Advances in Crop Science and Technology

Teshome et al., Adv Crop Sci Tech 2014, 2:5
http://dx.doi.org/10.4172/2329-8863.1000153

Research Article Open Access

Effect of Nitrogen and Compost on Sugarcane (*Saccharum Officinarum* L.) at Metahara Sugarcane Plantation

Zeleke Teshome*, Girma Abejehu and Hadush Hagos

Sugar Corporation, Research and Training, P.O. Box 15, Wonji, Ethiopia

Abstract

A study was conducted at Metahara Sugar Estate in Ethiopia with the objectives to determine the optimum rates of nitrogen and compost for sugarcane production, and the effect of compost on soil chemical properties. Four levels of nitrogen (0, 46, 92, and 138 Kg /ha) and five levels of compost (0, 5, 10, 15, and 20 ton/ha) were combined in factorial arrangement. The experiment was laid out in randomized complete block design with three replications. It was conducted on clay soils (Haplic Cambisols). Soil samples were taken before and after treatment application, and analyzed for pH (1:2.5), ECe, organic carbon, total N, available P, and available K. All the cultural practices were executed as per the estate's practice. Analysis of the soil indicated that except for pH value, all the salient soil properties including ECe, organic carbon, total nitrogen, available P, and available K were slightly increased due to compost application. Analysis of variance indicated that interaction effect between nitrogen and compost was significant ($p<0.05$) on stalk girth, stalk weight, cane yield, and sugar yield. Highest cane and sugar yields were obtained when 46 Kg N/ha applied with 15 ton of compost/ha. Net benefit to cost ratio was also found to be the highest, 1.12, for this combination. Therefore, 46 Kg N/ha with 15 ton of compost/ha is recommended for clay soils (Haplic Cambisols).

Keywords: Sugarcane; Compost; Filtercake; Vinasse; Nitrogen; Sugar yield

Introduction

Filter cake and vinasse are the common sugar industry byproducts. Vinasse is a corrosive contaminant liquid residue resulting from alcohol distilleries generated in great amounts which ranges from 12-15 liters per liter of alcohol production [1]. Filter cake is one of sugar processing byproduct mostly used as manure in sugarcane fields as it contains 2.0% P_2O_5, 1.0% nitrogen on dry matter basis, and some organic matter [2]. Vinasse contains high levels of organic matter, potassium, calcium and moderate amounts of nitrogen and phosphorus [1-4], particularly it is rich in potassium. Application of vinasse to the soils for sugarcane fertilization is known to reduce its deposition in waterways and its contaminant effects besides increasing sugarcane yields and reducing fertilizer expenses [5]. In many countries, vinasse is directly applied to sugarcane fields as a substitute for conventional potassium fertilizer products [6,7]. Nevertheless, composting of vinasse with filter cake reduces its deposition and contaminant effects through decomposition of raw organic matter in to soil building humus. In India, vinasse is mixed with filtercake to produce compost. Its application to soil increased the levels of organic matter, K, and P in the soil [2].

In most cases, recycling of vinasse either by direct application or after composting could be considered as an important disposal mechanism especially from environmental point of view. At Metahara Sugar Estate, filter cake together with mineral fertilizers have been used in cane production. Since recently, however, Metahara Sugar Estate is producing large quantity of vinasse from ethanol factory; and the estate is preparing compost for field application by mixing vinasse with filter cake to ensure safe disposal of vinasse. The application of filtercake-vinasse compost to sugarcane fields is used as disposing mechanism in addition to its use as potential source of fertilizer. However, nutrient content of the compost, rate of application, and its effects on sugar yield and soil properties were not yet known.

Therefore, the study was initiated with the following objectives:

- To determine optimum rates of nitrogen and compost for sugarcane production
- To determine the effect of compost on selected soil chemical properties

Material and Methods

Description of the study area

Metahara Sugar Estate is located at about 200 km southeast of the capital city, Addis Ababa. It is situated at 8^0 53' N, 39^0 52' E and an altitude of 950 m.a.s.l. The area has a semi-arid climatic condition. Most of the Estate soils are alkaline with pH normally above 8.0 (the soil may be sodic when pH above 9.5), strongly calcareous with $CaCO_3$ between 6 and 15%, very low or low (<0.2%) in total N, dominated by very high exchangeable Ca and Mg, very low or low (<10 ppm) in available P, very low in organic carbon, CEC between 40 and 75 meq/100 kg soil (some loamy and sandy soils have a CEC <40), and very high levels of exchangeable K but more variable amounts of available K [8]. From the soil fertility point of view, Metahara Sugarcane Plantation soils have been classified into F1 and F2 fertility units.

The experiment was executed on clay soils (Haplic Cambisols) of F1 soil fertility unit covering 63 % of Metahara Sugarcane Plantation. It was conducted for two crop seasons (2010/11-2012/13). The experiment was laid out in factorial randomized complete block design with three

***Corresponding author:** Zeleke Teshome, Sugar Corporation, Research and Training, P.O. Box 15, Wonji, Ethiopia, Tel: 0922811664; E-mail: zeleketesh@yahoo.com

Received: September 25, 2014; **Accepted:** November 10, 2014; **Published:** November 12, 2014

Citation: Teshome Z, Abejehu G, Hagos H (2014) Effect of Nitrogen and Compost on Sugarcane (*Saccharum Officinarum* L.) at Metahara Sugarcane Plantation. Adv Crop Sci Tech 2: 153. doi:10.4172/2329-8863.1000153

replications. The treatments included four levels of nitrogen (i.e., 0, 46, 92, and 138 Kg/ha) and five levels of vinasse-filtercake compost (i.e., 0, 5, 10, 15, and 20 ton/ha). Urea fertilizer was used as source of nitrogen.

The compost was prepared by the Sugar Estate using windrow composting method at the compost yard. Odour and colour of the compost were considered to determine the maturity before field application. Filtercake-Vinasse compost was applied before planting while nitrogen was applied at 2.5 months of cane age. Size of experimental plot was 52.2 m^2 (6 furrows of each 6 m long and 1.45 m wide). Test variety used was NCo334. All agronomic practices such as irrigation, molding, weeding etc. were applied uniformly to all experimental plots as per the standard practices followed by the Sugar Estate.

Representative Filtercake-Vinasse compost samples were taken before application. Soil samples were also collected from the study site before treatment application, and after treatment application (5th month). Both soil and compost samples were analyzed for pH (1:2.5), EC (1:2.5), organic carbon, total N, available P and available K following standard analytical procedures [9]. The soil electrical conductivity (EC) measured at 1:2.5 soil: water was converted to electrical conductivity of saturation paste (ECe) by multiplying by a factor of 4.3 [10].

Tiller and stalk population count were done at 3 and 10 months of cane age, respectively. At harvest, 20 millable stalks were sampled from the middle four furrows and the following parameters were determined: stalk length, stalk girth, stalk weight and S% C. Cane yield was calculated from stalk weight and stalk number while sugar yield were calculated from cane yield and S%C.

Statistical analysis

Statistical analysis of the variance was performed for the collected data using SAS software and mean separation was done at 5% probability levels by Duncan Multiple Range Test (DMRT).

Economic analysis

Economic analysis was done by considering the following assumptions and cost components: experimental sugar yield was adjusted down by 15% to reflect actual sugar yield at commercial level [11]. Price of Urea, 600 $USD/ton; haulage cost, 1.94 $ USD/ton of sugar; processing cost, 58 $USD/ton of sugar; compost preparation and transportation cost, 24.45 $USD /ton; production cost of sugar, 259.5 $USD/ton; selling price of sugar, 536 $USD /ton. Net benefit cost ratio was used to compare treatments. For partial budget analysis, factors with significant effects were considered [11]. Finally, net benefit cost ratio (NBCR) was computed using the appropriate relationships [12].

Result and Discussion

Chemical properties of matured compost

The analytical results of compost are presented in Table 1; pH and ECe values of the compost ranged from 6.3-7.1, and 219-258 dS/m, respectively. The values of organic carbon, total nitrogen, available phosphorus, and available potassium were 17.5%, 1.13%, 0.08%, and 6.33%, respectively. The values of nitrogen, phosphorus, and potassium content of the compost are high as compared to that of Sugar Factory by-products [13]. The C:N of the compost ranged from 14.75 to 19.01 with mean value of 15.48 indicating that the compost was matured; however, the nitrogen content was low in such cases nitrogen from the soil could be immobilized. If the organic materials have a C/N ratio of less than 20, there could be release of mineral nitrogen after application of compost to soil early in the decomposition process. However, the total nitrogen content of the organic substance being added to soil to be considered [14]. The same Author reported that concentrations of nitrogen in the organic manure is between 1.5 and 1.7% are usually sufficient to minimize immobilization of soil nitrogen. The total nitrogen of the compost was 1.13%; this is expected to favor immobilization of soil nitrogen at the start of decomposition. Thus, addition of extra nitrogen is required; otherwise microbes involving in compost decomposition process would compete with sugarcane for nitrogen and this could create shortage of nitrogen required for the crop.

Nutritionally, the compost greatly contributes to the fertility of soil through releasing essential nutrients including macro and micro-nutrients, and activating the living microbes in the soil. Further, it could help in solubilizing fixed elements in the soil. As indicated in Table 1, the mean value of nitrogen was 1.13%; by applying 1 tone of compost per ha, 11.3 kg N/ha can be supplied to the soil if all of the nitrogen is mineralized. However, these nutrients from such organic matters are released very slowly and hence necessitate supplemental fertilizer to avoid nutrient deficiency. In spite of the fact being found small quantities of both macro and micro nutrients in compost, its sole application to soil does not supply the required amount of nutrients to complete its growth and development.

Effect of compost on soil chemical properties

Soil analysis result indicated that the pH was not changed while the ECe values were increased from 2.02 to 2.27 dS/m. However, compared to ECe value of compost (Table 1), the ECe values of soil (Table 2) obtained after application to cane fields can be considered as low or within the normal range for optimal cane growth.

The salient soil properties, namely total nitrogen, organic carbon, available P and available K were not substantially increased (Table 2). This study justify that yield increment for most of compost studies is not only due to supplement of nutrients by compost but also important features of organic materials that activating the soil micro-organism and thereby enhance solubility of fixed plant nutrients in the soil.

Effects of nitrogen and compost on yield attributes and yield of sugarcane

Analysis of variance indicated that except for stalk girth and number, all the parameters including till number, stalk length, stalk weight, cane yield, S%C, and sugar yield were not significant ($p<0.05$) due to nitrogen rates applied (Table 3).

S/N	Sampling sites	pH (1:1:5)	ECe (dS/m)	Organic carbon, %	Total Nitrogen, %	C:N	Available p, %	Available K, %
1	S1	7.1	258	19	1.26	15.07	0.098	7.11
2	S2	6.6	228	17	0.89	19.01	0.082	6.35
3	S3	6.3	219	16	1.14	14.04	0.085	5.86
4	S4	6.6	237	18	1.22	14.75	0.066	6.01
Mean		**6.7**	**235.4**	**17.5**	**1.13**	**15.48**	**0.083**	**6.33**

Table 1: Major chemical properties of the compost.

Treatment application	pH (1:2.5)	ECe (dS/m)	OC, %	TN, %	C:N	Avail. P, ppm	Avail. K, ppm
BTA	8.0	2.02	1.60	0.148	10.8	4.19	444
ATA	8.0	2.27	1.69	0.150	11.3	4.77	448

N.B: BTA=before compost application; ATA= after application of compost application.

Table 2: Effect Major soil chemical properties.

Variable	Length (m)	Girth (cm)	Weight (kg)	Tiller number ('ooo ha^{-1})	Stalk number ('ooo ha^{-1})	Cane yield (t/ha)	S%C	Sugar Yield (t/ha)
Nitrogen (N)	NS	*	NS	NS	*	NS	NS	NS
Compost (C)	NS	NS	*	*	NS	*	NS	*
N*C	NS	*	*	NS	NS	*	NS	*
CV (%)	7.59	3.50	8.96	6.97	3.83	7.99	5.14	9.29

Table 3: Analysis of variance for the effect s of nitrogen and compost on yield attributes and yield of sugarcane.

N (kg/ha)	Cane Yield, ton/ha				
	Compost, ton/ha				
	0	5	10	15	20
0	262.6 (bcde)	253.5(bcde)	250.9(cde)	274.4(abcde)	275.0 (abcde)
46	287.6 (abcd)	264.5(bcde)	252.4 (cde)	315.6 (a)	264.7(bcde)
92	285.6 (abcde)	263.5 (bcde)	264.3 (bcde)	277.1(abcde)	276.1 (abcde)
138	243.0 (e)	289.3 (abc)	282.7 (abcde)	296.1 (ab)	264.7(bcde)
N (kg/ha)	Sugar Yield, ton/ha				
	Compost, ton/ha				
	0	5	10	15	20
0	34.10(bcd)	33.03(cd)	32.31(d)	36.41 (abcd)	39.44 (abc)
46	36.59 (abcd)	33.99 (bcd)	32.29 (d)	41.35(a)	33.67 (bcd)
92	37.28 (abcd)	35.72 (abcd)	33.11(cd)	35.28 (abcd)	35.28 (abcd)
138	31.61 (d)	38.95(abc)	36.78(abcd)	40.12 (ab)	34.03 (bcd)

Table 4: Cane and sugar yields as affected by the application of nitrogen and compost.

Nitrogen (Kg/ha)	Compost application rate (ton/ha)				
	0	5	10	15	20
0	0.89	0.81	0.70	0.96	1.08
46	0.98	0.82	0.74	1.12	0.77
92	1.00	0.85	0.70	0.83	0.83
138	0.74	0.94	0.80	0.98	0.74

Table 5: Net benefit cost ratio (NBCR) for nitrogen and compost combinations.

Compost application was significant ($p<0.05$) for tiller number, stalk weight, cane yield and sugar yield, but no significant effect was observed for stalk number, stalk length, stalk girth, and S%C. The interaction effect between nitrogen and compost was significant ($P<0.05$) for stalk girth, stalk weight, cane yield, and sugar yield while it was non-significant for tiller number, stalk length, stalk number, and S%C (Table 3).

Sole application of nitrogen at higher rate, 138 kg N/ha, gave the lowest cane yield as well as sugar yield; this could be due to the depressing effect of nitrogen when it is applied at higher rates. Combined application of 46 kg N/ha with 15 ton of compost/ha gave maximum cane and sugar yields (Table 4). This is in agreement with the findings of the experiment conducted in India that indicated inorganic fertilizer NP in combination with organic manure gave higher sugar yield than application of NP alone [15]. Similarly, this result is also in agreement with the research conducted at Metahara that gave best cane yield was recorded with the application of both nitrogen and compost than sole application of nitrogen or compost [16].

Economic analysis

Based on net benefit to cost ratio, nitrogen-compost combination (46 Kg N/ha and 15 ton /ha) was relatively with highest NBCR, 1.12, within one crop cycle (Table 5). This result should not be solely evaluated by its yield outcome or cost of fertilizer reduction, but it should also be evaluated with its potential outlet benefit for excess vinasse disposal.

Conclusion

Soil analysis result indicated that the compost was neutral in reaction with mean pH value of 6.7, and it contained mainly 17.5% organic carbon, 1.13% nitrogen, 0.083% phosphorus, and 6.33% potassium. Except pH, ECe, total nitrogen, organic carbon, available P and available K values were slightly increased due to the application of compost.

Interaction effect between nitrogen and compost was significant ($p<0.05$) on stalk girth, stalk weight, cane yield, and sugar yield. Highest cane and sugar yields were obtained when 46 Kg N/ha applied with 15 ton of compost/ha. Net benefit to cost ratio was also found to be the highest, 1.12, for this combination. Therefore, based on the present findings the following recommendations are forwarded:

- On clay soils, 15 ton of compost/ha should be applied with 46 Kg nitrogen/ha.

- Compost should be applied before furrowing while nitrogen fertilizer should be applied at 2.0-2.5 of after planting.
- Avoid application of compost on heavy (vertic) clay soils and fields prone to water logging.
- In the future, application rate and method should be studied for ratoon crops.

Acknowledgments

The Authors are grateful to Sugar Corporation, Research and Training, for financing the study and would like to thank those who participated in data collection and summarization. Authors are also indebted to Metahara Sugarcane Plantation Staff for their collaboration while conducting the study.

References

1. Rosseto AJ (1987) Cana-de-acucar, cultivo e utilizacao. Campinas. 435-504.
2. Rao PN (1990) Recent advances in sugarcane, 1st edition. The KCP LTD. India.
3. Melchor H, Garcia GIS, Lopez SP, Espinoza DJL, Estrada LICC, et al. (2008) Vinasse and filtercake compost as nutrient source for sugarcane in a molic gleysol of chips, Mexico. 33: 855-860.
4. Franco A, Marques MO, Melo WJ (2008) Sugarcane grown an Oxisol amended with sewerage sludge and vinasse: Nitrogen contents in soil and plant. J. Agri. sci, 65: 408-414.
5. CIMMYT (International Maize and Wheat Improvement Center) (1988) An Economic Training Manual: From Agronomic Data to Farmer's Recommendations. CIMMYT, Mexico 1-79.
6. Gomez J, Rodriguez O (2000) Effects of vinasse on sugarcane productivity. Revista de la Facultad de Agronomia LUZ. 17: 318-326.
7. Mariano AP, Crivelaro HR, Angelis DF, Bonotto DM (2009) The use of vinasse as an amendment to ex-situ bioremediation of soil and groundwater contaminated with diesel oil. Brazilian Archives of Biology and Technology. 52: 1043-1055.
8. Booker Tate (2009) Re-evaluation of plantation soils at Metahara Sugar Factory. Final Report. Booker Tate Limited, UK.
9. Sahilemedhin S, Taye B (2000) Procedures for soil and plant analysis. Addis Ababa, Ethiopia.
10. Kumar KS, Vijay KS, Verma KS (2002) Influence of use organic manure in combination with organic fertilizer on sugarcane and soil fertility. Indian Sugar 52: 177-182.
11. FAEF (2003) Salinidade dos Solos do Regadio de Cho´kwe`: Projecto Cheias Limpopo. Universidade Eduardo Mondlane, Departamento de Engnharia Rural, Maputo.
12. Camargo OA, Valadares JMAS, Berton RS, Sobrinho JT, Menk JRF (1987) Alteraçao de caracteristicas químicas de um latossolo vermelho-escuro distrofico pela aplicaçao de vinhaça. Boletim Científico do Instituto Agronomico de Campinas 9: 23.
13. HBCNA (2006) Handbook of Cost-Benefit-Analysis - Financial management reference material.
14. Zeleke T, Girma A, Abiy F (2013) Evaluation of composting materials at Metahara Sugar Estate: Advisory note. In: Zeleke Teshome, Abiy Getaneh, Yohannes Zekarias and Fikru W/Mariam (eds). Research and Training Miscellanea. Wonji, Ethiopia.
15. Tisdale SL, Nelson WL, Beaton JD (1985) Soil fertility and fertilizers (4thedn.) Macmillan Publishing Company. New York.
16. Haile G (1993) Response of sugarcane to compost and nitrogen. In:Ambachew Dametie and Girma Abejehu (eds). Review of sugarcane research in Ethiopia: Soils, Irrigation and Mechanization (1964-1998). ESISC Sh Co., Wonji, Ethiopia.

Citation: Teshome Z, Abejehu G, Hagos H (2014) Effect of Nitrogen and Compost on Sugarcane (*Saccharum Officinarum* L.) at Metahara Sugarcane Plantation. Adv Crop Sci Tech 2: 153. doi:10.4172/2329-8863.1000153