

Growth and yield of coriander (*Coriandrum sativum*) as influenced by weed management and nitrogen levels

S.S. YADAV¹, INDRA CHOUDHARY², L.R. YADAV³ AND G.L. KESHW⁴

S.K.N. College of Agriculture, S.K. Rajasthan Agricultural University, Jobner, Rajasthan 303 329

Received : December 2012; Revised accepted : September 2013

ABSTRACT

A field study was carried out during winter (*rabi*) season of 2007–08 and 2008–09 at Jobner, Rajasthan to evaluate the effect of weed-management treatments and nitrogen levels on weed-control efficiency and growth, yield and economics of coriander (*Coriandrum sativum* L.). Two hand-weedings done 20 and 40 days after sowing and pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing were the most effective in reducing the density and dry weight of weeds and improving the weed-control efficiency. Oxadiargyl at 0.06 kg/ha + hand-weeding at 40 days after sowing represented the lowest weed density and controlled the weeds to the extent of 94.9%. Two hand-weedings done at 20 and 40 days after sowing recorded the highest plant height, umbels/plant and test weight. It also provided the maximum seed and straw yields (1.37 and 2.58 t/ha) of coriander that were 164.7 and 116.9% more than unweeded control respectively. Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing was also found equally effective in increasing the growth and yield attributes as well as yield. The highest number of branches/plant, dry matter, umbellets and seeds/umbel were obtained under this treatment. It provided the seed and straw yields of 1.36 and 2.56 t/ha, respectively, indicating an increase of 162.5 and 116.9% than unweeded control. It also recorded the highest harvest index (35.01%) and lowest weed competition index (0.73%) among all the treatments. Providing seed yields of 1.20 and 1.17 t/ha with weed competition indices of 12.3 and 14.4%, 1 hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha were the next better and statistically similar treatments. The highest net returns (₹55,841/ha) and benefit: cost ratio (2.39) were obtained with 2 hand-weedings at 20 and 40 days after sowing treatment. Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing was found at par with hand-weeding twice fetching net returns of ₹54,308 and benefit: cost ratio of 2.3. Application of 75 kg N/ha significantly increased the growth and yield of coriander over preceding levels. It enhanced the seed yield of coriander to the extent of 11.9, 32.7 and 84.3% over 50 and 25 kg N/ha and control respectively. This level of N also maximized the net returns (₹54,412/ha) and benefit: cost ratio (2.35).

Key words : Crop production, Coriander, Growth, Nitrogen, Weed control, Yield

India is the largest producer, consumer and exporter of spices in the world. Coriander 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 in the world. It occupied prime place amongst the seed spices grown in northern India particularly in Rajasthan. In Rajasthan, the crop was grown on 2,67,000 ha with a production of 3,29,000 tonnes during the 2011–12. The average productivity of crop in the state is 1,229 kg/ha, which is very low (GoR, 2012). Amongst the different biotic constraints, heavy weed growth is a recognized major bottleneck in realizing the full yield potential. Since germination and initial growth of coriander are very slow,

weeds smother this delicate crop at every stage of growth by sharing water, nutrients, space, solar radiation as well as exerting allelopathic effects, resulting in yield loss to the extent of 20–50% (Yadav *et al.*, 2005). Weed management is important not only to check the yield losses but also to increase the fertilizer-use efficiency. Conventionally, weeds are controlled manually by hand-weeding, which is cumbersome, time consuming and labour intensive. Thus, with increasing necessity of labour, exploring the possibility of chemical weed control deserves attention. Adoption of exhaustive high-yielding varieties of crops in intensive agriculture has led to heavy withdrawal of nutrients particularly the N from soil during past few years but fertilizer use remained much lower than removal of nutrients. Most of the Indian soils, particularly the light-textured ones are deficient in N, where most of the coriander is grown. In view of these agronomic constraints, the

¹Corresponding author Email: ssyadav107@yahoo.in

^{1,3}Professors; ²Ph.D. Scholar; ⁴Dean, SKN College of Agriculture, Jobner, Rajasthan 303 329

present investigation was carried out to study the effect of different weed-control measures and N levels on growth and yield of coriander.

MATERIALS AND METHODS

The field experiment was carried out during the winter (*rabi*) seasons of 2007–08 and 2008–09 at Agronomy farm, S.K.N. College of Agriculture, Jobner (26°05' N, 75°28' E, and of 427 m above mean sea-level). The soil was loamy sand in texture, alkaline in reaction (pH 8.1), low in organic C (0.22%) available N (126.6 kg/ha) and available P (7.37 kg/ha) and medium in K (157.5 kg/ha). The experiment consisted of 28 treatment combinations comprising 7 weed-management treatments, viz. unweeded control, 1 hand-weeding at 20 days after sowing, 2 hand-weedings at 20 and 40 days after sowing, pendimethalin @ 1.0 kg/ha, pendimethalin @ 1.0 kg/ha + hand-weeding at 40 days after sowing, oxadiargyl @ 0.06 kg/ha and oxadiargyl @ 0.06 kg/ha + hand-weeding at 40 days after sowing allotted to main plots; and 4 levels of N viz. 0, 25, 50 and 75 kg/ha to subplots in split-plot design with 3 replications. Coriander variety 'RCr 436' spaced 30 cm apart was sown in the first week of November. A uniform dose of 30 kg P₂O₅/ha was drilled at the time of sowing. Half dose of N as basal and the remaining as top dressing with first irrigation was applied through urea as per treatments. Pendimethalin was applied as pre-emergence, whereas oxadiargyl as early post-emergence treatment at 20 days after sowing. In the plots for hand-weeding, the operation was done 20 and 40 days after sowing as per treatments. Density and dry weight of weeds at various stages were recorded with the help of a quadrat of 0.5 m × 0.5 m size and per cent reduction in weed dry weight in comparison to unweeded control was expressed as weed-control efficiency. To draw a valid conclusion, the weed count data were subjected to square root transformation ($\sqrt{x}$) before statistical analysis. Observations related to growth and yield attributes were recorded at specified growth stages of the crop. Seed and straw yields were recorded at harvest. Weed competition index (WCI) was also calculated.

RESULTS AND DISCUSSION

Weeds

The prominent weed flora observed in the experimental plots were *Chenopodium murale*, *Chenopodium album*, *Heliotropium ellipticum*, *Rumex acetosella*, *Cynodon dactylon*, *Asphodelus tenuifolius* and *Melilotus alba*. The highest density and dry weight of weeds were recorded in unweeded control (Table 1). All the weed-management treatments resulted significant reduction in density and dry weight of weeds at all the stages than

unweeded control. Treatment of 2 hand-windings at 20 and 40 days after sowing was the most effective in reducing the weed density and dry weight of weeds. It registered the lowest weed density of 3.68 and 7.42/0.25 m² at 50 and 80 days after sowing stages, respectively. Whereas, at harvest, the minimum density of 2.61/0.25 m² was recorded under oxadiargyl at 0.06 kg/ha + hand-winding at 40 days after sowing treatment. Pre-emergence application of pendimethalin at 1.0 kg/ha + hand-winding at 40 days after sowing was also found at par with these treatments at all the stages. Two hand-windings at 20 and 40 days after sowing, pendimethalin at 1.0 kg/ha + hand-winding at 40 days after sowing and oxadiargyl at 0.06 kg/ha + hand-winding at 40 days after sowing were the most superior and equally effective treatments in reducing the dry weight of weeds than unweeded control. These treatments attained the weed-control efficiencies of 95.4, 95.1 and 95.2% at 50 days after sowing; 91.1, 89.9 and 91.0% at 80 days after sowing and 95.1, 95.4 and 94.9% at harvest stage of the crop respectively. Similar results were reported by Yadav *et al.* (2005). Progressive increase in N level from 0 to 50 kg/ha at 50 days after sowing and up to 75 kg/ha at 80 days after sowing and harvest stages also resulted significantly higher accumulation of weed dry weight. The highest weed dry weight was recorded with 75 kg N/ha.

Growth parameters

Weed-management treatments differed significantly in their effect on growth parameters, viz. plant stand, plant height, number of branches and dry matter production (Table 2). All the treatments significantly enhanced these growth characters in comparison to unweeded control. Two hand-weedings done at 20 and 40 days after sowing and pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing were the most superior and equally effective treatments in improving growth parameters. Twice hand-weedings recorded the maximum plant height at maturity with a mean height of 103 cm, which was 42.0% more over unweeded control. It also attained significantly more branches/plant (8.0) and dry matter production (118.3 g/m row length) at harvest stage which was at par with pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing. Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing registered 41.1% higher mean plant height at harvest stage of the crop. One hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha were the next better treatments in enhancing the growth characters. Application of oxadiargyl at 0.06 kg/ha + hand-weeding at 40 days after sowing and oxadiargyl at 0.06 kg/ha alone, recorded significantly higher growth attributes over the also control, but remained inferior to hand-weeding

Table 1. Effect of weed-management and nitrogen levels on density and dry weight of weeds and weed control efficiency in coriander (pooled over 2 years)

Treatment	Weed density (per 0.25 m ²)			Dry-weight of weeds (kg/ha)			Weed-control efficiency (%)		
	50 DAS	80 DAS	At harvest	50 DAS	80 DAS	At harvest	50 DAS	80 DAS	At harvest
Weed management									
Unweeded control	8.32 (68.99)	8.53 (72.87)	6.23 (38.51)	317.9	1505.5	3242.2	-	-	-
HW once at 20 DAS	3.32 (10.57)	3.92 (14.92)	3.24 (10.06)	37.4	274.4	510.9	88.2	81.8	84.2
HW twice at 20 and 40 DAS	2.04 (3.68)	2.81 (7.42)	1.78 (2.68)	14.6	133.8	159.2	95.4	91.1	95.1
Pendimethalin @ 1.0 kg/ha	3.63 (12.69)	4.14 (16.64)	3.43 (11.28)	43.1	293.2	549.9	86.5	80.5	83.0
Pendimethalin @ 1.0 kg/ha + HW at 40 DAS	2.13 (4.04)	2.98 (8.38)	1.88 (3.05)	15.5	151.7	150.0	95.1	89.9	95.4
Oxadiargyl @ 0.06 kg/ha	3.61 (12.58)	4.10 (16.35)	3.38 (10.97)	41.7	291.3	559.3	86.9	80.6	82.7
Oxadiargyl @ 0.06 kg/ha + HW at 40 DAS	2.06 (3.74)	2.82 (7.45)	1.76 (2.61)	15.2	136.0	164.6	95.2	91.0	94.9
SEm [±]	0.06	0.07	0.05	1.80	8.76	16.93	-	-	-
CD (P=0.05)	0.17	0.19	0.14	5.25	25.49	49.26	-	-	-
Nitrogen (kg/ha)									
0	3.53 (16.07)	4.09 (19.67)	2.96 (10.21)	64.6	281.7	550.4	-	-	-
25	3.60 (16.60)	4.18 (20.40)	3.07 (11.06)	68.7	387.3	726.9	-	-	-
50	3.63 (16.83)	4.23 (20.85)	3.16 (11.71)	71.4	441.2	847.5	-	-	-
75	3.59 (16.93)	4.23 (21.37)	3.22 (12.26)	72.7	481.9	924.4	-	-	-
SEm [±]	0.03	0.04	0.03	0.88	4.18	8.30	-	-	-
CD (P=0.05)	NS	NS	0.08	2.48	11.71	23.27	-	-	-

Data in parentheses indicate the original weed density per 0.25 m²; square root transformation ($\sqrt{\times}$) was applied
DAS, days after sowing; HW, hand-weeding

and pendimethalin alone or along with hand-weeding. Unrestricted growth of weeds in unweeded plots resulted significant reduction in plant stand. Chaudhary (2000) reported similar improvement in growth of coriander.

Progressive increase in N level up to 75 kg/ha significantly increased plant height, number of branches and dry matter over lower levels (Table 2). However, plant stand remained unaffected due to N fertilization. Application of N at 75 kg/ha enhanced the plant height, number of branches and dry matter to the extent of 81.8, 4.5 and 84.4% over the control respectively. This could be ascribed to the increased availability of N to plants at higher levels, as reported by Yadav and Sharma (2004).

Yield attributes

Significantly higher values of yield attributes like umbels/plant, umbellets/umbel, seeds/umbel and test weight were recorded with mechanical and/or chemical methods compared to unweeded control (Table 2). Being at par with pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing, two hand-weedings done at 20 and 40 days after sowing resulted in the maximum umbels/plant and test weight. It also recorded significantly higher umbellets/umbel and seeds/umbel. Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing recorded the highest umbellets/umbel and seeds/umbel as well as higher umbels/plant and test weight. One hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha were the next better and equally effective treatments in enhancing yield attributes. Application of oxadiargyl at 0.06 kg/ha with subsequent hand-weeding at 40 days after sowing or oxadiargyl at 0.06 kg/ha alone also resulted significant improvement in yield attributes in comparison to unweeded control, yet remained inferior to above described treatments. The positive influence of weed-management treatments on these attributes seems to be directly associated with similar increase in growth parameters. Heavy weed growth in unweeded control plots significantly reduced the test weight by adversely affecting the seed size. These results are in agreement with Singh *et al.* (2002). It is further evident that every increase in level of N resulted in significant improvement in umbellets/umbel and test weight up to 50 kg/ha and umbels/plant and seeds/umbel up to 75 kg N/ha over the preceding levels.

Interactive effect of weed management and N fertilization showed that the highest umbels/plant were recorded with pendimethalin at 1.0 kg/ha + hand-

weeding at 40 days after sowing along with 75 kg N/ha (Table 4). It was found at par with hand-weeding twice at 20 and 40 days after sowing combined with N fertilization at 75 kg/ha.

Seed and straw yield

All the weed-management treatments resulted in significantly higher seed, straw and biological yields and

harvest index over the unweeded control (Table 3). Two hand-weedings done at 20 and 40 days after sowing excelled all the treatments with mean seed, straw and biological yields of 1.37, 2.58 and 3.95 t/ha, respectively, and harvest index of 34.77%. It increased the seed and straw yield to the tune of 35.7 and 27.9% over oxadiargyl at 0.06 kg/ha + hand-weeding at 40 days after sowing; 63.6 and 50.2% over oxadiargyl at 0.06 kg/ha alone, and 164.7 and

Table 2. Effect of weed-management and nitrogen levels on growth and yield attributes of coriander (pooled over 2 years)

Treatment	Plant stand/m row length	Plant height (cm)	Branches/ plant	Dry-matter (g/m row length)	Umbels/ plant	Umbellets/ umbel	Seeds/ umbel	Test weight (g)
<i>Weed management</i>								
Unweeded control	9.2	72.5	5.6	52.4	18.2	2.5	4.6	8.3
HW once at 20 DAS	10.0	95.2	7.6	110.1	24.6	4.2	6.8	9.1
HW twice at 20 and 40 DAS	10.2	103.0	8.0	118.3	27.0	4.7	8.2	9.3
Pendimethalin @ 1.0 kg/ha	10.0	93.2	7.4	108.2	24.3	4.3	6.7	9.0
Pendimethalin @ 1.0 kg/ha + HW at 40 DAS	10.2	102.3	8.2	120.7	26.6	4.8	8.3	9.3
Oxadiargyl @ 0.06 kg/ha	9.9	78.6	6.2	89.2	20.1	3.4	5.6	8.5
Oxadiargyl @ 0.06 kg/ha + HW at 40 DAS	10.0	86.2	6.8	98.5	22.1	3.8	6.1	8.8
SEm±	0.2	1.7	0.1	1.9	0.5	0.1	0.1	0.1
CD (P=0.05)	0.4	4.9	0.4	5.5	1.3	0.21	0.3	0.4
<i>Nitrogen (kg/ha)</i>								
0	9.8	61.5	5.6	67.8	15.8	2.8	4.5	8.1
25	9.8	85.3	6.9	94.1	21.9	3.9	6.3	8.7
50	9.9	102.0	7.9	111.7	26.1	4.5	7.4	9.3
75	10.1	111.8	8.1	125.0	29.2	4.6	8.3	9.5
SEm±	0.1	1.2	0.1	1.1	0.3	0.1	0.1	0.1
CD (P=0.05)	NS	3.3	0.2	3.0	0.85	0.1	0.23	0.2

DAS, days after sowing; HW, hand-weeding

Table 3. Effect of weed management and nitrogen levels on seed, straw and biological yield and harvest index of coriander

Treatment	Seed yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	weed-control efficiency (%)	Net returns (₹/ha)	Benefit: cost ratio
<i>Weed management</i>							
Unweeded control	0.52	1.18	1.70	30.36	62.2	9,461	0.46
HW once at 20 DAS	1.20	2.35	3.55	33.97	12.3	47,574	2.17
HW twice at 20 and 40 DAS	1.37	2.58	3.95	34.77	-	55,841	2.39
Pendimethalin @ 1.0 kg/ha	1.17	2.28	3.45	34.18	14.4	44,895	1.96
Pendimethalin @ 1.0 kg/ha + HW at 40 DAS	1.36	2.56	3.92	35.01	0.7	54,308	2.23
Oxadiargyl @ 0.06 kg/ha	0.84	1.72	2.56	33.04	38.9	26,826	1.25
Oxadiargyl @ 0.06 kg/ha + HW at 40 DAS	1.01	2.02	3.01	33.54	26.3	35,546	1.56
SEm±	0.02	0.05	0.07	0.43		1,140	0.05
CD (P=0.05)	0.06	0.16	0.19	1.256	-	3,316	0.15
<i>Nitrogen (kg/ha)</i>							
0	0.73	1.45	2.17	33.30	-	19,876	0.88
25	1.01	1.99	3.00	33.50	-	36,046	1.60
50	1.20	2.35	3.55	33.60	-	46,497	2.03
75	1.34	2.61	3.95	33.82	-	54,412	2.35
SEm±	0.01	0.03	0.04	0.26		805	0.04
CD (P=0.05)	0.04	0.08	0.11	NS	-	2,257	0.10

DAS, days after sowing; HW, hand-weeding

119.1% over unweeded control respectively. However, it was statistically similar with pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing. The highest harvest index of 35.01% as well as the lowest mean weed competition index of 0.73% in comparison to two hand-weedings (weed free), were also observed with pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing (Table 3). One hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha were the next better treatments in increasing the yield and harvest index. These treatments recorded 132.0 and 126.1% more seed yield than unweeded control. The corresponding increase in straw yield due to these treatments was 99.9 and 93.4% and in biological yield 109.4 and 103.4%. One hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha also showed lower weed competition indices of 12.3 and 14.4% respectively. Although, oxadiargyl at 0.06 kg/ha + hand-weeding at 40 days after sowing and oxadiargyl at 0.06 kg/ha alone also resulted significantly higher yield than the control, they remained inferior to the above-described treatments. The higher yield of coriander under these treatments is attributed to the corresponding increase in growth and yield-attributing characters. The results are in accordance with the findings of Patel *et al.* (2004) and Tiwari *et al.* (2005).

Successive increase in level of N up to its highest level of 75 kg/ha recorded significantly higher yield of coriander over lower levels and control. Application of 75 kg N/ha registered the highest seed yield, being 11.9, 32.7 and 84.3% higher than 50 and 25 kg N/ha and control respectively. The corresponding increase in straw yield was 11.0, 30.9 and 80.3% respectively. This was mainly owing to the improved growth and yield attributes under higher doses of N, as reported by Datta *et al.* (2008).

Interaction between weed management and N fertilization was found to significantly influenced the seed and straw yields of coriander (Table 4). Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing along with 75 kg N/ha recorded the significantly highest seed and straw yields of coriander. However, it was at par with 2 hand-weedings fertilized with 75 kg N/ha, which recorded seed and straw yields of 1.71 and 3.13 t/ha respectively. Hand-weeding twice at 20 and 40 days after sowing combined with 50 kg N/ha and Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing along with 50 kg N/ha were the next superior treatment combinations for getting higher seed yield.

Economics

All the weed-management treatments recorded significantly higher net returns and benefit: ratio than unweeded control. The highest net returns were obtained with 2 hand-weedings treatment. It increased the net returns by ₹ 20,295, 29,015 and 46,380/ha over oxadiargyl at 0.06 kg/ha + hand-weeding at 40 days after sowing, oxadiargyl at 0.06 kg/ha alone and unweeded control, respectively. The highest benefit: cost ratio of 2.93 was also recorded with this treatment. It was found at par with pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing, which fetched the net returns of ₹ 54,308/ha along with benefit: cost ratio of 2.23. One hand-weeding at 20 days after sowing and pendimethalin at 1.0 kg/ha alone, were the next better treatments in regard of enhancing the net returns and benefit: cost ratio. Among N levels, 75 kg N/ha was the most remunerative that gave the highest net returns (₹ 54,412/ha) and benefit: cost ratio (2.35).

It was concluded that 2 hand-weedings at 20 and 40 days after sowing combined with 75 kg N/ha is the most

Table 4. Interactive effect of weed management and nitrogen levels on umbels/plant, seed and straw yields (pooled over 2 years)

Weed management	Nitrogen levels (kg/ha)											
	Umbels/plant				Seed yield (t/ha)				Straw yield (t/ha)			
	0	25	50	75	0	25	50	75	0	25	50	75
Unweeded control	11.8	16.8	20.0	24.0	0.34	0.48	0.56	0.69	0.84	1.08	1.28	1.52
HW once at 20 DAS	16.4	22.8	27.43	31.7	0.80	1.12	1.33	1.56	1.54	2.23	2.60	3.04
HW twice at 20 and 40 DAS	17.8	25.4	31.09	33.7	0.91	1.29	1.58	1.71	1.76	2.47	2.97	3.13
Pendimethalin @ 1.0 kg/ha	16.2	23.0	27.07	31.1	0.79	1.11	1.31	1.49	1.55	2.16	2.54	2.88
Pendimethalin @ 1.0 kg/ha + HW at 40 DAS	17.5	24.9	29.97	33.9	0.90	1.29	1.52	1.73	1.72	2.43	2.85	3.22
Oxadiargyl @ 0.06 kg/ha	14.6	19.2	22.56	24.0	0.61	0.80	0.94	1.00	1.25	1.64	1.93	2.06
Oxadiargyl @ 0.06 kg/ha + HW at 40 DAS	16.1	21.4	24.89	26.0	0.74	0.97	1.14	1.20	1.47	1.94	2.28	2.39
For N at same level of W												
SEm±			0.8				0.04				0.08	
CD (P=0.05)			2.3				0.10				0.22	
For W at same or different levels of N												
SEm±			0.6				0.03				0.06	
CD (P=0.05)			1.7				0.08				0.18	

DAS, days after sowing; HW, hand-weeding

effective treatment combination for obtaining significantly higher seed yield. Pendimethalin at 1.0 kg/ha + hand-weeding at 40 days after sowing (PE) together with 75 kg N/ha is the most suitable option among herbicidal combinations for the areas where labour availability is scarce.

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