Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.7, No.23, 2017

Effect of Organic and Inorganic Fertilizers on Growth, Yield and Yield Components of Chick Pea (Cicerarietinum) and Enhancing Soil Chemical Properties on Vertisols at Ginchi, Central Highlands of Ethiopia

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Abstract
Soil fertility depletion and soil quality decline have been threatening the ecological and economic sustainability of crop production. In order to improve soil fertility and nutrient management approaches, on-farm integrated soil fertility management trials were conducted to evaluate the effect of organic and inorganic fertilizers on growth and yield of chick pea and enhancing soil chemical properties on vertisols at Ginchi, central high lands of Ethiopia. The soil treatments were eleven selected combinations of organic and inorganic nutrient sources (Farm yard manure, Compost, Vermicompost and TSP). The experiment was laid out as a randomized complete block design in a factorial arrangement and replicated three times. The study revealed that chick pea yield, some of the yield components and soil chemical properties significantly responded to the application of different soil fertility treatments. The highest chick pea grain yield (2712.2kg/ha) and biomass yield (10030 kg/ha) were obtained from the applications of 1.75t/ha of vermicompost (based on Phosphorus equivalent of recommended) and 50kg/ha of the recommended Phosphorus fertilizers followed by 2454.5and 9152kg/ha for grain yield and biomass yield, respectively. Chick pea grain yield showed significant and positive correlations with the biomass yield (r^2= 0.928). The application of 1.75t/ha of vermicompost (based on Phosphorus equivalent of recommended) with 50kg/ha of the recommended Phosphorus fertilizer rate resulted a superior yield compared with the yield of 100kg/ha Phosphorus fertilizers, which could be considered as an alternative use of integrated organic and inorganic nutrient source for sustainable soil health and crop productivity. The economic analysis result showed that the highest marginal rate of return was obtained from application of 1.75t/ha of vermicompost (based on Phosphorus equivalent of recommended) with 50kg/ha of the recommended Phosphorus fertilizer rate, which is economically the most feasible alternative on vertisols of central highlands of Ethiopian.
Keywords: Chick pea, Compost, Farm yard manure, Triple Supper Phosphorus fertilizer, Vermicompost, Vertisol

INTRODUCTION

Ethiopia is estimated to have 12.61 million hectares of vertisols, 63% of which is located in the highlands (Berhanu 1985) where chick pea (*Cicer arietinum* L.) is the second most important cultivated food legume in Ethiopia after faba bean (*Vicia faba* L.), with in an annual total production of about 122,496 tons and a total cultivated area of about 175,050 hectares (CSA, 1995). It is mainly grown under rainfall condition particularly on residual soil moisture due to its drought tolerance (Geletu, 1982). Besides its importance as food and source of cash income to the farm household, it has an additional advantage of restoring and ameliorating soil fertility by the virtue of its capacity of fixing atmospheric nitrogen.

The use of organic matter such as animal manures, human waste, food wastes, yard wastes, sewage sludge and composts has long been recognized in agriculture as beneficial for plant growth, yield and the maintenance of soil fertility. The new approaches /to the use of organic amendments in farming have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Organic agriculture has been recognized to aid in increasing crop production and ensuring quality harvest. It involves the use of farm wastes, urban wastes and industrial wastes as a source of nutrients for crops being raised. Traditional composting of organic matter wastes has been known for many years but new methods of thermophilic composting have become much more popular in organic waste treatment recently since they eliminate some of the detrimentally effects of organic wastes in the soil. Composting has been recognizing as a low cost and environmentally sound process for treatment of many organic wastes (Hoitink, 1993). A process related to composting which can improve the beneficial utilization of organic wastes is vermicomposting. It is a non-thermophilic process by which organic materials are converted by earthworms and micro-organisms into rich soil amendments with greatly increased microbial activity and nutrient availability. Vermicomposts have excellent chemical and physical properties that compare favorably to traditional composts (Paoletti, 1991).

A recent study conducted by none governmental organization called Institute for Sustainable Development (ISD) in Tigray region of Ethiopia indicated the importance of compost increasing yield and soil fertility restoration. According, Arancon and Edwards (2005) use of vermicompost in different location in Tigray region doubled the grain yield of several crops in comparison to each respective check (not fertilized) yield. The use of vermicompost also gave higher yields than the yields from compost and from chemical fertilizer was not as great as the differences between the use of compost and the check. In contrast, Bationo *et al.,* (1993) found that the use of mineral fertilizers without recycling of organic materials resulted in higher yields, but this increase was not sustainable without inclusion of soil amendments.

The most common fertilizers used in Ethiopia are diammonium phosphate (DAP) and urea. Such as unbalanced continuous application of limited fertilizers both in the amount and type may aggravate the depletion of other important nutrients such as K, Mg, Ca, S and micro-nutrients not supplied by the chemical fertilizers and may also lead to chemical soil degradation (Dibabe *et al*., 2007). Chemical fertilizers are also costly for farmers to apply the recommended rates. On the other hand, sole application of organic matter is constrained by access to sufficient organic inputs, low nutrient content, high labor demand for preparation and transporting. For instance, the low p content of most organic materials indicates the requirement of external sources of p to sustain crop productivity. Thus, the integration of organic and inorganic sources may improve and sustain crop yields without degrading soil fertility status. This study was therefore carried out to determine the effect of organic and inorganic fertilizers and their combinations on the grain yield of Chick pea.

MATERIALS AND METHODS

Study Site

The trial was conducted for two consecutive cropping years (2013 and 2014 main cropping seasons) at Ginchi west shewa, Central Highlands of Ethiopia. Chick pea widely grown in these areas and the environment is seasonally humid; the soil type is vertsols with low N, P and organic matter contents. Chick pea is commonly planted without fertilizers in the area; however, there has been an effort to plant it with fertilizer to enhance its productivity (personal communication). Ginchi located between 09° 02'N latitude and 38° 12'E longitude, 74 km west of Addis Ababa, at an altitude of about 2200 matter above sea level, with the long-term average annual rainfall of 1080 mm, about 85% of which is received from June to September.

The average minimum and maximum air temperatures are 9°C and 24°C, respectively (Getachew Agegnehu and Amare Ghizaw, 2004).

The treatments applied where:
T1 = Control-without fertilizer
T2 = Recommended phosphorus rate (100kg TSP/ha)
T3 = 13.9t/ha compost (based on P equivalent of recommended)
T4 = 8.9t/ha farmyard manure (based on P equivalent of recommended)
T5 = 3.5t/ha vermicompost (based on P equivalent of recommended)
T6 = 1.75t/ha vermicompost (50% of T5) +6.95t/ha compost (50% of T3)
T7 = 1.75t/ha vermicompost (50% of T5) + 4.45t/ha farm yard manure (50% of T4)
T8 = 1.16t/ha vermicompost (33% of T5) +4.6t/ha compost (33% of T3) +2.97t/ha farm yard manure (33% of T3)
T9 = 1.75t/ha vermicompost (50% of T5) + 50kg/ha recommended P (50% of T2)
T10 = 6.95t/ha compost (50% of T3) + 550kg/ha recommended P (50% T2)
T11= 4.45t/ha farm yard manure (50% of T4) + 50kg/ha recommended P (50% of T2)

The experimental design was a randomized complete block with three replications. Compost was prepared following the standard procedure for compost preparation (Getechew *et al*., 2005). Similarly, vermicompost containing earth warms was used for vermicompost preparation. Cattle manure with straw as bedding was used for the vermicomposting process. Bulks of composting processes were made and samples were collected from well decomposed manure, compost and vermicompost before it is applied in the field. Nitrogen and Phosphorus were analyzed at the soil and plant analysis laboratory of Holeta Agricultural Research Center before the onset of the trial so as to calculate the mineral fertilizer equivalence in the soil using the same analytical procedures. Manure and compost were applied three weeks before sowing and thoroughly mixed in the upper 15-20cm soil depth (Getechew *et al*., 2012). Di-Ammonium Phosphate (DAP) fertilizer was applied in the form of Phosphorus. To minimize loss and increase efficiency, Phosphorus was applied at planting. Chick pea (Shasho variety) was planted at the recommended seed rates of 100kg ha^{-1} in a row planting and with sowing dates of 18 and 22 September 2013 and 2014, respectively. Other recommended agronomic practices were applied during the crop growth period.

Data Collection and analysis

Composite soil samples were taken from the site at a depth of 0-30cm before treatment application. Soon after crop harvest soil samples were also taken in order to analyze soil pH, total organic carbon (OC), total N and available P. The N and P contents analyzed in the vermicompost before application were 0.86% and 1.72%, respectively on 55% dry- weight basis. In compost N and P contents before application were 0.97% and 0.43% on 55%, respectively in dry-weight basis. While N and P contents in manure before application were 1.67% and 0.67%, respectively on 50% dry weight basis. Soil reactions (pH) were measured in H_2O with a liquid to solid ratio of 2.5:1. Organic carbon was determined according to Walkley and Black method and total nitrogen using Kjeldahl method. Available phosphorus was determined using the Bray- II method. Plant parameters collected were grain yield, above ground total biomass, plant height, branch numbers per plant, thousand seed weight and pod numbers per plant (average 5 plants). Mature plant height was measured from the ground level to the tip of panicle at physiological maturity. To measure total biomass and grain yields, the entire plot was harvested at maturity. After threshing, the seeds were cleaned and weighed, and the moisture content was measured. Total biomass (on dry matter basis) and grain yields (adjusted to a moisture content of 12.5%) recorded on plot basis were converted to kg ha^{-1} for statistical analysis (Getechew *et al*., 2014). SAS software was used for data analysis. The total variability for each trait was quantified using separate and pooled analysis of variance over years using the following model (Gomez and Gomoz, 1984).

$$P_{ijk} = \mu + R_i + T_j + e_{ijk}$$

Where P_{ijk} is total observation, μ = grand mean, R_i is effect of the i^{th} replication, T_i is effect of the i^{th} treatment and e_{ijk} is the random error. Mean separation was performed using LSD value at P<0.05 probability level. Linear regression was performed between grain yield and some relevant component parameters.

Partial budget analysis

Partial budget analysis was done to identify the rewarding treatments. Yield from on – farm experimental plots was adjusted downward by 15% i.e., 10% for management difference and 5% for plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment (Getachew,2005). Three years average market grain price of chick pea (ETB 9.5kg^{-1}). Farm-gate price of P fertilizer (ETB 15kg^{-1}) and labour valued at ETB 40 per person-day were used. Labour for chick pea field management was estimated at 30 person- days per hectare.

RESULTS AND DISCUSSION

Effects of organic and inorganic fertilizers on soil chemical properties

Major causes of nutrient depletion in the study area are farming without replenishing nutrients over time, physical constraints of the soil, water logging, without fertilizer usage and poor nutrient management practices. Soil analytical data is important to identify the level of nutrients in the soil and to determine suitable rates and types of fertilizers for recommendation. Soil analysis results for the different treatments are shown in Table 1. Soil pH Values, organic carbon (OC), total nitrogen and phosphorus measured for samples taken after harvesting were significantly (P<0.001) affected by the application of different rate of organic and inorganic fertilizers. Similarly, total nitrogen was significantly (P<0.05) affected by the application of different rate of organic and inorganic fertilizers.

Soil pH has also been improved with the application of compost, manure and vermicompost. The application of 13 - 26 kg p ha^{-1} would be adequate for faba bean and chick pea production. In agreement to our findings, Mahler *et al*. (1988) reported that in terms of nutrient availability pea, lentil, chick pea and faba bean grow best in soils with pH values between 5.7 and 7.2 and require between 13 and 35 kg P ha^{-1} for adequate yields. The same author further indicated pulse crops grown on soils with a pH value of 5.6 and less give low yield. The highest pH values 6.59, 6.56 and 6.55were recorded from full doses of compost, farm yard manure and vermicompost, respectively .The average soil pH of the treatments was about 6.44, which is closer to neutral pH. The lowest soil pH (6.07) was observed in the control plots.

The highest organic carbon contents 3.40% and 3.36% were found in plots treated with full doses of farm yard manure and compost, respectively. For most of the treatments, average organic carbon content of the soil was 3.04, which is also categorized as medium range (Jones, 2003). In contrast, the total N and available P determined after harvesting were above the critical range. The highest soil N 0.32% and 0.31% were obtained from plots treated with full doses of farm yard manure and compost, respectively. Likewise, the highest soil available P 30.43ppm and 30.35ppm were noticed from plots treated with full doses of manure and compost, respectively. However, the lowest soil N and P contents 0.22% and 12.19 ppm were obtained from the control plots, respectively. The current finding indicates that integrated use of organic and inorganic nutrient sources markedly improve the overall condition of the soil as well as crop productivity if best alternative option is adopted in the area.

Table 1: Mean soil analysis results on Vertisols of Ginchi study site

Treatments	pH(H_2O)	Nitrogen (%)	Phosphorous (ppm)	OC (%)
Control	6.07^{c}	0.22^{b}	12.19^{c}	2.24^{c}
Recom. P(69/60)	6.3^{d}	0.24^{b}	24.15^{b}	2.83^{d}
Compost (Comp)	6.59^{a}	0.31^{a}	30.45^{a}	3.36^{ab}
Farmyard manure (FYM)	6.56^{ab}	0.32^{a}	30.43^{a}	3.40^{a}
Vermicompost (VC)	6.55^{ab}	0.29^{a}	30.83^{a}	3.12^{cd}
50% VC + 50% Comp	6.4^{bcd}	0.29^{a}	29.05^{ab}	3.0^{cd}
50% VC + 50% FYM	6.47^{abc}	0.28^{a}	28.9^{ab}	3.04^{cd}
33% VC + 33% Comp + 33% FYM	6.54^{ab}	0.28^{a}	29.44^{ab}	3.06^{cd}
50% VC + 50% P	6.4^{bcd}	0.29^{a}	29.03^{ab}	3.26^{abc}
50% comp + 50% P	6.38^{cd}	0.30^{a}	26.71^{ab}	3.02^{cd}
50% FYM + 50% P	6.48^{abc}	0.29^{a}	30.19^{a}	3.05^{cd}
Overall mean	6.44	0.28	27.39	3.04
LSD(0.05)	0.147***	0.037**	5.77***	0.293***
CV (%)	1.34	7.71	12.37	5.66

*Means in a column with different letters are significantly different *, **, *** at P< 0.05, 0.01 and 0.001 probability levels, respectively; NS= Not significant. Recom= Recommended rate.*

Productivity of chick pea

Applications of inorganic and organic nutrient sources either alone or in combination had a significant (P<0.05) effect on grain yield and biomass yield of chick pea (Table 2).However, plant height branch numbers per plant, pod numbers per plant and thousand grain weight did not vary with the application of different rates of organic and inorganic fertilizers. The highest chick pea grain yield and biomass grain yield were obtained with the application of 50% recommended rate of vermicompost plus half the recommended P rate and full doses of recommended rate of P with the yield advantages of about 281.1% and 254.4% compared to the control treatment, respectively. While, the application of half the recommended rate of both vermicompost with manure, vermicompost with compost, manure with P, compost with P fertilizers and one- third of vermicompost plus one-third of compost plus one-third of manure also increased chick pea grain yield by 193.8%, 189.8%, 246.9%, 227.8% and 215.8% when compared to control that is non- treated plot, respectively.

Table 2: Effects organic and inorganic fertilizers on chick pea branch numbers per plant (BNP), plant height (PHT), pod numbers per plant (PNP), biomass yield (BY) , grain yield (GY) and thousand grain weight (TGW) on Vertisols of Ginchi study site

Treatments-NPK/Organic(kg/ha)	BNP	PHT(cm)	PNP	BY(kg/ha)	GY(kg/ha)	TGW(kg /ha
ISFM- Treatments(T)						
Control	6.5	38.17	24	3680.3^{e}	964.7^{d}	247.8
Recom.P(69/60)	7.5	44	35.5	9152^{ab}	2454.5^{ab}	247.3
Compost (Comp)	8.0	41.3	31.0	6280.8^{d}	1901^{c}	244.8
Farmyard manure (FYM)	6.5	40.17	34.0	6679.5^{d}	1997.3^{c}	247.5
Vermicompost (VC)	7.0	44.17	34.3	6805.7^{d}	1889.3^{c}	242.17
50% VC + 50% Comp	8.3	43.5	35.3	6310.3^{d}	1831.3^{c}	245.17
50% VC + 50% FYM	7.17	41.5	37.8	6672.5^{d}	1869.3^{c}	245.8
33% VC + 33% Comp + 33% FYM	7.5	46.0	38.8	7223.3^{cd}	2082^{bc}	244.17
50% VC + 50% P	8.17	47.8	36.67	10030^{a}	2712.2^{a}	247.3
50% comp + 50% P	7.3	44.67	36.8	8542.7^{abc}	2197.7^{bc}	246.5
50% FYM + 50% P	7.67	42.0	35.0	7664.5^{bcd}	2381.7^{ab}	248.3
LSD $_{0.05}$	Ns	Ns	ns	1549.9	378.6	ns
CV (%)	16.9	9.02	12.3	18.5	16.04	1.87

*Means in a column with the same letter are not significantly different *, ** at P< 0.05 and P< 0.001, respectively; NS= Not significant. Recom= Recommended rate. ISFM=Integrated soil fertility management.*

Application of 100% recommended level of compost, farm yard manure and vermicompost as inorganic P equivalence ratio also increased chick pea grain yield by 197.1%, 207% and 195.8% compared to the control group, respectively. The current finding indicated that the application rate of either inorganic, organic or combination of both fertilizers doubled the grain yield under farmers' field condition compared to the farmers' usual practice. Previous research findings indicate that growth and yields of chick pea have responded differently to application of P on different soil types (Mamo *et al*., 2001; Ayalew, 2011; Agegnehu, 2014). Furthermore, the study showed that the significance of the integrated soil fertility management (ISFM) treatments containing both organic and inorganic forms under farmers' field condition could be considered as alternative options for sustainable soil and crop productivity in the degraded highlands of Ethiopia. The linear regression analysis indicated that grain yield had highly significant ($R^2 = 0.928$) and positive relationship with biomass yield (Figure 1). This implies that a unit increase in grain yield is brought about by a unit increment in biomass yield.

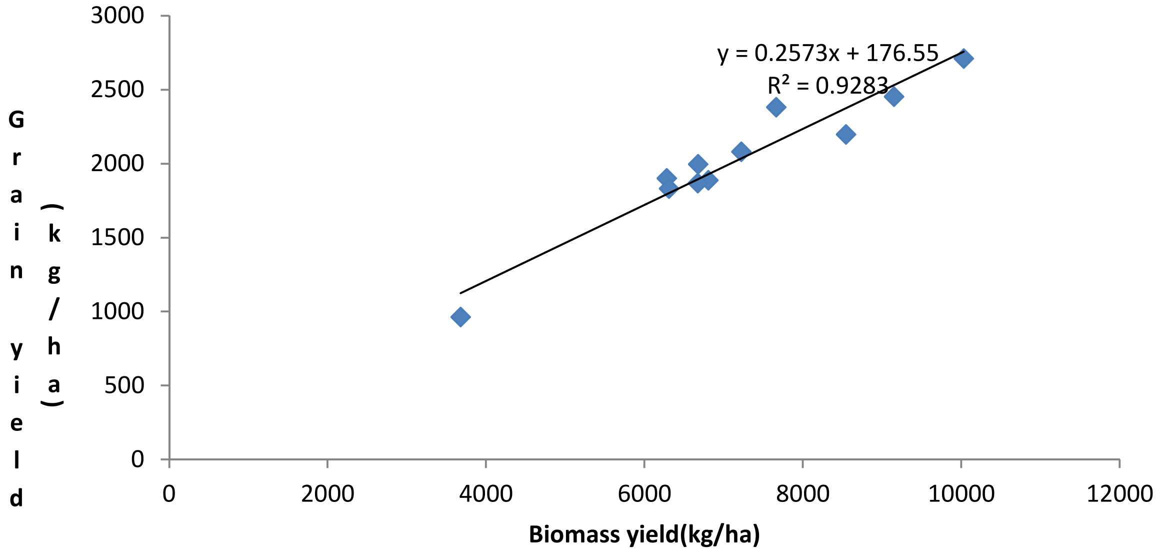

Figure 1: Correlation of chick pea grain yield with biomass yield

Economic analysis

The result of the partial budget analysis is shown in (Table 3). The economic analysis revealed that the highest net benefit of (birr 21480.9 ha^{-1}) was obtained from the application of 50% vermicompost plus 50% TSP fertilizers, where as the control treatment gave the lowest net benefit (birr 6964.65 ha^{-1}).

Table 3: Partial budget and dominance analyses of organic and inorganic fertilizers trial on chick pea on vertisols of Ginchi study site

Treatments	Average yield(kg/ha)	Adjusted yield-15% (kg/ha)	Gross benefits (ETB ha^{-1})	Costs that vary (ETB ha^{-1})			Net benefit (ETB ha^{-1})	Dominated
				Fertilizer	Labour	Total cost		
Control	964.7	819.9	9164.65		2200	2200	6964.65	D
Recom.P(69/60)	2454.5	2086.3	23317.75	2300	2000	4300	19017.75	D
Compost (Comp)	1901.5	1616.3	18059.5	-	3850	3850	14209.5	D
Farmyard manure (FYM)	1997.3	1697.7	18974.35	-	3550	3550	15424.35	D
Vermicompost (VC)	1889.3	1605.9	17948.35	-	4100	4100	13848.35	
50% VC + 50% Comp	1831.3	1556.6	17397.35	-	4050	4050	13347.35	D
50% VC + 50% FYM	1869.3	1588.9	17758.35	-	3950	3950	13808.35	D
33% VC + 33% Comp + 33% FYM	2082	1769.7	19779	-	3800	3800	15979	D
50% VC + 50% P	2712.2	2305.4	25765.9	1250	1835	3085	22680.9	
50% comp + 50% P	2197.7	1868.1	20878.15	1950	2850	4800	16078.15	
50% FYM + 50% P	2381.7	2024.5	22626.15	1750	2650	4400	18226.15	

Three years average price of chick pea is birr 9.50/kg and DAP birr 15/kg (1USD = 20.40 Ethiopia birr; D= Dominated, Recom= Recommended rate, ETB=Ethiopian birr

The economic analysis further revealed that the application of 50% vermicompost plus 50% recommended phosphorus fertilizers provided the highest marginal rate of the return (4652.7%) (Table 4) suggesting for each birr invested in chick pea production, the producer would reap birr 46.5 after recovering his investment. Since the marginal rate of return (MRR) assumed in this study was 100%, the treatment with application of 50% compost (based on P equivalent of recommended) and 50% recommended phosphorus fertilizer gave an acceptable marginal rate of return. Therefore, with economic basis, the application of 50% vermicompost (based on P equivalent of recommended) and 50% recommended phosphorus fertilizer on chick pea would be recommended on vertisols of central highlands of Ethiopia.

Table 4: Marginal analysis of organic and inorganic fertilizer effects on chick pea on vertisols at Ginchi study site

Particulars	Vermicompost	½ comp + ½ P	½ FYM +1/2 P	½ Vc +1/2P
Average yield(kg ha^{-1})	1889.3	2197.7	2381.7	2712.2
Adjusted yield-15%(kg ha^{-1})	1605.9	1868.1	2024.5	23054
Gross benefit(ETB ha^{-1})	17948.35	20878.15	22626.15	25765.9
Cost of fertilizer(ETB ha^{-1})	0.00	1950	1750	1250
Cost of labour(ETB ha^{-1})	4100	2850	2650	1835
TVC (ETB ha^{-1})	4100	4800	4400	3085
NB (ETB ha^{-1})	13848.35	16078.15	18226.15	22180.9
MC (ETB ha^{-1})		50	50	85
MB(ETB ha^{-1})		2229.8	2148	3954.75
MRR (%)		4459.6%	4296%	4652.7%

ETB = Ethiopian birr, NB= Net benefit, TVC= Total variable cost, MC= Marginal cost, MB= Marginal benefit, MRR= Marginal rate of return

CONCLUSION

The effects of organic nutrient source such as farm yard manure are not immediate as inorganic nutrient sources, but their effects are long-lasting and sustainable. The results of soil analysis after harvesting revealed that application of organic fertilizer improved soil pH, OC, N and available P and exchangeable cations. The overall result showed that the integrated application of organic and inorganic fertilizers improved productivity of chick pea as well as the fertility status of the soil. Application of organic fertilizer not only increases the nutrient content of soils, but also improves the physical and biological condition of soils. Therefore, integrated use of chemical fertilizer and locally available soil amendments is the best approach for achieving higher fertilizer-use efficiency and economic feasibility. This study suggests also use of 50% compost (based on P equivalent of recommended) with half doses of the recommended rate of P fertilizer can be the best alternative integrated soil fertility management measure considerably than the sole application of inorganic fertilizers

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Ethiopian Institute of Agricultural Research (EIAR) for sponsoring the study. Special thanks go to Mr. Tesfaye Negash, Mr. Haile Beza, Mrs. Kessech Birhanu, and Mrs. Tsige Kebede for their technical assistance during the execution of the experiments under field condition. We also thank soil laboratory staff of Holeta Agricultural Research Centre for analytical services.

REFERENCES

Agegnehu, G., M. Liben, A. Molla, A. Feyissa, A. Bekele and F. Getaneh. 2011. Research achievements in the soil fertility management in relation to barley in Ethiopia. In: Barley research and development in Ethiopia edited by B. Mulatu and S. Grando, 137-152. ICARDA, Aleppo, Syria.

Arancon, N.Q., Edwards, C.A., Biermann, P., Metzger, Z.D., luncht, C. 2005. Effects of vermicompost produced from cattle manure , food waste, and paper wast on the growth and yields of peppers in the field. Pedolbiologia 49: 297-306.

Ayalew, A. 2011. Application of NP fertilizers for better production of tef (*Eragrostistef*(zucc.) trotter) on different types of soils in sothern Ethiopia. *Journal of Natural Sciences Research*. 1(1), 1-11.

Bationo , A., C. B. Christianson and N.C. Klajim. 1993. The effects of crop residue and fertilizer use on pear millet yield in Niger. *Fertilizer Research* 34: 251-258.

Berhanu Debele. 1985. The vertisols of Ethiopia: their properties, classification and management. Fifth meeting of the Eastern African soil correlation and land evaluation sub- committee, 4-10 December 1983, Wad Medani, Sudan. World soil resources report PP. 31-54.56. FAO(Food and Agriculture Organization of the United Nations),Rome.

CSA (Central Statistical Authority).1995. Agricultural sample survey 1994/95. Report on production of major crops in meher season on private holding. Volume 1. Statistical Bulletin 143.

Dibabe, A., Bekele, T., Ahmed, R.V. 2007. The status of micronutrients in Nitisols, Vertisols, Cambisols and Fluvisols in majore Maize, wheat, tef and citrus growing areas of Ethiopia. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, pp: 77-96.

Geletu Bejiga, and Abebe Tullu. 1982. The influence of planting dates on yield of three chickpea (Cicer arietinum) varieties. *Eth. J. Agric. Sci*. 4: 61-66.

Getachew Agegnehu and Amare Ghizaw, 2004. Effects of drainage and genotype on yield and some yield components faba bean on a highland vertisol in Ethiopia. *Ethiopian Journal of Natural Resources* 6: 167 - 182

Getachew Agegnehu and Taye Bekele. 2005. On-farm integrated soil fertility management in wheat on Nitisols of central Ethiopian highlands. *Ethiopian Journal of Natural Resources* 7: 141-155

Getachew Agegnehu ,Angaw Tsigie and Agajie Tesfaye. 2012. Evaluation of crop residue retention, compost and inorganic fertilizer application on barley productivity and soil chemical properties in the centeral Ethiopia highland. Ethiopia. J. Agric. Sci. 22: 45-61.

Getachew Agegnehu, Berhane Lakew and Paul N. Nelson (2014) Cropping sequence and nitrogen fertilizer effects on the productivity and quality of malting barley and soil fertility in the Ethiopian highlands, Archives of Agronomy and Soil Science, 60:9, 1261-127.

Gomez, K.A., Gomez, A.A.1984. Statistical Procedures for Agricultural Research (2nd ed.). New Delhi, India: International Rice Research Institute, 680p.

Hoitink, Harry A.J and Harold M. Keener. 1993. Science and Engineering of composting: Design, Environmental, Microbiological and utilization Aspects. 728 printed pages.

Jones, J.B. 2003. Agronomic hand book: management of crops, soils, and their fertility. CRC Press, Boca Raton London New York Washington, D.C. 450pp.

Mahler R.L., Saxena M.C., Aeschlimann J. 1988. Soil fertility requirements of pea, lentil, chick pea and faba bean. In: R. J. Summerfield (ed.). World crops: Cool season food Legumes. Proceedings of the International Food Legumes Research Conference on pea, Lentil, Faba pea and chick pea. Washington, USA, 6-11 July, 1986,279-289.

Mamo,T., Erkossa, T., Tulema,B. 2001. Soil fertility and plant nutrition research on tef in Ethiopia. In: H. Tefera, G. Belay, M. Sorrels (eds). Tef research and development in Ethiopia. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, pp: 191-201.

Paoletti M.G., 1991. Sustainable Agro systems in Western Europe. *In*: Land use systems. An international workshop, Rodale Research Center, Kutztown, USA, 159- 166.