Original Research Article

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

ABSTRACT

Field studies were 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 experiments comprised 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, the highest grain and straw yields of Tef was recorded at recommended NP with application of K @50 kg/ha, 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

Tef [Eragrostis tef (Zucc.) Trotter] is a self-pollinated warm season small grained cereal crop [1] The crop requires 90 to 130 days for growth depending on variety and altitude, [2]. Teff grain is gluten free, and is a good flour source for segments of the population suffering from gluten intolerance [3]. It is adapted to environments ranging from drought-stressed to waterlogged soil conditions [4]. Moreover, the crop is among the major cereal crops in Ethiopia and occupies about 22.6% of the total cereals' land [5]. Nationally, teff is one of the important cereals that are at the center of the increasingly vibrant agricultural output markets of Ethiopia [6].

Despite of its importance and coverage of large area, its productivity is very low. The average national yield of Tef is about1.28 tone ha^{-1} [7]. Some of the factors contributing to low yield are low soil fertility and unbalanced use of mineral fertilizers [8]. 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 [2]. Therefore, improvement of soil fertility and balanced fertilization is important to obtain optimum crop yieldsuch 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 [9]. However, use of mineral fertilizers such as potassium and micronutrients are uncommon [10]. This is mainly due to the view that Ethiopian soils are not deficient in potassium and micro nutrients. On the other hand, [11] 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, [12] 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 experiments were conducted on Vertisols farmers' fields 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 7.7^{o}C - 24^{o}C inHawzen [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 fertilizerswere 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 in foliar forms. The plot size was 5m by 5m with spacing of 1m between blocks and 0.5m between plots.

The treatments were:

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

Comment [HT1]: Kindly, draw the treatments in tabular format.

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 [14], Organic carbon % [15], soil texture [16], available phosphorus [17], total nitrogen [18], cation exchange capacity, and exchangeable [19]. 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 DISCUSSIONS

3.1. Soil properties before planting

As indicated in the Table 1 below the initial soil of both districts have similar properties such as clay in texture [16], sat free in EC, neutral in pH, moderate to high in CEC [19] and low in exchangeable K [20]. 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 [21] and low in available P [17]. But, the three sites of Hawzen districts were medium in total nitrogen and organic carbon [21] and available P [17].

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

Comment [HT2]: Also, add graph of table 1: Soil physio-chemical properties of the site before sowing.

	Enderta			Hawzen		
Parameters	**Site1**	**Site2**	**Site3**	**Site1**	**Site2**	**Site3**
pH water (1:2.5)	6.5	6.85	7.2	7	6.9	7.2
EC (ds/m)	0.1	0.08	0.1	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	0.06	0.09	0.11
P-Olsen(mg/kg)	4.6	2.9	3.6	6.1	6.7	7.2
CEC (Cmol+/Kg)	34	30.2	30	33	29	32
Ex. K(Cmol+/Kg)	0.2	0.18	0.3	0.2	0.3	0.3
% Sand	19	21	17	21	20	18
% Silt	25	32	30	31	26	26
% Clay	56	47	53	48	54	56
Textural class	Clay	Clay	Clay	Clay	Clay	Clay

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 no 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 is 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 yields of Tef were 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 micro nutrients such as Cu, Zn and Typrosine did not showed higher yield increment of Tef yield 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.

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

Comment [HT3]: Add graph/figure of table 2 also.

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**	
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 + 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.

4. CONCLUSIONS

Field studies were conducted in Enderta and Hawzen districts on six farmers' fields aimed at evaluating of potassium and micro nutrients on yield and yield components of Tef. The experiments comprised eight treatments including control and recommended NP arranged in Randomized Complete Block Design (RCBD) with two replications. Results depicted that Tef yield was increased with potassium and micro nutrient application in both districts mathematically even though it was not consistent. However, the responses of Tef yield to application of potassium and micro nutrients considered under this study was statistically similar with the recommended NP. Thus, 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.

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