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Research Paper

Sustaining soil health and productivity of sugarcane (*Saccharum* species hybrid complex) plant-ratoon system through integrated use of organic and inorganic sources in clay loam soils of Rajasthan

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ABSTRACT

A field experiment was conducted during 2014–17 at Kota, Rajasthan to find out a suitable nutrient-management strategy for sustaining soil health and sugarcane production. The experiment consisted of 9 nutrient-management strategies, viz.T_1, no organic + 50% recommended dose of fertilizer (RDF) in plant and trash 10 t/ha + 50% RDF in ratoon;T_2, no organic +100% RDF in plant and trash 10 t/ha + 100% RDF in ratoon; T_3, no organic + soil-test recommendation (STR) in plant and trash 10 t/ha + STR in ratoon; T_4, FYM 20 t/ha + 50% RDF in plant and ratoon; T_5, FYM 20 t/ha + 100% RDF in plant and ratoon; T_6, FYM 20 t/ha + STR in plant and ratoon; T_7, FYM 10 t/ha + *Azotobacter* + phosphate-solubilizing bacteria (PSB) + 50% RDF in plant and ratoon; T_8, FYM 10 t/ha + *Azotobacter* + PSB + 100% RDF in plant and ratoon; T_9, FYM 10 t/ha + *Azotobacter* + PSB + STR in plant and ratoon, laid out in randomized block design with 3 replications. Among the treatment combinations, application of 10 t FYM/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + STR (150 : 50 : 30 kg N : P_2O_5 : K_2O/ha) had significant influence on germination at 45 days after planting (DAP) (51.0%), tillers at 150 DAP (183,000/ha), number of millable canes (125,800/ha), cane yield (88.2 t/ha), commercial cane sugar yield (10.8 t/ha), net return (110,500 ₹/ha) and benefit: cost (BC) ratio (2.00). Sugarcane-quality characteristics like brix (20.2%), sucrose (17.7%), commercial cane sugar (CCS, 12.2% and purity (87.4%) recorded were significantly superior with application of 20 t FYM/ha + STR (T_6). Significant increase in soil organic carbon content (0.55%) and infiltration rate (4.69 mm/hr) were also noted under application of FYM 20 t/ha + STR over T_1 and T_2 treatments, while soil *p*H (8.12) and bulk density (1.34 Mg/m^2) of soil reduced significantly. Available nitrogen (363.81 kg/ha), phosphorus (27.02 kg/ha) and potassium (331.13 kg/ha) in soil exhibited higher values under FYM 20 t/ha + 100% RDF, FYM 10 t/ha + *Azotobacter* + PSB + STR and FYM 20 t/ha + STR. Thus, the result showed that integrated application of FYM 10 t/ha + *Azotobacter* + PSB (12.5+12.5 kg/ha) + STR (150:50:30 kg N:P_2O_5:K_2O/ha) may be recommended for obtaining higher cane yield, net returns and sustained soil health in plant-ratoon system in spring season on clay loam soils of Rajasthan.

Key words : Integrated nutrient management, Net returns, Nutrient sources, Soil fertility, Sugarcane yield, Soil test recommendation

Sugarcane is a long-duration, nutrient-exhaustive cash crop, grown in India over an area of 5.04 million ha to meet the country's sugar requirement. Development of modern agricultural techniques, continuous use of heavy doses of fertilizers and plant-protection chemicals potentially impaired the soil microbial activity, leading to poor soil heath (Singh *et al*., 2007). On the other hand, little or no use of organic manure has led to depletion of major as well as micro-nutrients from the soil. The deterioration in soil health and crop productivity is associated with decline in soil organic carbon under intensive sugarcane farming system. To stop continuous decline in soil fertility and to meet adequately the nutritional requirements of sugarcane crop, it is recommended to use organic manure in combination with chemical fertilizers. Addition of organic amendments with balanced fertilization could represent an important strategy to protect cultivable lands from excessive soil-resource exploitation and to maintain sustain soil health. Organic amendments such as organic manure and reincorporation of trash residues can improve the nutrient status of the soil and increase soil organic carbon (SOC) levels. In general, addition of organic manure with

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biofertilizers and incorporating plant residues in soil can positively affect the soil microclimate. It also increases plant residue contact with soil. This increases residue decomposition, organic matter transformation and improves soil organic carbon and availability of nutrients. In ratoon crop, it may increase root biomass and effectiveness of soil microorganism, consequently soil health and crop growth. Organic mode of nutrition and nutrients applied based on soil-test-based recommendation is economically viable, it is expected to be adopted to manage soil structure, organic carbon dynamics, and nutrient availability. .

Integrated application of nutrients based on soil-test recommendation in combination with biofertilizers is also essential for sustaining soil health and sugarcane production. Considering these facts, the present study was therefore, undertaken to study the integrated effect of organic and inorganic nutrient sources in improving soil health and productivity of sugarcane plant-ratoon system and its economics in spring season on clay loam soil of south-east Rajasthan.

MATERIALS AND METHODS

The field experiment was conducted on clay loam soil during spring season for 3 years (1 plant and 2 ratoon crops) from 2014–15 to 2016–17 at Agricultural Research Station, Kota, Rajasthan to study the response of integrated application of organic and inorganic fertilization in improving soil health, sugarcane productivity and economics. The average annual rainfall received during the crop seasons was about 865 mm. The experimental soil was clay loam in texture, with a *p*H of 8.22, ECe 0.34 dS/m^2, medium in organic carbon (5.0 g/kg), available nitrogen (361 kg/ha), phosphorus (23.5 kg/ha) and high in potassium (325 kg/ha).The initial soil had bulk density 1.40 Mg/m^2 and infiltration rate 4.00 mm/h. Nine nutrient-management strategies, viz.T_1, no organic + 50% recommended dose of fertilizer (RDF)100 : 30 : 20 kg N : P_2O_5 : K_2O/ha in plant and application of trash 10 t/ha + 50% RDF in ratoon crop; T_2, No organic + 100% RDF (200 : 60 : 40 kg N : P_2O_5 : K_2O/ha) in plant and application of trash 10 t/ha + 100% RDF in ratoon crop; T_3, No organic+ soil-test recommendation (STR) 150 : 50 : 30 kg N : P_2O_5 : K_2O/ha in plant and application of trash 10 t/ha + STR in ratoon crop; T_4, application of FYM 20 t/ha + 50% RDF in plant and ratoon crop; T_5, application of FYM 20 t/ha + 100% RDF in plant and ratoon crop; T_6, Application of FYM 20 t/ha +STR in plant and ratoon crop; T_7, Application of FYM 10 t/ha + *Azotobacter* + PSB (Phosphate-solubilizing bacteria) 12.5 + 12.5 kg/ha + 50% RDF in plant and ratoon crop; T_8, application of FYM 10 t/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + 100% RDF in plant and ratoon crop; T_9, application of FYM 10 t/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + STR in plant and ratoon crop were tested in randomized block design with 3 replications. Recommended dose of 200 : 60 : 40 kg N : P_2O_5 : K_2O/ha), soil-test recommendation (150 : 50 : 30 kg N : P_2O_5 : K_2O/ha) fertilizers, FYM 10 or 20 t/ha and biofertilizer (*Azotobacter* + PSB) 12.5 kg/ha each (solid-based fertilizer 10^{7-8}cfu) for sugarcane were applied as per treatments. The nutrients, especially NPK, were supplied through urea, single superphosphate and muriate of potash fertilizers respectively. A uniform dose of 25 kg/ha zinc sulphate was applied at the start of the cycle. Trash @ 10 t/ha inoculated with cellulolytic organism such as *Trichoderma viride* as decomposer @ 500 g/tonne was applied at the time of ratooning as per treatments. Timing of trash application in the first and second ratooning was 7 March 2015–16 and 12 March, 2016–17, respectively. Full PK and ¼ N were applied as basal and remaining N was top-dressed in 3 equal splits within 120 days after planting. Sugarcane variety 'CoPK 05191' was planted at 75-cm-row distance, keeping 3 budded 4 setts per meter row length in the last week of February during 2014–15. The first and second ratooning were taken at fixed site during the first and second week of March 2015–16 and 2016–17 respectively. All recommended agronomic practices were followed throughout the crop season. Plot size for each treatment was 6.0 m × 4.5 m = 27.0 m^2. Initial and post-harvest soil samples after 3 years were collected from 0–15 cm depth, dried, processed and analyzed for physic-chemical properties of soil using the standard procedures (Jackson, 1973; Baruah and Borthakur, 1997). Core samples were collected using standard core cutter for determination of bulk density. Infiltration rate was determined using double ring infiltrometer. Growth and yield attributes, cane yield, quality characteristics recorded were analyzed as per standard statistical procedures and using formulae. The economics was worked out based on pooled yield data and considering market price of input and output.

RESULTS AND DISCUSSION

Growth and yield attributes

Application of FYM 10 t/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + STR (150 : 50 : 30 kg N : P_2O_5 : K_2O/ha) through inorganic source had significant effect on germination at 30 and 45 DAP (46.3 and 51.0%), tillers at 120 and 150 DAP (170,220 and 183,000/ha), cane length (237.4 cm), cane girth (8.9 cm) and number of millable canes(125,800/ha), over T_1, T_2 and T_7 treatments and at par with rest of treatments (Table 1). Balanced nutrition through integrated use of organic and inorganic (NPK enriched soil with FYM) fertilizers primarily improved fertility status of soil and brought about higher growth and

Table 1. Effect of integrated application of organic and inorganic on germination and yield attributes of sugarcane plant-ratoon system (pooled data of 3 years)

Treatment	Germination (%)		Tillers (10^3/ha)		Cane length (cm)	Cane girth (cm)	NMC (10^3/ha)	Cane weight (g)
	30 DAP	45 DAP	120 DAP	150 DAP				
T_1, No organic + 50% RDF in plant and application of trash 10 t/ha + 50% RDF in ratoon crop	37.8	41.1	144.4	148.0	198.8	6.8	100.4	653.9
T_2, No organic + 100% RDF in plant and application of trash 10 t/ha + 100% RDF in ratoon crop	41.9	43.7	162.2	170.8	221.2	8.2	116.5	785.0
T_3, No organic + STR in plant and application of trash 10 t/ha + STR in ratoon crop	42.0	43.6	165.4	171.9	222.7	8.3	115.3	785.6
T_4, Application of FYM 20 t/ha + 50% RDF in plant and ratoon crop	39.0	41.7	153.5	161.7	206.1	7.6	105.4	721.8
T_5, Application of FYM 20 t/ha + 100% RDF in plant and ratoon crop	45.6	50.6	168.7	177.3	236.7	8.5	121.1	800.5
T_6, Application of FYM 20 t/ha + STR in plant and ratoon crop	43.5	45.8	169.1	180.6	238.1	8.4	124.1	812.0
T_7, Application of FYM 10 t/ha + *Azotobacter* + PSB + 50% RDF in plant and ratoon crop	39.4	42.3	154.1	162.4	210.0	7.6	108.5	718.3
T_8, Application of FYM 10 t/ha + *Azotobacter* + PSB + 100% RDF in plant and ratoon crop	45.9	51.0	170.6	180.5	236.7	8.5	124.9	804.5
T_9, Application of FYM 10 t/ha + *Azotobacter* + PSB + STR in plant and ratoon crop	46.3	49.8	170.2	183.0	237.4	8.9	125.8	801.6
SEm±	1.67	2.05	5.70	6.03	8.12	0.45	5.10	34.34
CD (P=0.05)	4.73	5.83	16.20	17.14	23.10	1.28	14.47	97.64

RDF, Recommended dose of fertilizer; STR, soil-test recommendation; FYM, farmyard manure; NMC, number of millable canes; DAP, days after planting; PSB, phosphate solubilizing bacteria

yield attributes. Application of trash @ 10 t/ha enriched with *Trichoderma viride* + 100% RDF (200 : 60 : 40 kg N : P_2O_5 : K_2O/ha) significantly increased tillers, millable cane, cane length and cane girth and single cane weight than application of trash 10 t/ha + 50% RDF. Increase in growth and yield attributes of sugarcane owing to conjunctive use of organic with inorganic nutrient sources might be because of immediate and quick supply of plant nutrients through chemicals and steady supply of plant nutrients following decomposition and mineralization that would have increased the availability of plant nutrients at later stage. This also brought improvement in soil moisture-holding capacity, properties of soil and fertility status of the soil and thus increasing the absorption of plant nutrients. Organic manure and trash mulching increased the availability of soil water to crop plants. Balanced dose of NPK enriched with biofertilizers and FYM also reduced tiller mortality and helped in retention of more tillers, which converted into higher NMC and cane weight. Synergistic relationship between nutrients, i.e. nitrogen, phosphorus and potassium, with organics sources are also well known. Shukla (2007) also reported the improvement in tillers, millable canes and cane yield with balanced fertilization of NPK in addition to organics source. Our results confirm the findings of Kumar (2012) and Jha *et al.* (2015).

Cane yield and quality

The highest cane yield (88.2 t/ha) and commercial cane sugar (CCS) yield (10.8 t/ha) was obtained with the application of FYM 10 t/ha + enriched with *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + STR (150 : 50 : 30 kg N : P_2O_5 : K_2O/ha) through inorganic source (Table 2). The percentage increase in the cane yield owing to application of FYM 10 t/ha + enriched with *Azotobacter* + PSB (12.5 + 12.5 kg/ha) + STR was 26.7, 21.2 and 20.1 respectively, over the above treatments. The higher cane yield was the cumulative effect of higher number of millable canes, individual cane length and cane weight. Thus, cane yield and CCS were also higher at this level. The higher cane yield contributed larger share in improving CCS (10.8 t/ha) than cane-quality parameters. However, the highest brix (20.2), sucrose (17.7%), CCS (12.2%) and purity (87.4%) were obtained with the application of 20 t FYM/ha + STR (150 : 50 : 30 kg N : P_2O_5 : K_2O /ha) through inorganic source. It was significantly superior over T_1, T_2 and T_7 treatments, but it was at par with other treatments. Sinha *et al.* (2017) reported that integrated use of organic and inorganic nutrient sources were found beneficial for improving cane productivity and maintaining nutrient status of calcareous soil. Another possible reason could be that improved soil conditions, soil moisture-holding capacity and bulk density with balanced fertilization enriched with organic manure encouraged root growth and increased the absorption of plant nutrients. This improved structure of the soils could have allowed more efficient use of not only the soil water, but also the nutrients. Thus, combination of NPK along with organic manure increased the cane yield and sugar yield because of better nutrient supplying capacity of the soil throughout growing season. Our results confirm the finding of Shukla *et al.* (2011) and Jha *et al.* (2015).

Soil physical properties and available nutrients status in soil

The application of organic substances either through cane trash or manure/ biofertilizer in combination with inorganic fertilizer revealed significant treatment differences and conserved soil organic carbon to a greater extent (Table 3).The highest organic carbon content (0.55%) and infiltration rate (4.69 mm/h) was obtained under the application of FYM 20 t/ha + STR (150 : 50 : 30 kg N : P_2O_5 : K_2O/ha), while the lowest soil *p*H (8.12) and bulk density (1.34 Mg/m^2) of soil obtained under the same treatment. However, ECe (0.28 dS/m^2) values recorded in the different treatments did not vary significantly among them. This was owing to improvement in soil health with the application of FYM. Lower bulk density determined in manure-treated plots was because of higher organic matter content of soil. Our results confirm the findings of Jha *et al.* (2015) and Sinha *et al.* (2017).

Available status of NPK at the end of crop cycle revealed that a positive effect of nutrient management strategies was observed. Addition of organic manure either 20 or 10 t/ha in combination with inorganic fertilizer showed significantly improvement in available of nitrogen, phosphorus and potassium in the soil as compared to no use of organic in plant and application of trash in ratoon crop treatments. The highest available N (363.8 kg/ha) was recorded with the application of 20 t FYM/ha along with 100% RDF (200 : 60 : 40 kg N : P_2O_5 : K_2O/ha) in plant and ratoon crop. Application of FYM was found superior to trash in making higher amount of nutrients available for longer period during crop growth. Available soil phosphorus content increased significantly in treatments receiving organic manure (FYM) in combination with inorganic fertilizer. The highest available phosphorus (27.0 kg/ha) was recorded with the application of 10 t FYM/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) and 150 : 50 : 30 kg N : P_2O_5 : K_2O/ha as STR through inorganic source-enriched soil in plant and ratoon crop, which was significantly higher than T_1,T_2 and T_3 treatments and statistically at par

Table 2. Effect of integrated application of organic and inorganic on cane yield, CCS yield and juice quality of sugarcane plant-ratoon system (pooled data of 3 years)

Treatment	Cane yield (t/ha)	Brix (%)	Sucrose (%)	CCS (%)	CCS yield (t/ha)	Purity (%)
T_1, No organic + 50% RDF in plant and application of trash 10 t/ha + 50% RDF in ratoon crop	69.6	17.9	15.31	10.4	7.3	85.4
T_2, No organic + 100% RDF in plant and application of trash10 t/ha + 100% RDF in ratoon crop	82.0	18.5	15.88	10.8	8.9	85.9
T_3, No organic + STR in plant and application of trash 10 t/ha + STR in ratoon crop	81.1	19.7	17.14	11.8	9.5	87.0
T_4, Application of FYM 20 t/ha + 50% RDF in plant and ratoon crop	72.8	19.5	16.92	11.6	8.5	86.8
T_5, Application of FYM 20 t/ha + 100% RDF in plant and ratoon crop	83.8	20.1	17.59	12.1	10.2	87.4
T_6, Application of FYM 20 t/ha + STR in plant and ratoon crop	86.6	20.2	17.67	12.2	10.6	87.4
T_7, Application of FYM 10 t/ha + *Azotobacter* + PSB + 50% RDF in plant and ratoon crop	73.5	18.9	16.34	11.2	8.3	86.3
T_8, Application of FYM 10 t/ha + *Azotobacter* + PSB + 100 % RDF in plant and ratoon crop	87.2	20.2	17.62	12.1	10.6	87.4
T_9, Application of FYM 10 t/ha + *Azotobacter* + PSB + STR in plant and ratoon crop	88.2	20.2	17.65	12.2	10.8	87.4
SEm±	3.86	0.45	0.46	0.37	0.58	0.37
CD (P=0.05)	10.96	1.28	1.32	1.05	1.66	1.06

RDF: Recommended dose of fertilizer; STR, soil-test recommendation; FYM, farm-yard manure; PSB, phosphate-solubilizing bacteria; CCS, commercial cane sugar yield

Table 3. Effect of integrated application of organic and inorganic on soil properties and nutrient status of soil after harvesting of sugarcane plant- ratoon system (pooled data of 3 years)

Treatment	OC (%)	Soil *p*H	ECe (dS/m²)	Bulk density (Mg/m³)	Infiltration rate (mm/hr)	Available nutrients (kg/ha) N	P	K
T_1, No organic + 50% RDF in plant and application of trash 10 t/ha + 50% RDF in ratoon crop	0.50	8.19	0.31	1.39	4.07	313.6	17.7	295.8
T_2, No organic + 100% RDF in plant and application of trash 10 t/ha + 100% RDF in ratoon crop	0.50	8.20	0.32	1.39	4.12	318.9	20.7	307.1
T_3, No organic + STR in plant and application of trash 10 t/ha + STR in ratoon crop	0.51	8.19	0.30	1.38	4.11	335.3	20.4	303.8
T_4, Application of FYM 20 t/ha + 50% RDF in plant and ratoon crop	0.54	8.13	0.29	1.36	4.61	349.3	26.1	323.1
T_5, Application of FYM 20 t/ha + 100% RDF in plant and ratoon crop	0.54	8.14	0.29	1.35	4.61	363.8	26.6	326.8
T_6, Application of FYM 20 t/ha + STR in plant and ratoon crop	0.55	8.12	0.28	1.34	4.69	361.5	27.0	331.1
T_7, Application of FYM 10 t/ha + *Azotobacter* + PSB + 50% RDF in plant and ratoon crop	0.52	8.18	0.28	1.37	4.53	313.9	25.3	324.1
T_8, Application of FYM 10 t/ha + *Azotobacter* + PSB +100% RDF in plant and ratoon crop	0.52	8.17	0.27	1.37	4.62	358.1	26.2	329.5
T_9, Application of FYM 10 t/ha + *Azotobacter* + PSB + STR in plant and ratoon crop	0.54	8.14	0.27	1.36	4.69	360.4	27.0	329.8
SEm±	0.02	0.01	0.07	0.02	0.18	14.10	1.87	7.35
CD (P=0.05)	0.05	0.05	NS	0.05	0.52	40.12	5.38	20.91

RDF, Recommended dose of fertilizer; STR, soil-test recommendation; FYM, farmyard manure; PSB, phosphate-solubilizing bacteria; OC, organic carbon; EC, electrical conductivity

with rest of the treatments. The post-harvest available P content of the soil indicated a significant and progressive increase with corresponding FYM applied treatments. Besides supplying a proportionate balanced amount to sugarcane, considerable amount of unutilized P was left in the soil. The highest available potassium (331.1 kg/ha) in post harvest soil was recorded significantly under the application of 20 t FYM/ha and 150 : 50 : 30 kg N : P_2O_5 : K_2O/ha as STR. It was significantly higher than T_1, T_2 and T_3 treatments and at par with rest of the treatments. It must be assumed that either K was released from the reserves held in the clay inter layers or some other form of K has been taken up by sugarcane. Application of either 20/ 10 t FYM/ha enriched with biofertilizer and fertilizer either 100 % RDF or STR improved availability of N, P and K in soil by microbial activity, i.e. inoculation of *Azotobacter* and PSB. Improved P availability could be owing to greater mobilization of soil P because of reduced P sorption, while increased available K might be owing to addition of available pool because of mineralization of organic matter by microorganisms. The decomposition of added organic matter and its mineralization increased the availability of nutrient and fertility status of soil as reported by Thakur *et al.* (2012).The improvement in the soil-fertility status owing to application of inorganic fertilizer in combination with FYM + biofertilizer had positive interaction of applied nutrients in balanced amount which solubilize the soil nutrient reserve and make it available to crop. Jha *et al.* (2015) reported that soil fertility could be maintained with use of organic manure in combination with chemical fertilizers to meet adequately the nutritional requirements of sugarcane crop.

Economics

The economic analysis of different treatments indicated that net returns and benefit: cost ratio was influenced by the nutrient-management treatments. There were differences in cost of cultivation and net returns due to different variable costs. Application of 150 : 50 : 30 kg N : P_2O_5 : K_2O/ha as STR through inorganic source-enriched soil with 10 t FYM/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ ha) in plant and ratoon crop fetched significantly higher gross returns (220,600₹/ha), net returns (110,500₹/ha) and benefit: cost ratio (2.00) over no organic + 50% RDF (100 : 30 : 20 kg N : P_2O_5 : K_2O/ha) in plant and application of trash 10 t/ha + 50% RDF in ratoon crop, application of FYM 20 t/ha + 50% RDF in plant and ratoon crop and application of FYM 10 t/ha + *Azotobacter* + PSB (12.5+12.5 kg /ha) + 50% RDF in plant and ratoon crop and at par with rest of treatments (Table 4). It showed per cent increase of 48.0, 63.4 and 46.2 in net returns and 14.3, 25.8 and 17.7 in B : C ratio, over, respective treat-

Table 4. Relative cost and economics of different treatment combinations (pooled over 2014–15, 2015–16 and 2016–17)

Treatment	Treatment cost (× 10^3 ₹/ha)	Production cost (× 10^3 ₹/ha)	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
T_1, No organic + 50% RDF in plant and application of trash 10 t/ha + 50% RDF in ratoon crop	4.47	99.5	174.0	74.6	1.75
T_2, No organic + 100% RDF in plant and application of trash 10 t/ha + 100% RDF in ratoon crop	7.87	102.9	205.1	102.3	2.00
T_3, No organic + STR in plant and application of trash10 t/ha + STR in ratoon crop	6.39	101.4	202.7	101.3	2.00
T_4, Application of FYM 20 t/ha + 50% RDF in plant and ratoon crop	19.40	114.4	182.0	67.6	1.59
T_5, Application of FYM 20 t/ha + 100% RDF in plant and ratoon crop	22.80	117.8	209.5	91.7	1.78
T_6, Application of FYM 20 t/ha + STR in plant and ratoon crop	21.32	116.3	216.5	100.1	1.86
T_7, Application of FYM 10 t/ha + *Azotobacter* + PSB + 50% RDF in plant and ratoon crop	13.20	108.2	183.8	75.6	1.70
T_8, Application of FYM 10 t/ha + *Azotobacter* + PSB + 100 % RDF in plant and ratoon crop	16.60	111.6	218.1	106.5	1.95
T_9, Application of FYM 10 t/ha + *Azotobacter* + PSB + STR in plant and ratoon crop	15.12	110.1	220.6	110.5	2.00
SEm±	–	–	8.53	7.82	0.08
CD (P=0.05)	–	–	24.24	22.22	0.23

RDF, Recommended dose of fertilizer; STR, soil-test recommendation; FYM, farmyard manure; PSB, phosphate-solubilizing bacteria

ments. This indicates that the response to NPK as STR-enriched soil with FYM @ 10 t/ha +*Azotobacter* + PSB showed positive trend in economic analysis of different treatments. The lowest net returns of 67,600₹/ha and B : C ratio of 1.59 were obtained with FYM 20 t/ha + 50% RDF in plant and ratoon crop. The increase in yield attributes and cane yield fetched higher net returns and benefit: cost ratio. Our results confirmed the findings of Kumar *et al.* (2014), and Meena *et al.* (2015).

It was concluded that application of soil test recommendation(150 : 50 : 30 kg N : P_2O_5 : K_2O/ha) through inorganic source along with 10 t FYM/ha + *Azotobacter* + PSB (12.5 + 12.5 kg/ha) appeared to be the best nutrient-management option for sustaining soil health, getting higher yield and net returns of sugarcane plant-ratoon system in clay loam soil of south-east Rajasthan.

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