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Growth, Yield Attributes and Yield of Coriander (*Coriandrum sativum* L.) as Influenced by Weed Management Practices and Nitrogen Levels

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A B S T R A C T

An experiment was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *rabi* season of 2016-17 to study the effect of weed and nitrogen management in coriander (*Coriandrum sativum* L.). The experiment evaluated in Randomized block design with factorial concept and replicated three times. Results show that the significantly lower weed count at 40 (0.71m^{-2}) and 60 (0.71m^{-2}) DAS, dry weight of weeds (0.00 kg ha^{-1}) and weed index (0%). Whereas, the significantly higher weed control efficiency (100%), superior growth parameters, yield attributes and higher seed (1055 kg ha^{-1}) and straw (1688 kg ha^{-1}) yield were recorded under weed free (W_2) and was at par with pre emergence application of pendimethalin 1 kg ha^{-1} + interculturing followed by HW at 30 days after sowing (W_6). The application of 60 kg N ha^{-1} (N_3) recorded significantly higher values of growth parameters, yield attributes and maximum seed (849 kg ha^{-1}) and straw (1373 kg ha^{-1}) yield and was at par with 40 kg N ha^{-1} (N_2). Weed count and dry weight of weeds increased significantly with each increase in nitrogen levels from 20 to 60 kg N/ha. But number of weeds per m^2 was not influenced by different nitrogen levels. Whereas, the plant population and harvest index was not remarkably influenced by both weed management practices and nitrogen levels. This study revealed that, efficient weed management and remunerative higher yield of coriander can be obtained by adopting integrated weed management approach *i.e.*, application of pendimethalin 1 kg ha^{-1} as pre emergence + interculturing followed by hand weeding at 30 DAS along with application of 40 kg N ha^{-1} under North Gujarat Agro-climatic condition.

Introduction

India is the world's largest producers, consumers and exporter of seed spices. Among all the states of India, Gujarat and Rajasthan together contribute more than 80 per cent of the total seed spices production in the country and thus, both the states together are known as "Seed Spices Bowl" of India. Coriander (*Coriandrum sativum* L.) is an

annual herb from umbelliferae family with 90 to 120 days growth period. Coriander leaves are being used in cooking, flavouring, beverages *etc*., and seeds are being used for preparing value added products such as coriander powder, dhana dal, curry powder, oleoresin and essential oil. So, it is known as low volume but high value crop of arid and semi-arid regions. In Gujarat, coriander is cultivated in area of 553 thousand hectares and produced 462 thousand tonnes with averages productivity of 835 kg ha^{-1} during 2015 (Anon., 2015). Among different biotic constraint, heavy weed growth is recognized major bottleneck in realizing the full yield potential. Effective weed management is critical to maintaining agricultural productivity (Verma *et al*, 2015). Since germination and initial growth of coriander are very slow, weed smother this delicate crop at every stage of growth by sharing water, nutrient, space, solar radiation as well as exerting allelopathic effect, resulting in yield loss to the extent of 20-50 per cent (Yadav *et al.,* 2005).Weed management is important not only to check yield losses but also to increased fertilizer use efficiency.

Among the primary nutrients, nitrogen has a considerable effect, not only on quality of produce but on quantity of produce also. Nitrogen is one of the major elements for growth and development of plant. It is involved in photosynthesis, respiration and protein synthesis. It impart the dark green colour of the leaves, promotes vigorous vegetative growth and more efficient use of available inputs finally leads to higher productivity. At Parbhani (Maharashtra), an experiment was conducted during the *rabi* season of 2003-2004 to study effect of nitrogen rates (50, 75 and 100 kg ha^{-1}) and spacing on coriander. Application of nitrogen at a rate of 100 kg ha^{-1} resulted in the maximum plant height, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant, east-west spread of the plant, fresh weight of plant and yield per hectare (Pawar *et al.,* 2007). Therefore, the investigation was conducted with an objective to find out effect of different weed control practices on weed flora, yield attributes and yield of coriander and optimum dose of nitrogen for coriander.

Materials and Methods

The field experiment was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (North Gujarat), during *rabi* 2016-17. Eighteen treatment combinations consisting of six treatments of weed management *i.e.*, weedy check (W_1), weed free (W_2), IC + HW at 30 and 45 DAS (W_3), pendimethalin 1 kg ha^{-1} as pre emergence (W_4), pendimethalin 1 kg ha^{-1} as pre emergence + imazethapyr 75 g ha^{-1} as post emergence at 20-25 DAS (W_5), pendimethalin 1 kg ha^{-1} as pre emergence + interculturing followed by HW at 30 DAS (W_6) and three levels of nitrogen *i.e.*, 20, 40 and 60 kg ha^{-1} were evaluated in Randomized block design with factorial concept and replicated three times. Geographically, Sardarkrushinagar is situated at 24°/19' North latitude and 72°/19' East longitude with an elevation of 154.52 meters above mean sea level. The climate type of this area is sub-tropical. The soil of experimental field was loamy sand in texture (Sand-81.70%, Silt-5.62% and Clay-9.47%), neutral in pH (7.1), low in organic carbon (0.21) and available nitrogen (156 kg ha^{-1}), medium in available phosphorus (41 kg ha^{-1}) and rich in available potassium (296 kg ha^{-1}). Whereas, EC (0.17 dS m^{-1}) was very low showing that the soil was free from salinity hazard. International Pipette method, Piper, 1966 for physical properties, Schofield method (Jackson, 1973) for EC, Potentiometric method (Jackson, 1973) for soil pH, Walkley and Black's

method (Jackson, 1973) for organic carbon, Alkaline Potassium Permanganate method (Jackson, 1973) for available nitrogen, Olsen's method (Olsen *et al.*, 1954) for available phosphorus, Flame Photometer method (Jackson, 1973) for available potash.

Half nitrogen was applied as basal dose whereas, remaining half nitrogen applied as top dressing at 30 DAS. A common dose of 10 kg P ha^{-1} was applied through diaammonium phosphate as basal dose. The total weed count at 40, 60 DAS and dry weight of weeds at various growth stage 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 as expression as weed control efficiency by Kondap and Upadhyay (1985). To draw a valid conclusion, the weed count data were subjected to square root transformation before statistical analysis. Observations related to growth and yield attributes were recorded at specified growth stages of crop. Harvest index was calculated by using the formula given by Donald and Hamblin (1962) and Weed Index (%) was calculated by using the formula given Gill and Kumar (1969). Whereas, the statistical analysis of data for each characters studied in the experiment was carried out as per design of the experiment and simple correlation coefficient ('r') of each character was calculated.

Results and Discussion

Weed flora

Weed species found during the course of the investigation have been reported as monocot, dicot and sedge in Table 1. The major weed populations of monocot weed species *viz*., *Cynodon dactylon* L. Pers and dicot weed species *i.e.*, *Argemone maxicana* L., *Amaranthus viridis* L., *Chenopodium album* L., *Launaea mudicauli* H.K., *Asphoidelus tenuifolius* L., *Melilotus alba* Lamk, *Tribulus terrestris* L., *Eurphorbia hirta* L., *Rumex dentatus* L., *Leucas aspera* Wild were observed during the course of investigation. *Cyperus rotundus* L. as sedge weed additionally during the period of experiment.

Effect of weed management

The results in (Table 2) revealed that the total weed count, dry weight of weeds, weed control efficiency, weed index were significantly influenced by various weed management practices. The significantly lower weed count at 40 (0.71 m^{-2}) and 60 (0.71 m^{-2}) DAS, dry weight of weeds, weed index were recorded under weed free treatment (W_2) and was at par with pre emergence application of pendimethalin 1 kg ha^{-1} + interculturing followed by HW at 30 days after sowing (W_6). The probable reason for lower population weeds under W_6 treatment might be due to facts that limited weedy condition of field throughout crop life period by hand weeding and interculturing and also effective control of weeds by application of pendimethalin at early growth stages. These findings are in close conformity with the Mehriya *et al.*, (2007) and Patel *et al.*, (2015).

Different weed management practices significantly influenced the plant height at 30, 60 and 90 DAS as well as at harvest, number of branches *i.e.* primary, secondary and tertiary per plant (Table 3) and revealed that higher plant height at 60 (46.7 cm) and 90 (60.0 cm) DAS as well as at harvest (66.6 cm), number of branches *i.e.* primary (5.29), secondary (9.11) and tertiary (13.17) per plant were recorded under weed free treatment (W_2) and was at par with pre emergence application of pendimethalin 1 kg ha^{-1} + interculturing followed by HW at 30 days after sowing (W_6). Whereas, the plant population and plant height at 30 DAS was not remarkably

influenced by weed management practices. Similar kind of reports resulted by Chaudhary *et al.,* (2014), Gohil *et al.,* (2014) and Meena *et al.,* (2015). These improvement in growth parameters of coriander in weed free (W_2) treatment might be attributed to the reduction in the weed competitiveness by effective removal of weeds throughout crop growth period by physical and integrated weed management practices provide better space and resource to the crop plants *i.e.,* light, water, nutrient, space, *etc*. which ultimately favoured better environment for growth and development of the crop.

The data presented in Table 4 revealed that number of umbels per plant, umbellates per umbel, seeds per umbellate, seed and straw yield were significantly influenced by various weed management practices. The significantly maximum number of umbels (15.60) per plant, umbellates per umbel (6.01), seeds per umbellate (12.27), seed (1055 kg ha^{-1}) and straw (1688 kg ha^{-1}) yield were recorded under weed free treatment (W_2) and was at par with pre emergence application of pendimethalin 1 kg ha^{-1} + interculturing followed by HW at 30 days after sowing (W_6).

Whereas, the harvest index was not remarkably influenced by weed management practices. Appreciable reduction in number of weeds at 40 and 60 DAS and dry weight of weeds due to weed free condition (W_2) and was at par with pre emergence application of pendimethalin 1 kg ha^{-1} + interculturing followed by HW at 30 days after sowing (W_6) by effective removal of weeds throughout crop growth period by physical and integrated weed management practices provide better space and resource to the crop plants *i.e.,* light, water, nutrient, space, *etc*. which ultimately favoured better environment for growth and development of the crop might be increased yield and yield attributes.

Per cent increase in seed yield of coriander due to weed free condition (W_2) were 8.31, 13.56, 19.34, 74.09 and 336 over treatments W_6,W_3, W_4, W_5 and W_1, respectively. Similarly, seed yield increased in per cent by treatment W_6 were 4.84, 10.18, 60.72, and 302.47 over treatments W_3, W_4, W_5 and W_1, respectively. Whereas, the lower seed yield of coriander under treatment W_5 (Pendimethalin 1 kg ha^{-1} as PE + Imazethapyr 75 g ha^{-1} as PoE at 20-25 DAS) was observed might be due to phytotoxic effect of post emergence herbicide *i.e.,* imazethapyr on crop and weeds was not controlled effectively at later stage. These finding corroborate the results reported by and Mehariya *et al.,* (2007), Meena and Mehta (2009) Chaudhary *et al.,* (2014), Gohil *et al.,* (2014) and Meena *et al.,* (2015).

Effect of nitrogen levels

The perusal of data presented in Table 2 revealed that total weed count, dry weight of weeds, weed control efficiency, weed index were significantly influenced by various nitrogen levels. Critical examination of data showed that differences in weed count at 40 and 60 DAS not reach the level of significance (Table 2). However, maximum (3.20, 4.02) as well as minimum (3.04, 3.91) weed count at 40 and 60 DAS were recorded under the application of 60 and 20 kg N/ha, respectively which indicate that varying levels of nitrogen had not any beneficial or detrimental effect on weed count. As compared to 20 kg N/ha, the percentage of increase in dry weight of weeds under 60 and 40 kg N/ha were 18.53 and 10.51, respectively. Application of higher dose of nitrogen with split application increased the availability of nutrient for weed growth throughout the crop season which might be resulted in higher dry weight of weeds. These findings are agreements with results reported by Patel *et al.,* (2013), Yadav *et al.,* (2013) and Yadav *et al.,* (2015).

The data presented in Table 3 revealed that plant height at 30, 60 and 90 DAS as well as at harvest, number of branches *i.e.* primary, secondary and tertiary per plant were significantly influenced by various nitrogen levels. The application of 60 kg N ha^{-1} recorded significantly the higher plant height at 60 (43.4 cm) and 90 (58.0 cm) DAS as well as at harvest (61.8 cm), number of branches *i.e.* primary (4.62), secondary (8.29) and tertiary (11.67) per plant and was at par with 40 kg N ha^{-1}. The plant population, plant height at 30 DAS and harvest index was not remarkably influenced by different nitrogen levels. Similar kind of reports resulted by Naghera *et al.,* (2000), Datta *et al.,* (2008), Chaudhary *et al.,* (2014) and Lokhande *et al.,* (2015). Nitrogen, being a major structure constituents of cell, helps in stimulating the cell division and cell elongation, which increased in plant height. Better effect of higher levels of nitrogen might be attributed to rapid expansion of dark green foliage, which could intercept and utilize more light energy in the production of food through the process of photosynthesis. Thus, increased production of food help in increased in plant height and number of primary, secondary as well as tertiary branches per plant.

Different nitrogen levels significantly influenced then umber of umbels per plant, umbellates per umbel, seeds per umbellate, seed and straw yield (Table 4) and revealed that higher number of umbels (14.14) per plant, umbellates per umbel (5.45), seeds per umbellate (11.03), seed (849 kg ha^{-1}) and straw (1373 kg ha^{-1}) yield. The higher vegetative growth and yield attributes was reported by application of 60 kg N ha^{-1}. This might be due to increased supply of nitrogen, being a major structural constituent of cell, help in stimulating the cell division and cell elongation and the process of tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial might have increased in vegetative growth and more number of umbels per plant. Similarly, adequate supply of nitrogen sustains the uptake of nitrogen up to later crop growth stages.

Table.1 Weed flora observed in experiment

Sr. No.	Local name	Scientific Name	Family
(A)	**Monocot weed**		
1.	Dharo	*Cynodon dactylon* Pers.	Poaceae
(B)	**Dicot weeds**		
1.	Darudi	*Argemone maxicana* L.	Papavaraceae
2.	Tandalja	*Amaranthus viridis* L.	Amaranthaceae
3.	Chill	*Chenopodium album* L.	Chinopodaceae
4.	Bhoi pathri	*Launaea mudicauli* H.K	Compositeae
5.	Dungaro	*Asphoidelus tenuifolius* L.	Liliaceae
6.	Methyu	*Melilotus alba* Lamk L.	Leguminoseae
7.	Gokhru	*Tribulus terrestris* L.	Zygophyllaceae
8.	Dudheli	*Eurphorbia hirta* L.	Euphorbiaceae
9.	Jangli palk	*Rumex dentatus* L.	Cyperaceae
10.	Kubi	*Leucas aspera* Wild.	Lamiaceae
(C)	**Sedge weed**		
1.	Chidho	*Cyperus rotundus* L.	Cyperaceae

Table.2 Total weed count, dry weight of weeds, weed control efficiency and weed index as influenced by different weed management practices and nitrogen levels

Treatments	Total weed count (Number of weeds m^{-2})		Dry weight of weeds (kg ha^{-1})	Weed control efficiency (%)	Weed index (%)
Weed management (W)	**40 DAS**	**60 DAS**			
W_1: Weedy check	6.21 (38.11)	7.05 (49.30)	3366	-	77
W_2: Weed free	0.71 (0.00)	0.71 (0.00)	0.00	100	-
W_3: IC + HW at 30 and 45 DAS	2.04 (3.68)	2.89 (7.88)	646	80.83	12
W_4: Pendimethalin 1 kg ha^{-1} as PE	2.47 (5.63)	3.63 (12.70)	1334	60.41	16
W_5: Pendimethalin 1 kg ha^{-1} as PE + Imazethapyr 75 g ha^{-1} as PoE at 20-25 DAS	2.64 (6.47)	4.05 (15.93)	1818	46.05	42
W_6: Pendimethalin 1 kg ha^{-1} as PE + IC followed by HW at 30 DAS	1.69 (2.38)	2.65 (6.57)	337	90	7
S.Em. ±	0.08	0.11	45	-	-
C.D. at 5%	0.22	0.32	129	-	-
Levels of nitrogen (N)					
N_1: 20 kg ha^{-1}	3.04 (8.76)	3.91 (14.83)	1197	-	-
N_2: 40 kg ha^{-1}	3.17 (9.59)	4.01 (15.62)	1240	-	-
N_3: 60 kg ha^{-1}	3.20 (9.78)	4.02 (15.74)	1315	-	-
S.Em. ±	0.06	0.08	32	-	-
C.D. at 5%	NS	NS	91	-	-
C.V. %	8.92	9.78	11.0	-	-
Interaction effect (W×N)	NS	NS	NS	-	

Note: Retransform values of square root transformation ($\sqrt{x + 0.5}$) before analysis are writtenin parenthesis.
IC =Interculturing, HW= hand weeding, PE= pre emergence, PoE= Post emergence

Table.3 Growth parameter of coriander as influenced by different weed management practices and nitrogen levels

Treatments	Plant Population (Per meter row length)		Plant height (cm)				Number of branches pre plant		
Weed management (W)	**30 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**Primary**	**Secondary**	**Tertiary**
W_1 : Weedy check	10.04	9.96	10.1	38.4	51.1	56.1	3.09	5.78	8.67
W_2: Weed free	10.85	10.01	11.0	46.7	60.0	66.6	5.29	9.11	13.17
W_3: IC + HW at 30 and 45 DAS	10.65	10.30	10.7	42.0	54.7	60.5	4.61	7.90	11.69
W_4: Pendimethalin 1 kg ha^{-1} as PE	10.12	10.04	10.1	41.2	54.8	60.2	4.53	7.80	11.41
W_5: Pendimethalin 1 kg ha^{-1} as PE + Imazethapyr 75 g ha^{-1} as PoE at 20 - 25 DAS	10.48	9.29	9.5	37.8	53.7	57.2	3.81	6.89	10.22
W_6: Pendimethalin 1kg ha^{-1} as PE + IC followed by HW at 30 DAS	10.55	10.09	10.7	44.3	59.0	62.3	5.04	8.73	12.45
S.Em. ±	0.34	0.31	0.35	1.51	1.74	1.57	0.18	0.34	0.43
C.D. at 5%	NS	NS	NS	4.34	5.00	4.50	0.52	0.98	1.22
Levels of nitrogen (N)									
N_1: 20 kg ha^{-1}	10.36	10.00	10.2	39.3	52.0	58.1	4.07	7.01	10.59
N_2 : 40 kg ha^{-1}	10.56	9.93	10.5	42.5	56.6	61.5	4.50	7.80	11.56
N_3 : 60 kg ha^{-1}	10.42	9.92	10.4	43.4	58.0	61.8	4.62	8.29	11.67
S.Em. ±	0.24	0.22	0.25	1.07	1.23	1.11	0.13	0.24	0.30
C.D. at 5%	NS	NS	NS	3.07	3.53	3.18	0.37	0.69	0.86
C.V. %	9.73	9.37	10.11	10.87	9.38	7.76	12.50	13.34	11.35
Interaction effect (W×N)	NS	NS	NS	NS	NS	NS	NS	NS	NS

IC =Interculturing, HW= hand weeding, PE= pre emergence, PoE= Post emergence

Table.4 Yield parameters and yield of coriander as influenced by different weed management practices and nitrogen levels

Treatments Weed management (W)	Umbels per plant	Umbellates per umbels	Seeds per umbellate	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
W_1: Weedy check	9.66	4.26	7.34	242	493	32.31
W_2: Weed free	15.60	6.01	12.27	1055	1688	38.62
W_3: IC + HW at 30 and 45 DAS	13.92	5.06	10.97	929	1481	38.49
W_4: Pendimethalin 1 kg ha^{-1} as PE	13.97	5.25	10.57	884	1470	37.32
W_5: Pendimethalin 1 kg ha^{-1} as PE + Imazethapyr 75 g ha^{-1} as PoE at 20-25 DAS	12.39	4.28	8.59	606	1027	37.02
W_6: Pendimethalin 1kg ha^{-1} as PE + IC followed by HW at 30 DAS	14.93	5.65	11.62	974	1664	36.88
S.Em. ±	0.52	0.23	0.37	32	68.02	1.71
C.D. at 5%	1.49	0.66	1.06	93	195.49	NS
Levels of nitrogen (N)						
N_1 : 20 kg ha^{-1}	12.02	4.59	9.11	711	1196	37.64
N_2: 40 kg ha^{-1}	14.07	5.22	10.54	786	1342	36.72
N_3: 60 kg ha^{-1}	14.14	5.45	11.03	849	1373	38.36
S.Em. ±	0.37	0.16	0.26	23	48	1.21
C.D. at 5%	1.05	0.47	0.75	66	138	NS
C.V. %	11.63	13.70	10.83	12.41	15.64	13.64
Interaction effect (W×N)	NS	NS	NS	NS	NS	NS

IC =Interculturing, HW= hand weeding, PE= pre emergence, PoE= Post emergence

Table.5 Correlation coefficient (r) between seed yield and growth as well as yield attributing characters

Sr. No.	Characters	Correlation coefficient (r)
1	Plant height at harvest	0.663**
2	Number of primary branches per plant	0.898**
3	Number of secondary branches per plant	0.819**
4	Number of tertiary branches per plant	0.918 **
5	Number of umbels per plant	0.891**
6	Number of umbellates per umbel	0.740**
7	Number of seeds per umbellate	0.881**
8	Weed count at 60 DAS	- 0.897**
9	Dry weight of weeds (kg ha^{-1})	- 0.936**

* = Significant at 5 per cent level
** = Significant at 1 per cent level

Moreover, addition of optimum dose of nitrogen might have helped to better translocation of photosyanthates from leaves to sink site *i.e.*, umbellates and seeds, which finally led to more seed setting.

In general, seed and stover yield of coriander increased with increase in levels of nitrogen from 20 to 60 kg ha^{-1} but significant increase was observed up to 40 kg N ha^{-1}. As compared to 20 kg N ha^{-1}, the respective rise in seed and stover yield under application of nitrogen 40 and 60 kg ha^{-1} were 10.54 and 19.40 as well as 12.20 and 14.79 per cent, respectively. Increasing trends as observed in seed yield was evidently due to overall improvement in vegetative stage in the terms of plant height and number of branches per plant at higher levels of nitrogen, which positively influenced on yield contributing characters. Better effect of higher levels of nitrogen might be attributed to rapid expansion of dark green foliage, which could intercept and utilize more light energy in the production of food through the process of photosynthesis. Thus, increased production of food help in increased in growth attributes which might be responsible for higher straw yield. Similar findings are also reported by Thakaral *et al.*, (1992), Sivakumaran *et al.*, (1996), Naghera *et al.*, (2000), Patel *et al.*, (2004), Patel (2006), Pawar *et al.*, (2007), Datta *et al.*, (2008), Patel *et al.*, (2013), Chaudhary *et al.*, (2014) and Lokhande *et al.*, (2015).

Interaction effect

The interaction effect between weed management practices and nitrogen levels was not significant.

Correlation coefficient

The correlation coefficient ('r') between seed yield and growth as well as yield attributing character was worked out as per Table 5. It was noticed that growth parameters *viz.*, plant

height and number of primary, secondary and tertiary branches per plant and yield attributes *i.e.,* number of umbels per plant, umbellates per umbel and seeds per umbellate showed positive significant correlation with seed yield, while weed studies *i.e.,* total weed count at 60 DAS and dry weight of weeds showed negative significant correlation with seed yield. Similar finding have been also reported by Bhati *et al.,* (1989).

On the basis of experiment, it is concluded that efficient weed management and remunerative higher yield of coriander can be obtained by adopting integrated weed management approach *i.e.,* application of pendimethalin 1 kg ha^{-1} as pre emergence + interculturing followed by hand weeding at 30 DAS along with application of 40 kg N ha^{-1} under North Gujarat Agro-climatic condition.

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