

Original Research Article

Potassium and micronutrient fertilization for enhancement of Tef yield in Vertisols of Hawzen and Enderta districts, Tigrayregion, Ethiopia

ABSTRACT

Field study was conducted in Enderta and Hawzen districts of Tigray region on six farmers' fields aimed at evaluating potassium and micro-nutrient effect on yield and yield components of the tested crop. The experiment comprised of eight treatments including control and recommended NP arranged in Randomized Complete Block Design with two replications. Phosphorus fertilizers were applied at planting, while the nitrogen fertilizer was applied in two splits. The micronutrients and Tyrosine were applied in foliar forms. SAS version 9 statistical software was used for data analysis. The analyzed results depicted that Tef yield was increased with potassium and micro-nutrient application in both districts mathematically even though it was not consistent. In line to this, the highest grain and straw yields of Tef was recorded at recommended NP with application of 50 kg/ha K_2SO_4 and recommended NP with a foliar application of Tyrosine, respectively. But this result was statistically similar with the recommended NP. Thus, application of additional fertilizer without yield increment is uneconomical rather than maximizing costs. Hence, potassium, copper, and zinc in the current sources were not Tef yield limiting nutrients in the study sites even though the soil statuses are low. On the other hand nitrogen and phosphorus were observed the Tef yield limiting nutrients in this study. For this reason maximizing the use of nitrogen and phosphorus fertilizers with detailed research on its level and their interactions, sources and application times is important to maximize the Tef productivity in the Vertisols of Enderta and Hawzen district.

Keywords: Potassium, Vertisols, Micronutrient, Tef, Hawzen

1. INTRODUCTION

The pressure from increasing population and urbanization, coupled with land degradation and climate change are the major causes for food insufficiency in developing world [1]. Using agronomic management to maximize the production potential of high yielding and using of fertilizers have played a significant role in addressing this issue [2]. In line to this, applications of mineral fertilizers alone and in combination with organic amendments had significant effect on soil physical and chemical properties as well as crop and tree growth [3, 4]. Among mineral nutrients, nitrogen is the first and foremost nutrient required for crop plants as it is a vital structural constituent of many proteins and enzymes chlorophyll, Rubisco, nucleic acids, some hormones and thus N fertilization is an essential agronomic management practice to enhance the crop productivity and plays a significant role during the vegetative growth of crops [5].

Tef [*Eragrostis tef* (Zucc) Trotter] is a self-pollinated warm season small-grained cereal crop [6]. The crop requires 90 to 130 days for growth depending on crop variety and altitude, [7].

Teff grain is gluten free, and is a good flour source for segments of the population suffering from gluten intolerance [8]. It is adapted to environments ranging from drought-stressed to waterlogged soil conditions [9]. Moreover, the crop is among the major cereal crops in Ethiopia and occupies about 22.6% of the total cereals' land [10]. Nationally, teff is one of the important cereals that are at the center of the increasingly vibrant agricultural output markets of Ethiopia [11].

Despite of its importance and coverage of large area, its productivity is very low. The average national yield of Tef is about 128 kg/ha [12]. Some of the factors contributing to low yield are low soil fertility and unbalanced use of mineral fertilizers [13] for many cereal crops. In line to this in Ethiopia the combined effect of lodging, method of planting and fertilizer application resulting up to 22% reduction in grain and straw yield [12]. Therefore, improvement of soil fertility and balanced fertilization is important to obtain optimum crop yield such as Tef to feed the increasing population.

One of the methods to improve fertility of the soil is to use mineral fertilizers. Nitrogen and phosphorus fertilizers are the major fertilizer types applied by Ethiopian farmers growing tef on Vertisols [14]. However, use of mineral fertilizers such as potassium and micronutrients are uncommon [15,]. This is mainly due to the view that Ethiopian soils are not deficient in potassium and micro nutrients. On the other hand, [16] indicated that Continuous application of N and P fertilizers only may led to deficiencies of other nutrients including potassium, Copper and Zinc. In line to this, [17] indicated that elements like K and micro-nutrients are becoming depleted and deficiency symptoms are being observed on major crops in different areas of Ethiopia. So this trial was made to evaluate the contribution of potassium and some micronutrients on improving Tef productivity in Vertisols of Hawzen and Enderta districts.

2 MATERIALS AND METHODS

2.1. Study area

The experiment was conducted in farmers' fields (soil order: Vertisols) of Enderta and Hawzen districts, south eastern and eastern zone of Tigray. Geographically, Enderta district is located between 13°12'55" and 13°38'38" N latitude and 39°16'43" and 39°48'08" E longitudes. Similarly, Hawzen district is located between 13°48' and 14°8'N latitudes and 39°12' and 39°36' E longitudes. The mean annual temperature ranges between 11.5 - 24.4 °C in Enderta and between 7.7- 24 °C in Hawzen [10, 13]. Wheat, Tef and barley are the major crops of the in both of the districts.

2.2. Experimental design and procedures

The field experiment consists of eight treatments laid out in Randomized Complete Block Design (RCBD) with two replications. Phosphorus fertilizers were applied at planting, while the nitrogen fertilizers were applied twice during the crop growth stage that is 1/3 of the full dose at planting and the other 2/3 at the full tillering stage. The Micronutrients and Tyrosine fertilizer were applied through foliar applications. The plot size was 5m x 5m with spacing of 1m between blocks and 0.5m between plots.

The treatments were:

Chart 1 : Treatment details

Treatment	Description
T1	Control (without fertilizer)
T2	NP (64N and 46 P ₂ O ₅)
T3	NP+ 50 kg/ha K ₂ SO ₄
T4	NP+50 % Cu
T5	NP+70% Zn

3.2. Total above ground biomass and grain yield

Results depicted that biomass, grain and straw yields of Tef was significantly affected by the applied treatments in Enderta district while, in Hawzen district there were non-significant variation among the treatments on biomass, grain and straw yields of Tef. In line to this, the highest biomass and straw yields of Tef was recorded at recommended NP with foliar application of Tyrosine and was significantly higher than control and NP with foliar Cu application but it is statistically at par with the other treatments including NP in Enderta districts. Moreover, the highest grain yield of Tef was obtained from treatments received NP with K and is significantly higher than control and NP with foliar Cu application, but it is statistically similar with the other treatments. This indicated that in Enderta districts application of copper as foliar method decreased the efficiency of nitrogen and phosphorus. On the other hand, the non-significant results of Tef response to the potassium and micronutrients in Hawzen district might be due mineralization of the medium organic carbon and total nitrogen in the soil which contributes to availability of nitrogen, phosphorus, potassium and micronutrients and may not respond to additional fertilizer applications. On the other hand, the lowest total above ground biomass and grain yield of Tef was recorded at control treatments. Generally, the results in both districts showed that addition of potassium and the micronutrients such as Cu, Zn and Tyrosine did not showed yield increment of Tef and yield components mathematically or statistically over the recommended NP. Hence, Nitrogen and phosphorus is the Tef yield limiting nutrients in the areas under study.

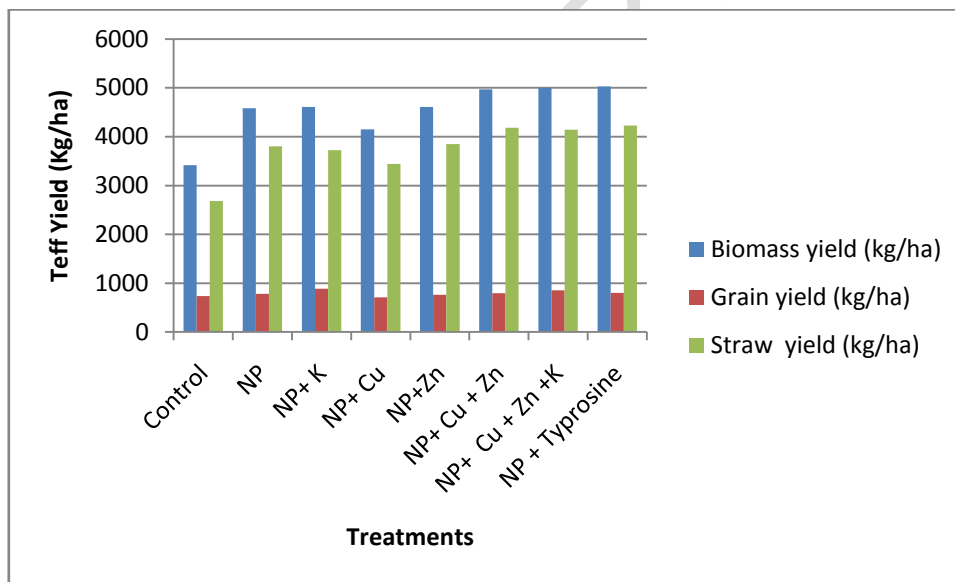


Figure 1. Tef response to potassium and micronutrients in Enderta district

As shown in the figure above the highest yield and yield components of Tef was recorded at the recommended NP with foliar application of Tyrosine mathematically and the lowest was recorded at the control treatments.

Table2: Effect of potassium and micronutrient on biomass and grain yields of Tef in Enderta and Hawzen farmers' fields

Treatment	Biomass yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Location
Control	3416.7c	735.43bc	2681.3c	Enderta Districts
NP	4583.3ba	780.56bac	3802.8ba	
NP+ K	4611.1ba	885.41a	3725.7ba	
NP+ Cu	4152.8bc	709.71c	3443.1b	
NP+Zn	4611.1ba	759.71bac	3851.4ba	
NP+ Cu + Zn	4972.2a	790.41bac	4181.8a	
NP+ Cu + Zn +K	5000a	853.49ba	4146.5a	
NP + Tyrosine	5027.8a	799.45bac	4228.4a	
Mean	4546.87	789.27	3757.61	
CV(%)	16.91	16.42	18.66	
Pvalue	0.002	0.05	0.0009	
Control	4666.7	1101.4	3565.3	Hawzen Districts
NP	6388.9	1033.3	5455.6	
NP+ K	6833.3	1054.2	5779.2	
NP+ Cu	6611.1	1145.9	5465.3	
NP+Zn	7111.1	1058.3	6052.8	
NP+ Cu + Zn	6388.9	1048.6	5340.3	
NP+ Cu + Zn+K	7611.1	1055.6	6555.6	
NP + Tyrosine	6277.8	1157	5120.8	
Mean	6486.11	1069.27	5416.84	
Cv (%)	17.42	24.19	18.19	
P value	NS	NS	NS	

Means followed by the same letter along columns are not significantly different. NP: Recommended nitrogen and phosphorus fertilizer CV: coefficient of variance.

4. CONCLUSION

The application of additional fertilizer without yield increment is uneconomical rather than maximizing costs. Moreover, K_2SO_4 as Source of potassium, 70%Zn as source of Zinc and 50%Cu as source of copper applied as foliar are not the Tef yield limiting nutrients in the study sites since they did not responded to Tef yield even though their status in the soils were low. So, other researches should be conducted selecting other sources of potassium and the micronutrients under study. For this reason maximizing using of nitrogen and phosphorus fertilizers with detailed research on its level and their interactions, sources and application times is important to maximize the Tef productivity in the Vertisols of Enderta and Hawzen district.

REFERENCES

- [1] Sarvade, S., Mishra, H.S., Kaushal, R., Chaturvedi, S., Tewari, S., Jadhav, T.A., 2014a. Performance of wheat (*Triticumaestivum* L.) crop under different spacings of trees and fertility levels. *African Journal of Agricultural Research* 9(9), 866–873.
- [2] Kumar, S., Agrawal, S., Jilani, N., Kole, P., Kaur, G., Mishra, A., Gupta, S., Singh, A.P. and Tiwari, H., 2023. Effect of integrated nutrient management practices on growth and productivity of rice: A review.
- [3] Pathariya, Priyanka, Dwivedi, B.S., Dwivedi, A.K., Thakur, R.K., Singh, Muneshwar and Sarvade, S. 2022. Potassium balance under soybean–wheat cropping system in a 44-year old long-term fertilizer experiment on a Vertisol. *Communications in Soil Science and Plant Analysis*. 53(2): 214–226
- [4] Sarvade, S., Mishra, H.S., Kaushal, R., Chaturvedi, S., Tewari, S., 2014b. Wheat (*Triticumaestivum* L.) yield and soil properties as influenced by different agri–silviculture systems of Terai Region, Northern India. *International Journal of Bio-resource and Stress Management* 5(3), 350–355.
- [5] Singh, D., Yadav, A., Tiwari, H., Singh, A.K., Singh, S., Yadav, R.K., Gangwar, P. and Sachan, D.S., 2023. Nitrogen Management through Nano Urea and Conventional Urea and its Effect on Wheat (*Triticumaestivum* L.) Growth and Yield. *Int. J. Plant Soil Sci*, 35(18), pp.1466-1473
- [6] Ketema, S., 1997. *Tef-Eragrostistef* (Zucc.) (Vol. 12). Bioersivity International.
- [7] Gebretsadik, H., Haile, M. and Yamoah, C.F., 2009. Tillage frequency, soil compaction and N-fertilizer rate effects on yield of teff (*Eragrostistef* (Zucc) Trotter) in central zone of Tigray, Northern Ethiopia. *Momona Ethiopian journal of science*, 1(1).

- [8] Miller, D., 2014. Teff grass—Crop overview and forage production guide 2nd ed. *Cal/West Seeds*. <https://kingsagriseeds.com/wp-content/uploads/2014/12/Teff-Grass-Management-Guide.pdf>. Accessed, 4(20), p.2020.
- [9] Menna, A., Semoka, J.M., Amuri, N. and Mamo, T., 2015. Wheat response to applied nitrogen, sulfur, and phosphorous in three representative areas of the central highlands of Ethiopia-I. *International Journal of Plant & Soil Science*, 8(5), pp.1-11.
- [10] FayeraAsefa, A.D. and Mohammed, M., 2014.Evaluation of tef [Eragrostistef (zuccagni).Trotter] responses to different rates of NPK along with Zn and B in Didessa District, South Western Ethiopia. *World Applied Sciences Journal*, 32(11), pp.2245-2249.
- [11] Minten, B., Stifel, D. and Tamru, S., 2014. Structural transformation of cereal markets in Ethiopia. *Journal of Development Studies*, 50(5), pp.611-629.
- [12] CSA (Central Statistic Authority), 2012. Agricultural Sample Survey: report on Area and production of major Crops (Private peasant holdings “meher” season), Volume I Addis Abeba, Ethiopia.
- [13] Berhe, T. and Zena, N., 2008, May. Results in a trial of system of teff intensification (STI) at Debrezeit.In *Proceedings of Annual Research Review Workshop* (pp. 16-17).
- [14] Haileselassie, B., Stomph, T.J. and Hoffland, E., 2011. Teff (Eragrostistef) production constraints on Vertisols in Ethiopia: farmers' perceptions and evaluation of low soil zinc as yield-limiting factor. *Soil Science and Plant Nutrition*, 57(4), pp.587-596.
- [15] Brhane, H., Mamo, T. and Teka, K., 2017. Optimum potassium fertilization level for growth, yield and nutrient uptake of wheat (*Triticumaestivum*) in Vertisols of Northern Ethiopia. *Cogent Food & Agriculture*, 3(1), p.1347022.
- [16] Astatke, A., Mamo, T., Peden, D.O.N. and Diedhiou, M., 2004. Participatory on-farm conservation tillage trial in the Ethiopian highland Vertisols: The impact of potassium application on crop yields. *Experimental Agriculture*, 40(3), pp.369-379.
- [17] Asgelil, D., Taye, B. and Yesuf, A., 2007. The status of micro-nutrients in Nitisols, Vertisols, Cambisols and Fluvisols in major maize, wheat, teff and citrus growing areas of Ethiopia. *Proceedings of Agricultural Research Fund*, 15(4), pp.77-96.

- [18] Haileselassie, B., Habte, D., Haileselassie, M. and Gebremeskel, G., 2014. Effects of mineral nitrogen and phosphorus fertilizers on yield and nutrient utilization of bread wheat (*Triticumaestivum*) on the sandy soils of Hawzen District, Northern Ethiopia. *Agriculture, Forestry and Fisheries*, 3(3), pp.189-198.
- [19] Rhoades, J.D. and Page, A.L., 1982. Methods of soil analysis. *American society of agronomy, Part, 2*.
- [20] Walkley, A. and Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, 37(1), pp.29-38.
- [21] Bouyoucos, G.J., 1962. Hydrometer method improved for making particle size analyses of soils 1. *Agronomy journal*, 54(5), pp.464-465.
- [22] Olsen, S.R., 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (No. 939).US Department of Agriculture.
- [23] Bremner, J.M. and Mulvaney, C.S., 1982. Nitrogen-total.In 'Methods of soil analysis.Part 2. Chemical and microbiological properties'.(Eds AL Page, RH Miller, DR Keeney) pp. 595–624. *Soil Science Society of America: Madison, WI, USA*.
- [24] Landon, J.R., 1991. *Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics*. Routledge.
- [25] Roy, R.N., Finck, A., Blair, G.J. and Tandon, H.L.S., 2006. Plant nutrition for food security. *A guide for integrated nutrient management.FAO Fertilizer and Plant Nutrition Bulletin*, 16(368).
- [26] Tadesse, T., Haque, I. and Aduayi, E.A., 1991. Soil, plant, water, fertilizer, animal manure and compost analysis manual. *ILCA PSD Working Document*.