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Effect of weed and nitrogen management on coriander (*Coriandrum sativum* L.) yield and economics

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Abstract

Field experiments were carried out during *rabi* 2007–08 and 2008–09 to evaluate the effect of different weed management measures and nitrogen (N) application on yield and economics of coriander. Results revealed that two hand weedings (HW) at 20 and 40 days after sowing (DAS) produced the highest seed and straw yields (13.71 and 25.83 q ha^{-1}). The highest net returns (Rs. 55841 ha^{-1}) and B : C ratio (2.39) were also obtained under this treatment. However, it was found to be at par with pendimethalin at 1.0 kg ha^{-1} + HW at 40 DAS, wherein seed and straw yields of 13.61 and 25.57 q ha^{-1}, respectively were obtained. The highest harvest index of 35.01% as well as the lowest mean weed index of 0.7%, were also observed under pendimethalin at 1.0 kg ha^{-1} + HW at 40 DAS. Results further revealed that application of N at 75 kg ha^{-1} significantly increased the seed yield to the extent of 11.9%, 32.7% and 84.3% and net returns by Rs. 7915, Rs. 18366 and Rs. 34536 ha^{-1} over 50, 25 kg N ha^{-1} and control, respectively. Correlation studies revealed that seed yield of coriander was significantly and positively correlated with growth and yield attributing characters and nutrient uptake by crop. Based on the response studies, 64.75 kg ha^{-1} was found to be the optimum level of N for coriander.

Keywords: coriander, correlation, economics, nitrogen, productivity, regression, weed management

Introduction

Coriander (*Coriandrum sativum* L.) popularly known as "*dhania*" is one of the oldest known and most widely used seed spice by mankind throughout the world. India is the largest producer and acreage holder of this crop. It occupies a prime place amongst the seed spices grown in Northern India particularly in Rajasthan, where the crop was grown on 245.09 thousand hectares with a production of 273.6 thousand tonnes during the year 2008–09. The average productivity of crop in the state is 896 kg ha^{-1} which is very low (Anonymous 2010). Among different biotic constraints, heavy weed growth is a major bottleneck in realizing the full yield potential. Being a slow growing crop during germination and initial stages, it is heavily invaded by a number of fast growing weeds that smother this delicate crop at every stage by sharing water, nutrients, space and solar radiation, as well as exerting

allelopathic effects. Thus, control of weeds is vitally important not only to check the yield losses caused by them but also to increase the fertilizer use efficiency. The conventional method of manual hand weeding for weed control is cumbersome, time consuming and labour intensive. Increased shortage of labour in intensive cropping systems provides opportunities for exploring the possibility of chemical weed control. Most of the Indian soils, particularly the light textured ones where most of the coriander is grown are deficient in nitrogen (N). In view of these agronomic constraints, this investigation was carried out to study the effect of different weed control measures and N fertilization on productivity and economics of coriander.

Materials and methods

The experiment was carried out during two consecutive *rabi* seasons of 2007–08 and 2008–09 at S.K.N. College of Agriculture, Jobner in Jaipur district of Rajasthan. It is situated at 26° 05′ North latitude, 75° 28′ East longitude and an altitude of 427 m above mean sea level. The soil of the experimental field was loamy sand in texture, alkaline in reaction (pH 8.1), low in organic carbon and available N and medium in available P and K. The experiment comprised of 28 treatment combinations consisting of seven weed management treatments (T_1=unweeded control, T_2=one hand weeding (HW) at 20 days after sowing (DAS), T_3=two HW at 20 and 40 DAS, T_4=pendimethalin @ 1.0 kg ha^{-1}, T_5=pendimethalin @ 1.0 kg ha^{-1} + HW at 40 DAS, T_6=oxadiargyl @ 0.06 kg ha^{-1} and T_7=oxadiargyl @ 0.06 kg ha^{-1} + HW at 40 DAS) allotted to main plots and four levels of N (0, 25, 50 and 75 kg ha^{-1}) in sub plots of split plot design with three replications. Coriander variety RCr 436 was sown at 30 cm apart on 1st and 3rd November during first and second year, respectively. A uniform dose of 30 kg P_2O_5 ha^{-1} was applied in all the plots at the time of sowing. Half dose of N was given as basal and the remaining half was top dressed at first irrigation through urea as per treatments. Pendimethalin was applied as pre emergence whereas, oxadiargyl was given at early post emergence. In the plots earmarked for HW, the operation was done at 20 and 40 DAS as per treatments. Usual crop husbandry practices were followed to raise a good crop. Observations related to growth and yield determining characters were recorded at specified growth stages of the crop. Seed and straw yields were recorded at harvest and subjected to statistical analysis. To draw a valid conclusion, weed competition index was calculated by taking twice hand weeded plot as weed free plot. For assessing practical viability of the treatments, a comprehensive economics was computed taking into account the prevailing market prices of inputs and the produce. To assess the relationship, correlation and regression coefficients between seed yield of coriander (Y) and the independent variables (X) were worked out using the procedure given by Snedecor & Cochran (1968). Regression equations were also fitted and tested for significance. To describe the relationship of seed yield (Y) as a function of the simple effect of N fertilization (X), correlation and regression studies were undertaken. Response equations were fitted to the yield data to describe them mathematically. The following equation proved to be the best fit:

$$Y = b_0 + b_1X + b_2X^2$$

Where,

Y= Expected yield (kg ha^{-1})
X= Unit of N level (kg ha^{-1})
b_0= Constant
b_1 and b_2 = Regression coefficients

After fitting response curve, optimum dose of N was worked out using the following formula:

$$X_{opt} = (1 / 2\, b_2 \times Q / P) - b_1$$

Where,

X_{opt}=Optimum dose of N
P=Price per kg of seed (Rs)
Q=Cost per kg N (Rs)
b_1 and b_2=Coefficients of response equation

Results and discussion

Seed and straw yield

All the weed management treatments produced

significantly higher seed and straw yield and harvest index of coriander over control during both the years as well as in pooled analysis (Table 1 and 2). Two HW done at 20 and 40 DAS excelled all the treatments providing mean seed and straw yields of 13.71 and 25.83 q ha^{-1}, respectively and harvest index of 34.77%. It improved the seed and straw yield by 35.7% and 27.9% over oxadiargyl at 0.06 kg ha^{-1} + HW at 40 DAS, 63.6% and 50.2% over oxadiargyl at 0.06 kg ha^{-1} alone and 164.7% and 119.1% over control, respectively. However, it was found at

Table 1. Effect of weed management and nitrogen levels on seed and straw yields of coriander

Treatments	Seed yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2007–08	2008–09	Pooled	2007–08	2008–09	Pooled
Weed management						
Control	5.10	5.25	5.18	111.41	12.17	11.79
One HW at 20 DAS	10.81	13.22	12.02	20.00	27.05	23.53
Two HW at 20 & 40 DAS	12.30	15.11	13.71	21.93	29.72	25.83
Pendimethalin @ 1.0 kg ha^{-1}	10.70	12.75	11.73	19.32	26.27	22.80
Pendimethalin @ 1.0 kg ha^{-1} + HW at 40 DAS	12.29	14.93	13.61	21.56	29.58	25.57
Oxadiargyl @ 0.06 kg ha^{-1}	7.88	8.87	8.38	14.52	19.88	17.20
Oxadiargyl @ 0.06 kg ha^{-1} + HW at 40 DAS	9.28	10.91	10.10	17.22	23.15	20.19
CD (P<0.05)	0.81	0.90	0.57	2.10	2.57	1.57
N level (kg ha^{-1})						
0.0	6.65	7.87	7.26	12.36	16.57	14.46
25.0	9.21	10.95	10.08	17.06	22.76	19.91
50.0	10.94	12.98	11.96	20.11	26.88	23.49
75.0	12.26	14.50	13.38	22.45	29.69	26.07
CD (P<0.05)	0.51	0.61	0.39	1.00	1.36	0.83

Table 2. Effect of weed management and nitrogen levels on harvest index (H.I.), weed index and economics of coriander (Pooled mean of two years)

Treatments	H.I. (%)	Weed index (%)	Net returns (Rs. ha^{-1})	Additional net returns over control (Rs. ha^{-1})	B : C Ratio
Weed management					
Control	30.36	62.2	9461	-	0.46
One HW at 20 DAS	33.97	12.3	47574	38113	2.17
Two HW at 20 & 40 DAS	34.77	-	55841	46380	2.39
Pendimethalin @ 1.0 kg ha^{-1}	34.18	14.4	44895	35434	1.96
Pendimethalin @ 1.0 kg ha^{-1} + HW at 40 DAS	35.01	0.7	54308	44847	2.23
Oxadiargyl @ 0.06 kg ha^{-1}	33.04	38.9	26826	17365	1.25
Oxadiargyl @ 0.06 kg ha^{-1} + HW at 40 DAS	33.54	26.3	35546	26085	1.56
CD (P<0.05)	1.26	-	3317	-	0.15
N level (kg ha^{-1})					
0.0	33.30	-	19876	-	0.88
25.0	33.50	-	36046	16170	1.60
50.0	33.60	-	46497	26621	2.03
75.0	33.82	-	54412	34536	2.35
CD (P<0.05)	NS	-	2257	-	0.10

par with pendimethalin at 1.0 kg ha^{-1} + HW at 40 DAS, wherein seed and straw yields of 1361 and 2557 kg ha^{-1}, respectively were obtained. The highest harvest index of 35.01% in pooled mean as well as the lowest mean weed index of 0.7%, were also observed under pendimethalin at 1.0 kg ha^{-1} + HW at 40 DAS treatment (Table 2). One HW at 20 DAS and pendimethalin at 1.0 kg ha^{-1} were the next superior treatments. These treatments recorded the mean seed yield of 1202 and 1171 kg ha^{-1} that was 132.0% and 126.1% higher than the yield obtained under control. The corresponding increase in straw yield due to these treatments was 99.9% and 93.4%. These treatments also showed lower weed indices of 12.33% and 14.44%, respectively. Although, oxadiargyl at 0.06 kg ha^{-1} + HW at 40 DAS and oxadiargyl at 0.06 kg ha^{-1} alone also gave significantly higher yield than control, they were inferior to the above described treatments. The improvement in yield of coriander under these treatments is directly associated with the corresponding increase in growth and yield attributing characters. Similar results have been reported by Patel *et al.* (2004) and Tiwari *et al.* (2005) in coriander.

It was further observed from the pooled data (Table 1) that progressive increase in level of N upto its highest level of 75 kg ha^{-1} resulted in significant increases in the yield of coriander over lower levels and control. Application of N at 75 kg ha^{-1} recorded the highest mean seed and straw yields of 1338 and 2607 kg ha^{-1} which was 11.9% and 11.0% higher than 50 kg N ha^{-1}; 32.7% and 30.9% than 25 kg ha^{-1} and 84.3% and 80.3% than control, respectively. This could be attributed to the improved growth and yield attributes under higher doses of N as reported by Tiwari & Banafer (1995) and Pareek *et al.* (2004). The harvest index remained unaffected due to application of N.

Economics

Perusal of data presented in Table 2 indicated that all the weed management measures resulted in significantly higher net returns and B : C ratio than unweeded control. Two hand weeding treatment fetched the highest net returns of Rs. 55,841 ha^{-1} and B: C ratio of 2.39. Pendimethalin at 1.0 kg ha^{-1} +HW at 40 DAS gave net returns of Rs. 54,308 ha^{-1} and B : C ratio of 2.23 and remained at par with this treatment. The quantitative increase in net returns was Rs. 8,267, 10,946, 20,295, 29,015 and 46,380 ha^{-1} due to two HW treatment and 6734, 9413, 18762, 27482 and 44847 ha^{-1} due to pendimethalin at 1.0 kg ha^{-1} + HW at 40 DAS over one HW at 20 DAS, pendimethalin at 1.0 kg ha^{1}, oxadiargyl at 0.06 kg ha^{1} + HW at 40 DAS, oxadiargyl alone and control, respectively. One HW at 20 DAS and pendimethalin at 1.0 kg ha^{1} showed statistical equivalence in net returns and B : C ratio. They increased net returns by Rs. 38,113 and 35,434 ha^{-1} over control. Oxadiargyl at 0.06 kg ha^{-1} with subsequent HW at 40 DAS and oxadiargyl alone, though fetched comparatively lesser returns, were significantly better than unweeded control. Results further revealed that increase in level of N upto 75 kg ha^{-1} fetched significantly higher net returns than lower levels and control. It provided the highest net returns of Rs. 54,412 ha^{-1} which was higher by Rs. 7,915, 18,366 and 34,536 ha^{-1} than 50 and 25 kg N ha^{-1} and control, respectively. It also registered the highest B : C ratio of 2.35. Similar findings were also reported by Chaudhary & Gupta (1991) in cumin and Thakral *et al.* (1992) in coriander.

Interactive effect of weed management and N fertilization was also found to significantly influence the seed and straw yield, net returns and B : C ratio (Table 3). Pooled data showed that pendimethalin at 1.0 kg ha^{-1} +HW at 40 DAS along with 75 kg N ha^{-1} produced significantly higher seed and straw yield (17.3 and 32.2 q ha^{-1}, respectively). However, the maximum net returns and B : C ratio were recorded with two HW integrated with 75 kg N ha^{-1}.

Correlation and regression studies

Data presented in Table 4 revealed that seed yield of coriander was significantly and positively correlated with crop dry matter, number of umbels per plant, number of umbellets and seeds per umbel, test weight and

Table 3. Combined effect of weed management and nitrogen levels on seed and straw yields of coriander, net returns and B : C ratio (Pooled mean of two years)

Treatments	Seed yield (q ha^{-1})				Straw yield (q ha^{-1})				Net returns (Rs ha^{-1})				B : C ratio			
	N_0	N_{25}	N_{50}	N_{75}	N_0	N_{25}	N_{50}	N_{75}	N_0	N_{25}	N_{50}	N_{75}	N_0	N_{25}	N_{50}	N_{75}
W_1- Control	3.4	4.8	5.6	6.9	8.3	10.8	12.8	15.2	-380	7448	11950	18827	-0.02	0.37	0.58	-0.91
W_2- One HW at 20 DAS	8.0	11.2	13.3	15.6	15.4	22.3	26.0	30.4	24931	43058	54659	67648	1.16	1.99	2.49	3.05
W_3- Two HW at 20 & 40 DAS	9.0	12.9	15.8	17.1	17.6	24.7	29.7	31.3	29322	51356	67646	75040	1.28	2.22	2.89	3.17
W_4- Pendimethalin @ 1.0 kg ha^{-1}	7.9	11.1	13.0	14.9	15.5	21.6	25.4	28.8	22945	41350	52398	62889	1.02	1.83	2.29	2.71
W_5- Pendimethalin @ 1.0 kg ha^{-1} + HW at 40 DAS	9.0	12.9	15.2	17.3	17.2	24.3	28.5	32.2	28185	50292	63607	74148	1.18	2.08	2.61	3.05
W_6- Oxadiargyl @ 0.06 kg ha^{-1}	6.1	8.0	9.4	10.0	12.5	16.4	19.3	20.6	14281	24721	32595	35708	0.68	1.16	1.51	1.63
W_7- Oxadiargyl @ 0.06 kg ha^{-1} + HW at 40 DAS	7.3	9.7	11.4	12.0	14.7	19.4	22.8	23.9	19846	34097	42621	45621	0.88	1.56	1.85	1.95
CD (P<0.05) for N at same level of W		1.03					2.20					5973	0.26			
CD (P<0.05) for W at same or different levels of N		0.76					1.80					4384	0.19			

Table 4. Correlation coefficients (r) and regression equations for the relationship between seed yield (Y) (kg ha^{-1}) and crop dry matter, yield attributes and nutrient uptake by crop (X)

Particulars	2007–08		2008–09	
	Correlation coefficient (r)	Regression equation $Y = a+b_y x .X$	Correlation coefficient (r)	Regression equation $Y = a+b_y x .X$
Crop dry matter at harvest stage (kg ha^{-1})	0.98907**	Y = -89.445 + 11.26591 X_1	0.97916**	Y = -180.452 + 12.78755 X_1
Number of umbels plant^{-1}	0.94510**	Y = -318.566 + 64.54139 X_2	0.92389**	Y = -506.950 + 62.92900 X_2
Number of unbellets umbel^{-1}	0.99219**	Y = -234.804 + 314.41362 X_3	0.98742**	Y = -519.543 + 413.93253 X_3
Number of seeds umbel^{-1}	0.97091**	Y = -114.305 + 171.34592 X_4	0.95548**	Y = -342.957 + 218.91952 X_4
Test weight (g)	0.94380**	Y = -3178.345+476.77700 X_5	0.94228**	Y = -48.626 + 663.89230 X_5
N uptake by crop (kg ha^{-1})	0.99549**	Y = 70.593 + 21.92817 X_6	0.99708**	Y = 70.833 + 21.68599 X_6
P uptake by crop (kg ha^{-1})	0.998737**	Y = -18.397 + 96.80143 X_7	0.99962**	Y = -5.319 + 93.07703 X_7
K uptake by crop (kg ha^{-1})	0.99632**	Y = -62.381 + 26.72137 X_8	0.99831**	Y = -68.494 + 24.64720 X_8

** Significant at P<0.01

N, P and K uptake. Regression coefficients (b) and regression equations were also worked out to quantify the amount of change in seed yield of coriander for a unit change in growth and yield attributes and nutrient uptake by crop. The increase in seed yield of coriander due to each unit increase in crop dry matter at harvest, number of umbels plant^{-1}, number of umbellets and seeds per umbel and test weight were 11.27, 64.54, 314.41,171.35 and 476.78 kg ha^{-1}during 2007-08 and 12.79, 62.93, 413.93. 218.92 and 663.89 kg ha^{-1} during 2008–09, respectively. Similarly, a unit increase in N, P and K uptake by crop was associated with the increase in seed yield of coriander by 21.92, 96.80 and 26.72 kg ha^{-1} during 2007-08 and 21.69, 93.08 and 24.65 kg ha^{-1} during 2008-09, respectively.

Response studies

To describe the relationship between seed yield and applied N, multiple regression studies were also undertaken (Table 5). This relationship of $Y= b_0 + b_{1..} N + b_2. N^2$ describing seed yield (Y) as a function of main effect of N levels showed a curvilinear trend expressed as a second degree polynomial. The predicated yield worked out from this quadratic function showed very high closeness to the observed data as evidenced from very high values of r^2 during both the years and in the mean data (0.949). The regression coefficients of the second order function fitted for two seasons data were found to be highly significant. A mean level of 64.75 kg N ha^{-1} was found to be optimum with seed yield of 12.93 q ha^{-1} and a mean response of 569 kg ha^{-1}. Thus, the mean response for optimum level of N was found to be 8.79 kg seed kg N^{-1} applied. Similarly, the response for 75 kg N ha^{-1} worked out to be 8.16 kg seed kg N^{-1} applied.

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Table 5. Seed yield as a function of nitrogen (N) fertilization ($Y=b_0+b_1. N + b_2 .N^2$)

Study parameters	Values		
	2007–08	2008–09	Pooled
Partial regression coefficients			
b_0	664	785	724
b_1	11.25**	13.55**	12.35**
b_2	-0.05**	-0.062**	-0.055**
Coefficient of			
(i) Determinations (R^2)	0.943**	0.954**	0.949**
(ii) Multiple correlation (r)	0.971**	0.977**	0.974**
Optimum level of N	62.5	65.3	64.75
Yield at optimum level of N	1172	1405	1293
Response of N optimum	508	620	569
Response per kg N at N_{opt}	8.128	9.495	8.788
Response per kg N at N_{75}	7.48	8.84	8.16

** Significant at P<0.01; Nutrient level, yield, response and intercepts (b_0) are given in kg ha^{-1}

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