

Sugarcane productivity and soil health in a bionutrition-based multi-ratooning system under sub-tropics*

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Sugarcane (*Saccharum* spp complex hybrid) cultivation in Indian sub-tropics is characterized by raising of as many number of ratoons owing to its substantially low cost of production. Ratoon crops however, seldom receive proper care and inputs due to being considered a free crop by majority of farmers poor in resources. Such an approach for a long duration (4–5 years) production system, like this often leads to significant deterioration in soil health (Singh *et al.* 2007). Continuous use of higher doses of chemical fertilizers on the other hand raises the cost of production so high that renders the system unprofitable. Application of organic matter replenishes soil organic carbon which improves soil structure and fertility and is being increasingly favoured (Dawe *et al.* 2003). Keeping these points in view, the present study was undertaken to assess the efficacy of different bioresources in sugarcane multi-ratoon production system in terms of sustaining soil health and crop productivity.

Field experiments were conducted during 2003–07 at Indian Institute of Sugarcane Research, Lucknow. Soil of the field was sandy loam having bulk density 1.40 Mg/m³, aggregate size (>0.25 mm) 15.2%, infiltration rate 4.1 mm/hr, organic carbon (0.32%), pH 7.7, EC 0.24 dS/m, available N 230 kg/ha, available P 21.5 kg/ha and exchangeable K 217.9 kg/ha, soil microbial biomass carbon 47.6 mg Co₂-C/kg soil/day and soil microbial biomass nitrogen 3.76 mg NH₄-N/kg soil/day.

Six treatments, viz control, vermicompost (10 tonnes/ha), farmyard manure (10 tonnes/ha), biogas slurry (10 tonnes/ha), sulphitation pressmud (10 tonnes/ha) and NPK (150:

60: 60 N + P₂O₅ + K₂O kg/ha) were conducted in randomized block design with 4 replications. All the resources were manually applied to field every year. Vermicompost, farmyard manure, biogas slurry and sulphitation pressmud contained 1.5, 0.5, 1.2 and 1.5% N; 0.5, 0.27, 1.2 and 0.75% P and 0.8, 0.25, 1.01 and 0.5% K, respectively. 'Co Se 92423' sugarcane was planted at 75 cm row spacing in first week of March 2003. Sugarcane plant crop was harvested from ground level on 15 February 2004 and immediately ratoon initiation was done. Four consecutive ratoon crops were taken in the same field and were harvested during December every year. Gap filling was required in third and fourth ratoon which was done by using slip setts. The soil samples were collected before commencement of experiment and at harvest of each crop and analyzed for soil properties using standard procedures.

Improvement in soil physical properties, like water stable aggregates, bulk density and water infiltration rate at harvest of fourth ratoon was recorded due to addition of various bioresources, whereas no or little change in these properties was observed under fertilizer application and in control. Bioresources caused decline in bulk density from 1.40 to 1.23 Mg/m³ and water stable aggregates increased from 15.2 to 18.3% under biomanure treatments. Increase in water infiltration rate due to different bioresources varied from 5.7 to 5.9 mm/hr as compared to 4.2 and 4.5 mm/hr recorded under control and fertilizer applied plots (Table 1). Enhanced soil physical properties due to biomanures is attributed to the granulation of soil leading to porous condition and low bulk density that help enhance the water infiltration rate in to soil as encountered in this study. This gets corroborated with the increase in mean weight diameter of water stable aggregates too.

Biomanures effected substantial increase in organic carbon content of the soil (Table 1). Highest increase leading to 0.67% organic carbon was recorded with sulphitation pressmud. In control too slight increase of organic carbon was recorded (0.36%) over initial level (0.32%) that may be due to the huge biomass addition through underground

*Short note

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Table 1 Physical properties, organic carbon and total soil N as influenced by different treatments at the end of plant multi-ratoon system

Treatment	Bulk density (Mg/m ³)	Water stable aggregate >0.25 mm mean wt. diameter (%)	Infiltration rate (mm/hr)	Soil organic carbon (%)	Total soil nitrogen (%)
Control	1.39	15.5	4.2	0.36	0.041
NPK (150: 60: 60 kg/ha)	1.40	15.5	4.5	0.45	0.056
Vermicompost (10 tonnes/ha)	1.24	17.9	5.7	0.62	0.069
Farmyard manure (10 tonnes/ha)	1.24	17.8	5.7	0.65	0.077
Biogas slurry (10 tonnes/ha)	1.24	17.7	5.7	0.63	0.068
Sulphitation pressmud (10 tonnes/ha)	1.23	18.3	5.9	0.67	0.082
CD (<i>P</i> =0.05)	0.12	0.45	0.30	0.12	0.015

Table 2 Microbial activity at grand growth stage, nitrogen uptake and balance at the end of crop sequence, cane yield and economics as influenced by different treatments (pooled over plant and subsequent 4 ratoon crops)

Treatment	SBMC (mg CO ₂ -C/kg soil/day)	SMBN (mgNH ₄ -N/kg soil/day)	Nitrogen uptake (kg/ha)	Nitrogen balance in soil at harvest of 4th ratoon (kg/ha)	Nitrogen gain or loss at harvest of 4th ratoon (kg/ha)	Cane yield (tonnes/ha)	B: C ratio
Control	89.8	2.5	100.3	130.1	-99.9	42.7	0.96
NPK (150: 60: 60 kg/ha)	101.7	2.3	218.6	255.9	+ 25.9	71.2	1.74
Vermicompost (10 tonnes/ha)	139.6	5.0	188.9	260.3	+ 30.3	70.7	0.48
Farmyard manure (10 tonnes/ha)	135.1	4.6	164.7	250.5	+ 20.5	67.2	1.78
Biogas slurry (10 tonnes/ha)	129.5	4.4	172.9	250.9	+ 20.9	67.1	1.76
Sulphitation pressmud (10 tonnes/ha)	145.2	5.1	198.6	273.4	+ 43.4	72.0	1.86
CD (<i>P</i> =0.05)	6.7	0.5	11.3	NA	NA	7.1	NA

SBMC, Soil microbial biomass carbon; SMBN, soil microbial biomass nitrogen; NA, not analyzed

stubbles of sugarcane crop. Plots added with recommended dose of NPK through chemical fertilizers recorded 0.45% organic carbon, whereas the increase in organic C through bio-resources ranged from 0.62 to 0.67% clearly indicating superior effect over the chemical fertilizers as far as build up of organic matter is concerned. Dee *et al.* (2003) reported enhanced organic carbon upon pressmud application under sugarcane that previously witnessed loss under conventional agriculture. Similarly, due to different bioresources increase in total nitrogen content varied from 0.069 (vermicompost) to 0.082% (sulphitation pressmud), whereas fertilizer application caused total soil nitrogen enrichment to the level of 0.056%. Soil enrichment in terms of organic carbon and total nitrogen due to addition of bioresources is attributable to increased soil microbial activity as observed at grand growth stage (Table 2) being highest with sulphitation pressmud (145.2 mg CO₂-C /kg soil/day), followed by vermicompost, biogas slurry and farmyard manure against 101.7 mg CO₂-C/kg soil/day recorded for chemical fertilizers leading to accumulation of microbial biomass nitrogen that was recorded highest with the addition of pressmud (5.1 mg NH₄-N/kg soil/day), closely followed by vermicompost (5.0 mg NH₄-N/kg soil/day) against the initial content (3.76 mg

NH₄-N/kg soil/day). Significantly higher microbial biomass nitrogen with bioresources over that with recommended NPK through chemical fertilizers (2.3 mg NH₄-N/kg soil/day) and control (2.5 mg NH₄-N/kg soil/day) indicate immobilization of nitrogen by microbial population which act as a reserve pool to effectively meet the crop requirement for longer periods as in multi-ratooning system and also due to reduced losses through leaching and volatilization owing to slow release of nutrients from biomanures (Gill and Brar 2005).

Nitrogen uptake under application of recommended fertilizers (218.6 kg/ha) was higher over that with addition of bio-resources (164.7 to 198.6 kg/ha). However, similar cane yield with recommended fertilizers (72.0 tonnes/ha) and addition of sulphitation pressmud (71.2 tonnes/ha) suggests that sulphitation pressmud (10 tonnes/ha) adequately meets the nitrogen requirement of sugarcane crop in a multi-ratooning system, which may be attributed to the availability of all the essential plant nutrients in pressmud and its faster decomposition as compared to other bioresources. Besides addition of bioresources for 5 consecutive sugarcane crops resulted in positive soil nitrogen balance at the harvest of fourth ratoon. The highest gain of 43.4 kg/ha was recorded with sulphitation pressmud, followed by vermicompost (30.3

kg/ha). Positive nitrogen balance (25.9 kg/ha) was also there with fertilizer application. However, control recorded a negative balance (99.9 kg/ha) at the end of the crop cycle. Economics as elucidated by benefit : cost (B:C) ratio indicated that addition of sulphitation pressmud resulted in higher B : C ratio (1.86) over the recommended NPK applied through fertilizers (1.74).

It is concluded that bioresources, viz sulphitation press mud, vermicompost and farmyard manure (10 tonnes/ha) in sugarcane multi-ratoon system not only enhanced the soil physical properties, soil organic carbon and microbial activity but also adequately met the nitrogen requirement leading to similar yield as with recommended fertilizers.

SUMMARY

A field experiment was conducted during 2003–07 to study the effect of nutrition through bioresources on sugarcane productivity and soil health in a multi-ratooning system. Substantial enhancement in soil health and physical properties was obtained due to different bioresources. Addition of sulphitation pressmud over the years produced similar cane yield (72 tonnes/ha) as that with recommended fertilizers (71.2 tonnes/ha). Removal of nitrogen by the crop under sulphitation pressmud application was 198.6 kg/ha against 218.6 kg/ha with recommended NPK. Finally a

positive nitrogen balance up to 43.4 kg/ha was recorded with the addition of bioresources as compared to 25.9 kg/ha with fertilizer application. Besides sulphitation pressmud application resulted in higher benefit : cost ratio (1.86) over that with fertilizer application (1.74). Bioresources effectively meet the nitrogen requirement of sugarcane crop in a multi-ratooning system that yields at par with fertilizer application with higher profitability.

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