

Effect of *Trichoderma* inoculated trash, nitrogen level and biofertilizer on performance of sugarcane (*Saccharum officinarum*) in calcareous soils of Bihar

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ABSTRACT

Field experiments were conducted during 2006-07 to 2008-09 at Sugarcane Research Institute, Pusa, Bihar to study the effect of *Trichoderma* inoculated trash, nitrogen level and biofertilizer on yield, nutrient uptake, juice quality of sugarcane (*Saccharum officinarum* L.) and soil nutrient availability in calcareous soils. Trash was inoculated with *Trichoderma viride* @ 500 g/t, one week before planting and applied @ 10 t/ha alone or in conjunction with different levels of N (75, 112.5 and 150 kg/ha). Application of trash alone increased the mean cane yield by 1.8% over control (45.4 t/ha) and with N levels 75, 112.5 and 150 kg/ha, increase in cane yield were 5.5, 3.3 and 0.8%, respectively over N applied alone. Trash applied with 75, 112.5 and 150 kg N/ha improved the organic carbon by 8.2, 11.3 and 13.6%, respectively over N applied alone while, available N by 7.0, 10.3 and 8.6%, P by 2.9, 7.6 and 4.6% and K by 7.4, 4.6 and 5.3%, respectively. Addition of trash and biofertilizer along with recommended dose of nitrogen (150 kg/ha) gave the highest net income (Rs. 22,832/ha) and B:C ratio (1.43). Hence, addition of *Trichoderma* inoculated trash @ 10 t/ha along with 150 kg N/ha and *Azotobacter* @ 4 kg/ha were found beneficial for sustaining soil health, enhancing sugarcane productivity and getting higher net returns.

Key words: Biofertilizer, Soil properties, Sugarcane, Trash, *Trichoderma*

Sugarcane (*Saccharum officinarum* L.) is an important cash crop of India which is cultivated in an area of about 5 million ha with an average productivity of 68 t/ha. The crop being long duration and nutrient exhaustive removes about 1.2, 0.022, 2.83 kg N-P-K/t of cane produced (Menhi Lal and Singh, 2002). Fertilizer use in India is inadequate, imbalanced, skewed and is in favour of nitrogen. The frequent and excessive use of chemical fertilizer has created problems like deterioration of soil health and ecology. It has been observed in recent years that yield of sugarcane has reached a plateau due to decline in factor productivity (Yadav *et al.*, 1998).

The loss in organic matter in soil is the root cause for decline in factor productivity. Soil organic matter is key factor in maintaining the soil fertility as it is reservoir of nutrients and provides metabolic energy for biological processes. Restoration of organic matter is thus, needed for maintaining soil health and improving productivity. The poor yield of sugarcane in Bihar is mainly due to erratic and imbalanced use of chemical fertilizer. The available soil nitrogen is low and addition of organic matter is not practiced. Thus, replenishment of nutrient drawn out

by the crop harvest is needed for sustaining sugarcane productivity. Sugarcane produces large amount of foliage (40% of total biomass) and a good crop of sugarcane produces about 10 to 15 t of trash depending upon variety and growth. It contains on an average 0.35-0.057-0.542% N-P-K, in addition to other secondary and micronutrients (Chandra *et al.*, 2008). Trash is a potential source of organic matter which contains about 46.5% of organic carbon (Dahia *et al.*, 2003). It is simply burnt by farmers which is undesirable. Recycling of crop residues in contrast to their removal or burning *in situ* improves soil physical, chemical and biological properties. Addition of trash in soil was found beneficial for increasing cane yield and maintaining soil health (Thakur *et al.*, 2007). However, slow decomposition of trash due to wider C/N ratio (84.3) is the main constraint in its recycling as it immobilises soil nutrients initially up to 100 days (Srinivas *et al.*, 2006). *Trichoderma* spp. was found effective for accelerating the decomposition of organic matter and for controlling soil borne pathogens (Harman, 2000). Thus, trash may be used as organic source of nutrients with inorganic fertilizers due to the paucity of organic manures to sustain the sugarcane productivity and maintaining soil health. Most of the research was confined to management

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of trash as soil mulch on sugarcane ratoon (Dahia *et al.*, 2003; Yadav *et al.*, 2009). Keeping the above points in view, the present experiment was conducted to examine *Trichoderma* inoculated trash with nitrogen and *Azotobacter* biofertilizer on performance of sugarcane in calcareous soil of Bihar.

MATERIALS AND METHODS

The field experiments were conducted from 2006-07 to 2008-09 at Sugarcane Research Institute, Pusa, Bihar (25°98'N, 85°67' E, 52.0 m elevation) to evaluate the effect of *Trichoderma* inoculated trash and biofertilizer on yield and quality of sugarcane. The climate of Bihar is sub-tropical and mean annual rainfall of the area is about 1,200 mm. The experiment was laid in randomised block design having eleven treatments with three replications. The experimental soil was sandy loam, calcareous (CaCO₃: 30.8%) having initial soil pH 8.35, EC 0.21dS/m, and 0.474% organic carbon. The available N, P and K were 232, 11.8 and 90.8 kg/ha, respectively. The treatments were T₁: control, T₂: sugarcane trash (ST) @ 10 t/ha, T₃: 50% recommended dose of nitrogen i.e. RDN (N_{50%}=75kg/ha), T₄: N_{50%}+ST, T₅: T₄+ *Azotobacter* (Az.), T₆: 75% RDN (N_{75%}=112.5kg/ha), T₇: N_{75%}+ ST, T₈: T₇+ Az, T₉: RDN (N_{100%}=150kg/ha), T₁₀: N_{100%}+ ST, T₁₁: T₁₀+Az. The recommended dose of fertilizers (37.5-50 kg P-K/ha) were applied through, diammonium phosphate and muriate of potash, respectively. Nitrogen as per treatment was applied in split doses, half at the time of planting, one fourth at the time of first irrigation and rest one fourth at the time of earthing up i.e. on onset of monsoon. Trash were chopped and moistend with water. *Trichoderma viride* @ 500 g/t of trash was applied uniformly and properly mixed one week before planting. The mid late variety of sugarcane 'BO 137' was planted in last week of February and harvested after one year. *Azotobacter* was applied @ 4 kg/ha at the time of planting. Powdered cultures of *Trichoderma viride* and *Azotobacter* contained viable cells of 10⁸ cfu/g of culture material. Other recommended practices for sugarcane crop and were adopted. Soil samples were collected initially and after harvest of crop were analysed for organic carbon, available N, P, K by standard procedure. Cane juice was extracted with power crusher and juice quality was estimated as per method given by Spencer and Meade (1955). Sugar yield was calculated as; Sugar yield (t/ha) = [S-0.4(B-S) x 0.73] x cane yield (t/ha) / 100; where S and B are sucrose and brix percent in cane juice. Whole cane sample was analysed for N, P and K content and their uptake was calculated. The economics was worked out on pooled data considering input and output of last year of study.

RESULTS AND DISCUSSION

Yield attributes and cane yield

The number of tillers at 120 days of planting, NMC and cane weight were significantly influenced due to addition of inoculated trash and biofertilizer with different levels of N over control. However, germination was not-significantly altered (Table 1). The application of nitrogen alone @ 75,112.5 and 150 kg/ha registered significant increase in cane yield. Addition of inoculated trash and *Azotobacter* alongwith different levels of N further increased the cane yield. It could be attributed to increase in nutrients availability by trash and also release of growth promoting substances by *Trichoderma* which might have enhanced the uptake of nutrients and cane yield (Harman, 2000). The beneficial effect of biofertilizer was not only its N fixing proficiency but also with the ability to produce antibacterial and antifungal compounds and growth regulators resulting into increase in cane yield (Pandey and Kumar, 1989). The cane yield was very less during 2007-08 because incidence of Plassey borer. Application of trash alone increased the mean cane yield by 1.8% over control and when applied it with N @ 75,112.5 and 150 kg/ha increase in mean yield were 5.5, 3.3 and 0.8%, respectively over N applied alone. The maximum cane yield was recorded in treatment receiving 150 kg N+ trash inoculated with *Trichoderma* + *Azotobacter* (T₁₁) which was on par with treatment (T₇) receiving 112.5 kg N alongwith inoculated trash. This showed that 25% N can be saved with addition of trash inoculated with *Trichoderma*. The results are in conformity of the reports of Yadav *et al.* (1994) and Dahiya *et al.* (2003). The cane juice quality viz. brix, sucrose and purity content in cane juice did not differ significantly due to different treatments. However, numerical increase in sucrose content in juice was recorded due to addition of trash and biofertilizer alongwith N level. Sugar yield, a function of cane yield and sucrose content exhibited similar trend of cane yield. Similar findings were also reported by Thakur *et al.* (2007).

Nutrient uptake and economics

The mean nutrient uptake of N, P and K by crop ranged from 88.7-150.8, 9.2-16.5 and 122.7-200.0 kg/ha, respectively (Table 2). Application of trash increased the uptake of N, P and K by crop and followed the trend of cane yield. The uptake of N, P and K by crop increased by 5.5,4.3 and 5.0%, respectively over control due to addition of trash alone. However, trash applied with different levels of fertilizer N increased the uptake of N by 3.1-5.6, P 5.8-10.9 and K 3.6-7.6%, respectively over N applied alone. This could be attributed to release of soluble chelating compounds during decomposition of trash by *Tricho-*

Table 1. Effect of inoculated trash, nitrogen level and biofertilizer on germination, yield attributes, juice quality, cane and sugar yield. (Pooled data for 3 years)

Treatment	Germination (%)	Tillers 120 DAP (x 000 ha)	No. of millable canes (x 000 ha)	Cane weight (g)	Cane yield (t/ha)			Brix (%)	Sucrose (%)	Purity (%)	Sugar yield (t/ha)
					2006-07	2007-08	2008-09				
T ₁ : Control	34.0	107.4	80.8	560	45.8	43.6	46.8	19.6	17.32	88.3	5.32
T ₂ :ST	34.1	109.3	81.2	571	47.1	44.4	47.0	19.7	17.35	88.2	5.54
T ₃ :N ₇₅	34.2	118.5	87.8	588	55.0	47.2	53.1	19.7	17.42	87.6	6.22
T ₄ :N ₇₅ + ST	34.5	122.0	90.7	590	58.6	47.7	56.6	19.8	17.44	88.4	6.58
T ₅ :N ₇₅ + ST +Azo.	34.5	125.3	92.1	598	59.2	47.8	58.8	19.7	17.44	87.9	6.65
T ₆ :N _{112.5}	34.6	129.6	96.5	600	60.2	48.0	61.5	19.6	17.45	88.4	6.94
T ₇ :N _{112.5} + ST	34.9	132.7	97.9	600	63.8	48.2	64.3	19.8	17.47	88.6	7.08
T ₈ :N _{112.5} + ST +Azo.	35.1	134.7	99.4	602	64.4	48.8	65.9	19.8	17.49	87.9	7.20
T ₉ :N ₁₅₀	35.1	136.0	101.6	602	65.4	52.8	68.7	20.0	17.53	87.9	7.41
T ₁₀ :N ₁₅₀ + ST	35.4	139.3	102.8	608	66.6	53.2	69.2	19.9	17.56	88.3	7.53
T ₁₁ :N ₁₅₀ + ST +Azo.	36.1	140.4	104.0	615	67.0	54.1	70.1	19.8	17.97	87.7	7.74
SEm±	0.7	2.5	2.6	11	3.1	1.6	2.0	0.2	0.22	0.8	0.22
CD (P=0.05)	NS	7.6	7.7	33	9.2	4.6	6.0	NS	NS	NS	0.64

ST, Sugarcane trash; Azo, *Azotobacter*; N₇₅, N_{112.5} and N₁₅₀ kg/ha; DAP, Days after planting

Table 2. Effect of trash, nitrogen level and biofertilizer on nutrient uptake (kg/ha) of sugarcane and economics (x 10³ Rs /ha).

Treatment	N			P			K			Economics		
	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	Cost of cultivation	Net income	B:C ratio
T ₁ : Control	95.5	78.4	92.3	9.3	8.8	9.5	134.1	114.2	120.0	51.09	3.39	1.07
T ₂ :ST	95.5	88.0	97.1	9.9	9.0	10.0	141.4	120.4	125.2	52.13	2.31	1.06
T ₃ :N ₇₅	119.6	96.1	115.4	11.4	10.8	10.8	168.7	132.1	143.4	51.73	10.43	1.20
T ₄ :N ₇₅ + ST	125.4	98.2	124.3	12.3	12.1	12.3	182.3	138.2	157.1	52.77	12.39	1.23
T ₅ :N ₇₅ + ST +Azo.	126.7	99.7	137.0	12.4	12.2	12.5	186.6	140.5	163.5	52.97	13.39	1.25
T ₆ :N _{112.5}	134.1	101.2	146.5	13.1	12.8	14.1	187.5	146.3	178.1	52.05	15.87	1.30
T ₇ :N _{112.5} + ST	146.1	102.4	154.2	14.2	13.0	14.9	200.9	150.2	188.0	52.09	18.47	1.35
T ₈ :N _{112.5} + ST +Azo.	146.7	103.0	161.1	14.4	13.6	15.3	202.5	154.1	193.4	53.29	18.35	1.34
T ₉ :N ₁₅₀	149.9	107.7	168.4	14.7	14.5	17.3	204.0	158.2	203.3	52.37	22.39	1.43
T ₁₀ :N ₁₅₀ + ST	152.6	112.4	174.5	16.0	15.8	17.3	208.0	164.4	213.2	53.41	22.19	1.42
T ₁₁ :N ₁₅₀ + ST +Azo.	156.1	115.8	180.6	16.0	16.0	17.5	211.0	172.2	217.1	53.61	22.83	1.43
SEm±	7.6	3.4	7.1	1.0	1.7	0.6	12.1	4.5	6.0			
CD (P=0.05)	22.8	10.1	22.0	3.1	5.1	1.7	36.2	13.2	18.0			

ST, Sugarcane trash; Azo, *Azotobacter*; N₇₅, N_{112.5} and N₁₅₀ kg/ha

derma which improved nutrient availability resulting higher uptake by crop (Harman, 2000). Addition of trash and biofertilizer alongwith 150 kg N gave the highest net income (Rs.22,832/ha) and B:C ratio (1.43).

Soil properties

Available nutrient status of post harvest soil revealed significant treatment differences (Table 3). Addition of trash significantly increased the organic carbon (OC) and available N,P and K content of soil after the harvest of the crop. Application of trash alone increased mean soil OC content by 8% over control while, applied in conjunction with N @ 75, 112.5 and 150 kg/ha, the increase was 8.2, 11.3 and 13.6%, respectively over N applied alone. Such

increase in organic carbon in soil with trash application was due to decomposition of added biomass which corroborates with the results of Chandra *et al.* (2008). Addition of trash in conjunction with fertilizers significantly improved the soil OC over trash applied alone. This might be due to stimulated growth and activity of microorganisms resulting in better root and shoot growth. Similar results were also reported by Dahia *et al.* (2003) and Thakur *et al.* (2007). The available soil nutrients after harvest of crop were significantly higher in trash treated plot. Addition of trash alone increased available N, P and K content of soil by 6.4, 6.7 and 6.1%, respectively over control. Trash applied with N @ 75,112.5 and 150 kg/ha increased the available N by 7.0, 10.3 and 8.6%, P by 2.9, 7.6 and

Table 3. Effect of trash, nitrogen level and biofertilizer on organic C (%) and available nutrient content (kg/ha) in soil after sugarcane.

Treatment	Organic C			N			P			K		
	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
T ₁ : Control	0.462	0.456	0.472	205	203	210	9.3	8.9	9.3	73.0	76.1	93.0
T ₂ : ST	0.490	0.501	0.510	212	218	228	10.0	9.5	10.0	76.1	81.3	99.6
T ₃ : N ₇₅	0.474	0.470	0.474	208	210	212	10.6	10.2	10.6	74.7	78.0	95.5
T ₄ : N ₇₅ + ST	0.501	0.518	0.516	214	228	232	10.6	11.0	10.9	81.3	87.2	97.9
T ₅ : N ₇₅ + ST +Azo.	0.524	0.522	0.514	216	230	236	10.7	11.1	11.3	82.2	88.0	99.6
T ₆ : N _{112.5}	0.476	0.474	0.478	210	214	218	11.0	10.6	11.5	81.3	87.2	102.9
T ₇ : N _{112.5} + ST	0.540	0.527	0.522	228	240	240	12.2	11.5	11.9	86.3	91.3	106.2
T ₈ : N _{112.5} + ST +Azo.	0.551	0.531	0.526	232	234	244	12.4	12.0	12.1	86.3	91.3	104.6
T ₉ : N ₁₅₀	0.477	0.478	0.480	234	218	220	12.1	12.0	13.4	84.7	89.6	107.9
T ₁₀ : N ₁₅₀ + ST	0.551	0.547	0.531	242	240	248	12.6	12.5	14.0	91.3	93.0	112.9
T ₁₁ : N ₁₅₀ + ST +Azo.	0.560	0.551	0.536	244	248	250	12.8	12.8	14.1	93.0	94.6	107.9
SEm±	0.006	0.009	0.002	4	3	2	0.5	0.5	0.6	3.3	2.7	2.3
CD (P=0.05)	0.018	0.026	0.005	13	8	7	1.7	1.5	1.7	9.9	7.8	5.6
Initial status	0.480	0.470	0.474	232	230	234	12.2	11.4	11.8	91.6	85.3	95.7

ST, Sugarcane trash; Azo, *Azotobacter*; N₇₅, N_{112.5} and N₁₅₀ kg/ha

4.6% and K by 7.4, 4.6 and 5.3%, respectively. The build up of soil available N could be attributed to greater multiplication of microbes due to addition of trash which helped in mineralization of soil N leading to higher available nitrogen. Trash inoculated with *Trichoderma* degraded fast and quickly released nutrients (Shukla *et al.*, 2008). The available soil N, P and K was highest in treatment (T₁₁) receiving trash and biofertilizer alongwith RDN. Improved P availability could be due to greater mobilization of soil P owing to reduced P sorption while, increased available K might be due to addition of K in available pool owing to mineralization of trash by micro organisms. The results are in conformity of findings of Thakur *et al.* (2007), Chandra *et al.* (2008) and Yadav *et al.* (2009). Addition of trash alongwith N and biofertilizer improved the soil properties viz. available N, P and K in general and organic carbon in particular over their initial value which indicated sustaining of soil fertility.

Thus, it may be concluded that addition of *Trichoderma* inoculated sugarcane trash @ 10 t/ha alongwith 150 kg N/ha and *Azotobacter* @ 4 kg /ha was found beneficial for sustaining soil health, enhancing sugarcane productivity and getting higher net returns and B:C ratio in calcareous soil of Bihar.

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