Research Article **AJAR (2019), 4:43**

American Journal of Agricultural Research
(ISSN:2475-2002)

Evaluation of Compost Integrated with Chemical Fertilizer for better production of Maize in Shashemene District of West Arsi Zone, Oromia

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ABSTRACT

The effect of integrated use of compost and urea on yield of and yield component was assessed in a field experiment in Shashemene district during 2016-2018. In this experiment, compost was replaced UREA at different rate depending on its quality. Compost quality was analyzed mainly for Total nitrogen to compute its equivalency with UREA. Accordingly, It was identified that average total nitrogen in compost was 1%.Therefore, 100kg UREA (46kg N) is equivalent to 4600kg compost (4.6ton). The treatments were control (100kg DAP+100kg UREA), 100%compost (4.6ton) +100kg DAP, 75% compost (3.45ton)+25%UREA+ 100kg DAP, 50% compost (2.3ton) +50%UREA+100kg DAP, 25%compost (1.15ton) +75%UREA +100kg DAP. Maize (variety: Shano)) was planted in rows. Data on grain yield and yield components were analyzed. Soil samples were also collected to evaluate the residual effect of compost on soil properties. The results indicated that maximum grain yield (93kunt ha-1) of maize was obtained in treatment (2) that received sole compost plus 100kg DAP ha-1. The next higher yield was obtained in treatment 3 and 4 that received both compost and UREA with the ratio of 75:25 and 50:50 respectively. Comparing with sole chemical fertilizer treatment, the crop yield was significantly higher and different ($p \leq 0.05$) in all treatments. The residual soil fertility after maize harvest was proportional to the level of compost used. Except for total nitrogen, available potassium and phosphorous in sole chemical fertilizer application is smaller and highly significantly different ($p \leq 0.05$) from the rest of the treatments indicating that all total nitrogen in compost is available for crop in the first year of application while potassium and phosphorous availability for the crop is partially delayed. Based on the result, it was economically and environmentally recommended to use ISFM for sustainable maize production in the area.

Key words:
Soil fertility, compost, inorganic fertilizer,yield and yield components

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How to cite this article:
Kasahun Kitila and Abay Chala. Evaluation of Compost Integrated with Chemical Fertilizer for better production of Maize in Shashemene District of West Arsi Zone, Oromia. American Journal of Agricultural Research, 2019,4:43.

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Introduction

Maize (Zea mays L.) is the most widely cultivated cereal crop in terms of area coverage (16%) and production (26%) with about 6.5 million ton of production in Ethiopia (CSA, 2013). It is also the major staple food crop and source of cash in the country .Although maize is one of the most productive crops in Ethiopia, it cannot play a significant role in ensuring food security because of various factors (Tolera, 2016)

Maize needs different kinds of nourishment during its growth which can be obtained from the chemical fertilizers. Nitrogen is the one of the most important element which used for the maize cultivation and its deficiency can be limiting the nutritional elements of this crop (Khalid Berin & Islam zadeh 2001). However, excessive or under use of chemical fertilizers decline soil fertility and grain quality (Singh et al., 2007; Dagne et al., 2008). Although different factors are contributing to low productivity, soil fertility is a major concern of crop production in Ethiopia in general and in Shashmene district in particular. Studies by Wondewosen, 2009 indicated that low soil fertility is recognized as an important constraint to food production and farmers income.

Despite the cultivation preferences by the farmers in the area, currently chemical fertilizers are beyond the capacity of most farmers due to high price and its inconsistency of supply. The contrary, the alternative organic fertilizers cannot meet crop nutrient demand over large area because of limited availability, low nutrient composition and high labor requirement for its preparation (Tolera et al., 2005). On the other hand, post-harvest use of crop residue for soil fertility management is low due to other uses of the materials like for construction, feeding, fencing, fuel wood and as a source of income through direct selling of crop residues (Tenaw et al., 2006). Therefore, practices that would address the problem of nutrient deficiency are needed.

The ISFM paradigm acknowledges the need for integration of both organic (compost) and mineral inputs to sustain soil health and crop production due to positive interactions and complementarities between them (Zenebe., 2007; Vanlauwe et al., 2002). According to Mesfin T. et al., 2009, the use of compost double the grain yield of cereal crops as compared to the chemical fertilizer, hence, Continuous usage of inorganic fertilizer affects soil structure and microbial biomass and their activities, whereas compost reduces production cost and it is an environmentally friendly method of agricultural in puts technology.

Accordingly, the higher the price of chemical fertilizers and the higher organic residue demand in the field, could call up the combined use of compost with inorganic fertilizer approach which is called integrated soil fertility management. As reported by Razwan et al., 2007; Wakene et al., 2001a, the integration of organic fertilizer with inorganic fertilizer increases the potential of the applied fertilizer there by increases crop productivity. So far, in spite of the advice given for farmers' in order to prepare and use compost for their crops, information on the impact of sole compost and/or integrated use of compost with inorganic fertilizer on soil properties and performance of maize productivity is lacking in this district. Therefore, this study was conducted to achieve the following objective:

General Objective: To evaluate the effect of compost integrated with chemical fertilizer on yield and yield components of maize, on soil property, and economic performance of maize in response to integrated fertilizer application.

Materials and Methods

The study was conducted in Shashemene district where maize production is the most important part of the livelihood. Shashemene district is one of the districts in West Arsi zone of oromia located 250km from Addis Ababa on the main road to the south.

Geographically, it is located at 38° 56´ N, 7° 23´ E, and average altitude of 2002 m.a.s.l. The rainfall pattern of the district is characterized by bimodal distribution with small rainy season *belg* (March-June) and main rainy seasons *Meher* (July-November). The annual total rainfall is 1520 mm and annual average temperature of 20°c

As far as soil type is concerned, the dominant soil unit of Shashemene district is andosol. Texturally, the soils of the area are classified as sandy loam. Wheat, Barley, potato, maize and teff are the major crops produced in this district.

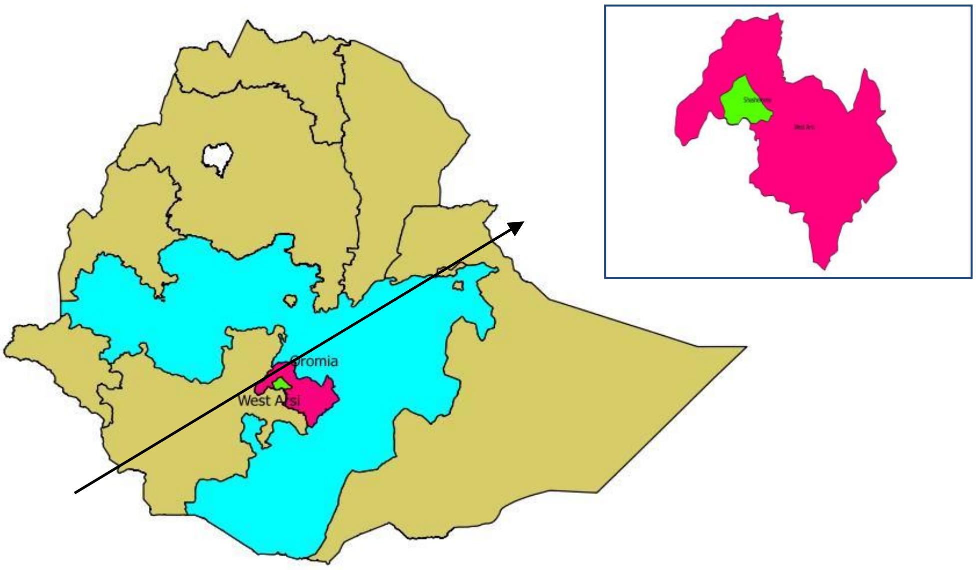

Figure: Location of Shashemene district: 38° 56´ N, 7° 23´ E, and average altitude of 2002 m.a.s.l.

Experimental design and treatments

The experiment had five treatments with four replications designed in RCBD. The area was 3mx4m for each plot. Pioneer hybrid ''Shone'' maize variety, which is the most commonly, sown by the farmers in the area, was used to evaluate the treatments. Recommended chemical fertilizer rate for maize in the district, which is 100kg DAP and 100kg UREA, were applied. Composite soil samples were collected to the depth of 20cm from the experimental site before application or planting to characterize the soil in terms of physical and chemical properties. Soil samples were also collected from each experimental plot after harvesting to evaluate the residual impact of the treatments on soil properties.

Compost was prepared using conventional technique (pit method) from the locally available material following compost making standard. Compost samples were taken and analyzed for its quality particularly for its total Nitrogen. Accordingly, the compost contains 1% of total nitrogen on average bases. This value was computed for its equivalency with nitrogen fertilizer available in UREA. Therefore, 100kg of UREA contains 46kg N implies that 4600kg of compost (4.6 ton) can supply 46kg of N, which is equivalent to 100kg UREA.

Treatments:

T1= Recommended rate of chemical fertilizer (control)
100kg DAP +100kg UREA

T2 = 100% Eq. level of compost
+ 100kg DAP

T3 = 25%UREA +75% Equivalent level of compost
+ 100kg DAP

T4= 50%UREA +50% Equivalent level of compost
+ 100kg DAP

T5=75% UREA +25% Equivalent level of compost

+ 100kg DAP

Data collection:

Yield and yield components were collected after harvesting from all plots. Soil samples were also collected to the depth of 20cm before planting and after harvesting to evaluate the residual effect of applying compost on soil chemical properties like soil pH, CEC, total N, available P, and available K. Economic data such as production cost (labor cost, input cost), gross income and net income based on the current market price of the yield and inputs.

Data Analysis

The collected data was interred to the Microsoft excel and analyzed using SAS 9.0 software version. Soil and compost samples were analyzed for physical and chemical properties following analytical standards at Batu soil research center. The actual economic analysis was done based on the Gross Margin Analysis, in which the gross margin serves as the unit of analysis in evaluating the economic performance of Maize farm.

Result and discussion

The results obtained on the effect of integrated use of compost and chemical fertilizer on yield and yield component of maize are presented and discussed below:

Grain Yield and yield components of Maize

The result showed that there is significant (P<0.05) differences among the treatments in grain yield response (Table 2). In the same table, mean of thousand seed weight and the number of cobs per plant showed no significant difference between the treatments. The maximum grain yield of 93.06 quintal ha-1 and 26.50% yield advantage were obtained in treatment two (2) that received sole compost (100% compost) plus 100kg DAP followed by the treatment 3(three) and treatment 4 (four) that received 75% compost plus 25%UREA and 50% compost plus 50%UREA respectively. The grain yield was minimum (73.70 quintal ha-1) in the treatment five (5) that received 25% compost and 50%UREA (Table 1). All treatments produced relatively higher grain yield and positive yield advantage (5-26.5%) as compared with the control treatment that received sole recommended chemical fertilizer (Table 2)

Table1: summary of result for yield and yield component

Treatments	Variable	Mean	Std. Dev	Minimum	Maximum
T1	Yield/Ku/ha	73.73	2.97	68.45	77.25
	‘’000’’Seed weight in Kg	0.46	0.07	0.38	0.65
	No. of cobs/plant	1.33	0.49	1.00	2.00
T2	Yield/Ku/ha	93.06	3.28	85.36	97.28
	‘’000’’Seed weight in Kg	0.49	0.10	0.39	0.75
	No. of cobs/plant	1.50	0.52	1.00	2.00
T3	Yield/Ku/ha	90.08	1.59	85.98	92.50
	‘’000’’Seed weight in Kg	0.47	0.04	0.42	0.55
	No. of cobs/plant	1.20	0.02	1.00	2.00
T4	Yield/Ku/ha	83.51	2.61	80.00	87.65
	‘’000’’Seed weight in Kg	0.48	0.05	0.42	0.60
	No. of cobs/plant	1.17	0.39	1.00	2.00
T5	Yield/Ku/ha	77.54	2.53	72.68	80.50
	‘’000’’Seed weight in Kg	0.49	0.05	0.41	0.59
	No. of cobs/plant	1.33	0.49	1.00	2.00

T1=control (100kg DAP+100kg UREA), T2=100%compost (4.6ton) +100kg DAP, T3=75% compost (3.45ton)+25%UREA+ 100kg DAP, T4= 50% compost (2.3ton) +50%UREA+100kg DAP, T5=25%compost (1.15ton) +75%UREA +100kg DAP

The result in this experiment was also in agreement with the study by Wakene N. *et.al* (2002) who reported that the application of 5 t compost ha-1 without N fertilizer increased maize yield by 3.45 t ha-1 while the recommended chemical fertilizer rate (110/20 N/P kg ha-1) increased the yield by 1.41 t ha-1 over the control treatment. Similar study also reported that the application of recommended rates of chemical fertilizers plus 5t compost ha-1 gave the highest average maize grain yield Shah and Ahmad (2006). Furthermore, Abunyewa *et al.* (2007) found higher maize grain yield from compost plus light fertilizer application than sole heavy fertilizer application. In addition, Rajeshwari et al. (2007) also noticed higher grain yield from the integrated use of fertilizer application. The increase in grain yield was mainly due to the compost applied to substitute the recommended N fertilizer (UREA) which can also supplement both macro and micro nutrients for better nutrient use efficiency and better grain development. Ayoola and Makinde (2006) also reported that there are higher nutrient use efficiencies with the combined organic and inorganic fertilizer applications. Similarly, Heluf (2002) reported an increment of 0.47 t ha-1 in grain yield of maize in western Hararghe zone during the first year due to application of compost compared to no compost application. In addition, Getachew (2009) reported that the use of organic manures in combination with mineral fertilizers maximized crop yield than the application of inorganic fertilizers alone.

Table 2: Mean of yield and yield component

Treatment	Mean crop yield in ku/ha	Mean '000' seed weight (kg)	Mean number of cobs/plant	Yield advantage of substituting compost (%)
Treatment1	73.70[d]	0.45	1.33	Control (no compost)
Treatment2	93.06[a]	0.48	1.55	26.50
Treatment3	90.08[a]	0.49	1.33	22.22
Treatment4	83.51[b]	0.47	1.16	13.31
Treatment5	77.53[c]	0.47	1.00	5.19
CV(%)	3.00	13.56	23.66	-
LSD	3.17	0.07	0.49	-
P-value	<0.0001	0.65	0.06	-

T1=control (100kg DAP+100kg UREA), T2=100%compost (4.6ton) +100kg DAP, T3=75% compost (3.45ton)+25%UREA+ 100kg DAP, T4= 50% compost (2.3ton) +50%UREA+100kg DAP, T5=25%compost (1.15ton) +75%UREA +100kg DAP

Additions of inorganic N with the N from compost produced an increase in yields and N use efficiency Zahir Shah *et al* (2007). This study showed that the higher yields obtained from compost was attributed mainly due to additional better nutrient availability to crop and addition of inorganic N can also improves synchrony by increasing the N supply at the initial stages of net immobilization resulting from applications of compost. Application of organic materials alone or in combination with inorganic fertilizer helped in proper nutrition and maintenance of soil fertility (Salim *et al*., 2008; Talashiker and Rinal, 2006). Shah and Ahmad (2006) recently established that combined application of urea and FYM in such a way that former contributing 75 % and later 25 % N produced the highest crop and N yields of wheat in a field experiment in Peshawar Valley.

Table 3: Mean crop yield and yield components across the experimental sites

Sites	Mean crop yield in ku/ha	Mean '000' seed weight (kg)	Mean number of cobs/plant
Halache FTC	84.66	0.47	1.45[a]
Bute FTC	83.50	0.46	1.00[b]
Karara FTC	85.25	0.48	1.35[a]
CV(%)	9.51	13.55	22.23
LSD	3.78	0.05	0.30
P-value	0.76	0.78	0.002

Crop yield and yield components are not significantly different between the experimental sites indicating that other yield determining environmental factors like soil, climate and management practices are similar among the experimental sites.

Economic importance of using integrated soil fertility management

Partial budget analysis (Table 4) and marginal rate of return (Table 5) were carried out for the integrated use of compost and NP fertilizers in maize production. As indicated in the Table 4, the highest net benefit (70,448 Eth. Birr ha-1) was recorded for treatment 2 (two) where 100% compost plus 100kg/ha NPS fertilizers were applied followed by treatment 3 (three) where 75% compost plus 25% UREA and 100kg NPS were applied resulted net benefit of 66,939 Eth. Birr ha-1.

Residual effect of compost integrated with chemical fertilizer on soil fertility

To evaluate the residual effect of applying compost integrated with chemical fertilizer, soil samples were collected from each plot of the treatments. The samples were analyzed for different soil chemical parameters which are used to indicate the fertility status of the soil (table 6)

Table4: Economic advantage of using integrated soil fertility management (ETB)

Treatments	Mean yield/ha	Input cost /ha			Labor costs /ha	Total variable cost/ha	Market price of Maize/kun	Gross income/ha	Net income/ ha	Differences with control (ETB)
		DAP	UREA							
T1	73.7	1300	1200	2400	4900	800	58960	54060	0.00	0
T2	93.06	1600	0	2400	4000	800	74448	70448	16388.00	26.5
T3	90.08	1600	1125	2400	5125	800	72064	66939	12879.00	22.22
T4	83.51	1600	750	2400	4750	800	66808	62058	7998.00	13.31
T5	77.53	1600	375	2400	4375	800	62024	57649	3589.00	5.19

T1=control (100kg DAP+100kg UREA), T2=100%compost (4.6ton) +100kg DAP, T3=75% compost (3.45ton) +25%UREA+ 100kg DAP, T4= 50% compost (2.3ton) +50%UREA+100kg DAP, T5=25%compost (1.15ton) +75%UREA +100kg DAP

Table 6: Summary of residual effect of compost integrated with chemical fertilizer

Treatment	Variable	Mean	Std Dev	Minimum	Maximum
T1 Recommended rate *(100kg DAP+100kg UREA)*	TN	0.34	0.05	0.3	0.41
	PH	5.53	0.13	5.4	5.7
	EC	0.18	0.06	0.12	0.25
	OC	1.54	0.42	1.22	2.12
	Av_P	10.96	1.15	9.68	12.25
	Av_k	296	32.26	251	325
	CEC	20.28	5.86	14.35	28.25
T2 *100%compost (4.6ton) +100kg DAP*	TN	0.37	0.05	0.31	0.41
	PH	5.85	0.06	5.8	5.9
	EC	0.28	0.05	0.24	0.35
	OC	2.95	0.2	2.7	3.12
	Av_P	22.41	3.62	18.01	26.86
	Av_k	556	26.14	531	581
	CEC	41.26	1.97	39.23	43.94
T3 *75% compost (3.45ton) +25%UREA+ 100kg DAP*	TN	0.38	0.02	0.35	0.4
	PH	5.9	0.12	5.8	6
	EC	0.24	0.03	0.21	0.27
	OC	3.16	0.64	2.42	3.96
	Av_P	20.65	2.57	18.71	22.43
	Av_k	558	35.45	516	600
	CEC	39.63	2.68	36.14	42.65
T4 *50% compost (2.3ton) +50%UREA+100kg DAP*	TN	0.34	0.04	0.3	0.39
	PH	6	0.14	5.9	6.2
	EC	0.3	0.08	0.24	0.42
	OC	3	0.53	2.51	3.72
	Av_P	17.68	2.79	13.9	20.28
	Av_k	506.75	90.61	442	641
	CEC	37.50	2.68	35.25	38.65
T5 *25%compost (1.15ton) +75%UREA +100kg DAP*	TN	0.33	0.04	0.29	0.37
	PH	5.88	0.05	5.8	5.9
	EC	0.29	0.05	0.24	0.36
	OC	3.07	0.34	2.75	3.55
	Av_P	12.59	2.33	9.22	14.54
	Av_k	468.25	45.28	405	511
	CEC	28.47	4.78	23.25	32.89

Table: Mean comparison of soil chemical properties

Soil chemical parameters	Treatments					CV (%)	LSD	P-Value
	T1	T2	T3	T4	T5			
TN	0.34	0.37	0.32	0.34	0.37	11.10	0.08	0.330
PH	5.52^{b}	5.85^{a}	5.87^{a}	6.00^{a}	5.90^{a}	1.79^{a}	0.22^{a}	0.002
EC	0.18	0.27	0.28	0.29	0.24	22.32	0.12	0.060
OC	1.53^{b}	2.95^{a}	2.99^{a}	3.07^{a}	3.16^{a}	16.45	0.98	0.006
Av_P	15.95^{b}	22.40^{a}	25.58^{a}	21.67^{a}	24.64^{a}	12.42	5.71	0.001
Av_k	396.00^{b}	556.00^{a}	568.25^{a}	606.75^{a}	558.00^{a}	9.95	112.37	0.001
CEC	20.28^{b}	41.25^{a}	28.46^{b}	39.62^{a}	37.41^{a}	11.33	8.26	0.001
C:N								

Residual effect of compost on Major soil nutrient

The compost contained considerable amounts of essential macro and micronutrients that can play an important role in plant growth and yield development. Except for total nitrogen, available potassium and phosphorous in treatment one (1) is smaller and highly significantly different (p≤0.05) from the rest of the treatments indicating that all total nitrogen in compost is available for crop in the first year of application while potassium and phosphorous availability for the crop is partially delayed.

This result is also strongly agreed with the study by other authors Eadwards *et al*., (2007) indicating that nutrients contained in compost and FYM are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect, supporting better root development, leading to higher crop yields even better than the yield of inorganic fertilizer. The study by Kasahun *et al* 2016 also indicated that after the first crop harvesting, available phosphorous and potassium in the soil treated with compost is higher than control treatment that treated with sole inorganic fertilizer.

As regards the P from organic amendments, Getachew et al. (2009) reported that compost applications can increase plant available P in the soil. The soil extractable P concentration increased on average from 7.2 to 86 mg kg−1 soil with enhanced application rates from 0 to 200 t ha−1 (Zaller et al., 2007). Furthermore, Eghball (2002) suggested that 4-year beef cattle manure and composted manure application based on N needs of corn could eventually result in soil accumulation of P, since the manure or compost N/P ratio is usually smaller than the corn N/P uptake ratio. Overall literature analysis demonstrates that several organic amendments' long-lasting applications enhanced soil available potassium, extractable phosphorous and organic carbon content.

Conclusion and Recommendations

These results suggested that integrated use of chemical fertilizer and compost performed better maize yield response as compared with sole application of chemical fertilizer. Maximum grain yield was obtained in treatment two where compost substitutes Urea by 100% followed by treatment three and four where compost subsites Urea by 75% and 50% respectively. Equal amount of DAP (100kg/ha) was applied for all treatments. Soil samples were collected after crop harvest to evaluate the residual effect of compost on soil fertility statues. Accordingly, the level of major crop nutrients such as available phosphorous, available potassium, cation exchange capacity and organic carbon are higher than their level available in control treatment where compost was not applied. Therefore, application of compost integrated with chemical fertilizer has appositive residual effect on soil fertility.

Based on the result, instead of using chemical fertilizer alone, it is recommended to use compost integrated with chemical fertilizer for better production of maize and to improve soil fertility which is an opportunity for the better production of the consequent crop

Acknowledgement

The authors greatly acknowledge Oromia Agricultural research institute (OARI) for funding this study. Batu Soil research center and Oromia water works design and supervision are highly Acknowledged in analyzing the soil samples collected during the experimental period. Shimelis Gizachew, Yasin Esmael, Bariso Bati and Asfaw Negesse are highly acknowledged for their support in socio economic data analysis

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