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Effect of organic manure and zero budget technique on soil fertility and productivity of sugarcane plant and ratoon crop

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ABSTRACT

A field experiment was conducted on clay loam soils at Regional Research Station, Chaudhary Charan Singh Haryana Agricultural University, Karnal, Haryana for three year (2018-2021) to investigate the effect of different organic treatments such as farmyard manure (FYM), bio fertilizers (BF) and green manuring (GM) with Sesbania or trash mulching (TM) on sugarcane yield, quality and soil fertility status. Cane length, cane girth, number of millable canes and commercial soluble sugar percent increased with the application of FYM, BF and GM/TM as compared to zero budget technique. The treatment that received 30 t FYM ha^{-1} +BF+GM/TM+ integrated pest management (IPM) recorded 15.8 and 12.3 % increase in cane yield over zero budget technique in plant and ratoon crops, respectively. Both in plant and ratoon crop, higher available nitrogen (145.7 and 147.8 kg ha^{-1}), phosphorus (18.57 and 18.43 kg ha^{-1}) and potassium (406.8 and 412.8 kg ha^{-1}) were recorded where 30 t FYM ha^{-1} was applied along with BF+GM/TM+IPM. The application of 30 t FYM ha^{-1}+BF+GM/TM+ IPM was found at par with treatment 20 t FYM ha^{-1}+BF+GM+IPM for plant crop and 25 t FYM ha^{-1}+BF+TM + IPM for ratoon crop. The treatment 20 or 25 t FYM ha^{-1} + BF + GM/TM + IPM were at par with the RDF treatment. The cane yield and juice quality obtained as a result of application of 20t FYM ha^{-1} + BF+GM+IPM for sugarcane plant crop and 25t FYM ha^{-1} +BF+TM+IPM for sugarcane ratoon crop was comparable with that of RDF.

Keywords: Organic manure, bio-fertilizer, zero budget technique, soil fertility, sugarcane plant and ratoon crop

INTRODUCTION

Sugarcane (*Saccharum officinarum*) is an important cash crop of India. It needs hot and humid climate for proper growth and can be grown on a variety of soils which can retain moisture. It is grown on roughly 26.27 million hectares (M ha) of land in about 109 countries, yielding 1.91 billion tons (b t) of sugarcane globally (FAO STAT, 2020). Mono cropping system, intensive cultivation, utilization of high yielding varieties, exclusive use of chemical fertilizers and unavailability of organic manure leads to depletion of soil health and also creates imbalance in the composition as well as availability of micronutrients (Rama Lakshmi *et al.* 2011). Further, indiscriminate use of insecticides and pesticides has deteriorated the quality of agriculture products with declining yield. There is direct need to adopted technologies which are environmental friendly and sustainable. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Balanced use of organic, inorganic and biofertilizers is essential to maintain a good soil physical and chemical environment and also serve as energy source for the soil microbial biomass (Roohi *et al.* 2021). Integrated nutrient management holds great promise in meeting the growing nutrient demands of intensive sugarcane agriculture and maintaining productivity at higher levels with overall improvement in the quality of resource base. It helps to improve and sustain soil fertility and provides a sound basis for crop production systems to meet the changing needs. As organic manures often leave profound residual effect, recommendations need to be made on cropping system basis. As a result, there is a clear need to promote the use of technologies that are more productive, cost-effective, and ecologically sound. The usage of organic manure has been identified as a requirement for improving the sustainable soil productivity. FYM is identified as a major source of macro and micronutrients, which promote crop productivity by increasing soil organic carbon status. Sugarcane produces a lot of biomass and takes a lot of nutrients out

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of the soil for regular growth and development. It is estimated that 100 t of sugarcane production will remove 140 kg of nitrogen, 34 kg of phosphorus, and 332 kg of potassium from the soil (Bokhtiar *et al.*, 2001). Adding back biomass created after sugarcane harvest helps to improve soil organic matter and, following microbial breakdown, releases essential nutrients into the soil that the plant need for optimum growth and development. Organic matter from animal manure, crop wastes, and green manuring has been demonstrated to replenish soil organic C while also improving soil fertility (Srivastava *et al.* 2009). So, to elucidate the advantages of organic farming over inorganic farming in sustainable agriculture, the current research was carried out with the goal of determining the effect of organic sugarcane cultivation under various treatments on yield, quality, and soil fertility status of the sugarcane crop.

MATERIALS AND METHODS

A three years (2018-19, 2019-20 and 2020-21) field experiment was conducted at Regional Research Station, CCS Haryana Agricultural University, Karnal, Haryana situated at 29.72 N latitude, 76.98 E longitudes and at an altitude of 253 meters above mean sea level. The experimental site used for the study was an undisturbed piece of land which was never being cultivated before. The soil of the experimental site was clay loam in texture having pH 8, EC 0.16 dS m^{-1}, organic carbon 3.8 g kg^{-1}, available nitrogen 115.2 kg ha^{-1}, available phosphorus 10 kg ha^{-1} and available potassium 384 kg ha^{-1}.

The experiment was conducted for a comparative study between purely organic farming and zero budget farming with conventional farming using both plant and ratoon crop of sugarcane variety i.e., CoH 160. Various organic treatments were compared using randomized block design with three replications. The treatments were different for plant and ratoon crop.

Treatments	Plant crop	Ratoon crop
1	10 t FYM ha^{-1} at the time of sowing + Biofertilizers (BF) + Green manuring of *Sesbania* in inter row spaces (GM) + control of insect pests and diseases through organic practices (IPM)	20 t FYM ha^{-1} at the time of ratoon initiation+ Biofertilizers (BF) + trash mulching in alternate rows (TM) + control of insect pests and diseases through organic practices (IPM)
2	20 t FYM ha^{-1} at the time of sowing +BF+GM+IPM	25 t FYM ha^{-1} at the time of ratoon initiation +BF+TM+IPM
3	30 t FYM ha^{-1} at the time of sowing +BF+GM+IPM	30 t FYM ha^{-1} at the time of ratoon initiation +BF+TM+IPM
4	Zero budget technique (ZBT): Seed treatment with organic formulation I* and application of organic formulation II @ 200 lit./acre with irrigation water and spray at 21 days interval upto growth phase + control of insect pest with natural pesticides	Zero budget technique (ZBT): Seed treatment with organic formulation I* and application of organic formulation II @ 200 lit./acre with irrigation water and spray at 21 days interval upto growth phase + control of insect pest with natural pesticides
5	Recommended dose of NPK (RDF)** + control of insect pests and diseases through chemical practices	Recommended dose of NPK (RDF)** + control of insect pests and diseases through chemical practices

*Organic formulation I was prepared by mixing 5 kg indigenous cow dung, 5 L of cow urine, 50 g lime, handful of undisturbed soil and 20 L water. Sugarcane setts were treated with this formulation for 30 minutes.

*Organic formulation II was prepared by mixing 10 kg of indigenous cow dung, 10 L of cow urine, 1.5 kg of gram flour, 1.5 kg of jaggery and handful of undisturbed soil in 200 L of water

**Recommended dose of NPK (RDF): For plant crop: 187.5-62.5-62.5 kg/ha, for ratoon crop: 225-50-50 kg/ha

Organic manure was applied at the time of sowing before opening the ridges. The setts were treated with biofertilizers *viz. Azotobacter/Acetobacter* + phosphate solubilizing bacteria and *Trichoderma viridae* before sowing. The soil samples were collected

from each plot at a depth of 0-15cm after harvest of plant and ratoon sugarcane crop. The soil pH, EC and OC were determined using the method outlined by Jackson (1973). The available N was determined by the method outlined by Subbiah and Asija (1956) and available P and K by Merwin and Peech (1950).

Cane length and cane girth were recorded after taking 5 samples from each plots of plant and ratoon crop. Juice analysis was carried out prior to harvesting. The commercial cane sugar (CCS %) in juice were determined by the method suggested by Meade and Chen (1977). Number of millable canes (NMC) and cane yield was recorded at the time of harvesting. The sugar yield (t ha^{-1}) was calculated using the formula: Cane yield (t ha^{-1}) × CCS % /100. The data obtained from the study were statistically analyzed at 5 % level of significance as per procedure given by Sundaraj *et al.* (1972).

RESULTS AND DISCUSSION

Sugarcane Yield

In sugarcane plant crop, application of 30 t FYM ha^{-1}+BF+GM+IPM resulted in significantly higher cane yield (81.55 t ha^{-1}). Although, the yield recorded by the above treatment was at par with the yield obtained with 20t FYM ha^{-1} + BF + TM + IPM (78.48 t ha^{-1}) and RDF (80.55 t ha^{-1}). This could be due to the use of organic manure, which enhanced the organic matter content of the soil and the availability of all required nutrients to the plant throughout its life cycle, allowing all physiological processes in sugarcane to run smoothly. However, lowest cane yield (70.42 t ha^{-1}) was observed by the treatment in which zero budget technique was adopted (Table 1). In the ratoon crop, application of 30t FYM ha^{-1} + BF + TM + IPM (T3) recorded highest cane yield (94.90 t ha^{-1}) which was at par with 25t FYM ha^{-1} + BF + TM + IPM (81.9 t ha^{-1}) and RDF only (89.71 t ha^{-1}) (Table 1). Adoption of zero budget technique recorded lowest sugarcane yield (84.50 t ha^{-1}). Shilpa *et al.* (2017) also documented an increase in sugarcane yield by 5-10 % with the inclusion of biofertilisers in nutrient management programme. The increase in yield of sugarcane plant crop and ratoon crop due to 30t FYM ha^{-1} + BF + TM + IPM were 15.80% and 12.30% over zero budget, respectively.

Yield Attributes

Among different yield attributing characters, cane length and cane girth was recorded at the end of grand growth stage and NMC was recorded at the time of harvesting. Perusal of data (Table 1) clearly revealed that the maximum cane length (208 cm), cane girth (2.41 cm) and NMC (77412 ha^{-1}) of sugarcane plant crop were obtained on addition of 30 t FYM ha $^{-1}$+BF+ TM+IPM which was at par with 20 t FYM ha^{-1}+BF+ TM+IPM and RDF. Adoption of zero budget technique resulted in least cane length (193.7 cm) and NMC (75922 ha^{-1}) in sugarcane plant crop. In sugarcane ratoon, maximum cane length (198.3 cm), cane girth (2.35 cm) and NMC (86861 ha^{-1}) were recorded with 30t FYM ha^{-1}+BF+TM+IPM.

Table 1: Effect of different treatments on yield and yield attributes of sugarcane plant and ratoon crop (mean of 3 years)

Treatments	Cane length (cm)	Cane girth (cm)	NMC (ha^{-1})	Cane yield (t ha^{-1})
Sugarcane plant crop				
T_1: 10t FYM ha^{-1} + BF + GM + IPM	198.0	2.33	72568.6	74.83
T_2: 20t FYM ha^{-1} + BF + GM + IPM	204.9	2.40	75568.6	78.48
T_3: 30t FYM ha^{-1} + BF + GM + IPM	208.0	2.41	77411.7	81.55
T_4: Zero budget technique	193.7	2.39	72784.3	70.42
T_5: RDF	204.0	2.40	75921.6	80.55
CD (P=0.05)	8.4	NS	2,297	5.56
Sugarcane ratoon crop				
T_1: 20t FYM ha^{-1} + BF + TM + IPM	178.3	2.28	81361.1	83.58
T_2: 25t FYM ha^{-1} + BF + TM + IPM	183.8	2.35	84972.2	90.40
T_3: 30t FYM ha^{-1} + BF + TM + IPM	188.3	2.35	86861.1	94.90
T_4: Zero budget technique	168.7	2.29	80388.9	84.50
T5: RDF	185.4	2.34	85472.2	89.71
CD (P=0.05)	5.9	NS	2,653.9	6.95

Lowest cane length (178.7 cm) and NMC (80389 ha^{-1}) was recorded by zero budget technique. This may be attributed to lack of other essential nutrients, which has lowered photosynthesis and ion translocation among all treatments. Sharma *et al.* (2017), Nooli and Biradar (2019), Yadav *et al.* (2019), Jha and Thakur (2018) reported similar results.

Qualitative parameters

The CCS and sugar yield varied from 11.9 to 13.2 % and 8.4 to 10.8 t ha^{-1}, respectively in sugarcane plant crop. Application of 30 t FYM ha^{-1} + BF+TM+ IPM reported highest CCS (13.2 %) and sugar yield (10.8 t ha^{-1}) over other treatments in sugarcane plant crop followed by RDF (13% and 10.4 t ha^{-1}). On the other hand, zero budget technique reported lowest CCS (12 %) and sugar yield (7.41 t ha^{-1}). In ratoon crop also, application of 30 t FYM ha^{-1} + BF + TM + IPM registered the highest CCS (13.4 %) and sugar yield (10.2 t ha^{-1}). Application of 25 t FYM ha^{-1}+BF+TM+IPM and RDF were statistically at par with respect to CCS and sugar yield. The lowest CCS (11.7 %) and sugar yield (7.1 t ha^{-1}) was achieved by zero budget technique among all the treatments. Tayade *et al.* (2019) has reported similar results. The sugar yield in sugarcane plant crop was relatively higher than that of ratoon crop.

Table 2: Effect of application of different treatments on quality parameters of sugarcane plant and ratoon crop (mean of 3 years)

Plant			Ratoon		
Treatments	CCS (%)	Sugar Yield (t ha^{-1})	Treatments	CCS (%)	Sugar yield (t ha^{-1})
T_1: 10t FYM ha^{-1} + BF+GM+IPM	12.1	9.1	T1: 20t FYM ha^{-1} + BF+TM+ IPM	12.1	7.6
T_2: 20t FYM ha^{-1} + BF+GM+IPM	12.9	10.1	T2: 25t FYM ha^{-1} + BF+TM+ IPM	12.8	9.1
T_3: 30t FYM ha^{-1} + BF+GM+IPM	13.2	10.8	T3: 30t FYM ha^{-1} + BF+TM+ IPM	13.4	10.2
T_4: Zero Budget Technique	11.9	8.4	T4: Zero Budget Technique	11.7	7.1
T_5:RDF	13.0	10.4	T5:RDF	13.2	9.4
CD (P=0.05)	0.8	0.97	C.D (P=0.05)	0.69	1.09

Soil Fertility

The results (Table 3) clearly revealed that none of the treatments had any significant effect on soil pH, EC and organic carbon in both sugarcane plant and ratoon crop. This could be due to soil buffering capacity, which can resist changes in soil pH. The addition of different nutrients to the soil through FYM in both the plant and ratoon crop of sugarcane did not result in significant changes in soil pH, EC and organic carbon. However, a moderate effect was noticed over inital with FYM treatments which might be attributed to the chelation of aluminum (Al^{3+}) ions by organic molecules which decreased their activity in the soil solution (Sarwar *et al.* 2010). The available N, P and K contents in soil were significantly influenced with the application of different organic treatments. In plant crop, application of 30t FYM ha^{-1} + BF + GM + IPM had recorded higher available N (145.77 kg ha^{-1}), P (18.57 kg ha^{-1}) and K (406.6 kg ha^{-1}) over application of 20 or 10 t FYM ha^{-1} and ZBT. This may be due to the addition of various organic sources such as FYM, trash mulch, biofertilizers and organic formulations, which increased the available nutrient content by increasing soil microorganism activity which leads to decomposition of organics and consequently mineralization of nutrients in the soil. Similar results were reported by Shilpa *et al.* (2017). Similarly, in ratoon crop maximum availability of N (147.87 kg ha^{-1}), P (18.43 kg ha^{-1}) and K (412.80 kg ha^{-1}) was recorded with the application of 30t FYM ha^{-1} +BF+ TM + IPM over other treatments. This might be due to residual and cumulative effect of added organic manures in succeeding ratoon crop, although ratoon crop will exhibit more nutrient uptake. Available N, P and K contents recorded by the application of RDF were 144.43 kg ha^{-1}, 18.17 kg ha^{-1} and 410.67 kg ha^{-1}, respectively. Minimum values of available N, P and K were recorded in ZBT (130.00 kg ha^{-1}, 14.38 kg ha^{-1} and 393.17 kg ha^{-1}, respectively). Shridevi *et al.* (2016), Suma and Savitha (2015) reported similar results.

Table 3: Effect of application of various treatments on physico- chemical properties and nutrient status of the soil in plant and ratoon crop of sugarcane (mean of 3 years)

Treatments	pH	EC (dS m^{-1})	Organic Carbon (g kg^{-1})	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})
Sugarcane Plant Crop						
T1: 10t FYM ha^{-1} + BF+GM+IPM	7.95	0.126	5.3	128.93	15.93	393.9
T2: 20t FYM ha^{-1} + BF+GM+IPM	7.94	0.123	5.7	142.50	18.17	404.0
T3: 30t FYM ha^{-1} + BF+GM+IPM	7.96	0.131	5.7	145.77	18.57	406.6
T4: Zero budget technique	7.95	0.125	4.9	127.97	14.83	391.3
T5:RDF	7.94	0.122	5.1	145.37	18.03	404.8
CD (P=0.05)	NS	NS	NS	12.087	1.332	8.14
Sugarcane Ratoon crop						
T1: 20t FYM ha^{-1} + BF+TM+IPM	7.90	0.125	5.4	133.33	15.19	396.50
T2: 25t FYM ha^{-1} + BF+TM+IPM	7.92	0.130	5.7	143.63	18.37	408.03
T3: 30t FYM ha^{-1} + BF+TM+IPM	7.94	0.122	5.9	147.87	18.43	412.80
T4: Zero budget technique	7.95	0.129	4.7	130.00	14.38	393.17
T5:RDF	7.97	0.126	5.2	144.43	18.17	410.67
CD (P=0.05)	NS	NS	NS	10.952	1.254	9.217

It may be concluded from the results that application of 20 t FYM $ha^{-1}$for plant and 25 t FYM ha^{-1} for ratoon combined with the application of biofertiliser and green manuring produced higher yield and improved juice quality of sugarcane plant and ratoon crop which was comparable with RDF. However, zero budget technique achieved lesser yield than RDF application. Available N, P and K contents were also found significantly higher in organic treatments over zero budget technique.

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