

Performance of pit planted sugarcane (*Saccharum officinarum*) under organic management

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ABSTRACT

An experiment was conducted during 2011–12 and 2012–13 at Navsari, Gujarat to study the effect of different proportion of organics on productivity of pit planted sugarcane (*Saccharum officinarum* L.) under organic farming system. The experiment was laid out in randomized block design with 3 replications comprising 8 organic treatments and 1 inorganic treatment as control (250:125:125 kg NPK/ha). Significantly higher plant height (399.7 cm), millable canes (129.8 t/ha), cane height (298.2 cm), and single cane weight (1.54 kg) were recorded with 50% recommended dose of nitrogen (RDN) through vermicompost and 50% RDN through castor cake. However, application of nitrogen through vermicompost (50% RDN) along with either castor cake or neem cake (50% RDN) were found equally effective and recorded significantly higher millable cane (129.8 and 128.2 t/ha respectively) and trash yield (23.2 and 22.7 t/ha respectively). In organic vs inorganic-(control) analysis, application of 100% RDF through inorganic fertilizers recorded significantly higher values of growth and yield parameters, and yield of sugarcane crop. Hence for producing higher and profitable cane yield of sugarcane, the crop should be fertilized with 100% RDF (250:125:125 NPK kg/ha) under south Gujarat conditions. Further, for organic production of sugarcane crop, application of 50% RDN through vermicompost and remaining 50% RDN either through castor cake or neem cake was found remunerative.

Key words : Banana pseudostem waste, Castor cake, Fertilizers, Neem cake, Organic, Sugarcane, Vermicompost

Agriculture is the mainstay of our country's economy. Though India has achieved self-sufficiency in food production in the shortest span of time, our traditional agro-eco system has suffered a great setback, especially owing to the indiscriminate use of fertilizers, insecticides, fungicides and herbicides. Further, intensive agriculture and excessive use of chemicals during the green revolution have resulted in deterioration of soil health and productivity. Moreover, in the present agriculture scenario, due to use of inorganic fertilizers alone and scarce use of organic manures, the cultivable lands are rapidly depleted of organic carbon content, becoming unfertile creating problems of multiple nutrient deficiencies. (Trivedi *et al.*, 1996). This is one of the main causes of low productivity of sugarcane in Gujarat (Anonymous 2003). There is an

urgent need to take a holistic view of this problem to curb its negative impact. Numerous studies have shown that organic farming leads to higher soil quality and soil biological activity than conventional farming. Infact, organic farming methods can produce equally good or higher yields than conventional methods. Agricultural by-products, e.g. animal dung and crop residues are potential sources of plant nutrients. In southern Gujarat region, farmers are majorly cultivating sugarcane, banana, rice and pulses, hence large amount of crop residues are available for recycling. Banana *pseudostems* are waste (leaves, stem and rhizome), which cause economic loss, if left as such in the agricultural field. Further, it takes several months for natural degradation and also causes environmental pollution. It's a rich source of potassium and phosphorus with significant amount of micronutrients and growth hormones like cytokine, gibberellins etc. Further *pseudostems* are easy to decompose because of high moisture (75%) and cellulose (50% of dry weight) content with lower C:N ratio. Similarly, sugarcane, rice and others crop waste are also utilized for making biocompost as well

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vermicompost. Most of the crop residues obtained after the harvest of the crop are burned or disposed by farmers as waste hence easily available at very cheap rate. It is well established that composting modifies biological, physical and chemical status of the residue, gradually reducing its C:N ratio, increasing the surface area exposed to microorganisms, and this making it much more favourable for microbial activity. Sugarcane is an important cash crop widely cultivated in India, the second largest sugar producer in the world. Sugar industry is the second largest agro based industry and about 50 million farmers are involved in sugarcane cultivation, harvesting and ancillary activities, constituting 7.5% of the rural population.

Sugarcane is generally planted in furrows in single rows and paired rows with deep trenches. In another system of planting, called pit or ring planting system, cane setts are placed horizontally in circular pits. This method prevents crop lodging, improves the nutrient-use efficiency through localized placement, and helps to maintain multiple ratoons. The crop under pit system primarily consists of mother shoots that are thicker and heavier. Yadav and Kumar (2005) had reported the yield advantage of pit method over conventional furrow method. Keeping in view the need to grow sugarcane profitably while sustaining the soil health, a field experiment was designed to evaluate different proportion of organics on productivity of pit planted sugarcane crop and to identify the best suited practice.

MATERIALS AND METHODS

The experiment was conducted during 2011–12 and 2012–13 at Organic Farm, F block, N.M. College of Agriculture, Navsari Agricultural University, Navsari (20° 57' N, 72° 54' E and 10 m above the mean sea-level), Gujarat. The soil was clay (14.05% sand, 18.15% silt and 67.80% clay) with pH 7.65, organic carbon 0.55%, low available nitrogen (247 kg/ha), medium available phosphorus (41.5 kg/ha) and high available potassium (310 kg/ha). The experiment was laid out in randomized block design with 3 replications. Total 9 treatments comprising different organics manures and inorganic fertilizers were T₁, 50% recommended dose of nitrogen (RDN) through biocompost and 50% RDN through castor cake; T₂, 50% RDN through biocompost and 50% RDN through neem cake; T₃, 50% RDN through vermicompost and 50% RDN through castor cake; T₄, 50% RDN through vermicompost and 50% RDN through neem cake; T₅, 25% RDN through biocompost, 50% RDN through castor cake and 25% RDN through banana *psuedostem* waste; T₆, 25% RDN through biocompost, 50% RDN through neem cake and 25% RDN through banana *psuedostem* waste; T₇, 25% RDN through vermicompost, 50% RDN through castor

cake and 25% RDN through banana *psuedostem* waste; T₈, 25% RDN through vermicompost, 50% RDN through neem cake and 25% RDN through banana *psuedostem* waste and T₉, 100% RDF through inorganic fertilizers. The recommended dose of inorganic fertilizers was 250 : 125 : 125 N : P₂O₅ : K₂O kg/ha. The pits (0.6 m dia. × 0.45 m depth), were prepared at a spacing of 2.4 m × 1.2 m (between 2 pits) and farmyard manure 10 kg/pit was applied before 15 days of planting. Bio-compost, vermicompost, castor cake and neem cake were applied as per treatments and mixed well with the soils in respective pit before planting. For treatments T₅ to T₈, pits were filled with shredded banana *psuedostem* waste along with dung (0.5 kg/pit) (as slurry) a week prior to sugarcane setts planting. Healthy setts of sugarcane variety 'Co-N-5071' were selected for planting. Two-budded setts were used for planting @ 8 setts/pit (Fig. 1). The setts were treated with hot water before planting. The wet planting method was adopted and subsequently irrigation was given.

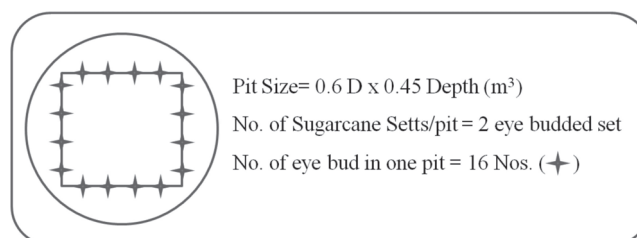


Fig. 1. Two budded setts plantation for pit planted sugarcane

At harvest, ten canes were randomly selected from net plot for recording the bio-metric observations such as height, number of internodes, girth, cane and trash weight of sugarcane plant crops. The data recorded were statistically analyzed using MSTATC software. LSD test at 5% probability level was applied when analysis of variance showed significant effect for treatments (Steel and Torrie, 1980). To calculate the cost of cultivation, the cost of each treatment was determined and then compared with each other according to the prevailing market prices of sugarcane.

RESULTS AND DISCUSSION

Growth

Application of 50% RDN either through vermicompost or biocompost along with 50% RDN either through castor cake or neem cake significantly increased the total plant height and millable cane height compared to rest of the treatments. The increase in total plant height and millable cane height in these treatments may be due to the fact that castor cake and vermicompost having a low C:N ratio contributed nutrients quickly to the plant at early growth stage. Organic manures like banana *psuedostem* waste and

biocompost have high C:N ratio which caused immobilization and short supply of nutrients in early growth phase, which affected growth and development of crop. Similar finding were reported by Patel (2006).

In organic vs inorganic-(control) analysis, treatments receiving recommended dose of fertilizer i.e., 250:125:125 N:P₂O₅:K₂O kg/ha recorded significantly higher total plant height (402.5 cm) and millable cane height (304.2 cm) compared to the organic treatments. This can be ascribed to the immediate availability of nutrients to sugarcane crop by application of inorganic fertilizer as compared to organic sources that release nutrients slowly. Application of N and P might have accelerated the synthesis of chlorophyll and amino acids which are associated with major photosynthetic processes of plants responsible for the growth and development of plant. This result is in close agreement with that reported by Patel (2006) and Patel and Patel (2010).

Yield and yield attributes

Sugarcane, being an exhaustive crop, needs heavy application of fertilizers for good growth and higher yield. Nutrient requirement, when supplied through vermicompost, castor cake and neem cake also play an important role in growth and yield of sugarcane. Number of internodes/cane and single cane weight increased significantly when crop was nourished with 50% RDN through vermicompost and 50% RDN through castor cake or neem cake. Biocompost and castor cake (50% each)

also recorded at par values. Treatment effect was not observed on cane girth and number of millable canes/ha. Ultimately, results of the organic manure treatments were reflected on millable cane and trash yields of sugarcane. The highest cane yield (129.8 t/ha) and trash yield (23.2 t/ha) were recorded with integrated application of vermicompost + castor cake (50% RDN from each). Moreover, application of 50% RDN through vermicompost and 50% RDN through castor cake recorded 23.44 and 32.17% higher millable cane and trash yields of sugarcane as compared to 25% RDN through biocompost, 50% RDN through castor cake and 25% RDN through banana *psuedostem* waste. However, application of 50% RDN through vermicompost and 50% RDN through neem cake was equally effective in comparison to 50% RDN through vermicompost and 50% RDN through castor cake. Vermicompost with castor cake or neem cake having narrow C:N ratio, might have supplied plant nutrients quickly to tillers and steadily throughout the growth period. Studies have shown that the chemical composition of the applied organic matter with particular reference to C:N ratio affects the mineralization rate, being highest for the narrow C:N ratio and vice versa. The low response of sugarcane to mixed banana *psuedostem* waste could be associated with its slow mineralization rate and lack of potential to supply nutrients during the vital stages of growth and development. Senesi *et al.* (1992) compared the quality of humic acids present in vermicompost with those found in natural soils using spectroscopic analysis

Table 1. Effect of organics on growth and yield attributing characters of pit planted sugarcane under organic farming system (mean of 2 years)

| Treatment | Growth characters | | | Yield characteristics | | |
|-------------------------------------|-------------------------|---------------------------|------------------------|-----------------------|--------------------------|-------------------------|
| | Total plant height (cm) | Millable cane height (cm) | No. of internodes/cane | Cane girth (cm) | No. of millable canes/ha | Single cane weight (kg) |
| Organic manures | | | | | | |
| BC + CC (50% + 50% RDN) | 379.7 | 281.0 | 25.8 | 3.58 | 78,685 | 1.51 |
| BC + NC (50% + 50% RDN) | 377.7 | 279.4 | 25.0 | 3.53 | 78,616 | 1.50 |
| VC + CC (50% + 50% RDN) | 399.7 | 298.2 | 28.2 | 3.67 | 84,164 | 1.54 |
| VC + NC (50% + 50% RDN) | 393.0 | 293.6 | 27.0 | 3.62 | 84,894 | 1.51 |
| BC + CC + BPW (25% + 50% + 25% RDN) | 335.8 | 238.4 | 21.5 | 3.50 | 83,373 | 1.26 |
| BC + NC + BPW (25% + 50% + 25% RDN) | 353.7 | 256.4 | 23.0 | 3.48 | 81,817 | 1.33 |
| VC + CC + BPW (25% + 50% + 25% RDN) | 350.8 | 251.9 | 22.5 | 3.47 | 86,040 | 1.28 |
| VC + NC + BPW (25% + 50% + 25% RDN) | 343.5 | 246.0 | 23.5 | 3.57 | 78,046 | 1.42 |
| Mean | 366.7 | 268.1 | 24.6 | 3.55 | 81,954 | 1.42 |
| SEm± | 9.7 | 9.4 | 0.9 | 0.12 | 3,082 | 0.04 |
| CD (P=0.05) | 27.9 | 27.1 | 2.7 | NS | NS | 0.11 |
| 100% RDF (250:125:125 NPK kg/ha) | 402.5 | 304.2 | 29.0 | 3.70 | 84,267 | 1.65 |
| Control vs rest | | | | | | |
| SEm± | 6.9 | 6.7 | 0.7 | 0.06 | 2,214 | 0.03 |
| CD (P=0.05) | 20.0 | 19.3 | 1.9 | NS | NS | 0.08 |

BC, Biocompost; CC, castor cake; NC, neem-cake; VC, vermicompost; BPW, banana *psuedostem* waste; RDN, recommended dose of nitrogen; RDF, recommended dose of fertilizer; NS, non-significant.

procedures and reported that metal-humic acid like substances containing appreciable amounts of iron and copper, present in organic materials processed by earthworms, are similar to the humic acids common in soils and other sources irrespective of the nature of the parent material. This indicated that vermicomposting can produce considerable amounts of humic acid. Patel and Patel (2010) also reported that application of castor cake and neem cake in combination with vermicompost significantly influenced the growth and yield of sugarcane. They contain all the essential nutrients and their incorporation in to the soil released the nutrients slowly through microbial mediation leading to adequate availability of nutrients throughout the growing season, resulting in improved cane productivity. Soil ameliorating effect of the addition of organic resources manures must have further contributed to improved cane yield. Moreover, application of concentrated organic manures castor cake and neem cake, have been shown to fight against soil-borne pest and diseases.

In inorganic-(control) vs organic analysis, crop receiving recommended dose of fertilizer (250:125:125 N:P₂O₅:K₂O kg/ha) recorded significantly higher no. of internodes/millable cane (29.0), single cane weight (1.65 kg), millable cane yield (138 t/ha) and trash yield (25.2 t/ha) as compared to the organic treatments. The millable cane and trash yield under control was higher to the tune of 19.60 and 26.38% as compared to organic treatments mean respectively. This may be due to more absorption of readily available nutrients that helped to improve the

yields attributes and ultimately the cane yield. Moreover, sugarcane is a heavy feeder crop requiring large quantity of plant nutrients that can be supplied through fertilizers at critical stage. Similar findings were reported by Virdia and Patel (2010).

Soil fertility

Application of organic manures from various sources significantly increased the organic carbon content in soil as compared to inorganic fertilizer application. Available nitrogen, phosphorus and potassium also improved significantly by addition of organic manures. Application of 50% RDN through vermincompost and 50% RDN through castor cake showed significantly higher available nitrogen (287.8 kg/ha), phosphorus (53.8 kg/ha) and potassium (361 kg/ha) among the various organic sources. It was however on par with vermicompost along with neem cake (50% RDF each) for all available nutrients. This may be due to the fact that organic manure treated plots release organic acids during microbial decomposition of organic matter which might have enhanced the solubility of native nutrients, thus increasing the available nutrient pool in the soil. Moreover, the complex organic anions chelate Al⁺³, Fe⁺³ and Ca⁺³ and thus decrease the cationic macro- and micronutrients as well as phosphate precipitating power of these cations and thereby increase nutrient availability. Further, the build-up of soil available nitrogen may also be attributed to the greater multiplication of microbes due to the addition of organic matter who facilitated the conver-

Table 2. Effect of organics on yield, organic carbon, available nutrients and economics of pit planted sugarcane under organic farming system (mean of 2 years)

| Treatment | Yield (t/ha) | | Organic carbon (%) | Available nutrients (kg/ha) | | | Net returns (×10 ³ ₹/ha) | Benefit: cost ratio |
|-------------------------------------|---------------|-------|--------------------|-----------------------------|-------------------------------|------------------|-------------------------------------|---------------------|
| | Millable cane | Trash | | N | P ₂ O ₅ | K ₂ O | | |
| <i>Organic manures</i> | | | | | | | | |
| BC + CC (50% + 50% RDN) | 118.5 | 20.5 | 0.77 | 280.7 | 44.5 | 321.2 | 163.8 | 2.9 |
| BC + NC (50% + 50% RDN) | 117.3 | 20.0 | 0.76 | 277.9 | 47.5 | 323.6 | 159.3 | 2.8 |
| VC + CC (50% + 50% RDN) | 129.8 | 23.2 | 0.78 | 287.8 | 53.8 | 361.0 | 161.3 | 2.5 |
| VC + NC (50% + 50% RDN) | 128.2 | 22.7 | 0.77 | 284.7 | 48.9 | 355.3 | 155.8 | 2.4 |
| BC + CC + BPW (25% + 50% + 25% RDN) | 105.2 | 17.5 | 0.73 | 247.8 | 42.2 | 302.4 | 131.4 | 2.5 |
| BC + NC + BPW (25% + 50% + 25% RDN) | 108.8 | 18.1 | 0.75 | 258.3 | 48.4 | 312.5 | 137.0 | 2.5 |
| VC + CC + BPW (25% + 50% + 25% RDN) | 109.7 | 18.3 | 0.74 | 285.5 | 43.7 | 351.3 | 127.7 | 2.2 |
| VC + NC + BPW (25% + 50% + 25% RDN) | 110.0 | 19.6 | 0.73 | 256.1 | 48.2 | 355.0 | 126.3 | 2.2 |
| Mean | 115.9 | 20.0 | 0.76 | 271.1 | 47.1 | 335.3 | | |
| SEm± | 3.5 | 0.7 | 0.02 | 9.3 | 1.9 | 9.5 | | 3.5 |
| CD (P=0.05) | 10.2 | 2.1 | NS | 28.3 | 5.8 | 28.9 | | 10.2 |
| 100% RDF (250:125:125 NPK kg/ha) | 138.7 | 25.2 | 0.57 | 243.3 | 35.3 | 294.7 | 197.1 | 3.5 |
| <i>Control vs rest</i> | | | | | | | | |
| SEm± | 7.4 | 1.5 | 0.02 | 32.1 | 5.6 | 29.3 | | |
| CD (P=0.05) | 8.4 | 9.9 | 0.06 | 5.9 | 6.9 | 4.9 | | |

BC, Biocompost; CC, castor cake; NC, neem-cake; VC, vermicompost; BPW, banana *psuedostem* waste; RDN, recommended dose of nitrogen; RDF, recommended dose of fertilizer; NS, non-significant.

sion of organically bound nitrogen to inorganic form and helped in the mineralization of soil nitrogen leading to build-up of higher available nitrogen in soil. Similarly, organic manure also led to greater mobilization of native soil phosphorus by reducing the capacity of soil mineral to fix phosphorus and increase its availability through release of organic acid. The organic matter framed a protective cover on calcium carbonate (CaCO_3), thus reducing the phosphate fixing capacity of soil, thereby, increased available phosphorus status of soil. Similar results were reported by Patel (2006) and Patel and Patel (2010).

Economic Analysis

Economics is the major consideration for farmers, while taking a decision regarding the adoption of new technology. Treatment receiving application of RDF recorded higher net returns (₹ 197,144/ha) and B:C ratio (3.5) over organic treatments. Among organic treatments, 50% RDN through biocompost and 50% RDN through castor cake recorded highest net returns (₹ 163,839/ha) followed by 50% RDN each from vermicompost and castor cake (₹ 161,280/ha), 50% RDN biocompost and neem cake (₹ 159,342/ha), and 50% RDN from each vermicompost and neem cake (₹ 155,753/ha). This was because of lower production cost in control as compared to organic treatments that had combination of castor cake, neem cake or vermicompost, which are expensive.

It can be concluded that successful and profitable cultivation of sugarcane crop under organic farming can be achieved with application of 50% RDN through

vermicompost and remaining 50% RDN either through castor cake or neem cake, besides improvement in chemical properties of the soil. However, application of 100% RDF (250:125:125 N:P₂O₅:K₂O kg/ha) was most productive and remunerative for cultivation of sugarcane crop.

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