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Research Article

Evaluation of Integration Application of Vermicompost with Inorganic Fertilizers and Their Combination Effect on Maize Yield in Mettu District

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Abstract

The application of vermicompost and NPS fertilizer together increases crop productivity. However it is crucial to identify the combined application level. A field experiment was carried out in Mettu district in 2022/23 cropping season to determine the effect of integrated use of Vermicompost and inorganic fertilizers on the yield of maize and to determine the optimum rate of NPS fertilizer and Vermicompost on growth and yield of maize. Three levels of vermicompost (0, 1.5 and 3 t ha^{-1}) and three levels of NPS fertilizer (0, 100 and 200 kg ha^{-1}) were used for the study in randomized complete block design (RCBD) with three replicates. The interaction effect of NPS with vermicompost showed that significant differences on maize grain yield, days to tasseling and plant height. The highest maize grain yield (7861.10 kg ha^{-1}) and (1597.20 kg ha^{-1}) was obtained from the treatment combination of 3 t ha^{-1} vermicompost with 200 kg ha^{-1} NPS and 46 kg ha^{-1} N. Whereas, the lowest grain yield (1597.20 kg ha^{-1}) was gained from control plot. However, this combination was statically at par with the treatment combination of 1.5 t ha^{-1} vermicompost with 200 kg ha^{-1} NPS and 46 t ha^{-1} N, which gave maize grain yield (7699.1 kg ha^{-1}). Application of 200kg ha^{-1} of NPS alone with recommended N ha^{-1} fertilization is profitable and recommended for farmers. However, in terms of net benefit and soil health point of view for the study area 200kg ha^{-1} NPS with 1.5t ha^{-1} was recommended.

Keywords

Vermicompost, NPS Fertilizer Rate, Maize, Economic Analysis

1. Introduction

Soil has been an essential part of this planet, giving support to all the ecosystems of this earth. In the terrestrial ecosystem, soil serves as a main component that endows dwelling home for animals, microorganisms as well as plants [1]. The excess use of chemical fertilizers and pesticides has resulted in numerous negative effects on the environment, including water, soil [2], and food pollution [3], degradation of soil quality [2], and losses of agricultural biodiversity [4, 5]. To solve such problems, more sustainable agricultural practices are urgently required. Compared with chemical agriculture, organic farming has been thoroughly proven as beneficial in maintaining both biodiversity and environmental sustainability [6, 7]. Organic farming has been gradually adopted by agriculturalists, particularly in developed countries [8, 9], because of its higher economic and ecological benefits. Moreover, integrated soil fertility management involving the judicious use

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of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints. Combined organic/ inorganic fertilization both enhanced carbon storage in soils and reduced emissions from nitrogen fertilizer use while contributing to high crop productivity in agriculture [10]. It is more helpful to use organic matter in combination with other organic or inorganic fertilizers than to apply it alone [11]. Maize (*Zea mays L.*) it is worldwide ranks the third position among cereal crops after wheat and rice and it is important staple food in many countries. The grains of maize contain 13% moisture, 10% crude protein and 70.3% carbohydrate [12]. It is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socio- economic conditions typically under rain fed production [13]. Increasing maize production is one of the most important goals for the Ethiopian agricultural policy to face the human and animal demands. Sustainability of the agriculture production systems is the most crucial issue as our natural resources are continuingly being degraded. The increasing population and food demand has forced farmers to use high doses of chemical fertilizers. The unscientific use of fertilizers (nutrient imbalances, incorrect amount) is a serious threat to the sustainable agriculture production system [14]. The use of both organic and inorganic fertilizer by farmers has been reported to increase yield, sustain productivity and improved soil chemical properties [15]. Similarly, [16] reported that maize growth and yield were significantly increased by farmyard manure (FYM) application enriched with chemical fertilizers. Therefore: the objectives this study were to determine the effect of integrated use of Vermicompost and inorganic fertilizers on the yield of maize and determine the optimum rate of NPS fertilizer and Vermicompost on growth and yield of maize in Mettu district.

2. Materials and Methods

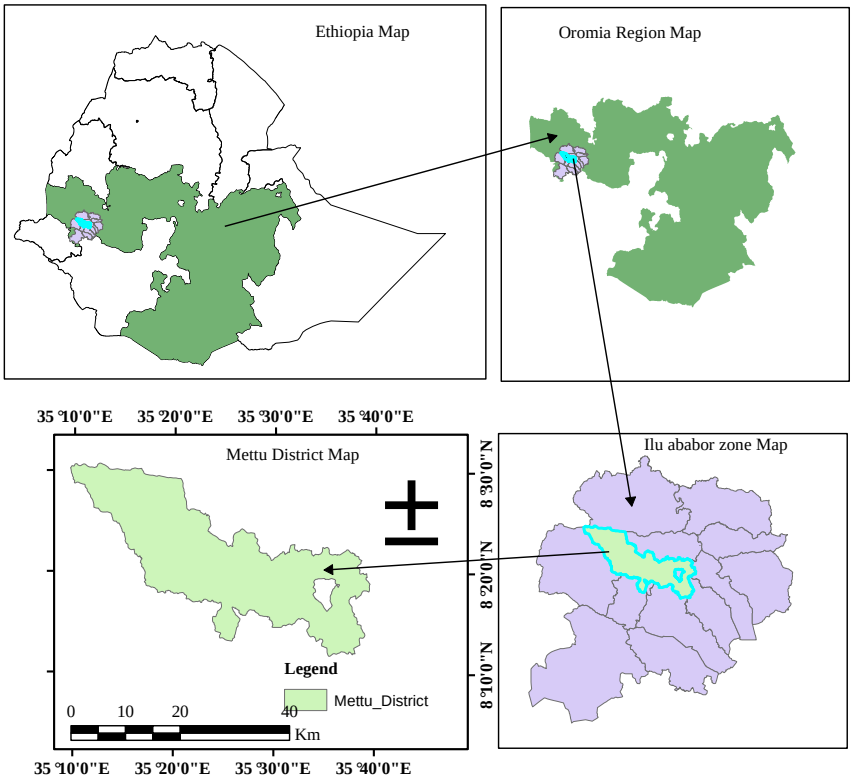

Figure 1. *Map of the study area.*

The trial was conducted during the 2022/23 cropping season at three locations in Mettu district. Mettu district is a one of district found in Ilu Aba bor zone, Oromia Regional National State. The district is located between 8°10'0"N to 8°30'0"N and 35°10'0"E to 35°40'0"E, altitude 1605 meters above sea levels is about 620km road distance southwest of Finfine.

2.1. Soil Sampling Before Sowing

Soil samples were collected from each selected sites at the depth of 0-20 cm of top soil using auger from 15 to 20 spots before cultivation then one composite soil sample of each sites were subject to analyses of selected soil chemical prop-

erties such as pH (H_2O), exchangeable acidity, total nitrogen, organic carbon, available phosphorus and cation exchange capacity (CEC). To know the status of the farm land. The collected sample was air dry and analyzed in Bedele Agricultural Research Center.

2.2. Treatments

Treatments and experimental Design. Experiment were laid out in a randomized complete block design (RCBD) with factorial arrangement and replicated three times. The treatments consisted of three levels of VC (0, 1.5 and 3 t ha^{-1}) and three levels of NPS fertilizer (0, 100 and 200 kg ha^{-1}). The experiments had a total of nine treatments. The growth plot size 3m*4m ($12m^2$). BH 661 maize variety was used and the experiment was prepared by using oxen plough according to traditional convectional farming practices. Full dose of vermicompost and phosphorus fertilizer and half of urea was applied at sowing time and the remain dose of N-fertilizer (Urea) was applied by topdressing after 30 days of sowing. All expected management practices for disease and insect pest control were done.

3. Results and Discussions

A field experiment was carried out during 2022/23 cropping season to study determination of combination of vermicompost with NPS fertilizer rate for Maize in Mettu district. Record of the data collected from the field and laboratory analyses were subjected to statistical analysis and the results obtained were presented and discussed accordingly.

3.1. Surface Soil Samples Collected Before Planting Were Characterized as Follows

The obtained Soil PH classified as very strongly acidic ranged from (5.0 to 5.4) (Table 1). These results agreed with [17, 18]. As well as available Phosphorus also very low ranged from (0.41 to 1.63 ppm). The obtained results linked with [18], which rate available phosphorus value range <5 are very low. The recorded total Nitrogen ranged from Low to medium (0.14 to 0.25%) as indicated [18]. The obtained organic carbon low ranged from (1.63 to 2.47%) and Low to moderate CEC ranged from (8.4 to 23 cmol (+)/kg soil) this results similar to [18] rates.

Table 1. *Soil data before planting.*

Sites	PH (H_2O)	Exchangeable Acidity (cmol (+)/kg soil)	Available Phosphorus (ppm)	Organic Carbon (%)	Total Nitrogen (%)	Cation exchange capacity (cmol (+)/kg soil)
1	5.00	1.12	0.41	1.63	0.14	8.40
2	5.40	0.12	0.67	2.47	0.21	13.00
3	5.15	0.12	1.46	2.93	0.25	23.00

3.2. Response of NPS-Fertilizer and VC on Plant Height

Table 2. *The Effect of NPS and vermicompost on maize Plant height (cm).*

NPS level (Kg ha^{-1})	Vermicompost rates (tonha^{-1})			Mean
	0	1.5	3	
0	247.67^{c}	239.55^{c}	258.61^{bc}	248.66^{bc}
100	259.67^{bc}	274.39^{ab}	280.72^{ab}	271.59^{ab}
200	272.61^{ab}	285.06^{a}	279.61^{ab}	279.09^{a}
LSD (0.05)	23.96			
CV (%)	7.72			

The interaction effect of NPS with vermicompost showed that significant differences on maize plant height (Table 2). As integration of organic and inorganic fertilizer rate increases the plant also increases. These results agreed with [19]

who stated that application more fertilizer it tends to increases plant height than unfertile. The tallest plant height (280.72cm) was obtained from the treatment combination of 3 t ha^{-1} VC with 100 kg ha^{-1} NPS and 46 kg ha^{-1} N. Whereas, the shortest plant height (239.55cm) was gained from 1.5t of vermicompostha^{-1}.

3.3. Response of NPS-Fertilizer and VC on Days to Tasseling of Maize

The interaction effect of NPS with vermicompost showed that significant ($p<0.05$) influenced on days to tasseling of maize (Table 3). This results indicated that the longest maize days to tasseling (100.50days) was observed from unfertile (control) and the lowest (90.50days) observed from the treatment treated by combination of 1.5 t ha^{-1} VC with 200 kg ha^{-1} NPS and 46 kg ha^{-1} N. These results linked with [19] who stated that unfertilized maize tends to tassel later than fertilizer maize because fertilization provides essential nutrients that promote healthy and timely growth.

Table 3. *The Effect of NPS and vermicompost on maize days to tasseling.*

NPS level (Kg ha^{-1})	Vermicompost rates (tonha^{-1})			Mean
	0	1.5	3	
0	98.66^{a}	98.00^{a}	100.50^{a}	99.05^{a}
100	96.50^{ab}	92.00^{bc}	96.00^{ab}	94.83^{a}
200	91.5^{bc}	90.50^{c}	95.50^{abc}	92.33^{b}
LSD (0.05)	5.45			
CV (%)	4.91			

3.4. Response of NPS-Fertilizer and VC on Maize Grain Yield

The mean grain yield of maize was showed that significantly ($P<0.05$) influenced between the interaction effect of NPS with vermicompost (Table 4). As integration of organic and inorganic fertilizer rate increases the maize grain yield also increases. These results agreed with [20] who stated that application of organic and inorganic fertilizers together increases crop productivity and soil fertility. The highest mean grain yield (7861.10 kg ha^{-1}) and (1597.20 kg ha^{-1}) was obtained from the treatment combination of 3 t ha^{-1} VC with 200 kg ha^{-1} NPS and 46 kg ha^{-1} N. Whereas, the lowest grain yield (1597.20 kg ha^{-1}) was gained from control plot. However, this combination was statically at par with the treatment combination of 1.5 t ha^{-1} VC with 200 kg ha^{-1} NPS and 46 t ha^{-1} N, which gave maize grain yield (7699.1 kg ha^{-1}). Similarly, the use of both organic and inorganic fertilizer by farmers has been reported to increase yield, sustain productivity and improved soil chemical properties [15].

Table 4. *The Effect of NPS and vermicompost on maize grain yield (Kgha^{-1}).*

NPS level (Kg ha^{-1})	Vermicompost rates (tonha^{-1})			Mean
	0	1.5	3	
0	1597.20^{e}	2923.60^{d}	2960.60^{d}	2493.8^{c}
100	4916.70^{c}	5356.50^{c}	6439.80^{b}	5571.0^{b}
200	6412.00^{b}	7699.10^{a}	7861.10^{a}	7324.7^{a}
LSD (0.05)	691.73			
CV (%)	11.58			

3.5. Economic Analysis

The partial budget and dominance analysis showed that the highest net benefit 109527.73 Birr ha^{-1} was gained in the treatment that was treated by 200kg/ha NPS with 1.5tha^{-1} Vermicompst with recommended N, whereas the lowest net benefit 26924.00 Birr ha^{-1} was obtained in the control treatment (Table 5). In overall, the economic analysis showing that, a farmer's investment of one Birr in 200kg ha^{-1}NPS without Vermicompost with recommended N ha^{-1} on maize grain yield earns the one Birr and gives an additional 4.86 Birr (Table 5). However, in soil heath point of view chemical fertilizer used only for one year yield production not the next year.

Table 5. *Partial budget analysis.*

Description									
Trt	NPS (kgha^{-1})	Vermicompost (t ha^{-1})	AverageGrain yield (kgha^{-1})	Adjusted Grain yield (kgha^{-1})	Total variable cost (birr)	Growth benefit (birr)	Net benefit (birr)	Dominance	Marginal ret of return
1	0	0	1597.20	1437.48	1825.60	28749.60	26924.00		-

Description									
Trt	**NPS (kgha^{-1})**	**Vermicom-post (t ha^{-1})**	**AverageGrain yield (kgha^{-1})**	**Adjusted Grain yield (kgha^{-1})**	**Total variable cost (birr)**	**Growth benefit (birr)**	**Net benefit (birr)**	**Domi-nance**	**Marginal ret of return**
4	100	0	2923.60	4425.03	12497.79	88500.60	76002.81		4.59
2	0	1.5	2960.60	2631.24	13841.67	52624.80	38783.13	D	-
7	200	0	4916.70	5770.8	17084.92	1154160	98331.08		4.86
5	100	1.5	5356.50	4820.85	23500.48	96417.00	72916.52	D	-
3	0	3	6439.80	2664.54	24383.97	53290.80	28906.83	D	-
8	200	1.5	6412.00	6929.19	29056.07	138583.80	109527.73		0.93
6	100	3	7699.10	5795.82	35238.69	115916.40	80677.71	D	-
9	200	3	7861.10	7074.99	39741.24	141499.80	101758.56	D	-

4. Conclusions

Moreover, the use of integrated organic and inorganic fertilizers it is better to restore soil fertility improvement for a long time. For this reason 200 kgha^{-1} NPS with 1.5 tha^{-1} Vermicomposting is good the next year to maintain soil fertility improvement and crop production. The analysis of variance showed that grain yield, date to tasseling and plant height was significantly ($P < 0.05$) influenced by interaction effect of NPS with vermicompost with recommended N on control plot. However, treatment which was treated by 200kg ha^{-1} NPS with 1.5t ha^{-1} and 200kg ha^{-1} NPS with 3t ha^{-1} the results obtained there were not showed significance differences. The highest grain yield (7861.10 kg ha^{-1} and 7699.10kg ha^{-1}) were obtained in response to application of 200 kgha^{-1} NPS with 3t ha^{-1} and 200 kgha^{-1} NPS with 1.5t ha^{-1} inorganic and organic fertilizers, respectively. Whereas the lowest grains yield (1597.20 kg ha^{-1}) was obtained in response to control (unfertile treatment). The economic analysis revealed that for a treatment to be considered valuable to farmers (100% marginal rate of return), application of 200kg ha^{-1} of NPS alone with recommended N ha^{-1} fertilization are profitable and recommended for farmers. However, in terms of net benefit and soil health point of view for the study area 200kg ha^{-1} NPS with 1.5t ha^{-1} was recommended.

Abbreviations

RCBD	Randomized Complete Block Design
N	Nitrogen
Kg	Kilogram
NPS	Nitrogen Phosphorus Sulfate Fertilizer
Ha	Hector
CEC	Cation Exchange Capacity
VC	Vermicompost
FYM	Farm Yard Manur

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Author Contributions

Bati Dube: Conceptualization, Investigation, Writing – original draft, Writing – review & editing

Gedefa Sori: Funding acquisition, Methodology, Project administration, Resources, Supervision, Visualization

Dagne Chimdessa: Data curation, Methodology, Software

Conflicts of Interest

The authors declare no conflicts of interest.

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