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Phenology and Yield of Coriander (*Coriandrum sativum* L.) at Different Sowing Dates

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ABSTRACT

In order to study the effects of sowing dates on phenology and yield of coriander (*Coriandrum sativum* L.), an experiment was conducted during 2010-2012 based on a randomized complete block design with three replications in HRS, Mondouri, BCKV, India. Six sowing dates included 5th November (D1), 12th November (D2), 19th November (D3), 26th November (D4), 3rd December (D5) and 10th December (D6). The results showed that a delay in sowing from November 5 to December 10 decreased plant height, number of primary branches per plant, days to 50% germination, days to flower initiation, days to 50% flowering and days to fruit maturity significantly. The 5th November exhibited significant improvement in yield attributes namely numbers of umbels per plant (25.58), umbellets per umbel (6.85), seeds per umbel (30.55), test weight (12.61 g), seed weight per plant (6.85 g) and seed yield ha^{-1} (1098.33 kg ha^{-1}).

Key words: *Coriandrum sativum*, coriander, phenology, sowing date, yield

INTRODUCTION

Coriander (*Coriandrum sativum* L.), an annual herbaceous plant of Apiaceae family, is one of the important seed spices occupying a prime position throughout the globe to add taste, flavour and pungency in various food items. Moreover, it is a frequent ingredient in the preparation of Ayurvedic medicines and is a traditional home therapy for different ailments viz., rheumatism, joint pain, gastrointestinal complaints, flatulence (Said *et al*., 1996), indigestion, insomnia, convulsions, anxiety, loss of appetite (Emamghoreishi *et al*., 2005), etc. Coriander is a tropical crop and generally sown in the winter season for seed production.

Time of sowing is crucial for crop for the vegetative growth and ultimate expressions of yield. Any early or late sowing may hamper the growth, yield as well as quality of the crop. Time of planting controls the crop phenological development along with efficient conversion of biomass into economic yield (Khichar and Niwas, 2006). In case of coriander, early sowing leads to early flowering but may be vulnerable to damage in case of extreme cold and frost. On the other hand late sowing affected the growth as well as yield and quality in an adverse way. Meena and Malhotra (2006) reported that early sowing and selection of less susceptible variety proved a suitable component for the management of aphid on coriander. Gujar *et al*. (2005) reported from an experiment that the maximum values were recorded for all the characters when the seeds were sown on 10 October followed by 25 October. Standardizations of time of sowing with due consideration to the different growth stages of crop, therefore, is an important area which need due

intervention. There are several research efforts on this crop by many workers on date of sowing (Mirshekari *et al*., 2011; Soleimani *et al*., 2011; Moosavi *et al*., 2012; Moosavi, 2012; Yildirim and Gok, 2012; Moniruzzaman *et al*., 2013), as well as on other aspects viz., water, nutrient and weed management, leaf cutting, allelopathic weed control, etc. (Datta *et al*., 2008; Singh *et al*., 2000; Nagar *et al*., 2009; Tripathi *et al*., 2009; Rajaraman *et al*., 2010; Sharangi, 2011; Sharangi *et al*., 2011) for standardization of agrotechniques towards enhanced production and quality. Among all these, date of sowing is still considered as one of the important area to be taken care of in this regard. However, most of the findings on dates of sowing are local in nature and very few findings are sufficient to be conclusive, in general. With this in view an investigation on the effect of date of sowing was carried out for identifying the best date of sowing towards the highest seed production of coriander.

MATERIALS AND METHODS

Field experiments were conducted on coriander (*Coriandrum sativum* L.) during 2010-11 and 2011-12 at The Horticultural Research Station, Mondouri, BCKV (Agricultural University), India. BCKV is located at the east of India at 23.5° North latitude, 89° East longitude having an average altitude of 9.75 m above mean sea level. The climate is sub-tropical humid. The soil was sandy clay loam with a pH of 7. In the present investigation coriander was sown in six different dates namely D1, D2, D3, D4, D5 and D6 in both the years. The respective dates were 5th November, 12th November, 19th November, 26th November, 3rd December and 10th December. The experiment was laid out in factorial randomized block design with three numbers of replications and 18 number of treatment combination in the plots of 2×1.5 m size. Observations on growth parameters including phenology viz., plant height (cm), number of branches, duration from sowing to first flower initiation (days), duration from sowing to 50% flower initiation (days), duration from sowing to first fruit initiation (days), duration from sowing to fruit maturity (days) and yield attributing parameters viz., number of umbels per plant, number of umbllets per plant, number of seeds per umbel, test weight (g), seed yield per plant (g), seed yield per plot (g), seed yield (kg ha^{-1}), etc. were recorded. The statistical analysis was done by using SAS 9.3 and MS Excel (Daniel's XL Toolbox Version 4.01) software.

RESULTS

Growth attributes: The results obtained from the study showed significant variation with different dates of sowing with regard to growth attributes like plant height at 30 DAS (5.60-11.67 cm), at 60 DAS (17.99-27.18 cm), at 90 DAS (66.27-81.20 cm) and at harvesting stage (83.36-95.76 cm) (Table 1). Moreover, number of primary branches (6.26-8.04), days to 50% germination (7.94-12.28 days), days to flower initiation (56.56-68.56 days), days to 50% flowering (66.50-80.61 days) and days for fruit maturity (126.17-142.56 days) were also highly influenced by sowing dates (Table 2). It is clear that a delay in sowing from November 5 to December 10 decreased plant height, number of primary branches per plant, days to 50% germination, days to flower initiation, days to 50% flowering and days to fruit maturity significantly.

Yield attributes: The results with regard to yield attributes (Table 3, 4 and Fig. 1) such as number of umbellets per umbel (4.68-6.85), number of umbel per plant (15.38-25.58), number of seeds per umbel (21.24-30.55), test weight (12.16-12.61), seed weight per plant (4.07-6.85 g) and seed yield ha^{-1} (607.33-1098.33 kg ha^{-1}) showed significant variation with different dates of

Table 1: Influence of date of sowing on growth parameters of coriander

Sowing date (D)	Plant height											
	30 DAS (days)			60 DAS (days)			90 DAS (days)			Harvesting (days)		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
D1	10.95^{b}	9.280^{b}	10.11^{b}	27.24^{a}	27.12^{a}	27.18^{a}	83.18^{a}	80.42^{a}	81.80^{a}	96.65^{a}	94.85^{a}	95.76^{a}
D2	12.28^{a}	11.260^{a}	11.67^{a}	25.58^{b}	25.71^{b}	25.64^{b}	77.52^{b}	74.46^{b}	75.99^{b}	93.93^{b}	92.52^{b}	93.23^{b}
D3	7.24^{c}	6.580^{c}	6.91^{c}	20.65^{c}	21.09^{c}	20.87^{c}	72.63^{c}	68.66^{c}	70.65^{c}	90.09^{c}	87.95^{c}	89.02^{c}
D4	7.00^{d}	6.140^{dc}	6.57^{dc}	23.51^{d}	23.01^{d}	23.26^{d}	70.23^{d}	67.07^{d}	68.65^{d}	92.35^{d}	89.63^{d}	91.00^{d}
D5	6.66^{e}	5.630^{dc}	6.15^{de}	19.49^{e}	19.61^{e}	19.55^{e}	64.59^{f}	61.99^{f}	63.29^{f}	86.69^{e}	85.28^{e}	85.98^{e}
D6	6.23^{f}	4.940^{e}	5.60^{e}	17.99^{f}	17.98^{f}	17.99^{f}	67.57^{e}	64.97^{e}	66.27^{e}	84.26^{f}	94.85^{f}	83.36^{f}
SEm (±)	0.00^{6}	0.475	0.17	0.19	0.12	0.12	1.08	1.18	1.09	0.51	0.72	0.41
CD $_{0.05}$	0.18	1.365	0.49	0.37	0.34	0.37	3.11	3.39	3.13	1.47	2.07	1.18

Y1: 2010-11, Y2: 2011-12, P: Pooled, NS: Non significant. Means with the same letter (s) in each column had no significant difference at 5% level. D1: 5th November, D2: 12th November, D3: 19th November, D4: 26th November, D5: 3rd December and D6: 10th December

Table 2: Influence of date of sowing on growth parameters of coriander

Sowing date (D)	Growth parameters														
	50% germination (days)			No. of primary branches			Flower initiation (days)			50% flowering (days)			Fruit maturity (days)		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
D1	7.780^{e}	8.110^{e}	7.940^{e}	8.060^{a}	8.030^{a}	8.040^{a}	69.220^{a}	67.890^{a}	68.560^{a}	81.000^{a}	80.220^{a}	80.610^{a}	143.000^{a}	142.110^{a}	142.560^{a}
D2	10.560^{c}	10.780^{c}	10.670^{c}	7.900^{b}	7.850^{b}	7.900^{b}	66.000^{b}	64.890^{b}	65.440^{b}	78.670^{b}	76.000^{b}	77.330^{b}	138.220^{b}	138.110^{b}	138.170^{b}
D3	9.560^{d}	10.000^{d}	9.780^{d}	7.180^{c}	7.110^{c}	7.140^{c}	64.110^{c}	63.220^{c}	63.670^{c}	76.000^{c}	74.440^{b}	75.220^{c}	135.220^{c}	134.440^{c}	134.830^{c}
D4	11.560^{b}	12.000^{ba}	11.780^{ba}	6.810^{d}	6.830^{d}	6.810^{d}	60.000^{e}	58.220^{e}	59.110^{e}	69.890^{e}	68.890^{c}	69.390^{d}	133.560^{d}	132.220^{d}	132.890^{d}
D5	11.440^{b}	11.330^{b}	11.390^{b}	6.420^{e}	6.360^{e}	6.400^{e}	62.000^{d}	60.440^{d}	61.220^{d}	72.780^{d}	70.560^{c}	71.670^{d}	130.560^{e}	128.780^{e}	129.670^{e}
D6	12.330^{a}	12.220^{a}	12.280^{a}	6.250^{f}	6.200^{f}	6.260^{f}	57.110^{f}	56.000^{f}	56.560^{f}	67.000^{f}	66.000^{d}	66.500^{e}	127.440^{f}	124.890^{f}	126.170^{f}
SEm (±)	0.261	0.260	0.185	0.043	0.045	0.034	0.351	0.491	0.264	0.424	0.684	0.408	0.331	0.385	0.285
CD $_{0.05}$	0.750	0.748	0.530	0.123	0.128	0.097	1.008	1.410	0.760	1.218	1.965	1.172	0.952	1.106	0.820

Y1: 2010-11, Y2: 2011-12, P: Pooled, NS: Non significant. Means with the same letter (s) in each column had no significant difference at 5% level. D1: 5thNovember, D2: 12th November, D3: 19th November, D4: 26th November, D5: 3rd December and D6: 10th December

Table 3: Influence of date of sowing and Irrigation (Main effects) on yield attributes of coriander

	Yield attributes								
	Umbellets umbel^{-1}			Umbels plant^{-1}			Seeds umbel^{-1}		
Date of sowing (D)	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
D1	6.990^{a}	6.700^{a}	6.850^{a}	25.700^{a}	25.460^{a}	25.580^{a}	31.060^{a}	30.030^{a}	30.550^{a}
D2	6.610^{b}	6.330^{b}	6.470^{b}	22.310^{b}	21.880^{b}	22.100^{b}	29.880^{b}	28.540^{b}	29.210^{b}
D3	5.980^{c}	5.740^{c}	5.860^{c}	20.190^{c}	19.830^{c}	20.010^{c}	26.600^{c}	26.330^{c}	26.470^{c}
D4	5.500^{d}	5.380^{d}	5.440^{d}	18.650^{d}	18.120^{d}	18.390^{d}	24.060^{d}	23.400^{d}	23.730^{d}
D5	4.810^{e}	4.710^{e}	4.760^{e}	17.520^{e}	16.470^{e}	17.000^{e}	22.600^{e}	21.610^{e}	22.110^{e}
D6	4.770^{e}	4.580^{e}	4.680^{e}	15.640^{f}	15.120^{f}	15.380^{f}	21.570^{f}	20.910^{f}	21.240^{f}
SEm (±)	0.047	0.081	0.054	0.263	0.211	0.171	0.170	0.152	0.119
CD $_{0.05}$	0.135	0.232	0.156	0.757	0.607	0.490	0.489	0.438	0.342

Y1: 2010-11, Y2: 2011-12 and P: Pooled. Means with the same letter (s) in each column had no significant difference at 5% level. D1: 5th November, D2: 12th November, D3: 19th November, D4: 26th November, D5: 3rd December and D6: 10th December

Table 4: Influence of date of sowing on yield attributes of coriander

	Yield attributes								
	Test weight (g)			Seed weight per plant (g)			Projected seed yield ha^{-1} (kg ha^{-1})		
Sowing date (D)	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
D1	12.72^{a}	12.51^{a}	12.61^{a}	6.960^{a}	6.740^{a}	6.850^{a}	1120.110^{a}	1076.560^{a}	1098.330^{a}
D2	12.57^{ba}	12.38^{a}	12.47^{ba}	5.630^{b}	5.500^{b}	5.570^{b}	874.220^{b}	848.220^{b}	861.220^{b}
D3	12.34^{bca}	12.35^{ba}	12.34^{cb}	5.270^{c}	5.040^{c}	5.160^{c}	804.220^{c}	793.440^{c}	798.830^{c}
D4	12.25^{cb}	12.28^{ba}	12.27^{cb}	4.370^{d}	4.310^{d}	4.340^{d}	701.000^{d}	690.000^{d}	695.500^{d}
D5	12.04^{cb}	12.33^{ba}	12.19^{c}	4.020^{e}	3.990^{e}	4.010^{e}	640.440^{de}	624.780^{e}	632.610^{e}
D6	12.19^{c}	12.13^{b}	12.16^{c}	4.090^{de}	4.050^{e}	4.070^{e}	615.110^{e}	600.560^{e}	607.830^{e}
SEm (±)	0.150	0.079	0.075	0.102	0.076	0.059	22.817	11.333	11.988
CD $_{0.05}$	0.432	0.227	0.215	0.294	0.217	0.169	65.576	32.570	34.453

Y1: 2010-11, Y2: 2011-12, P: Pooled, NS: Non significant. Means with the same letter (s) in each column had no significant difference at 5% level. D1: 5th November, D2: 12th November, D3: 19th November, D4: 26th November, D5: 3rd December and D6: 10th December

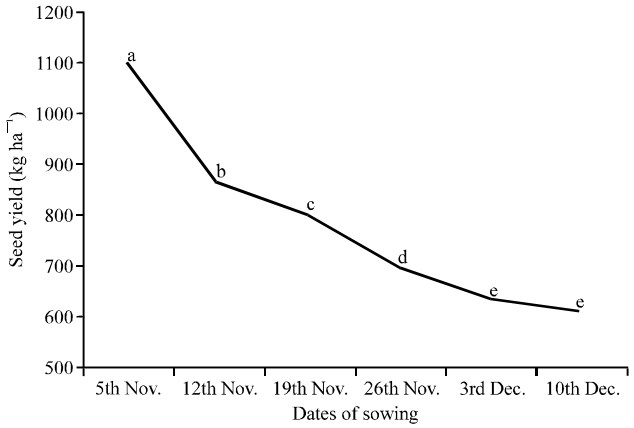

Fig. 1: Effect of dates of sowing on seed yield of coriander. The different alphabets (a-e) indicate significant difference at 5% level as calculated through Duncan's multiple test

sowing. The earliest date of sowing i.e. (D1) 5th November exhibited significant improvement in yield attributes namely number of umbels per plant, (25.58), umbellets per umbel (6.85), seeds per umbel (30.55), test weight (12.61 g), seed weight per plant (6.85 g) and seed yield ha^{-1} (1098.33 kg ha^{-1}).

Relationship between number of primary branches and plant height with number of umbels per plant, seeds per umbel, seed yield and test weight: A positive linear relationship was obtained between number of primary branches and each of number of umbels per plant, seeds per umbel, seed yield and test weight (Fig. 2a-d). They were found to be highly significant (with correlation coefficient values, r = 0.96**, 0.99**, 0.93** and 0.98**, respectively). The positive relationship indicated that each of number of umbels per plant, seeds per umbel, seed yield and test weight increased with the increase in number of primary branches. The linear equations (y = 4.764x-14.04, R^2 = 0.934; y = 5.070x-10.40, R^2 = 0.988; y = 227.2x-829.3,

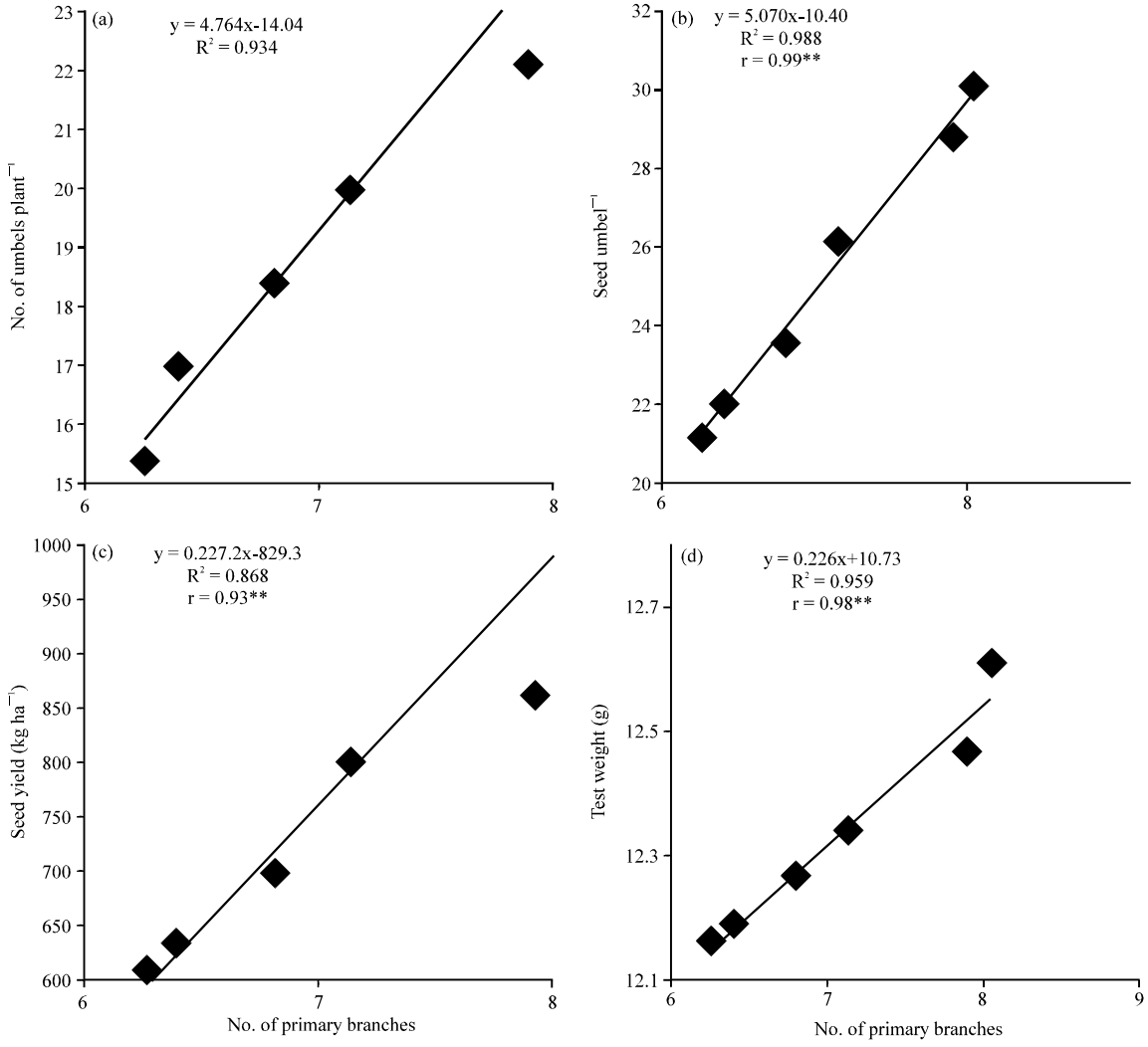

Fig. 2(a-d): Relationship between number of primary branches with (a) No. of umbels plant^{-1}, (b) Seeds umbel^{-1}, (c) Seed yield and (d) Test weight

R^2 = 0.868; y = 0.226x+10.73, R^2 = 0.959, respectively) stated that for every increase in the number of primary branches, a respective increase to the tune of about 5,5,227 kg ha^{-1} and 0.22 g in number of umbels per plant, seeds per umbel, seed yield and test weight were found. The values of coefficient of determinations (R2 s) indicated that about 93.4, 98.8, 86.8 and 95.9% increases in number of umbels per plant, seeds per umbel, seed yield and test weight were due to higher number of primary branches.

Similarly a positive linear relationship was obtained between plant height and each of number of umbels per plant, seeds per umbel, seed yield and test weight (Fig. 3a-d). They were found to be highly significant (with correlation coefficient values, r = 0.94**, 0.91**, 0.89** and 0.93**, respectively). The positive relationship indicated that each of number of umbels per plant, seeds per umbel, seed yield and test weight increased with the increase in plant height. The linear equations (y = 0.755x-48.05, R^2 = 0.883; y = 0.762x-42.87, R^2 = 0.839; y = 35.42x-2396, R^2 = 0.792; y = 0.035x+9.186, R^2 = 0.87, respectively) stated that for every centimeter increase in plant height, a

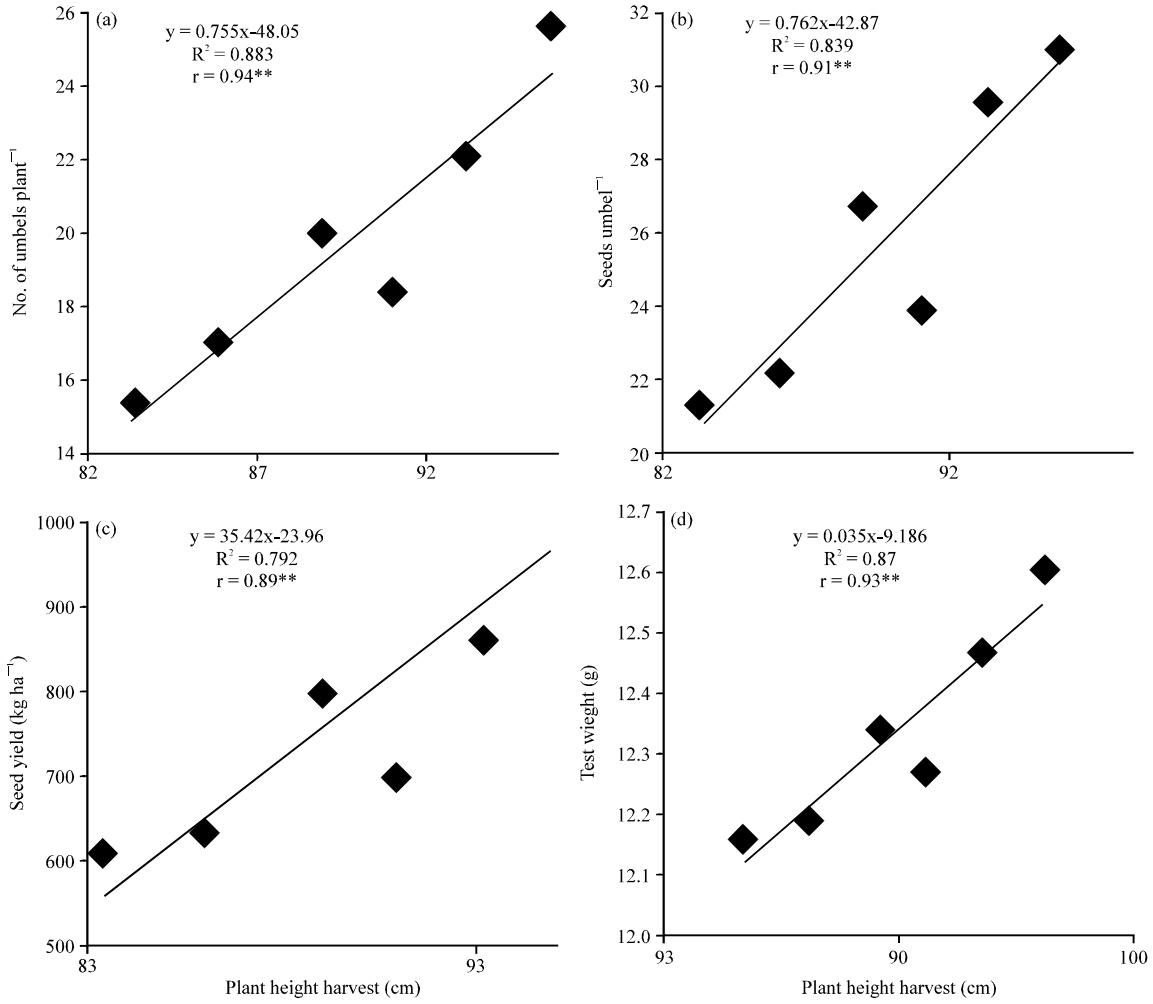

Fig. 3(a-d): Relationship between plant height (cm) at harvest with (a) No. of umbels $plant^{-1}$, (b) Seeds $umbel^{-1}$, (c) Seed yield and (d) Test weight

respective increase to the tune of about 0.75, 0.76, 35 kg ha^{-1} and 0.79 g in number of umbels per plant, seeds per umbel, seed yield and test weight were found. The values of coefficient of determinations (R^2_s) indicated that about 88.3, 83.9, 79.2 and 87.0% increases in number of umbels per plant, seeds per umbel, seed yield and test weight were due to higher plant heights.

DISCUSSION

Date of sowing is an important management factor for almost all seed spices including coriander. Change in sowing time leads to significant change in weather microclimate (Fig. 4-6) and

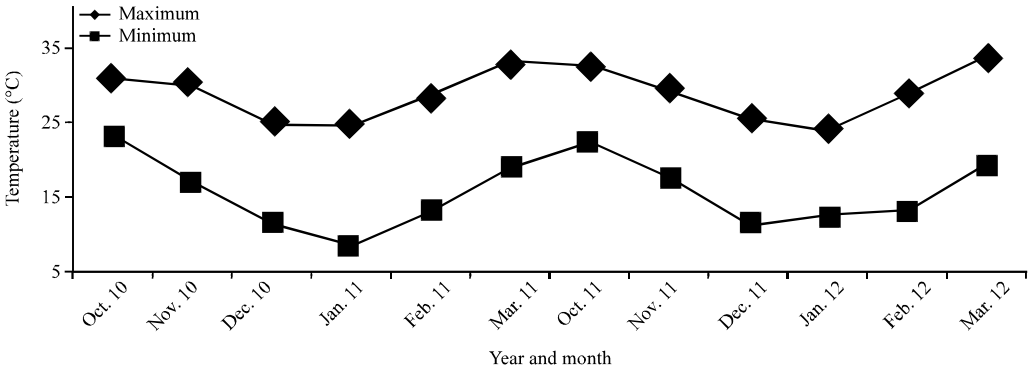

Fig. 4: Meteorological data pertaining to temperature

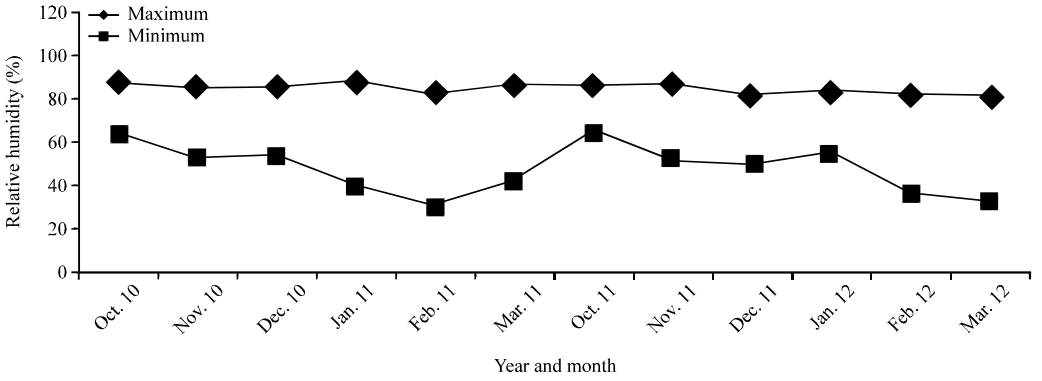

Fig. 5: Meteorological data pertaining to relative humidity

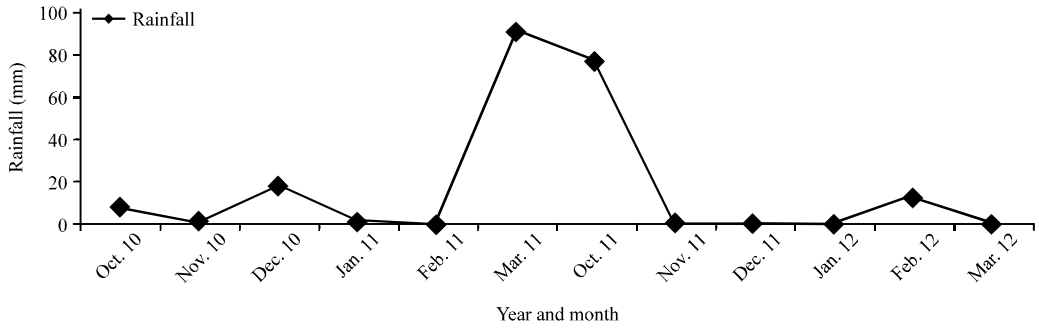

Fig. 6: Meteorological data pertaining to rainfall

subsequently the performance of the crop. In addition, the physical environment has profound influence on growth, biomass partitioning and ultimately the yield of coriander. Temperature, humidity, rainfall and other meteorological factors may individually or collectively limit the plant growth and production. Time of sowing controls the crop phenological development along with efficient conversion of biomass into economic yield (Khichar and Niwas, 2006). In a study on the effects of date of sowing, Rassam *et al.* (2007) found that with the delay in sowing from March 30 to April 29, plant height of coriander decreased, significantly. Also, delayed dates of sowing resulted in decreased plant height of different wheat cultivars (Subhan *et al.*, 2004), mungbean (Malik *et al.*, 2006), Thai hemp (Sengloung *et al.*, 2009), plant height and number of umbrella per plant of black cumin (Sadeghi *et al.*, 2009), coriander (Carrubba *et al.*, 2006) and fennel (Moosavi, 2011; Ayub *et al.*, 2008), plant height, number of branches per plant, number of capsules per plant and number of capsules per branch of Sesame (Sarkar *et al.*, 2007). The significant decrease in morphological traits associated with the delay in sowing can be related to higher temperatures that the plants at the later sowing dates experienced which limited their growing period and assimilate-building because of the early maturity of plants. Thus, the plants did not have adequate opportunity for photosynthesis and in turn their height and branch-bearing capacity decreased. Better vegetative growth expressed by plant height in earlier date of sowing is perhaps due to more favourable temperature and more sunshine reaching the crop during its growth period (Pan *et al.*, 2003). Datta *et al.* (2008) also found an increase in plant height as well as increasing trend in number of primary and secondary branches per plant in early sown plants in black cumin. Majumder *et al.* (2011) also found the similar trend in black cumin. Gujar *et al.* (2005) also are in agreement with the early sowing. Singh *et al.* (2005) too found higher umbellets per umbel, in the 30 October sowing compared to the 15 and 30 November sowings in fennel. Ehteramian (2003) studied the effect of sowing date for cumin and opined that delayed sowing date decreased seed weight and the number of umbels per plant. Bhadkariya *et al.* (2007) also found that the maximum number of seeds per umbel, in earlier sowing. A similar finding was reported by Sadeghi *et al.* (2009) in black cumin. Higher seed yields can be explained by higher above ground biomass, the No. of umbels per plant, the number of seed per umbels and plant height (Zolleh *et al.*, 2009). These results are in correspondence with Chaudhari *et al.* (1995) who reported that sowing date had significant effects on seed yield. The highest seed yield (2.47 g plant^{-1}, 9.83 q ha^{-1}), 1000 seed weight (11.28 g) were obtained from earlier sowing. Baswana *et al.* (1989) opined that lower yield in delayed sowing was due to insufficient time for vegetative growth as the plant entered the reproductive phase at a faster rate.

Seed yield per plant was reported to be strongly and positively correlated with plant height ($r = 0.99^{**}$) at genotypic level (Kassahun *et al.*, 2013). The direct effect of plant height on seed yield per plant was positive and comparatively high (0.44). Positive direct effect of plant height on seed yield was also reported by Jindla *et al.* (1985) in coriander. Correlation and path coefficient analysis by Singh *et al.* (2006) in coriander indicated that umbels of plants and branches of plant were the most important traits as they exerted positive direct effect on seed yield. Singh and Singh (2013) found the maximum genotypic coefficient of variability (18.39%), broad sense heritability (93.5%) and genetic advance over mean (36.60%) for umbels/plant. Seed yield was positively associated with several characters such as plant height, number of primary branches plant, number of secondary branches plant, number of umbels plant, number of umbellets plant, number of seeds umbel and umbel diameters. Carrubba *et al.* (2006) reported that the plant height of coriander was tightly associated with yield and with all yield determinants; the correlation coefficient between plant height and number of umbels per plant was highly significant. Phenotypic correlations of

grain yield per plant were highly significant and positive with umbellets per plant, umbels per plant, number of effective branches, straw yield per plant, number of primary branches, plant height, number of grains per umbellet and harvest index (Bhandari and Gupta, 1991).

The study showed a significantly influential effect of date of sowing on growth and yield of coriander. The results revealed that coriander sown on 5th November is found to obtain higher seed yield which means early winter season. Consequently, the findings may suggest farmers and agricultural researchers to carefully consider the date of sowing which appears to be a challenging task in the context of global climatic scenario. However for better understanding reliability and validation, such studies may be conducted for several years taking into account the microclimatic factors of the particular locality.

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