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Cumin yield and some traits as affected by sowing date and seeding level

Homayon Shakeri, Seyyed Gholamreza Moosavi*, Mohamad Javad Seghatoleslami

Departement of Agricultural, Birjand Branch, Islamic Azad University, Birjand, Iran

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Abstract

In order to examine the effect of sowing date and seeding level on yield and yield components of cumin, a factorial experiment was conducted in 2009-2010 based on a randomized complete block design with three replications. The main plot was sowing date at four levels (December 9, January 8, February 7 and March 9) and the sub-plot was seeding level at three levels (15, 30 and 45 kg/ha) The results showed that sowing date significantly affected 1000-seed weight, seed and biological yields, seed and biomass yields of single plant at 1% probability level. Also, seeding level significantly affected biological yield and seed and biomass yields of single plant at 1% probability level and seed yield and harvest index at 5% probability level. The interaction between sowing date and seeding level significantly affected seed yield, 1000-seed weight, harvest index and seed and biomass yields of single plant. Means comparison showed that the delay in sowing from January 8 to March 9 decreased seed and biological yields by 59.04 and 63.01%, respectively. In addition, the delay in sowing from January 8 to February 7 and March 9 significantly decreased seed yield of single plant by 50.7 and 70.7%, respectively. According to the results, as seeding level was increased from 15 to 45 kg/ha, seed yield, decreased by 4%, but biological yield increased by 13.28%. Given the results, it can be recommended to use sowing date of January 8 with the seeding level of 15-30 kg/ha for the cultivation of cumin in Birjand, Iran.

* **Corresponding Author:** Seyyed Gholamreza Moosavi ✉ s_reza1350@yahoo.com

Introduction

Medicinal herbs have been traditionally regarded as valuable crops in Iran and have played an important role in diversifying and sustaining of ecosystems. Cumin (*Cuminum cyminum* L.) is a medicinal herb from the family Apiaceae (Kafi *et al*., 2006). It is appetizer, antispasm, pain-killer, antiflatulence (Omidbeigi, 2000; Mazandarani *et al*., 2004). It has a relatively short growing season and demands low water (Hosseini *et al*., 2006; Jahani *et al*., 2008; Kafi *et al*., 2006) and therefore, it has an established position in the planting pattern of arid and semi-arid regions (Tuncturk and Tuncturk, 2006), especially in Iran (Khosh-khui and Bonyanpour, 2006) including the province of Khorasan (Kafi et al., 2006). Cumin is an important crop with respect to its export as well as its role in increasing the efficiency and recovery of the fields in arid and semi-arid regions and also its low water demand (Ehteramian, 2001).

Given the importance of maximum utilization of environmental parameters during growth period, it is crucially important to choose an appropriate sowing date and plant density for any crop anywhere. On other hand, cumin is short day plant, thus planting date is very important factor that influence on the plant flowering date.

Soheili (2007) indicated that the delay in planting from November 12 to March 2 decreased cumin yield and 1000-seed weight. The conventional seeding which is reportedly used in India is 12 kg/ha and the conventional plant density in Rajasthan, India is 1330000 plants/ha (Kafi, 2002). Ghorbani *et al.* (2009) stated that cumin yield was significantly affected by sowing date, so that the highest and lowest yields were obtained at the sowing dates of December 11 and March 1. Also, the delay in sowing decreased biological yield. Mollafilabi (1992) observed higher yield of cumin at January sowing compared with March sowing. Rahimian Mashadi (1992) found that the delay in sowing from Decembe 9 to March 26 decreased cumin seed number and 1000-seed weight. In a study on sowing dates of November 6, December 21, February 6 and March 6, Ehteramian *et al.* (2001) reported that the change in sowing date significantly affected cumin 1000-seed weight, biological yield and seed yield, but its effect on harvest index was not significant. The study of the effect of two sowing dates of November 15 and 30 on cumin yield in Rajasthan, India showed that the highest seed yield with an average amount of 834 kg/ha was obtained at the sowing date of November 15 (Yadav and Dahama, 2003). In another study on the effect of sowing dates of October 15 and March 16 on fennel yield, it was reported that the highest yield (418.7 kg/ha, on average) was obtained at sowing date of October 15 (Ahmad *et al*., 2004). Moosavi *et al.* (2008) studied the effect of three sowing dates of March 19, April 9 and April 30 on fennel seed yield in Birjand, Iran and stated that the effect of sowing date on seed yield was significant, so that a 41-day delay in sowing decreased seed yield by 86.1%.

In a study on the effect of sowing date and plant density on black cumin yield, Sadeghi *et al.* (2007) reported that the delay in sowing from March 3 to March 13 and 23 significantly decreased seed yield, biomass and but 1000-seed weight was not affected. They stated that plant density significantly affected seed yield and shoot biomass at 1% level, but 1000-seed weight and harvest index were not affected. Also, seed yield, shoot biomass and plant height were significantly affected by the interaction between sowing date and plant density. In other study on the effect of sowing dates of December 20, January 20 and March 12 and the densities of 100, 120 and 140 plants/m^2 on cumin traits, Veisi (2007) concluded that sowing date significantly affected most traits and the highest 1000-seed weight and seed yield was obtained at the first sowing date. Also, seed yield showed significant differences at different densities, so that the highest seed yield was obtained at the density of 140 plants/m^2. Heidari Zoleh *et al.* (2009) studied the effect of three sowing dates of March 2, March 12 and March 22 and four densities of 50, 100, 150 and 200 plants/m^2 and reported that cumin yield was significantly affected by the interaction between sowing date and plant density. But harvest index and seed weight were not affected by sowing date and

plant density.

Given the low water demand of cumin, it is necessary to study appropriate sowing date and seeding rate for each region. Therefore, the objective of the current study was to study the effect of sowing date and seeding rate on yield and some traits of cumin in Birjand, Iran.

Materials and methods

Study site

The study was carried out in Majan Plain, Khosf, Province of South Khorasan, Iran (Lat. 13°49´ N., Long. 32°53´ E., Alt. 1495 m.) in 2009-2010. Mean of long time for regional precipitation is 187 mm with maximum temperature of 38.9°C, minimum temperature of 16.8°C and mean daily temperature of 12.1°C. Table 1 shows Statistics of temperature and precipitation during 2009-2010 in Birjand, Iran.

Experimental design and treatments

It was a factorial study based on a randomized complete block design with three replications. The main plot was sowing date at four levels (Dececmber 9, January 8, February 7 and March 9) and the sub-plot was seeding level at three levels (15, 30 and 45 kg/ha). Each experimental plot was 4 m×6m with inter-plot spacing of 1 m and inter-block spacing of 2 m.

Cultivation practices

The study field was left fallow in the prior year. They included 10 sowing rows with 5 furrows. The seeds of cumin were sown at both sides of the furrows with row spacing of 40 cm. The seeds were from a local landrace of Sabzevar, Iran which had been disinfected by fungicide carboxin 2:1000.

At the end of growing season, an area of 3m² was harvested from the middle of each plot and the plants were put in plastic bags with a specified weight. Then, they were dried under the sun and afterwards, they were weighed (biological yield). To separate the seeds from the umbels, the plants were put on a table under open air to be dried by sun during which their moisture reached about 10%. After winnowing of the seeds, the net seeds were weighed by a digital scale to determine the seed yield per unit area. Harvest index was the division of seed dry weight in biological yield multiplied by 100. Three samples of 1000 seeds were picked from each plot and were weighed by a 0.001-precision digital scale to determine 1000-seed weight

Data analyzing

At the end, the data were analyzed by statistical software SAS and the graphs were drawn by software MS-Excel. The means were compared by Duncan Multiple Range Test at 5% level.

Results and discussion

Seed and biological yield

The results of analysis of variance showed the significant effect of sowing date on seed and biological yields at 1% level and significant effect of seeding level on seed yield at 5% level and biological yield at 1% level. The interaction between sowing date and seeding level significantly affected seed yield at 1% level but it did not significantly affected biological yield (Table 2).

Table 1. Statistics of temperature and precipitation during 2009-2010 in Birjand, Iran.

Month	Max. monthly temp. (°C)	Min. monthly temp. (°C)	Mean daily prec. (mm)	Total prec. (mm)
October-November	28.2	-2.4	0	0
November-December	22.6	-6.8	0.25	7.7
December-January	11.2	-19.8	1.23	37
January-February	24.6	-17.6	0.37	11.1
February-March	26.2	-9.2	0	0
March-April	30.4	2.2	0.13	4.3
April-May	37.8	4.8	0.093	2.9
May-June	42.5	13.2	0	0

The second sowing date (January 8) had the highest seed yield (352.08 kg/ha) and the last sowing date (March 9) had the lowest one (144.20 kg/ha) (Table 3). The yield of second sowing date was 144.2% higher than that of the last sowing date. In addition, the delay in sowing from January 8 to March 9 decreased cumin biological yield by 63.01% (Table 3). Given that cumin is a long-day crop, earlier sowing increased biological yield, umbel number per unit area and finally, seed yield through lengthening growth period and increasing leaf area and auxiliary branch number. Kafi *et al.* (2002) too concluded that the earlier cumin was sown, the better vegetative growth it had and the higher umbel number, seed number per plant and yield it had because of its sensitivity to day length. These results are in agreement with the results of Veisi (2007), Heidari Zoleh *et al.* (2009), Esfandeyri et al. (2010), Rahimian Mashadi (1991) and Rahimi (2014).

Table 2. Results of analysis of variance for the effect of sowing date and seeding level on cumin yield and some traits.

Sources of variation	df	1000-seed weight	Seed yield/plant	Seed yield	Single-plant Biomass	Biological yield	Harvest index
Replication	2	0.038ns	0.006ns	971ns	0.028ns	5109.89ns	16.5ns
Sowing date (A)	3	2.749**	0.074**	77718.12**	0.266**	332843.6**	20.2ns
Seeding level (B)	2	0.042ns	0.115**	1883.31*	0.283**	17854.74**	105.1*
A × B	6	0.07*	0.02**	3032.86**	0.069**	1020.76ns	126.8**
Error	22	0.021	0.004	492.12	0.013	1775.58	31.6
C.V. (%)	-	6.27	33.95	8.02	33.84	8.0	10.5

ns, * and ** show non-significance and significance at 5 and 1% level, respectively.

With respect to the seed yield, the treatments of applying 30 and 45 kg seed/ha had the highest and lowest seed yield (289.67 and 264.67 kg/ha), respectively (Table 4). The application of 30 kg cumin seed/ha had higher seed yield than the application of 45 and 15 kg seed/ha by 9.4 and 5.1%, respectively (Table 4).

Means comparison of biological yield at different seeding level showed that the treatments of application of 30 and 15 kg seed/ha had the highest and lowest dry matter production potential (547.71 and 477.99 kg/ha), respectively and the treatments of application of 30 and 45 kg seed/ha were ranked in the same group (Table 4).

Table 3. Effect of sowing date on yield and some traits of cumin.

Sowing date	1000-seed weight (g)	Seed yield/plant (g)	Seed yield (kg/ha)	Single-plant Biomass (g)	Biological yield (kg/ha)	Harvest index (%)
Dec. 9	2.51 a	0.243 a	328.03 b	0.442 a	639.46 b	51.61 a
Jan. 8	2.57 a	0.270 a	352.08 a	0.511 a	669.09 a	52.97 a
Feb. 7	1.46 b	0.133 b	282.43 c	0.255 b	533.57 c	55.00 a
Mar. 9	2.60 a	0.079 b	144.20 d	0.136 c	247.44 d	54.28 a

Means with similar letter(s) in each column did not show significant difference at 5% level using Duncan Multiple Range Test.

At higher densities although the competition between plants from the same species decreased single-plant weight, the increase in plant density compensated this weight loss and then, biological yield per unit area increased as the seeding level was increased from 15 to 30 and 45 kg/ha which is agreement with the results of and Mollafilabi (1992). Moreover, Mirshekari *et al.* (2011) stated that seed yield of

cumin was reduced significantly in lower plant densities.

As shown in Table 5, the highest seed yield (385.73 kg/ha) was obtained under the treatment of sowing date of January 9 and application of 15 kg seed/ha and the lowest one (130.51 kg/ha) was obtained under the treatment of March 9 sowing date with the application of 15 kg seed/ha. The difference in sowing date and seeding level of cumin brought about a 195.6% difference in the treatments of the highest and lowest seed yield.

Table 4. Effect of seeding level on yield and some traits of cumin.

Seeding level (kg/ha)	1000-seed weight (g)	Seed yield/plant (g)	Seed yield (kg/ha)	Single-plant Biomass (g)	Biological yield (kg/ha)	Harvest index
15	2.26 a	0.285 a	275.37 ab	0.495 a	477.99 b	56.19 a
30	2.35 a	0.169 b	289.67 a	0.324 b	547.71 a	53.89 ab
45	2.24 a	0.090 c	264.67 b	0.188 c	541.47 a	50.32b

Means with similar letter(s) in each column did not show significant difference at 5% level using Duncan Multiple Range Test.

Seed and biomass yields of single plant

The results of analysis of variance showed the significant effect of sowing date and seeding level on seed and biomass yields of single plant at 1% level. Also, the interaction between sowing date and seeding level significantly affected these traits at 1% level (Table 2).

The first and second sowing date (December 9 and January 8) had the highest seed yield of single plant (0.243 and 0.27g/plant). In addition, the delay in sowing from January 8 to February 7 and March 9 significantly decreased seed yield of single plant by 50.7 and 70.7%, respectively. Moreover, sowing date had relatively similar effect on biomass yield of single plant in cumin so that the delay in sowing from January 8 to February 7 and March 9 significantly decreased biomass yield of single plant by 50.1 and 73.4%, respectively (Table 3).

Table 5. Interaction of sowing date and seeding level on yield and some traits of cumin.

Sowing date	Seeding level (kg/ha)	1000-seed weight (g)	Harvest index	Seed yield/plant (g)	Seed yield (kg/ha)	Single-plant Biomass (g)	Biological yield (kg/ha)
Dec. 9	15	2.52cd	58.68 ab	0.472a	347.47 bc	0.805 a	592.27 c
	30	2.58cd	50.15 de	0.204 d	335.10 bcd	0.408 c	670.39 a
	45	2.43de	45.99 e	0.052 f	301.53 ef	0.113 de	655.72 ab
Jan. 8	15	2.31 e	62.10 a	0.308 b	385.73 a	0.499 bc	621.28 bc
	30	2.81 a	50.91 de	0.290 bc	350.60 b	0.569 bc	688.83 a
	45	2.61 bc	45.89 e	0.212 d	319.90 de	0.464 bc	697.17 a
Feb. 7	15	1.47 f	57.25 abc	0.236 cd	239.20 g	0.466 bc	473.39 e
	30	1.46 f	55.89 bcd	0.110 ef	325.41 cd	0.196 de	582.11 cd
	45	1.45 f	51.85 cde	0.052 f	282.71 f	0.102 de	545.22 d
Mar. 9	15	2.75ab	46.72 e	0.122 e	130.51 i	0.209 d	225.05 f
	30	2.58cd	58.59 ab	0.072 ef	147.57 hi	0.123 de	249.50 f
	45	2.48 cd	57.54 abc	0.043 f	154.53 h	0.075 e	267.78 f

Means with similar letter(s) in each column did not show significant difference at 5% level using Duncan Multiple Range Test.

The decrease in seed yield of single plant with the delay in sowing can be related to the shortening of growth period and the decrease in assimilate production which in turn, decreases plant branching potential. It can be said that earlier sowing increased seed and biomass yields per single plant through

lengthening growth period, increasing leaf area and producing a plenty of auxiliary branches. It appears that favorable environmental conditions especially light and temperature at the first and second sowing dates allowed the plants to better use these conditions, to produce more assimilates and finally, to increase their seed yield. These results are in agreement with the results of Moosavi *et al.* (2014) on fennel.

As means comparison showed, the increase in seeding level from 15 to 45 kg seed/ha led to 68.4 and62% decrease in seed yield per plant and single-plant biomass (Table 4). It seems that at higher seeding level, inter-plant competition usually increases and hence decreases seed yield per plant and single-plant biomass. These results are in agreement with the results of Moosavi *et al.* (2014) on fennel.

As shown in Table 5, means comparison of the interaction between sowing date and seeding level indicated that the treatment of sowing date of December 9 with seeding level of 15 kg seed/ha had the highest potential seed yield per plant and single-plant biomass (0.472 and 0.805 g, respectively) and the treatment of sowing date of March with seeding level of 45 kg seed/ha had the lowest ones (0.043 and 0.075 g, respectively) (Table 5).

1000-seed weight

The results of analysis of variance indicated that 1000-seed weight was affected by sowing date at 1% level and by the interaction between sowing date and seeding level at 5% level, but it was not affected by seeding level (Table 2).

March 9 sowing date produced the highest 1000-seed weight (2.60 g) which was 78.1% higher than that produced at February 7 sowing date (1.46 g) (Table 3). Rahimian Mashadi (1991), Heidari Zohel *et al.* (2009), Ehteramian (2007), Mashayekhi Sardooyi *et al.* (2011) and Veisi (2007) found similar results. But Torabi *et al.* (2014) reported that the effect of sowing date on weight of 1000 seeds was not significant.

Means comparison of the interaction between sowing date and seeding level showed that the treatment of January 9 sowing date and application of 30 kg seed/ha had the highest 1000-seed weight (2.81 g) and the treatment of sowing date of February 7 with the application of 45 kg seed/ha had the lowest one (1.45) (Table 5).

Harvest index

As analysis of variance showed, harvest index was not affected by sowing date, i.e. the change in sowing date had relatively similar effect on seed yield: biomass ratio. However, the change in seeding level significantly affected harvest index at 5% level (Table 2).

According to means comparison, the highest harvest index (56.10%) was obtained under the seeding level of 15 kg/ha and the lowest one (50.32%) was obtained under the seeding level of 45 kg/ha (Table 3).

The results indicated that the higher the seeding level was, the lower the harvest index was because at lower densities, the plants well grow with the application of less seeds, then seed number per plant increases and as a result, seed yield and harvest index increase; but, at higher densities of plants per unit area, plants cannot appropriately use the nutrients and environmental parameters for its reproductive phase and in other words, auxiliary branch number, umbel number per plant, seed number per plant and seed yield decreases despite the increase in biomass which leads to the decrease in seed yield: biomass ratio or harvest index.

The interaction between sowing date and seeding level significantly affected harvest index at 1% probability level (Table 2). As means comparison of the interaction between sowing date and seeding level showed, the highest harvest index (62.1%) was obtained under the treatment of sowing date of January 8 with the application of 15 kg seed/ha and the lowest one (45.89%) was obtained under the treatment of sowing date of December 9 with the application of 45 kg seed/ha (Table 5).

Conclusion

Given the results, it can be recommended to use sowing date of January 8 with the seeding level of 15-30 kg/ha for the cultivation of cumin in Birjand, Iran.

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