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Evaluation of Potassium Fertilizer for Better Wheat (*Triticum aestivum* L.) Production at Banja District, Awi Zone of Ethiopia

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Abstract: A field experiment was conducted to evaluatePotassium (K) fertilizer on yield and yield components of wheat at Banja District, Awi zone of Ethiopia.The experiment included three levels of K fertilizer (25, 50 and 75 K_2O kg/ha) along with recommended rates of N (44.6kg N/ha) and P (46 kg P_2O_5/ha) fertilizers. The positive (Recommended NP fertilizer alone) and negative control (without any fertilizer) treatments were also included in the experiment. Treatments were replicated three times in Randomized Complete Block Design. Urea (46-0-0), TSP (0-46-0) and K_2SO_4 (0-0-52) fertilizers were used as sources of N, P and K, respectively. Initial soil physico-chemical properties analysis result revealed that the soil was strongly acidic (pH-H_2O: 4.94) with high content of exchangeable K (0.658 meq $100g^{-1}$). Analysis of variance indicated that application of K fertilizer did not significantly ($p>0.05$) increase wheat grain yield, biomass yield, thousand seed weight, plant height and panicle length as compared to recommended NP fertilizer. Moreover, the parameters neither showed increasing nor decreasing pattern with increased K application. Therefore, the present study doesn't recommend application of K fertilizer for wheat production as study area's soil K status is high. In addition, further evaluation of K fertilizer should be conducted on reclaimed acidic soils with medium to low status of exchangeable K.

Key words: K fertilizer · Wheat · Yield and yield components · NP fertilizer · Exchangeable K

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important food crop cultivated in Ethiopia, ranking fourth after teff, maize and sorghum. However, its productivity in Ethiopia is one of the lowest in the world, the national average grain yield being about 2.54 tons ha^{-1} [1]. Low soil fertility is among the factors which limit wheat production in Ethiopia [2]. The utilization of organic and mineral fertilizer is important to improve soil productivity and crop production. In Ethiopia, farmers use only N and P fertilizers to improve crop productivity. Currently, 100 kg DAP (21 kg P and 18 kg N) and 100 kg urea (46 kg N) ha^{-1} are being used for wheat and other cereal crops in Northern Highlands of Ethiopia [3]. However, yield gains from NP fertilizer are decreasing with time despite year by year steady increase in per capita fertilizer consumption.

Depletion of potassium (K) nutrient from the soil is one of the most likely reasons for this to happen. Potassium is the third most important essential element next to N and P that limit plant productivity. It plays a significant role in physiological processes, such as cell division, photosynthesis, nitrate reduction, protein synthesis, enzyme activity [4], transportation of water and nutrients, nitrogen utilization and stimulation of early growth and in insect and disease resistance [5]. However, the use of K fertilizer was not exercised due to a long established understanding of Ethiopian soils are rich in K and ranged from 0.53 to 5.79 meq $100g^{-1}$ [6]. However, some reports indicated that crop lands lack potassium nutrient. For example, Mesfin [7] reported low presence of exchangeable K under acidic soils, while Alemayehu [8], Abiye *et al*. [9] and Wassie and Shiferaw [10] reported the deficiency of K in some Ethiopian soils. In addition, emerging research evidences based on the responses of potato and wheat proved that it is indeed becoming a limiting nutrient in some soils of Ethiopia [11]. However, no scientific information is available on the response of wheat to K fertilizer for the study area. Therefore, this study was conducted to evaluate K fertilizer effects on yield and yield components of wheat.

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MATERIALS AND METHODS

Experimental Site Description: The study was conducted under rain fed conditions at Banja District located in Awi Zone of Amhara Regional State of Northwestern Ethiopia. The area is located at the distance of about 415 kilometers from Addis Ababa in the Northwestern direction. The climatic condition of the area is highland with wet and cool weather and an altitude of 2501 meter above sea level. The mean annual rain fall of the District is 1300mm.

Experimental Design and Procedure: A field experiment was laid out in Randomized Complete Block Design with three replications. The unit plot sizes were 5m*5m. Three levels of K fertilizer (25, 50 and 75 K_2O kg ha^{-1}) along with recommended rates of N (44.6kg N ha^{-1}) and P (46 kg P_2O_5 ha^{-1}) fertilizers as well as the positive (Recommended NP fertilizer alone) and negative control (without any fertilizer) were the test treatments of the experiment. N was applied in split, at the time of planting and three weeks after planting by side dressing along the row. All doses of P and K were applied at planting time following in row application method. Urea (46-0-0), TSP (0-46-0) and K_2SO_4 (0-0-52) fertilizers were used as sources of N, P and K.

Wheat (*Triticum aestivum* L.) variety *Denda* was used as a test crop and sown manually at a seed rate of 150 kg ha^{-1} using manual row maker with a spacing of 20 cm between rows. Conventional tillage (farmers practice) for land preparation and manual weeding were carried out equally for all treatments. Major agronomic parameters, yield and yield components of the test crop were collected. The data on crop parameters except grain and total biomass yield were measured from ten randomly selected plants of the sampling area of each treatment. Grain and biomass yields were measured from the total harvestable area of each treatment. Grain yield per hectare was then calculated on l2% moisture content.

Soil Sampling, Preparation and Laboratory Analysis: Soil samples before planting with block basis and after harvest with treatment basis were collected from the depth of 0 to 30cm. The soil samples collected were air dried, crushed and passed through a 2 mm sieve for the analysis of selected soil physical and chemical properties following standard procedure. The soil analysis was carried out at the Soil Laboratory of Pawe Agricultural Research Center.

Soil particle size distribution was analyzed by the hydrometer method [12]. Soil textural class names were determined using textural triangle of USDA system [13]. pH at 1:2.5 (soil: water and soil to KCl) solid to solution ratio was measured using digital pH meter [14]. Exchangeable acidity and aluminium were determined by leaching the soils by neutral 1N potassium chloride (KCl) solution [14]. Organic carbon (OC) was determined by using Walklay and Black [15] wet digestion method. Then, Organic matter (OM) was estimated by multiplying the soil organic carbon by a factor of 1.724 following the assumptions that OM is composed of 58% OC. Total N was analyzed using the Kjeldhal method as described by Blake [16]. Extractable P was determined using the standard Bray-II [17] and Olsen [18] extraction methods. Exchangeable K and Na were determined after extracting the soil samples by 1M ammonium acetate at pH 7.0. Exchangeable K and Na in the extract were measured by using flame photometer as described by Rowell [13]. The CEC was determined from the same soil that was leached with ammonium acetate through distillation and titration of ammonia, after washing down of excess ammonium acetate by ethyl alcohol as described by Sahlemedhin and Taye [19].

Statistical Analysis: The effect of K fertilizer on wheat yield and after harvest soil chemical properties were evaluated by analyses of variance (ANOVA), using the statistical analysis system (SAS 9.1) software. Fisher's least significant difference (LSD) at 0.05 was used for mean separation. The mean soil analytical results of the trial site was interpreted as very low, low, medium, high and very high using standard ratings.

RESULTS AND DISCUSSION

Initial Soil Physico-Chemical Properties of the Experimental Site: Some selected initial soil physico-chemical properties of the trial site are presented below in Table 1. The textural class of the experimental site soil is categorized as clay, with clay accounting 47.5% of the soil texture. The pH-H_2O was below 5.3 and it is under the range of strongly acidic condition [20]. The values of soil OM (5.231%) and total N (0.26 %) were under the range of very high based on criteria developed by Tekalign [20]. Available Bray II P (34.7ppm) and Olsen P (27.3 mg kg^{-1}) contents falls under range of high [21]. The CEC (29.3 meq $100g^{-1}$) considered to be high [21] whil exchangeable K (0.658 meq $100g^{-1}$) also falls under the range of high [22]. The soil of the studied site was low in Na content as per the rating suggested by FAO [22].

Table 1: Initial soil physico-chemical properties of the experimental site.

Soil properties	Values
Clay (%)	47.5
Silt (%)	35.0
Sand (%)	17.5
Textural class	Clay
pH- H_2O (1:2.5)	4.94
pH-KCl (1:2.5)	3.84
Exchangeable Acidity (meq $100g^{-1}$)	1.81
Exchangeable Al (meq $100g^{-1}$)	1.65
Available Bray-II P (mg kg^{-1})	34.71
Olsen available P (mg kg^{-1})	27.3
Total N (%)	0.26
Organic Matter (OM) (%)	5.231
Cation exchange capacity (CEC) (meq $100g^{-1}$)	29.32
Exchangeable K (meq $100g^{-1}$)	0.658
Exchangeable Na (meq $100g^{-1}$)	0.166

Table 2: Effect of K fertilizer on grain and biomass yield of wheat

Treatments	Grain Yield (kg ha^{-1})	Biomass Yield (kg ha^{-1})
Control/No fertilizer	671^{b}	2033^{b}
Rec-NP	1184^{a}	3782.5^{a}
Rec-NP + 25 kg/ha K_2O	1204.5^{a}	3902^{a}
Rec-NP + 50 kg/ha K_2O	1032.5^{a}	3489^{a}
Rec-NP + 75 kg/ha K_2O	1189^{a}	4272^{a}
CV (%)	10.41	8.54
LSD (0.05)	77.7	211.1

Means followed by the same letter along columns are not significantly different. Rec-NP: Recommended N and P fertilizer, CV: coefficient of variance, LSD: Least Significant Difference

Table 3: Effect of K fertilizer on thousand seed weight, plant height and panicle length

Treatments	1000 Seed weight (gm)	Plant Height (cm)	Panicle Length (cm)
Control/No fertilizer	719^{b}	68	6.4^{b}
Rec-NP	1470^{ab}	75.5	7.4^{ab}
Rec-NP + 25 kg/ha K_2O	1210.5^{ab}	76.5	7.8^{ab}
Rec-NP + 50 kg/ha K_2O	1378.5^{ab}	70	7.9^{ab}
Rec-NP + 75 kg/ha K_2O	1717.5^{a}	76	8.2^{a}
CV (%)	22.69	9.15	20.31
LSD (0.05)	208.46	NS	1.08

Means followed by the same letter along columns are not significantly different. Rec-NP: Recommended N and P fertilizer, CV: coefficient of variance, LSD: Least Significant Difference

Table 4: Effect of K fertilizer on Selected Soil chemical properties

	Treatments					
Soil chemical properties	Control /No fertilizer	Rec-NP	Rec-NP + 25 kg ha^{-1} K_2O	Rec-NP + 50 kg ha^{-1} K_2O	Rec-NP + 75 kg ha^{-1} K_2O	LSD (0.05)
pH- H_2O (1:2.5)	5.03	5.04	5.02	5.08	5.01	NS
pH-KCl (1:2.5)	3.86	3.86	3.84	3.88	3.83	NS
Available P (ppm)	21.29	21.83	20.66	17.31	17.23	NS
Ex. Acidity (meq $100g^{-1}$)	1.952	1.952	2.193	2.112	2.193	NS
Ex. Al (meq $100g^{-1}$)	1.614	1.775	1.936	1.695	1.855	NS
CEC (meq $100g^{-1}$)	30.32	31.12	31.12	33.53	33.13	NS
Ex. K (meq $100g^{-1}$)	0.654	0.580	0.714	0.729	0.640	NS
Ex.Na (meq $100g^{-1}$)	0.152	0.178	0.152	0.203	0.254	NS

Rec-NP: Recommended N and P fertilizer, LSD: Least Significant Difference, Ex: Exchangeable, NS: Non-significant

Response of K fertilizer on Yield and Yield Components of Wheat: The analysis of variance presented in Tables 2 and 3 indicated that application of K fertilizer did not significantly ($p>0.05$) increase wheat grain yield, biomass yield, thousand seed weight, plant height and panicle length as compared to recommended NP fertilizer. The result might be due to high status of exchangeable K (0.658 meq $100g^{-1}$)and alsoit was above the threshold level (0.38 meq $100g^{-1}$) for most crops for K fertilizer requirement [23]. In line with this experiment, Abay and Sheleme [24] indicated that application of K fertilizer did not significantly increased potato production at Angacha Research Station area that had exchangeable K (0.45 meq $100g^{-1}$) content above the threshold level. Junfang Niu *et al*. [25] also reported that K fertilization had no significant effect on wheat yield improvement.

On the other hand, Hagos and Kassa [26] reported that yield and yield components of wheat was significantly responded from the application of K fertilizerconducted on Cambisols of Tigray, Northern Ethiopia that had medium status of exchangeable K (0.29 meq $100g^{-1}$) or below the threshold level (0.38 meq $100g^{-1}$) for most crops for K fertilizer requirement [23]. In general, the yields recorded from all treatments were far below an average wheat grain yield of Ethiopia (2540 kg ha^{-1}) [1], indicating that the soil acidity might have limited the performance of the crop. Therefore, the experiment should be repeated on reclaimed acidic soil with medium to low status of exchangeable K.

Influence of K Fertilizer on Selected Soil Chemical Properties: Application of K fertilizer did not significantly influenced selected soil chemical properties (Table 4). Considering exchangeable K, the concentration showed an increasing pattern with the increasing rate of K application indicating that application of K fertilizer increased the soil K status. Whereas the status of soil exchangeable K recorded under the treatment received only NP fertilizer decreased from 0.65 to 0.58 meq $100g^{-1}$. This decrement could be due to an efficient use of K by wheat from the applied NP fertilizer. However, the concentration of exchangeable K remained under the treatment received only NP fertilizer is well above the threshold level (0.38 meq $100g^{-1}$) for most crops for K fertilizer requirement [23]. This result revealed that evaluation of K fertilizer will be better after knowing whether the status of K nutrient in the soil is deficient or below the threshold level for most crops for K fertilizer requirement.

CONCLUSIONS

For better wheat production considering the major production constraints especially the soil fertility aspect is crucial. This study evaluates K fertilizer for better wheat production and the results revealed that application of K fertilizer did not significantly increase wheat yield advantage over recommended NP fertilizer. Therefore, the present study doesn't recommend application of K fertilizer for wheat production as study area's current soil K (0.658 meq $100g^{-1}$) status is high and evaluation of K fertilizer will be better after knowing whether the status of K nutrient in the soil is deficient or below the threshold level for most crops for K fertilizer requirement. The results also demonstrated the yields recorded from all treatments were far below the national average grain yield of wheat (2540 kg ha^{-1}), indicating that the soil's strongly acidic (pH-H_2O: 4.94) condition might have limited the performance of the crop. Therefore, further evaluation of K fertilizer should be conducted on reclaimed acidic soil and soils with medium to low status of exchangeable K.

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