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Effect of irrigation, nitrogen and phosphorus on seed yield and water use of rajmash (*Phaseolus vulgaris*)

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ABSTRACT

A field experiment was conducted during the winter seasons of 1993-94 and 1994-95 at Kumarganj to study the effect of irrigation, nitrogen and phosphorus on seed yield and water use of rajmash (*Phaseolus vulgaris* L.). Scheduling irrigation at 0.7 IW/CPE ratio was significantly better than other irrigation schedules in terms of yield attributes and yield. However, water-use efficiency was lowest at 0.7 IW/CPE ratio. Application of N up to 100 kg/ha and phosphorus up to 60 kg P_2O_5/ha significantly increased the yield attributes, yield and water-use efficiency. Interaction of irrigation and N, and N and P was significant for pods/plant and seed yield. Highest values of pods/plant and seed yield were recorded under the treatment combinations of 0.7 IW/CPE along with 100 kg N/ha, and 100 kg N with 60 kg P_2O_5/ha.

Key words: Rajmash, Irrigation, Nitrogen, Phosphorus

Rajmash (*Phaseolus vulgaris* L.) is one of the precious and highly relished pulses of northern India. It does not nodulate with the native rhizobia in the plains. Consequently, the application of nitrogen becomes imperative for exploiting its yield potential. Rajmash also responds well to phosphorus application (Ahlawat and Sharma, 1989). It does not grow well in moisture deficient areas, hence, assured irrigation is a prerequisite for its successful cultivation. The present investigation was, therefore planned and undertaken to study the effect of N, P and irrigation on yield and water use of rajmash in eastern Uttar Pradesh.

MATERIALS AND METHODS

The experiment was conducted during the winter seasons (*rabi*) of 1993-94 and 1994-95 at Agronomy Research Farm, N. D. University of Agriculture and Technology Kumarganj, Faizabad. The soil of the experimental site was silty loam in texture, low in organic carbon (0.40%) and available N (190.4 kg/ha), medium in available P (14.7 kg/ha) and available K (256 kg/ha) and slightly alkaline in reaction (pH 7.8). Three irrigation levels [irrigation at 0.3, 0.5 and 0.7 IW/CPE ratios] were taken as main plot treatment and three levels each of N (0, 50 and 100 kg/ha) and P (0, 30 and 60 kg P_2O_5/

ha) as sub plot treatment in split-plot design with 4 replications. Rajmash cultivar 'PDR 14' was sown in rows 30 cm apart @ 125 kg seed/ha on 8 November and 2 November during 1993 and 1994 respectively. A uniform distance of about 10 cm between plants was maintained by thinning at 20-25 days after sowing. Half dose of N, full dose of P_2O_5 as per treatment and a uniform dose of potassium @ 40 kg K_2O/ha was applied as basal and remaining N as per treatment after common irrigation. Irrigation treatments were superimposed after uniform irrigation to obtain an even crop stand. Crop was irrigated with 5 cm irrigation water (measured with the help of Parshall flume) every time. The number of irrigations including one common irrigation for 0.3, 0.5 and 0.7 IW/CPE ratios were 1, 2 and 3 during 1993-94 and 2, 3 and 4 during 1994-95, respectively. Other agronomic practices were followed as per requirement of the crop. The total rainfall received during crop growth period was 47.7 and 25.4 mm in first and second year, respectively.

RESULTS AND DISCUSSION

Yield attributes

During both the years, pods/plant, pod length, seeds/pod and 1000-seed weight were significantly highest when irrigations were scheduled at 0.7 IW/CPE ratio (Table 1). However, during 1993-94, 1000-seed weight remained unaffected. Irrigation scheduling at 0.7 IW/CPE ratio increased pods/plant by 45.0%, pod length by 19.3%, seeds/pod by 16.8% and 1000-seed weight by 7.8% over control during 1993-94. The corresponding increase was 56.4, 16.2, 16.3 and 6.3% during1994-95. The results are in line with the findings of Dahatonde and Nalamwar (1996).

Yield attributes increased significantly with increasing levels of N up to 100 kg/ha during both the years (Table 1). Among yield attributes pods/plant was greatly influenced by N levels. Application of 100 kg N/ha gave 8.47 and 7.66 more number of pods/plant during first and second year as compared to without N. The results are in conformity with those of Dahatonde and Nalamwar (1996).

Significant effect of P was noticed on various yield attributes during both the years (Table 1). However pod length was not influenced by P application during 1993-94. Pods/plant and seeds/pod increased significantly up to 60 kg P_2O_5/ha while 1000-seed weight and pod length up to 30 kg P_2O_5/ha. Verma and Saxena (1995) reported similar results.

The interaction effect of irrigation and N was significant for pods/plant during both the years (Table 3). Increasing levels of N from 0 to 100 kg/ha significantly increased the pods/plant at each irrigation level. At 50 and 100 kg N/ha, significant increase in pods/plant was recorded with increase in irrigation level up to 0.7 IW/CPE ratio. Maximum pods/plant (15.93 and 15.18) was obtained when irrigations were scheduled at 0.7 IW/CPE along with 100 kg N/ha application.

The interaction effect of N and P was also significant for pods/plant during both the years (Table 4). The highest pods/plant (15.35 and 13.83) was recorded with 100 kg N + 60 kg P_2O_5 kg/ha which was significantly superior to all other N x P combinations.

Yield

Seed yield increased progressively and significantly with irrigation up to an IW/CPE ratio of 0.7 during both the years (Table 1). It increased by 20.5% with 0.5

Table 1. Yield attributes, yield and harvest index of rajmash as influenced by irrigation, nitrogen and phosphorus levels

Treatment	No. of pods/plant		Pod length (cm)		No. of seeds/ pod		1000-seed weight (g)		Seed yield (q/ha)		Straw yield (q/ha)		Harvest index (%)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Irrigation (IW/CPE ratio)														
0.3	7.87	6.77	8.53	8.16	2.80	2.76	349.3	347.3	11.52	10.99	12.79	12.44	48.29	46.23
0.5	9.98	8.72	9.34	8.86	3.14	3.03	372.3	366.2	13.88	13.07	14.43	13.88	48.32	47.75
0.7	11.41	10.59	10.18	9.48	3.27	3.21	376.4	369.3	15.55	14.66	15.03	14.49	50.00	49.23
CD (P = 0.05)	0.57	0.33	0.95	0.40	0.24	0.13	NS	13.77	0.97	0.75	0.89	0.62	NS	1.75
Nitrogen level (kg/ha)														
0	5.07	4.57	8.65	8.02	2.62	2.64	315.2	306.9	5.77	5.27	6.52	6.16	46.69	45.79
50	10.65	9.28	9.11	8.87	3.20	3.10	368.7	364.1	15.36	14.61	15.99	15.70	48.82	47.99
100	13.54	12.23	10.29	9.60	3.30	3.27	414.2	411.7	19.82	18.84	19.74	18.94	51.10	49.43
CD (P = 0.05)	0.44	0.33	0.56	0.32	0.13	0.13	9.5	10.6	0.60	0.63	0.55	0.62	2.74	1.72
Phosphorus level (P_2O_5/ha)														
0	8.58	7.76	9.23	8.53	2.82	2.78	355.0	352.0	11.51	10.99	13.17	12.80	47.58	45.62
30	9.78	8.68	9.39	8.83	3.10	3.02	367.9	363.2	13.49	12.67	13.93	13.39	48.59	47.82
60	10.90	9.63	9.43	9.12	3.29	3.20	374.3	367.6	15.96	15.05	15.15	14.61	50.44	49.77
CD (P = 0.05)	0.44	0.33	NS	0.32	0.13	0.13	9.5	10.6	0.60	0.63	0.55	0.62	NS	1.72

Table 2. Moisture extraction pattern, consumptive use and water use efficiency of rajmash as influenced by irrigation, nitrogen and phosphorus levels

Treatment	Moisture extraction pattern (cm) at soil depth								Total extraction (cm)		Consumptive use of water (cm)		Water use efficiency (kg/ha-cm)	
	0-15 cm		15-30 cm		30-60 cm		60-90 cm							
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Irrigation (IW/CPE ratio)														
0.3	3.85 (35.91)	4.86 (35.65)	3.28 (30.59)	4.39 (32.20)	2.30 (21.46)	2.86 (20.98)	1.29 (12.03)	1.52 (11.15)	10.72	13.63	15.80	16.84	70.20	62.63
0.5	5.33 (37.69)	6.90 (37.48)	4.55 (32.18)	5.86 (31.83)	2.71 (19.17)	3.82 (20.75)	1.55 (10.96)	1.83 (9.94)	14.14	18.41	17.92	22.02	74.69	57.28
0.7	8.09 (40.29)	8.86 (39.82)	6.48 (32.27)	7.02 (31.55)	3.61 (17.98)	4.42 (19.87)	1.90 (9.46)	1.95 (8.76)	20.08	22.25	26.26	26.32	56.76	53.15
Nitrogen level (kg/ha)														
0	4.66 (37.88)	5.52 (36.75)	4.15 (33.74)	5.16 (34.35)	2.24 (18.21)	2.95 (19.64)	1.25 (10.16)	1.39 (9.25)	12.30	15.02	17.31	18.65	33.85	28.35
50	5.74 (38.03)	6.91 (37.84)	4.85 (32.14)	5.83 (31.93)	2.90 (19.22)	3.74 (20.48)	1.60 (10.60)	1.78 (9.75)	15.09	18.26	20.10	21.90	78.32	67.49
100	6.87 (39.12)	8.18 (38.95)	5.32 (30.30)	6.28 (29.90)	3.48 (19.82)	4.42 (21.05)	1.89 (10.76)	2.12 (10.10)	17.56	21.00	22.57	24.63	89.48	77.22
Phosphorus level (kg P_2O_5/ha)														
0	5.76 (40.65)	6.91 (40.20)	4.30 (30.35)	5.23 (30.42)	2.64 (18.63)	3.43 (19.95)	1.47 (10.37)	1.62 (9.42)	14.17	17.19	19.17	20.82	59.64	51.80
30	5.71 (38.37)	6.85 (37.66)	4.74 (31.85)	5.84 (32.11)	2.86 (19.22)	3.72 (20.45)	1.57 (10.55)	1.78 (9.79)	14.88	18.19	19.89	21.81	67.02	56.53
60	5.80 (36.48)	6.87 (36.29)	5.27 (33.14)	6.20 (32.75)	3.13 (19.69)	3.97 (20.97)	1.70 (10.69)	1.89 (9.98)	15.90	18.93	20.91	22.55	74.99	64.73

Figures in parentheses indicate per cent contribution of individual layer to total extraction

IW/CPE and by 35.0% with 0.7 IW/CPE over 0.3 IW/CPE ratio during 1993-94. The corresponding increase was 18.9 and 33.4% during 1994-95. Straw yield was on par with 0.5 and 0.7 IW/CPE ratios which produced significantly higher straw yield over 0.3 IW/CPE ratio. The increase in yield at higher IW/CPE ratios might be due to increase in cell turgidity, better opening of stomata and finally increasing the partitioning of photosynthates to sink. These findings are in agreement with those of Ahlawat and Sharma (1989) and Dahatonde and Nalamwar (1996). Harvest index was significantly higher at 0.7 IW/CPE ratio over 0.3 ratio during 1994-95. This might be attributed to relatively more increase in seed yield rather than in straw yield.

Nitrogen fertilization increased the seed as well as straw yield and harvest index significantly up to 100 kg N/ha during both the years (Table 1). The difference in harvest index between 50 and 100 kg N/ha was, however, not significant. Application of 100 kg N/ha produced more than three folds higher yield (19.82 and 18.84 q/ha) to that obtained without N (5.77 and 5.27 q/ha). Such increase in yield might be due to increased availability of N, causing accelerated photosynthetic rate and thus leading to more production of carbohydrates. The results are in agreement with those of Dahatonde and Nalamwar (1996).

Application of P up to 60 kg P_2O_5/ha increased the seed and straw yields significantly during both the years (Table 1). The increase in seed yield was 17.2 and 38.7% owing to 30 and 60 kg P_2O_5/ha over no P during 1993-94 and 15.3 and 36.9% during 1994-95, respectively. P application in-

Table 3. Interaction effect of irrigation and nitrogen on pods/plant and seed yield of rajmash

Irrigation (IW/CPE ratio	Nitrogen levels (kg/ha)					
	0		50		100	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
			Pods/plant			
0.3	4.20	3.95	8.62	7.33	10.80	9.02
0.5	5.23	4.50	10.82	9.18	13.88	12.48
0.7	5.78	5.25	12.52	11.33	15.93	15.18
			Seed yield (q/ha)			
0.3	4.75	4.30	13.29	12.74	16.54	15.95
0.5	5.94	5.59	15.45	14.76	20.24	18.85
0.7	6.63	5.91	17.34	16.35	22.69	21.72

CD (P = 0.05)	*Pods/plant*		*Seeds yield*	
	1993-94	1994-95	1993-94	1994-95
For comparing 2 levels of N at same level of I	0.76	0.58	1.04	1.09
For comparing 2 I at same or different levels of N	1.36	1.00	1.97	1.92

I, Irrigation; N, Nitrogen

Table 4. Interaction effect of nitrogen and phosphorus on pods/plant and seed yield of rajmash

Nitrogen level (kg/ha)	Phosphorus level (kg P_2O_5/ha)					
	0		30		60	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
	Pods/plant					
0	4.58	4.33	5.17	4.58	5.47	4.78
50	9.38	8.23	10.68	9.33	11.88	10.28
100	11.78	10.72	13.48	12.13	15.35	13.83
CD (P = 0.05)	0.76	0.58				
	Seed yield (q/ha)					
0	4.80	4.43	5.82	5.18	6.70	6.18
50	13.46	12.94	15.24	14.41	17.38	16.49
100	16.25	15.60	19.41	18.43	23.81	22.48
CD (P = 0.05)	1.04	1.09				

creased the photosynthetic activities and translocation of photosynthates to sink, which consequently resulted in better development of yield attributes and higher seed yield. Harvest index increased significantly with P application up to 60 kg P_2O_5/ha during 1994-95. Similar results were recorded by Verma and Saxena (1995).

Irrigation and N significantly interacted for seed yield during both the years (Table 3). Seed yield increased significantly up to 100 kg N/ha at all irrigation levels. Irrigation at 0.7 IW/CPE ratio and N @ 100 kg/ha gave maximum yield of 22.69 and 21.72 q/ha in first and second year, respectively. Seed yield was not influenced by irrigation levels associated with no N. At 50 and 100 kg N/ha, seed yield increased significantly up to 0.7 IW/CPE ratio. The results are in conformity with those of Dahatonde and Nalamwar (1996).

Interaction between N and P for seed yield was found significant during both the years (Table 4). N application up to 100 kg/ha gave significantly higher seed yield at all P levels. Application of 100 kg N + 60 kg P_2O_5/ha gave 19.01 and 18.05 q/ha higher yield as compared to no N and P combination during first and second year, respectively.

Moisture-extraction pattern

Generally contribution of upper 0-30 cm soil layer in moisture extraction was higher (65-70%) than that of lower (30-90 cm) layer (Table 2). Treatments with lower IW/CPE ratios accounting less number of irrigations resulted in more contribution of water from lower layers, whereas higher IW/CPE ratios accounting more irrigations, upper layer contributed more. The application of N up to 100 kg/ha increased the moisture extraction from 30-90 cm soil profile due to better growth and presence of roots in these layers. Varying levels of P did not appreciably influence the moisture extraction. However, moisture extraction increased with increasing levels of P up to 60 kg P_2O_5/ha

from deeper layer (30-90 cm) might be due to increased root growth under these layers.

Consumptive use of water

Consumptive use of water increased with the increase in frequency of irrigation. Consumptive use of water was maximum under 0.7 IW/CPE ratio followed by 0.5 and 0.3 ratios (Table 2). This increase is attributed to more evapotranspiration losses due to better canopy development at higher irrigation levels. The results corroborate the findings of Ahlawat and Sharma (1989). Consumptive use of water increased considerably with increasing levels of N up to 100 kg/ha. Such increase was due to better plant growth resulted in more leaf area which increased transpiration losses. The results are in conformity with the findings of Hegde and Srinivas (1989). P did not influence much the consumptive use of water. However, consumptive use of water increased up to 60 kg P_2O_5/ha due to increased plant growth.

Water-use efficiency

Water-use efficiency was higher with irrigation at 0.5 IW/CPE ratio (74.69 kg seed/ha-cm) during the first year and at 0.3 IW/CPE ratio (62.63 kg seed/ha-cm) during the second year (Table 2). Higher water-use efficiency in these treatments might be due to production of relatively higher grain yields with minimum water use. The results confirm the findings of Ahlawat and Sharma (1989). Water-use efficiency increased with increasing levels of N up to 100 kg/ha and P up to 60 kg P_2O_5/ha during both the years. It might be due to increased yield at higher levels of N and P. Hegde and Srinivas (1989) also reported similar results.

It is concluded that rajmash 'PDR 14' should be irrigated at 0.7 IW/CPE ratio (3-4 irrigations) and fertilized with 100 kg N and 60 kg P_2O_5/ha for obtaining higher seed yield in eastern Uttar Pradesh.

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