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# Potassium and Micronutrient Fertilization for Enhancement of Tef Yield in Vertisols of Hawzen and Enderta Districts, Tigray Region, Ethiopia

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors HB and DB designed the study, wrote the protocol, conduct laboratory analyses, analyzed and interpreted the data and wrote the manuscript. Both authors read and approved the final manuscript.*

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## 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 Typrosine 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,

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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 Typrosine, 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 [14]. Nitrogen and phosphorus fertilizers are the major fertilizer types applied by Ethiopian farmers growing tef on Vertisols [15]. However, use of mineral fertilizers such as potassium and micronutrients are uncommon [16,17]. This is mainly due to the view that Ethiopian soils are not deficient in potassium and micro nutrients. On the other hand, [18] indicated that Continuous application of N and P fertilizers only may led to deficiencies of other nutrients including potassium, Copper and Zinc. Inline to this, [19] 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 - 24ºC 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 Typrosine fertilizer were applied through foliar applications. The plot size was 5m × 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 $P_2O_5$) |
| T3 | NP+ 50 kg/ha $K_2SO_4$ |
| T4 | NP+50 % Cu |
| T5 | NP+70% Zn |
| T6 | NP+ 50% Cu + 70% Zn |
| T7 | NP+ 50% Cu + 70% Zn + 50 kg/ha $K_2SO_4$ |
| T8 | NP + Typrosine |

Representative composite soil samples from each farmer field were taken before planting following the standard soil sampling procedures.

The initial soils of the experimental field were analyzed for texture, pH, EC, total nitrogen, organic carbon, cation exchange capacity (CEC), available phosphorus, and exchangeable K. The methods used were: Soil pH [20], Organic carbon % [21], soil texture [22], available phosphorus [23], total nitrogen [24], Cation Exchange Capacity, and exchangeable [25]. Data on biomass and grain yield were collected.

### 2.3 Data Analysis

Analysis of variance (ANOVA) was carried out using Statistical Analysis Software (SAS) version 9. Whenever treatment effects were significant, mean separations were made using the least significant difference (LSD) test at the 5% level of probability.

## 3. RESULTS AND DISCUSSION

### 3.1 Soil Properties Before Planting

As indicated in the Table 1 the initial soil of both districts have similar properties such as clay in texture [22], sat free in EC, neutral in pH, moderate to high in CEC [25] and low in exchangeable K [21]. However, there was a variation in the level of organic carbon, total nitrogen, and available P between the districts. As a result, the three sites of Enderta districts were low in organic carbon and total nitrogen [26] and low in available P [23]. But, the three sites of Hawzen districts were medium in total nitrogen and organic carbon [26] and available P [23].

### 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 Typrosine 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 Typrosine 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.

**Table 1. Soil physio-chemical properties of the site before sowing**

| Parameters | Enderta | | | Hawzen | | |
|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 1 | Site 2 | Site 3 |
| pH water (1:2.5) | 6.5 | 6.85 | 7.2 | 7.0 | 6.9 | 7.2 |
| EC (ds/m) | 0.1 | 0.08 | 0.1 | 0.0 | 0.1 | 0.1 |
| Organic Carbon (%) | 0.7 | 0.52 | 0.7 | 1.6 | 2.1 | 1.8 |
| Total N (%) | 0.1 | 0.07 | 0.0 | 0.06 | 0.09 | 0.11 |
| P-Olsen (mg/kg) | 4.6 | 2.9 | 3.6 | 6.1 | 6.7 | 7.2 |
| CEC (Cmol+/Kg) | 34.0 | 30.2 | 30.0 | 33.0 | 29.0 | 32.0 |
| Ex. K (Cmol+/Kg) | 0.2 | 0.18 | 0.3 | 0.2 | 0.3 | 0.3 |
| Sand (%) | 19.0 | 21.0 | 17.0 | 21.0 | 20.0 | 18.0 |
| Silt (%) | 25.0 | 32.0 | 30.0 | 31.0 | 26.0 | 26.0 |
| Clay (%) | 56.0 | 47.0 | 53.0 | 48.0 | 54.0 | 56.0 |
| Textural class | Clay | Clay | Clay | Clay | Clay | Clay |

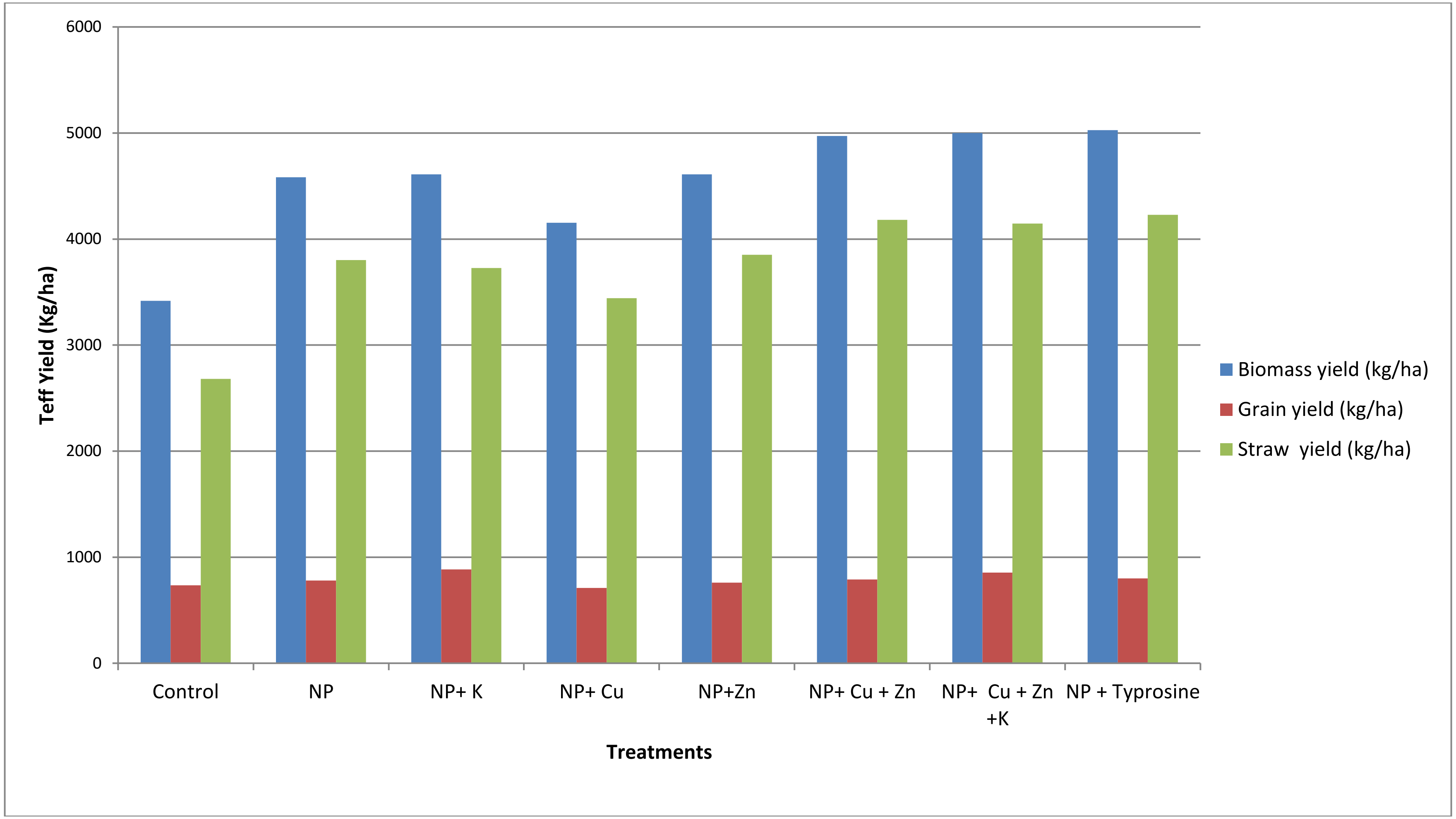


**Fig. 1. Teff response to potassium and micronutrients in Enderta district**

**Table 2. 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 + Typrosine | 5027.8a | 799.45bac | 4228.4a | |
| **Mean** | **4546.87** | **789.27** | **3757.61** | |
| **CV (%)** | **16.91** | **16.42** | **18.66** | |
| ***P value*** | **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 + Typrosine | 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*

As shown in the Fig. 1 the yiest yield and yield components of Tef was recorded at the recommended NP with foliar application of Typrosine mathematically and the lowest was recorded at the control treatments.

## 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.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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