Nature Environment and Pollution Technology
An International Quarterly Scientific Journal
p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454
Vol. 19 | No. 4 | pp.1737-1741 | 2020
Original Research Paper
https://doi.org/10.46488/NEPT.2020.v19i04.045
Open Access Journal

Evaluation of Sugarcane and Soil Quality Amended by Sewage Sludge Derived Compost and Chemical Fertilizer

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 03-01-2020
Revised: 21-01-2020
Accepted: 05-03-2020

Key Words:
Sugarcane
Soil nutrients
Sludge
Compost
Chemical fertigation

ABSTRACT

The impact of compost prepared from sewage sludge in addition/alteration to chemical fertilizer makes a unique direction for effective waste management with high crop productivity. The study aims to compare the quality, agronomic parameters of sugarcane amended by sewage sludge compost with that using optimum chemical fertilizer (NPK 150-50-90 kg/ha) in the two random fields near sewage treatment plant (STP) of our institute and also to predict the soil quality in that field before sowing and after ripening. Dimensional analysis, Brix, Pol, Purity, Sugar recovery and other necessary quality analysis were estimated for the sugarcane samples. Similarly, soil physico-chemical parameters such as pH, electrical conductivity, forms of nitrogen, organic carbon and other nutrients were also monitored. Obtained sugarcane purity of 89.2% from sludge derived compost (SDC) over the 82.8% using chemical fertilizer amendment leads to the sustainable management system. The % recovery of 12.23 of cane shows the optimum value for the compost amendment. The results scientifically reveal the suitability of sludge compost to the replacement of chemical fertilizers in terms of productivity and soil quality.

INTRODUCTION

India's most important socio-economic crop is sugarcane which promotes the rural agricultural practices to the good income generating based category (Tripathi et al. 2017). Sugarcane is also one of the largest sowing cash crops in India. About 42 lakh farmers are involved in sugarcane farming. Quality and yield of sugarcane highly depend upon temperature, sunlight and moisture conditions. The hot climatic condition with sufficient moisture is the ideal condition for growth. Accumulation of sucrose content in the internodes of basal to the apex is commonly said to be ripening (Pathak et al. 2018). White sugar and jaggery are the two important products from sugarcane juice extraction. Sugarcane quality also depends upon various parameters such as soil characteristics, breeds, tillers, age of tillers, etc. Juice clarification process focuses on removing non-sugars and colouring contents. The major by-products are bagasse and molasses. They are used extensively for making various products (Kumar et al. 2015). In addition to this, invasion of sugarcane borer highly interferes with the quality of sugarcane (de S. Rossato Jr et al. 2013). By comprehending the aforementioned basic introduction, it is inevitable to devise a suitable research methodology for the problems of sugarcane cultivation. Sugarcane yield of our country is significantly low when we compare to the other countries with similar environmental conditions. This might be due to several factors and fertilizer usage balance is the notable one and cause low yield (Nawaz et al. 2017, Kumar et al. 2014), since sugarcane is a typical heavy feeding crop which consumes most of the vital nutrients in the soil and consequently increases the production cost (Nawaz et al. 2017). Deficiency in organic carbon poses a serious threat to the fertility of Indian soil (Gaind & Nain 2012). Suitable fertigation with sufficient nitrogen, phosphorus and potassium is the vital requirement for the sugarcane quality. To get good juice quality and high yield it is important to consider the potassium fertilizer high (Soomro et al. 2014). However, continuous chemical fertilizer usage for high sugarcane yield resulted in deprived soil health, altered chemical composition and available micronutrients. At the same time, organic amendment enhances the soil organic matter and other nutrients within less time by optimising the dosage (Lakshmi et al. 2011). Consistent application of nutrients to the soil is not feasible in all conditions. It depends upon the type of soil and atmospheric conditions. Many researchers made different trials using organic amendments, inorganic and integrated organic and inorganic amendments to optimize the dosage for high sugarcane quality and yield economically (Nawaz et al. 2017). Managing the organic wastes effectively in our soil is the best way to enhance soil organic carbon with an economical approach. Besides, this also enhances the carbon sequestration potential (Gaind & Nain 2012). One of the best organic waste management techniques is composting. Composting is the process of converting organic wastes into humus like substances which is rich in nutrients. Microorganisms in the presence of air generally degrade the complex waste materials and yield compost, carbon dioxide and water (Atalia et al. 2015). Alternately, sewage sludge application on land is the best economical practice and in turn, it increases the water holding capacity, aeration, and organic matter and soil nutrients (Bhat & Agarwal 2013, Kootenaei et al. 2014), even though, many workers reported that sewage sludge application also results in heavy metal accumulation and cause metal contamination in edible crops (Singh et al. 2017). However, the limited proportion of sewage sludge as compost amendment up to 45% best suited for healthy soil conditioning and fertilizer for the plant growth (Chu 2017). Thereby, sugarcane quality analysis is very important for many things, especially for optimizing the cultivation process and production management. Xiao et al. (2017) analysed and reported the sugarcane quality indexes such as Brix %, pol %, purity and sugarcane recovery %. Brix (°Bx) is the sugar substance of a fluid arrangement. One degree Brix is 1 gram of sucrose in 100 grams of solution and speaks to the quality of the solution as rate by mass. The optical device refractometer used to find Brix under the refractive index principle. Pol (°Z) is another important quality index which is also sucrose content of the sugarcane juice. It is also said to be apparent sucrose. Purity is the ratio between pol and Brix.

So far, the synergistic approach of managing sewage treatment plant sludge as the composting substrate to enhance sugarcane quality not addressed well in our Indian conditions. By considering this need and above importance the main objectives of the study focussed to compare the quality, agronomic parameters of sugarcane amended by SDC with that using chemical fertilizer (NPK 150-50-90 kg/ha) and also to predict the soil quality in that field before sowing and after ripening, thus reporting the suitability of sludge compost to the replacement of chemical fertilizers in terms of productivity and soil quality.

MATERIALS AND METHODS

Investigational Location and Environmental Conditions

Sugarcane crop was sown during monsoon and post-monsoon seasons of 2018 at an investigational ranch near Sewage Treatment Plant (STP) located at Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu, India (Lat. 11.49520 and Long. 77.27640). The experimental soil type at the site was a clayey-loam.

Co-compost Preparation

Dynamic sludge gathered from the sludge waste line of STP along with other organic fraction of municipal wastes segregated from the institute was fed into the non-destructive sheet-metallic canister to get ready in-vessel aerobic compost. The substances were blended altogether once per week. The moisture of substance and temperature were observed day by day (Lokeshwari et al. 2017). The canister was checked for a time of 40 days and tests were taken routinely to assess the maturity of SDC in terms of different vital physico-chemical parameters.

STP Compost Amended Sugarcane Quality Analysis

Ten stalks from the field have been chosen randomly for analysis where STP compost amended. The average weight of a stalk is 1.5 kilogram and length ranges from 230 to 250 cm. The stalks were taken to Bannari Amman Sugars, crushed and filtered for analysis. Around five litres of juice was extracted from the crusher. The quality control lab analysed the quality parameters. Lead sulphate was added to the extract, and the sample taken to the optical device refractometer's cell compartment to find out the Brix value. Pol value was found by pouring the processed filtrate into the quartz plate of the polarimeter. Apparent purity found by taking the ratio between pol and Brix (Lingle et al. 2010).

The percentage of cane recovery was determined by the following equation.

$$\%\ \text{Recovery Cane} = [\text{Pol}\% - \{(\text{Brix}\% - \text{Pol}\%) \times 0.4\}] \times 0.75 \quad \ldots(1)$$

Agronomic Characteristics of Sugarcane

The agronomic investigation (germination %, tillers per plant, millable canes and cane yield) for the two field sugarcane samples carried out as per the methods suggested by Soomro et al. (2014). After 45 days of implant, the number of plantlets came out in every plot were counted and then by the formula below was converted into germination percentage.

$$\text{Germination}\ (\%) = \frac{\text{Number of germinated buds}}{\text{Total number of buds}} \times 100 \quad \ldots(2)$$

Physico-Chemical Analysis

For the chemical analysis, 5 g of each soil sample and compost were extracted with 50 mL of 2M potassium chloride

(Shahandeh et al. 2011, Amponsah et al. 2014) solution for 2 hours using an orbital shaker. After settling, the supernatant was filtered through syringe filters (20 μm) and directly used for measuring pH (Elico LI120) and electrical conductivity (Elico CM 180). The presence of total organic carbon (TOC) and total nitrogen (TN) was analysed by TOC Analyzer (Shimadzu, TOC L, TNM L, Malaysia) with 6800^{o}C combustion (catalytic oxidation) and non-dispersive infrared detection (NDIR) method (Vasudevan et al. 2019). It is a preferred method for estimating organic carbon in environmental samples over the conventional Walkley-Black method and loss-on-ignition (LOI) method for its comprehensive and accurate detection mechanism (Bautista et al. 2016). The aqueous concentration of phosphorus (P), nitrate-nitrogen (NO_3-N) and ammonia-nitrogen (NH_4-N) was estimated using UV-Visible spectrophotometer (Systronics PC based 2202) (Nartey et al. 2017, Benito et al. 2018). The concentration of potassium (K) was estimated by a digital flame photometer (Labtronics LT-65) (Sharma et al. 2017). All the experiments were in triplicate for analysing the statistical significance using (LSD) least significant difference test with 5% probability.

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of the Matured SDC

The compost bin periodically assessed for its maturity and the final results were tabulated after 40 days of degradation (Table 1). The observed pH (7.35) was near to neutral and EC values (1.2 dS/m) were less than 4.0 dS/m. This reveals the maturity of stable compost (Gaind & Nain 2012). The suitability of SDC for the field application can be comprehended by the author guidelines (Ahmad et al. 2007) for the maturity of compost.

Amendment Impact on Sugarcane Quality

The study results of sugarcane quality amended by the SDC and chemical fertilizer (NPK 150-5-90 kg/ha) are shown in Fig. 1. The SDC Brix value of 19.21 % was sucrose content which is optimum for the sugar crystallization. Similarly, the polarimeter value of 17.14 pol % was apparent sucrose; the apparent purity 89.2% and the recovery % cane 12.23%. Whereas, chemical fertigated sugarcane quality differs in terms of Brix 20.6, pol 17.36, apparent purity 82.8% and recovery % cane 13.15%. These findings harmonize with the results of Soomro et al. (2014) and high enough when compared with the fertilizer dose of Bokhtiar et al. (2005) and Lingle et al. (2010). It reveals that the maximum apparent purity can be attained through the SDC amendment (89.2%). However, the Brix and pol values of SDC compost were slightly less when compared to chemical fertilizer and in turn, the recovery cane % also deprived to some extent.

Impact of SDC Compost and Chemical Fertigation on Soil

The soil from the two fields was taken for analysis after SDC and chemical fertilizer amendment. The SDC amended soil yielded high quality sugarcane (89.2% purity) and optimum recovery cane % over the chemical fertigated sugarcane. The amendments compared to the feasibility of soil nutrient dynamics. Initially, the composite soil samples were taken from respective fields and assessed for physico-chemical characteristics before sowing. Similarly, after the ripening

Table 1: Matured compost physico-chemical parameter values.

Parameter	Mean Values
pH	7.35
EC (dS/m)	1.2
Moisture (%)	18
OM (%)	42.66
N (%)	1.62
NO_3-N (mg/kg)	35.73
NH_4-N (mg/kg)	1.56
OC (%)	24.8
C/N	15.3
P (%)	0.62
K (%)	1.2

OM-Organic matter, OC-Organic carbon, N-nitrogen

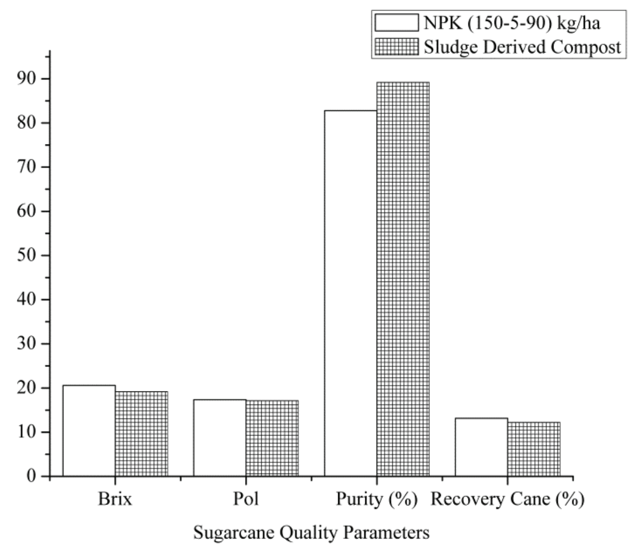

Fig. 1: Comparison of sugarcane quality parameters.

Table 2: Physico-chemical analysis of soil.

Parameter	Sludge Derived Compost amended field		NPK (150-50-90) kg/ha amended field	
	Before sowing	After harvesting	Before sowing	After harvesting
pH	7.72	7.69	8.03	7.92
EC (dS/m)	0.62	0.9	0.81	0.8
OC (%)	0.42	0.45	1.52	1.58
N (%)	0.038	0.035	0.134	0.142
C/N	11.05	12.85	11.34	11.12
P (ppm)	3.9	3.81	4.22	4.96
K (ppm)	118	123	356	372

Table 3: Sugarcane agronomic characteristics.

Amendment	Germination %	Tillers per plant	Millable canes/ha	Yield, t/ha
SDC	66.24	3.92	132.6	148.72
NPK (150-50-90 kg/ha)	48.33	2.81	126.2	98.26

also, the soil parameters assessed for fertility. Generally, soil nutrients are highly consumed by sugarcane crop because it is a heavy fed crop, still due to the STP compost amendment, the soil quality after ripening did not deteriorate much. The SDC amended soil pH value of 7.69 is optimum for further crop production and slightly decreased with the initial pH level of 7.72. Whereas, before sowing chemical fertigated soil showed high level pH of 8.03 and decreased to 7.92 after ripening. These typical pH values were following the similar results of Teshome et al. (2010). Similarly, EC, OC %, N % along with P and K values also reveal that soil fertility is protected (Table 2).

Agronomic Characteristics of the Sugarcane

The two fields near STP were periodically observed and the vital agronomic characteristics were tabulated (Table 3). The germination percentage of 48.33 was observed for chemical fertilizer amended field. This low value might be due to elevated nitrogen value. Rapid availability of nutrients enhanced the tillering values in both the fields and it also resulted in high millable canes (Sarwar et al. 2010). High yield and other parameters were observed for the SDC amendment.

CONCLUSION

The implications of the findings of this research on the quality of sugarcane best suits for sustainable waste management policies. The juice quality extracted from the sugarcane stalks of sludge compost amendment field has higher apparent purity 89.2% over the chemical fertigated sugarcane stalks. The Brix, pol and recovery % of cane were optimum ranges with that of chemical fertilizer dose (NPK 150-50-90 kg/ha). The synergistic approach of waste management in terms of sludge derived compost amendment can be recommended for the high yield and quality sugarcane economically. This can be understood from the agronomic characteristic's variation. The co-compost prepared with STP sludge and other community wastes have the natural potential to hold vital nutrients in the soil for further cropping.

ACKNOWLEDGEMENTS

This work was supported by the Management and staff of Bannari Amman Institute of Technology, Sathyamangalam and funded by Science and Engineering Research Board, Department of Science and Technology, Government of India under Swacch Bharat Mission [ECR/2016/001114/ES].

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