The Bioscan 9(4): 1513-1520, 2014
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

PHENOLOGY AND YIELD OF CORIANDER AS INFLUENCED BY SOWING DATES AND IRRIGATION

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KEYWORDS
Coriandrum sativum
Coriander
Phenology
Sowing date
Yield

Received on :
06.03.2014

Accepted on :
10.11.2014

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ABSTRACT
Effect of 3 irrigations viz., 15 + 30 + 45 + 60 + 75 + 90 + 105 DAS + seed set (I1), 15 + 30 + 45 + 60 DAS + seed set (I2), 15 + 30 DAS + seed set (I3) alongwith 6 sowing dates viz., 5th,12th,19th, 26th November, 3rd and 10th December were studied on coriander based on a RBD with 3 replications in HRS, Mondouri, BCKV, India. A delay in sowing from November 5 to December 10 decreased growth and influenced phenology. November 5 exhibited significant improvement in yield attributes namely umbel and umbellets plant^{-1}(25.58 and 6.85), seeds umbel^{-1} (30.55), test weight(12.61 g), seed weight plant^{-1} (6.85 g), essential oil (o.25%-0.33%) and yield hectare^{-1}(1098.33 kg ha^{-1}). Similarly irrigation influenced plant height at 60 DAS (19.45 cm - 25.28 cm), 90 DAS (64.26 - 76.93 cm) and harvesting (80.16 cm- 97.59 cm), number of primary branches (6.69-7.37), 50% germination (10.28-11.03 days), flower initiation (60.19-63.94 days), 50% flowering (71.56-75.06 days) and fruit maturity(127.61-139.44 days). It can be concluded that the optimum date of sowing viz.5th November along with irrigation level viz.I1 showed best results for important growth parameters and all yield attributes and quality characters of coriander.

INTRODUCTION

Coriander is one of the important seed spices which are acclaimed throughout the globe for its enormous uses of seeds as well as leaf (Hnamte *et al.,* 2013). Besides being used as spice it has several medicinal values and recently gaining momentum as an important value added export item in the global market. The successful production of this important seed spice is constrained by many factors. Productivity too is low as compared to actual yield potential due to incorrect application of agro techniques (Patel *et al.,* 2013). Among them proper date of sowing and judicious application of irrigation water are the most important ones. Time of sowing is crucial for crop for the vegetative growth and ultimate expressions of yield. Any early or lateness in sowing may hamper the growth, yield as well as quality of the crop. 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 affects the growth as well as yield and quality in an adverse way. Sharangi and Roychowdhury (2014) found that the 5th November sowing of coriander exhibited significant improvement in yield attributes namely numbers of umbels per plant, umbellets per umbel, seeds per umbel, test weight, seed weight per plant and seed yield ha^{1}. Meena and Malhotra (2002) 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.

Similar to the time of sowing, irrigation is also very important for good growth and development of coriander. There are several growth phases viz. germination, peak vegetative growth period, flower initiation, seed set, fruit maturity. Any lacking of moisture supply in these stages hampers the yield and quality of coriander seed. So, efficient water management is necessary to obtain good economic yield also. According to Singh and Gangwar (1991), for maximum seed yield, coriander (*Coriandrum sativum*) should be given frequent irrigation at 15 days intervals. In West Bengal it is sown as a cool season crop for commercial seed production, but the average productivity is much less as compared to other coriander producing states (Panda *et al.*, 2007).

Though few researchers studied on the effects of sowing dates (Pan *et al.*, 2003; Carrubba *et al.,* 2006; Bhadkariya *et al.*, 2007; Singh *et al.*, 2005; Khah, 2009, Guha *et al.*, 2013) as well that of irrigation (Lakpale *et al.,* 2007; Kumar *et al.*, 2008; Tripathi *et al.*, 2009; Nadjafi *et al.*, 2009) in coriander, comprehensive information in this regard is very much scanty and very few works had been reported on the specific influence of sowing dates and irrigation on phenology and yield of coriander. If the crop is sown on several dates of sowing and irrigation is provided on various crop growth stages which are crucial for the growth and development of the crop the results may provide information sufficient to find out the best option with logical understanding. Keeping these in view it was considered worthwhile to undertake the experiment to identify the best date of sowing as well as the effect of irrigation for ideal growth, development and enhanced yield of seed in coriander.

MATERIALS AND METHODS

An investigation on the effect of date of sowing and irrigation in coriander *(Coriandrum sativum L)* was carried out at The Horticultural Research Station, Mondouri, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya (Agricultural University), West Bengal during the year 2010-2011 and 2011-12 in the months of November to March for identifying the best date of sowing and efficient water management practices to get the highest seed production under Gangetic alluvial plains of West Bengal. The Research Station is located at 23.5º North latitude and 89º East longitude having an average altitude of 9.75m above mean sea level. The experimental site (Mondouri) is located in sub-tropical humid climate with Gangetic alluvial soil having sandy clay loam texture, with good water holding capacity, well drained, and with acidic to neutral reaction and moderate fertility status.

In the present investigation two different factors were included, date of sowing and irrigation levels. The coriander was shown in six different dates namely D1, D2, D3, D4, D5 and D6 by using three irrigation levels at different day's interval viz. I1, I2 and I3 in both the years. The respective dates were 5th November, 12th November, 19th November, 26th November, 03rd December and 10th December in both the seasons (2010-11 and 2011-12). The I1, I2 and I3 comprises of 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set, 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set, 15 DAS + 30 DAS + seed set respectively. The experiment was laid out in Factorial Randomized Block Design with three numbers of replications and eighteen number of treatment combination in the plots of 2 x 1.5 m^2 size. Standard agrotechnical methods were followed for the entire growth and developmental period of the crop (Peter, 2004). The statistical analysis was done by using SAS 9.3 and MS Excel software by following the principles of Gomez and Gomez (1984) and the results of the experiment on the basis of two years pooled data have been summarized below.

RESULTS

Growth attributes

The results obtained from the study showed significant variation with different dates of sowing with regard to growth parameters like plant height at 30 DAS (5.60 cm - 11.67 cm), at 60 DAS (17.99 cm - 27.18 cm), at 90 DAS (66.27 cm - 81.20 cm) and at harvesting stage (83.36 cm - 95.76 cm), number of primary branches (6.26 - 8.04), days to 50% germination (7.94 - 12.28 days), days for flower initiation (56.56-68.56 days), days for 50% flowering (66.50-80.61 days) and days for fruit maturity (126.17-142.56 days) (Table 1 and 2). Similarly irrigation also showed a significant influence on plant height at 60 DAS (19.45 cm - 25.28 cm), at 90 DAS (64.26 - 76.93 cm) and at harvesting stage (80.16 cm- 97.59 cm), number of primary branches (6.69-7.37), days to 50% germination (10.28-11.03 days), days for flower initiation (60.19-63.94 days), days for 50% flowering (71.56-75.06 days) and days for fruit maturity (127.61-139.44 days) (Table 1 and 2). The interaction effects of date of sowing and irrigation were mostly found non-significant except plant height at 60 DAS (15.63 cm-30.00 cm), number of primary branches (6.13-8.47) and fruit maturity (118.47-119.30 days).

Yield attributes

The results with regard to yield attributes such as number of umbellets per umbel (4.68-6.85), numbers 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 gm - 6.85 gm) and seed weight per hectare (607.33 - 1098.33 kg/ha) and with regard to quality parameters such as essential oil content (0.25%-0.33%) showed significant variation with different dates of sowing . Irrespective of dates of sowing the levels of irrigation also executed significant influence on all the parameters like numbers of umbellets per umbel (5.31-6.17), numbers of umbel per plant (18.04-22.60), number of seeds per umbel (23.21-27.94), seed weight per plant (4.50

Table 1: Influence of date of sowing and Irrigation (Main effects) on growth parameters of coriander

Treatment	Plant Height											
	30DAS (days)			60 DAS (days)			90 DAS (days)			Harvesting (days)		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
Date of sowing (D)												
D1	10.95b	9.28b	10.11b	27.24a	27.12a	27.18a	83.18a	80.42a	81.80a	96.65a	94.85a	95.76a
D2	12.28a	11.26a	11.67a	25.58b	25.71b	25.64b	77.52b	74.46b	75.99b	93.93b	92.52b	93.23b
D3	7.24c	6.58c	6.91c	20.65c	21.09c	20.87c	72.63c	68.66c	70.65c	90.09c	87.95c	89.02c
D4	7.00d	6.14dc	6.57dc	23.51d	23.01d	23.26d	70.23d	67.07d	68.65d	92.35d	89.63d	91.00d
D5	6.66e	5.63dc	6.15de	19.49e	19.61e	19.55e	64.59f	61.99f	63.29f	86.69e	85.28e	85.98e
D6	6.23f	4.94e	5.60e	17.99f	17.98f	17.99f	67.57e	64.97e	66.27e	84.26f	94.85f	83.36f
SEm (±)	0.06	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
Irrigation (I)												
I1	8.39p	7.52p	7.96p	25.22p	25.33p	25.28p	78.36p	75.49p	76.93p	98.45p	96.73p	97.59p
I2	8.35p	7.09p	7.82p	22.32q	22.72q	22.52q	73.93q	70.33q	72.13q	92.35q	90.49q	91.42q
I3	8.34p	7.39p	7.72p	19.70r	19.21r	19.45r	65.56r	62.96r	64.26cr	81.19r	79.12r	80.16r
SEm (±)	0.044	0.036	0.24	0.14	0.08	0.09	0.76	0.83	0.77	0.36	0.50	0.29
CD 0.05	NS	NS	NS	0.40	0.24	0.26	2.20	2.39	2.214	1.04	1.49	0.83

Values in a column followed by the same letter are not significantly different at P d" 0.05, Duncan's multiple range tests; Y1: 2010-11, Y2:2011-12, p: Pooled; D:Depth of sowing: 5th November (D1), 12th November(D2),19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6). I:irrigation : 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

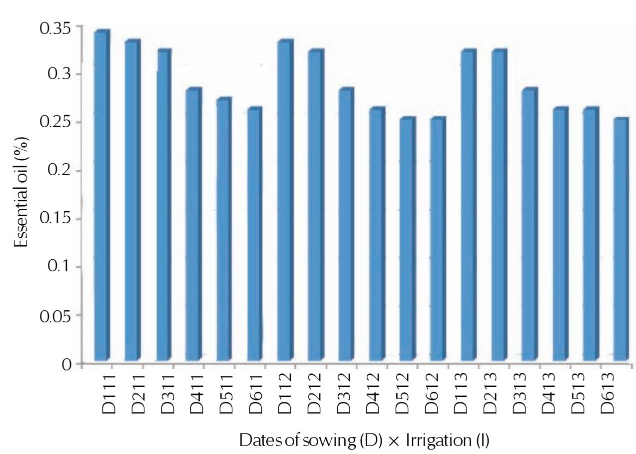
Table 2: Influence of date of sowing and Irrigation (Main effects) on growth parameters of coriander

Treatment	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
Date of Sowing (D)															
D1	7.78e	8.11e	7.94e	8.06a	8.03a	8.04a	69.22a	67.89a	68.56a	81.00a	80.22a	80.61a	143.00a	142.11a	142.56a
D2	10.56c	10.78c	10.67c	7.90b	7.85b	7.9b	66.00b	64.89b	65.44b	78.67b	76.00b	77.33b	138.22b	138.11b	138.17b
D3	9.56d	10.00d	9.78d	7.18c	7.11c	7.14c	64.11c	63.22c	63.67c	76.00c	74.44b	75.22c	135.22c	134.44c	134.83c
D4	11.56b	12.00ba	11.78ba	6.81d	6.83d	6.81d	60.00e	58.22e	59.11e	69.89e	68.89c	69.39d	133.56d	132.22d	132.89d
D5	11.44b	11.33cb	11.39b	6.42e	6.36e	6.4e	62.00d	60.44d	61.22d	72.78d	70.56c	71.67d	130.56e	128.78e	129.67e
D6	12.33a	12.22a	12.28a	6.25f	6.20f	6.26f	57.11f	56.00f	56.56f	67.00f	66.00d	66.50e	127.44f	124.89f	126.17f
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
Irrigation (I)															
I1	10.22q	10.33q	10.28q	7.24q	7.18q	7.21q	64.44p	63.44p	63.94p	75.61p	74.50p	75.06p	139.72p	139.17p	139.44p
I2	10.50pq	10.72pq	10.61q	7.40p	7.30p	7.35p	63.56p	62.72p	63.14q	74.39q	73.11p	73.75q	135.44q	134.72q	135.08q
I3	10.89p	11.17p	11.03p	6.72r	6.67r	6.69r	61.22q	59.17q	60.19r	72.67r	70.44q	71.56r	128.8r	126.39r	127.61r
SEm (±)	0.185	0.184	0.130	0.030	0.032	0.024	0.248	0.347	0.187	0.300	0.484	0.288	0.234	0.272	0.202
CD 0.05	0.531	0.529	0.375	0.087	0.091	0.069	0.713	0.997	0.537	0.862	1.390	0.829	0.673	0.782	0.580

Values in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's multiple range test; Y1: 2010-11, Y2: 2011-12, P: Pooled; D: Depth of sowing: 5th November (D1), 12th November (D2), 19th November (D3), 26th November (D4), 03rd December (D5) and 10th December (D6). I: irrigation :: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

gm - 5.65 gm) and seed weight per hectare (662.39 - 920.03 kg/ha) and quality parameter like essential oil content (0.28%-0.30%) except test weight. Like their individual effects interaction effect of date of sowing and irrigation found to be significant on umbellets per umbel (4.34-7.61), numbers of umbel per plant (15.11-28.34), number of seeds per umbel (20.30-33.89), seed weight per plant (3.88 gm - 8.29 gm) and seed weight per hectare (559.67- 1340 kg/ha) and quality parameter like essential oil content (Fig. 1) except test weight.

The investigation revealed that the optimum date of sowing viz.D1 (5th November) along with irrigation level viz.I1 (15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105DAS + seed set) showed best results for important growth parameters and all yield attributes and quality characters of coriander. The treatment D1I1 proved most effective as it exceed other treatments in growth parameters like plant height (60 DAS: 30.00 cm, 90 DAS: 88.68 cm and harvesting stage with 105.03 cm) and earlier germination (7.83 days), as well as yied attributes like higher number of umbellets per umbel (7.61), higher numbers of umbel per plant (28.34), higher number of seeds per umbel (33.89), higher test weight (12.80 gm)higher seed weight per plant (8.29 gm) and higher, seed weight per hectare (1340kg/ha) and quality parameter like essentiali oil content (0.34%), followed by D1I2 (sowing on 5th November with irrigations on 15 DAS + 30 DAS + 45 DAS + 60 DAS + seedset) in some parameters with the value of like plant height (90 DAS with 83.84 cm) and earlier 50%germination (8.00 days), numbers of umbels per plant (25.36), higher seed weight per plant (6.83 gm) and higher, seed weight per hectare (1116kg/ha) and D2I1 (sown on 12th November and irrigation had given 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + Seed set) in some other parameters with the value like plant height (60 DAS with 28.95 cm and harvesting stage with 100.23 cm), number of umbellets per umbel (7.19) and number of seeds per umbel (31.50). But regarding number of primary branches D1I2 showed the higher value (8.47). But so far as the higher



D: Depth of sowing: 5th November (D1), 12th November(D2),19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6); I: irrigation: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

Figure 1: Essential oil percentage of coriander as influenced by different sowing dates and irrigation

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

Treatment	Yield attributes								
	Umbellets/umbel			Umbel/plant			Seed/umbel		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
Date of Sowing(D)									
D1	6.99a	6.70a	6.85a	25.70a	25.46a	25.58a	31.06a	30.03a	30.55a
D2	6.61b	6.33b	6.47b	22.31b	21.88b	22.10b	29.88b	28.54b	29.21b
D3	5.98c	5.74c	5.86c	20.19c	19.83c	20.01c	26.60c	26.33c	26.47c
D4	5.50d	5.38d	5.44d	18.65d	18.12d	18.39d	24.06d	23.40d	23.73d
D5	4.81e	4.71e	4.76e	17.52e	16.47e	17.00e	22.60e	21.61e	22.11e
D6	4.77e	4.58e	4.68e	15.64f	15.12f	15.38f	21.57f	20.91f	21.24f
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
Irrigation(I)									
I1	6.25p	6.07p	6.17p	22.64p	22.56p	22.60p	28.26p	27.61p	27.94p
I2	5.70q	5.39q	5.54q	19.04q	18.13q	18.59q	26.03q	24.97q	25.5q
I3	5.36r	5.26q	5.31r	18.33r	17.75r	18.04r	23.59r	22.83r	23.21r
SEm (±)	0.033	0.057	0.038	0.186	0.149	0.121	0.120	0.108	0.084
CD 0.05	0.096	0.164	0.110	0.535	0.429	0.347	0.346	0.310	0.242

Values in a column followed by the same letter are not significantly different at P d" 0.05, Duncan's multiple range test; Y1: 2010-11,Y2:2011-12,P:Pooled; D:Depth of sowing:: 5th November (D1), 12th November(D2),19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6). I:irrigation :: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

Table 4: Influence of date of sowing and Irrigation (Main effects) on yield attributes of coriander

Treatment	Yield attributes								
	Test weight (gm)			Seed weight per plant (gm)			Projected seed yield per ha (kg/ha)		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
Date of Sowing(D)									
D1	12.72a	12.51a	12.61a	6.96a	6.74a	6.85a	1120.11a	1076.56a	1098.33a
D2	12.57ba	12.38a	12.47ba	5.63b	5.50b	5.57b	874.22b	848.22b	861.22b
D3	12.34bca	12.35ba	12.34cb	5.27c	5.04c	5.16c	804.22c	793.44c	798.83c
D4	12.25cb	12.28ba	12.27cb	4.37d	4.31d	4.34d	701.00d	690.00d	695.50d
D5	12.04cb	12.33ba	12.19c	4.02e	3.99e	4.01e	640.44de	624.78e	632.61e
D6	12.19c	12.13b	12.16c	4.09de	4.05e	4.07e	615.11e	600.56e	607.83e
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
Irrigation(I)									
I1	12.38p	12.30p	12.34p	5.74p	5.57p	5.65p	933.56p	906.50p	920.03p
I2	12.33p	12.33p	12.33p	4.91q	4.77q	4.84q	773.89q	755.61q	764.75q
I3	12.34p	12.36p	12.35p	4.52r	4.49r	4.50r	670.11r	654.67r	662.39r
SEm (±)	0.106	0.056	0.053	0.072	0.054	0.041	16.134	8.013	8.477
CD 0.05	NS	NS	NS	0.208	0.154	0.119	46.369	23.030	24.362

Values in a column followed by the same letter are not significantly different at P d" 0.05, Duncan's multiple range test ; Y1: 2010-11,Y2:2011-12,P:Pooled,NS: Non significant; D:Depth of sowing:: 5th November (D1), 12th November(D2),19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6). I:irrigation :: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

seed yield and more essential oil content in seed was our primary target, D1I1 can be said the best treatment among this all. But the treatments like D1I1, D1I2, D2I1 took comparatively more time for flower initiation (70.83 days, 69.00 days, 66.83 days), 50% flowering (81.33 days, 83.00 days, 77.83 days) and fruit maturity (142.50 days, 148.17 days, 138.17 days) than the treatments like D6I3 and D5I3 which took 57.50 and 53.67 days for flower initiation, 67.67 and 64.67 days for flower initiation, 122.67 and 119.30 days for fruit maturity. It is due to the fact that earlier treatments were having sown earlier sowing dates and they got favourable temperature, humidity and moisture in different growth stages and took proper vegetative growth under efficient irrigation. That is why they took some more time than the treatments sown later and with lower irrigation levels.

Observation on water management

Field water supply

Field water supply through irrigation was 50 mm for I_2, 100 mm for I_3 and 150 mm for I_4 (Table 6). The depth of irrigation was 50 mm (5 cm) for each irrigation. The maximum field water supply was recorded in irrigation at 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (8 irrigations). *i.e.*, I_1 as treatment received higher number of irrigation and the lowest (3 irrigations) was found in I3 (15 DAS + 30 DAS + seed set) during the period of experiment.

Soil moisture status at the time of sowing and harvesting

Soil moisture at the time of sowing ranges from 18.20 to 18.98% (Table 5). The data at the time of sowing revealed that soil moisture at different depth had sufficient soil water reserve for proper germination of the crop. Surface layer (0- 15 cm) had less initial soil moisture content due to soil evaporation. At harvest, soil water status varied depending upon the water mining pattern by the plant influenced by different sowing

Table 5: Soil moisture status at sowing and harvesting of coriander

Treatment	Soil moisture content (%) at different depths (cm)			
	0 - 15 cm	15 - 30 cm	30 - 45 cm	45 - 60 cm
	Initial(at sowing)			
	18.2	18.42	18.23	18.98
	At Harvest			
D1I1	11.94	13.74	14.26	15.32
D1I2	10.73	12.15	12.48	14.03
D1I3	10.06	10.47	12.04	13.69
D2I1	12.38	13.83	14.13	15.20
D2I2	11.53	12.68	13.87	14.03
D2I3	10.59	11.27	12.43	12.83
D3I1	12.70	13.92	13.87	15.15
D3I2	11.58	12.72	12.78	14.03
D3I3	11.13	11.31	11.82	13.17
D4I1	12.83	13.96	13.92	15.24
D4I2	11.62	12.81	12.72	14.12
D4I3	11.40	11.40	11.35	13.82
D5I1	13.37	15.42	14.94	14.00
D5I2	12.11	12.86	13.65	13.09
D5I3	11.18	11.75	12.17	13.09
D6I1	13.50	14.27	14.09	15.20
D6I2	12.16	12.95	14.08	12.87
D6I3	11.40	11.84	13.87	11.65

D: Depth of sowing:: 5th November (D1), 12th November(D2), 19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6). I: irrigation :: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

Table 6: Field water supply as influenced by levels of irrigation in coriander

Treatment	Irrigation		ER(mm)	Total
	No.	Amount(mm)		
I1	8	400	87.80	487.80
I2	5	250	87.80	337.80
I3	3	150	87.80	237.80

dates and irrigation. Soil water status was higher in I1 treatment (15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set) closely followed I_2 (15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set) treatment due to maximum number of irrigation whereas low water content was recorded in I3 (15 DAS + 30 DAS + seed set). Different sowing dates irrespective of irrigation treatments showed significant effect on moisture content at harvest. Due to higher extraction of earlier sown plants as they got favourable temperature, humidity and moisture in different growth stage and took proper vegetative growth under efficient irrigation lower the moisture percentage in soil.

Profile contribution (Pc)

Contribution from soil reserve was maximum under irrigation at I3 (15 DAS + 30 DAS + seed set) (Table 7) ranging from 3.80-6.27 cm. Profile contribution (Pc) was high under I3 comparing with I2 and I1 treatments. Profile contribution came mostly from the top layers (0 - 15 to 15 - 30 cm) irrespective of the levels of irrigation as compared with the bottom layers (30 - 45 to 45 - 60 cm). The total profile contribution was highest under plants sown on the first sowing date (5th November) *i.e.*, D1. Profile contribution is varied due to variation in irrigation scheduling and different sowing dates.

Soil moisture extraction pattern

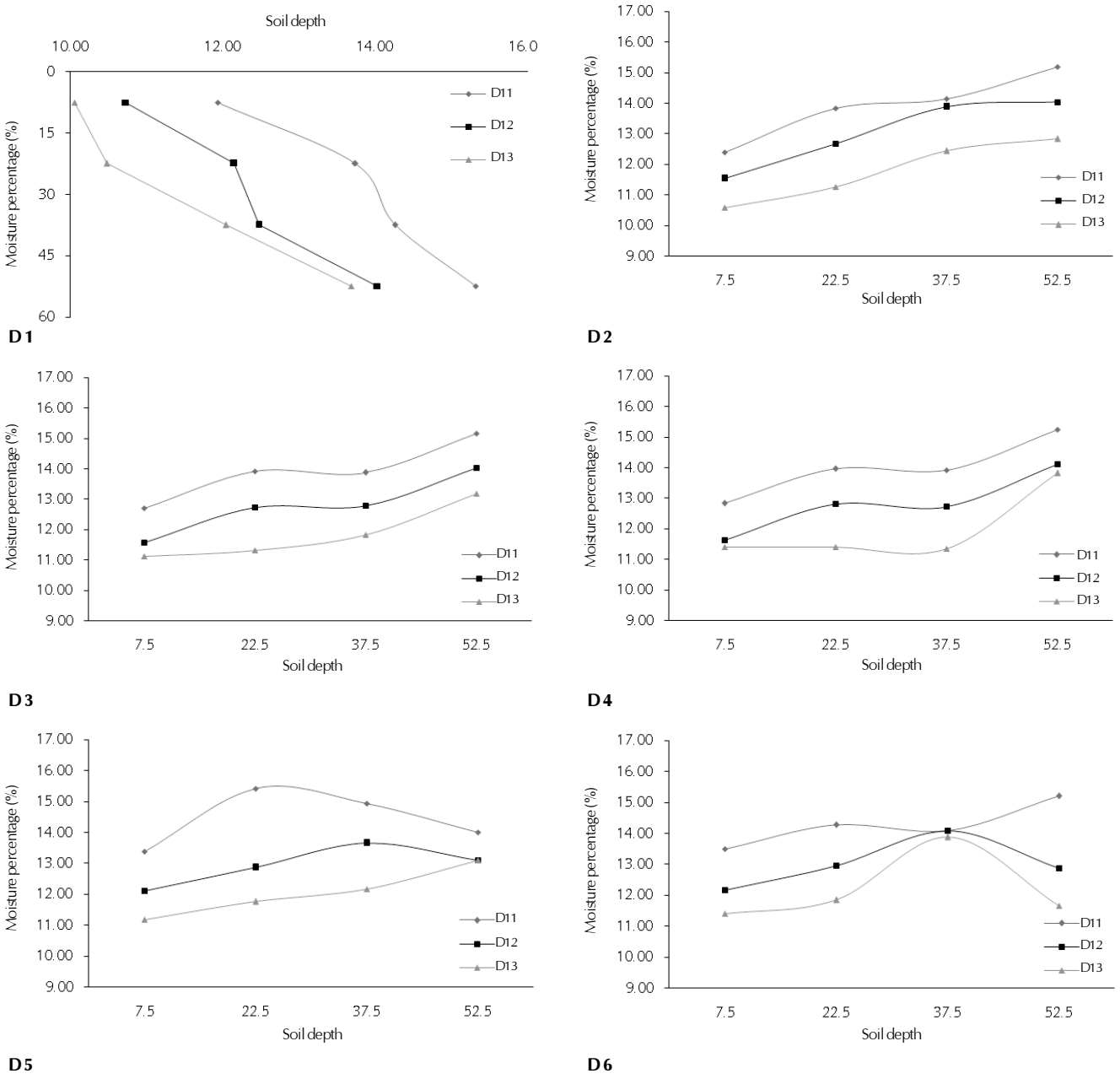
Relative contribution of different soil layers was very distinctive (Fig. 2a-f). Under I3, different soil layers contributed equally to the total water uptake by plant because plant face water stress in the upper layers, so lower layers contributed much to the top layers. However, under I2 and I1treatments the top layers (0 - 15 and 15 - 30 cm) contributed (> 50%) more moisture than the lower layers (30 - 45 and 45 - 60 cm). Surface layer (0 - 15 cm) contribution was the maximum irrespective of the levels of irrigation. On the other hand, bottom layer (45 - 60 cm) contributed the least moisture under irrigated treatments. Under nutrient management, the contribution of the surface layer was highest when plants were sown on first date (5th November) *i.e.*, D1, irrespective of the levels of irrigation.

DISCUSSION

Coriander is a tropical crop and generally sown in the winter season for seed production. Dry and cold weather during the early stage favours better vegetative growth where as dry and relatively high temperature promotes seed production. Better

Table 7: Water balance components as influenced by different sowing dates and irrigation

Treatment	PC (cm)	R (cm)	I (cm)	CU (cm)	WUE(kg/ha/cm)
D1I1	4.22	10.00	40.00	53.00	25.28
D1I2	5.56	10.00	25.00	39.34	28.37
D1I3	6.27	10.00	15.00	30.05	27.92
D2I1	4.16	10.00	40.00	52.94	19.57
D2I2	4.94	10.00	25.00	38.72	21.12
D2I3	6.08	10.00	15.00	29.86	24.45
D3I1	4.14	10.00	40.00	52.92	17.99
D3I2	5.17	10.00	25.00	38.95	19.34
D3I3	6.01	10.00	15.00	29.79	23.20
D4I1	4.07	10.00	40.00	52.85	15.60
D4I2	5.14	10.00	25.00	38.92	17.17
D4I3	5.89	10.00	15.00	29.67	20.01
D5I1	3.80	19.00	40.00	52.58	13.47
D5I2	5.04	19.00	25.00	38.82	16.22
D5I3	5.84	19.00	15.00	29.62	18.90
D_6I1	3.82	19.00	40.00	52.60	12.53
D_6I2	4.96	19.00	25.00	38.74	15.57
D_6I3	5.71	19.00	15.00	29.49	19.02



D: Depth of sowing:: 5th November (D1), 12th November(D2),19th November(D3), 26th November(D4), 03rd December(D5) and 10th December(D6). I: irrigation :: 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set (I1), 15 DAS + 30 DAS + 45 DAS + 60 DAS + seed set (I2) and 15 DAS + 30 DAS + seed set (I3)

Figure 2 (a-f): Moisture percentage of soil during harvesting of coriander in different soil depths at different sowing dates

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 in black cumin with the advancement of sowing time upto 15th November and thereafter it decreased gradually. Majumder *et al.* (2011) also found similar trend of 50% germination in black cumin. Datta *et al.* (2008) also found increasing trend in number of primary and secondary branches per plant in early sown plants in black cumin. Bhadkariya *et al.* (2007) reported that the maximum days to first flowering was observed with early-sown seeds. Singh *et al.* (2002) reported that days to 50% flowering significantly increased with increasing irrigation intensity. Singh *et al.* (2005) also found higher umbellets per umbel, in the 30 October sowing compared to the 15 and 30 November sowings in fennel. Kumar *et al.* (2008) also showed that water should be given in the important growth phases to obtain better yield.

The environment created by temperature, humidity, rainfall and other meteorological factors has profound influence on growth, biomass partitioning and ultimately the yield of coriander which may individually or collectively limit the plant

growth and production. The phenological development of the crop along with efficient conversion of biomass into yield is precisely influenced by time of sowing (Khichar and Niwas, 2006). Bhadkariya *et al.* (2007) also found the maximum number of seeds per umbel in earlier sowing. It can be explained by higher above ground biomass, the number of umbels/plant, the number of seed/umbels and plant height. The decrease in yield with later sowing dates might be due to insufficient time for vegetative growth as the plants enter the reproductive phase at a faster rate. Shadap *et al.* (2013) also opined in a similar way with differential sowing time in ginger. According to Mehta *et al.* (2010), yield of fenugreek were exhibited significantly higher with irrigation. Higher test weight in early sown plants is due to the fact that crop got sufficient time for its growth under favourable condition (Pan *et al.,* 2003). Khah (2009) reported that the highest seed yields was obtained in the AUS variety from the earliest sowing. The results were also in agreement with (Tripathi *et al.,* 2009). The better performance of coriander under irrigation level I3 could be due to higher and physiological activities favouring higher nutrient uptake and photosynthesis which might be responsible for formation of more photosynthates under this treatments ultimately resulting in more yield (Lakepale *et al.,* 2007).

The study showed a significant effect of both date of sowing and irrigation on growth and yield of coriander. So at last it may be concluded from the results that to obtain higher seed yield and essential oil coriander seeds should be sown earlier and irrigation should be given in all the growth phases. Specifically seeds should be sown on 5th November and irrigations should be given at 15 DAS + 30 DAS + 45 DAS + 60 DAS + 75 DAS + 90 DAS + 105 DAS + seed set, in the new alluvial zone of West Bengal to obtain higher yield.

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