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Integrated Application of NP, Vermicompost and Lime at 50% of the Recommended Rate Improve Barley Production in Strongly Acidic Areas of Bule District, Southern Ethiopia

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Abstract

Land degradation due to soil acidification is a major constraint causing lower agricultural productivity and food insecurity problem in highland areas of Ethiopia. A field experiment was conducted at Bule district, Gedeo zone Ethiopia in 2023 main cropping season (summer) to evaluate the integrated application of 50% NP, 50% vermicompost and 50% lime for acidic soil amelioration and better barley production. About four treatments ((1) 50% recommended NP+ 50% vermicompost + 50% lime, (2) 50% recommended NP + 50% lime, (3) 100% recommended NP only and (4) 100% lime only) were arranged in randomized complete block design with six replications (farmers as replications).150 kg/ha NPS and 150 kg/ha urea were used as recommended NP rate. 4 t/ha vermicompost was used as 50 % of the recommended rate. Lime requirement for each farmer's field was calculated based on exchangeable acidity of the soil. The statistical analysis result of the study showed that application of 50% recommended NP+ 50% vermicompost + 50% lime showed higher result grain yield result (3520.0 a) compared to all other treatments. Lower yield result ((2100.0c) was recorded from the sole application of 100% lime. This result implies that the study area had not enough soil nutrients to produce higher barley yield other than soil acidity. Therefore, from the present study it can be recommended that integrated application of 50% recommended NP+ 50% vermicompost + 50% lime can be an option for enhanced soil fertility, reduced soil acidity and improved barley yield in the study area and other similar agro-ecologica zones of the country.

Keywords: Soil Acidity, Integrated Application, NP, Vermicompost, Lime, Barley

Background and justification

Land degradation is one of the major challenges causing food insecurity and instability in Ethiopia. The primary consequence is a direct reduction in agricultural productivity due to the loss of fertile soils, which exacerbates food insecurity. For instance, the agriculture in the country is under a threat because of the escalating land degradation issues. (Solomon N, *et al*. 2024) [9]. Despite the potential richness of the nation's land resources and agro-ecologies, agricultural production is low, and the country frequently faces food shortages and hunger (Mohammed A, *et al*. 2021) [7].

Soil acidification is one of the forma of land degradation that can be caused by several factors, from the nature of the soil and climatic conditions (mainly rainfall) to anthropogenic factors such as poor soil and crop management practices. The process of soil acidification results in the replacement of basic cations (Ca, Mg and K) in the soil exchange sites with Al, Mn and Fe and increased the concentration of H^+ ion in the soil solution.

Where soil pH is lower than 5.5, availability of important soil nutrients necessary for plant growth is highly reduced. This condition also usually leads to Al and Mn toxicity and deficiency in availability of N, P, K, Mg, Ca and various micronutrients. This has implications for plant growth and nutrient management as it leads to lack of or reduced response to applied fertilizers due to high P fixation by Al and nutrient deficiency which can result in 50% and more yield reduction (IFPIR, 2010). As a result, farmers in these areas tend to apply much higher rates of fertilizers than the recommended rates as the soils are not responsive to fertilizer applications or fertilizer use efficiencies are significantly reduced.

In Ethiopia, around 9 million hectares of agricultural land is affected by different levels of acidity Out of which over 3 million hectares of agricultural lands are estimated to be affected by strong acidity (pH < 5.5) with a significant impact on crop productivity (Temesgen 2023) [11]. Most importantly, the bulk of these strongly affected areas are found in the highlands of the country which receive the highest annual rainfall where wheat, barley, maize, and teff are widely grown. Thus, it is strongly and negatively impacting food security of communities and the national economy.

Liming is an effective method to increase soil pH, reduce the adverse effects of soil acidity and aluminum toxicity, and thereby increase availability of nutrients (Taye G, *et al*. 2020) [10]. However, the practice of liming by smallholder farmers is rare in Ethiopia because lime is required in large amount leads to difficulty for transportation and application. The application of vermicompost is also another effective strategy to improve soil pH, increases soil microbial activity such as nitrogen-fixing and phosphorus-solubilizing organisms. It also provides several essential macro and micronutrients, enhances oxygen availability, regulates soil temperature, improves porosity and infiltration, and boosts crop yield and quality. However, applying vermicompost alone cannot replenish depleted nutrients due to slow release of nutrients, and its bulkiness (Selim M. 2020) [8].

Therefore, the practice of well-planned soil fertility management should be implemented to reduce soil acidity and increase crop yield. Integrated application of organic fertilizer and lime along with mineral fertilizers has become ecologically sustainable and economically feasible approach to reduce soil acidity, enhance soil fertility and increase crop productivity. Previous researches done in different acid affected areas indicated that combination of NP fertilizer, organic resource (compost, vermicompost or farmyard manure) and lime to be effective to reclaim soil acidity and improve productivity of staple crops (Habtamu G., 2024, Amante L. *et al*, 2025) [1]. Therefore the this study was aimed to evaluate the effects of integrated application of mineral fertilizer, lime and vermicompost at 50% of the recommended rates for better barley production in Bule district, Gedeo zone Ethiopia.

Materials and Methodologies

Description of the Study Area

The study area (Bule district) is found in Gedeo zone, Ethiopia with geographic coordinates between 60°4′16″ and 6°23′50″N latitude and 38°16′20″ to 38°26′11″E longitude. The area spans an altitude range of 1700 and 3000 m above sea level. The district covers an estimated area of 125,430 ha. The climate of the area is characterized by a tepid moist and cool weather, typical of Ethiopian highland agro-ecology. The mean annual rainfall and temperature in the area range from 1200 to 1800 mm and 12–20 °C, respectively. The soil type of the area is mainly Nitisols. The dominant soil textural class of the surface layer is clay loam in the upper and middle slope positions and clay in the lower slope position. The district is highly prone to soil acidity problem. Mixed farming system that integrates crops, livestock, and trees is the dominant farming practice in the area. Out of the total area of the study district, perennial crops cover 11,876 ha (46 %), annual crops cover 10,115 ha (39 %), forests cover 1855 ha (7 %), and grazing land cover 459 ha (1.8 %). Annual crops grown in the area include barley, wheat, beans, peas and potato, and a perennial crop enset (*Ensete ventricosum*) is also widely cultivated (Getahun H. *et al*, 2024) [3].

Experimental Design and Treatments

The experiment has been executed since 2023 G.C. in the main cropping (summer) season on six farmers' fields with plot size of 25m * 25m. About four treatments were arranged in RCBD design was used with 6 replication (farmers as replication). The treatments were (1) 50% recommended NP+ 50% vermicompost + 50% lime, (2) 50% recommended NP + 50% lime, (3) 100% recommended NP only and (4) 100% lime only. 150 kg/ha NPS and 150 kg/ha urea were used as recommended NP rate. 4 t/ha vermicompost was used as 50 % of the recommended rate. Lime requirement for each farmers field were calculated based on exchangeable acidity using the formula:

$$LR = \frac{EA \times BD \times Depth\ (m) \times 10^4 m^2 \times 1000}{2000}$$

Where LR = Lime requirement (CaCO3/Kg); EA = exchangeable acidity of the soil in cmol (+)/Kg; BD = bulk density of the soil in $Mg/m^3$and depth = the depth of the plow layer (0.15 m); $10^4 m^2$ = farm size; 1000 and 2000 = conversion factors from cmol/Kg of acidity to Kg/ha of CaCO3 (Kamprath, 1970).

All doses of vermicompost and NPS fertilizer was applied at planting time while Urea was applied in split with $1/3^{rd}$ and $2/3^{rd}$ at planting and at 45 days after planting respectively. Lime was applied at planting in micro dosing system. Barley seeds were sown in separations of 20 cm and 1m between rows and plots respectively. All other agronomic practices were applied as per recommendations.

Table 1: soil acidity status of the study area

Farmers field (replications)	pH	Exchangeable acidity	Bulk density
1	4.75	4.47	1.03
2	4.7	4.23	1.05
3	4.8	3.99	1.03
4	4.9	3.75	1.06
5	4.89	3.83	1.05
6	4.8	3.8	1.06

Results and discussions

The statistical analysis result of the study showed that application of 50% recommended NP+ 50% vermicompost + 50% lime significantly influence the above ground biomass and yield parameters (Table 2). Application of 50% recommended NP+ 50% vermicompost + 50% lime showed higher result grain yield result (3520.0a) compared to all other treatments. Application of 50% recommended NP + 50% recommended lime and 100% recommended NP only gave statistically similar yield result (2940.0b and 2660.0b) respectively. Out of all treatments lower (2100.0c) grain yield result was recorded from application of 100% lime only. This result implies that the study area had not enough soil nutrients to produce higher barley yield other than soil acidity. The above ground biomass result of the treatment also indicated that sole application of 100% lime cannot gave enough biomass compared to all other treatments. In line with the present study Derb Kifle and his friends reported that application of 50% recommended NP+ 50% vermicompost + 50% lime significantly improved the grain

yield of faba bean and soil chemical properties in acid prone area of Ejere district (Derb K. *et al*, 2023) [2]. The research finding of Amante Lema and his friends also revealed that integrated application of vermicompost and NP fertilizer under liming condition can significantly improve the growth and yield parameters of bread wheat with economically acceptable net income (150,872 ETB)in Kofele district (Amante L, *et al*. 2025) [1].

Table 2: effects of application of vermicompost, NP and lime on growth and yield parameters of barley

Treatments	Plant hieght (cm)	Spike length (cm)	Biomas (t/ha)	Grain yield (kg/ha)
50% recommended NP+ 50% vermicompost + 50% lime	92.500	6.0000	14.700a	3520.0 a
50% recommended NP + 50% recommended lime	90.750	5.8500	11.600ab	2940.0b
100% recommended NP only	90.750	5.4000	10.700ab	2660.0b
100% recommended lime only	79.250	4.8000	8.500b	2100.0c
CV	7.85	14.11	15.27	25.36
LSD	NS	NS	7.71	499.05

Conclusion

The result of the present study revealed that integrated application of organic and inorganic fertilizer along with lime is better for barley production in the study area. About 3520 Kg/ha grain yield was obtained from the integrated application of 50% recommended NP+ 50% vermicompost + 50% lime followed by 2940.0 Kg/ha and 2660.0 Kg/ha from the application of 50% recommended NP + 50% recommended lime and 100% recommended lime only respectively. On the other hand lower grain yield was obtained from sole application of 100% lime. Therefore, it can be recommended that application of 50% recommended NP+ 50% vermicompost + 50% lime is better for better barley production and soil acidity amelioration in the study area.

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