www.biodicon.com Biological Diversity and Conservation

ISSN 1308-5301 Print; ISSN 1308-8084 Online 3/1 (2010) 23-27

Study of sowing date and plant density affect on Black Cumin (*Cuminum carvi*) yield, in Iran

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Abstract

An experiment was conducted to evaluate the effect of sowing date and plant density on yield and yield components of Black Cumin (*Cuminum carvi* L.) under dry farming conditions. Four plant densities (50, 100, 150 and 200 plants m^{-2}) and three sowing dates (3, 13 and 23 of March) were applied. Result showed that seed yield was influenced by sowing date and plant density interaction. Early sowing date resulted in higher seed yields as evident from higher aboveground biomass, the number of umbrella per plant, the number of seed per umbrella and plant height. Harvest index and 1000-seed weight were not affected by sowing date and planting density. Earlier sown plants with density of 200 m^{-2} resulted in higher seed yields.

Key words: Sowing date; Plant density; Black Cumin; Yield; Yield components

1. Introduction

Black Cumin (*Cuminum carvi* L.) is a member of Apiaceae. This species originated in Egypt and East Mediterranean, but is widely cultivated in Iran, Japan, China and Turkey. Black Cumin has a long history of use as food flavors, perfumes and medicinal values. Essential oil has been used for bringing smell to some medicines, for sterilizing of surgical operation fiber, for producting of some veterinary and agricultural medicines and plastic (Simon et al, 1984). Black Cumin seeds have an aromatic odor and bitter taste. They are used as an essential ingredient in soup, sausages, cheese, cakes and candies (Behera, et al., 2004). Presently, Iran is an important Black Cumin exporter, constituting 20-40% of world market (Barros et al,2004). In semiarid area such as Iran, water is the most limiting factor for farming. Black Cumin can be some as fallow crop in wheat or barley fallow in dry land farming of Iran. In suitable plant density, plants completely use environmental conditions (water, air, light and soil) and inter- or intra-specific competition is minimum. Yield loss due to unfavorable sowing date has been reported in many crops such as sunflower (Barros et al,2004) and fennel (Bianco et al, 1994 and Kafi,1990). Yield components of Black Cumin include the number of plant in area unit, the number of umbrella per plant, the number of seed per umbrella and seed weight. The number of plant per unit area is the most important among yield components (Kafi,2003). Ahmed and Haque (1986) studied the effect of row spacing (15, 20, 25 and 30 cm) and time of sowing (November 1, November 20, December 10 and December 30) on the yield of black cumin in Bangladesh, they found that closer row spacing (15 cm) and early sowing (November 1) were the best for higher seed yield of black cumin (Ahmed and Haque,1986). The number of umbrella per plant has the second rank of importance in yield components. Aminpour and Karimi (1995) reported that 96% of seed yield variation was related to this yield component (Aminpour and Karimi,1995). The number of seed per umbrella is affected by environmental, field management and its number was reported from 11.3 to 16.8 under varying plant densities (Kafi,2003). The weight of Black Cumin seed varied in different experiments. Kafi (2003) reported that it was from 2.79 to 2.99 g under varying plant densities. Shortening of the growing cycle decreased the amount of radiation

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intercepted during the growing season and thus total dry weight of plant (Andrade,1995). With delayed sowing, development is accelerated because the crops encounter higher temperatures during the vegetative growth (Damato et al,1994). Ehteramian (2003) reported that delayed sowing date was better because of occurrence lack of suddenly winter chilling. Delayed sowing date decreases seed weight and the number of umbrella per plant (Ehteramian,2003). Optimum plant density and sowing date of Black Cumin in Khorasan province of Iran has not yet been investigated. This study aimed at the determination of the optimum sowing date and plant density of Black Cumin for achievement of maximum seed yields under the conditions of the west of Iran.

2. Materials and methods

The experiment was conducted in 2005 at Research Farm, Faculty of Agriculture, Tehran University, Karaj, Iran (latitude 35° 50´ N, longitude 50° 58´ E, and altitude 132 m). Long term average precipitation was 456 mm and this area is semiarid according to De Martonne classification. The soil texture at the experimental area was clayey with pH 7.64 and EC 1.3 dS m^{-1}.

Design characteristics and cultural practices. The experiment was conducted as a factorial arrangement of a randomized complete block design with four replications. Three sowing dates (3, 13 and 23 of March) were applied. Four plant densities (50, 100, 150 and 200 plants m^{-2}) were applied. Row spacing was 0.3 m and plot length was 2.1 m, plot wideness 2.1 m and plot area 4.41 m^2 .The distances between plots and between blocks was 1m and 2 m respectively. According to meteorological statistics of the area, there was no danger of chilling at this time. Experiment was conducted as dry farming. Khorasan cultivar was used. Seeding depth was 0.5 cm. Before sowing, the soil was leveled then 100 kg ha^{-1} of diamonium phosphate (DAP) fertilizer was applied. Seeding was done by hand. At 3-4 leaf stage, the seedlings were thinned with expected densities. Weeds were removed with hands. Seven insecticide was applied for the control of ants.

Plant determinations and statistical analysis. In order to determine the yield and other characters under varying plant densities and sowing dates, a number of plant samples were taken by 1 m2 quadrate (Latond, 1994). Up to 50 cm, primer and edge lines were discarded and four planting rows were harvested. All plots were evaluated on 1 m2 area. In order to measure the seed yield and total dry matter, plants were cut and after drying, dry matter and seed yield were measured. Plants were harvested at physiological maturity stage when plants yellowed. Six plants randomly were selected in each plot to measure the number of umbrella per plant and plant height. Three umbrellas in each plant (from six selected plants as mentioned above) were selected and the number of seed was calculated. Harvest index was computed as the ratio of the seed yield to aboveground dry matter at harvest. Analysis of variance (ANOVA) was used to determine significant differences. The Multiple Range Test of Duncan performed the separation of means when the *F*-test revealed the error probability to justify the difference minor. Correlation coefficients were calculated for the relationship between seed yield and several crop parameters. All statistics were performed with the program MSTATC (version 2.10) and SPSS (version 10.0).

3. Results and discussion

Seed yield. The effect of sowing date, plant density and their interaction on seed yield were significant (Table I). At the first sowing date, plants with density of 200 plants m^{-2} had the highest seed yield. However, their yield did not have significant difference compared with 150 plants m-^{2}. Under the second sowing date (D2), studied plant densities except plant densities of 150 and 200 plants m-2 did not have significant difference. Under the third sowing date (D3), plant density of 150 plants m^{-2} resulted in higher seed yield; however it did not have significant difference from plant density of 200 plants m-2. Plant densities of 50 and 100 plants m-2 had a yield reduction of 58% and 42% respectively compared with 150 plants m^{-2} (Table II). Plant density of 200 plants m^{-2} under D1 and D2 resulted in higher seed yields however this plant density did not have significant difference from 150 plants m^{-2} under D1 and 50 and 100 plants m^{-2} under D2 . Under D3, plant densities of 150 to 200 plants m-2 had the highest seed yields. El-Gengai and Abdallah (1978) and Bianco et al. (1994) reported significant effect of sowing date and plant density on seed yield of fennel (*Foeniculum vulgare* Mill.). Results obtained from the study were comparable with Ehteramian (2003) findings, but contrary to those of Damato et al. (1994). There was a positive correlation between seed yield and aboveground biomass (r=0.91**). Early sowing dates resulted in higher seed yields that can be explained by higher aboveground biomass, the number of umbrella per plant, the number of seed per umbrella and plant height (Table II). In view of the sensitivity of Black Cumin to climatic factors especially to photoperiod and temperature, it is essential that sowing should be done on time so that there is enough time for vegetative growth. Delayed sowing results in reduced vegetative growth leading to reduced number of umbrella per plant and plant height (Okut,2001, Rahimian Mashhadi,1991 and Sharratt & Gesch,2004). Under optimum plant density, plants show efficient use of available water, light and nutrient while under high plant density, there is competition among plants.

Table 1. Analysis of variance results (Mean of Square) for different traits of Black Cumin under varying sowing dates and plant densities.

Trait	sowing date	plant density	plant density * sowing date
Seed yield	429.165**	216.894**	153.101**
Aboveground biomass	4172.934**	1839.311**	611.679**
Number of umbrella per plant	109.841*	47.079	36.385
Number of seed per umbrella	3.468**	2.643**	2.576**
1000-seed weight	00.201	0.082	0.046
Harvest index	0.156	0.051	0.065
Plant height	20.976**	0.504	4.726*

* Significant at the 0.05 level; ** Significant at the 0.01 level.

Aboveground biomass. The effect of sowing date, plant density and their interaction were significant for aboveground biomass (Table I). The aboveground biomass showed an increasing trend, with increases in plant density under the first sowing date (D1), plant density of 200 plants m^{-2} had the highest aboveground biomass (Table II). There was strongly correlation (r=0.91**) between seed yield and aboveground biomass, but a negative one (r= -0.68*) between aboveground biomass and harvest index. The effect of sowing date and plant density interaction on aboveground biomass was like seed yield.

Yield components. The effect of plant density on the number of umbrella per plant was not significant (Table I), which might be due to compensatory capacity of the other yield components such as the number of seed per umbrella. With changing plant density, each plant changes the number of seed per umbrella that results in fixed number of umbrella per plant. There was no significant correlation between the number of umbrella per plant and seed yield (r=0.16ns). Ehtramian (2003) reported that correlation between seed yield and the number of umbrella per plant was r=0.22. Bianco et al. (1994) found significant effect of plant density on the number of umbrella per plant. In this research, average number of umbrella per plant was 16.56. Kafi (2003) reported that the number of umbrella per plant under varying plant densities was from 18.9 to 31.3. The results in the present study were lower than those of Tuncturk and Tuncturk (2006), Arslan and Bayrak (1987) and Okut (2001). These differences were due to probably variations in environmental conditions, genotype and soil properties. Sowing date had the significant effect on the number of umbrella per plant (Table I) that related to high sensitivity of this yield component to photoperiod and temperature, which conforms to the finding of Rahimi (1993). The highest number of umbrella per plant was achieved under the first sowing date (give actual sowing dates). Three sowing dates (3, 13 and 23 of March). Plants under second (13, March) and third (23, March) sowing dates had 25 and 18% lower umbrella number compared with the first sowing date (3, March) (Figure 1).

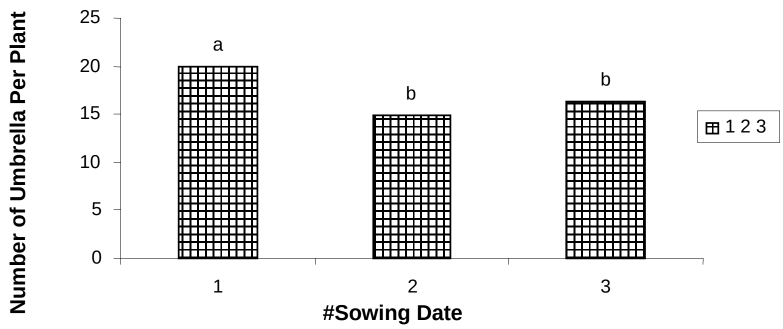

Figure 1.Mean comparisons for the number of umbrella per plant under different sowing dates Means followed by the same letter are not significantly different at *P*=0.05 (*) or *P*=0.01(**) according to Duncan Multiple Range Test (#sowing dates of 1, 2, and 3 are 3, 13 and 23 of March respectively)

The effect of sowing date and plant density and their interaction on the number of seed per umbrella was statistically (Table I). The number of seed per umbrella showed a decreasing trend, with decreases in plant densities and the plant density of 50 plants m^{-2} had the highest number of seed per umbrella and the plant densities of 100 and 150 plants m^{-2} had no significant difference for the number of seed per umbrella (Table II). Because seed set depend on providing the sufficient nutrients and environmental conditions while shift from vegetative to reproductive stage, increased plant densities result in limited availability of nutrients, light and water so the number of reproductive units decrease; at last seed number reproduction decreases. Kafi (2003) found that the number of seed per umbrella under different plant densities (40, 80 and 200 plants m-2) decreased. Our results were comparable to the finding of Kafi (2003), who noted no correlation between the number of seed per umbrella and seed yield (r=-0.006). Ehteramian (2003) reported that correlation between seed yield and the number of seed per umbrella was (r=0.75). The first sowing date (D1) except under plant densities of 50 and 200 plants m^{-2} had the highest number of seed per umbrella in relation to D2 and D3. It is due to sensitivity of the number of seed per umbrella to photoperiod and temperature (Table II). Environmental conditions during pollination at the first stage of seed set, determine the number of seed per umbrella (16 quote properly). The effect of sowing date and plant density on 1000-seed weight was not significant (Table I), which seemed to be more dependent on genetic than environmental factors (18 quote properly). These data were in contrast results of Barros et al. (2004) and Tuncturk and Tuncturk (2006). Data indicated no correlation between seed yield and 1000-seed weight (r=0.429), but a negative one between 1000- seed weight and plant height (r=-0.677*). In this study, 1000-seed weight was 2-3 g, which was lower than that reported by Arslan and Bayrak (1987), Okut (2001) and Tuncturk and Tuncturk (2006), but similar to that of Kafi (2003).

Table 2. Mean comparisons for different traits of Black Cumin under varying sowing dates and plant densities.

	Seed yield (g m^{-2}) **			Plant height (cm)*			Aboveground biomass (g m^{-2}) **			number of seed per umbrella**		
Plant density	Sowing date#			Sowing date			Sowing date#			Sowing date		
	1	2	3	1	2	3	1	2	3	1	2	3
50	24.96 cd	27.63abc	11.47e	12.62bc	12.99 abs	12.27bc	61.95bc	67.00bc	21.9e	6.930ab	7.475a	6.740abc
100	21.46 cde	25.61 bcd	16.07de	13.46 abc	12.27 bc	12.36bc	63.75bc	47.81cd	25.71de	6.922ab	5.675cde	5.355e
150	27.73 abc	19.52cde	27.58abc	14.19ab	13.4abc	11.59cd	62.55bc	56.17bc	60.78bc	7.280a	5.185e	5.995bcde
200	36.64 a	35.36ab	18.53cde	15.01a	12.95abc	9.97d	93.7a	78.55ab	49.04cd	6.485abcd	5.570de	7.415a

Means followed by the same letter are not significantly different at *P*=0.05 (*) or *P*=0.01(**) according to Duncan Multiple Range Test. #Sowing dates of 1, 2, 3 are 3, 13 and 23 of March respectively.

Harvest index and plant height. The effect of sowing date and plant density on harvest index was not significant (Table I), which is due to that with changed plant density or sowing date. Changes in reproductive and vegetative parts had the same rate, as with changing the plant density or sowing date. The decrease or increase in aboveground biomass of single plant was consistent with changes in seed yield per plant (Table II). Ball et al. (2000), Behera et al. (2004) and Kafi (2003) also reported the same result. There was no correlation between harvest index and seed yield, but that of harvest index with aboveground biomass was negative (r=-0.608). The average harvest index of this study was 0.45 that was different from that reported by Ehteramian (2003). The effect of sowing date, plant density and their interaction on plant height were significant (Table I). Delayed sowing decreased plant height (Table II). The first sowing date (D1 give actual date) except under plant density of 50 and 100 plants m^{-2} resulted in higher plant height than third sowing date (D3 give actual date). It may be explained by a higher dry matter accumulation and vegetative growth due to early sowing, while delayed sowing reduced plant height due to high sensitivity to photoperiod and temperature. Under early sowing date, plant densities of 50, 100 and 150 plants m-2 had a plant height reduction of 16, 10 and 5% compared with plant density of 200 plants m-2. Such an increase in plant height with increased plant density may be explained by increasing activity of stem growth hormone due to light deficiency (10 quote properly). El-Gengai and Abdallah (1978) and Bianco et al. (1994) found that sowing date and plant density had significant effect on plant height of fennel. There was no correlation between seed yield and plant height (r=0.455), while Correlation of plant height and 1000-seed weight was negative (r=-0.677*).

4. Conclusion

Black Cumin is sensitive to plant density and sowing date. Early sowing in dry land Black Cumin was critical to increased seed yield possibly due to higher aboveground biomass, the number of umbrella per plant and plant height. Lower densities do not produce sufficient of seed per unit of area. However, the relatively small absolute differences in seed yield between some plant densities demonstrate the remarkable compensation capacity of Black Cumin between the different yield components.

Acknowledgment. The authors express their appreciation to University of Tehran, Payame Noor University and Azad Islamic University for full support of the project.

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(Received for publication 14 November 2008; The date of publication 01 April 2010)