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# Effects of Integrated Use of Organic and Inorganic Fertilizer on Yield and Yield Components of Maize (*Zea Mays* L) in Yeki District, Southwest of Ethiopia

**Mulisa Wedajo*, Shiferaw Temteme and Guta Amante**

*Teppi Agricultural Research Center, P.O.Box 34, Teppi, Ethiopia*

**Corresponding author*

## Abstract

Maize is an important food crop in Ethiopia and it also one of the main smallholder food crops in the Yeki district, although suboptimal fertilizer applications have caused soil nutrient depletion and yields decline. For instance, integrated organic and inorganic fertilizer effects on yield and yield components of maize during the 2018 and 2019 main cropping seasons were studied. The treatment consists control (no fertilizer), 100% of recommended inorganic NP fertilizer, 100% recommended N from vermicompost, 100% recommended N from compost, 25% recommended NP + 75% vermicompost, 50% recommended NP + 50% vermicompost, 75% recommended NP + 25% vermicompost, 25% recommended NP + 75% compost, 50% recommended NP + 50% compost and 75% recommended NP + 25% compost based on N equivalence were laid out in a randomized complete block design and total of teen treatments with three replication. Data on selected yield and yield components of maize and profitability of fertilizer were taken. Yield and yield components of maize were subjected to statistical analysis using SAS; the mean treatment difference was compared using LSD. Significantly higher maize grain yield and biomass were obtained with the application of 25% recommended NP + 75% vermicompost and 50% recommended NP + 50% Vermicompost respectively. Maize grain yield of 9524.20 kg ha-1 was obtained from the application of 25% recommended NP + 75% vermicompost based on N equivalence. The economic analysis confirmed the profitability of the integrated use of 25% recommended NP + 75% vermicompost are recommended for maize production in Yeki district and similar agro-ecology. Therefore, the integrated use of organic and inorganic fertilizer is increasing yield and is one of the sustainable features to maintain soil fertility.

## Article Info

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## Keywords

Compost, Vermicompost, Grain yield and economic.

## Introduction

An agricultural system involving a combination of sustainable production practices has the following major attributes; it conserves resources is environmentally non-degrading, technically appropriate and economically and social acceptable (FAO, 2008). In practice sustainable agriculture uses less external inputs and employs locally available natural resources more efficiently (Lee, 2005).

It has been acknowledged that organic and inorganic inputs cannot be substituted entirely by one another and are both required for sustainable crop production (Vanlauwe *et al.*, 2002a). This is due to fertilizer or organic resources alone may not provide sufficient amount or may be unsuitable; for alleviating specific constraints to crop growth (Sanchez and Jama, 2002). The potential for added benefits created through positive interactions between organic and mineral inputs in the short-term and the various roles each of these inputs play in the longer term. One key complementarily is that organic resources enhance the soil organic matter status and the functions it supports, while mineral inputs can be targeted to key limiting nutrients. Organic agriculture is a promising agricultural method with positive effects on the human ecological and social environment (Vogl *et al.,* 2017).

In Ethiopia most smallholder farmers lands have been feature fragmented fields and practiced by continuous cropping with little or no external input, removal of crop residues, miss management of farm yard manure and over grazing in between cropping seasons. These acts of farmers for centuries resulted in soil fertility depletion and became a threat to sustainability of soil productivity. Combined application of half the recommended rate of NP fertilizer with 50% of the recommended dose of compost (3t/ha) can be an alternative best integrated soil fertility management measure instead of only inorganic fertilizers for sustainability (Agegnehu *et al.,* 2012). Integration of organic fertilizer with inorganic fertilizer increases the potential of the applied fertilizer thereby increases crop productivity (Negassa *et al.,* 2007). Therefore the present study was to determine the integrated use of organic and inorganic fertilizer on maize yield in Yeki district.

## Materials and Methods

The study was conducted in Yeki District Southwest of Ethiopia at Teppi Agricultural Research Centre. Yeki District located in Southwest of Ethiopia in SNNPR State at an elevation of 1200 m.a.s.l and it is located at Latitude of $7^{0}10^{'}54.5''$ and with a Longitude of $35^{0}$ 25' 04.3'' East of Ethiopia and is situated approximately 611 km Southwest of Addis Ababa. The mean annual rainfall of the area is 1559 mm that extends from April to December, with hot to warm humid lowland agro-ecology with a maximum and minimum temperatures of $29.7^{o}$Cand $15.5^{o}$C**,** respectively and the area dominated by Nitisols.

## Experimental Design

The experiments would be laid out in randomized complete block design and ten treatments (Control, 100% of recommended inorganic NP fertilizer, 100% of recommended N from vermicompost, 100% of recommended N from compost, 25% recommended NP + 75% Vermicompost, 50% recommended NP + 50% Vermicompost, 75% recommended NP + 25% Vermicompost, 25% recommended NP + 75% compost, 50% recommended NP + 50% compost and 75% recommended NP + 25% compost) with three replications. Urea (46-0-0) and TSP would be used as sources of N and P fertilizer respectively. All P fertilizer would be applied as basal application at planting and N (urea) would be applied in split form. Organic materials would be hand applied three weeks before sowing. The rate of both organic sources (vermicompost and compost) would be calculated based on recommended inorganic N fertilizer equivalence.

## Data collection

### Plant height (cm)

It was measured as the height from the soil surface to the base of the tassel at maize physiological maturity.

### Number of ear per plant

Number of ear per plant was visually counted from a single maize plant.

### Cob length (cm)

It was measured from the cob attached to node to tip of cob.

### Thousand grain weight (gm)

It was determined from 1000 randomly taken grains from each plot and weighed using sensitive balance.

### Grain yield (kg $ha^{-1}$)

Maize crop harvesting was done after the crop had reached physiological maturity. Then, husk was removed and the grains were shelled manually and their weights were recorded by electronic balance. The grain was sun-dried until it had constant weight and reweighed to determine moisture content. After drying the grain yield adjusted to 12.5% moisture content, the final dry weight was determined and recorded and then convert to a hector basis.

### Above biomass (t $ha^{-1}$)

Total above ground of four maize plants from each internal three rows of net plot were randomly harvested at physiological maturity by hand. It was measured from a plant harvested from the net plot and weighed after uniformly sun-dried until it had constant weight and then weighed and converted to a hector basis.

### Economic analysis

Economic analysis such as partial budget, total variable cost ratio, and marginal rate of return of maize yield was evaluated. Costs of fertilizer were 14.84 EB $kg^{-1}$urea, 15.09 EB $kg^{-1}$TSP, cost of vermicompost estimated as 250 EB per ton and compost 350 EB per ton. The cost of fertilizer transportation was considered as EB 15 per 100 kg fertilizer and labour cost of fertilizer application EB 27per day for 8 hours for 100 kg fertilizer. Whereas the transportation and application cost of compost and vermicompost were 50 EB and 270 EB per ton for each respectively.

The Local market selling price of one-kilogram of maize in Ethiopia birr at the Teppi area was five birr for the average of past five year. The average yield was adjusted downward by 10% and was used to reflect the difference between the experimental field and the expected yield from farmers' fields with farmers' practices from the same treatments (Agegnehu and Fessehaie, 2006).

Analysis of marginal rate of return (MRR) was carried out for non-dominated treatments and the MRR were compared to a minimum acceptable rate of return (MARR) of 100% to select the optimum treatment (CIMMYT, 1998).

### Statistical Analysis

The data collected were statistically analysed using the Analysis of Variance (ANOVA) by using SAS (SAS Institute, 2008) by SAS version 9.0). Means were separated using the LSD test to signify the treatment differences at a 5% level of probability (Steel and Torrie).

### Results and Discussion

During the cropping season (2018) the result showed application of organic, inorganic fertilizer alone as well as application of integration of both were significantly ($p<0.05$) different in plant height, grain yield and total above ground biomass when compared with control treatment.

Application of T4, T5, T6, T9 and T10were significantly ($p<0.05$) influence number of ear per plant when compared with the control treatment, but other treatments were none significantly ($p>0.05$) influenced number of ear per plant when compared with the control treatment. Application of T2 and T8 were none significantly ($p>0.05$) different from the control treatment whereas all other treatment were significantly ($p<0.05$) influenced cob length.

In 2019 cropping season thousand grain weight and grain yield of maize were significantly ($p<0.05$) influenced when compared with the control treatment whereas other parameter were showed inconsistent significant ($p<0.05$) difference.

The overall two year result of analysis of variance showed that plant height, thousand seed weight and grain yield of maize in all treatment were significantly ($p<0.05$) influenced when compared with control treatment.

Total above ground biomass were significantly ($p<0.05$) influenced in all treatment except application of T9 when compared with the control treatment, while number of ear per plant, cob length and thousand seed weight were inconsistently influenced (Table 2).

The highest maize grain yield (9524.2 kg $ha^{-1}$) was obtained from the application of T5 (25% of recommended inorganic NP fertilizer with 75% vermicompost). The highest maize total above biomass yield (9.44 t $ha^{-1}$) was obtained from the application of T6 (50% of recommended inorganic NP fertilizer with 50% vermicompost).The application of T5 (25% of recommended inorganic NP fertilizer with 75% vermicompost) improved maize grain yield by 40.98% when compared with the control treatment.

Abera *et al.*, (2019) reported that thousand seed weight, plant height, grain yield of maize significantly influenced by the application of sole and integrated use of NPS fertilizer and vermicompost.

Similar results have been reported by Negassa *et al.*, (2007) integrated use of organic fertilizer with low dose of NP fertilizer or farm yard manure increase maize grain yield and plant height. For instance, the integrated use of low dose of NP fertilizer with different organic fertilizers such as farm yard manure (Negassa *et al.*, 2002a), compost (Negassa *et al.*, 2001) and significantly increased maize grain yield in Bako area. Vermicompost contains high available nutrients, allowing not only a short supply of plant nutrient but also increasing reserves for the succeeding crops (Jat and Ahlawat, 2006).

**Table.1** Effect of integrated organic and inorganic fertilizer on yield and yield component of maize during 2018and 2019 season

| Treatments | During 2018 | | | | | | During 2019 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PH cm | NEPP | CL cm | TSW gm | GLY kg ha$^{-1}$ | BM t ha$^{-1}$ | PH cm | NEPP | CL cm | TSW gm | GLY kg ha$^{-1}$ | BM t ha$^{-1}$ |
| T1 | 242.13c | 0.99c | 15.4c | 355.14b | 3545.8c | 7.61d | 225.57b | 1b | 13.2b | 296b | 4428.8e | 7.65b |
| T2 | 260.96ab | 1.03bc | 16.13bc | 378.03ab | 8700.4ab | 10.34a | 244.77a | 1.13a | 14.467ab | 403a | 10128.4ab | 8.31ab |
| T3 | 264.08ab | 1.03bc | 17.67a | 375.8ab | 7537.2b | 9.46abc | 248a | 1.03b | 14.67a | 392.33a | 8685.3d | 8.19ab |
| T4 | 254.75b | 1.13ab | 17.06ab | 382.67ab | 9040.3a | 9.44abc | 246.07a | 1.13a | 14.47ab | 380.33a | 9570.6bc | 8.37ab |
| T5 | 257.13ab | 1.18a | 16.67ab | 362.23b | 8698.8ab | 9.46ab | 249.07a | 1.03b | 14.67a | 380a | 10349.7a | 8.08ab |
| T6 | 264.63ab | 1.12ab | 17.13ab | 372.24ab | 8596.7ab | 10.06ab | 245.5a | 1.13a | 13.93ab | 396.3a | 9546.6bc | 8.81a |
| T7 | 270.92a | 1.04bc | 17.67a | 392.95a | 8857.5ab | 10.42a | 247.33a | 1.03b | 14.8a | 359.67a | 8947.5cd | 8.19ab |
| T8 | 261.25ab | 1.04bc | 16.53abc | 380.01ab | 8524.3ab | 9.28bc | 251.23a | 1b | 14.47ab | 389.5a | 9095.8cd | 8.5ab |
| T9 | 259.58ab | 1.12ab | 16.86ab | 374.49ab | 8338.2b | 8.92c | 242.4a | 1ab | 14.4ab | 366.5a | 8422.3d | 8.25ab |
| T10 | 260.10ab | 1.13ab | 16.86ab | 377.95ab | 8644.7ab | 10.05ab | 245.83a | 1.03b | 14.33ab | 357.67a | 8590.5d | 8.62a |
| LSD | 11.99 | 0.11 | 1.16 | 30.2 | 1489 | 0.98 | 16.23 | 0.08 | 1.33 | 51.68 | 757.89 | 0.89 |
| CV% | 2.7 | 6.15 | 4.02 | 4.7 | 10.78 | 6.04 | 3.85 | 4.61 | 5.37 | 8.06 | 5.01 | 6.21 |

Means followed by the same letters across column and rows were not significantly different at 5% level of significance, LSD=list significant different, CV= coefficient of variation, ns=none significant. PH=Plant height in cm, NEPP=Number ear per plant,CL=cob length, TSW=thousand seed weight in gm, GLY=grain yield in kg ha$^{-1}$ BM=biomassin t ha$^{-1}$, T1= No fertilizer (Control), T2= 100% of recommended inorganic NP fertilizer, T3= 100% of recommended N from vermi-compost T4= 100% of recommended N from compost,T5= 25% recommended NP + 75% Vermi-compost, T6= 50% recommended NP + 50% Vermi-compost, T7= 75% recommended NP + 25% Vermi-compost, T8= 25% recommended NP + 75% compost, T9= 50% recommended NP + 50% compost and T10= 75% recommended NP + 25% compost.

**Table.2** Overall two year maize yield and yield attributes

| Treatment | PH | NEPP | CL | TSW | GLY | BM |
|---|---|---|---|---|---|---|
| No fertilizer (Control) | 233.846b | 0.97d | 14.3b | 325.57b | 3987.3d | 7.63b |
| 100% of Recommended inorganic NP fertilizer | 252.863a | 1.08abc | 15.3ab | 390.52a | 9414.4a | 9.33a |
| 100% of recommended N from vermicompost | 256.042a | 1.03bcd | 16.17a | 384.07a | 8111.2c | 8.82a |
| 100% of recommended N from compost | 250.408a | 1.13a | 15.77ab | 381.5a | 9305.5ab | 8.91a |
| 25% recommended NP + 75% Vermicompost | 253.096a | 1.10ab | 15.67ab | 371.11a | 9524.2a | 8.77a |
| 50% recommended NP + 50% Vermicompost | 255.063a | 1.12a | 15.53ab | 384.27a | 9071.6ab | 9.44a |
| 75% recommended NP + 25% Vermicompost | 259.125a | 1.04bcd | 16.23a | 376.31a | 8902.5abc | 9.30a |
| 25% recommended NP + 75% compost | 256.242a | 1.02cd | 15.5ab | 384.76a | 8810abc | 8.89a |
| 50% recommended NP + 50% compost | 250.992a | 1.06abc | 15.63ab | 370.5a | 8380.2bc | 8.58ab |
| 75% recommended NP + 25% compost | 253.396a | 1.08abc | 15.6ab | 367.81a | 8617.6abc | 9.34a |
| LSD | 14.8 | 0.08 | 1.8 | 32.95 | 927 | 1.05 |
| CV% | 5.05 | 6.19 | 9.95 | 7.59 | 9.48 | 10.19 |

Means followed by the same letters across column and rows were not significantly different at 5% level of significance, LSD=list significant different, CV= coefficient of variation, ns=none significant. PH=Plant height in cm, NEPP=Number ear per plant, CL=cob length in cm, TSW=thousand seed weight in gm, GLY=grain yield in kg $ha^{-1}$ BM=biomass in t $ha^{-1}$.

**Table.3** Effect of integrated use of organic and inorganic fertilizers on economic profitable of Maize in Yeki District

| Treatment | GLY kg $ha^{-1}$ | Adjusted grain yield 10% | GFB EB $ha^{-1)}$ | NB (EB $ha^{-1)}$ | TVC EB $ha^{-1}$ | MRR ( %) |
|---|---|---|---|---|---|---|
| No fertilizer (Control) | 3987.30 | 3588.57 | 17942.85 | 17942.85 | 0 | D |
| 100% of Recommended inorganic NP fertilizer | 9414.40 | 8472.96 | 42364.80 | 36986.30 | 5378.50 | 6.60 |
| 100% of recommended N from vermicompost | 8111.20 | 7300.08 | 36500.40 | 35919.00 | 1151.40 | 15.61 |
| 100% of recommended N from compost | 9305.50 | 8374.95 | 41874.75 | 35710.75 | 6164.00 | 4.63 |
| 25% recommended NP + 75% Vermicompost | 9524.20 | 8571.78 | 42858.90 | 39770.35 | 3088.55 | 17.75 |
| 50% recommended NP + 50% Vermicompost | 9071.60 | 8164.44 | 40822.20 | 37842.25 | 2979.95 | 1.05 |
| 75% recommended NP + 25% Vermicompost | 8902.50 | 8012.25 | 40061.25 | 35882.025D | 4179.23 | D |
| 25% recommended NP + 75% compost | 8810.00 | 7929.00 | 39645.00 | 33877.38 | 5767.63 | 3.49 |
| 50% recommended NP + 50% compost | 8380.20 | 7542.18 | 37710.90 | 32944.65D | 4766.25 | D |
| 75% recommended NP + 25% compost | 8617.60 | 7755.84 | 38779.20 | 33204.325D | 5574.88 | D |

D=dominated, GLY=grain yield, GFB =growth field benefit in Ethiopian birr per hector, NB=net benefit in Ethiopian birr per hector, TVC= total cost that vary, MRR=marginal rate of return in per-cent

Vermicompost application is required in organic farming systems to provide the best direct and residual effect on the availability of soil nutrient, plant nutrient uptake and crop yield (Nurhidayati *et al.*, 2018). There are some key differences in the way that the organic systems contribute to soil fertility. Organic sources will differ in terms of nutrient content, mineralization processes in which nutrients in the organic matter can become available to the crop, and the provision of other soil fertility. Differences in chemical composition of raw materials of organic matters such as organic carbon (C), total nitrogen (N) and lignin content as well as carbon to nitrogen ratio (C:N) affect the rate of decomposition and release of nutrient into the soil (Moore *et al.*, 2011 and Wardle *et al.*, 2009). The mineralization controls the soil solution concentration directly when the soil mineral does not release nutrient into the soil solution (Comerford, 2005).

From the application of 25% recommended NP + 75% Vermicompost could be enable the farmers to earn a return of 17.75 EB for every 1 EB investment, this implies high profit of maize due to the use of integration of available local organic material with inorganic fertilizer (Table 3). The economic analysis confirmed that maize production with the application of 25% recommended NP + 75% Vermicompost is profitable for Yeki District.

The integrated use of organic and inorganic fertilizer was significantly improved yield and yield components of maize. The highest grain yield of maize was obtained from the integration of 25% of recommended NP fertilizer with 75% vermicompost based on the N equivalence application. The application of 25% of recommended NP fertilizer with 75% vermicompost gave net profit advantage of 39652 EB with marginal rate of return of 17.75% followed by application of 100% recommended N from vermicompost gave net benefit of 33707.4EB with marginal rate of return 15.61%. Therefore, the application of 25% of recommended NP fertilizer with 75% vermicompost based on the N equivalence application was recommended for optimum grain yield and economically profitable maize production for farmer in Yeki district, Southwest of Ethiopia.

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