

RESEARCH ARTICLE

EFFECT OF GREEN CANE TRASH BLANKETING AND MICROBIAL CONSORTIA APPLICATION ON SOIL COMPACTION AND PRODUCTIVITY OF MECHANICALLY HARVESTED SUGARCANE RATOON CROPS

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Abstract

Burning of sugarcane crop residue in India is a common practice among the farmers due to scarcity of labour and slow decomposition of trash due to wider C/N ratio. In-situ trash management and green cane trash blanketing can be good alternate strategies to mitigate these problems. Microbial consortia comprising of *Trichoderma viride*, *Humicola spp*, *Paecilomyces lilacinus*, *Gluconacetobater diazotropicus*, *Azospirillum brasilense* and *Bacillus subtilis* have great potential to recycle crop residue and restore soil fertility, eventually promote sugarcane growth. Impact of green cane trash blanketing (GCTB) and microbial consortia application on the growth and yield of ratoon sugarcane was assessed in farmer's field at Talwaipettai, in Erode District, Tamil Nadu, India. A replicated field experiment comprising of four green cane trash blanketing treatments in randomised block design was conducted in machine harvested first and second ratoon crops during 2013-14 and 2014-15 respectively. The result of trials revealed that in machine harvested plant and first ratoon crop 16.29 and 20.11 t ha⁻¹ of sugarcane trash with appreciable amount of nutrients i.e. N(0.5 %), P(0.12 %) and K (0.73 %) was available for recycling for subsequent first and second ratoon crop, respectively. The practice of green cane trash blanketing couple with manipulation of upper soil layer by off-barring after machine harvested first ratoon crop, could reduce the soil compaction (2.21 MPa) in surface soil i.e. 0-15 cm thereby improved cane weight, cane height and overall sugarcane growth. Comparable sugarcane shoots were recorded at 90 and 240 days after ratoon initiation. Green cane trash blanketing and microbial consortia application recorded the highest mean cane yield of 128.55 t ha⁻¹ than trash removal (123.2 t ha⁻¹) treatment.

Key words: Sugarcane, green cane trash blanketing, microbial consortia, soil compaction

Introduction

Sugarcane (*Saccharum officinarum* L.) is an important cash crop of India which is cultivated on 4.5 m ha, producing nearly 306 million tonnes (Anonymous, 2017). The crop being long duration and nutrient exhaustive removes about 205 kg N, 55 kg P₂O₅, 275 kg K₂O and a large amount of micronutrients from the soil. In order to sustain productivity, major nutrients are provided at recommended application rates, which

in the tropical part of India are 280 kg N ha⁻¹ for sugarcane plant crop and 350 kg N/ha for its ratoon crop and 60 and 120 kg each of P₂O₅ and K₂O ha⁻¹ for both the plant and ratoon crops. However, the efficiency of sugarcane to utilize N is very less moreover, fertilizer application in tropical India is inadequate, imbalance, skewed and in favour of nitrogen. The frequent and excessive use of chemical fertilizer has created problems like deterioration of soil health and ecology. It has

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observed that in recent years yield of sugarcane has reached a plateau due to decline in factor productivity in the Tropical India. Deterioration in the physio- chemical and biological properties of the soil is considered to be the prime reason for the declining sugarcane productivity (Garside, 1997; Speir et al., 2004). In the current stagnating sugarcane yield scenario in the tropical India, conservation of dwindling natural resources such as soil and water are the prime option for sustaining and enhancing the crop yield. In this context, crop residue incorporation plays vital role in maintaining and improving soil organic matter. By and large, good crop of sugarcane produced about 10 to 15 t ha⁻¹ of trash. It contains on an average 0.42 per cent N, 0.15 per cent P and 0.57 per cent K, in addition to other secondary and micronutrients; moreover, it is a potential source of organic matter (46.5%) in sugarcane farming. Soil incorporation of trash releases nutrients after decomposition. This may build up the nutrients in soil and change physical properties of soil. Thus, for improving the sugarcane production base and harnessing higher yield per drop of water, greater thrust needs to be given on conservation measures through using on-farm resources. Green cane trash blanketing (dry leaves, tops and pieces of stalks retained on soil after mechanised sugarcane harvest) is abundantly available in mechanically harvested field. It also provides multiple physical, chemical and biological benefits to the soil and sustains crop yields. However, high C:N ratio (73.1:1), immobilisation of soil nutrients up to 100 DAR, high fibre content, lack of proper composting techniques and prolonged decomposition of sugarcane trash in the field are the main constraint in its recycling (Tayade et al., 2016). Hence, a comprehensive study was conducted to know the

soil compaction due to mechanised harvesting and effect of green cane trash blanketing and microbial consortia application on soil compaction and sugarcane yield .

Materials and Methods

The study was conducted at farmer's field in a participatory mode. The experimental site was located at Thalavaipettai, Tamil Nadu, India (Fig.1).

The soil of the experimental site was low in available nitrogen and medium in available P and K. Replicated field experiments comprising of four green cane trash blanketing treatments in randomised block design were conducted in first and second ratoon crops during 2013-14 and 2014-15, respectively. Sugarcane cultivar Co 0323 was planted in wide rows spaced 1.5 metre and good plant crop was raised by adopting standard agronomic practices. The plant cane was harvested mechanically without burning at 12 month maturity and the crop residues (dry leaves, stalks and tops) were left on the soil surface. The soil compaction due to harvesting was monitored with the soil penetrometer in first and second ratoon. The dry weight of sugarcane trash left on the soil surface was determined by sampling one m² area in each treatment plots. A total of 16.29 and 20.11 t ha⁻¹ dry sugarcane trash with appreciable amount of nutrients i.e. organic carbon (36.57 %), N(0.5), P(0.12), K (0.73) and C:N (73.1:1) was available for recycling for subsequent first and second ratoon crop, respectively. Ratoon operations in sugarcane were started from 13/3/2013 and four green cane trash blanketing (GCTB) treatments viz., Control (removal of trash) + 100 % RDF, GCTB + 100 % RDF, GCTB + application of microbial consortia (MC) + 100 % RDF and GCTB + MC +75 %



Fig. 1. Experimental site for GCTB experiment in machine harvested sugarcane crop

RDF were implemented. A recommended dose of fertilizers, i.e. 350:60:120 kg N:P₂O₅:K₂O ha⁻¹ was adopted wherein full dose of P was applied at the time of ratoon initiation. After eighty days of ratooning, fertigation of N and K was done through subsurface drip irrigation system. Microbial consortia comprising *Trichoderma viride* (5 x 10⁶ colony forming units (cfu) g⁻¹ culture), *Humicola* spp. (2 x 10⁶cfu g⁻¹ culture) and *Paecilomyces*

lilacinus (2 x 10⁶cfu g⁻¹ culture) at 10 kg ha⁻¹ each and *Gluconacetobacter diazotrophicus* (1.4 x 10⁷cfu g⁻¹ culture), *Azospirillum brasilense* (2.1 x 10⁸cfu g⁻¹ culture) and *Bacillus subtilis* (1 x 10⁷cfu/g culture) at 10 kg/ha each were mixed with composted coir pith and applied twice at 30 and 60 DAR. After application of microbial consortia field was irrigated. The shoot counts were measured during crop establishment

whereas, number of millable canes (NMC), cane height, single cane weight, cane yield and juice quality parameters were recorded at the time harvesting. Juice quality parameters, viz. Brix (%), Pol (%) and purity (%) were analyzed as per standard methods of Meade and Chen (1977). Commercial cane sugar % was calculated using the formula $[(\text{Sucrose}\% \times 1.022) - (\text{Brix} \times 0.292)]$. The data were subjected to statistical analysis for interpretation of the results.

Results and Discussion

Growth and yield attributes

The shoot count recorded in first ratoon crop at 90 days after ratoon initiation (Table 1) showed that during initial crop phase, the effect of green cane trash blanketing on tiller numbers was nonsignificant which is indicative of the fact that trash blanketing could not affect the establishment of ratoon crop. In the tropics, the effects of trash blanketing on tillering are transitory and can be compensated for in the longer growing

seasons (Torres and Villegas 1995). The results here contrast with that of the Viator et al. (2009) showed lower populations in Louisiana's humid, temperate environment.

As crop progressed towards grand growth (210 DAR) decrease in shoot numbers was observed. Reduction in shoot count in the later growth phase of crop mostly associated with competition between the shoots for nutrients, light and soil moisture wherein maximum reduction in shoot count was recorded in GCTB + 75% RDF application because of reduction in 25% of RDF. Whereas, all the three green cane trash blanketing treatments with 100% RDF application (green trash blanketing alone and GCTB plus microbial consortia application and removal trash (126222 shoots ha⁻¹) recorded least reduction in shoot count and were found statistically on par with each other.

With respect to cane length, in first ratoon crop, at 90 and 210 days after ratooning, plant height did not influence significantly due to various green

Table 1. Effect of green cane trash blanketing on growth and cane yield of first ratoon sugarcane crop

Sl. No.	Treatments	90 DAR		210 DAR		At harvest		
		Plant height (cm)	Shoots ha-1	Plant height (cm)	Shoots ha-1	NMC ha-1	SCW (kg)	Yield (t ha ⁻¹)
1	Trash removal +100 % RDF	68.80	172889	184.60	126222	116222	1.126	131.27
2	GCTB+ 100 % RDF	75.20	174444	186.60	117333	107333	1.232	132.72
3	GCTB+ MC+100% RDF	70.00	173778	184.00	114444	104444	1.278	133.57
4	GCTB+MC+ 75 % RDF	74.00	172889	184.00	112222	102222	1.206	121.32
	S. Ed.	5.26	4618.27	10.37	3250.07	2561.83	0.0400	1.021
	LSD at 5%	NS	NS	NS	7081.30	7081.30	0.0873	2.23

GCTB : Green Cane Trash Blanketing, RDF: Recommended Dose of Fertilizer, MC: Microbial Consortia, DAR : Days After Ratooning , SCW: Single Cane Weight, NMC: Number of Millable Cane

Table 2. Effect of green cane trash blanketing on growth and cane yield of second ratoon sugarcane crop

S. No.	Treatments	Cane length (cm)	Single cane weight(kg)	NMC ha ⁻¹	Cane Yield (t ha ⁻¹)
1	Trash removal +100 % RDF	190.6	1.18	97299.43	115.10
2	GCTB+ 100 % RDF	239.0	1.38	85827.74	118.27
3	GCTB+ MC+100% RDF	226.0	1.42	88356.00	124.38
4	GCTB+MC+ 75 % RDF	202.0	1.19	93859.20	111.50
	S. Ed.	13.97	0.05	4454.18	4.86
	LSD at 5%	30.44	0.12	NS	NS

GCTB: Green Cane Trash Blanketing, RDF: Recommended Dose of Fertilizer, MC: Microbial Consortia, DAR: Days After Ratooning , SCW: Single Cane Weight, NMC: Number of Millable Cane.

cane trash blanketing treatments. Whereas in the second ratoon crop, due to drought like situation, treatments differences for cane length were more pronounced at harvest wherein significant improvement in cane length due to green cane trash blanketing (239 cm) was noticed over trash removal (190.6 cm). The beneficial effect of green cane trash blanketing on cane length was attributed to higher soil moisture and multiple benefits of trash on growth of sugarcane. This finding is consistent with earlier work published by Tayade et al., (2016).

Retention of green cane trash blanketing (GCTB) coupled with microbial consortia (MC) application in first and second ratoon sugarcane crop was resulted in higher single cane weight (1.28 and 1.41kg), moreover, it was found significantly superior over trash removal. Growth promoting substances released by *Trichoderma viride*, *Humicola spp*, *Paecilomyces lilacinus*, *Gluconacetobater diazotropicus*, *Azospirillum brasiliense* and *Bacillus subtilis* could have enhanced the uptake of nutrients and single cane weight (Harman 2000).

Number of millable canes (NMC) and cane yield

Number of millable canes ha⁻¹ was influenced significantly by the various green cane trash blanketing treatments during first ratoon crop wherein green cane trash blanketing + 100 % RDF was on par with trash removal. During second ratoon crop, NMC was not influenced due to various green cane trash blanketing treatments suggesting that green cane trash blanketing treatments didn't affect crop establishment and finally the NMC (Table 1 and 2). Sugarcane yield is mainly a function of number of millable canes available in the field and the composition of mother shoots, primary, secondary and tertiary tillers at the time of harvest. It is well known fact that higher number of mother shoots and initial tillers brings about higher cane yield. It was observed that effect of green cane trash blanketing on cane yield during first and second ratoon crop was significant wherein retention of green cane trash blanketing + 100 % RDF plus application of microbial consortia recorded the maximum cane yield of 133.57 t ha⁻¹

and 124.38 t ha⁻¹, respectively. The mean (2 years) cane yield improvement of 5.79 and 12.57 t/ha by GCTB + 100% RDF + MC treatment over trash removal and GCTB+75% RDF+MC application was observed. The incremental cane yields were basically associated with improved initial stand establishment, comparable NMC and increased cane length and single cane weight. Hari and Srinivasa (2005) also found better improvement in yield attributing parameters of sugarcane due to integral applications of biofertilizers with chemical fertilizers. The results of the present investigation suggest green cane trash blanketing with 100 % RDF and microbial consortia application provides better yields than trash removal under tropical Indian conditions. This agrees with Van Antwerpen (2001) who reported a significant yield benefit in green cane harvesting under long term residue management study in a tropical, arid growing environment of South Africa, presumably because of higher rainfall efficiency, reduced weed competition and favourable soil properties such as moisture retention, nutrients recycling and organic matter addition. Similarly Dhanapal et.al., 2018 also reported higher cane yield in composted coir pith and trash applied sugarcane crop than control. The treatments GCTB + 100 % RDF and trash removal were on par with retention of green cane trash blanketing + 100 % RDF plus application of microbial consortia during first ratoon. All the green cane trash blanketing treatment with 100 % RDF application recorded significantly higher cane yield over GCTB + 75 % RDF. This suggests the need of mineral NPK application during the first and second ratoon crop as there is temporary immobilization of nitrogen due to availability of huge amount cane trash after mechanical cane harvest.

Sugarcane juice quality

The sugarcane juice analysis done at harvest revealed (Fig. 2) that sugarcane juice quality parameters such as Pol %, Purity % and CCS % were not influenced by the green cane trash blanketing treatments in first ratoon crop at harvest.

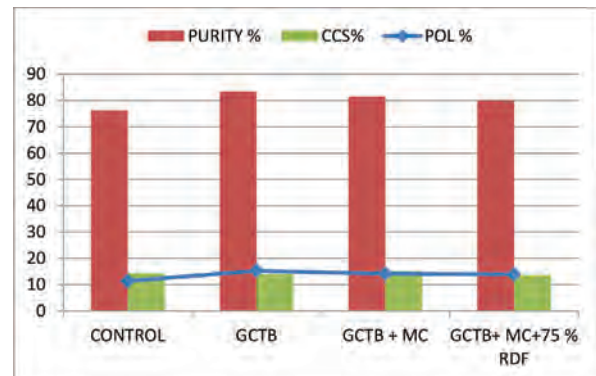


Fig. 2. Sugarcane juice quality parameters at harvest in the first ratoon crop

Soil compaction and available soil nitrogen

The soil compaction due to harvesting was monitored with the soil penetrometer in first and second ratoon (fig.3 and fig.4). Compared to manual harvesting, soil compaction was more in machine harvested plots. This was in agreement with findings of Usaborisut and Sukcharoenvipharat, 2011, who reported the highest bulk density (1.79 kg m⁻³) in mechanized farming while the lowest

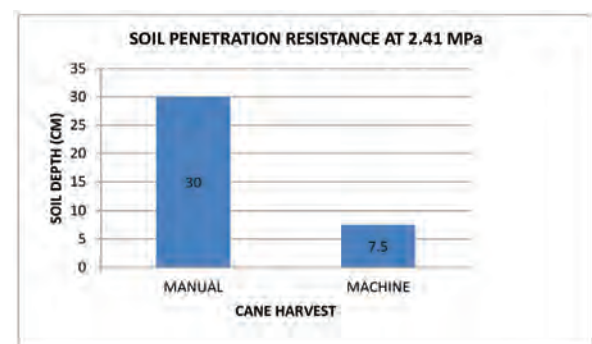


Fig. 3. Soil compaction after machine harvest of plant crop (20.03.2013)

value (1.24 kg m^{-3}) in the field cultivated using manual labour.

Retention of green cane trash blanketing in first and second ratoon crop influenced the soil compaction wherein lower soil compaction was registered for it, which may be attributed to soil bulk density difference under different green cane trash blanketing treatments. The lower bulk density under trashing than burning, particularly in the inter-row, is partially attributed to the higher organic matter content and the greater resilience of the soil to compaction (Soane, 1990). Similarly Graham and Haynes (2006) also reported a greater bulk density under burnt than trashed sugarcane and was greater in the inter-row than row, particularly under burning. Data on soil compaction after machine harvested first ratoon crop (fig. 4) indicated that soil compaction in surface soil i.e. 0-15 cm soil depth was less as compared to subsurface soil may be due to manipulation of upper soil layer during ratooning operation such as off-barring and green cane trash blanketing.

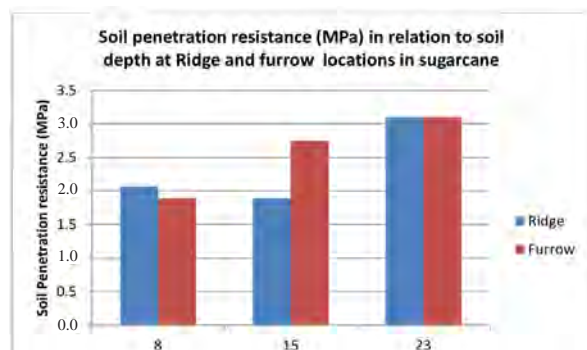


Fig. 4. Soil compaction after machine harvest of first ratoon crop (21.05.2014)

Lower values of soil compaction (2.21 MPa) before the harvest of second ratoon crop (figure 5) suggested that the green cane trash blanketing

and ratooning practices over period of two years might have lessened the soil compaction.

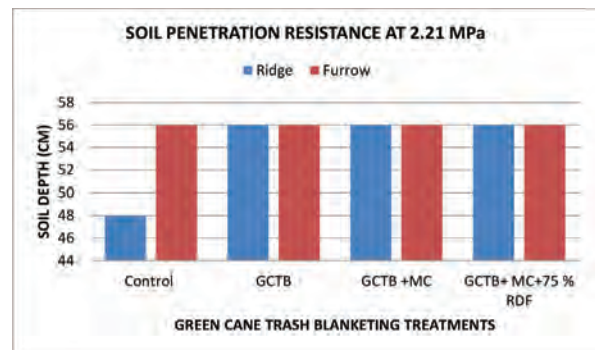


Fig. 5. Measurement of soil compaction by using soil penetrometer before harvest of second ratoon crop (16.12.2014)

Numerically lower soil EC and pH values were observed in control plot whereas, numerically higher soil available nitrogen values after harvest of first ratoon crop were recorded in GCTB + 100% RDF and GCTB + 100% RDF + microbial consortia application treatments (Figure 6). The probable reason was soil enrichment by green cane trash blanketing and beneficial role played by the microbial consortia.

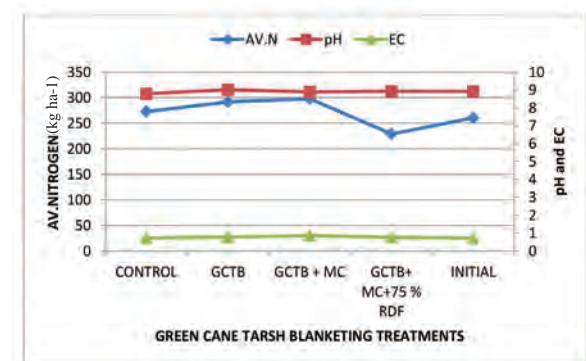


Fig. 6. Effect of green cane trash blanketing on soil chemical properties after harvest of first ratoon crop

Trash retention on soil surface have positive effects on soil chemical properties and organic matter content (Graham et al., 2002) and increase the size and activity of the microbial community.

Numerous investigators have measured or modelled soil enrichment for green cane harvesting on both long-term basis (Van Antwerpen, et al. 2001) and even on short-term basis (Wiedenfeld 2009).

Conclusion

The result of trials revealed that machine harvested plant and first ratoon crop, 16.29 and 20.11 t ha⁻¹ of sugarcane trash with appreciable amount of nutrients i.e. N(0.5 %), P(0.12 %) and K (0.73 %) was available for recycling for subsequent first and second ratoon crop, respectively. The practice of green cane trash blanketing couple with manipulation of upper soil layer by off-barring after machine harvested first ratoon crop, could reduce the soil compaction (2.21 MPa) in surface soil i.e. 0-15 cm thereby improved cane weight, cane height and overall sugarcane growth. For sustained sugarcane production, green cane trash blanketing and microbial consortia application over trash removal could be recommended in sugarcane ratoon crops under tropical Indian conditions.

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