Impact of organic manures on soil health, yield and quality of pit planted sugarcane

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DOI: https://doi.org/10.22271/chemi.2020.v8.i1ak.8636

Abstract
An experiment was conducted at Organic Farm, Navsari Agricultural University, Navsari to study the effect of different proportion of organics on productivity of pit planted sugarcane during three consecutive years of 2013, 2014 and 2015. The experiment was conducted at fixed plot site with 8 set of organics treatments and 1 inorganic treatment as control (250:125:125 kg NPK/ha) arranged outside the experimental plot, laid down in randomized block design replicated thrice. Significantly higher millable cane height, number of internodes/ millable cane and single millable cane weight were recorded when crop nourished with 50% RDN each of vermi compost and castor cake. Further, application of vermi compost (50% RDN) along with neem cake or castor cake (50% RDN) were found equally effective and recorded significantly higher millable cane and trash yields. In organics vs inorganic analysis, application of 100 per cent RDF through inorganic fertilizers recorded significantly higher values of growth and yield parameters and yields of sugarcane crop. 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 condition. Further, it is also inferred that for organic production of sugarcane crop, application of 50% RDN through vermi compost and remaining 50% RDN either through castor cake or neem cake was found remunerative.

Keywords: Banana pseudostem waste, bio compost, castor cake, fertilizers, neem cake, sugarcane, vermicompost

Introduction
Agriculture is life and blood of our country’s economy. It was highly gratifying that India achieved self-sufficiency in food production in the shortest span of time in the world, but despite everything, our traditional agro-eco system 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 present agriculture, unfortunately, due to use of inorganic fertilizers alone and scarce use of organic manures, the cultivable lands are rapidly depleted in organic carbon content and becoming unfertile and created the problems of multiple nutrient deficiencies. This is one of the main causes of low productivity of sugarcane in Gujarat. There is an urgent need to take a holistic view of this problem to curb its negative impact. A growing numbers of studies showed that organic farming leads to higher soil quality and more soil biological activities than conventional farming. Infect, organic farming methods can produce equally good or higher yields than conventional methods. Sugarcane (Saccharum officinarum L.), an important cash crop cultivated from 8°N to 30°N latitude covering variety of climate and soil of India, having the second largest sugar production in the world. Sugar industry is the second largest agro based industry after textile industry located in rural areas of India. About 50 million sugarcane farmers, their dependents and large mass of agricultural labourers are involved in sugarcane cultivation, harvesting and ancillary activities and constituting 7.5 per cent of the rural population. Besides, about 0.5 million skilled and semi skilled workers, mostly from the rural areas are engaged in the sugar industry. The industry not only generates power for its own requirement but surplus power for export to the grid based on by product bagasses. It also produced ethanol, an eco-friendly and renewable energy for blending with petrol. Sugarcane is generally planted in furrow in single rows and pair row 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. The yield advantage of pit method over conventional furrow method has been documented by Yadav and Kumar (2005) [10]. Keeping in view, a field experiment was designed to find out the best suitable proportion of organic manures on productivity of pit planted sugarcane crop.

Materials and Methods

A field experiment was conducted during 2013, 2014 and 2015 at organic farm, Navsari Agricultural University on deep black soil. The soil of experiment field was deep black with organic carbon (0.55%), pH (7.65), EC (0.425 dS/m), Available N (247 kg/ha), available P2O5 (41.5 kg/ha) and Available K2O (310 kg/ha). The experimental plots were prepared by deep ploughing, harrowing and levelling. The pits of 0.6 m x 0.6 m x 0.45 m were dug out with the help of tractor drawn agar at spacing of 2.4 m (between two rows) x 1.2 m (Between two pits) and well decomposed fine textured farm yard manure @ 10 kg/pit was applied at planting time. The experiment was laid out in randomised block design, keeping with eight organic combinations and one chemical fertilizer (outside the organic farm) treatments with three replications. All the organics on N equivalent basis are applied in basal in pit at the time of planting except banana pseudostem waste. Banana pseudostem waste was filled in pit along with dung @ 0.5 kg/pit (as slurry) a week prior to planting of sugarcane. The treatment receiving inorganic fertilizers (250-125-125 NPK kg/ha) i.e., N, P and K were applied through urea, single super phosphate and muriate of potash, respectively. The full dose of phosphorus and potash and 15% nitrogen was applied at basal. Remaining nitrogen 30% at 45 days after planting, 20% at 90 days after planting and 35% at 135 days after planting was top dressed respectively. Beside uniform dose of Biofertilizers having 108 viable counts of Azotobacter, PSB and Acetobacter were applied @ 5 kg/ha each to all the treatments at the time of planting and earthing up of sugarcane.

Result and Discussion

Yield attributes and yield

Application of 50% RDN through vermi compost and 50% RDN through castor cake (T1) recorded significantly higher millable cane height, no. of internodes per millable cane and single millable cane weight as compared to 25% RDN through bio compost + 50% RDN through castor cake and 25% RDN through banana pseudostem waste. However, application of 50% RDN through vermi compost and 50% RDN through neem cake was found equally effective in comparison to 50% RDN through vermi compost and 50% RDN through castor cake. This might be due to use of vermi compost with castor cake or neem cake having narrow C: N ratio gave immediate and quick supply of plant nutrients to tillers and steady supply of plant nutrients throughout the growth periods. Evidences have shown that the chemical composition of the applied organic matter with particular reference to C: N ratio plays an important role on the mineralization rate, being the highest for the narrow C: N ratio and vice versa. The low responses of sugarcane to the mixed banana pseudostem waste could be inferred to the slow mineralization rate and to lack in the potential of nutrient supply during the stages of growth development. Senesi et al. (1992) [11] compared the quality of humic acids present in vermicompost, with those found in natural soils, using spectroscopic analysis procedures. They demonstrated that the 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 and as far as their metal complication properties and behavior are concerned.

The earlier study made by Chaudhary and Sinha (2001) [12] and Patel and Patel (2010) [13] reported that the application of castor cake and neem cake in combination to vermi compost significantly influenced the growth and yield of sugarcane. Because, they carry of all the essential nutrients and their incorporation in to the soil released the nutrient slowly through microbial mediation, it leads to their adequate availability throughout the growing season, resulting in improve cane productivity. Soil ameliorating effect of addition of organic resources manures must have further contributed to improved cane yield as reported by Srivastava et al. (2008) [13]. Moreover, application of castor cake and...
neem cake, both concentrated organic manures which fight against soil born pest and diseases.

In inorganic-control Vs organic analysis, treatments receiving recommended dose of fertilizer i.e., 250:125:125 N: P₂O₅: K₂O kg/ha for sugarcane recorded significantly higher millable canes and trash yield as compared to organic treatments mean. The corresponding millable cane and trash yield tended to increase in tune of 19.83 and 26.39% as compared to organic treatments mean, respectively. This may be due to more absorption of nutrient helped to improve the yield attributes and ultimately convert in to cane yield. Secondly, sugarcane is a heavy feeder crop required large quantity of plant nutrients that can be supplied through fertilizers at critical stage. This finding is supported by Thakur et al. (2007)\textsuperscript{[14]} and Virdia and Patel (2010)\textsuperscript{[15]}.

Quality

The quality parameters viz., sucrose per cent in juice and cane, purity per cent, CCS per cent and CCS yield were determined after harvest of sugarcane. The effect of organic treatments was found non significant on all the quality parameters of plant crops. But when we compared with Inorganic-control, all quality parameters i.e., sucrose content in juice and cane, Purity (%), CCS (%) and CCS yield (t/ha) were found significantly higher due to organic treatments than inorganic-control. It means that combined application of organic manures hold good promise. This higher sucrose content can be closely related to K content of cane. An improvement in quality of produce with the use of organics alone could be attributed to the better physical, biological and chemical conditions of soil with organics than RDF alone. Similarly, earlier workers Bangar et al. (2000)\textsuperscript{[2]} and Patel and Patel (2010)\textsuperscript{[8]} also reported an improvement in quality of sugarcane with the use of organics alone or in combination with fertilizers.

Uptake

Application of 50% RDN through vermi compost and 50% RDN through castor cake recorded higher uptake of N, P, K, Fe, Mn and Zn by cane and trash compared to 25% RDN through bio compost + 50% RDN through castor cake and 25% RDN through banana pseudostem waste. However, application of 50% RDN through vermi compost and 50% RDN through neem cane was found equally effective in comparison to 50% RDN through vermi compost and 50% RDN through castor cake. 25% RDN through bio compost + 50% RDN through castor cake and 25% RDN through banana pseudostem waste recorded lower uptake of N, P, K, Fe, Mn and Zn which might be due to insufficient quantity of nutrients at the initial stage of the crop growth period. The slow release of nutrients from banana pseudostem waste becomes available only in the later stages and thus, making the crop suffers in the early growth period. On the contrary, an important feature of vermi composts during the processing at the various organic wastes by earthworms is that many of the nutrients that they contain are changed to forms that are more readily taken up by plants, such as nitrate or ammonium nitrogen, exchangeable phosphorus and soluble potassium, calcium and magnesium (Edwards, 1982)\textsuperscript{[4]}. In support to this finding by Jadhav et al. (1997)\textsuperscript{[6]} observed considerable increase in the uptake of major and secondary nutrients such as N, P, K, Ca and Mg by rice under vermi compost treatment than FYM. Application of 50% RDN through castor cake or neem cake with vermi compost gave higher nutrient uptake which might be due to the combination low C:N ratio, resulted in higher biological process and increased microbial activity and soil enzymatic activity helping in degradation of organics resulting in better availability of major and micronutrients throughout the crop growth period.

In control vs organic analysis, the uptake of N, P₂O₅ and K₂O by cane and uptake of N, P₂O₅, K₂O and Mn by sugarcane trace were comparatively higher with 100% RDF through inorganic than organics mean. This evidence directly related to higher content of major and micronutrient in sugarcane plant part and also higher dry matter yield of cane and trash. Similar results were recorded by Virdia and Patel (2010)\textsuperscript{[15]} and Patel and Patel (2010)\textsuperscript{[8]}.

Soil health

The content of available nutrients in soil were affected due to different organic treatments. In all the cases, application of 50% RDN through vermi compost and 50% RDN through castor cake or 50% RDN through neem cake maintained significantly higher status of available major (N, P₂O₅ and K₂O) as well as micro nutrients (Fe, Mn and Zn) as compared to 25% RDN through bio compost + 50% RDN through castor cake and 25% RDN through banana pseudostem waste. This might be due to higher nutrients were added directly through vermi compost in combination with castor cake or neem cake. The availability of these elements might have improved due to amendment of vermi compost which might have facilitated better microbial transformation. The overall improvement in soil fertility ultimately reflected on the yield of sugarcane which was significantly higher either with application of 50% RDN through vermi compost and 50% RDN through castor cake or 50% RDN through neem cane. Similar findings were also reported by Thakur et al (2007)\textsuperscript{[14]}. In organics vs inorganic-control analysis, almost in all cases, organic treatments maintained significantly higher status of available major (N, P₂O₅ and K₂O) as well as micro nutrients (Fe, Mn and Zn) as compared to inorganic-control from initial levels of respective elements. This may fact that organic manures treated plots release organic acids during microbial decomposition of organic matter which might have helped in the solubility of native nutrients, thus increased the available nutrient pool in the soil. Secondly, the complex organic anion chelate Al\textsuperscript{+3}, Fe\textsuperscript{+3} and Ca\textsuperscript{+2} and thus decrease the cationic macro and micronutrients as well as phosphate precipitating power of these cations and there by increase in availability (Reddy et al., 1990)\textsuperscript{[10]}. Similar results were reported by Pawar (1996)\textsuperscript{[9]} with vermi compost and Babhulkar et al. (2000)\textsuperscript{[1]} with FYM. Further, the build up of soil available nitrogen of soil may also be attributed to the greater multiplication of microbes due to addition of organic matter for the conversion of organically bound nitrogen to inorganic from and helped in the mineralization of soil nitrogen leading to buildup of higher available nitrogen. Similarly, greater mobilization of native soil phosphorus by reducing the capacity of soil mineral to fix phosphorus and increased its availability through release of organic acid. The organic matter framed a protective covered on CaCO₃, thus reduces the phosphate fixing capacity of soil, hence, increased available phosphorus status of soil (Thakur et al. 2007)\textsuperscript{[14]}.

Looking to the overall performance of organics, collectively might have resulted in higher availability of the remaining major and micro nutrient of soil. More or less similar result was reported by Patel (2006)\textsuperscript{[7]} and Patel and Patel (2010)\textsuperscript{[8]}. Application of organics significantly improved organic carbon content of soil irrespective of its sources and superior than inorganic control. Because, direct addition of large quantity of
organic matter in soil. Contrary to this, soil pH and EC was not altered significantly due to various organic treatments. The role of organic matters in maintaining physico-chemical properties of soil were also reported by Sharma et al. (2006) [12] and Virdia and Patel (2010) [15].

Table 1: Performance of yield attributes, yield and economics of pit plated sugarcane under organic farming (pooled)

| Treatments                                      | Millable cane height (cm) | No. of internodes per millable cane | No. of millable canes/ha | Single millable cane weight (kg) | Yield (t/ha) | Millicable cane | Trash | Net Benefit (Rs/ha) | Cost: Benefit ratio |
|-------------------------------------------------|----------------------------|--------------------------------------|--------------------------|---------------------------------|--------------|-----------------|-------|-------------------|--------------------|
| **Organic manures**                             |                            |                                      |                          |                                 |              |                 |       |                   |                    |
| BC + CC (50 + 50% RDN)                          | 281                       | 25.8                                 | 78685                    | 1.51                            | 119          | 20.45           | 16389.12 | 2.93               |                     |
| BC + NC (50 + 50% RDN)                          | 279                       | 25.0                                 | 78616                    | 1.50                            | 117          | 19.96           | 159341.63| 2.83               |                     |
| VC + CC (50 + 50% RDN)                          | 298                       | 28.2                                 | 84164                    | 1.54                            | 130          | 23.17           | 161279.64| 2.45               |                     |
| VC + NC (50 + 50% RDN)                          | 294                       | 27.0                                 | 84894                    | 1.51                            | 128          | 22.68           | 155753.15| 2.37               |                     |
| BC + CC + BPW (25 + 50 + 25% RDN)               | 238                       | 21.5                                 | 83373                    | 1.26                            | 105          | 17.53           | 131401.96| 2.47               |                     |
| BC + NC + BPW (25 + 50 + 25% RDN)               | 256                       | 23.0                                 | 81817                    | 1.33                            | 109          | 18.06           | 137047.47| 2.50               |                     |
| VC + CC + BPW (25 + 50 + 25% RDN)               | 252                       | 22.5                                 | 86040                    | 1.28                            | 110          | 18.30           | 127675.72| 2.24               |                     |
| VC + NC + BPW (25 + 50 + 25% RDN)               | 246                       | 23.5                                 | 78046                    | 1.42                            | 110          | 19.64           | 126328.23| 2.21               |                     |
| **Mean**                                        | 268                       | 24.6                                 | 81954                    | 1.42                            | 116          | 19.97           |                   |                   |                    |
| S. Em. ±                                        | 9.36                      | 0.92                                 | 3082                     | 0.04                            | 3.5          | 0.72            |                   |                   |                    |
| C. D. at 5%                                      | 27.12                     | 2.67                                 | NS                       | 0.11                            | 11.0         | 2.07            |                   |                   |                    |
| 100% RDF (250:125:125 NPK kg/ha)                | 304                       | 29.00                                | 84267                    | 1.65                            | 139          | 25.24           | 197143.68| 3.46               |                     |
| **Control vs rest**                             |                            |                                      |                          |                                 |              |                 |       |                   |                    |
| S. Em. ±                                        | 6.68                      | 0.66                                 | 2214                     | 0.03                            | 7.4          | 0.51            |                   |                   |                    |
| C. D. at 5%                                      | 19.25                     | 1.91                                 | NS                       | 0.08                            | 8.4          | 1.47            |                   |                   |                    |

BC: Bio Compost; CC: Castor Cake; NC: Neem Cake; VC: Vermi Compost; BPW: Banana Psuedostem Waste; RDN: Recommended Dose of Nitrogen; RDF: Recommended Dose of Fertilizer

* Data on pooled basis

Table 2: Nutrients uptake by cane and trash as influenced by pit plated sugarcane under organic farming (pooled)

| Treatments                                      | Uptake by cane | Uptake by trash |
|-------------------------------------------------|----------------|-----------------|
| **Organic manures**                             |                |                 |
| BC + CC (50 + 50% RDN)                          |                |                 |
| BC + NC (50 + 50% RDN)                          |                |                 |
| VC + CC (50 + 50% RDN)                          |                |                 |
| VC + NC (50 + 50% RDN)                          |                |                 |
| BC + CC + BPW (25 + 50 + 25% RDN)               |                |                 |
| BC + NC + BPW (25 + 50 + 25% RDN)               |                |                 |
| VC + CC + BPW (25 + 50 + 25% RDN)               |                |                 |
| VC + NC + BPW (25 + 50 + 25% RDN)               |                |                 |
| **Mean**                                        |                |                 |
| S. Em. ±                                        |                |                 |
| C. D. at 5%                                      |                |                 |
| 100% RDF (250:125:125 NPK kg/ha)                |                |                 |
| **Control vs rest**                             |                |                 |
| S. Em. ±                                        |                |                 |
| C. D. at 5%                                      |                |                 |

BC: Bio Compost; CC: Castor Cake; NC: Neem Cake; VC: Vermi Compost; BPW: Banana Psuedostem Waste; RDN: Recommended Dose of Nitrogen; RDF: Recommended Dose of Fertilizer

* Data on pooled basis

Table 3: Quality of sugarcane influenced by pit plated sugarcane under organic farming (pooled)

| Treatments                                      | Brix (%) | Sucrose (%) in Juice | Sucrose (%) in Cane | Purity (%) | Fibre (%) | CCS (%) | CCS Yield (t/ha) |
|-------------------------------------------------|----------|----------------------|---------------------|------------|-----------|---------|-----------------|
| **Organic manures**                             |          |                      |                     |            |           |         |                 |
| BC + CC (50 + 50% RDN)                          | 20.78    | 18.48                | 13.76               | 88.99      | 15.51     | 11.81   | 14.06           |
| BC + NC (50 + 50% RDN)                          | 20.54    | 18.29                | 13.59               | 89.12      | 15.68     | 11.70   | 13.88           |
| VC + CC (50 + 50% RDN)                          | 21.54    | 19.22                | 14.32               | 89.18      | 15.54     | 12.33   | 16.22           |
| VC + NC (50 + 50% RDN)                          | 21.31    | 19.05                | 14.22               | 89.39      | 15.33     | 12.26   | 15.85           |
| BC + CC + BPW (25 + 50 + 25% RDN)               | 20.14    | 17.48                | 12.97               | 86.76      | 15.87     | 10.82   | 11.39           |
| BC + NC + BPW (25 + 50 + 25% RDN)               | 20.71    | 18.12                | 13.43               | 87.45      | 15.90     | 11.34   | 12.47           |
| VC + CC + BPW (25 + 50 + 25% RDN)               | 20.34    | 17.73                | 13.16               | 87.15      | 15.82     | 11.04   | 12.35           |
| VC + NC + BPW (25 + 50 + 25% RDN)               | 20.74    | 18.15                | 13.48               | 87.50      | 15.74     | 11.36   | 12.45           |
| **Mean**                                        | 20.76    | 18.32                | 13.62               | 88.19      | 15.68     | 11.58   | 13.58           |
| S. Em. ±                                        | 0.64     | 0.63                 | 0.52                | 1.09       | 0.71      | 0.52    | 0.75            |
| C. D. at 5%                                      | NS       | NS                   | NS                  | NS         | NS        | NS      | 2.27            |
| 100% RDF (250:125:125 NPK kg/ha)                | 19.87    | 15.71                | 11.50               | 79.29      | 16.78     | 8.42    | 11.76           |

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### Table 4: Physico chemical property of soil influenced by pit plated sugarcane under organic farming (pooled)

| Treatments | pH  | EC (dS/m) | Organic Carbon (%) | Available N (kg/ha) | Available P₂O₅ (kg/ha) | Available K₂O (kg/ha) | DTPA extractable Fe (mg/kg) | DTPA extractable Mn (mg/kg) | DTPA extractable Zn (mg/kg) |
|------------|-----|-----------|--------------------|---------------------|------------------------|-----------------------|-----------------------------|-----------------------------|----------------------------|
| **Organic manures** |     |           |                    |                     |                        |                       |                             |                             |                            |
| BC + CC (50 + 50% RDN) | 7.45 | 0.324     | 0.77               | 275.08              | 44.51                  | 321.21                | 14.72                       | 25.44                       | 0.72                       |
| BC + NC (50 + 50% RDN) | 7.43 | 0.328     | 0.76               | 273.33              | 47.46                  | 323.63                | 15.82                       | 26.95                       | 0.74                       |
| VC + CC (50 + 50% RDN) | 7.52 | 0.320     | 0.78               | 283.33              | 53.75                  | 361.03                | 17.92                       | 28.55                       | 0.83                       |
| VC + NC (50 + 50% RDN) | 7.46 | 0.317     | 0.77               | 278.96              | 48.92                  | 355.29                | 16.71                       | 27.39                       | 0.77                       |
| VC + CC + BPW (25 + 50 + 25% RDN) | 7.52 | 0.341     | 0.73               | 242.88              | 42.16                  | 302.41                | 14.66                       | 23.90                       | 0.66                       |
| VC + NC + BPW (25 + 50 + 25% RDN) | 7.47 | 0.343     | 0.75               | 253.12              | 48.38                  | 312.45                | 15.11                       | 25.71                       | 0.66                       |
| **Mean** | 7.47 | 0.332     | 0.76               | 267.17              | 47.13                  | 335.29                | 16.11                       | 26.61                       | 0.74                       |
| **Control vs rest** |     |           |                    |                     |                        |                       |                             |                             |                            |
| S. Em. ± | 0.08 | 0.013     | 0.02               | 8.29                | 1.90                   | 9.53                  | 0.72                        | 0.78                        | 0.03                       |
| C. D. at 5% | NS    | NS        | NS                 | 25.16               | 5.75                   | 28.92                 | 2.18                        | 2.36                        | 0.10                       |
| 100% RDF (250:125:125 NPK / ha) | 7.60 | 0.346     | 0.57               | 240.00              | 35.32                  | 294.74                | 9.30                        | 22.03                       | 0.61                       |
| **Control vs rest** |     |           |                    |                     |                        |                       |                             |                             |                            |
| S. Em. ± | 0.08 | 0.013     | 0.02               | 9.54                | 1.93                   | 10.09                 | 0.76                        | 0.82                        | 0.03                       |
| C. D. at 5% | NS    | NS        | 0.06               | 27.73               | 5.62                   | 29.34                 | 2.21                        | 2.38                        | 0.10                       |

**Conclusion**

For producing higher and profitable yield of sugarcane, the crop should be fertilized with 100% RDF (250:125:125 NPK kg/ha). Further, it is also inferred that for organic production of sugarcane crop, application of 50% RDN through vermi compost and remaining 50% RDN either through castor cake or neem cake was found remunerative.

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