

# The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars

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## ABSTRACT

Rapeseed (*Brassica napus* L.) is an important alternate oilseed crop in eastern Anatolia, Turkey. No information on plant density for rapeseed is available in this region. Therefore a study was initiated to investigate the effects of spacings between rows and spacings within rows on the yield and agronomic characteristics of two genotypes of spring rapeseed (Tower and Lirawell) in Erzurum, eastern Anatolia, during 1994 and 1995. The effects of spacings between or within rows on the yield and yield components of Tower and Lirawell, two cultivars of *Brassica napus* L., were studied for 2 years in Erzurum, Turkey. Rows were spaced at 15, 30 and 45 cm. Spacings within rows were 5, 10 and 15 cm. The results of this study suggested that seed yield was significantly affected by spacings between rows but not by spacings within rows, and that rape yields were higher at the narrow (15 cm) row spacing compared to the middle (30 cm) and wider (45 cm) spacings.

**Keywords:** rapeseed; *Brassica napus* L.; plant density; row spacing; seed yield

In general, Turkey has a suitable climate for many oilseeds. This is not completely true of eastern Anatolia with low temperatures and short growing season, where the oilseed crops usually perform poorly except sunflower and rapeseed. Rapeseed is a new and promising oilseed crop for this region (Ozer and Oral 1997).

In oilseed rape, row spacing or plant density vary considerably worldwide, depending on the environment, production system and cultivar. Previous studies have shown that plant density is an important factor affecting rapeseed yield. Plant density in rapeseed governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock 2000). Al-Barzinjy et al. (1999) investigated the effects of different plant densities ranging from 20 to 130 plants/m<sup>2</sup> in rapeseed. They concluded that pods per plant, seed weights and dry matter per plant decreased as plant density increased. Leach et al. (1999) also reported that plants grown at high density had fewer pod-bearing branches per plant but produced more branches, and that with an increase in density 1000-seed weight increased. The same researchers also observed that there was no effect of density on seed oil content. Rapeseed is sometimes grown in rows with spacings wide enough to allow for mechanical cultivation. In most areas where herbicides are used, the crop is either broadcast seeded or planted in drill rows spaced 15–20 cm apart (Lewis and Knight 1987).

Rapeseed has generally slight or inconsistent seed yield responses to various row spacings. Therefore, optimum densities for each crop and each environment should be determined by local research. However, there are no published research data on the plant density or row spacing response of rapeseed in the region of eastern Anatolia, Turkey.

The objective of this study was to evaluate the effects of different spacings between or within rows on the agronomic characteristics of two genotypes of *Brassica napus* L., cv. Tower and Lirawell.

## MATERIAL AND METHODS

This research was conducted during 1994 and 1995 at the Agricultural Research and Extension Center in Erzurum (29°55'N and 41°16'E, 1950 m elevation), Faculty of Agriculture of Atatürk University, Turkey. The soil at the experimental site was loamy, with approximately 14.4 g/kg organic matter. The 0–30 cm soil layers contained respectively 1 050 kg/ha total N, 108.6 kg/ha available P and 406.8 kg/ha available K. The previous crop for the plots sown in 1994 and 1995 was barley (*Hordeum vulgare* L.). The plots were mouldboard ploughed in the fall and cultivated twice in the spring. Individual plots were 4 rows by 5 m long. Seeds were hand-sown on 1 May in 1994 and 3 May in 1995, respectively.

In this study, two spring rapeseed cultivars, Tower and Lirawell, were used. Cultivar selection was based on performance in yield trials (Ozer and Oral 1997). The experimental design was a randomized block design with four replications. Treatments consisted of two cultivars (Tower and Lirawell), three spacings between rows (15, 30 and 45 cm) and three spacings within rows (5, 10 and 15 cm). In both years, the experiment was fertilized before sowing by the following fertilization rates: 60 kg N/ha as ammonium sulphate and 60 kg P<sub>2</sub>O<sub>5</sub>/ha as triple superphosphate. Additional 60 kg N/ha was applied in both the study years, just before flowering. Spacings between plants were established by dense seeding and then thinning to the desired within-row

spacing. No herbicides were applied to the field experiment in either year. Weeds were controlled by hand weeding or by mechanical cultivation as needed. Plots were irrigated five times during both growing seasons. Each irrigation brought the soil moisture back to near the field capacity. All sowings were sprayed with Malathion before flowering to protect against a beetle (*Omophlus cafcasicus*) and aphids.

Treatments were hand-harvested when 30–40% of the seeds changed their color from green to brown in both years. Seed yields were taken at maturity by harvesting the central two rows of each plot for seed yield determination. Seed yield was adjusted to a 10.0% moisture basis. 15 plants were collected randomly from the central two rows and the following growth and yield component variables were recorded for each plot, days to maturity, plant height, branch number per plant, pod number per plant, number of seeds per pod and 1000-seed weight. Seed oil content was determined with the Soxhlet apparatus, and seed protein content by micro-Kjeldahl method.

The data were subjected to analysis of variance using the MSTAT-C software. When the *F*-test indicated statistical significance at the *P* = 0.05 level, Duncan's multiple-range test was used to determine the significance between means. Data were averaged across years because no significant year by treatment interactions occurred.

## RESULTS AND DISCUSSION

The monthly rainfall, average temperatures and relative humidity data for 1994 and 1995 are presented in Table 1. Air temperatures during the two growing seasons were close to the long-term mean. April to September temperature, which averages 14.2°C at this location, was slightly below normal in 1994 and 1995. Rainfall amounts in the study years were close to each other. The 1994 and 1995 rainfall was below the long-term average. The mean of the 1994 relative humidity was similar to the long-term mean, whereas relative humidity in 1995 was above normal (Table 1).

Both cultivars used in this study responded to treatments in the same way, thus there was no interaction of cultivars with spacings within rows. Similarly, no spacing between rows × spacing within rows interaction was observed for any yield or agronomic traits (Table 2). Furthermore, three-way interactions for all parameters investigated were insignificant. In this study, significant effects of cultivar × spacing between rows interaction on days to flowering, days to maturity, protein content and oil content were observed.

### Plant growth

Results of this study for days to flowering are presented in Table 2. Days to flowering showed variations between the cultivars. The cultivar Tower was significantly earlier in terms of days to flowering than cv. Lirawell. Tower and Lirawell flowered in 55.6 and 62.5 days, respectively. The effect of spacing between or within rows was significant (*P* < 0.01).

Increasing the spacing between rows considerably delayed the flowering of cultivars. Essentially, such a situation could be expected. This finding agrees with that of Van Deynze et al. (1992), who reported that increased row spacing delayed flowering in rape. In this study, days to flowering varied more than three days across the row spacings (15, 30 and 45 cm). Similarly, days to flowering tended to increase with an increase in spacings within rows. The effect of the cultivar × spacing between rows interaction was significant (*P* < 0.01).

The cultivar, spacing between rows, and the cultivar × spacing between rows interaction were significant (*P* < 0.01) for days to maturity. The results of this study revealed that Tower (123.0 days) matured earlier than Lirawell (131.4 days) (Table 2). With different spacings between rows, large differences occurred in days to maturity as shown in Table 2. The maturity of rape cultivars was generally shorter at the close row spacing than at wide row spacings (30 or 45 cm). This effect can be due to the fact that the crop growth rate increased as plant density increased (Morrison et al. 1990a). Significant differences were found for the cultivar × spacing between rows

Table 1. Monthly and growing season precipitation, temperature, and relative humidity in Erzurum in 1994 and 1995

Months	Precipitation (mm)			Temperature (°C)			Relative humidity (%)		
	1994	1995	normal*	1994	1995	normal	1994	1995	normal
April	57.5	54.0	53.8	8.2	4.4	5.3	56.7	72.3	64.9
May	104.7	39.3	73.1	10.7	11.7	10.8	60.7	67.0	60.9
June	14.7	72.5	53.1	14.1	14.4	15.4	52.9	66.7	56.6
July	14.0	30.5	29.1	19.1	17.9	19.2	51.1	58.8	49.9
August	13.9	15.0	18.9	18.6	18.8	19.5	50.3	55.9	46.7
September	8.6	17.0	24.7	15.8	13.4	14.9	49.8	57.9	49.2
Total or mean	213.4	228.3	252.7	14.4	13.4	14.2	53.6	63.1	54.7

\* normal refers to the long-term average, 65-year average

interaction that were caused by the cultivars reacting to the various spacings in a different manner. There were no significant differences for spacings within rows (Table 1).

As can be seen in Table 2, there were large differences between the cultivars in plant height. Plant heights for Tower and Lirawell were 101.4 and 118.3 cm, respectively. Plant height decreased with increasing plant densities, but this variation was more pronounced in Tower than in Lirawell. The effect of spacings between rows on plant height was significant ( $P < 0.01$ ). Increased spacings between rows increased plant height from 104.7 to 114.3 cm. The widest spacing (45 cm) gave the highest plant height for the cultivars (Table 2). Morrison et al. (1990a) also reported that rape grown at the highest plant densities produced smaller plants. Plant height did not differ across spacings within rows.

## Yield components

Branch numbers for the cultivars were nearly similar and ranged from 4.69 (Tower) to 4.76 (Lirawell). Significant differences in branch numbers per plant occurred between the various spacings between rows. Generally, an increase in row spacing led to significantly higher

branching. This was consistent with the findings of Ali et al. (1996), who reported that low density resulted in an increased number of branches per plant.

The data presented in Table 2 show that the number of pods per plant for Lirawell was higher (176.5) than for Tower (167.8), but the difference was not found significant (Table 2). The highest number of pods per plant was recorded for a 45 cm row spacing. The differences in this character between the three row spacings (15, 30 and 45 cm) were large. Similarly, Momoh and Zhou (2001) stated that the number of effective branches and pods per branch decreased with increasing plant density. Higher branching observed in wide row spacings was a major cause of the increased number of pods per pod.

Table 2 demonstrates that the number of seeds per pod for Tower and Lirawell was approximately equal (24.10 and 25.05, respectively). There were also significant differences due to row spacings. An increase in row spacings resulted in consistent increases in the number of seeds per pod in both rape cultivars. Similar results were also observed by Taylor and Smith (1992).

Data collected in the average results of two study years indicate that there were no significant differences for 1000-seed weight between the cultivars. The increase in row spacing did not significantly affect 1000-seed weight

Table 2. Two-year (1994 and 1995) mean values of several agronomic characteristics and seed yield as affected by cultivar, spacing between or within rows in Erzurum

Treatments	Days to flowering (d)	Days to maturity (d)	Plant height (cm)	Branch numbers per plant	Number of pods per plant	Number of seeds per pod	1000-seed weight (g)	Seed yield (kg/ha)	Protein content (%)	Oil content (%)
<b>Cultivar (A)</b>										
Tower	55.69	123.00	101.4	4.69	167.8	24.10	4.232	1039	24.39	39.74
Lirawell	62.50	131.36	118.3	4.76	176.5	25.05	4.11	1065	25.86	40.48
	**	**	**	ns	ns	ns	ns	ns	**	**
<b>Spacing between rows (cm) (B)</b>										
15	57.58 c	126.08 b	104.73 b	4.14 b	127.7 b	23.67 b	4.16	1195 a	25.51	39.70
30	58.87 b	126.67 b	110.46 ab	4.94 a	184.2 a	24.91 a	4.17	1106 a	25.22	40.31
45	60.83 a	128.79 a	114.32 a	5.11 a	204.5 a	25.15 a	4.17	857 b	24.62	40.32
	**	**	**	**	**	*	ns	**	ns	ns
<b>Spacing within rows (cm) (C)</b>										
5	58.46 b	126.92	108.9	4.59	160.3	24.85	4.19	1121	40.05	40.05
10	59.12 ab	126.96	111.0	4.72	171.3	24.34	4.20	1068	40.23	40.23
15	59.71 a	127.67	109.6	4.87	184.8	24.54	4.12	968	40.06	40.06
	**	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	1.41	2.45	5.05	9.34	8.56	2.74	4.87	10.60	4.52	5.07
<b>Interactions</b>										
A × B	**	**	ns	ns	ns	ns	ns	ns	**	**
A × C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
B × C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
A × B × C	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Effects were significant at the 5% (\*) or 1% (\*\*) level or not significant (ns)

$LSD_{0.01} = 0.9843, 1.208, 1.9737$  and  $1.1630$  for A × B interaction effects on days to flowering, days to maturity, protein content and oil content, respectively

(Table 2). This agrees with previous papers which found out that 1000-seed weight was not significantly affected by plant densities (Kondra 1977, Morrison et al. 1990b, O'Donovan 1996). The cultivars Tower and Lirawell gave about the same 1000-seed weight at the 15, 30 and 45 cm row spacing. Seed weight did not respond to changes in spacings within rows (5, 10 and 15 cm).

### Seed yield

The results indicated that Lirawell outyielded Tower in seed yield. Seed yields for Tower and Lirawell were 1039 and 1065 kg/ha. The difference between the cultivars was insignificant (Table 2). The yield values obtained in the present study are lower than the average commercial seed yields reported for rapeseed in the previous studies. This result was possibly due to the low temperatures and short growing season of eastern Anatolia. Indeed, lower seed yields are also obtained in other crops grown in this area.

The close row spacing of 15 cm gave the maximum seed yield of 1195 kg/ha. On average, 15 cm row spacing produced about 8 and 40% higher seed yield than 30 and 45 cm spacings. There are some reports of increased yield with narrower row spacing in rapeseed (Christensen and Drabble 1984, Morrison et al. 1990b, O'Donovan 1994). On the other hand, high plant populations can also contribute to the control of the growth and development of weeds in rapeseed plants (O'Donovan 1994).

The data of the present study suggest that summer rape grown at higher plant density would produce higher seed yield compared to the lower population density.

### Seed protein content

A comparison of Tower and Lirawell used in this study showed highly significant differences in protein content (Table 2). The cultivar Lirawell had higher protein content (25.86%) than cv. Tower (24.39%). In contrast, the protein content was not affected by changes in plant density. This result concurs with the findings of Kondra (1977) and Van Deynze et al. (1992), who reported that protein content did not change with varying plant densities. However, Shrief et al. (1990) reported that protein content was higher under higher population densities.

### Seed oil content

Seed oil content of cv. Lirawell as the average results of the two years was found to be higher (40.81%) than that of cv. Tower (39.74%). Oil content did not change due to various spacings between or within rows. Increased spacings between rows (from 15 to 45 cm) caused an increase in the oil content of rape. However, the variations observed in oil content were insignificant (Table 2). This result is in agreement with Morrison's et al. (1990b) finding that there were no consistent effects

of row spacing and seeding rate on the oil concentration of summer rape.

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## ABSTRAKT

### Vliv hustoty porostu na růst, výnos a výnosotvorné prvky dvou odrůd jarní řepky

Řepka (*Brassica napus* L.) je v Turecku významnou alternativní olejninou východní Anatolie. Informace o hustotách porostů řepky v tomto regionu nejsou k dispozici. Proto vznikla studie zkoumající vliv meziřádkové vzdálenosti a vzdálenosti mezi rostlinami v řádku na výnos a agronomické charakteristiky dvou genotypů jarní řepky (Tower a Lirawell) v Erzurum (východní Anatolie) v letech 1994 a 1995. Byly zvoleny meziřádkové vzdálenosti 15, 30 a 45 cm a vzdálenosti mezi rostlinami v řádku 5, 10 a 15 cm. Výsledkem této studie je zjištění, že výnos byl průkazně ovlivněn vzdáleností mezi řádky, ale nikoli vzdáleností mezi rostlinami v řádku, a že výnosy řepky byly vyšší u užších řádků (15 cm) ve srovnání se středními (30 cm) a širšími (45 cm) řádky.

**Klíčová slova:** řepka; *Brassica napus* L.; hustota porostu; meziřádková vzdálenost; výnos semen

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