Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not. Bot. Hort. Agrobot. Cluj 38 (1) 2010, 171-175

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Influence of Sowing Properties on Winter Oilseed Rape in a Sub-humid Mediterranean Environment

Mehmet SINCIK, Abdurrahim Tanju GOKSOY, Zeki Metin TURAN

Uludag University, Faculty of Agriculture, Department of Field Crops, 16059, Bursa, Turkey; sincik@uludag.edu.tr

Abstract

The effects of three row spacings (17.5, 35.0 and 52.5 cm) and four seeding rates (100, 200, 300 and 400 viable seeds m^{-2}) on seed yield and some yield components of winter oilseed rape (*Brassica napus* L.) were evaluated under rainfed conditions in Bursa, Turkey in the 2005-2006 and 2006-2007 growing seasons. Row spacing and seeding rate significantly affected most yield components measured. The number of plants per unit area increased with increasing seeding rate and decreasing row spacing. Greater plant heights were obtained from narrow row spacings and higher seeding rates. Narrow row spacings and higher seeding rates reduced the number of primary branches and the number of pods per terminal raceme. Also, the number of seeds per pod and 1000-seed weight were not affected by either row spacing or seeding rate. In contrast, the number of pods per plant clearly increased with increasing row spacing but decreased with increasing seeding rate. The highest seed yields were obtained for the 17.5 cm row spacing (1709.2 kg ha^{-1}) and 200-seeds m^{-2} seeding rate (1721.4 kg ha^{-1}).

Keywords: *Brassica napus* L., row spacing, seed yield, seeding rate, yield components

Introduction

Oilseed rape is cultivated and processed for many different purposes: as a source of oil for human nutrition, as a renewable raw material for the chemical industry, as a source of regenerative energy, as a source of high energy and protein content for animal nutrition in the form of rape cake and meal, as a catch crop for green manure and as a forage crop (Orlovius, 2003). The importance of rape has thus increased in recent years and today it is one of the most important oil seed crops in the world (Bybordi and Tabatabaei, 2009).

The seed yield of oilseed rape is a function of population density, number of pods per plant, number of seeds per pod and seed weight. However, yield structure is very plastic and adjustable across a wide range of populations. The number of pods per plant is the most responsive of all the yield components in oilseed rape (Diepenbrock, 2000). Low-density populations produce more branches that carry fertile pods, thus prolonging the seed development phase. Plants grown at high densities are often more susceptible to lodging and increased disease incidence without the benefit of any yield increase, but the presence of fewer pod-bearing branches should produce more synchronous pod and seed development and result in more uniform seed maturation, improved harvesting ability and possibly lower seed glucosinolate and higher oil contents (Leach *et al.*, 1999). Higher plant population density has been recommended and adopted to ensure a competitive crop and to control weeds in the early growth stages (Morrison *et al.*, 1990a). McGregor (1987) compared the yield of very low-density plant populations (<22 plants m^{-2}) with that of the highest-density population (114 to 200 plants m^{-2}) during one growing season. Canola yield plasticity in that study varied widely, indicating the importance of weather conditions in determining the optimum population density. McGregor (1987) also noted a 20% yield reduction when comparing winter oilseed rape stands of 40 plants m^{-2} to full stands of 200 plants m^{-2}. Angadi *et al.* (2003) noted that plant populations reduced from 80 to 40 plants m^{-2} produced similar seed yields when plant stands were uniformly distributed. Chen *et al.* (2005) found that a seeding rate of 32 to 65 seeds m^{-2} produced optimum oilseed rape yields.

Clarke *et al.* (1978) reported that *B. napus* grown at a 30 cm row spacing in southern Saskatchewan, Canada, yielded more than the broadcast seeding at each of four seeding rates ranging from 2.5 to 20 kg ha^{-1}. Greater oilseed rape production when grown in rows was thought to be due to altered plant morphology and enhanced source and sink development. Christensen and Drabble (1984) observed that similar yields were produced by stands of *B. rapa* and *B. napus* grown at 15 and 23 cm row spacings in northwest Alberta. Seed yield from stands grown at 7.5 cm row spacing was 29 and 36% greater than that from 15 cm row spacing for *B. rapa* and *B. napus*, respectively. No influence of seeding rate (7 or 14 kg ha^{-1}) on yield was found for either species. In Alaska, Lewis and Knight (1987) observed equivalent yield from *B. rapa* grown at row spacings of 18 and 36 cm. Morrison *et al.* (1990a) reported studies conducted in southern Manitoba that showed that *B. napus* yield was greater from stands grown at a 15 cm row spacing compared with those using a 30 cm row spacing. Different seed sources used between years resulted in a large seed size disparity and different seeding rates among site-years, which confounded the analysis of stand density across site-years. The researchers did not observe a consistent effect of row spacing or seeding rate on seed oil content. May *et al.* (1993) noted that row spacings of 9 and 18 cm did not influence yield or oil content of three *B. napus* cultivars in Ontario. They did observe that yield increased as seeding rate increased from 1.0 to 9.0 kg ha^{-1}.

Yield improvements and market price increases are needed to make winter oilseed rape economically competitive with winter wheat in sub-humid Mediterranean areas. In addition, rotational considerations such as yield benefits for wheat production, improved soil tilth, and fewer weed problems make this crop attractive to producers. However, little is known about the effect of row spacing and seeding rate on seed yield of winter oilseed rape in the sub-humid Mediterranean environment. This study was conducted to determine the effects of row spacing and seeding rate on seed yield and its components in oilseed rape under rainfed conditions into the Turkish sub-humid Mediterranean environment.

Materials and methods

A field study was conducted during the 2005-2006 and 2006-2007 growing seasons in the experimental plots of the Faculty of Agriculture, Uludag University (near Bursa) to evaluate the integrated effects of row spacing and seeding rate on seed yield and yield components of oilseed rape (*Brassica napus* L. cv. 'Jet Neuf').

The soil at this site is a slightly alkaline (pH 7.2) clay loam, with 180 kg ha^{-1} potassium and 71 kg ha^{-1} phosphorous and low organic matter (1.4%). According to climatic data taken from the nearest weather station in Bursa, the long-term average total precipitation is 713 mm $year^{-1}$. The mean temperature for the whole year is 14.6°C, and the relative humidity is 68%. A sub-humid climate prevails in the region, based on the mean annual rainfall (600-700 mm) (Jensen, 1980). Long-term average precipitation during the growing period of oilseed rape (October-June) is 616.0 mm, while growing season precipitation measured in the 2005-2006 and 2006-2007 growing seasons was 466.3 and 467.1 mm, respectively. Average temperature during the same months varied from 5.3 to 22.1°C, 5.5 to 21.5°C and 5.8 to 24.4°C for the long-term average, 2005-2006 and 2006-2007 growing seasons, respectively. On average, the relative humidity is about 70% in the October-June period (Tab. 1). These data indicate that row spacings and seeding rates were evaluated across a considerable range of weather conditions. In particular, the rainfall received during the experimental growing seasons was significantly lower (24.2% on average for the 2005-2006 and 2006-2007 growing seasons) than the long-term average. The lack of seasonal rainfall is likely to restrict seed yield and its components in winter oilseed rape.

Factorial arrangements of three row spacings (17.5, 35.0 and 52.5 cm) and four seeding rates (100, 200, 300 and 400 viable seeds m^{-2}) were evaluated in a randomized complete block design with three replications. Seeding rates were 100-400 seeds m^{-2}, equivalent to seeding rates of 5-20 kg ha^{-1}. The individual plot size was 2.8×5 m=14 m^2. Sowing was done by hand on October 25, 2005 and October 27, 2006, respectively. Trifluralin at 1.0 kg ha^{-1} was sprayed after sowing for weed control and hand hoeing was carried out when necessary. Nitrogen fertilization of 100 kg ha^{-1} after sowing and 50 kg ha^{-1} in spring was uniformly applied to all plots as ammonium nitrate. There were no significant problems with pests, diseases or weeds during the course of the study. Ten plants from each replication were randomly collected at the full podding stage for morphological measurements. Plant height, number of primary branch per plant, number of pods per terminal raceme, pod number per plant, seed number per pod, and 1000-seed weight were measured for each individual. Plant stand was counted at harvest along a 1 m length of the interior rows of each plot in two replications. When the seeds had matured in June, the plots were harvested with a Hege 125 C Plot Combine (Hans-Ulrich Hege Maschinenbau, Hohebuch, Germany).

Tab. 1. Monthly rainfall (mm), temperature (°C), and relative humidity (%) in 2005-2006 and 2006-2007 growing seasons with long term averages (1928-2002)

	2005-2006			2006-2007			Long-Term		
Months	Rainfall (mm)	Temp.* (°C)	RH** (%)	Rainfall (mm)	Temp.* (°C)	RH** (%)	Rainfall (mm)	Temp.* (°C)	RH** (%)
October	37.5	13.2	72.7	45.6	16.7	77.1	60.4	15.6	72.8
November	109.3	9.3	74.6	43.1	13.8	75.2	76.3	11.2	75.6
December	58.0	6.1	70.2	68.2	8.7	71.4	99.9	7.6	74.2
January	78.3	5.5	71.1	86.7	5.8	72.6	88.8	5.3	74.1
February	71.3	7.4	69.4	73.4	7.1	67.8	77.5	6.2	73.4
March	38.8	9.2	68.2	45.2	10.1	67.4	69.8	8.3	70.2
April	20.4	12.1	74.0	26.5	13.4	72.1	62.9	13.0	70.3
May	9.2	16.6	61.4	31.8	19.9	62.0	50.0	17.6	69.5
June	43.5	21.5	64.2	46.6	24.4	57.1	30.4	22.1	62.9
Total/mean	466.3	11.2	69.5	467.1	13.3	69.2	616.0	11.9	71.4

*: Temp. = temperature; **: RH= relative humidity

All data were subjected to analysis of variance for each character using MINITAB (University of Texas, Austin, TX) and MSTAT-C (Version 2.1, Michigan State University, East Lansing, MI) software. The significance of treatment, main effects and interactions were determined at the 0.05 and 0.01 probability levels by the F-test. The F-protected least significant difference (LSD) was calculated at the 0.05 probability level.

Results and discussion

An ANOVA of the combined two-year data indicated significant main effects according to year, row spacing and seeding rate for most parameters (Tab. 2 and Tab. 3). Apart from the number of seeds per pod, 1000-seed weight and seed yield, year effect was significant for most parameters. Row spacing and seeding rate interactions were not significant except for plant stand and pod number per plant. Therefore, row spacing and seeding rate characteristics are discussed independently for most parameters. The results are summarized in Tab. 2 and Tab. 3.

As expected, the number of plants per unit area increased with increasing seeding rate and decreasing row spacing. Average plant stand, i.e., the number of mature plants/seeding rate, was only 21.4% at the highest seeding rate compared with 43.0% at the lowest seeding rate, which suggests self-thinning during the later stages of development after emergence, particularly for high seeding rates (Tab. 2). In close agreement with our findings, Almond *et al.* (1986) found that the plant stand of oilseed rape decreased from 57% to 19% when seeding rate was increased from 41.5 to 664.0 seeds m^{-2}. The effect of the row spacing × seeding rate interaction on plant stand was statistically significant (Tab. 4). Plant stand increased with increasing seeding rate, but the magnitude of the increase in plant stand gradually declined with widening row spacing.

Mean comparisons of simple effects showed that with different row spacings, the tallest plant height (132.5 cm) was obtained for the 17.5 cm row spacing. Among different seeding rates, the tallest plant height (133.5 cm) was produced by the 400-plants m^{-2} seeding rate. Plant height for winter oilseed rape was statistically similar when grown at 17.5 or 35.0 cm row spacings and 300 or 400 seeds m^{-2} seeding rates (Tab. 2). Kondra (1975) reported that increased seeding rates resulted in shorter plants and concluded that more competition results in shorter plants. The number of branches per plant was reduced by narrow row spacings and high seeding rates. The number of pods per terminal raceme declined slightly with decreasing row spacing and increasing seeding rate (Tab. 2). Our results are in agreement with those reported by Clarke and Simpson (1978).

Tab. 2. Effects of row spacing and seeding rate on plant stand, plant height, number of primary branch per plant and number of pods per terminal raceme components in oilseed rape (2-year average)

Treatments		Plant stand (plants m^{-2})	Plant height (cm)	Branches/plant	Pods/terminal raceme
Row spacing (cm)^a					
17.5		107.1^a	132.5^a	5.3^c	38.5^b
35.0		57.0^b	131.0^a	5.6^b	39.8^b
52.5		34.4^c	128.0^b	6.0^a	42.9^a
LSD (0.05)		1.22	2.47	0.14	1.78
Seeding rate (seeds m^{-2})^b					
100		43.0^d	125.9^c	6.0^a	42.9^a
200		59.1^c	130.0^b	5.7^b	41.3^{ab}
300		76.8^b	132.6^{ab}	5.5^c	39.7^{bc}
400		85.9^a	133.5^a	5.3^d	38.0^c
LSD (0.05)		1.41	2.85	0.16	2.06
Summary of ANOVA					
Source	d.f.	Means of squares			
Year (Y)	1	78.11**	1369.39**	76.05**	475.35**
Blocks (Year)	4	6.90^{ns}	5.82^{ns}	0.18*	5.53^{ns}
Row spacing (RS)	2	33195.21**	121.54**	2.87**	123.17**
Seeding rate (SR)	3	6535.32**	209.81**	1.93**	79.49**
RS x SR	6	1310.20**	2.47^{ns}	0.01^{ns}	0.98^{ns}
Y x RS	2	2.22^{ns}	0.32^{ns}	0.03^{ns}	0.39^{ns}
Y x SR	3	3.51^{ns}	0.98^{ns}	0.01^{ns}	0.01^{ns}
Y x RS x SR	6	2.20^{ns}	0.41^{ns}	0.01^{ns}	0.17^{ns}
Error	44	4.44	18.05	0.06	9.41

* statistical difference at $P < 0.05$; ** statistical difference at $P<0.01$; ns= no statistical difference at $P<0.05$ and $P<0.01$; d.f.: degrees of freedom, a: data are the means of 2 years, 3 replicates and 4 seeding rates; b: data are the means of 2 years, 3 replicates and 3 row spacings, means within each column followed by the same letter are not different (least significant difference (LSD) test, $p<0.05$)

Tab. 3. Effects of row spacing and seeding rate on pod number per plant, seed number per pod, seed yield, and 1000-seed weight components in oilseed rape (2-year average)

Treatments		Pods/plant	Seeds/pod	1000-seed weight (g)	Seed yield (kg ha^{-1})
Row spacing (cm)[a]					
17.5		220.6[c]	27.5	4.7	1709.2[a]
35.0		245.5[b]	27.2	4.8	1640.6[ab]
52.5		290.9[a]	27.2	4.8	1608.9[b]
LSD (0.05)		1.74	ns	ns	75.83
Seeding rate (seeds m^{-2})[b]					
100		286.7[a]	27.6	4.9	1545.5[b]
200		262.3[b]	27.2	4.7	1721.4[a]
300		239.7[c]	27.3	4.7	1700.6[a]
400		220.7[d]	27.1	4.7	1644.1[a]
LSD (0.05)		2.01	ns	ns	87.56
Summary of ANOVA					
Source	d.f.	Means of squares			
Year (Y)	1	264.51**	17.50ns	0.48ns	56280.01ns
Blocks (Year)	4	5.11ns	2.93ns	0.07ns	59976.12ns
Row spacing (RS)	2	30450.94**	0.96ns	0.05ns	63014.41*
Seeding rate (SR)	3	14652.01**	0.78ns	0.12ns	111474.22**
RS x SR	6	60.92**	0.07ns	0.03ns	269.04ns
Y x RS	2	2.40ns	0.31ns	0.01ns	322.01ns
Y x SR	3	1.83ns	0.01ns	0.01ns	3099.19ns
Y x RS x SR	6	1.71ns	0.12ns	0.01ns	676.31ns
Error	44	8.95	4.83	0.14	16987.42

*=statistical difference at P < 0.05; **= statistical difference at P < 0.01; ns= no statistical difference at P < 0.05 and P < 0.01; d.f.: degrees of freedom;
a: data are the means of 2 years, 3 replicates and 4 seeding rate, b: data are the means of 2 years, 3 replicates and 3 row spacings, means within each column followed by the same letter are not different (least significant difference (LSD) test, $p < 0.05$)

The number of pods per plant was greatly affected by both row spacing and seeding rate. The total number of pods increased with increasing row spacing but decreased with increasing seeding rate (Tab. 3). Angadi *et al.* (2003) reported that the number of pods per plant increased with decreasing plant population density in all environments, although the magnitude of the decline was different. Moreover, the row spacing × seeding rate interaction was significant for the number of pods per plant (Tab. 4). The lowest number of pods per plant was observed when plants were grown at 17.5 cm row spacing and 400-seeds m^{-2} seeding rate, whereas other treatments showed higher numbers of pods per plant.

The number of seeds per pod and 1000-seed weight were not affected significantly by row spacing and seeding rate (Tab. 3). McGregor (1987) found that the number of seeds per pod and 1000-seed weight was not strongly influenced by plant population density, as was the number of pods per plant. Early-formed pods at the top of the canopy or on the main raceme have a developmental advantage (Mendham and Salisbury, 1989), which might explain the smaller variations in number of seeds per pod and 1000-seed weight.

Seed yield generally increased as the row spacing decreased. The maximum seed yield occurred at the 17.5 cm row spacing, with small and non-significant differences with 35.0 cm row spacing. Differences among yields at the three higher seeding rates (200, 300 and 400 seeds m^{-2}) were not significant. However, the 200-seeds m^{-2} seeding rate had the greatest seed yield (1721.4 kg ha^{-1}) (Tab. 3). Morrison *et al.* (1990a) reported studies conducted in southern Manitoba showing that *B. napus* yield was greater from stands produced at a 15 cm row spacing compared with 30 cm row spacing. Plants exhibited greater dry weight per unit area and at certain growth stages, greater leaf area index when grown in rows spaced at 15 cm compared with 30 cm (Morrison *et al.*, 1990b). Clarke *et al.* (1978) reported that winter oilseed rape grown at 30 cm row spacing in southern Saskatchewan, Canada yielded more than broadcast seeding at each of four seeding rates ranging from 2.5 to 20.0 kg ha^{-1}. Hanson *et al.* (2008) stated that seed yield increased with increasing seeding rates in spring oilseed rape.

Most of the final seed yield is contributed by the terminal raceme on the main stem and pods on the primary branches in oilseed rape genotypes. Pods on secondary branches are of minor importance in the determination of seed yield in this crop (Campbell and Kondra, 1978; Scarisbrick *et al.*, 1982). In the present study, however, there was no obvious relationship between seed yield and number of pods per terminal raceme or number of pods per plant, neither for row spacing or for seeding rate.

In summary, winter oilseed rape exhibited plasticity in morphological characteristics to maintain total seed

Tab. 4. Plant stands and number of pods per plant of winter oilseed rape at different row spacing and seeding rate (2-year average)

Row spacing (cm)	Seeding rate (seeds m^{-2})	Plant stand (plants m^{-2})	Pods/plant
17.5	100	64.0^{f*}	251.0^{g*}
	200	94.5^{c}	229.5^{h}
	300	126.0^{b}	212.5^{i}
	400	144.0^{a}	189.5^{j}
35.0	100	38.0^{i}	283.0^{c}
	200	51.3^{g}	255.5^{f}
	300	66.5^{e}	230.0^{h}
	400	72.3^{d}	213.5^{i}
52.5	100	27.0^{k}	326.0^{a}
	200	31.5^{j}	302.0^{b}
	300	38.0^{i}	276.5^{d}
	400	41.3^{h}	259.0^{e}
LSD(0.05)		2.44	3.47

*means within each column followed by the same letter are not different (least significant difference (LSD) test, p>0.05)

yield across a wide range of population densities in the sub-humid Mediterranean environment. However, winter oilseed rape grown at narrow row spacing and a higher seeding rate produces higher seed yield compared to wide row spacing and a low seeding rate.

References

Almond, J. A., T. C. K. Dawkins and M. F. Askew (1986). Aspects of crop husbandry, pp. 127-175. In: Scarisbrick D. H. and D. W. Daniels (Eds.). Oilseed Rape, Collins Professional and Technical Books, London.

Angadi, S. W., H. W. Cutforth, B. G. Mcconkey and Y. Gan (2003). Yield adjustment by canola grown at different plant population under semiarid conditions. Crop Science 43:1358-1366.

Bybordi, A. and J. Tabatabaei (2009). Effect of salinity stress on germination and seedling properties in canola cultivars (*Brassica napus* L.). Notulae Botanicae Horti Agrobotanici Cluj-Napoca 37(1):71-76.

Campbell, D. C. and Z. P. Kondra (1978). Relationships among growth patterns, yield components and yield of rape seed. Canadian Journal of Plant Science 58:87-93.

Chen, C. G., G. Jackson, K. Neill, D. Wichman, G. Johnson and D. Johnson (2005). Determining the feasibility of early seeding canola in the northern Great Plains. Agronomy Journal 97:1252-1262.

Christensen, J. V. and J. C. Drabble (1984). Effect of row spacing and seeding rate on rapeseed yield in Northwest Alberta. Canadian Journal of Plant Science 64:1011-1013.

Clarke, J. M., F. R. Clarke and G. M. Simpson (1978). Effects of method and rate of seeding on yield of *Brassica napus*. Canadian Journal of Plant Science 58:549-550.

Diepenbrock, W. (2000). Yield analysis of winter oilseed rape (*Brassica napus* L.): A review. Field Crops Research 67:35-49.

Hanson, B. K., B. L. Johnson, R. A. Henson and N. R. Riveland (2008). Seeding rate, seeding depth, and cultivar influence on spring canola performance in the northern great plains. Agronomy Journal 100:1339-1346.

Jensen, M. E. (Ed.) (1980). Design and operation of farm ırrigation systems. American Society of Agricultural Engineering. St. Joseph, MI.

Kondra, Z. P. (1975). Effects of row spacing and seeding on rape seed. Canadian Journal of Plant Science 55:339-341.

Leach, J. E., A. H. Stevenson, A. J. Rainbow and L. A. Mullen (1999). Effects of high plant populations on the growth and yield of winter oilseed rape (*Brassica napus* L.). Journal of Agricultural Science, Cambridge 132:173-180.

Lewis, C. E. and C. W. Knight (1987). Yield response of rapeseed to row spacing and rates of seeding and fertilization in interior Alaska. Canadian Journal of Plant Science 67:53-57.

May, W. E., D. J. Hume and B. A. Hale (1993). Effects of agronomic practices on free fatty acid levels in the oil of Ontario-grown spring canola. Canadian Journal of Plant Science 74:267–274.

Mc Gregor, D. I. (1987). Effect on plant density on development and yield of rapeseed and its significance to recovery from hail injury. Canadian Journal of Plant Science 67: 43-51.

Mendham, N. J. and P. A. Salisbury (1989). Physiology: Crop development, growth and yield, pp. 11-64 . In: Kimber, D. and D. I. McGregor (Eds.). *Brassica* oilseeds: Production and utilization. CAB International, UK.

Morrison, M. J., P. B. E. McVetty and R. Scarth (1990a). Effect of row spacing and seed rates on summer rape in southern Manitoba. Canadian Journal of Plant Science 70:127-137.

Morrison, M. J., P. B. E. McVetty and R. Scarth (1990b). Effect of altering plant density on growth characteristics of summer rape. Canadian Journal of Plant Science 70:139-149.

Orlovius, K. (2003). Oilseed rape. In: Kirbky, E. A. (Ed.).Fertilizing for High Yield and Quality, Bulletin 16. IPI, Basel.

Scarisbrick, D. H., R. W. Daniels and A. B. Noor Rawi (1982). The effect of varying seeding rate on the yield and yield components of oilseed rape (*Brassica napus* L.). Journal of Agricultural Science, Cambridge 99:561-568.