Response of Maize, Malt Barley and Tomato to Potassium

Tadele Amare, Tesfaye Feyisa and Yihenew G.Selasie

ABSTRACT

This paper presents about the status of soil potassium and the response of tomato, maize, and malt barley for the applied potassium. Three potassium rates (0 kg K_2O/ha, 50 kg K_2O/ha and 100 kg K_2O/ha) were compared for all testing crops for all locations with uniform recommended nitrogen and phosphorus. Under all locations and testing crops there was a good response for the applied potassium though insignificant statistically. The minimum cumulative tomato yield (26913 and 20773 kg/ha for first and second year respectively) was recorded from control (0 K_2O/ha) while the maximum (29333 and 23580 kg/ha for first and second year respectively) was recorded from maximum potassium rate (100 kg K_2O/ha). Minimum (4687 kg/ha) and maximum (4905 kg/ha) maize yield at Dangla (second year) were obtained from control and 100 kg K_2O/ha treatments respectively. At Mota the minimum (2950.8 kg/ha) and maximum (3929.4 kg/ha) yield of maize in the first year were recorded from control and 100 kg K_2O/ha respectively. At Lay Gaint the highest malt barley yield (3127.3 kg/ha) was obtained from the highest level of potassium while the lowest (2742.7 kg/ha) from control for first year and similar trend of response was observed for the second year too. As yield increased to addition of potassium fertilizer brought insignificant result over control, application of potassium fertilizer is not, worthy but needs regular follow-ups.

INTRODUCTION

The productivity of the land is the function of ray of factors which can be grouped in to two main categories: uncontrollable (sun shine, rainfall etc) and controllable soil fertility etc). Ethiopian agriculture depends on the rainfall conditions and the fertility status of the soil. A slight variation in amount and distribution of rainfall has a very high and significant influence on the agricultural sector. Effective utilization of the rain water resource with various soil fertility management options is one of the strategies to enhance the productivity of the land resources (soil). The rate of chemical fertilizers added per unit area is very small to build the fertility of soil and boost production sustainable, because of various reasons including economy. There is a negative input-output balances of nutrients under Ethiopian farming resulted from low chemical fertilizer use, lose of nutrients by erosion, leaching, gaseous lose and mining (Smaling, 1993) and Smaling et al, (1993) leading to a non sustainable and subsistence agriculture.

Detailed studies for the potential supplies of nitrogen and phosphorus across different soils and different agro-ecology was assessed. Crops' response ranged from medium (pulse crops) to very high (cereal crops) for nitrogen and phosphorus and blanket fertilizer recommendation exists. Awareness about the relevance of nitrogen and phosphorus nutrients is very high everywhere across the country and demand is steadily increased every year. However information is scarce about other plant nutrients including potassium in the country.

Potassium is the 3rd major nutrient next to nitrogen and phosphorus needed by plants to accomplish biological process. It is important for the synthesis and translocation of carbohydrates, encouraging cell wall thickness and stalks strength, influence uptake of other nutrients, respiration, transpiration etc. Fertilizer containing potassium nutrient is a less priority in East Africa in general and Ethiopia in particular as soils parent materials of East Africa are assumed to be rich with clay minerals such as feldspars and micas that have high potassium. Upon weathering these minerals give free potassium ion (K^+) available to plants. However, Smaling (1993) clustered Ethiopia to countries where high rate of potassium depletion (40 kg k_2O/ha/year) occurs. According to Smaling et al (1993), the input-output balance of potassium is negative under Ethiopian farming system. According to Sahlemedihin Sertsu and Pedro A. Sanchez (1978), the level of k was not reach to critical level of 0.2 meq K/100 ml even by burning of the vertisols of Sheno. According to the reports of Atlas of common beans production in Africa (www.ciat.cgia.africa/pdf/atlas_bean_africa), potassium is less important at Awasa, hararge highlands and rift valley.

Abayneh, Demeke and Ashenafi (2006) reported low relative proportions of K^+ for the soil of Adet, Finote Selam and Dibretabor research stations. Regional studies for demands of potassium by faba bean showed no response while Yihenew et al (2007) reported that potato responded at Injibara, where the exchangeable K is below 0.3 centi-mol/kg of soil, while other sites did not show any significant response. Intensive research work on major nutrients (N, P, K) and other macro and micro nutrients under different agro-ecologies is still untouched. Thus this research was initiated for the objective designed below. The objectives of this study is to investigate whether potassium is a yield limiting nutrient or not for the production of maize, malt barley and tomato.

MATERIALS AND METHODS

Three testing crops (tomato, malt barley and maize) were used. Tomato was studied under irrigation system. A processing type of tomato (var. Melkasa) was used. Seedlings were raised at the nursery and transplanted to the farm. , when reached at physiological stage. Three potassium levels (0 kg K_2O/ha, 50 kg K_2O/ha and 100 kg K_2O/ha) with uniform 105 Kg N/ha and 92 kg P_2O_5 were used. All phosphorus and potassium were applied at planting, while half rates of nitrogen at planting and the other half at flower initiation stage. All yields from a plot were collected whenever it reached to maturity (every week on average). Yields at each harvesting date was compared and analysed independently to see change of response overtime. Cumulative yield is used for each harvesting date except for the first harvesting with the formula $Y_{2T} = Y_1 + Y_{2t}$, $Y_{3T} = Y_{2T} + Y_{3t}$, $Y_{4T} = Y_{3T} + Y_{4t}$

etc… Where Y_{2T} is the total yield at second harvest, Y_1 total yield at first harvest, Y_{2t} amount yield collected from the field at second harvest etc.

Malt barley was studied during the rainy season at three locations (Lay gaint, Erob Gebeya/Gozamin and Injibara) and three sites per location using variety Beka. Three potassium levels (0 kg K_2O/ha, 50 kg K_2O/ha and 100 kg K_2O/ha) with uniform 60 kg N/ha and 60 kg P_2O_5/ha were evaluatedin the study. All phosphorus and potassium were also applied at planting, while half nitrogen at planting and the other half nitrogen at tillering. All crop managements were done accordingly to the procedure.

Maize was also studied during the rainy season at two locations (Dangla and Mota) and at three sites for each location with variety BH 540. Three potassium levels (0 kg K_2O/ha, 50 kg K_2O/ha and 100 kg K_2O/ha) with uniform of 60 kg N/ha and 60 kg P_2O_5 /ha at Dangla and 120 kg N /ha and 46 kg P_2O_5/ha at Mota were used for comparison. All phosphorus and potassium were applied at planting while half nitrogen at planting and half nitrogen at knee height. All crop management practices were done accordingly.

Soil sampling and analysis

Soil samples were taken at a depth of 0 - 40 cm with augur and analysed for the following parameters with specific procedures.The pH of the soil with soil water ratio of 1:2.5 (in volumetric base), organic matter with wet digestion (walkley) procedure and available P-with Olsen procedure were determined. By percolating one mole of NH_4-acetate, exchangeable potassium was analysed and it was computed by the formula

$$K_{exchangeable} = 1.279(a-b)/m \times (100+W)/100,$$

Where, K exchangeable is exchangeable potassium in c mole/kg of soil,

a = concentration of K in the percolates mg/l,

b = concentration of K in the blanks mg/l,

m = mass of air dried soil sample in gm and

w = the water content in percentage.

All biological data was summarised and subjected to statistical analysis with SAS program.

RESULTS AND DISCUSSION

Soil analysis

The pH of the soil was range from 4 - 6 which is acidic in general classification. The result laid within the range of most agricultural soils of the north western Amhara and in accordance to other reports. Exchangeable potassium was ranged from 0.29-0.43 cent-mole /kg of soil. It was not in the range of higher category (3 cent-moles/kg). This low level of exchangeable potassium might be resulted due to erosion, leaching, mining and crop residue removal from the field. The organic matter content was below 2% which lies in a range of low category. The available Phosphorus (P-Olsen) was also in the range of lower class (2-4 mg/kg of soil).

The result of soil analysis indicated that there is an urgent need of integrated soil management intervention to improve the quality of the soil and enhance productivity of the soil for longer time.

Biological yield responses

Effect of potassium on tomato fruit weight

The yield of tomato was increased uniformly starting from 5th harvest as shown on Table 1

Table 3. Tomato yield (kg /ha) for combined years

Harvesting dates	Treatments Control	50 kg K_2O/ha	100 kg K_2O/ha	LSD $_{0.05\%}$	c.v. %
End of harvesting	24233	24980	26460	NS	23.4

The combined year result (Table 3) showed similar trends to the 1st and 2nd year.

Effect of potassium on number of fruits

For both year 1 and year 2 the effect of potassium on tomato fruit number production was not inconsistence as shown on Table 4, Table 5 and Table 6.

Table 4. Number of tomato fruits /plot (15 m^{2}) at different harvesting dates (Year 1)

Harvesting dates	Treatments Control	50 kg K_2O/ha	100 kg K_2O/ha	LSD $_{0.05\%}$	c.v. %
1st	115	106	81	NS	-
2nd	318	299	271	NS	-
3rd	512	455	414	NS	-
4th	885	782	753	NS	-
5th	1400	1194	1224	NS	-
6th	1769	1729	1895	NS	-
7th	2116	1943	2017	NS	26.3

From Table 1, 2 and 3, the effect of potassium especially for the last harvests were increased proportionally to the rate of potassium applied. However the effect on the number of fruits was not inline with weights, implying potassium did not play a role to increase the number of fruits. There were conditions that lower number of fruits from high rates of potassium. Indicating individual fruits gave higher weights and contribute for the higher total yields as the rate of potassium increased.

Table 5. Number of tomato fruits /plot (15 m^{2}) at different harvesting dates (Year 2)

Harvesting dates	Treatments Control	50 kg K_2O/ha	100 kg K_2O/ha	LSD $_{0.05\%}$	c.v. %
1st	70	60	168	NS	-
2nd	507	405	552	NS	-
3rd	868	711	863	NS	-
4th	1115	913	1096	NS	-
5th	1260	1039	1227	NS	-
6th	1425	1202	1371	NS	-
7th	1668	1416	1551	NS	-
8th	1851	1574	1709	NS	-
9th	2053	1712	1848	NS	-
10th	2317	1927	2021	NS	-
11th	2607	2180	2204	NS	-
12th	2682	2254	2285	NS	27.5

Table 6. Number of tomato fruits /plot (15 m^2) for the combined year

Harvesting dates	Treatments Control	50 kg K_2O/ha	100 kg K_2O/ha	LSD $_{0.05\%}$	c.v. %
End of harvesting	2399	2099	2151	NS	22.5

In general, application of potassium increased the yield (weight), which is not significant but does not have an effect on the number of fruits.

Maize

For both locations (Dangla and Mota) and seasons, there was an increase in grain and biomass yield for increased potassium rates. At Dangla the highest (19716.7 kg/ha) and the lowest (18202 kg/ ha) biomass was from 100kg k_2O/ha and control treatment respectively for the year 1. The second year data also showed similar response to applied potassium (Table 7).

Table 7. Effect of potassium on maize yields at Dangla

	Year 1			Year 2		
Treatments	Height (cm)	Grain (Kg/ha)	Biomass (Kg/ha)	Height (cm)	Grain (Kg/ha)	Biomass (Kg/ha)
Control	220.6	4473.2	18202.6	163.5	4687	9101.9
50 kg K_2O/ha	230.3	4121.3	18395	165.2	4729	9343.9
100 kg K_2O/ha	224.1	4403.3	19716.7	162.2	4905	9615.1
LSD 0.05%	NS	NS	NS	NS	NS	NS
c.v. %	6.4	14.9	16.5	6.7	17.4	17.3

The highest (4905 kg/ha) and the lowest (4687 kg/ha) grain yields were recorded from 100kg K_2O/ha and control treatment respectively in year 2 (Table 7)

Table 8. Effect of potassium on maize yields at Mota

Treatments	Year 1			Year 2		
	Height (cm)	Grain (Kg/ha)	Biomass (Kg/ha)	Height (cm)	Grain (Kg/ha)	Biomass (Kg/ha)
Control	242.0	2950.8	18976.0	159.7	2530.42	9949.2
50 kg K_2O/ha	249.0	3428.0	21648.5	157.2	2467.07	10246.9
100 kg K_2O/ha	241.6	3929.4	22692.4	154.3	2614.55	10188.8
LSD $_{0.05\%}$	NS	NS	NS	NS	NS	NS
c.v. %	4.5	35.7	17.4	5.6	20.5	11.4

At Mota the maximum grain yield was obtained in both years from treatments with higher rates of potassium fertilizer, while the minimum was obtained from control (Table 8). Similar trends response was recorded for biomass production. In general, yield of maize at both locations responded insignificantly to the applied potassium rates.

Malt Barley

The effect of potassium on the yield and other agronomic parameters of malt barley were found insignificantly increased. At Injibara (Table 9) grain yield was increased from 1539.2 kg/ha to 2275.6 kg/ha for year 1 from without potassium and highest rate of potassium (100 kg/ha), respectively. However, while at Gozamin yield response to potassium was inconsistent (Table 10). In Lay Gaint malt barley responded to applied potassium insignificantly to for most parameters (Table 11).

Table 9: Effect of potassium on yield and yield components of malt barley at Injibara

Year	Treatments	Height (cm)	Spike numbers /m2	Grain Kg/ha	No. tillers /m2	Spike length (cm)
I	Control	88.2	618.0	1539.2	319	7.9
	50 kg K_2O/ha	92.5	638.0	2142.6	306	7.9
	100 kg K_2O/ha	90.3	808.0	2275.6	431	7.8
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	5.9	15.8	23.9	22.8	7.0
II	Control	93.55	319.2	1323.2	323.22	7.8
	50 kg K_2O/ha	97.6	297.1	1360.7	325.22	7.9
	100 kg K_2O/ha	98.2	319.2	1536.2	346.33	7.8
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	9.1	37	7.1	34.7	16.2

Table 10: Effect of potassium on malt barley at Erob Gebeya (Gozamin)

Year	Treatments	Height (cm)	Fertile spike /m2	Grain Kg/ha	No. tillers /m2	Spike length (cm)
I	Control	87.0	524	1441.8	280	6.82
	50 kg K_2O/ha	91.0	600	1998.7	321	7.12
	100 kg K_2O/ha	93.7	661	1661.0	326	6.98
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	5.4	12.2	26.3	12.8	3.7
II	Control	69.	217.3	740.8	310.33	7.1
	50 kg K_2O/ha	67.0	297.3	606.4	423.	7.0
	100 kg K_2O/ha	67.8	263.0	646.7	367.3	6.8
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	9.7	17.8	39.7	32.5	14.2

Yield was increased from 2742.7 to 3127.3 kg/ha respectively, for the application of 0 kg K_2O/ha (control) and 100 kg K_2O/ha for year 1. For year 2, the highest (1495.1 kg/ha) and the lowest (1867.5 kg/ha) malt barley yields were recorded from application of 0 kg K_2O/ha (control) and 100 kg K_2O /ha respectively. In general biological yields of malt barley were slightly increased with the application of different rates of potassium. However, the increase with potassium application was insignificant.

Table 11. Effect of potassium on malt barley at Lay Gaint

Year	Treatments	Height (cm)	Fertile spike /m2	Grain Kg/ha	No. tillers /m2	Spike length (cm)
I	Control	123.0	572	2742.7	471	8.8
	50 kg K_2O/ha	123.7	601	2884.2	491	8.8
	100 kg K_2O/ha	122.6	611	3127.3	512	8.3
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	5.2	17.2	13.9	18.9	6.4
II	Control	97.5	220.3	1495.1	225	6.4
	50 kg K_2O/ha	99.3	194.0	1753.9	201	7.7
	100 kg K_2O/ha	103.7	243.3	1867.5	246.	7.2
	LSD $_{0.05\%}$	NS	NS	NS	NS	NS
	c.v. %	7.1	14.3	28.4	13.5	5.3

CONCLUSION

Soil status of exchangeable potassium was not as high as expected. For all testing crops (tomato, maize and malt barley) yields were yield is increased by increasing the potassium rates. However, for all crops under all locations, the yield increase was statistically insignificant to incorporate potassium as a package for the test crops.

RECOMMENDATION

For all testing crops at all locations, there was insignificant yield advantage by potassium application. However, there was a positive response by potassium application and the level of exchangeable potassium for all the study sites is not in a range of high level indicating future strategies must be designed for the management of potassium and enhance yield production sustainable. According to the current data potassium is not a yield limiting nutrient for tomato, maize and barley for the sites addressed by the study. Hence there is no need to add potassium fertilizer at these sites. But the response and change of soil potassium must be regularly monitored.

ACKNOWLEDGEMENTS

We thank ato Muhamed Abdela for his active involvement throughout the life of the research. We thank also ato Anteneh Abawa his support tomato data encoding. We are indebted to Ato Tamiru Dagnachew, Ato Dereje Abebe, and Ato Zewdu Adisu for their valuable contributions for the accomplishment of this research. The last but not the least we appreciate researchers and technical assistants at Debre Tabor and Finote Selam sub- centre for their active collaboration to the research.

REFERENCES

Abayneh Esayas, Demeke Tafesse and Ashenafi Ali. 2006. Soils of Adet Agriculture Research Centre and Its Testing Sites. Ethiopian Agricultural Research Organization, National Soil Research Centre, Soil Survey and Land Evaluation Section, Addis Ababa, Ethiopia.

Atlas of common beans in Africa (WWW.CIAT.CGIA.africa/pdf/atlas_bean_africa)

Sahlemedhin Sertsu and Pedro A. Sanchez. 1978. Effects of heating on some changes in Soil properties in relation to an Ethiopian land management practice. Soil Sci. Soc.Am. J. 42:940-944.

Smaling, E.M.A .1993. Soil nutrient depletion in Subsaha Africa: In ed. H.van Reuler, W.H. Prins (1993), The Roles of Plant Nutrients for Sustainable Food Crop Production in Sub-Saharan Africa.

Smaling EMA, Stoorvogel JJ and Windmeijer PN.1993. Calculating soil balance in Africa at different scales: II District scales. In Fertilizer research, 35(1993), pp.237-250

Yihenw G.Selassie, Tesfaye Feyisa and Tadele Amare. 2007. Soil K Status and K Requirement of Potato Growing On Different Soils of Western Amhara.