Effect of Organic and Inorganic Fertilizers on Growth and Yield of Chick Pea (*Cicer arietinum*) on Vertisols in the Central High Lands of Ethiopia

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Abstract

A field experiment was conducted for two consecutive cropping seasons (2014-2015) on farmers' fields in Dendi district of Oromia Regional State. The objective of the study was to evaluate the effect of organic and inorganic fertilizers on growth and yield of chick pea and soil chemical properties. The treatments included eleven selected combinations of organic and inorganic nutrient sources (Farm yard manure, Vermicompost, Compost and Phosphorus). The design of the experiment was randomized complete block with three replications. The results showed that chick pea yield, some yield components and soil chemical properties were significantly affected by the application of organic and inorganic fertilizer sources. The highest chick pea grain yield (2712.2kg ha^{-1}) and biomass yield (10030 kg ha^{-1}) were obtained from applications of 1.75t ha^{-1} of Vermicompost (based on Phosphorus equivalent of recommended) and 50 kg ha^{-1}of the recommended Phosphorus fertilizers. Besides, higher yield of 2454.5 and 9152 kg ha^{-1} grain yield and biomass yield, respectively, was obtained due to the applications of 100 kg ha^{-1}of the recommended phosphorus fertilizer. Application of the different organic fertilizers improved the organic matter, Total N, available P and pH of the soil in the study area. The results also showed that the highest marginal rate of return was obtained from application of 50kg ha^{-1} of the recommended Phosphorus fertilizer rate + 1.75t ha^{-1}vermicompost (based on equivalent P rate), which is economically the most feasible alternative on vertisol of central Ethiopian highlands.

Keywords: Chick pea, Compost, Farm yard manure, Phosphorus fertilizer, Vermicompost, Vertisol

Introduction

Chickpea (*Cicer arietinum* L) is one of the world's most important but lesser-studied leguminous food crops with nearly 10 million ha grown across the Americas, the Mediterranean basin, East Africa, the Middle East, Asia and Australia. Chickpea (*Cicer arietinum* L.) was classified in the tribe Cicereae Alef. (Kupicha 1977; Nozzolillo 1985; Van Der Maesen, 1987). It is one of the first grain legumes to be cultivated in the old world. The crop originated in the present southeastern Turkey and along its boundary with Syria (Vavilov, 1926, 1949-1950; cited in Van Der Maesen, 1987). World-wise chickpea cultivation accounts for 15% of the land area cultivated to all pulses and 13% of pulses production of (FAO 1982, cited in Judah and Subbarao, 1987). In the developed world, chickpea represents a valuable crop for export, while in the developing world; it provides a protein-rich supplement to cereal-based diets. Besides its food value, chickpea helps in the management and risk aversion where there is crop failure of major cereals due to recurrent drought. Chickpea also helps in soil fertility management, particularly in dry land areas, through symbiotic nitrogen fixation. This role of improving soil fertility is a key factor in sustaining the production of cereals in the rain fed dry areas in the developing world (Saxena, 1987 and Geletu and Yadeta, 1994).

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 195,994 tons and a total cultivated area of about 531,665 hectares (CSA, 2002). 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.

In Ethiopia, century-long, low-input agricultural production systems and poor agronomic management practices, limited awareness of communities and absence of proper land-use policies have aggravated soil fertility degradation (Agegnehu. G., 2011).This has also encouraged the expansion of farming to marginal, non-cultivable lands, including steep landscapes and range lands. Agricultural system consider integrated soil fertility management to be an approach to sustainable and cost-effective management of soil fertility and attempts to make the best use of inherent soil nutrient stocks, locally available soil amendments and mineral fertilizers to increase land productivity while, maintaining or enhancing soil fertility. Integrated soil fertility management strategies include the combined use of soil amendments of organic materials and mineral fertilizers to replenish soil nutrient pools and improve the efficiency of external inputs (Lee, 2005).

Rong Xiang *et al*., (2001) reported that organic and inorganic fertilizers, when combined, increased yields significantly over inorganic fertilizers mainly because these materials decompose, and hence release nutrients gradually over the crop growth period and they also build up organic carbon content essential for maintaining soil structure and the water holding capacity of soil.

The use of organic matter such as animal manures, human waste, food wastes, backyard wastes, sewage sludge, and composts has long been recognized in agriculture as beneficial source for plant nutrients and thereby improving yield of crops. Traditional composting of organic wastes has been known for many years but new methods of thermophilic composting have become much more popular since it eliminates some detrimental effects of organic wastes in the soil and it is also cost effective and environmentally sound process for treatment of many organic wastes (Hoitink and Keener, 1993). When the composting process is assisted by the presence of the earthworms in the compost heap, it is named 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. Vermicomposting differs from composting in several ways (Gandhi *et al*., 1997). It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10–32°C (not ambient temperature but temperature within the pile of moist organic material).

The most common fertilizers used in Ethiopia are diammonium phosphate (DAP) and urea. Such unbalanced and 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. Micro-nutrients not supplied by these chemical fertilizers may also lead to soil chemical 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 experiment was carried out on farmers' field and at Ginchi sub-center in 2014 and 2015 cropping seasons with objectives of determining the effect of organic and inorganic fertilizers and their combinations on the grain yield of Chick pea.

Materials and Methods

Experimental Site

The trials were conducted for two consecutive cropping seasons (2014 and 2015 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 was vertsols with low N, P and organic matter contents. Ginchi located between 09^0 02'N latitude and 38^0 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 is 1080 mm, about 85% of which is received from June to September. The average minimum and maximum air temperatures are 90[c] and 240[c], respectively (Getachew Agegnehu and Amare Ghizaw, 2004).

Table 1: Treatment Combinations

No.	Treatments	Description
1	Control (C)	
2	Recommended Phosphorus (RP)	46 kg/ha P
3	Conventional Compost (CC)	13.9 ton/ha
4	Farmyard manure (FYM)	8.9 ton/ha
5	Vermicompost (VC)	3.5 ton/ha
6	50% VC + 50% CC	1.75 ton/ha VC + 6.95 ton/ha CC
7	50% VC + 50% FYM	1.75 ton/ha VC + 4.95 ton/ha FYM
8	33% VC + 33% CC + 33% FYM	0.88 ton/ha VC + 4.6 ton/ha CC + 2.97 ton/ha FYM
9	50% VC + 50% Rec. P	4.2 ton/ha VC + 23 kg/ha P
10	50% CC + 50% Rec. P	6.95 ton/ha CC +23 kg/ha P
11	50% FYM + 50% Rec. P	1.8 ton/ha FYM + 23 kg/ha P

These treatment combinations were arranged in Randomized Complete Block Design (RCBD) with three replications. Compost was prepared following the standard procedure for compost preparation (Getachew Agegnehu *et al*., 2012). Similarly, Vermicompost (VC) was produced by using earth worms and the same inputs i.e. cattle manure and straw as bedding materials for the vermicomposting and bulking in the composting process. Vermicompost was prepared from organic materials such as green plants, animal dung, pulse straw, leaves and ash. The raw materials were placed in layers in the following sequence according to Suparno *et al*. (2013):

1. A layer of crop residues/green plants (20 cm) = 60%

2. A layer of manure (animal dung, sheep manure) (5-10 cm) = 30%

3. A layer of topsoil/ash (2-4 cm) = 10%

The decomposition process was facilitated by earth worms and fresh organic matters incorporated in the compost bin and above 75% moisture was maintained for free motility and breathe of the worms. Because worms breathe through their skin so as they need appropriate moisture content in the bedding for easy stretching of their body. Then when decomposition properly begins, about a month later, the worms, species of *Eisenia foetida* collected from Ambo Agricultural Research Centre were added into the bedding and they feed on fresh organic matter. Three months later, the important end product Vermicompost (the worm casting) was ready for fertilization. DAP fertilizer was applied in the form of Phosphorus. To minimize loss and increase efficiency, Phosphorus was applied at planting.

Chick pea (Var. Shasho) was planted at the recommended seed rates of 100kg ha^{-1} by row planting. The sowing dates were 18 and 22 September in cropping season of 2014 and 2015 respectively. Other recommended agronomic practices were applied during the crop growth period according to common practices.

Data Collection and analysis

Composite soil samples were collected from the site at 0-30cm soil depth before treatment application) and immediately after harvesting for analysis of soil pH, total organic carbon (OC), total N, available P. The contents of N and P in the analyzed Vermicompost before application were 0.86% and 1.72% respectively on 55% dry- weight basis, 0.97% N and 0.43% P in compost on 55% dry-weight basis, and 1.67% N and 0.67% P in manure 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 while total nitrogen was determined using Kjeldahl method. Available phosphorus was analysed 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 plan 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 in February 2014 and 2015. After threshing, the seeds were cleaned and weighed, and the moisture content was measured. Total biomass (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). The SAS statistical computer package (SAS, 2002) was used to test for presence of outerliers and normality of residuals. 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).

$$Pijk = \mu + Yi + Rj(i) + Tk + Ty(ik) + eijk$$

Where pijk is total observation, μ = grand mean, yi= effect of the i^{th} year, Rj(i)is effect of the j^{th} replication(with in the i^{th} year), Tk is effect of the K^{th} treatment with i^{th} year TY(ik) is the interaction of k^{th} treatment with i^{th} year and eijk is the random error. Results were presented as means and least significance difference (LSD) at 5% probability level was used to establish difference among means. Linear regression was performed between grain yield and some relevant component parameters.

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, their physical constraints of the soil, water logging, without fertilizer usage and poor nutrient management practices (Dibabe *et al*., 2007). 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. As presented in (Table 2), soil pH values, organic carbon (OC), 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 as indicated in (Table 2). Total nitrogen was also significantly ($P<0.05$) affected by the application of different rate of organic and inorganic fertilizers as indicated in (Table 2).

The results of the study revealed that soil pH has been improved through application of compost, manure and vermicompost. The application of 13 - 26 kg p ha^{-1} would be adequate for chick pea production. Similarly 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. Mahler *et al*. (1988) further indicated pulse crops grown on soils with a pH value of 5.6 and less give low yield. The highest pH value 6.59, 6.56 and 6.55 were 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 nearest to neutral (Tabe 2). The lowest soil pH (6.07) was recorded from the control plots.

Though the status of OC was at medium range, the highest organic carbon 3.40% and 3.36% were recorded from plots treated with full doses of farm yard manure and compost respectively (Table2). The average organic carbon content of the experimental soil was 3.04, which is also categorized in medium range (Jones, 2003). In contrast, the total N and available P determined after harvesting was above the critical range except negative control treatment. As mention above for organic carbon, the highest soil N 0.32% and 0.31% were recorded from plots treated with full doses of farm yard manure and compost respectively. Similarly, the highest soil available P, 30.43ppm and 30.35ppm, were recorded from plots treated with full doses of manure and compost respectively (Table 2). While, the lowest soil N and P contents 0.22% and 12.19 ppm were obtained from the control plots respectively (Table 2). In generally, the results indicate that integrated use of organic and inorganic nutrient sources significantly improved the overall condition of the soil as well as agricultural productivity as previously indicated (Getachew, 2012).

Table 2: Mean soil analytic results for the trial site at Ginchi for samples taken after harvesting, 2014- 2015

Treatments	pH(H_2O)	Nitrogen (%)	Phosphorous (ppm)	OC (%)
Control	6.07^{c}	0.22^{b}	12.19^{c}	2.24^{c}
Recom. P(46)	6.3^{d}	0.24^{b}	24.15^{b}	2.83^{d}
Compost	6.59^{a}	0.31^{a}	30.45^{a}	3.36^{ab}
Farmyard manure	6.56^{ab}	0.32^{a}	30.43^{a}	3.40^{a}
Vermicompost	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
F-probability	***	**	***	***

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

Productivity of Chick pea

Results of the experiments indicated that productivity of chick pea was significantly affected by different soil fertility treatment levels, although the combined analysis of variance over two years revealed that the effect of cropping season was highly significant ($p < 0.001$) on biomass yield and grain yield of chick pea (Table 3). The highest mean biomass yield and grain yield of chick pea were recorded in 2015 cropping season Applications of inorganic and organic nutrient sources either alone or in combination had a significant ($p<0.001$ and $p<0.05$) effect on grain yield and biomass yield of chick pea, but not on its plant height branch numbers per plant, pod numbers per plant and thousand grain weight. Analysis of variance over two years result indicated that the year by soil fertility treatment level interaction (Y x T) effect of was significant ($p<0.05$ and $p<0.001$) for chick pea grain yield and biomass yield but not for plant height branch numbers per plant, pod numbers per plant and thousand grain weight (Table 3).

The highest chick pea grain yield and biomass yield were obtained from the application of 50% recommended rate of vermicompost plus half the recommended P rate and full doses recommended rate of P with yield advantages of about 281.1% and 254.4% compared to the control respectively. 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 plot respectively (Table 3).

Table 3: 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 Central highlands of Ethiopia

Treatments-NPK/Organic(kg/ha) Year	BNP	PHT(cm)	PNP	BY(kg/ha)	GY(kg/ha)	TGW (kg /ha)
2014	7.18[a]	41.7[b]	28.5[b]	3590.96[b]	1615.18[b]	247.5[a]
2015	7.67[a]	44.4[a]	40.6[a]	10780.3[a]	2435.91[a]	244.7[b]
F-Probability	Ns	Ns	**	***	**	Ns
LSD $_{0.05}$	0.62	1.93	2.11	660.9	161.42	2.29
ISFM- Treatments(T)						
Control	6.5	38.17	24	3680.3[e]	964.7[d]	247.8
Recom. P(46)	7.5	44	35.5	9152[ab]	2454.5[ab]	247.3
Compost	8.0	41.3	31.0	6280.8[d]	1901[c]	244.8
Farmyard manure	6.5	40.17	34.0	6679.5[d]	1997.3[c]	247.5
Vermicompost	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 $_{0.05}$	1.46	4.52	4.95	1549.9	378.6	5.37
Y x T	Ns	Ns	Ns	***	**	Ns
CV (%)	16.9	9.02	12.3	18.5	16.04	1.87

**, **= significant at P< 0.05 and P< 0.001, respectively; NS= Not significant. Means in a column with the same letter are not significantly different (P<0.05).*

Application of 100% recommended rates 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% when compared to control plot respectively (Table 3). The results of this study has clearly indicated that the application of fertilizers rate as combination of inorganic and organic was doubled under farmers' field condition the yield grain will be more than 50% compared to the farmers' applied rate. A similarly trend was observed in the chick pea grain yield and biomass yield due to the application of full dose of manure and compost as inorganic Phosphorus equivalence. 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 the significance of the ISFM treatments containing both organic and inorganic forms under farmers' field condition that they could be considered as alternative options for sustainable soil and crop productivity in the degraded highlands of Ethiopia. The observed simple linear correlation analysis indicated that grain yield was positively and highly significantly correlated with biomass yield (R^2 = 0.928***) (Figure2).

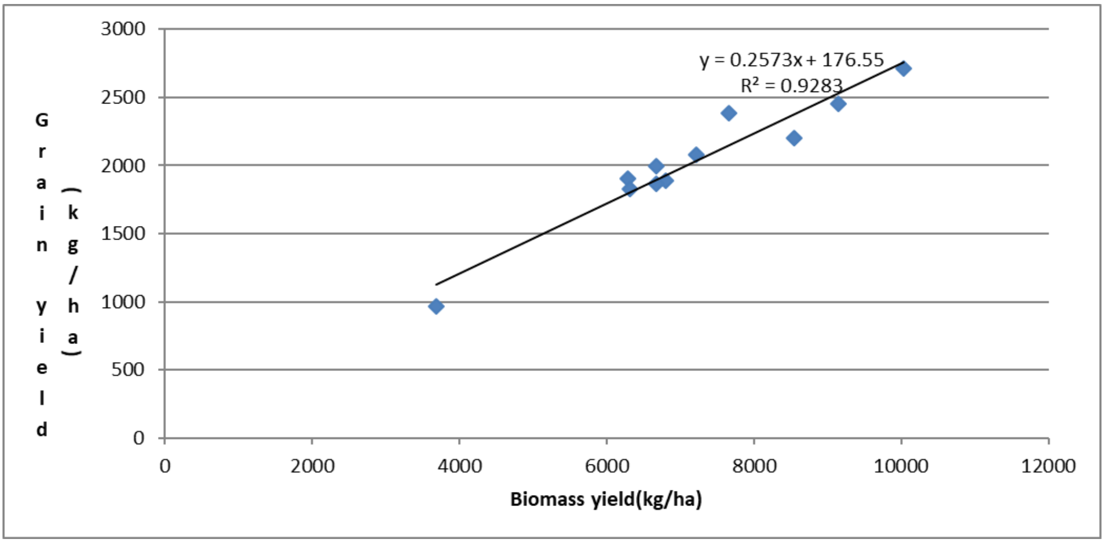

Figure 1: Correlation of chick pea grain yield with biomass yield

Economic analysis

As farmers attempt to evaluate the economic benefits of shift in practice, 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).

Table 4: Partial budget and dominance analyses of organic and inorganic fertilizers trial on chick pea

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	Labor	Total cost		
Control	964.7	819.9	9164.65		2200	2200	6964.65	D
Recom. P(46)	2454.5	2086.3	23317.75	2300	2000	4300	19017.75	D
Compost	1901.5	1616.3	18059.5	-	3850	3850	14209.5	D
Farmyard manure	1997.3	1697.7	18974.35	-	3550	3550	15424.35	D
Vermicompost	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 9.50kg^{-1} and DAP birr 15kg^{-1} (1USD = 20.40 Ethiopia birr; D= Dominated

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 manage was 30 person- days per hectare. The result of the partial budget analysis is given in (Table 4). The economic analysis revealed that the highest net benefit (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}).

The economic analysis further revealed that the application of 50% vermicompost plus 50% recommended phosphorus fertilizers provided the highest marginal rate of the return of 4652.7% (Table 4) suggesting that for each birr invested in chick pea production , the producer would reap birr 46.5 after recovering his investment. Since the MRR assumed in this study was 100%, the treatment with application of 50% compost (based on P equivalent of recommended rate) and 50% recommended phosphorus fertilizer rate gave an acceptable marginal rate of return. There for, on economic grounds, 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 5: Marginal analysis of organic and inorganic fertilizer effects on chickpea at Ginchi, 2014 - 2015

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(ETH ha^{-1})	17948.35	20878.15	22626.15	25765.9
Cost of fertilizer(ETH ha^{-1})	0.00	1950	1750	1250
Cost of labour(ETH ha^{-1})	4100	2850	2650	1835
TCV (ETH ha^{-1})	4100	4800	4400	3085
NB (ETH ha^{-1})	13848.35	16078.15	18226.15	22180.9
MC (ETH ha^{-1})		50	50	85
MB(ETH ha^{-1})		2229.8	2148	3954.75
MRR (%)		4459.6%	4296%	4652.7%

Conclusion

Integrated use of organic and inorganic fertilizers plays a critical role in a both short- term nutrient availability and longer- term maintenance of soil organic matter and sustainability crop productivity in most smallholder farming systems in the tropics. 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 organic fertilizer improved soil pH, OC, N and available P and exchangeable cations. The two year 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. Applications of organic fertilizers not only improve the nutrient content of soils, but also improve the physical and biological condition of soils.

Therefore, appropriate technologies must be developed and implemented to ensure economically viable and ecological sound nutrient conserving cropping systems. Integrated use of chemical fertilizer and locally available soil amendments are the best approach for achieving higher fertilizer-use efficiency and economic feasibility. This study suggests use of 50% compost (based on P equivalent of recommended rate) with half doses of the recommended rate of P fertilizer can be the best alternative integrated soil fertility management measure than the sole application of inorganic fertilizers. Further research on the long-term effects of the integrated soil fertility management techniques and the use of inorganic fertilizers on productivity and soil fertility is recommended.

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