Indian Journal of Agronomy **60** (2): 217–223 (June 2015)

Research Paper

Productivity and profitability of clusterbean (*Cyamopsis tetragonoloba*)-cumin (*Cuminum cyminum*) cropping system as influenced by nutrient management under arid condition of Rajasthan

RAJ SINGH[1]

Central Arid Zone Research Institute, Jodhpur, Rajasthan 342 003

Received : April 2014; Revised accepted : May 2015

ABSTRACT

A field experiment was conducted during 2008–09 to 2010–11 at the Central Arid Zone Research Institute, Jodhpur, Rajasthan to study the effect of nutrient-management practices on the productivity and profitability of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]-cumin (*Cuminum cyminum* L.) cropping system. Application of 50% N by farmyard manure (FYM) + 50% N by urea recorded significantly higher growth, yield attributes and seed yield of clusterbean, and the seed yield was 13.9, 12.2 and 34.7% higher over the application of 100% N by FYM, 100% N by urea and control respectively. Maximum growth, yield attributes and seed yield of succeeding cumin (0.49 t/ha) were recorded owing to residual effect of 100% N applied through FYM to clusterbean. Increase in the seed yield of cumin owing to residual effect of 100% N through FYM to clusterbean was 11.2 and 15.3% higher over 100% N by urea and control respectively. Among the direct nutrient-management treatments in cumin, application of 100% recommended dose of fertilizer (RDF) (40 kg N + 13 kg P) being at par with 75% RDF recorded significantly higher seed yield than 50% RDF and the control. Significantly highest system productivity (1.02 t/ha) of clusterbean-cumin cropping system in terms of cumin seed-equivalent yield (CSEY), net returns (₹60.23 × 10^3/ha), benefit: cost ratio (1.43), crop profitability (₹286.81/ha/day), crop productivity (4.88 kg/ha/day) and nutrient uptake (43.3 kg N, 11.6 kg P and 41.4 kg K/ha) of the cropping system were registered with the combination of 50% N through FYM + 50% N through urea applied to clusterbean. As regards to nutrient management in cumin, an application of 100% RDF also resulted in the highest system productivity (1.03 t/ha), net returns (₹42.48 × 10^3/ha), benefit: cost ratio (1.43), crop profitability (₹289.39/ha/day) and crop productivity (4.92 kg/ha/day) followed by 75% RDF. Interaction effect of nutrient management in clusterbean and in cumin on total system productivity was found significant. However, application of 50% N by FYM + 50% N by urea to clusterbean along with the application of 100% RDF to cumin was found most effective in obtaining the highest cumin seed-equivalent yield (1.11 t/ha) and net returns (₹69.01 × 10^3/ha) by clusterbean-cumin cropping systems under arid condition of Rajasthan.

Key words: Clusterbean, Cumin, Nutrient management, Preceding crop, Residual effect

Clusterbean and cumin both are most important commercial crops grown during the rainy (*kharif*) and winter (*rabi*) season, respectively, mainly in arid region of Rajasthan. The endosperm of clusterbean seed contains 30–33% gum, which has industrial importance for many industries like in mining, petroleum drilling, refineries, textiles, pharmaceuticals, bakeries etc. Similarly, cumin seed is largely being used as condiment, stimulant, spices, carminatives, flavouring agent and for medicinal purposes. India is the largest producer of clusterbean and cumin seed in the world. It contributes nearly 80% of clusterbean and 70% of cumin seed to the total global production. Country has earned about ₹2,12,870.10 million by exporting of clusterbean gum (APEDA Agri. Exchange, Statistics, 2012–13) and ₹1,530.68 million by the export of cumin seed (Spices Board, India, 2012–13) during 2012–13. Rajasthan is a leading state of clusterbean and cumin seed production in the country. The state occupies first rank in clusterbean seed and second in cumin seed production after Gujarat in the country. Both crops are widely grown in the arid region of Rajasthan, with an area of 2.87 million ha and 1.40 million tonnnes production of clusterbean seed and 0.32 million ha area and 0.06 million tonnnes of cumin seed annually. In recent times, owing to increasing demand and raising the price of clusterbean and cumin seed in International market, cultivation of both the crops

[1]**Corresponding author Email**: rajsingh221996@gmail.com
[1]Principal Scientist, Division of Agronomy, Indian Agricultural Research Institute, New Delhi 110 012

is gaining more popularity in the arid region of the state. Clusterbean-cumin cropping system is also emerging in the region because of expansion of irrigated area, shrinking land-holding size and high monetary returns from the system. Though arid region leads in the production of clusterbean and cumin seed, but low average productivity of both the crops in the region is a major concern. Besides, many biotic and abiotic factors, inherently low status of organic matter, nitrogen and other nutrients (Tripathi and Kumar, 2000) in arid soils and imbalanced supply of nutrients (Singh and Singh, 2008) are the major factors responsible for low productivity of both the crops in the region. Moreover, intensive cropping deteriorates the soil health due to over-mining of nutrients from the soil. Therefore, it is need of the day to develop appropriate nutrient-management practices which can be effective for increasing productivity of the cropping system besides sustaining soil fertility. The application of nutrients through the combination of organic and inorganic sources not only sustains crop productivity and soil fertility but also benefits the succeeding crop to a great extent because of carryover effect of nutrients (Hegde, 1998). Hence the present investigation was undertaken to study the effect of nutrient management on the production potential of clusterbean-cumin cropping system under arid condition of Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted during 2008–11 at the Central Arid Zone Research Institute, Jodhpur (26' 18' N, 73' 04' E and 232 m above the mean sea-level). The soil of the experimental field was sandy loam, with *p*H of 7.9, low in organic carbon (0.24%), available N (132 kg/ha), medium in available P (12.8 kg/ha) and adequate in K (248 kg/ha). A total rainfall of 437, 187.2 and 562.2 mm was received during the crop period of the respective years of the study. Six nutrient-management treatments (control, 100% N by FYM, 100% N by urea,75% N by FYM + 25% N by urea, 50% N by FYM + 50% N by urea and 25% N by farmyard manure (FYM) + 75% N by urea) were replicated thrice in randomized block design during the rainy (*kharif*) season. FYM contained 0.51, 0.28 and 0.52% N, P and K, respectively, was incorporated into the soil 2 weeks before the sowing, while entire dose of N through urea was applied at the time of sowing as per treatments. The recommended dose of N (20 kg/ha) for clusterbean was considered to supply 100% N. The level of recommended dose of phosphorus (17.4 kg P/ha) for clusterbean was maintained by the application of single superphosphate in all the plots except control. During the winter (*rabi*) season, same layout was used to assess the residual effect of nutrient-management practices on the succeeding cumin. Each plot was divided into 4 sub-plots and 4 nutrient-management levels [control, 100% recommended dose of fertilizer (RDF: 40 kg N + 13.20 kg P/ha), 75% RDF and 50% RDF] were superimposed in factorial randomized block design with 3 replications.

Clusterbean 'RGC 936' was sown on 7, 9 and 7 July in rows, 45 cm apart, by using seed rate of 15 kg/ha under rainfed condition and harvested on 25, 27 and 29 September during 2008, 2009 and 2010 respectively. After harvesting of clusterbean, cumin 'RZ 209' was sown on 12, 14 and 17 November during 2008, 2009 and 2010, respectively, at 30-cm-row spacing using a seed rate of 12 kg/ha under irrigated condition. The crop was harvested on 28, 29 and 20 March during 2009, 2010 and 2011 respectively.

Growth and yield-attributing parameters of both the crops of the system were recorded at the time of harvesting. The yield of clusterbean was converted into cumin seed-equivalent yield (CSEY) by multiplying seed yield of clusterbean with its prevailing market price and dividing by the price of cumin seed. System productivity was computed by adding CSEY of clusterbean and seed yield of cumin for the respective years. Crop productivity (kg/ha/day) was worked out by dividing system productivity with total duration of both the crops of the system. Economics was worked out on the basis of prevailing market prices of inputs and outputs in the local market. Mean of prevailing market price of clusterbean and cumin seed was ₹100/kg. Crop profitability (₹/ha/day) was computed by dividing net returns of the system by total duration of both the crops of the system. Total N, P and K content were analysed following the modified Kjeldahl's method, calorimetric method and flame photometer method respectively. All the data recorded on growth, yield attributes, yield and N, P and K uptake were statistically analysed as per the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Direct effect of nutrient management on clusterbean

Pooled analysis of 3 years showed that all treatments significantly increased plant height, yield attributes (pods/plant, seeds/plant and 1,000-seed weight) and seed yield of clusterbean compared with the control (Table 1). Application of 50% N by FYM + 50% N by urea attained the maximum plant height, which was statistically at par with rest of the treatments except the control. Yield-attributing parameters like pods/plant, seeds/pod and 1,000-seed weight were also significantly higher with the combined application of 50% N by FYM + 50% N by urea followed by the application of 75% N by FYM + 25% N by urea and 25% N by FYM + 75% N by urea. Optimum supply of nutrients throughout the crop-growth period owing to the

Table 1. Effect of nutrient-management practices on the growth, yield attributes and seed yield of clusterbean

Treatment	Plant height (cm)	Pods/ plant	Seeds/ pod	1,000-seed weight (g)	Seed yield (t/ha)			Mean seed yield (t/ha)
					2008	2009	2010	
Control	55.8	32.2	4.1	28.3	0.42	0.23	0.46	0.37
100% N by FYM	67.8	51.6	5.7	29.5	0.54	0.34	0.57	0.48
100% N by urea	68.3	48.0	5.8	29.3	0.59	0.33	0.56	0.49
75% N by FYM + 25% N by urea	68.6	61.8	6.1	29.6	0.65	0.35	0.61	0.53
50% N by FYM + 50% N by urea	69.5	65.0	6.9	29.9	0.70	0.36	0.62	0.56
25% N by FYM + 75% N by urea	67.9	62.2	6.9	29.5	0.66	0.34	0.61	0.54
SEm±	0.9	2.19	0.3	0.5	0.011	0.008	0.013	0.012
CD (P=0.05)	3.2	6.78	0.9	1.7	0.030	0.023	0.038	0.035

FYM, Farmyard manure

combination of organic and inorganic sources resulted in higher growth and yield attributes (Choudhary *et al.*, 2011).

Among all the 3 years, the minimum seed yield of clusterbean was recorded during 2009, which was due to the occurrence of less rainfall during the year. The highest mean seed yield was obtained with the combined application of 50% N by FYM + 50% N by urea, and being statistically at par with the application of 25% N by FYM + 75% N by urea and 75% N by FYM + 25% N by urea recorded significantly higher than the seed yield obtained with the application of 100% N by FYM, 100% N by urea and the control. Combined application of 50% N by FYM + 50% N by urea resulted in 13.9, 12.2 and 34.7% higher seed yield than 100% N by FYM, 100% N by urea and the control respectively. The highest increase in growth and yield attributes with the combined application of 50% N by FYM+50% N by urea led to significant improvement in the seed yield of clusterbean. The results are in accordance with those reported by Singh and Singh (2009).

Residual effect on succeeding cumin

Growth, yield attributes and seed yield of succeeding cumin was influenced significantly due to residual effect of nutrients applied to the preceding clusterbean (Table 2). Application of 100% N through FYM to clusterbean recorded the highest plant height, branches/plant, seeds/plant, seed yield/plant and 1,000-seed weight of succeeding cumin, but remained statistically at par with that of 75% N by FYM + 25% N by urea and 50% N by FYM + 50% N by urea. However, no significant increase in the growth and yield-attributing parameters of succeeding cumin was observed due to the residual effect of 100% N by urea and 25% N by FYM + 75% N by urea applied to preceding clusterbean. Thus increase in growth and yield attributing parameters might be owing to the enrichment of soil fertility due to carry-over effect of nutrients applied through FYM to the preceding clusterbean. Upadhyay (2003) also reported similar results.

The highest seed yield of succeeding cumin was recorded owing to residual effect of 100% N applied through FYM to clusterbean, which being at par with that of 75% N by FYM + 25% N by urea and 50% N by FYM + 50% N by urea found significantly higher than the application of 100% N by urea, 25% N by FYM + 75% N by urea and the control. Increase in the seed yield of succeeding cumin due to residual effect of 100% N applied through FYM to preceding clusterbean was 10.2, 10.2 and 12.2% over the application of 100% N by urea, 25% N by FYM + 75% N by urea and the control respectively. This might be attributed to the improvement of growth, and yield attributes of succeeding cumin because of residual effect of FYM, that ultimately enhanced the seed yield of the crop. Jamwal (2005) also reported benefit of residual effect of nutrients applied through organic manures on the succeeding crop.

Direct effect of nutrient-management on cumin

Direct application of the nutrient-management treatments recorded significantly higher growth and all yield attributes except 1,000-seed weight over the control (Table 2). Application of 100% RDF (40 kg N + 13.2 kg P/ha) being at par with 75% RDF recorded significantly higher plant height, branches/plant, seeds/plant and seed yield/plant, over the application of 50% RDF and the control. The highest mean seed yield (0.54 t/ha) was also recorded with the application of 100% RDF closely followed by the application of 75% RDF. Application of 100% RDF significantly increased the seed yield by 23.6 and 53% over the application of 50% RDF and the control respectively. It might be attributed to the availability of nutrients in adequate amount with the application of 100% RDF required for proper growth and development of the crop. Yadav and Jangir (1999) also reported significant increase in the seed yield with the application of 100% N in cumin.

System productivity

System productivity of the cropping system expressed in terms of cumin seed-equivalent yield (CSEY) was significantly affected due to different nutrient management treatments applied in clusterbean (Table 3). Significantly highest CSEY was recorded with the combined application of 50% N by FYM + 50% N by urea, which remained at par with the application of 75% N by FYM+ 25% N by urea and 25% N by FYM + 75% N by urea. The CSEY was 4.9, 9.6 and 22.6% higher with the application of 50% N by FYM + 50% N by urea than 100% N by FYM, 100% N by urea and the control respectively. The highest crop productivity was also registered with the application of 50% N by FYM + 50% N by urea. The in-

Table 2. Residual and direct effect of nutrient-management practices on the growth, yield attributes and seed yield of cumin

Treatment	Plant height (cm)	Branches/ plant	Seeds/ plant	Seed yield/ plant (g)	1,000-seed weight (g)	Seed yield (t/ha) 2008–09	2009–10	2010–11	Mean seed yield (t/ha)
Preceding crop treatment									
Control	35.5	8.9	363.5	1.8	4.5	0.41	0.38	0.49	0.43
100% N by FYM	37.3	11.6	441.5	2.2	4.7	0.47	0.43	0.57	0.49
100% N by urea	35.2	9.6	383.0	1.9	4.6	0.44	0.39	0.50	0.44
75% N by FYM + 25% N by urea	36.5	11.1	419.5	2.1	4.6	0.46	0.42	0.56	0.48
50% N by FYM + 50% N by urea	35.9	10.8	401.5	2.1	4.6	0.44	0.41	0.54	0.46
25% N by FYM + 75% N by urea	35.6	10.0	392.5	2.0	4.6	0.42	0.39	0.52	0.44
SEm±	0.5	0.5	16. 2	0.2	0.4	0.009	0.012	0.004	0.009
CD (P=0.05)	1.4	1.5	47. 3	0.6	NS	0.027	0.035	0.012	0.026
Nutrient management in cumin									
Control	34.0	9.3	334.0	1.4	4.5	0.32	325	0.41	0.35
100% RDF (40 kg N + 30 kg P_2O_5/ha)	37.7	11.1	455.3	2.3	4.7	0.52	458	0.62	0.54
75% RDF	36.9	10.9	429.5	2.2	4.7	0.50	433	0.60	0.51
50% RDF	34.6	10.2	382.0	1.6	4.6	0.41	392	0.50	0.43
SEm±	0.6	0.3	10.7	0.2	0.3	0.014	0.018	0.022	0.027
CD (P=0.05)	1.7	0.8	31.2	0.6	NS	0.041	0.053	0.064	0.079

FYM, Farmyard manure; RDF, recommended dose of fertilizers

Table 3. System productivity and economics of clusterbean-cumin cropping systems as influenced by nutrient-management practices in clusterbean and cumin

Treatment	Mean CSEY of system (t/ha)	Cost of cultivation (× 10^3 ₹/ha)	Net returns (×10^3 ₹/ha)	Benefit: cost ratio	Crop profitability (₹/ha/day)	Crop productivity (kg/ha/day)
Preceding crop treatments						
Control	0.80	39.73	39.60	0.99	188.4	3.78
100% N by FYM	0.97	43.23	54.26	1.25	258.4	4.64
100% N by urea	0.94	41.23	52.30	1.26	249.0	4.45
75% N by FYM+ 25% N by urea	1.01	43.73	57.60	1.32	274.1	4.82
50% N by FYM+ 50% N by urea	1.02	42.23	60.23	1.43	286.8	4.88
25% N by FYM + 75% N by urea	0.98	41.73	56.56	1.35	269.3	4.68
SEm±	0.14	-	-	-	-	-
CD (P=0.05)	0.40	-	-	-	-	-
Nutrient management in cumin						
Control	0.85	40.93	43.77	1.07	208.4	4.03
100% RDF (40 kg N + 30 kg P_2O_5/ha)	1.03	42.48	60.77	1.43	289.4	4.92
75% RDF	1.01	42.11	58.52	1.38	278.7	4.79
50% RDF	0.93	41.72	51.32	1.23	244.4	4.43
SEm±	0.02	-	-	-	-	-
CD (P=0.05)	0.06	-	-	-	-	-

FYM, Farmyard manure; RDF, recommended dose of fertilizers; CSEY, cumin seed-equivalent yield crease in the system productivity of the cropping system could be attributed due to the fact that combination of 50% N through FYM + 50% N through urea supplied balanced nutrients throughout the growth period of clusterbean, besides benefiting succeeding cumin owing to residual effect of FYM. Islam and Munda (2012) also reported increase in system productivity owing to combined application of organic and inorganic fertilizers to preceding crop and residual effect of organic fertilizer on succeeding crop.

Direct application of different nutrient-management treatments to cumin significantly influenced the system productivity (Table 3). Significantly highest CSEY was obtained owing to the application of 100% RDF, which was at par with the application of 75% RDF, but resulted in significantly higher CSEY over the application of 50% RDF and the control by 9.9 and 18.0% respectively. Supply of balanced nutrients with the application of 100% RDF increased total biological yield as well as promoted sink and source balance, resulting in significantly increase of total system productivity. Singh and Singh (2006) also reported significant improvement in the system productivity with application of 100% RDF compared to 50% of RDF.

Interaction

The CSEY was significantly influenced with the interaction effect of nutrients applied to clusterbean and succeeding cumin (Fig. 1). Highest CSEY of clusterbean-cumin cropping system was recorded with the application of 50% N by FYM + 50% N by urea to clusterbean along

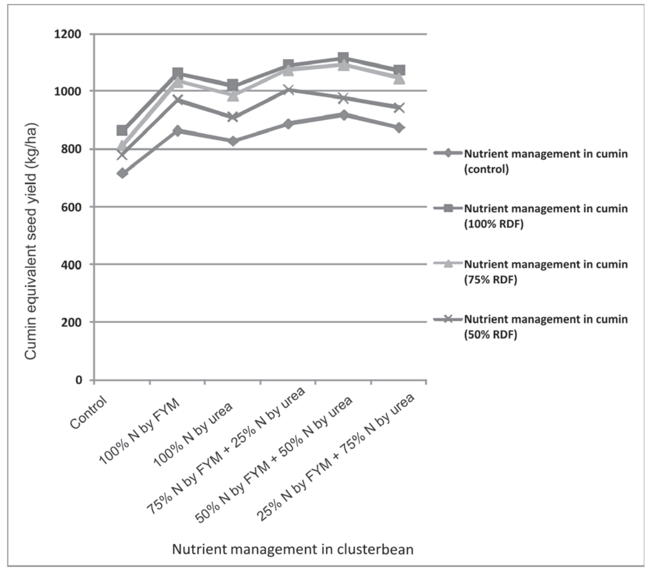

Fig. 1. Interaction effects of nutrient-management practices in clusterbean and in cumin on system productivity of clusterbean-cumin cropping system.

with the application of 100% RDF to cumin. The CSEY recorded with the application of corresponding treatments to both the crops found significantly superior to the application of 50% N by FYM + 50% N by urea to clusterbean along with 50% RDF to cumin and 100% N applied either by FYM or urea to clusterbean followed by 100% RDF to cumin. The increase in CSEY owing to the application of 50% N by FYM + 50% N by urea to

Table 4. Effect of nutrient-management practices on N, P and K uptake in clusterbean-cumin cropping system

Treatment	N, P and K uptake by crops (kg/ha)						Total N, P and K uptake by the cropping system (kg/ha)		
	Clusterbean			Cumin					
	N	P	K	N	P	K	N	P	K
Preceding crop treatment									
Control	16.7	3.4	13.4	16.0	5.5	21.3	32.7	8.8	34.7
100% N by FYM	22.0	4.0	16.2	19.3	7.5	24.5	41.3	11.5	40. 7
100% N by urea	22.2	4.0	15.3	16.2	5.8	21.7	39.4	9.8	36.9
75% N by FYM + 25% N by urea	24.0	4.3	17.1	18.7	7.0	23.5	42.7	11.3	40.6
50% N by FYM + 50% N by urea	25.5	5.0	17.7	17.8	6.7	23.7	43.3	11.6	41.4
25% N by FYM + 75% N by urea	24.4	4.2	16.5	16.7	5.9	22.1	41.2	10.0	38.5
SEm±	0.82	0.13	0.60	0.94	0.37	0.34	0.73	0.46	0.82
CD (P=0.05)	2.41	0.38	1.76	2.77	1.08	0.98	2.10	1.32	2.40
Nutrient management in cumin									
Control	21.6	4.0	15.4	13.4	4.8	17.5	35.0	8.8	32.9
100% RDF (40 kg N + 30 kg P_2O_5/ha)	23.0	4.3	17.2	20.2	7.9	27.2	43.2	12.3	44.4
75% RDF	22.6	4.3	16.8	19.4	6.9	25.5	42.0	11.2	42.3
50% RDF	22.7	4.1	16.5	16.5	5.9	21.0	39.2	10.0	37.5
SEm±	0.22	0.12	0.18	0.94	0.46	1.20	1.10	0.74	1.90
CD (P=0.05)	0.64	NS	0.59	2.87	1.35	3.49	3.26	2.38	5.58

FYM, Farmyard manure; RDF, recommended dose of fertilizer clusterbean followed by 100% RDF to cumin was 12.4, 4.8 and 8.4% over the application of 50% N by FYM + 50% N by urea to clusterbean along with 50% RDF to cumin, 100% N by FYM and 100% N by urea to clusterbean each supplemented by 100% RDF to cumin respectively. The improvement in the CSEY of the cropping system with the corresponding treatments combination could be attributed to the adequate supply of nutrients required for the proper growth and development of both the crops of the system. This led to higher yield of both the crops, ultimately increased CSEY of the cropping system. Aruna and Mohammad (2005) also reported similar findings.

Nutrient uptake

The N, P and K uptake by both the crops of the clusterbean-cumin cropping system increased significantly with the application of nutrient-management treatments in clusterbean and cumin (Table 4). Among the nutrients applied to clusterbean, the highest N, P and K uptake by the cropping system was recorded when 50% N was applied by FYM and 50% N by urea, closely followed by the application of 75% N by FYM + 25% N by urea and 100% N by FYM. Application of 50% N by FYM + 50% N by urea recorded 9.0, 15.7 and 10.8% increase in total N, P and K uptake by the cropping system over the application of 100% N by urea respectively. The higher N, P and K uptake by the cropping system was owing to continuous release of nutrients with the combined application of 50% N by FYM + 50% N by urea, leading to more production of biological yield of clusterbean and subsequently increase in seed yield of succeeding cumin due to residual effect of FYM.

Significant variation in N, P, and K uptake by cropping system was recorded due to direct nutrient application in cumin. The highest uptake of N, P and K was recorded with the application of 100% RDF to cumin, which was significantly higher than 50% RDF and the control. But no significant difference was observed between N, P and K uptake with the application of 100% RDF and 75% RDF. However, application of 100% RDF resulted in 10.2, 14.2 and 16.2% higher N, P and K uptake over 50% RDF and 22.9, 29.3 and 35.0% higher N, P and K uptake over the control respectively. The maximum increase of biological yield of cumin with 100% RDF led to increase of N, P and K uptake by the cropping system. Murthy *et al*. (2012) also reported similar results.

Economics

Net returns, benefit: cost ratio and crop profitability/day of the cropping system was realized highest with the application of 50% N by FYM + 50% N by urea to clusterbean followed by 75% N by FYM + 25% N by urea (Table 3). The magnitude of increase of net returns with the application of 50% N by FYM + 50% N by urea was 9.9 and 13.2% over 100% N applied through FYM and 100% N through urea respectively. Similarly, benefit: cost ratio and crop profitability were also progressively increased with the application of 50% N by FYM + 50% N by urea. This was owing to maximum increase of seed yield of clusterbean and succeeding cumin due to direct and residual effect of 50% N by FYM+50% N by urea. Direct application of 100% RDF to cumin fetched the highest net returns, benefit: cost ratio and crop profitability and thus net returns was 3.7, 15.5 and 28% higher over the application of 75% RDF, 50% RDF and control respectively. It indicates the importance of supply of optimum dose of nutrients for realizing more yield and monetary benefit.

It was concluded that productivity and profitability of clusterbean-cumin cropping system could be increased due to integrated application of 50% N by FYM + 50% N by urea to clusterbean along with application of 100% RDF to succeeding crop (cumin) under arid region of Rajasthan.

REFERENCES

Aruna, E. and Mohammad, S. 2005. Influence of conjunctive use of organic and inorganic source of nutrients in rice (*Oryza sativa*) on crop growth, yield components, yield and soil fertility in rice (*Oryza sativa*)–sunflower (*Helianthus annuus*) sequence. *Indian Journal of Agronomy* **50**(4): 265–68.

Choudhary, B.R., Gupta, A.K., Parihar, C.M., Jat, S.L. and Singh, D.K. 2011. Effect of integrated nutrient management on fenugreek (*Trigonella foenum-graecum*) and its residual effect on fodder pearl millet (*Pennisetum glaucum*). *Indian Journal of Agronomy* **56**(3): 189–95.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* International Rice Research Institute, loss Banos, Manila.

Hegde, D.M. 1998. Long-term sustainability of production in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system in subhumid ecosystem through integrated nutrient supply. *Indian Journal of Agronomy* **43**(2): 189–98.

Islam, M. and Munda, G.C. 2012. Effect of organic and inorganic fertilizer on growth, productivity, nutrient uptake and economics of maize (*Zea mays* L.) and toria (*Brassica campestris* L.). *Agricultural Science Research Journals* **2**(8): 470–79.

Jamwal, J.S. 2005. Productivity and economics of maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system under irrigated nutrient supply system in rainfed areas of Jammu. *Indian Journal of Agronomy* **50**(2): 110–12.

Murthy, Ramana, K.V., Reddy, D.S. and Reddy Prabhakara, G. 2012. Response of rice (*Oryza sativa*) varieties to graded levels of nitrogen under aerobic culture. *Indian Journal of Agronomy* **57**(4): 367–72.

Singh, A. and Singh, N.P. 2006. Direct and residual effects of organic and inorganic sources of nutrients under urdbean

(*Vigna mungo*)–wheat (*Triticum aestivum*) cropping sequence in foot hills of Uttaranchal. *Indian Journal of Agronomy* **51**(2): 97–99.

Singh, R. and Singh, B. 2008. Effect of preceding crops and nutrient management on productivity of wheat (*Triticum aestivum*)-based cropping system in arid region. *Indian Journal of Agronomy* **53**(4): 267–72.

Singh, R. and Singh, B. 2009. Integrated nutrient management in clusterbean–Indian mustard cropping system in arid zone. (In) *Legumes in Arid Areas*, pp. 333–39, Kumar, D., Henry, A. and Vittal, K.P.R. (Eds). Indian Arid Legumes Society and Scientific Publishers (India), Jodhpur, India.

Tripathi, K.P. and Kumar, P. 2000. Phosphate adsorption in aridosols in relation to soil properties. *Annals of Arid Zone* **39**(2): 131–35.

Upadhyay, V.B. 2003. Fertilizer management in soybean (*Glycine max* L.)–wheat (*Triticum aestivum* L.) cropping system in Malwa Plateau of Madhya Pradesh. *Journal of Oilseeds Research* **20**(2): 278–79.

Yadav, R.S. and Jangir, R.P. 1999. Effect of sowing method, plant population and nitrogen level on yield of cumin (*Cuminum cyminum* L.). *Annals of Arid Zone* **38**: 79–80.