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Response of Cumin (*Cuminum cyminum* L.) to Sowing Date and Plant Density

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Abstract: In order to evaluate the effect of sowing date and plant density on yield and yield components of cumin *(Cuminum cyminum* L.) under dry farming conditions of Kermanshah in Iran, a factorial arrangement of a randomized complete block design with four replications was conducted. Four plant densities (50, 100, 150 and 200 plants m^{-2}) and three sowing dates (3, 13 and 23 March) were applied. According to result of this research; seed yield was influenced by sowing date and plant density interaction. Early sowing date 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. Harvest index and 1000-seed weight were not affected by sowing date and plant density. Under earlier sowing date, plants with density of 200 plants m^{-2} resulted in higher seed yields.

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

INTRODUCTION

Cumin *(Cuminum cyminum* L.) is a member of Apiaceae and a plant originated in Egypt and East Mediterranean. But it is widely cultivated in Iran, Japan, China and Turkey.

Cumin has a long history of use as food flavors, perfumes and medicinal values. Essential oil has been used for bring smell to some medicines, for sterilizing of surgical operation fiber, for producing of some veterinary and agricultural medicines and plastic [23].

Cumin seeds have an aromatic odor and bitter taste. They are used as an essential ingredient in soup, sausages, cheese, cakes and candies [7].

In semiarid area such as Iran, water is the most limiting factor for farming. Cumin has a potential to be in wheat or barley fallow in dry land farming of Iran. At the present time, Iran is an important cumin exporter in the world market, cumin production of Iran is approximately, 20- 40% of world market [15].

In suitable plant density, plants completely use environmental conditions (water, air, light and soil) and inter specific or intra specific competition is minimum.

Grain yield loss of many crops such as sunflower *(Helianthus annus* L.) [6] and fennel *(Foeniculum vulgar* Mill.) [13, 8] was reported due to unfavorable sowing date. Yield components of 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 in area unit has the most important role among yield components. Probably, deficiency of plant density was partially compensated by the number of umbrella and seed per plant but in low plant densities, it is not sufficient [14].

Ahmet and Haque[1] studied effects 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 (*Nigella sativa)* 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.

The number of umbrella per plant has the second rank of importance in yield components. Aminpour and Karimi [2] reported that 96% of seed yield variation related to this yield component. The number of seed per umbrella is affected by environmental conditions of field management and its number was mentioned from 11.3 to 16.8 under varying plant densities [14]. The weight of cumin seed had varied in different experiments, Kafi [14] reported that it was from 2.79 to 2.99 g under varying plant densities. Shortening of the growing cycle decreases the amount of radiation intercepted during the growing season and thus total dry weight of plant[3]. With delayed sowing,

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development is accelerated because the crops encounter higher temperatures during the vegetative growth [10]. Ehteramian [12] studied the effect of sowing date and nitrogen fertilizer on yield and yield components of cumin in Fars province of Iran and he 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. Optimum plant density and sowing date of cumin in Kermanshah province of Iran has not yet been investigated. This study aimed at the determination of the optimum sowing date and plant density of cumin for achievement of maximum seed yields under the conditions of the west of Iran.

MATERIALS AND METHODS

The experiment was conducted in 2003 at Research Farm, Faculty of Agriculture, Razi University, Kermanshah, Iran(latitude 34° 19′ N, longitude 27° 7′E, and altitude 1322 m). Long term average precipitation was 456mm and this area is semiarid according to De Martonne classification. The soil texture at the experimental area was clay (PH=7.81 and EC= 1.2 mmho/ cm).

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 March) were applied. According to meteorological statistics of the area, danger of chilling was removed at this time. 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. Experiment was conducted as dry farming. Before sowing, the soil was leveled then 100 kg/ha of diamonium phosphate fertilizer was applied. Seeding was performed by hand. When the seedlings were 3-4 leaves, they were thinned with expected densities. Weed control was performed by hand weeding. Sevin insecticide was applied for the control of ants. Seeding depth was 0.5 cm.

Plant Sampling and Statistical Analysis: In order to investigate and analyze the yield and other characters of cumin under varying plant densities and sowing dates, a number of plant samples were taken. Plant samples were taken by 1 m^2 quadrate[16]. Up to 50 cm of primer line and edge line were discarded and four planting rows were harvested. All plots were evaluated on 1 m^2 area.

In order to measure the seed yield and total dry matter, plants were cut and after drying, dry matter (DM) and seed yield were measured. Plants were harvested at physiological maturity stage when plants yellowed.

In order to measure the number of umbrella per plant and plant height, six plants were randomly selected in each plot. To measure the number of seed per umbrella, three umbrellas in each plant (from six selected plants as mentioned above) were selected and the number of seed per them was calculated. Harvest index was computed as the ratio of the grain to the aboveground dry matter at harvest.

In this study, the effects of varying plant densities and sowing dates on plant height, harvest index, the number of umbrella per plant, the number of seed per umbrella, 1000-seed weight and seed yield were evaluated.

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).

RESULTS AND DISCUSSION

Seed Yield and Aboveground Biomass:
Seed Yield: The effect of sowing date, plant density and their interaction on seed yield were significant (table 1). According to table 2, under 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}.

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 [13] and Bianco *et al.*[8] reported the significant effect of sowing date and plant density on seed yield of fennel *(Foeniculum vulgar* Mill.). Results obtained from the study were in compatible with Ehteramian [12] findings. But the results were in contrast to Damato *et al.* [11] findings.

Table 1: Analysis of variance results (Mean of Square) for different traits of 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	0.20 1	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.

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

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

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 March respectively.

There was a positively significant 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 2).

In consideration of the sensitivity of cumin to climatic factors especially to photoperiod and temperature, it is essential that sowing of this plant be on time so that there is enough time to have vegetative growth. Delayed sowing resulted in insufficient vegetative growth and plant immediately responded to photoperiod so the number of umbrella per plant and plant height reduced [21,18,1].

Under optimum plant density, plants have efficient use of environmental conditions such as water, light and nutrient while under high plant density, there is competition among plants.

Aboveground Biomass: the effect of sowing date, plant density and their interaction were statistically significant for aboveground biomass (table 1). According to table 2, 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. There was strongly significant correlation(r=0.91**) between seed yield and aboveground biomass. There was negatively significant correlation (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 statistically significant (table 1). It is 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 ($r=0.16^{ns}$). Ehtramian [12] reported that correlation between seed yield and the number of umbrella per plant was 0.22. Bianco *et al.*[8] found statistically 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[14] reported that the number of umbrella per plant under varying plant densities was from 18.9 to 31.3. The results were found as lower than that of Tuncturk and Tuncturk[24], Arslan and Bayrak [4] and Okut [19]. These differences were due to probably variations in environmental conditions, genotype and soil properties. Sowing date had the statistically significant effect on the number of umbrella per plant (table 1) that related to high sensitivity of this yield component to photoperiod and temperature. These results were in compatible with the finding of Rahimi[20]. The highest number of umbrella per plant was achieved under the first sowing date (D1). Plants under the second (D2) and third (D3) sowing dates had a number of umbrella reduction of 25% and 18% compared with the first sowing date, respectively (D1) (figure 1).

The effect of sowing date and plant density and their interaction on the number of seed per umbrella was statistically significant (table 1). According to table 2; 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} did not have significant difference in terms of the number of seed per umbrella. Because seed set depends on providing the sufficient nutrients and environmental conditions at stage of changing from vegetative to reproductive and at the later stage after it, increasing plant densities result in limitation of nutrients, light and water so the number of reproductive units decrease, or at the later stage, with increasing competition for environmental conditions (light, nutrients, water), some reproductive units were removed. At last, seed number reproduction decreases. Kafi [15] found that the number of seed per umbrella under different plant densities (40, 80 and 200 plants m^{-2}) decreased.

Our results were in compatible with the finding of Kafi[14].There was no significant correlation between the number of seed per umbrella and seed yield(r=-0.006). Ehteramian[12] reported that correlation coefficient between seed yield and the number of seed per umbrella was 0.75. In this research, the average seed number per umbrella was 6.42 that were lower than finding of Kafi[14].

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 (table 2). It is due to sensitivity of the number of seed per umbrella to photoperiod and temperature (table 2). Environmental conditions during pollination at the first stage of seed set, determine the number of seed per umbrella[15].

The effect of sowing date and plant density on 1000-seed weight was not statistically significant (table 1). It seems that seed weight is more dependent on genetic factors than environmental factors and environmental stresses and cultural factors can not reduce seed weight a lot because the plant provides the least required nutrients for each seed by reducing the number of seed[17]. The results of the experiment were in contrast to results of Barros *et al.*[6] and Tuncturk and Tuncturk[24]. There was no significant correlation between seed yield and 1000-seed weight (r=0.429). There was negatively significant correlation between 1000- seed weight and plant height (r=- 0.677*). In this study 1000-seed weight was 2-3 gr. These results were lower than findings of Arslan and Bayrak [4], Okut, [19]and Tuncturk and Tuncturk[24] but these results were in compatible with the findings of Kafi[14].

Harvest Index and Plant Height: The effect of sowing date and plant density on harvest index was not statistically significant (table 1). It is due to that with changing of 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 equal the decrease or increase of seed yield of single plant. Ball *et al.*[5] and Sharratt and Gesch[22] also reported the same result. There was no significant correlation between harvest index and seed yield. Correlation coefficient between harvest index and aboveground biomass was negatively significant(r=-0.608*). The average harvest index of this study was 0.45 that was incompatible with the finding of Ehteramian[12].

The effect of sowing date, plant density and their interaction on plant height were statistically significant (table 1). Delayed sowing date resulted in decreasing trend of plant height (table 2). The first sowing date (D1) except under plant density of 50 and 100 plants

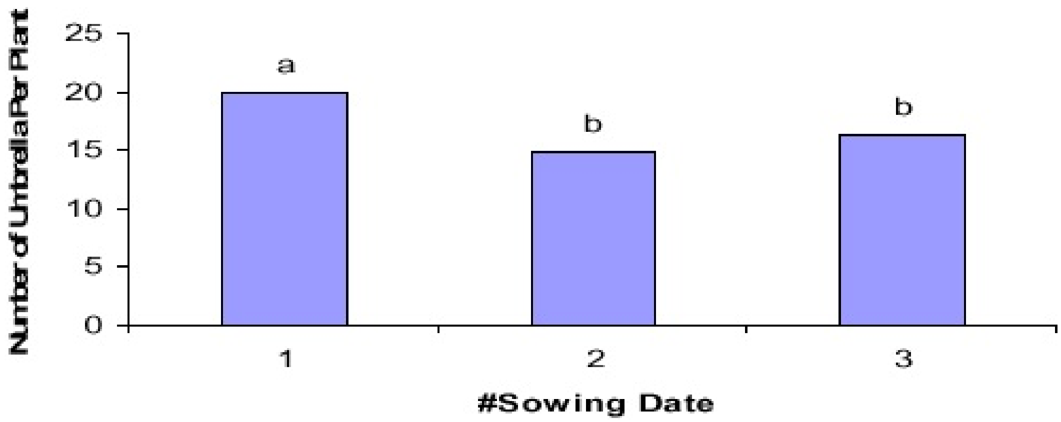

Fig. 1: Mean comparisons for the number of umbrella per plant under different sowing dates Means followed by the same letter are not significantly different at P=0.05 (*) according to Duncan Multiple Range Test. #sowing dates of 1, 2, and 3 are 3, 13 and 23 March respectively.

m^{-2} resulted in higher plant height than third sowing date (D3). It may be explained by a higher dry matter accumulation and vegetative growth under early sowing, while under delayed sowing date, plant height reduced due to strong sensitivity to photoperiod and temperature. Under the first sowing date (D1), there was increasing plant height trend, with increasing in plant density. Under this sowing date (D1), plant height of 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}, respectively. Increasing plant height with increases in plant density may be explained by increasing activity of stem growth hormone due to light deficiency[9]. El-Gengai and Abdallah[13] and Bianco *et al*.[8] found that sowing date and plant density had significant effect on plant height of fennel *(Foeniculum vulgar* Mill.) that were incompatible with the finding of this study. There was no significant correlation between seed yield and plant height ($r=0.455^{ns}$). Correlation between plant height and 1000-seed weight was negatively significant (r=-0.677*).

Conclusions: Cumin is a plant which is sensitive to plant density and sowing date. Under ecological conditions of the west of Iran, an early sowing dates of 3 and 13 March in dry land cumin proofs to be a decisive cropping practice in order to increase seed yield. The disadvantage of low temperatures in early sowings and a consequent delay in the plant emergence is compensated by a higher probability of more favorable moisture conditions. Early sowing dates of 3 and 13 March resulted in higher seed yields due to higher aboveground biomass, the number of umbrella per plant and plant height.

Optimum plant density of cumin in this study under the first and second sowing date (D1and D2) was 200 plants m^{-2}, while under the third sowing date (D3), 150 plants m^{-2} resulted in higher seed yield. Lower densities do not produce sufficient seed per unit of area. However, the relatively small absolute differences in seed yield between some plant densities demonstrate the remarkable compensation capacity of cumin between the different yield components.

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REFERENCES

1. Ahmed, N.U. and K.R. Haque, 1986. Effect of row spacing and time of sowing on the yield of black cumin *(Nigella sativa L.).* Bangladesh. J. Agric., 1: 21-24.
2. Aminpour, R. and M. Karimi, 1995. Effect of irrigation number on water potential, yield and yield components of cumin (*Cuminum cyminum*) Master of Science Thesis of Agronomy, Isf. Univ. Technol., Isfahan, Iran.
3. Andrade, F.H., 1995. Analasis of growth and yield of maize, soybean grown at Balcare, Argentina. Field Crop Res., 41: 1-12.
4. Arslan, N. and A. Bayrak, 1987. Effects on yield and some yield components of cumin (*Cuminum cyminum* L.) of different sowing times. Doğa Tu Agr. and For. Jour. 11, 2, Ankara, Turkey.
5. Ball, R.A., L.C. Purcell and E.D. Vories, 2000. Short-season soybean production and yield compensation in response to plant population and water regime. Crop Sci., 40: 1070-1078.

6. Barros, J.F.C., M. Del Carvalho and G. Basch, 2004. Response of sunflower (*Helianthus annus* L.) to sowing date and plant density under Mediterranean conditions. Europ. J.Agronomy, 21: 347-356.
7. Behera, S., S. Nagarajan and L.J.M. Rao, 2004. Microwave heating and conventional roasting of cumin Seeds *(Cuminum cyminum* L.) and effect on chemical composition of volatiles. Food Chemistry, 87(1): 25-29.
8. Bianco, V.V., G. Damato and A. Gridi, 1994. Sowing date, plant density and crowing cutting on yield and quality of Florence fennel seed. International Symposium on Agrotechnics and Storage of Vegetative and Ornamental Seeds. Bari, Italy.
9. Brummell, D.A. and J.L. Hall, 1980. The role of the epidermis in auxin-induced and fusicoccin-induced elongation of Pisum sativum stem segments. Planta, 150(5): 371-379.
10. Cirilo, A.G. and F.H. Andrade,1994. Sowing date and maize productivity. II. Kernel number determination. Crop Sci., 34: 1044-1046.
11. Damato, G., V.A. Biaco and M. Laterza, 1994. First result of plant density and nitrogen rate on yield and quality of Florence fennel (*Foeniculum vulgar Mill.* Var. Azotericum Thell.) seeds. International Symposium on Agrotechnics and Storage of Vegetative and Ornamental Seeds. Bari, Italy.
12. Ehteramian, K., 2003. The effects of different levels of nitrogen fertilizer and plant dating on cumin (*Cuminum cyminum* L.) in Kooshkak region in the Fars province. Master of Science Thesis of arid area management. Shiraz Univ., Shiraz., Iran.
13. El-Gengai, S. and N. Abdallah, 1978. The effect of date of sowing and plant spacing on yield of seed and volatile oil of fennel *(Foeniculum vulgar* Mill.). Pharmazie, 9: 605-6.
14. Kafi, M., 1990. Study on weed control number, row spacing and plant density on growth and yield of cumin (*Cuminum cyminum L.).* Master of Science Thesis of Agronomy, Ferdowsi Univ. Mashhad., Mashhad, Iran.
15. Kafi, M., 2003. Cumin- Production and Processing. Ferdowsi Univ. Mashhad Publication. Mashhad, Iran, pp. 195.
16. Karam, F., J. Breidy, C. stephan and J. Rouphael, 2003. Evapotranspiration, yield and water use efficiency of drip irrigated corn in the Beka Valley of Lebanon. Agric. Water Manage, 63: 125-137.
17. Latond, G.P., 1994. Effect of row spacing, seeding rate and nitrogen on yield of barley and wheat under zero-till management. Can. J. Plant Sci., 74: 703-711.
18. Mollafiani, A.A., 1992. Effect of sowing date and row spacing on yield of cumin under dry land and rainfed farming. Iranian Research Organization for Science and Technology. Khorasan Reseach Center. Khorasan, Iran.
19. Okut, N., 2001. Effects of different nitrogen doses and row spaces on the yield and quality components of cumin *(Cuminum cyminum* L.).PhD Thesis. Yüzüncü Yıl Univ. Van, Turkey.
20. Rahimi, M., 1993.Study on possibility of chemical weed control of cumin. Iranian Research Organization for Science and Technology. Khorasan Reseach Center. Khorasan., Iran.
21. Rahimian Mashhadi, H., 1991. Effect of sowing date and irrigation regime on growth and yield of cumin. Iranian Research Organization for Science and Technology. Khorasan Reseach Center. Khorasan., Iran.
22. Sharratt, B.S. and R.W. Gesch, 2004. Water Use and Root Length Density of Cuphea spp. Influenced by Row Spacing and Sowing Date. Agron. J., 96: 1475-1480.
23. Simon, J.E., A.F. Chadwick and L.E. Crack, 1984. Herbs: An Indexed Bibliography. 1971- 1980. The scientific literature on selected herbs, and aromatic and medicinal plants of the temperate zone. Arcon Book press, Hamden CT, pp. 770.
24. Tuncturk, R. and M. Tuncturk, 2006. Effects of Different Phosphorus Levels on the Yield and Quality Components of Cumin *(Cuminum cyminum L.).* Res. J. Agric. & Biol. Sci., 2(6): 336-340.