-1 supported this phenomenon. There was much lower precipitation in April, May and June compared to other months of the growing period but the temperature was gradually getting higher in these months as a typical Mediterranean environment. Hence, late sowing plants were not able to escape the warmer temperatures and water stresses that arisen at the end of the growing season causing to lower seed yield.

Not only direct effects of environmental conditions but also indirect effects *via* number of pods per plant, number of branches, 100-seed weight, stem height to the first pod, plant height and thus fruiting zone length had a great impact on seed yield at late sowings. According to Thurling[16] and Scarisbrick *et al.*[17], the most important cause of lower yields at late sown oilseed rape is a decrease in number of pods per plant. The differences in sowing dates had significant influences on pod number of canola cultivars. Delayed sowings resulted in a significant decrease in the number of branches per plant as a consequence of shorter growing period and less growth before anthesis. This decline also caused a reduction in the number of pods on all branches.

Cultivars responded similar to sowing date differences for plant height and stem height to the first pod. The shortening in the vegetative and reproductive phases of canola development in delayed sowings caused to consistent reduction in plant height and stem height to the first pod characters.

Number of seeds per pod was not influenced by sowing dates. This result supports the finding of Momoh and Zhou[7] who noted that the number of seeds per pod was not affected by increased plant density and delayed transplanting. Nevertheless, sowing dates has significant influences on 1000-seed weight. This contrast showed that later sowings caused to produce less assimilates due to water deficiency and shorter grain-filling period. Apparently, the means of cultivars for 1000-seed weight in the second year had higher than the first year of the experiment. This was, in general, reverse for number of seeds per pod. These two traits are genotype-dependent characteristics. The characteristics have been shown differ due to various growing conditions such as delayed sowings. The reduction in the 1000-seed weights of the late-sown rapeseed can be attributed to increasing temperature[9] and a decrease in the magnitude of leaf area (data not shown), which is considered a factor of practical importance in terms of seed set and development of rapeseed[2]. These observations also support the contrast between number of seeds per pod and 1000-seed weight as mentioned above.

In summary, in both years of the study, the highest yields were achieved when canola was planted in the first week of October. This is adequate time following second crop (*i.e.*, maize, sesame, soybean, *etc.*) harvest to prepare the field and plant canola as a main crop. Seed yield of canola was much higher when sown early. The decrease in seed yield potential with late sowings is due to shortening the length of the reproductive period and consequently the potential grain-filling period. Oil content was not influenced by the sowing dates. Similar percentage of oil can be obtained even in the late sowings. For this reason, sowing times should be arranged for the seed yield character. This information provided by this experiment may be helpful for the recommendation of sowing date and its influences on canola flowering, development, oil content and production in similar climatic conditions of the world.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Akdeniz University Scientific Research Project Unit. Seed material for the research was kindly provided by Monsanto and Çimsan Seed Companies, to whom the authors are also grateful.

REFERENCES

1. D.J. Miralles, B.C. Ferro and G.A. Slafer, *Field Crops Res.*, **71**, 211 (2001).
2. H. Ozer, *Eur. J. Agron.*, **19**, 453 (2003).
3. FAO, www.fao.org (2006).
4. F.J. Adamsen and T.A. Coffelt, *Ind. Crops Prod.*, **21**, 293 (2005).
5. C.P. Gunasekera, L.D. Martin, K.H.M. Siddique and G.H. Walton, *Eur. J. Agron.*, **25**, 1 (2006).
6. R. Freed, S.P. Einmensmith, S. Guetz, D. Reicosky, V.M. Smail and P. Wolberg. User's Guide to MSTAT-C, An Analysis of Agronomic Research Experiments, Michigan State University, USA (1989).
7. E.J.J. Momoh and W. Zhou, *J. Agron. Crop Sci.*, **186**, 253 (2001).
8. M.J. Robertson, J.F. Holland and R. Bambach, *Aust. J. Exp. Agric.*, **44**, 43 (2004).
9. P.J. Hocking and M. Stapper, *Aust. J. Agric. Res.*, **52**, 623 (2001).
10. U. Bilgili, M. Sincik, A. Uzun and E. Acikgoz, *J. Agron. Crop Sci.*, **189**, 250 (2003).

11. N.J. Mendham, J. Russell and N.K. Jarosz, *J. Agric. Sci.*, **114**, 275 (1990).
12. P.J. Hocking, *Plant Soil*, **155/156**, 387 (1993).
13. R.A. Richards and N. Thurling, *Aust. J. Agric. Res.*, **29**, 469 (1978).
14. N.J. Mendham, P.A. Shipway and R.K. Scott, *J. Agric. Sci. Camb.*, **96**, 389 (1981).
15. T.O. Tayo and D.G. Morgan, *J. Agric. Sci. Camb.*, **92**, 363 (1979).
16. N. Thurling, *Aust. J. Agric. Res.*, **25**, 711 (1974).
17. D.H. Scarisbrick, R.W. Daniels and M. Alcock, *J. Agric. Sci. Camb.*, **97**, 189 (1981).

(*Received*: 11 March 2008; *Accepted*: 10 November 2008) AJC-7012