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Effect of irrigation and nitrogen on water use, moisture extraction pattern, nitrogen uptake and yield of coriander (*Coriandrum sativum* L.) in north-western irrigated plains of Rajasthan

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Abstract

An experiment was conducted at Sriganganagar (Rajasthan) to study water use, water use efficiency, nitrogen uptake, yield and economics of coriander (*Coriandrum sativum*) cultivars (RCr 41, RCr 435) under various levels of nitrogen (20, 40 and 60 kg ha^{-1}) and irrigation (IW/CPE ratios 0.6, 0.8 and irrigation at branching + flowering + seed formation stages). The highest seed yield (10.98 q ha^{-1}), yield attributes and benefit: cost ratio (2.65) were recorded with 60 kg nitrogen ha^{-1}. Increasing levels of nitrogen also recorded higher consumptive use of water and nitrogen uptake. Plants under higher levels of nitrogen (60 kg ha^{-1}) extracted more water from the lower depth (60-90 cm) than lower level of nitrogen (20 kg ha^{-1}). Increase in irrigation frequency significantly enhanced the yield and yield attributes of both the cultivars. Similarly, water use, nitrogen uptake and benefit:cost ratio were also higher with higher levels of irrigation.

Keywords: *Coriandrum sativum*, coriander, nitrogen, water use efficiency.

Introduction

The productivity of coriander (*Coriandrum sativum* L.) in Rajasthan is influenced by many factors of which mineral nutrition, especially nitrogen and irrigation are important. In eastern Rajasthan, coriander is generally grown with application of 60 kg nitrogen ha^{-1} and 20 kg phosphorus ha^{-1}. However, in north western Rajasthan, it can be grown with less amount of nitrogen owing to higher organic matter content of soils. Adoption of suitable high yielding varieties can further boost the productivity of the crop. However, no research work has been carried out on the influence of nitrogen and irrigation of coriander in north-western plains of Rajasthan. Hence, the present study was undertaken to find out an optimum nitrogen level and irrigation schedule and a suitable variety to maximize production of coriander in the north-western plains of Rajasthan.

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Materials and methods

The field experiment was conducted during winter seasons for three consecutive years (2002-03, 2003-04, 2004-05) at Agricultural Research Station (Rajasthan Agricultural University), Sriganganagar (Rajasthan), in a split-plot design with three replications. The treatments comprised of two varieties (RCr 41 and RCr 435) and three nitrogen levels (20, 40, 60 kg ha^{-1}) in main plots, and three levels of irrigation (at branching + flowering + seed formation stages and at IW:CPE ratios of 0.6 and 0.8) in sub-plots. A pre-sowing irrigation of 100 mm was applied for field preparation and germination. Thereafter, post sowing irrigation of 60 mm each was applied as per treatment. Nitrogen was applied as per treatment through urea in two equal splits - at sowing and first irrigation. Phosphorus (20 kg ha^{-1}) was applied as basal through single super phosphate. The soil (Alluvial) was sandy loam in texture having field capacity 16.3%, permanent wilting point 6.5%, bulk density 1.48 gcc^{-1}, pH (1:2) 8.1, electrical conductivity (1:2) 0.2 dsm^{-1}, organic carbon 0.28% and available N, P and K 118, 19 and 306 kg ha^{-1}, respectively. The crop was sown on 6^{th}, 6^{th} and 9^{th} November during 2002, 2003 and 2004, respectively, using a seed rate of 20 kg ha^{-1} and harvested on 8^{th} April, 29^{th} March and 12^{th} April during 2003, 2004 and 2005, respectively. A spacing of 30 cm x 10 cm was maintained. Rainfall received during crop growing period was 58.5, 19.9 and 137.6 mm during 2002-03, 2003-04 and 2004-05, respectively and corresponding pan evaporation was 381.4, 294.6 and 297.4 mm.

Results and discussion

Variety

Among the two varieties, RCr 41 performed better than RCr 435 for yield, yield attributes, water use, water use efficiency, nitrogen uptake, monetary return and benefit:cost ratio (Tables 1-3). RCr 41 also consumed (ET) more water (260.8 mm) and registered higher water use efficiency of 4.21 kg $ha^{-1}mm^{-1}$ as against 253.9 mm and 3.96 kg $ha^{-1}mm^{-1}$ with

Table 1. Effect of nitrogen and irrigation on yield, yield attributes, harvest index and nitrogen uptake of coriander (pooled data of 3 years)

Treatment	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)	Height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Umbels $plant^{-1}$	Umbellets $umbel^{-1}$	Seeds $umbel^{-1}$	Test weight (g)	Benefit: cost ratio	Nitrogen uptake (kg ha^{-1})
Variety												
RCr 41	10.98	35.32	24.06	113.6	6.7	18.1	34.1	5.9	34.3	5.50	2.64	30.3
RCr 435	10.06	32.75	23.87	105.6	6.8	17.7	33.1	5.8	33.6	5.30	2.41	27.5
CD (P=0.05)	0.43	1.21		1.4	0.3	1.0	1.1	0.3	1.2	0.05		1.0
Nitrogen (kg ha^{-1})												
20	9.42	31.11	23.47	103.4	5.9	16.1	31.6	5.7	32.7	5.10	2.32	24.5
40	10.92	33.61	25.01	107.2	7.1	18.4	34.0	5.9	33.8	5.46	2.62	30.0
60	11.30	33.38	23.42	112.3	7.4	19.4	35.2	6.1	34.7	5.63	2.65	32.3
CD (P=0.05)	0.49	1.50		1.7	NS	1.3	1.4	0.4	1.4	0.05		1.3
Irrigation												
B + F + S	9.73	31.56	23.84	105.4	6.5	16.9	32.4	5.8	33.1	5.15	2.35	25.8
IW:CPE 0.6	10.55	33.24	24.53	107.8	6.7	17.7	33.9	5.9	32.3	5.42	2.54	27.2
IW:CPE 0.8	11.56	37.25	23.99	109.6	6.9	19.3	34.5	6.0	34.9	5.63	2.75	33.2
CD (P=0.05)	0.76	1.21		2.5	0.4	1.3	1.6	0.4	1.3	0.11		2.8

B + F + S=Branching + Flowering + Seed formation stages

Table 2. Interaction effect of variety and irrigation on seed yield (q ha^{-1}) of coriander (2002-03)

Variety	Irrigation level		
	B + F + S	IW:CPE 0.6	IW:CPE 0.8
RCr 41	11.43	11.69	13.23
RCr 435	10.42	11.06	13.12
CD (P=0.05%)	0.13		

B + F + S= Branching + Flowering + Seed formation stages

Table 3. Interaction effect of nitrogen and variety on seed yield (q ha^{-1}) of coriander (2004-05)

Variety	Nitrogen level (kg ha^{-1})		
	20	40	60
RCr 41	11.43	11.69	13.23
RCr 435	10.42	11.06	13.12
CD (P=0.05)	0.15		

RCr 435, respectively (Table 4). It might be due to higher growth of RCr 41 as evidenced by higher height and yield attributes (Table 1). RCr 435 extracted more water (48.8%) from upper layer (0-30 cm) compared to RCr 41 (47.3%). However, RCr 41 extracted more moisture (22.1%) from lower level (60-90 cm) against 21.7% by RCr 435.

Nitrogen

Nitrogen had significant effect on yield attributes of coriander (Table 1). Higher height, secondary branches plant^{-1}, umbels plant^{-1}, umbellets plant^{-1}, seed umbel^{-1} and test weight were recorded with every higher dose of nitrogen. Consequently, highest seed (11.30 q ha^{-1}) and stover (37.38 q ha^{-1}) yield were recorded at higher dose of nitrogen (60 kg ha^{-1}). However, highest harvest index (25.01%) was recorded at 40 kg N ha^{-1} as compared to 20 and 60 kg N ha^{-1}. Higher yield with higher dose of nitrogen also enhanced benefit: cost ratio and nitrogen uptake. These results are in conformity with Tomar *et al*. (1994). Water use increased with increasing levels of nitrogen, being maximum (266.0 mm) with 60 kg N ha^{-1} (Table 4). Similarly, water use efficiency of 4.25 kg ha^{-1}mm^{-1} was also the highest with 60 kg N ha^{-1}. The increasing levels of nitrogen might have promoted the root growth that increased the moisture extraction from lower layers. Increase in nitrogen levels also increased the nitrogen uptake significantly and the highest nitrogen uptake of 32.3 kg ha^{-1} was recorded with 60 kg N ha^{-1}.

Irrigation

Irrigation frequencies significantly influenced the yield and yield attributes of coriander (Table 1). Irrigation treatment IW: CPE ratio 0.8 yielded (11.56 q ha^{-1}) higher than rest of

Table 4. Effect of nitrogen and irrigation on water use, water use efficiency, moisture extraction pattern (%) of coriander

Treatment	Consumptive use (mm)	Water use efficiency (kg ha^{-1}mm^{-1})	Water extraction pattern (%)		
			0-30 cm	30-60 cm	60-90 cm
Variety					
RCr 41	260.8	4.21	47.3	30.6	22.1
RCr 435	253.9	3.96	48.8	30.5	21.7
Nitrogen (kg ha^{-1})					
20	248.3	3.79	48.9	31.0	20.0
40	257.8	4.23	47.9	30.8	21.3
60	266.0	4.25	47.4	29.8	22.8
Irrigation					
B + F + S	239.6	4.06	47.5	31.4	21.1
IW:CPE 0.6	250.0	4.22	49.1	30.8	21.1
IW:CPE 0.8	282.5	4.10	49.3	29.4	22.3

B + F + S=Branching + Flowering + Seed formation stages

irrigation levels. Higher irrigation frequency increased the availability of nutrients and thus enhanced the uptake of nutrients which consequently improved the crop growth and yield. IW:CPE ratio 0.8 increased seed yield by 18.81% and 9.57% over three irrigations at branching + flowering + seed formation stages (9.73 q ha^{-1}) and 0.6 IW : CPE ratio (10.55 q ha^{-1}), respectively. These findings are in conformity with those of Yadav *et al*. (2008) in coriander. Increased irrigation level of 0.8 IW: CPE ratio also improved benefit : cost ratio (2.75). More water was extracted from upper and lower layers when higher frequency (0.8 IW : CPE) of irrigation was applied.

Variety and irrigation and nitrogen interaction

Interaction effects of variety and irrigation and nitrogen were significant during 2002-03 and 2004-05, respectively (Tables 2 & 3). RCr 41 gave the highest seed yield of 13.23 q ha^{-1} with IW:CPE ratio 0.8 and with three irrigations at branching + flowering + seed formation stages. The variety gave significantly higher seed yield than RCr 435 which might be due to more tolerance of RCr 41 to moisture stress than RCr 435. RCr 41 gave significantly higher seed yield at 40 and 60 kg N ha^{-1}, whereas, RCr 435 recorded significantly higher seed yield (8.62 q ha^{-1}) at 20 kg N ha^{-1}. Highest seed yield of 11.64 q ha^{-1} was recorded by RCr 41 at 60 kg N ha^{-1} and this seed yield was at par with 40 kg N ha^{-1} (11.61 q ha^{-1}).

It is concluded that coriander variety RCr 41 with the application of 40 kg nitrogen and 20 kg phosphorus ha^{-1} and irrigation level of IW/CPE ratio 0.8 is optimum for obtaining higher yield in the north-western plains of Rajasthan.

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