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Effects of different row spacings on the seed yield and some other characteristics of phacelia (*Phacelia tanacetifolia* Bentham.) varieties

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Abstract

This study was conducted in order to determine the effects of different row spacings (17.5-35.0-52.5 cm) on the seed yield and some other related characteristics of two phacelia varieties (Menemen and Barcelia) under Mediterranean ecological conditions of Izmir,Turkey, in 2006-2007. The experimental design was a randomised complete blocks with four replications. Results indicated that row spacings significantly affected the plant stand, plant height, number of branch and flower per plant, seed yields and other related traits. The highest seed yield was obtained from 17.5 cm row spacing and Barcelia yielded higher than Menemen cv.

Key words: Phacelia, *Phacelia tanacetifolia*, row spacing, variety, seed yield.

Introduction

Aegean region, Turkey, having favourable ecological conditions and winter rainfall resources provides most proper conditions for many different field crops production. Therefore, crop cultivation can be maintained by benefiting from different type of technical facilities throughout the year. As a major example, second forage crop cultivation including corn, sorghum, etc. in summer or annual legumes in winter can be easily practiced by farmers[8]. Particularly, second forage crop production of vetch and vetch-barley mixtures in winter are generally preferred by farmers considering the low inputs of cultivation in Aegean region.

Phacelia (*P. tanacetifolia*) is a promising new alternative as a winter second crop in the area. Phacelia is being used in a wide range of climatic regions, and this illustrates its adaptability to climate and soil types. The plant is an herbaceous, non-leguminous, flowering annual in the Hydrophyllaceae family [4]. It is also a versatile crop that is used extensively in USA and Europe, both as a cover crop and as bee forage. Crop is also being increasingly used to exploit winter rainfall in Mediterranean areas.

Phacelia is listed as one of the top 20 honey-producing flowers for honeybees and also highly attractive to bumblebees and syrphid flies [10]. Phacelia's habit of flowering abundantly and for a long period can increase beneficial insect numbers and diversity, because it provides high quality nectar and pollen. Autumn and spring planted phacelia flowers app. 6-8 weeks after germination and flowering continues for 6 to 8 weeks [5].

Researches in other regions show phacelia has the potential to produce abundant biomass and does a good job at catching excess nitrate. Its use as a fall/winter cover crop may be appropriate when it will be followed by a vigorous cash crop (e.g. cotton, maize) in early spring. Europe has developed many varieties. The fact that Europeans imported US native plant and have bred for specific characteristics indicate its value in a crop rotation system. Its positive traits may prove useful also in Mediterranean part of Turkey [8]. We need more information about this potentially useful plant and on how to cultivate it in Mediterranean basin. Seed production technique of phacelia is also of primary significance. In this study, two phacelia varieties in three different row spacings under rain-fed conditions were tested for the seed yield and some other related traits for two years.

Materials and Methods

A field study was conducted in 2005-2006 and 2006-2007 winter growing season (Table 1) at Bornova experimental area (38°27.236N, 27°13.576E) in Ege University, Izmir, Turkey, at about 28 m a.s.l. with typical Mediterranean climate characteristics. The soil was heavy textured with 30.2% sand, 32.5% silt, 37.3% clay, 1.1% organic matter and a pH of 7.8.

Factorial arrangements of three row spacing (17.5, 35.0 and 52.5 cm) and two phacelia varieties (Barcelia and Menemen) were evaluated in a randomized complete block design with three replications. Seeding rates were 5 kg ha^{-1}. Individual plot size was 2.1 m x 5 m = 10.5 m^{-2}. Sowing was done by hand on 6 Dec. and 11 Nov. in 2005 and 2006, respectively. Herbicide was not applied for weed control and hand-hoeing was carried out when necessary. NPK fertilization of 50 kg ha^{-1} before sowing and 50 kg ha^{-1} DAP in early spring was uniformly applied to all plots. There were no significant problems with pests, diseases or weeds during the course of the study.

Randomly, ten plants from each replication were taken at semi-maturity stage of racemes for morphological measurements. Plant

Table 1. Monthly average temperatures, total precipitations and average humidity recorded at Bornova,Turkey, location during 2005 - 2007 growing seasons and long-term period (1980-2000).

	Temperature (ºC)			Precipitation (mm)			Relative humidity (%)		
Month	2005-2006	2006-2007	Long-term	2005-2006	2006-2007	Long-term	2005-2006	2006-2007	Long-term
November	12.3	12.4	13.2	129.8	63.1	80.3	59.9	68.6	68.0
December	11.1	9.7	9.9	54.3	9.6	122.3	54.7	67.5	70.0
January	6.9	10.6	8.1	56.5	33.1	109.7	56.7	62.2	68.0
February	9.6	10.6	8.6	98.6	22.6	89.8	59.8	66.9	67.0
March	12.1	13.4	10.8	129.7	29.7	72.3	60.6	59.8	65.0
April	17.4	16.2	15.0	27.0	19.3	48.9	55.2	48.8	62.0
May	21.1	22.4	20.2	-	44.1	32.7	44.3	52.2	58.0
June	25.7	27.5	25.0	19.2	0.3	8.2	37.9	44.7	50.0
Mean, Σ	14.5	15.4	13.9	515.1	221.8	564.2	53.6	58.8	63.5

heights, number of branches, number of terminal flowers per plant, number of racemes per plant and number of florets per raceme, biomass and seed yields and thousand seed weight were investigated individually. Plant stands were counted at harvest along a 1 m length of the interior rows of each plot in two replications. When the seeds were matured on 7 June and 28 May in 2006 and 2007, respectively, the plots were harvested by hand.

All data were statistically analyzed using analysis of variance (ANOVA) with the Statistical Analysis System [6]. Probabilities equal to or less than 0.05 were considered significant. If ANOVA indicated differences between treatment means an LSD test was performed to separate them.

Results and Discussion

Row spacing and variety interactions for all traits were not significant but for seed yield. Therefore, row spacing and variety treatments were evaluated independently. The results are summarized in Table 2. Experimental area is located in the Mediterranean zone of the country with quite mild winters and hot summers. Field studies were started in late autumn with low air temperature, and satisfactory moisture levels were experienced in the germination and emergence period of relatively small seeds. Therefore, stands were excellent in both years.

Plant stand: Variety and year effects were not significant on plant stand, but on row spacing. Row spacing of 17.5 cm had the highest plant stand (53.5 plant m^{-2}) whereas 35.0 cm and 52.5 cm row spacings had significantly lower plant stands, 36.4 and 23.5 plant m^{-2}, respectively. Average plant stand, i.e. number of mature plants per row spacing, was only 8.7% at the widest rows compared to 60.9% at the narrowest row spacing, which suggests self-thinning during the later stages of development after emergence, particularly for wider row spacing. In close agreement with our findings, some researchers [1-8] found that the establishment ratio decreased when the number of seeds per row was increased.

Plant height: Phacelia plant height increased with the increasing rate of the row spacings (Table 2). Row spacing of 17.5 cm had the highest average plant height (74.6 cm), whereas plant height was lowest in 52.5 cm row spacing (66.2 cm). There was not any significant difference between varieties. Year effect was also significant and average phacelia height of the first year (72.6 cm)

Table 2. Plant stand (plants m^{-2}), plant height (cm), number of branches per plant, terminal flower per plant, racemes per plant, floret per raceme, biomass yield (kg ha^{-1}), seed yield (kg ha^{-1}) and thousand seed weight (g) of phacelia varieties as affected by row spacings at Bornova in 2006-2007.

Row spacing (cm)	Plant stand	Plant height	Branch	Terminal flower	Raceme	Floret	Biomass yield	Seed yield	1000 seed weight
17.5	53.5	74.6	5.2	7.02	25.93	96.5	6490	591	2.013
35.0	36.4	71.8	5.7	7.63	26.99	100.6	5730	488	2.110
52.5	23.5	66.2	5.8	8.22	32.59	109.1	4800	412	2.098
Mean	37.8	70.9	5.6	7.62	28.50	102.1	5673	497	2.074
LSD	3.7	2.1	0.4	0.31	1.18	1.6	430	36	ns
F-test	*	*	**	**	**	*	*	**	ns
Variety									
Menemen	37.3	71.7	5.7	7.36	27.71	101.5	5260	467	2.057
Barcelia	38.2	70.0	5.4	7.88	29.31	102.7	6090	527	2.090
Mean	37.8	70.9	5.6	7.62	28.51	102.1	5675	497	2.074
LSD	ns	ns	0.3	0.25	0.96	ns	350	29	ns
F-test	ns	ns	**	**	**	ns	*	**	ns
Year									
2006	38.8	72.6	5.9	8.04	29.38	108.1	6020	620	2.023
2007	36.7	69.0	5.5	7.21	27.63	96.1	5330	374	2.123
Mean	37.8	70.8	5.7	7.63	28.51	102.1	5675	497	2.073
LSD	ns	1.7	ns	0.25	0.96	1.3	350	29	0.098
F-test	ns	*	ns	**	**	**	*	**	**

*: significant at P≤0.05, **: significant at P≤0.01, ns: non-significant.

was higher than in the second year (69.0 cm). The plant height of varieties increased with the increasing rate of row spacing, although this trait was not significantly influenced by varieties. In close agreement with our findings, Karadag and Buyukburc [2] found that plant height highly increased as the row spacing decreased from 60 cm to 20 cm in phacelia stands. Thick-stemmed and branched plants developed at wider rows, experiencing significant difference between cultivars. Menemen cv. branched significantly more than Barcelia cv. Our results are in agreement with those reported by Tworkowski *et al*. [9].

Branches and terminal flower numbers and racemes per plant, florets per raceme: Number of branches in phacelia varieties increased by increasing rate of row spacing, and 52.5 cm row spacing had the highest number of branches (5.8). Varieties were also significantly effective on number of branches (Table 2), and Menemen cv. (5.7) had more branches than Barcelia cv. (5.4). Any significant difference in terms of branch number was not observed between the years.

Differences between row spacings were significant, and 52.5 cm row spacing had the highest number of terminal flowers (8.22). There were significant differences between varieties, and Barcelia cv (7.88) had more terminal flowers than Menemen cv. (7.36). Effect of years on terminal flower numbers was also significant, and the second year average (7.21) was lower than the first year one (8.04).

Average raceme numbers of row spacings were significantly different, and raceme number of 52.5 cm row spacing (32.59) was higher than in the other treatments. The number of racemes varied with varieties, and Barcelia cv. (29.31) had more racemes per plant than Menemen cv. (27.71). Significant effect of years on racemes per plant was also evident, and average raceme numbers in the first year (29.38) was higher than the average of succeeding year (27.63).

Number of florets per raceme of phacelia crops decreased by decreasing rate of row spacings (Table 2), 52.5 cm row spacing having highest number of florets per plant (109.1). Although there was not any significant difference between varieties, year effect was significant, and average number of florets per raceme of the first year (108.1) was higher than in the second year (96.1).

The number of terminal flowers, raceme per plant and floret per raceme declined significantly with decreasing rate of row spacings. It was concluded that increasing number of branches per plant in wider rows resulted in higher number of terminal flowers and racemes per plant and florets per raceme. Confirming our results, some researchers [2-3] stated that wider row spacing had higher number of flowers, racemes and florets in phacelia. Apparently, generative parts of the crops are closely associated with branches per plant [7]. Barcelia cv. was again more productive than Menemen cv. in terms of above mentioned properties. Year effect was also significant indicating better humidity and rainfall conditions for the maturation of crops in 2006 compared to 2007 (Table 2).

Biomass and seed yield: Biomass yield of phacelia crops increased noticeably in narrow row spacings, 17.5 cm row spacing possessing highest biomass yield (6490 kg ha^{-1}). Varieties were also significantly effective on biomass yield, Barcelia cv. providing higher biomass production (6090 kg ha^{-1}) than Menemen cv. (5260 kg ha^{-1}). Year effect was also found to be significant, and the first year (6020 kg ha^{-1}) yielded higher average biomass than the second year (5330 kg ha^{-1}).

Seed yield increased by decreasing rate of row distances. The differences between the row spacings were highly significant, and 17.5 cm row spacing had the highest seed yield (591 kg ha^{-1}). There were also significant differences between the varieties, Barcelia cv. yielded highest amount of seed (527 kg ha^{-1}). The year effect on seed yield was significant, and the first year average (620 kg ha^{-1}) was higher than the second year one (374 kg ha^{-1}). Row spacings, varieties and years had significant effects on biomass and seed yield. Biomass and seed yield decreased as the row spacing increased. The maximum biomass and seed yields occurred at 17.5 cm row spacing, being quite higher than at 35.0 and 52.5 cm row spacings. This result suggests that number of plants per row can cause a strong competition among the crops and depress the yield properties of individual plant in narrow row spacing [1]. Nevertheless, since the numbers of plants per unit area in narrow rows were quite higher than in wider rows which were sparsely populated stands, it was also suggested that total biomass and seed yields were highest in 17.5 cm row spacing. The number of branches per plant, terminal flowers per plant, racemes per plant and florets per raceme decreased with the increasing rate of row spacing. It was also concluded that biomass and seed yield increased in narrow row spacing due to the increasing number of plants per unit area. Our results are in agreement with those reported by many researchers [2, 3, 7]. Tworkowski *et al*. [9] also indicated that well branched phacelia plants at wider row spacings had not satisfactory contribution to the seed yield. Thus, the contribution of well branched plants in wider rows was negligible. Barcelia produced higher biomass and seed yield than Menemen cv. Average biomass and seed yield of 2006 was higher than in 2007. The data related to biomass and seed yields and yield components of Barcelia cv. also indicated that this variety was highly adaptable to the experimental area. Highly significant differences among the years were an indication of yield variation of varieties depending on the changes of climatic parameters of years.

1000 seed weight: Thousand seed weights were not significantly different between row spacings and varieties but the year effect was significant. Average seed weight of second year (2.123 g) was higher than the first year (2.023 g). Thousand seed weight was not affected significantly by either row spacing or varieties. Some researchers [8, 9] also reported that thousand seed weights of phacelia genotypes were not affected by experimental treatments. Average thousand seed weight of 2007 was higher than in 2006, most probably because of decreasing number of plants per unit area which had a significant effect on most of the yield component traits of many crops [1].

In summary, phacelia for biomass or seed production could be successfully cultivated in autumn-sown practices under rain fed conditions in a Mediterranean-type environment having significant differences throughout the years. The highest biomass and seed yield can be obtained from 17.5 cm row spacing of Barcelia cv.

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