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Potassium Fertilization and its Level on Wheat (*Triticum aestivum*) Yield in Shallow Depth Soils of Northern Ethiopia

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Abstract

Many un-updated reports indicated that potassium was not deficient in Ethiopian soils. However, it was later proved that many Ethiopian soils are potassium deficient. Hence, the Ethiopian Soil Information System (EthioSIS) has initiated potassium fertilizer demonstrations in 2014 using K containing blended fertilizers in different parts of the country. But, there were no evidences about the K in the blended fertilizer is enough for wheat demand or not. Thus, a field experiment was conducted to evaluate the response of wheat to additional K rates on top of the K containing blended fertilizers. The experiments were laid out in Randomized Complete Block Design with 4 levels of potassium (0, 30, 60, 90, of K_2O kg/ha) replicated 3 times. Data on yield and yield components of wheat crop were collected and analysis of variance was done. Results depicted that plant height and harvest index were not significant. However, spike length, grain yield and straw yields of wheat were significantly affected by K application rates. Hence, the highest spike length was obtained at a rate of 90 kg/ha K_2O but the highest grain and straw yield of wheat were obtained at 30 kg/ha K_2O. Besides, the highest apparent K recovery and agronomic use efficiency were found at 30 kg K_2O/ha. Therefore, potassium fertilization is important and its level in the blended formula did not meet the wheat requirement in the study area.

Keywords: Potassium; Blended fertilizer; Wheat; Shallow soils; Enderta

Introduction

Wheat (*Triticum aestivum*) is an important food crop in Ethiopia but its mean yield is around 2.54 Mt/ha, well below experimental yields [1]. Low soil fertility is among the factors which limit wheat production in Ethiopia [2]. Usage of organic and mineral fertilizer is important in replacing the depleted soils, and to improve soil productivity and crop production in the country. In Ethiopia, many of the smallholder farmers have good awareness about the contribution of fertilizer for crop production, but nationally only 35% of farmers applies fertilizer on about 40% of the area under crop production [3].

Moreover, for the past several years, farmers in the country had used a limited type of mineral fertilizers such as blanket recommendation of nitrogen and phosphorus in the form of urea and DAP respectively as an input to increase crop production. However, studies in Ethiopia indicated that application of N and P fertilizers without considering other nutrients such as K, and micro-nutrients led to the depletion of other soil nutrients [4].

Potassium is among the macro nutrients which are taken up by plants in large amount. It plays significant roles in transportation of water, nutrients, nitrogen utilization, and stimulation of early growth and in insect and disease resistance [5]. Potassium is also important in the transportation of prepared food from the leaves to the rest of the plant parts, quality of seeds and fruits, strengthens the roots, stem and branches of plants and reduce lodging.

Potassium fertilization had shown yield improvement of crops in various areas of the world [6]. Research findings in India, Bangladesh and Iran indicated that Potassium fertilizer increased grain and straw yield of wheat at various rates [7-10].

Nowadays, efforts have been started to include K as fertilizer in Ethiopia through K containing blended fertilizers. On the other hand, there was no evidence whether the K in blended formula and the recommended rate was enough for wheat demand or not. Thus, this study was aimed at investigating the response of wheat to the recommended blended fertilizers and increasing rates of K fertilizer applied as KCl) in Enderta district, northern Ethiopia.

Materials and Methods

Study area

The study was carried out in Enderta district located in the southeastern zone of Tigray region, northern Ethiopia. Geographically, the area is located between 13°12'55" and 13°38'38" N latitudes and 39°16'43" and 39°48'08" longitudes. The average elevation of the district is about 2200 m above sea level [11]. Based on data collected from the nearest weather station (Mekelle airport), the annual rainfall of the ranges between 258 and 756 mm and mean annual temperature ranges between 11.5°C and 24.4°C.

Experimental design and procedures

The experiment consisted 4 levels of potassium (0, 30, 60 and 90 K_2O kg/ha) designed in a RCBD with three replications and applied as KCl on top of the initially recommended blended fertilizers (NPKSZn at 100 kg/ha) that contains 8 kg/ha of K in the form of K_2O.

On top of the blended fertilizers which contain 15.2% N, 48.8% Nitrogen was also added to satisfy N wheat requirements. The blended fertilizer was applied at planting, while the nitrogen and K fertilizers

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were applied twice in the crop growth stage that is 1/3 of the full dose at planting and the other 2/3 at the full tillering stage. Sowing was done manually at a seed rate of 150 kg/ha using manual row maker with a spacing of 0.20 m between rows.

The initial experimental field soils were analyzed for texture, pH, organic matter, cation exchange capacity (CEC), total nitrogen, available phosphorus and exchangeable K. The method used for soil physical and chemical analysis was: Soil pH, Organic carbon %, soil texture by hydrometer, available Phosphorus, total nitrogen by Kjeldhal method, Neutral Ammonium acetate method for cation exchange capacity and Exchangeable K^+ [12-17]. After maturity, wheat crop samples were collected and partitioned into grain and straw parts. The grain and straw samples were analyzed for nitrogen and potassium. Plant total nitrogen was analyzed using Kjeldhal method whereas potassium using dry ashing method. Data on plant height, spike length, grain yield, straw yield and harvest index were collected [16,18].

Moreover, apparent K recovery and K agronomic use efficiency were calculated by the formula developed [19].

$$\textit{Apparent K recovery (kg/kg)} = \left(\frac{Un - Uo}{n}\right)$$

Where; Un stands for nutrient uptake at 'n' rate of fertilizer and Uo stands for nutrient uptake at control (no fertilizer) and 'n' stands for fertilizer applied.

$$\textit{Agronomic K use efficiency(kg/kg)} = \left(\frac{Gn - Go}{n}\right)$$

Where Gn and Go stand for grain yield of fertilized plots at 'n' rates of fertilizer and grain yield of unfertilized plots, respectively, and 'n' stands for nutrient applied.

Data analysis

Analyses of variance (ANOVA) were 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.

Results and Discussion

Soil properties before planting

The physical and chemical properties of the soil before planting are indicated in Table 1. The soil of the study site is neutral in pH, medium in Organic carbon and total nitrogen, low in available P and high in CEC and Exchangeable K [15,17,20,21]. The medium organic carbon content might have contributed to the high level of CEC and medium total nitrogen because of mineralization in the study area.

Parameters	Value
pH Water (1:2.5)	7.32
Organic Carbon (%)	2.1
Total N (%)	0.22
P-Olsen(mg/kg)	2.64
Exchangeable K(cmol/kg)	0.69
CEC (cmol (+) kg^{-1})	35.8
% Sand	25
% Silt	31
% Clay	44
Textural class	Clay Loam

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

Plant height, spike length, grain yield, straw yield and harvest index

Data presented in Tables 2 and 3 showed that the K fertilizer rate showed that average plant height and spike length had increased with increasing K application rates even though the trend was not consistent. The highest plant height was obtained from treatments receiving 60 kg/ha K_2O but it is statistically like other treatments. However, spike length, grain yield and straw yields of wheat significantly affected by K application rates. The highest spike length was obtained from plots receiving 90 kg/ha K_2O. In agreement with this result, higher K rate treatments had significantly longer spike length as compared to the check treatments (without potassium fertilizer) [22]. Grain and straw yields of wheat increased from 0 to 30 kg /ha K_2O and decreased from 30 to 90 kg/ha K_2O in the study site and the highest grain yield of wheat gained from plots receiving 30 kg/ha K_2O was significantly superior to all other treatments while in straw yield it is superior only to control. In line to this, it increased grain yield of wheat by 29.3%, 27.24% and 30.03% over treatments which received 0, 60 and 90 kg/ha K_2O respectively. On the other hand, the non-significant harvest index in the site might be due to the initial high level of soil exchangeable potassium and the mineralization of medium organic matter in the soil brought K, which is available to wheat plants requirement and increasing K level as fertilizer may be used as luxury consumption and contribute equal effects to grain and biological yield. This result agreed with the research findings that potassium effect on harvest index was not significant indicating approximately equal positive effects of potassium on seed and biological yield [23].

Generally, the significant grain yield obtained in this experiment with K application rate agrees with the research findings [10,22,24,25].

Treatment	Plant height (cm)	Spike length (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index
Control	41.7	4.3^{C}	633.5^{C}	1099.8^{B}	36.7
RBF (100 kg/ha)	52.3	5.2^{BC}	1076.3^{B}	2212.6^{A}	32.7
RBF+30 K_2O kg/ha	53.9	5.9^{BA}	1391.8^{A}	2519.3^{A}	35.5
RBF+60 K_2O kg/ha	54.7	6.0^{BA}	1093.8^{B}	2150.7^{A}	33.8
RBF+90 K_2O kg/ha	54.4	6.3^{A}	1070.4^{B}	2140.7^{A}	33.4
CV	9.88	9.47	13.07	12.87	6.47
P	0.06	0.012	0.002	0.002	0.26

Means followed by the same letter along columns are not significantly different. RBF: Recommended blended fertilizer (NPKSZn), CV: coefficient of variance, P: probability level

Table 2: Effect of potassium fertilizer rates on wheat plant height, spike length, grain yield, straw yield, and harvest index.

Treatment	Values	
K rates (K_2O kg/ha)	ARK (kg/kg)	AUEK (kg/kg)
30	0.52	25.28
60	0.25	7.67
90	0.15	4.85

ARK=Apparent recovery of potassium; AUEK=Agronomic use efficiency of potassium

Table 3: Effect of potassium fertilizer rate on apparent recovery and agronomic use efficiency.

Apparent recovery and agronomic K use efficiency

Potassium application rate influenced apparent potassium recovery and agronomic K use efficiency. Both recovery and agronomic K use efficiency consistently decreased with increasing potassium rates. Hence, the highest apparent K recovery and agronomic efficiency was obtained at 30 kg/ha K_2O.

Conclusions

A field experiment was done to evaluate the response of wheat to different potassium fertilizer rates and to determine the optimum rate of potassium for wheat on shallow soils of Eenderta district. Results from the experiment shown that the application of different potassium fertilizer rates significantly affected the yield of wheat in the study area. So, this falsifies the thought that potassium fertilization is unnecessary for Ethiopian soils and the level of potassium in the blended formula which was initially recommended by EthioSIS does not meet yield requirement of wheat since the yield of wheat has significantly responded from the additional K levels.

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