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THE INFLUENCE OF ROW AND INTRA-ROW SPACING TO SEED YIELD AND ITS COMPONENTS OF WINTER SOWING CANOLA IN THE TRUE MEDITERRANEAN TYPE ENVIRONMENT

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Abstract

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The objectives of the study were to assess the effects of row and intra-row spaces to seed yield and its components and also determine the optimum row and intra-row spacing for canola in order to obtain better yield in Mediterranean type environment conditions. The field experiment was intended factorial randomized complete blocks design with three replications in West Mediterranean Agricultural Research Institute's fields of Antalya at 2006-2007 and 2007-2008 growing seasons. Rows were spaced of 10, 20, 30, 40 cm; intra-rows were spaced of 5, 10, 15, 20 cm with a registered canola cultivar. Traits such as seed yield, plant height, number of branches, stem height to the first pod, number of pods per plant, number of seeds per pods and 1000 seed weight were analyzed. The results indicated that row spacing had a significant effect on seed yield, number of branches, number of pods per plant, number of seeds per pods in two growing seasons. The highest seed yield was obtained in 10 cm row spacing along with 5-10 cm intra row spacing. Number of branches, number of pods per plant and number of seeds per pods were affected negatively by narrow row spaces. Narrow row spaces affected seed yield, positively and strongly. Narrow row spaces are prerequisites for obtaining higher yields in canola in Mediterranean-type environment.

Key words: Brassica napus L., canola, row spacing, yield

Introduction

Canola (*Brassica napus* L.) is an important oilseed, which can be grown as winter and summer crop. It belongs to *Crucifera* family and is the most cultivated species in this family (Snowdon et al., 2006). *Brassica napus* L. originated from the Mediterranean region of South-West Europe where the two contributing parents, *B. oleracea* and *B. rapa*, with natural hybridization (Saha et al., 2008). It has commercial importance with having high oil content (about 30-45%) (Oad et al., 2001). Canola oil (low glucosinolate and erucic acid) originated high erucic acid rapeseed oil (Przybylski et al., 2005). Because high erucic acid caused to cardial problems in humans (Gopalan et al., 1974 and Renarid

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and McGregor, 1976). Canola oil was developed which has low erucic acid and glucosinalates also known as “double zero” varieties made the canola oil more popular (Saleem et al., 2001). In addition, higher unsaturated fatty acids and lower saturated fatty acids contributed to popularity of canola oil. Its production reached 17.95 million metric tones and has become of third important oilseed crop about oil production after soybean and palm oil (USDA, 2008).

Canola has a great advantage that it can be grown in winter unlike the most of the other oilseed crops enabling it to no competition with other oilseed crops. It has therefore made the crop that is grown in the many parts of the world. Apart from canola is cultivated as winter crop in the Europe and Asia, it is cultivated only spring form in Canada, Northern Europe, and Australia (Snowdon et al., 2006). In Europe and Asia regions where have Mediterranean climate, winter canola production has a great potential since it is an alternative to temperate cereals in the winter-spring growing season of temperate agricultural regions with no competition of other oil seed crops (Uzun et al., 2009). This provided constant production in a rotational cropping system throughout the year.

In agricultural systems, yield efficiency is affected interaction between genetic, agriculture and environmental factors. Soil type and salinity (Bybordi et al., 2010 and Hosaini et al., 2009), tillage method (Saglam et al., 2009), sowing time and method, seed rate, fertilizers, time of irrigation and row spacing are some of these factors and very important for higher yield (Shahin and Valiollah, 2009). Row spacing is important agricultural factor and has great effect on seed yield and the yield components of individual plants (Diepenbrock, 2000). Canola seems that one of these individual plants and choosing appropriate row spacing in winter canola helps in efficient use of available resources such as water, light and soil nutrients (Morteza et al., 2008). The previous researches showed that proper row spacing affected seed yield and oil containing in cultivars (Oad et al., 2001), because different researchers clearly propounded this result for rapeseed in different regions of the world. Basalma (2006) reported that sowing density affected to yield 31.68%, positively. Ohlsson (1974) observed in Sweden, yield and oil content were lower when sown at 48 cm apart followed by 24 and 12 cm row spacing. Christensen and Drabble (1984) and Morrison et al. (1990) obtained that narrow row spaces had more yield than wide rows in Manitoba and Alberta, respectively. Morteza et al. (2008) obtained maximum seed yield at the density of 80 plants m^2 in Mazandaran, Iran. Ozer (2003) has indicated that 15 cm row spacing have brought about 8-40% higher seed yield than 30 and 45 cm in Erzurum, Turkey. In Pakistan, although Oad et al. (2001) claimed that wide rows provided higher yield, Cheema (2001) observed that seed yield higher when narrow rows were used. This different result may arise from soil, seed and climate differences.

In addition, plant establishment not only affected seed yield but also influenced plant characters, insects, weeds, diseases, soil environment, germination and emergency (Lauer and Rankin, 2004). Johnson and Hanson (2003) expressed that cultivar x row spacing interactions affected plant height character which was greater when wide rows. Dosdall et al. (1998) identified, lower flea beetle damage to *B. napus* and *B. rapa* when sown at wider row spacing. In case of disease and moisture, wider row spacing was caused more mortality (Christensen and Drabble, 1984) and approximately 200 plants/m^2 significantly reduced the impact of weeds on canola yield (Odonovan, 1994).

Canola is a pioneering crop for oil production. In order to obtain better yields in different environments, agronomic practices should be identified for different climate zones. Therefore, the objective of this research was to evaluate the distribution of seed yield and yield components between row and intra-row spaces of canola genotype grown in Mediterranean type environment for obtaining higher seed yield in canola.

Material and Methods

The research was conducted in the West Mediterranean Agricultural Research Institute's fields of Antalya (36^{0}52'N. 30^{0}50'E. 15 m elevation) at 2006-2007 and 2007-2008 growing seasons to evaluate the effects of inter- and intra-row spacing on seed yield and yield components of canola (*Brassica napus* L.). A registered variety, Licrown, which has the best yield in the environment (Uzun et al., 2009) was used as a genetic material in the study. The crop was sown on 6th and 10th October of 2006 and 2007, harvested on 12nd and 18th May of 2007 and 2008, respectively. The experiment was set up in factorial randomized complete blocks design with three replications. Four different row and intra-row spacing were applied in the study. Row and intra row spaces were 10, 20, 30, 40 cm and 5, 10, 15 and 20 cm, respectively.

The experimental area is located in the southern region of the country with hot in summers and mild cold in winters as a typical type of Mediterranean environments. According to climate data, the experimental area was highly suitable for growing canola. The monthly rainfall, humidity and average temperatures for 2006-07 and 2007-08 within the growing period of canola (October-May) are presented in Table 1. The highest rainfall was observed in October in 2006-07 and in December in 2007-08. Air temperatures and humidity were close to the long term averages during the two growing seasons but annual rainfall is different in the experimental years. 2007-08 growing season was a relatively dry year and monthly rainfall during the growing season (October–May) were lower than 2006-07 and long-term averages. Lower rainfall was monitored in the second experimental year caused to obtain relatively lower yields in all the intra and intra-row spacing comparing to those of the first year.

The soil of the experimental field was alkaline clay (8.60) with organic matter of 1.90%. Nitrogen, phosphorus and potassium were applied at a rate of 80 kg per hectare. During the growth stages, weeds were removed by hand. Following to sowing, all the plots were irrigated once for encouraging emer-

Table 1
Monthly temperature, humidity and rainfall values in the growing period of 2006-2007 and 2007-2008

Months	Temperature, ^{O}C			Humidity, %			Rainfall, mm		
	2006-2007	2007-2008	Long-term averages*	2006-2007	2007-2008	Long-term averages*	2006-2007	2007-2008	Long-term averages*
October	19.6	22.8	19.5	68.5	55.2	61.0	494.7	38.2	76.2
November	13.5	16.2	14.2	60.7	68.2	66.0	126.4	87.0	190.8
December	11.3	13.0	10.7	56.2	49.1	68.0	66.4	247.2	279.1
January	11.4	10.7	9.5	57.3	46.1	66.0	113.8	12.6	218.8
February	12.1	11.3	9.9	67.1	52.1	64.0	152.7	10.8	136.4
March	14.6	15.7	12.2	59.9	64.3	67.0	39.1	66.4	110.5
April	17.4	17.6	15.7	50.8	70.7	68.0	12.5	41	66.0
May	21.7	21.1	20.3	69.4	62.7	66.0	1.9	2.2	31.8

*30 years

gence. Seed yield (kg/ha), plant height, number of branches, stem length to the first pod, number of pods per plant, number of seeds per pods and 1000 seed weight measurements were taken in each plot. The obtained data were analyzed using SAS statistical package program (SAS Institute Inc., 1997). Means were compared by least significant differences (LSD test).

Results and Discussion

Row spacing identified accurately has a large effect on growth, development, seed yield and yield components of canola. When a yield advantage is indicated by crop production at a certain row spacing, producers will adopt that practice if the advantage is consistent over time and if the return on investment to replace or modify equipment is short and lasting (Johnson and Hanson, 2003). The optimum row and intra-row spacing should therefore be determined in every ecological condition.

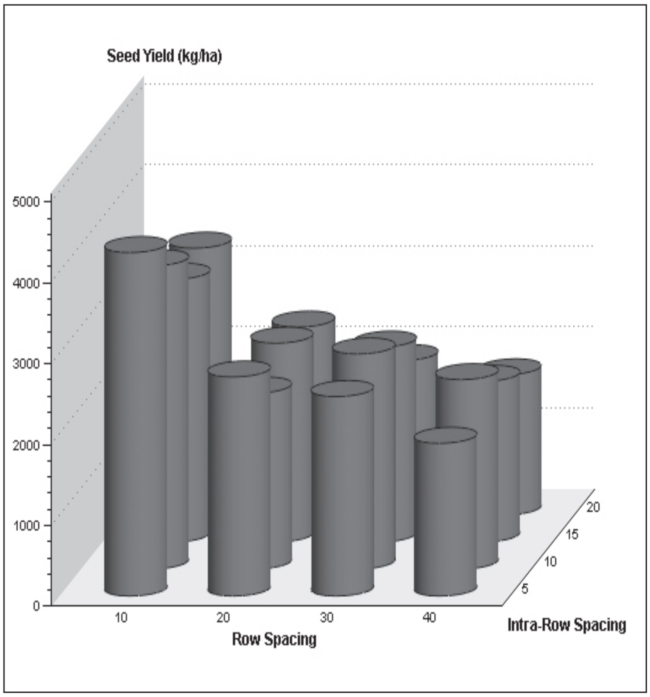

Fig. 1. Distribution of seed yield according to row and intra-row spacing

Seed Yield

The differences in row and intra-row spaces has caused to significant changes in seed yield of canola cultivar (Table 2). Based on the statistical results, we detected that seed yield was significantly influenced by row spacing in each year but intra-row spacing and interaction did not affect seed yield. Among the row spaces, 10 cm produced significantly higher seed yield (Figure 1). Two experimental years was observed that average yield increased when row spaces decreased. This situation indicated that plant establishment rates for 10, 20, 30 and 40 cm row spacing was greater in narrow rows than wide rows for higher seed yield. The previous studies showed that narrow row spaces gave rise to higher seed yield in canola. Our findings are in agreement with those of Morrison et al. (1990), Basalma (2006), Saleem et al. (2001) and Momoh and Zhou (2001). Similarly, Christensen and Drabble (1984) and Bilgili et al. (2003) reported for *B. rapa,* one of the contributing parents for rapeseed, showed higher grain yield in the narrower row spacing compared with wider. On the other hand, Shahin and Valiollah (2009) and Ozer (2003) indicated that highest seed yield was obtained at narrow row spaces compared to wider rows for spring canola. Unlike these parallel results, some researchers, May et al. (1994), Clarke et al. (1978) and Lewis and Knight (1987) claimed that seed yield was not influenced by row spacing for spring canola. These variations in yield among oilseed rape might be due to difference genetic potential of the variety and environment (Sarwar, 2008).

Yield components

Row spacing was found to be important, statistically for plant height while intra row spacing and interaction had no statistically significant effect on it (Table 2). According to the results, the widest row spaces, 30-40 cm, cause to higher plant height in the first year. This result was supported by Oad et al. (2001), Johnson and Hanson (2003), Ozer

(2003) and these studies indicated that the wider row spaces increased plant height in canola cultivars. This may be due to sufficient space resulted plants grow well and showed greater height. In our experiment, the highest plant height was 216.0 cm in the 2006-07 growing season and 161.3 cm in the second year. There was a big difference between two years due to the fact that the rainfall within the growing period of canola in the second year was highly lower than those of first year. This big difference in plant height may generate a vital economic attention for either research or commercial production. Also, Johnson and Hanson (2003) expressed that cultivar x row spacing interactions affected plant height character which was greater when wide rows.

Number of branches showed statistically significant differences in both trial years. The mean values for number of branches ranged from 8.3 to 10.7 in the first year and from 4.7 to 7.3 in the second year. The highest number of branches was in 30-40 cm row spaces and found to be statistically significant while intra row-spacing and interaction had no statistically importance. This result indicated that low density populations produce more branches that carry fertile pods, thus prolonging the seed development phase and these outcomes in a range of seed maturity at harvest which may affect seed quality and increase the risk of seed loss through pod shatter and poor harvesting (Leach et al., 1999). As a result, lower plant population encouraged branching and it was supported by McGregor (1987), Momoh and Zhou (2001), Oad et al. (2001), Ozer (2003), Hasanuzzaman and Karim (2007) and Shanin and Valiollah (2009).

Analysis of variance showed that significant difference obtained in number of pods per plant in two growing seasons. The highest values were 391.0 in 2006-07 and 259.7 in 2007-08 and these values were monitored in 40 cm row spacing which was separated from the other rows, statistically. Similarly, number of branches was observed in wider row spacing which plants had more branches per plant, thus confirming that a reduction in the plant population significantly increases branching and the number of pods per plant (Momoh and Zhou, 2001).

Both trial years, number of seeds per pods was statistically affected by sowing density although the mean values were highly close to each other. Intra row-spacing and interaction were not important, significantly. 40 cm which was the highest row spacing produced highest values in both years, statistically, indicating that higher row spacing gave rise to higher seeds per pods and it was confirmed by Oad et al. (2001) and McGregor (1987).

There was no statistically significant change for 1000 seed weight in both years. Similarly, Ozer (2003), Morrison et al. (1990), Momoh and Zhou (2001) and Saleem et al. (2001) identified that there were no significant differences in row spacing for 1000 seed weight. Moreover, 1000 seed weight was not affected in canola seeding method (Clarke et al*.,* 1978). Only intra-row spacing was statistically important in 2007-08.

Conclusions

Seed yield, number of branches, number of pods per plant, number of seeds per pods were significantly influenced by row spacing in this study (Table 2). The highest seed yield was observed in narrow row spacing. Intra-row spacing importance was not presented clearly due to not a significant in experiment however narrow intra-row spaces should be available. Contrary to seed yield, other yield components were affected by wider row spaces as expected by enabling more space per plant. It can be concluded that canola sown at narrow row spacing produces higher seed yields than when sown in more widely spaced rows. This study showed that narrow row-spacing (10 cm) was very effective for winter grown canola. In order to make a deep impact on seed yield of canola,

Table 2
Influence of population density on yield and yield components in canola grown in 2006-2007 and 2007-2008 growing seasons

Row spacing	Intra-row spacing	Seed yield, kg ha^{-1}		Mean of two years	Plant height		Mean of two years	Number of branches		Mean of two years
		2006-2007	2007-2008	2006-2008	2006-2007	2007-2008	2006-2008	2006-2007	2007-2008	2006-2008
10	5	5150.0	3340.0	4245.0	203.3	157.3	180.3	8.3	5.3	6.8
	10	5316.7	2176.7	3746.7	208.3	150.3	179.3	9.3	5.3	7.3
	15	4016.7	2476.7	3246.7	203.3	148.7	176.0	9.0	4.7	6.9
	20	4966.7	1630.0	3298.4	204.3	154.0	179.2	9.7	6.3	8.0
20	5	3500.0	1915.0	2707.5	199.7	150.3	175.0	8.7	5.0	6.9
	10	2783.3	1565.0	2174.2	203.3	161.3	182.3	9.3	5.7	7.5
	15	3333.3	1581.7	2457.5	204.3	152.3	178.3	8.3	5.7	7.0
	20	3200.0	1445.0	2322.5	187.0	145.0	166.0	8.7	6.0	7.4
30	5	3072.2	1858.9	2465.6	214.0	158.7	186.4	10.7	7.0	8.9
	10	3233.3	2082.2	2657.8	213.7	158.3	186.0	10.3	6.7	8.5
	15	2955.5	1862.2	2408.9	210.0	151.7	180.9	10.7	7.0	8.9
	20	2216.6	1598.9	1907.8	213.7	152.0	182.9	9.7	6.3	8.0
40	5	2475.0	1300.0	1887.5	206.7	157.3	182.0	9.0	6.3	7.7
	10	3245.8	1435.8	2340.8	216.0	157.0	186.5	10.0	6.3	8.2
	15	2716.7	1254.2	1985.6	206.7	160.7	183.7	10.3	7.3	8.8
	20	2183.3	1282.5	1732.9	210.0	153.3	181.7	10.7	6.0	8.4
$LSD_{R.S}$		460.6**	528.8**		10.4*	ns		0.9**	0.7**	
$LSD_{I.R.S}$		ns	ns		ns	ns		ns	ns	
$LSD_{R.I.\ x}$ Cultivar		ns	ns		ns	ns		ns	Ns	

*. **: Statistically significant at 0.05 and 0.01 significance level. respectively. ns: not significant. R.S.: Row spacing. I.R.S: Intra-row Spacing.

Table 2 continued

Row Spacing	Intra-row Spacing	Stem height to the first pod		Mean of two years	Number of pods per plant		Mean of two years	Number of seeds per pods		Mean of two years	1000 seed weight		Mean of two years
		2006-2007	2007-2008	2006-2008	2006-2007	2007-2008	2006-2008	2006-2007	2007-2008	2006-2008	2006-2007	2007-2008	2007-2008
10	5	155.3	107.0	131.2	221.7	174.3	198.0	28.3	27.7	28.0	2.9	3.3	3.1
	10	159.7	106.0	132.9	234.0	126.0	180.0	27.3	28.3	27.8	2.7	3.5	3.1
	15	150.7	97.7	124.2	225.0	120.3	172.7	27.3	28.7	28.0	2.9	3.6	3.3
	20	150.3	107.0	128.7	233.7	180.7	207.2	29.3	29.0	29.2	3.0	3.0	3.0
20	5	145.0	104.3	124.7	226.7	145.3	186.0	29.3	28.0	28.7	2.9	3.7	3.3
	10	150.0	113.3	131.7	255.0	151.7	203.4	30.0	29.3	29.7	2.8	2.9	2.9
	15	152.0	104.3	128.2	255.3	182.3	218.8	28.0	29.3	28.7	2.9	3.1	3.0
	20	150.3	98.7	124.5	215.0	153.3	184.2	30.3	28.3	29.3	3.0	2.9	3.0
30	5	155.0	114.3	134.7	293.3	187.7	240.5	28.0	29.3	28.7	3.1	3.3	3.2
	10	160.0	111.7	135.9	292.0	176.7	234.4	26.7	30.3	28.5	2.8	3.5	3.2
	15	155.3	105.3	130.3	301.7	211.0	256.4	29.3	29.7	29.5	2.9	3.7	3.3
	20	156.7	113.7	135.2	271.3	191.3	231.3	29.0	29.7	29.4	2.9	3.1	3.0
40	5	160.0	108.7	134.4	279.7	176.7	228.2	29.3	30.0	29.7	2.9	3.3	3.1
	10	159.7	111.0	135.4	330.7	209.7	270.2	29.3	30.0	29.7	2.9	2.9	2.9
	15	148.7	108.3	128.5	391.0	259.7	325.4	30.0	30.3	30.2	3.1	3.3	3.2
	20	157.0	107.3	132.2	354.3	221.7	288.0	30.0	29.7	29.9	3.3	3.2	3.3
$LSD_{R.S}$		ns	ns		40.1**	34.9**		1.27*	1.1**		ns	ns	
$LSD_{I.R.S}$		ns	ns		ns	ns		ns	ns		ns	0.2**	
$LSD_{R.I. x}$ Cultivar		ns	ns		ns	ns		ns	ns		ns	ns	

*. **: Statistically significant at 0.05 and 0.01 significance level. respectively. ns: not significant. R.S.: Row spacing. I.R.S: Intra-row Spacing.

narrow row spaces should therefore be selected in the Mediterranean-type environments.

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