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Substitution of chemical fertilizers with organics for sustaining sugarcane productivity in *Vertisol*

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ABSTRACT

A field experiment was conducted during 2002 to 2005 at Central Sugarcane Resaerch Station, Padegaon, Maharashtra (India) to assess the possibility of replacing chemical fertilizers by using organic sources and its influence on bio-physico chemical properties of soil, yield and quality of pre-seasonal sugarcane. Application of recommended dose of NPK with FYM and the recommended dose of NPK with trash incorporation recorded significantly higher cane (117 and 107 t ha^{-1}) and Commercial Cane Sugar yield (16.5 and 15.42 t ha^{-1}) for plant cane and ratoon crops respectively. Results clearly indicated that, use of chemical fertilizers alone or organic manures alone were not found beneficial for sugarcane crop as compared to integrated use of chemical and organics. There were no much changes in soil pH and EC. However, soil organic carbon content and available nutrients were improved slightly in the treatments where, organic sources were used.

Key words : *Substitution, Chemical and Organic fertilizer, Sugarcane, Soil.*

Introduction

The use of chemical fertilizers is the quickest and quite certain way of boosting crop production. However, the constraints arising out of their excessive or imbalanced use of fertilizers in developed areas either due to non-availability or financial constraints in under developed areas; it necessitates exploiting potential alternative sources of nutrients. Complementary use of available renewable sources of plant nutrients along with chemical fertilizers in an integrated manner, are of great importance not only for boosting the crop productivity but also for maintaining the soil fertility.

India has vast potential of crop residues. However, the entire crop residues with feed value are needed to support larger livestock population and such residues may not be available for using as complementary resource to chemical fertilizers. But in the region where, mechanical harvesting is done, a sizeable quantity of residues is left behind in the field, which can form a natural source of nutrient supply.

Application of organic manures in combination with chemical fertilizers helps in checking plant nutrient depletion and in maintaining soil fertility including soil structure and crop productivity for future and also it increases the fertilizers use efficiency. The availability of FYM in adequate quantities for integrated and conjunctive use with inorganic fertilizers to meet the requirements of the crops grown in the state is a major limitation. However, there is scope for supplementing FYM with other organic sources like sugarcane trash, pressmud cake compost, vermicompost, green manuring crops and use of biofertilizers, etc. Applica-

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tion of nitrogen in the form of organic manures and inorganic fertilizers tended to improve sugar recoveries (Prasad Rao, 1998). Thus, for higher productivity of sugarcane and sugar per unit area on sustainable basis, application of inorganic fertilizers and different organics alongwith biofertilizers is the need of hour. Therefore, the present investigation was undertaken to assess the possibility to replace chemical fertilizers by different organics and its effect on biophysico-chemical properties of soil, yield and quality of preseasonal sugarcane.

Material and Methods

The field experiments was conducted during 2002 to 2005 for one plant cane and one ratoon at CSRS, Padegaon, Maharashtra, India on *Vertisol*. The experiment was laid out in randomized block design having six treatments with four replications. The sugarcane crop was planted on 27th November 2002 was harvested on 15th January 2004.

However, the ratoon was harvested on 18th January 2005. The details of the treatments are as under (Table 1).

Soil samples were collected initially and after harvest of plant cane and ratoon. Dry and processed soil samples were used to determine chemical properties using standard procedures. Soil samples were analyzed for pH and EC in 1:2.5 soil suspension ratio, organic carbon by Nelson and Sommers (1982), Available N by alkaline permanganate method (Subbiah and Asija, 1956), available P as per method Olsen *et al.*, (1954) and available K determined by flame photometrically as described by Kundsen *et al* (1982).

Different organic sources were analyzed for their total N content using methods given by Tondon (1993). The 25% recommended dose of nitrogen was given through FYM (0.80% N) , VC (1.85% N) and CSPM (1.50% N) considering moisture (32%, 35% & 40% respectively) were applied at the rate of 13.7 tha^{-1}, 6.2tha^{-1} and 8.3tha^{-1} respectively. Plant samples were analyzed for total nutrient uptake as per methods given by Parkinson and Allen (1975). Cane juice quality was determined using procedure outlined by Spencer and Meade (1964) and commercial cane sugar (CCS) was calculated. The data obtained on chemical properties of soil, uptake of nutrients by plant, quality of juice and yield of sugarcane were analyzed statistically by using procedure laid down by Panse and Sukhatme (1978).

Results and Discussion

Yield parameter

The data in table 2 showed that highest cane yield was obtained where recommended dose of NPK and FYM was used (117 t ha^{-1}) for plant cane. However, in ratoon crop, significantly highest yield was obtained where recommended dose of NPK and trash was used (107 t ha^{-1}), which was on par with application of NPK @ 75% RD + trash + BF (104 t ha^{-1}). Ahmed and Reddy (2004) also reported that, use of FYM in sugarcane may curtail the N requirement by 30 per cent. Kathireson (2004) reported that integrated use of organic and inorganic with biofertilizer both in N fixer and P solubilization in sugarcane economized the application of N and P by 25% without sacrificing the yield and quality of cane. Shinde *et al.*, (1992) reported highest cane and CCS yield with trash incorporation in sugarcane ratoon as compared to conventional method of trash burning. Further substitution of inorganic fertilizers

Table 1. Treatment details

Treat.	Plant cane						Ratoon				
No.	NPK RD %	FYM (Ton)	BF	GM	VC (Ton)	CSPM (Ton)	NPK RD %	Trash	BF	CSPM (Ton)	VC (Ton)
T_1	100	x	x	x	x	x	100	x	x	x	x
T_2	100	25	x	x	x	x	100	Yes	x	x	x
T_3	75	25	Yes	x	x	x	75	Yes	Yes	x	x
T_4	50	25	Yes	Berseem	x	2.5	50	Yes	Yes	2.5	2.5
T_5	25	25	Yes	Berseem	5	5	25	Yes	Yes	5	5
T_6	0	25	Yes	Berseem	10	10	0	Yes	Yes	10	10

Note: CSPM- Composted sulphitation press mud, BF- Biofertilizer
VC - Vermicompost, GM- Green Manuring (Dhaincha)

by organics subsequence resulted in declining the yield and it was only 93 t ha^{-1}in plant cane and 98 t ha^{-1} in ratoon crop in the treatment where only organic manures were used and no chemical fertilizers were used. The data clearly indicated that, the combination of organics and chemical were better over using only chemical fertilizers or only organic manures, so far as the yield and quality of sugarcane plant and ratoon is concern. These results are in conformity with the findings of Bhoi *et al.*, (2004).

Soil properties

There were no much changes in soil pH and EC after harvest of sugarcane plant and ratoon due to use of different sources of nutrients (Table 3). However, organic carbon content was improved slightly by using organic sources. Soil available nutrients were maintained / improved in almost all treatments where organic sources were used with and without chemical fertilizers. However, slight reduction in soil available nutrients was observed in treatment no.5 and 6. In general, there was slight improvement in physical properties and microbial count where the organic sources were used with and without chemical fertilizers (Table 4). Jadhav at. al. (2000) also reported that, the use of organic matter has improved the organic carbon as well as available NPK content in the soil.

Nutrient uptake

In general, 2.18 to 2.44 kg N, 0.33 to 0.40 kg P_2O_5 and 2.48 to 2.70 kg K_2O were required to produce one ton of cane in plant cane. Similarly, 2.11 to 2.27 kg N, 0.36 to 0.47 kg P and 2.44 to 2.65 kg K were required to produce one ton of cane in ratoon crop (Table 5). Uptake of nitrogen kg t^{-1} and kg ha^{-1} was reduced as

Table 4. Effect of different treatments on soil physical and biological properties after harvest of sugarcane plant and ratoon.

Treat.	Bulk Density (mg/m^3)	Porosity (%)	Microbial count (10^5)	
			N Fixer	P solubilizer
Initial	1.16	56.0	2.1	1.5
T_1	1.16	56.0	2.7	3.5
T_2	1.15	57.0	5.8	4.2
T_3	1.14	57.0	5.3	3.4
T_4	1.13	57.4	6.9	4.1
T_5	1.11	58.1	6.7	3.8
T_6	1.11	58.1	6.5	2.7

Table 2. Effect of different treatments on yield parameters of sugarcane plant and ratoon

Treat. No.	Yield(t ha^{-1})		CCS(t ha^{-1})		ACW(kg)		NMC(000 ha^{-1})		CCS %cane	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
T_1	101	99	13.2	12.85	1.07	1.12	95	88.70	12.8	12.94
T_2	117	107	16.5	15.42	1.14	1.21	103	88.27	14.1	14.46
T_3	112	104	15.4	14.15	1.11	1.18	101	88.27	13.7	13.51
T_4	106	101	14.5	13.55	1.07	1.14	100	88.90	13.6	13.39
T_5	101	99	13.8	13.45	1.07	1.12	95	88.23	13.5	13.52
T_6	93	98	12.3	12.60	1.02	1.06	92	92.27	13.2	13.94
SE $\pm$	1.7	1.27	0.3	0.65	0.02	0.005	1.0	1.23	0.2	0.56
CD 5%	5.1	3.83	1.0	1.97	0.07	0.016	3.0	NS	0.5	NS

CCS : Commercial Cane Sugar, ACW : Average Cane Weight, NMC : Number of Millable cane.

Table 3. Effect of different treatments on soil chemical properties after harvest of sugarcane plant and ratoon

Treat. No.	pH		EC(dS m^{-1})		Org. C(%)		Av. Nutrients (kg ha^{-1})					
							N		P_2O_5		K_2O	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Initial	8.15	8.20	0.28	0.22	0.82	0.84	162	195	13.2	14.5	440	470
T_1	8.16	8.10	0.27	0.19	0.83	0.89	161	195	14.6	16.9	452	439
T_2	8.08	7.95	0.30	0.15	0.88	0.92	172	193	14.6	14.7	548	497
T_3	8.06	7.99	0.29	0.14	0.87	0.92	170	202	13.4	15.6	518	509
T_4	8.07	7.99	0.28	0.14	0.90	1.00	167	199	13.4	13.3	496	507
T_5	8.05	7.96	0.29	0.13	0.92	1.02	165	193	12.8	13.2	486	481
T_6	8.07	7.66	0.35	0.14	0.95	1.06	164	190	12.9	13.0	489	483

Table 5. Effect of different treatments on nutrient uptake by sugarcane plant and ratoon

Treat. No.	Kg ha^{-1}						Kg ton^{-1}					
	N		P		K		N		P		K	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
T_1	246	220	40.4	38.7	269	248	2.44	2.21	0.40	0.39	2.66	2.50
T_2	281	242	44.8	44.4	316	283	2.40	2.27	0.38	0.42	2.70	2.65
T_3	268	233	44.7	48.7	297	268	2.39	2.24	0.39	0.47	2.65	2.57
T_4	246	219	37.1	42.2	277	250	2.32	2.16	0.35	0.42	2.61	2.47
T_5	230	211	34.3	41.1	261	241	2.28	2.13	0.34	0.42	2.58	2.44
T_6	203	205	30.7	35.5	231	241	2.18	2.11	0.33	0.36	2.48	2.47

the percentage of inorganic fertilizers was reduced and percentage of organics was increased. Whereas, uptake of phosphorus kg t^{-1} and kg ha^{-1} was higher in ratoon crop than plant cane. This might be due to addition of different organic sources for both the crops. Highest uptake kg ha^{-1} was obtained in the treatment where recommended doses of NPK and FYM were used in plant cane and where recommended doses of NPK and trash were used in ratoon crop.

Conclusion

Use of chemical fertilizers alone or organic manures alone were not found beneficial for sugarcane plant and ratoon as compared to integrated use of chemical and organics. Use of recommended dose of NPK along with recommended dose of FYM for plant cane, followed by recommended dose of NPK along with trash incorporation for ratoon crop or 75 per cent recommended dose of NPK along with recommended dose FYM and biofertilizers for plant cane, followed by 75 per cent recommended dose of NPK along with trash and biofertilizers for ratoon crop were found beneficial in terms of yield.

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