

Evaluating the influence of organic source of wastes from sugar estateson durum wheat (Triticum durum L.assassa) production and soil quality on Vertisols

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Abstract
The ever escalating prices of chemical fertilizers for the poor farming communities forced the researcher to find an alternative means to provide sufficient food for the ever increasing human populationin Ethiopia. Though the use of organic wastes as a soil amendment and improvement on soil quality has been a well established fact,little has been done in Ethiopia especially in connection with wastes generated from sugar estates. Accordingly, this experiment was conducted on wastes collected from two long serving sugar estates in Ethiopiaso as to assess their effects on durum wheat performance and soil quality on Vertisols. The ashes and filter cakes along with the recommended NP rates and compost prepared from the local materials were evaluated against the control for their influence on the production of durum wheat (Triticum durum L. assassa) and on selected soil physico-chemical properties using RCBD experimental design with three replications.The analytical results indicated that these wastes do have a potential that can be served as a soil amendment as they provide organic matter, exchangeable bases and micronutrients which have not been considered in Ethiopian Agriculture previously.
Keywords: Ash, compost, filter cake, soil amendments**,** soil quality

Introduction

The ever escalating prices of chemical fertilizers following the skyrocketing and un-stabilized costs of fuel strained most farmers to opt for reducing its application and hence forced the yield to decline against the ever increasing human populations. On the contrary, the protracted use of the existing chemical fertilizers has witnessed altering the soil environment through continuous application. Urea, for example, is blamed to acidify the soils across its course of application over periods of time through nitrification process while the residual effect of the applied Dia-Ammonium Phosphate (DAP) as a source of nitrogen and phosphorous leads Vertisols not to respond to the external phosphorous application and changed its chemistry (DZARC, 2011; Mesfin, 2012). Therefore, exploiting the availability of different sources of organic wastes becomes vital in sustaining soil quality and optimum crop production.

Sugar production in Ethiopia was started in 1954/55 when the Wenji Sugar Factory produced 15,843 tons of white sugar in the first campaign. The development of the sugarcane plantation was started on 5000 hectares in the upper reaches of the Awash basin, 100km of Southeast of Addis Ababa. Then, it was followed by Metehara(1969) and Finchaa(1974) sugar estates in the Awash and Blue Nile Basins, respectively. The present level of national production from the three-sugar estates is estimated about 261,041 tons of sugar and 87,257 tons of molasses per annum respectively.These three sugar factories have a production capacity of 280,000 tons of sugar annually from 23,769 hectares of land (EIA, 2008). In 2006,Tendaho Sugar Development Project is established as a fourth sugar development project in the country and continue with developing sugar estates in TanaBeles, OmoKuraz and Welkait on different river basins (http://www.etsugar.gov.et/en)

Therefore, the expanding sugar estates in Ethiopia provide an ideal opportunity in using these wastes as a source of soil amendments and enhance crop performance. Consequently, evaluating the possible sources of organic wastes from this estate as alternative options for optimum crop productions and sounding the soil environment has becoming vital for sustainable agricultural productivity and growth on Vertisols.

The objectives of this experiment were, therefore, to evaluate the influence of these wastes on the performance of durum wheat (Triticum durum L. assassa) andto see their effect on selected soil chemical properties (pH, EC, OM, Total Nitrogen and Available P, Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}, Fe^{2+}, Cu^{2+}, Zn^{2+} and Mn^{2+})

Materials and Methods

The experiment was conducted at Akaki and Debre Zeit for two (2011-2012) cropping seasons.

Site description:

Akaki is geographically located between $8^{0}33'$-$8^{0}57'$ N latitude and $38^{0}43'$-$38^{0}50'$ E longitude. The average annual range of maximum temperature lies between 15 ^{0}C and 20 ^{0}C, whereas, low temperature lies between 10 ^{0}C and 15 ^{0}C. The average annual range of rainfall is from 800-1200 mm. The District lies between the altitudinal ranges of 1500 and 2300 m a.s.l. which fall in the two agro-ecological zones of Weyna-dega (mid-highlands) 98% and Dega (highlands) 2 % (Damitewet al., 2012). According to WRB (2006) and FAO (2006), Vertisols is the most dominant soil types.

Debre Zeit is located at 45 km south east of Addis Ababa, and coordinates of $8^0$45'52''N to $8^0$48'45''N latitude and $38^0$58'53''E to $39^0$01'00''E longitude with altitude of 1950 masl. It is characterized by a humid tropical climate and heavy precipitations from June to August having annual mean rainfall of 801.3 mm (NMA, 2007). The mean annual maximum temperature is at 25.5^0C and monthly values range between 23.7^0C in July and 27.7^0C in May. The mean annual minimum temperature is 10.5^0C and monthly values range between 7.4^0C in December and 12.1^0C in July and August. According to FAO soil classification (WRB, 2006) Vertisols are the dominant soil types of the area. Geologically, these soils consist of alkaline basalt and trachyte belonging to the Bishoftu Formation of the Cenozoic volcanic eruptions (Teferaet al., 1996). The soil is characterized by neutral pH ranging from 6.9-7.3 and experience water logging (Abayneh and Demeke, 2003).

Treatments set-up and experimental details

The plot sizes were 5m by 5m and durum wheat (Triticum durum L. assassa) is used as a test crop. Seven rates of treatments were used in this experiment and replicated three times in a Randomized Complete Block Design (RCBD). They were control, recommended NP, compost, Filter Cake (FC), Ash (A) from Wenji plus half recommended NP, Filter Cake (FC) and Ash (A) from Metehara plus half recommended NP. Except for the control and recommended NP,the equivalent rate of N and P, and coefficient of availability through time for cropping season were calculated before setting as treatment and the equivalent values were applied in terms of weight of the respective treatments.All the recommended cultural practices were adopted to manage the experiment and the data were subjected to analysis of variance (ANNOVA) using the GLM procedure of SAS.

Results and Discussion

The chemical compositions of these materials werefound to be promising to apply as a soil amendment for agricultural purposes (Patterson, 1999). Except for ash from Wenji, the rest materials possess OM that falls in high category and were found to be higher than 23.2, 209.2, 43.6, 209.2 and 197.20% as compared to the soil OM for ash and filer cake from Wenji and Metehara,respectively and compost (Table 1). This will have a potential in alleviating the problems associated with physico-chemical properties of the soil like improving infiltration.

The pH and EC

The analytical results showed that these organic wastes do have a reaction a bit higher than the neutral pH having the ashes possess a relatively higher reaction than the filter cakes in both samples (Table 1). The pH units are increased by 11 (W) and 16 % (M) for ashes and decreased by 2 and 5 % for filter cakes for the same. Almost no difference was observed between the soil and compost reaction. Similarly, the EC were also increased by 11.54 and 19.23 % and decreased by 76.93 and 80.77 % for the same material and location respectively. 80.77 % decrease for compost was recorded. Ashes relatively contain higher amount of exchangeable bases that could contribute for higher soil reaction and electrical conductivity as compared to the filter cake where by having low in them but containing higher amount of micronutrients.

The OM, Total Nitrogen and Available P

The organic matter (OM) was considerably varied between 23.2 (W) and 211.2 % (W) as compared to the soil OM where highest value is for filter cakes and compost whiles the lowest for ashes. Accordingly, 23.2 (W) and 43.6 % (M) for ashes and 197.2 (C), 209.2 (W) and 211.2 % (M) were recorded.

Table 1 Characteristics of the organic wastes generated from Wenji and Metehara sugar estate farms

Organic waste	pH	EC (dS m^{-1})	OM (%)	TN (%)	Av. P (ppm)	Exchangeable Cations (c mole $^{(+)}$ kg^{-1})				Micronutrients (ppm)			
						Na	K	Ca	Mg	Fe	Cu	Zn	Mn
Ash(W)	8.44	0.29	3.08	0.23	80	1.76	0.24	12.92	1.13	3.98	0.58	1.08	1.49
FC (W)	7.39	0.06	7.73	2.32	142	0.60	0.72	48.69	3.58	28.50	11.01	13.1	63.70
Ash (M)	8.82	0.31	3.59	0.32	90	1.82	1.41	13.81	5.82	2.81	2.29	1.46	2.56
FC (M)	7.15	0.05	7.78	2.13	114	0.72	2.25	98.84	15.98	57.36	3.49	8.40	48.13
Compost	7.65	0.05	7.43	2.19	174	4.96	2.54	41.99	15.92	17.17	1.38	5.89	55.51
Soil	7.60	0.26	2.50	0.15	22	0.18	0.37	40.12	8.28	10.62	0.93	0.35	15.04

* W and M refers to materials collected from Wenji and Metehara sugar estates respectively

Similar to the OM, the total nitrogen content is considerably vary between 53.33(W) and 1446.67 % (W) as compared to the soil TN where highest value is for filter cakes and compost while the lowest for ashes. 53.33(W) and 113.33 % (W) for ashes and 1360 (M), 1446.67(W) and 1320 % (C) were found.As available P is a constituent of OM, its values follow similar trends like total nitrogen. Accordingly, the its value considerably increased in a range from 263.63 (W) to 690.91 % (C) as compared to the soil TN where highest value is for filter cakes and compost while the lowest for ashes. 263.63 (W) and 309.09 % (M) for ashes and 690.91 (W), 545.46 (M) and 418.18 % (C) for compost and filter cakes from Wenji and Metehara, respectively

The exchangeable cations(Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}, Fe^{2+}, Cu^{2+}, Zn^{2+} and Mn^{2+}))

Except in Mg for filter cakes from Metehara, all the organic materials possess higher values of exchangeable cations that could range from 0.35 to 58.72 % increase advantage of using them as a source of nutrient inputs (Table 2) which contribute to higher pH and EC (Table 1)

Table 2 Gain or loss of comparative advantage of exchangeable cations using these wastes

Materials	Gain or loss			
	Na	K	Ca	Mg
Ash(W)	1.58	0.87	12.80	7.15
FC (W)	0.42	0.35	8.57	4.70
Ash (M)	1.64	1.04	13.69	2.46
FC (M)	0.54	1.88	58.72	7.70
Compost	4.78	2.17	1.87	7.64

The micronutrients(Fe^{2+}, Cu^{2+}, Zn^{2+} and Mn^{2+})

On the contrary, the concentrations of micronutrient were found to be very low and even below the soil for the ashes while filter cake possess better (Table 3) which contribute to lower pH and EC (Table 1). The concentration of micronutrient was found to variably differ unlike exchangeable bases where Ashes and filter cakes were believed to contain.

Table 3 Gain or loss of comparative advantage of micronutrients using these wastes

Materials	Gain or loss			
	Fe	Cu	Zn	Mn
Ash(W)	-6.64	-0.35	0.73	-13.55
FC (W)	17.88	10.08	12.75	48.66
Ash (M)	-7.81	1.36	1.11	-12.48
FC (M)	46.74	2.56	8.05	33.09
Compost	6.55	0.45	5.54	40.47

It is not surprising that the recommended chemical fertilizer beat all the organic sources of fertilizer owing to the fact that it is highly soluble in water and easily taken up by the plant. Filter cake or mud in Akaki and Ash from Wonji and half of the recommended rates of chemical fertilizers follow with a magnitude of less than 2 and 4 qunitals (Table 4).

Table 4 Mean grain and straw yields at Akaki and Debre Zeit.

Treatments	Akaki		Debre Zeit	
	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
Control	2002.5	990.0	1066.7	315.00
Rec. NP	2620.0	1418.3	1193.3	810.00
Compost	1830.0	836.7	1383.3	1475.00
Filter Mud W	2355.0	1645.0	1283.3	455.00
Ash (W)+1/2 NP	1706.7	960.0	1228.3	938.33
Filter Mud M	2120.0	1380.0	1523.3	505.00
Ash (M)+1/2 NP	1612.5	823.3	1441.7	562.50
CV (%)	9.05	15.5	12.18	15.82
LSD (5%)	325.08	518.2	199.0	96.51
R^2	0.84	0.65	0.93	0.98

Summary and conclusion

The potential of these organic sources of wastes generated these two long serving sugar estates were exploited and this study confirmed that they have a positive influence of selected soil physico-chemical properties of Vertisols. Therefore, long term research experiments should be carried out on these wastes and from the upcoming sugar estates to reach on a sound conclusion on a specific soil quality attributes.

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