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Yield and soil nutrient balance of sugarcane (*Saccharum officinarum*) plant–ratoon system under integrated nutrient management

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ABSTRACT

A field experiment was conducted during 2002 to 06 to find out suitable integrated nutrient management practice for sustenance of soil health and productivity in sugarcane (*Saccharum officinarum* L.) plant–ratoon cropping system for two cropping cycles. Integrated nutrient management strategies involving combinations of inorganics (NPK) + organic nutrient sources (FYM, pressmud, vermicompost, green manuring and trash incorporation) were tested against inorganic fertilizer (NPK) alone laid out in randomized block design with four replications. Results revealed that supply of nutrients to sugarcane plant through combined use of 120-60-40 kg N-P-K/ha + FYM (25% N) + *Azotobacter* + phosphate solubilizing bacteria (PSB) 2.5 kg/ha each and integrated use of 150-60-40 kg N-P-K/ha + trash 5 tonnes/ha incorporation with cellulolytic culture 1 kg/tonne of trash + *Azotobacter* + PSB in ratoon gave the highest cane yield of 99.8 and 92.1 tonnes/ha under plant and ratoon cane, respectively. The treatment also showed significant improvement in soil health at the end of crop cycle by 47.9% substantial increase in soil organic carbon (0.88 to 1.05%), 165.2% increase in soil microbial biomass-C (213 to 297 mg $C\text{-}CO_2$/kg soil) and 128.6% enhancement in soil microbial biomass–N (3.7 to 4.8 mg $N\text{-}NH_4$/kg soil) over initial value (0.71%, 112 mg $C\text{-}CO_2$/kg soil, and 2.1 mg $N\text{-}NH_4$/kg soil). Besides integrated nutrient management modules resulted in significant increase in the contribution of soil microbial-C to soil organic C varying from 2.38 to 3.03% against 1.58% of initial value. Soil physical properties were also enhanced as bulk density reduced from 1.57 to 1.42 Mg/m^3, water stable aggregates swelled from 0.345 mm to 0.482 mm diameter under integrated nutrient management modules at ratoon harvest. This practice was proved to be the most profitable (B: C ratio 1.94 and 2.90) for sugarcane plant and ratoon crop, respectively. Availability status of major nutrients (NPK) in soil after harvest of ratoon crop recorded a positive balance due to application of various treatments over the initial status.

Key words: Cane yield, Integrated nutrient management, Microbial biomass, Nutrient balance, Physical properties, Profitability

Profitability of sugarcane cultivation has drastically declined owing to increased cost of cultivation and declining factor productivity of monetary inputs, such as fertilizers and plant protection chemicals. Continuous use of heavy doses of fertilizers and plant protection chemicals potentially impair the soil microbial activity, leading to poor soil health (Singh *et al.,* 2007). Imbalanced application of fertilizers results in poor yields, deterioration of soil fertility and emergence of multiple nutrient deficiencies. Situation, therefore warrants for adoption of organic based resources that supply nutrients to plants through microbial mediation and in the process enrich soil organic carbon and microbial balance. Despite this, doubts are often raised over profitable production of long-duration crops, like sugarcane through exclusive use of organic sources only (Chhonkar and Dwivedi, 2004).

In recent past, the yield level of sugarcane is plateauing and productivity has been found to decline fast. The reasons to this effect are related to fewer amounts of organic matter and environmental pollution due to burning of sugarcane trash in intensive sugarcane growing areas and greater drain from nutrient pool of the soil (Spier *et al.,* 2004). Maintenance of adequate soil organic carbon is, therefore, of paramount significance. At present, when sustainability of the crop and soil productivity is burning issue, the integrated use of organics and inorganics needs to be emphasized to use nutrients and energy more efficiently than conventionally managed system as reported by Mader *et al.* (2002). By combined use of natural nutrient resources including FYM, sulphitation pressmud, vermicompost, green manuring in-situ, trash decomposition with cellulolytic culture and bio-fertilizers plus inorganics can be adequately met the nutrient requirement

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of sugarcane leading to profitable higher cane yield and soil productivity on sustainable basis in sugarcane based cropping system (Singh and Singh, 2002).

Hence, the present investigation was carried out to devise suitable integrated nutrient management module for sugarcane plant and ratoon crop and to assess its effect on soil physico-chemical and biological properties, nutrient balance, yield and economics of plant-ratoon system.

MATERIALS AND METHODS

A field experiment was conducted during 2002-06 at G.B.Pant University of Agriculture & Technology, Pantnagar situated at 29^0N latitude, 79.5^0 E longitude and 243.8 meters above mean sea level, represents a typical subtropical climate. The soil was silty clay loam in texture with pH 7.2, organic carbon 0.71%, total nitrogen 0.086%, available N 191 kg/ha, available P 18.3 kg/ha, available K 179 kg/ha and bulk density 1.57 Mg/m^3. Ten combinations o various sources of nutrients *viz.* T_1: recommended NPK in plant and ratoon crop, (control); T_2: 75% NPK + 25% N through farmyard manure (FYM) in plant crop and 100% NPK+ trash incorporation in ratoon; T_3: 75% NPK + 25% N through composted sulphitation pressmud (CSPM) in plant crop and 100% NPK + trash incorporation in ratoon; T_4: 100% NPK in plant crop and 75% NPK + green manuring in ratoon; T_5: 75% NPK + 25% N (FYM)+ biofertilizer in plant crop and 100% NPK + trash incorporation+ biofertilizers in ratoon; T_6: 75% NPK + 25% N (CSPM) + biofertilizer in plant crop and 100% NPK + trash incorporation + biofertilizers in ratoon; T_7: 50% NPK + 25% N (FYM) + biofertilizers in plant crop and 50% NPK + green manuring + biofertilizers in ratoon; T_8: 50% NPK + 25% N (CSPM)+ biofertilizers in plant crop and 50% NPK + green manuring + biofertilizers in ratoon; T_9: 50% NPK + 25% N through vermicompost (VC) + biofertilizers in plant crop and 75% NPK+25% N (VC) + biofertilizers in ratoon; T_{10}: 100% NPK + 25% N (FYM)+ biofertilizers in plant crop and 100% NPK + trash incorporation + biofertilizers in ratoon, were laid out in randomized block design with four replications. Recommended NPK dose for plant and ratoon was 120-60-40 and 150-60-40 kg/ha, respectively. Full dose of P and K was applied as basal, whereas N was applied in three splits, *viz.* 1/3 at sowing, 1/3 at tillering and remaining 1/3 with onset of monsoon. Soil inoculation with bio-fertilizers namely phosphate solubilizing bacteria (PSB) and *Azotobacter* 2.5 kg/ha each was done as basal. About 6000 kg/ha seed cane of 'COS 97264' sugarcane having three budded cane setts was planted in furrows 75 cm apart in third week of March and ratoon was initiated in third week of February. In trash incorporation treatment, about 5 tonnes/ha was spread over the plot and decomposed with cellulolytic culture (1 kg *Trichoderma* decomposing culture + 8 kg urea + 10 kg single superphosphate) in ratoon crop. Dhaincha (*Sesbania sesbane* L.) was planted in between two rows of sugarcane ratoon and; it was turned down manually for green manuring *in-situ* at flowering stage. Nutrient content in organic manures before application was analyzed on dry weight basis (FYM: 0.71-0.37-0.68; pressmud: 0.60-0.75-0.18; vermicompost: 0.51-0.35-0.57; trash: 0.52-0.06-0.44; *dhaincha:* 1.67-0.19-1.21% N-P-K). Observations were recorded using standard techniques. Soil pH was determined by pH meter. Bulk density at 0-15 cm soil depth in initial and at ratoon harvest was measured using core sampler; mechanical analysis was done following International Pipette method and aggregate size distribution (wet sieving) by Yodor (1936) method. Infiltration was measured using double ring infiltrometer (Bertrand, 1965). Soil samples were analyzed for organic carbon, total N, available N, P and K by standard methods. Soil microbial biomass C and N were determined using chloroform fumigation extraction method (Anderson, 1982). Plant samples of plant and ratoon crop were analyzed for determination of total N, P and K uptake. To work out economics, B: C ratio, cost of cultivation and net return were calculated for plant and ratoon crops separately.

RESULTS AND DISCUSSION

Soil physico-chemical and biological properties

Significant improvement in soil physical properties such as bulk density, water infiltration rate and size of stable aggregates was recorded under integrated nutrient management modules (Table 1). The highest reduction in bulk density (9.55%) at the harvest of ratoon crop over the initial (1.57 Mg/m^3) was observed through use of 100% NPK + 25% N (FYM) + biofertilizers in plant crop and 100% NPK+ trash incorporation+ biofertilizers in ratoon. Similarly, at harvest of ratoon, there was 47.1 to 94.1% increase in water infiltration rate as compared to initial (3.4 mm/hr), being the highest with T_{10}; at par with that of T_9 and the lowest with T_4; being at par with that of T_2. Least change in infiltration rate (38.2%) over initial value was observed in 100% NPK to plant and ratoon (T_1). The conspicuous improvement in soil health including physical properties upon the addition of organic manures is attributable to the role of organic matter in the granulation of soil particles, i.e. reduced bulk density and enhanced water infiltration rate may be attributed to the simultaneous increase in mean weight diameter of water stable aggregates from 0.376 to 0.482 mm at ratoon harvest under integrated nutrient management modules over the initial mean weight diameter (0.345 mm).

Data depicted in Table 1 revealed that at the end of plant-ratoon cycle, soil organic C ranged from 0.88 to 1.05% under different integrated nutrient management modules against control plot (T_1) 0.73% and initial value 0.71%. There was only 2.8% increase in organic C in 100% NPK to plant and ratoon (T_1) over initial. Magnitude of enhancement in soil organic carbon to the extent of 47.9% due to various integrated nutrient management modules over initial value was found highest (1.05%) with the application of 100% NPK + 25% N (FYM) + biofertilizers in plant cane and 100% NPK + trash + biofertilizers in ratoon (T_{10}), closely followed by 75% NPK + 25% N (FYM) + biofertilizers in plant crop and 100% NPK + trash incorporation+ biofertilizers in ratoon (T_5). Soil microbial biomass carbon was found significantly highest (297 mg CO_2-C/kg soil/day) under 100% NPK + 25% N (FYM) + biofertilizers in plant cane and 100% NPK + trash + biofertilizers in ratoon (T_{10}) and was at par (154.5% higher over initial) with 75% NPK + 25% N (CSPM) + biofertilizers in plant crop and 100% NPK + trash incorporation+ biofertilizers in ratoon (T_6) against initial value 112 mg CO_2-C/kg soil/day. Resultant increase in soil microbial biomass carbon (SMBC) up to 165.2% under various integrated nutrient management modules over initial may be largely attributed due to addition of sufficient quantity of biomass through different organic manures and its concomitant decomposition under hot-humid climate of sub-tropics and the supply of nutrients through 100% NPK to plant and ratoon (T_1) enhanced SMBC by 79.5% only over initial value. Consequently, the soil microbial biomass nitrogen was significantly highest (4.8 mg NH_4-N/kg soil/day) under 100% NPK + 25% N (FYM)+ biofertilizers in plant cane and 100% NPK + trash + biofertilizers in ratoon (T_{10}), followed by 50% NPK + 25% N (VC)+ biofertilizers in plant crop and 75% NPK + 25% N (VC)+ biofertilizers in ratoon (T_9) (4.7 mg NH_4-N/kg soil/day) against initial value 2.1 mg NH_4-N/ kg soil/day. There was 71.4% increase in SMBN through 100% NPK to plant and ratoon (T_1) over initial status. Similar to microbial biomass carbon, there was remarkable increase in microbial biomass nitrogen to the extent of 128.6% under various treatments indicating enhanced availability of nitrogen. These findings evidenced the fact that highly soluble C and N concentrations stimulate microbial activities, since organic substrates are chief source of energy for microbes. Moreover, contribution of microbes has been more pronounced in low fertile soils (Oliveira *et al*., 2006) as in this case.

At ratoon harvest, contribution of soil microbial C to soil organic C ranged between 2.38 and 3.03% (Table 1). None of our treatments reduced the ratio of soil microbial C: organic C at end of plant-ratoon system, indicating more accumulation of C into soil. Microbial biomass, al-

Table 1. Effect of different treatments on physico-chemical and biological properties of soil after harvest of sugarcane plant and subsequent ratoon (Pooled data of two cycles)

Treatment: *Plant*	Treatment: *Ratoon*	Bulk density (Mg/m^3)	Soil aggregate (mean weight diameter, mm)	Infiltration rate (mm/hr)	Soil organic C (%)	SMBC(mgC-CO_2/kg soil)	SMBN (mgN-NH_4/ kg soil)	% contribution of soil microbial C to soil organic C
100% NPK	100% NPK	1.50	0.374	4.7 (38.2)	0.73 (02.8)	201 (79.5)	3.6 (71.4)	2.75 (74.1)
75% NPK+25% N (FYM)	100% NPK+ trash	1.48	0.446	5.1 (50.0)	1.02 (43.7)	243 (117.0)	4.1 (95.2)	2.38 (50.6)
75% NPK+25% N (CSPM)	100% NPK+ trash	1.48	0.452	5.4 (58.8)	1.01 (42.3)	249 (122.3)	4.3 (104.8)	2.46 (55.7)
100% NPK	75% NPK+ GM	1.50	0.376	5.0 (47.1)	0.89 (25.4)	213 (90.2)	3.7 (76.2)	2.39 (51.3)
75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	1.46	0.458	5.7 (67.6)	1.05 (47.9)	279 (149.1)	4.4 (109.5)	2.66 (68.4)
75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	1.46	0.459	6.3 (85.3)	1.04 (46.5)	285 (154.5)	4.5 (114.3)	2.74 (73.4)
50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	1.44	0.470	6.4 (88.2)	0.91 (28.2)	257 (129.5)	4.6 (119.0)	2.82 (78.5)
50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	1.44	0.473	6.5 (91.2)	0.90 (26.8)	273 (143.8)	4.6 (119.0)	3.03 (91.8)
50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	1.42	0.476	6.6 (94.1)	0.88 (23.9)	258 (130.4)	4.7 (123.8)	2.93 (85.4)
100%NPK+25%N (FYM)+BF	100% NPK+ trash+ BF	1.42	0.482	6.6 (94.1)	1.05 (47.9)	297 (165.2)	4.8 (128.6)	2.83 (79.1)
SEm±		0.01	0.009	0.09	0.006	6.1	0.12	
CD (P=0.05)		0.03	0.027	0.28	0.02	17.7	0.33	
Initial		1.57	0.345	3.4	0.71	112	2.1	1.58

Figures in parentheses indicate improvement over initial value. SMBC, soil microbial biomass carbon; SMBN, soil microbial biomass nitrogen though small, plays a key role in controlling the nutrient recycling and energy flow due to its fast turnover (Li and Chen, 2004). Greater is the proportion of microbial carbon higher is the total microbial activity and better is the soil health. Moreover, since soils of subtropical India have organic carbon content upto 1% only, theses parameters are very sensitive indicators of soil quality and our findings indicated conspicuous improvement in soil microbial activity due to adoption of different integrated nutrient management modules in sugarcane-based production system.

Nutrient uptake and balance in soil

Sugarcane is a highly nutrient exhaustive crop as evident from nutrient removal data presented on a collective basis for plant and ratoon crop. At the end of plant-ratoon cycle, total N uptake was 405.1 kg/ha under 100% NPK alone to plant and ratoon crop (T_1) as compared to lowest uptake (304.5 kg/ha) in T_8 (Table 2). Among integrated use of fertilizers, the highest N was removed under T_{10} (511.3 kg/ha), followed by T_5 (479.8 kg/ha). The net N balance was found to be more negative under 100% NPK fertilizers in plant and ratoon crop (T_1), whereas it was positive in all other treatments except T_4 and T_9. The highest net gains of 32.0 and 21.0 kg N/ha were recorded with T_{10} and T_5, respectively; followed by T_6 (18.0 kg/ha). The minimum net gain of 3.0 kg N/ha was observed under T_8. Uptake of P was highest (63.7 kg/ha) with 100% NPK + 25% N (FYM) + biofertilizers in plant crop and 100% NPK+ trash+ biofertilizers in ratoon (T_{10}), followed by T_6 (60.3 kg/ha) as compared to 51.7 kg/ha in T_1 (Table 3). At end of plant-ratoon cycle, a net gain of 8.0 kg P/ha was found in T_{10}, followed by 6.3 kg P/ha under T_6. K uptake ranged from 469.6 to 682.9 kg/ha against 562.8 kg/ha in T_1. Uptake of K was the highest in T_{10}, followed by T_6 (638.3 kg/ha) (Table 4). The highest net gain of 57.0 kg K/ha in soil was recorded with T_{10}, followed by T_5 (50.0 kg K/ha). Significantly higher nutrients uptake under various integrated nutrient management modules over that of inorganics (control) indicated unrestricted availability of these nutrients in labile pool to support the crop growth and yield. The positive soil N, P and K balance observed in plots receiving organic manures plus inorganics+ biofertilizers at end of plant-ratoon cycle may be attributed to the richness of these sources in terms of organic matter and enhanced microbial activity. Although any permanent change in soil organic C pool is very slow, any substantial increase in the temporary organic C pool of the soil will definitely act as a source of nutrients on a long term basis. Availability status of N, P and K at end of plant-ratoon cycle revealed a positive effect of integrated nutrient management modules. The highest improvement in fertility status due to application of 100% NPK + 25% N (FYM) + biofertilizers in plant crop and 100% NPK + trash incorporation + biofertilizer in ratoon (T_{10}) may be attributed to cementing properties of FYM integrated with biofertilizers releasing organic acids which solubilise the soil nutrient reserve and make it available to crop as well as soil ameliorating effect of trash rich in nutrient content fortified with lignified compound present in organic manures responsible for slow release of nutrients resulting in reduced losses and build up of soil N pool. Positive balance of major nutrients (N, P and K) in soil at the end of crop cycle revealed soil fertility enriching effect of various integrated nutrient management modules, indicating adequate availability of N, P and K nutrients to ensure remunerative crop production.

Table 2. Effect of different treatments on the N balance in the soil after harvest of the sugarcane plant crop and the subsequent ratoon (Pooled data of two cycles)

Treatment: *Plant*	Treatment: *Ratoon*	Initial Soil N status (kg/ha)	N added (kg/ha)	Soil N status (kg/ha) after harvest of ratoon	N uptake by plant + ratoon (kg/ha)	Soil N balance (kg/ha)
100% NPK	100% NPK	191.0	270.0	173.0	405.1	- 18.0
75% NPK+25% N (FYM)	100% NPK+ trash	191.0	296.0	204.0	412.8	+ 13.0
75% NPK+25% N (CSPM)	100% NPK+ trash	191.0	296.0	201.0	405.1	+ 10.0
100% NPK	75% NPK+ GM	191.0	274.0	189.0	394.3	- 02.0
75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	191.0	346.0	212.0	479.8	+ 21.0
75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	191.0	346.0	209.0	467.6	+ 18.0
50% NPK+25% N (FYM)+ BF	50% NPK+GM+ BF	191.0	257.0	204.0	336.2	+ 13.0
50% NPK+25% N (CSPM)+ BF	50%NPK+ GM+ BF	191.0	257.0	194.0	304.5	+ 03.0
50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	191.0	290.0	187.0	329.4	- 04.0
100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	191.0	376.0	223.0	511.3	+ 32.0
SEm±				4.0	9.3	
CD (P=0.05)				11.6	26.9	

Cane yield, yield attributes and economics

Economic (cane) yield of sugarcane plant and ratoon crops in each crop cycle are the function of number of millable canes and the individual cane length at harvest of either plant crop or ratoon. All the integrated nutrient management modules brought about significant improvement in yield attributing characters and cane yield over that of control (Table 5). Significantly higher number of millable canes in plant and ratoon crops (1,31,200 and 1,38,800/ha), cane length (236.2 and 243.1 cm) and cane yield (99.8 and 92.1 tonnes/ha) were produced under 100% NPK+ 25% N (FYM) + biofertilizers in plant crop and 100% NPK + trash incorporation + biofertilizers in ratoon (T_{10}). However, application of 100% NPK to plant and ratoon (T_1) registered number of millable canes (1,10,500 and 1,18,900/ha); cane length (184.7 and 224.9 cm) and cane yield (78.1 and 79.2 tonnes/ha) in plant and ratoon crops, respectively. It is noteworthy that cane yield in plant and ratoon crops under various integrated nutrient management modules was higher than the average national cane productivity (62.0 tonnes/ha) realized with modern cultivation practices involving synthetic fertilizers and other agricultural organics and bio-inoculation inputs indicating adequate efficiency of organics in fulfilling the crop-nutrition requirements. Higher yield of plant and ratoon crops owing to different integrated nutrient management strategies over the cane productivity in inorganics alone may be attributed due to enhanced nutrient availability; improved

Table 3. Effect of different treatments on the P balance in the soil after harvest of the sugarcane plant crop and the subsequent ratoon (Pooled data of two cycles)

Treatment: Plant	Treatment: Ratoon	Initial Soil P status (kg/ha)	P added (kg/ha)	Soil P status (kg/ha) after harvest of ratoon	P uptake by plant+ratoon (kg/ha)	Soil P balance (kg/ha)
100% NPK	100% NPK	18.3	120.0	15.1	51.7	- 3.2
75% NPK+25% N (FYM)	100% NPK+ trash	18.3	124.0	20.8	51.1	+ 2.5
75% NPK+25% N (CSPM)	100% NPK+ trash	18.3	146.0	20.8	53.0	+ 2.5
100% NPK	75% NPK+ GM	18.3	110.0	19.7	50.5	+ 1.4
75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	18.3	148.0	23.6	60.2	+ 5.3
75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	18.3	170.0	24.6	60.3	+ 6.3
50% NPK+25% N (FYM)+ BF	50% NPK+GM+ BF	18.3	105.0	20.3	43.6	+ 2.0
50% NPK+25% N (CSPM)+ BF	50%NPK+ GM+ BF	18.3	127.0	20.6	43.5	+ 2.3
50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	18.3	141.0	18.9	44.0	+ 0.6
100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	18.3	163.0	26.3	63.7	+ 8.0
SEm±				0.05	1.5	
CD (P=0.05)				0.14	4.9	

Table 4. Effect of different treatments on the K balance in the soil after harvest of the sugarcane plant crop and the subsequent ratoon (Pooled data of two cycles)

Treatment: Plant	Treatment: Ratoon	Initial Soil K status (kg/ha)	K added (kg/ha)	Soil K status (kg/ha) after harvest of ratoon	K uptake by plant+ratoon (kg/ha)	Soil K balance (kg/ha)
100% NPK	100% NPK	179.0	80.0	191.0	562.8	+ 12.0
75% NPK+25% N (FYM)	100% NPK+ trash	179.0	121.0	221.0	574.5	+ 42.0
75% NPK+25% N (CSPM)	100% NPK+ trash	179.0	101.0	217.0	568.2	+ 38.0
100% NPK	75% NPK+ GM	179.0	100.0	198.0	548.4	+ 19.0
75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	179.0	121.0	229.0	550.7	+ 50.0
75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	179.0	101.0	223.0	638.3	+ 44.0
50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	179.0	99.0	211.0	480.8	+ 32.0
50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	179.0	79.0	215.0	469.6	+ 36.0
50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	179.0	118.0	204.0	496.6	+ 25.0
100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	179.0	131.0	236.0	682.9	+ 57.0
SEm ±				4.4	8.3	
CD (P=0.05)				12.6	24.2	

Table 5. Effect of different treatments on cane yield, yield attributes and economics of sugarcane plant-ratoon system (Pooled data of two cycles)

Treatment		NMC (× 10^3/ha)		Cane length (cm)		Cane yield (tonnes/ha)		Cost of cultivation (×10^3 ₹/ha)		Net return (×10^3 ₹/ha)		B:C ratio	
Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
100% NPK	100% NPK	110.5	118.9	184.7	224.9	78.1	79.2	33.5	25.4	53.5	63.0	1.60	2.48
75% NPK+25% N (FYM)	100% NPK+ trash	123.7	125.5	218.5	226.0	91.5	80.6	36.4	25.7	64.8	64.3	1.78	2.50
75% NPK+25% N (CSPM)	100% NPK+ trash	122.6	128.6	215.4	229.7	89.3	84.3	37.8	25.9	60.9	68.2	1.61	2.63
100% NPK	75% NPK+ GM	110.7	115.2	185.1	221.2	79.0	76.1	33.5	24.9	54.5	60.0	1.62	2.41
75% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	128.7	131.6	226.0	228.0	96.7	87.9	36.8	26.2	70.6	71.8	1.92	2.74
75% NPK+25% N (CSPM)+ BF	100% NPK+ trash+ BF	125.7	135.2	222.7	235.1	94.0	85.8	38.1	26.1	66.1	69.8	1.73	2.68
50% NPK+25% N (FYM)+ BF	50% NPK+ GM+ BF	120.5	104.5	212.4	211.7	87.9	69.2	35.6	23.9	61.4	53.5	1.72	2.24
50% NPK+25% N (CSPM)+ BF	50% NPK+ GM+ BF	119.7	109.1	209.6	215.3	84.9	70.4	37.0	23.9	56.8	54.8	1.54	2.29
50% NPK+25% N (VC)+ BF	75% NPK+ 25% N (VC)+ BF	116.9	115.5	205.5	223.5	83.8	77.7	35.4	28.4	57.3	58.2	1.62	2.05
100% NPK+25% N (FYM)+ BF	100% NPK+ trash+ BF	131.2	138.8	236.2	243.1	99.8	92.1	37.7	26.4	73.4	76.5	1.94	2.90
SEm±		3.4	5.3	8.2	8.4	2.5	2.5			1.4	1.8	0.05	0.06
CD (P=0.05)		10.8	16.8	24.5	NS	8.1	8.2			3.9	5.5	0.13	0.17

NMC: Number of millable canes

soil health and soil physical properties resulting in more profitability of sugarcane based production system. Organic resources are not only sources of major nutrients, but they also provide several micronutrients and plant growth-promoting hormones, which get together leading to better crop yields (Mader *et al.* 2002).

Comparing the profitability under various modules, based on benefit: cost ratio (Table 5), it was found that in case of plant crop, highest B: C (1.94) was realized with 100% NPK + 25% N (FYM)+ biofertilizers (T_{10}). It was followed by 75% NPK+ 25% N (FYM) + biofertilizers (T_5) as against 1.60 under inorganics alone (T_1). Whereas, 100% NPK+ 25% N (FYM) + biofertilizers in plant crop and 100% NPK + trash incorporation + biofertilizers in ratoon (T_{10}) was found getting highest net return (₹76,500/ha) through ratoon crop with B: C ratio 2.90, followed by 75% NPK + 25% N (FYM) + biofertilizers in plant cane and 100% NPK + trash incorporation+ biofertilizers in ratoon (T_5) as against 2.05 in T_9. The increase in B: C ratio in ratoon was mainly due to reduced cost of cultivation (approximately <30% than plant crop).

It might be concluded that a nutrient package of 100% NPK through chemical fertilizers along with 25% N through farm yard manure supplemented with biofertilizers may be adopted for plant sugarcane cultivation under integrated nutrients application mode in subtropical climate, whereas for subsequent ratoon 100% NPK through inorganics along with trash incorporation with cellulolytic culture plus biofertilizers. It not only gave better economic output, but also improved the soil health in terms of positive nutrient balance and higher microbial activity.

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