Evaluation of polyhalite (POLY4) as a multi-nutrient fertilizer for corn grain yield under Southern Highlands conditions of Tanzania

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Abstract

Recent exploration of new multi-nutrient potassium fertilizers such as polyhalite (POLY4®) and its lack of understanding on corn grain yield performance motivated establishing six corn (*Zea mays* L.) trials in Southern Highland region of Tanzania under rain-fed conditions in 2015. The objective was to elucidate whether 20 kg of K_2O from two different sources beyond the recommended practise of 120-60-0 kg ha^{-1} (N, P_2O_5 and K_2O), helps in increasing corn grain yields. Measured treatments were: 1) Control in which no fertilizer was applied; 2) Recommended practise (NP treatment, 120-60-0); 3) Muriate of Potash (MOP, 20 kg K_2O ha^{-1}); 4) POLY4 (20 kg K_2O ha^{-1}); and 5) MOP+Kieserite (20 kg K_2O ha^{-1}). Kieserite was applied to the last treatment to balance the 27 kg S ha^{-1} as provided by the POLY4 treatment. Measured variables were grain yield, cob weight, stover weight, number of cobs and vigour. Treatments of interest were compared by using single degree freedom linear contrasts. As expected all treatments significantly outperformed control at five out of six locations. Recommended practise, POLY4 and MOP+Kieserite recorded significantly higher grain yields than MOP at one, two and two out of six locations, respectively. The same treatments numerically, recorded higher grain yields at four, five and five locations out of six. On average across the six locations; recommended practise, POLY4 and MOP+Kieserite recorded a higher grain yield of 357, 621 and 662 kg ha $^{-1}$ than MOP alone, respectively. These results indicate the importance of both potassium and sulphur nutrition and POLY4 could be used as an option as a source these nutrients under Southern Highland regions of Tanzania.

Introduction

A search for alternate potassium sources led to the exploration of polyhalite ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) in North Yorkshire in the United Kingdom (POLY4®) and New Mexico in the USA . This could ultimately lead to decreased reliance on MOP as a potassium source. Cost could be an advantage for POLY4, owing to its lower processing losses than for MOP. Hence there is a need for more evidence to agronomic performance of POLY4 and its understanding is essential for African region due to the cost of resources and under applied nutrient conditions.

The majority of the soils from Tanzania humid and sub-humid regions were categorised as severely weathered, acidic, infertile and had limited but variable nutrient releasing capacities to sustain low-input agriculture. The Southern Highlands of Tanzania (Figure 1) is an agriculturally important area growing a range of crops such corn, beans, wheat, potatoes and vegetables. Current fertilizer recommendations to offset nutrients deficiencies in most parts of Southern Highlands for corn are 80-120 kg N ha^{-1} in two splits; and 23-68 kg P_2O_5 ha^{-1} as basal application. However, critical nutrient deficiencies of N, P, K, S and Ca have increased in the Southern Highlands, such that fertilizers with S and Ca nutrients are increasingly important in ensuring balanced nutrition of crops to attain high yield and quality of the produce.

Objectives

The specific objectives of the current study is to evaluate POLY4 as a multi-nutrient fertilizer for corn in Southern Highland conditions of Tanzania and quantify the probability of yield response by changing the source from MOP to POLY4.

Methods

Six corn trials were established in 2014-15 in the Southern Highlands of Tanzania. Locations were selected in such a way that it represents major corn growing belt of Southern Highlands conditions (Figure 1). Composite soil samples from a depth of 0-25 cm were taken from the experimental sites with the results listed in Table 1.

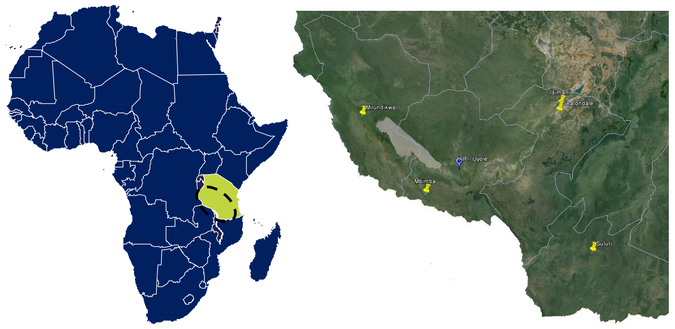

Figure 1 – Study location; Southern Highlands of Tanzania. ARI Uyole is the main research station

Table 1 – Summary of soil analysis at each site

Variable/Trial name	Ismani	Uyole	Mbimba	Suluti	Seatondale	Milundikwa
pH (H_2O)	5.6	5.6	5.2	5.3	5.5	5.5
SOM (g kg^{-1})	8.4	20	18.4	6.2	6.1	25.5
N (g kg^{-1})	2.4	1.7	2.2	2.1	1.8	2.5
P (mg kg^{-1})	4.2	2.1	5.2	10.1	13.3	5.2
CEC (cmol(+)/kg)	14.9	17.7	15.8	12.1	4.9	16.3
K (mg kg^{-1})	234	917	246	230	117	445
Ca (mg kg^{-1})	774	1240	394	270	356	944
Mg (mg kg^{-1})	403	149	149	210	192	257
S (mg kg^{-1})	36.3	13.0	15.7	12.0	20.2	9.2
Texture	Sandy clay	Sandy clay loam	Clay	Sandy clay	Sandy loam	Sandy clay

All experiments were sown in the month of November with the onset of rains. Land preparation involved a deep cultivation followed by disking. Manual weeding was done in each experiment twice, at 20 and 40 days after sowing (DAS) . Irrigation followed the standard practices.

Treatments

Table 2 – Nutrients applied by fertilizer at each site

Variable/Nutrient	N	P_2O_5	K_2O	CaO	MgO	S
Control	0	0	0	0	0	0
NP	120	68	20	0	0	0
MOP	120	68	20	0	0	0
POLY4	120	68	20	24	9	27
MOP + Kieserite	120	68	20	0	34	27

Treatments were same at all sites except at Ismani, where N and P_2O_5 were applied at the rate of 80 and 46 kg ha^{-1} respectively. Nitrogen was applied twice; at pre-planting and 40 DAS or V6 growth stage. Entire phosphorus and potassium fertilizers were applied at 7 days before planting.

Experiment design

Experimental design at each site is a randomised complete block design with four replications. Each experimental plot was 6 m x 5 m. Spacing between rows was 75 cm and between plants is 30 cm. Genotype UH 615 was sown at 125 kg ha^{-1}

Statistical analysis

Statistical analysis was carried out using GenStat software version 17 (VSN International, 2011) using ANOVA. Due to interest in the comparison of specific treatments, data was analysed at each location using single degree freedom orthogonal contrasts whenever the p value is less than 0.1.

Results

Grain yield

- Ismani did not respond to fertilizer application thus is excluded from analysis
- Data analysis by location indicated significantly lower yields for MOP when compared with NP, POLY4 and MOP + Kieserite at 1, 2 and 2 instances out of 5 responding sites. MOP recorded lower yields than NP, POLY4 and MOP + Kieserite numerically at 4, 5, and 4 out of 5 locations respectively (Figure 2).
- No significant differences between NP and POLY4 or NP and MOP + Kieserite were observed at all locations. However, POLY4 recorded numerically higher yield than NP at 4 out of 5 responding locations and the average difference across the locations was 218 kg ha^{-1} (Figure 2).
- In comparison, MOP + Kieserite recorded numerically higher yield than NP treatment at 3 out of 5 responding locations and the average difference across the locations was 53 kg ha^{-1} (Figure 2).

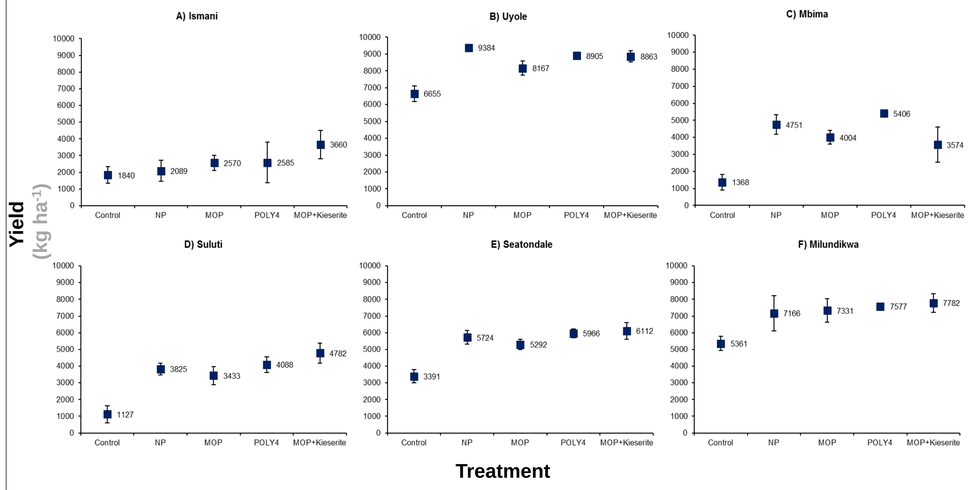

Figure 2 - Effect of treatments on corn grain yield(kg ha^{-1}) at six different locations in Southern Highlands of Tanzania. Error bars indicate the standard error of mean.

Vigour

- Crop vigour was measured at 5 locations (Figure 3). Similar to yield, significant differences among treatments was observed at all these 5 locations ($p<0.085$).
- As expected, control was less vigorous than other treatments.
- In summary, no significant differences among NP, MOP, POLY4 and MOP + Kieserite were observed.
- POLY4 recorded numerically higher vigour than NP, MOP and MOP + Kieserite at 4, 3 and 1 locations out of 5 respectively.

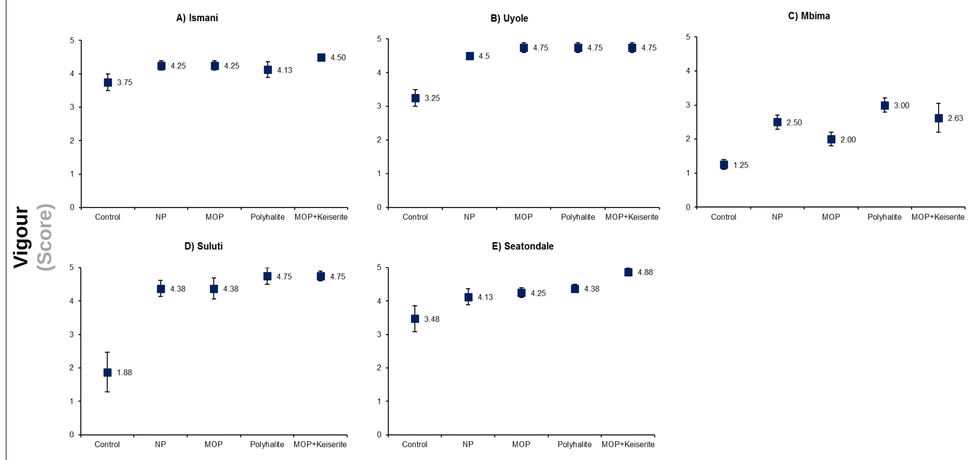

Figure 3 - Effect of treatments on corn vigour at five different locations in Southern Highlands of Tanzania. Error bars indicate the standard error of mean.

Conclusions

- **MOP application on its own has not increased corn grain yield at any of the tested six locations but significantly depressed yield at one instance. MOP recorded numerically lower yields than NP treatment at 4 out of 6 instances**
- **POLY4 significantly increased yield at one of five responding sites and numerically enhanced yield at five out of six sites under Southern Highland conditions of Tanzania MOP+Kieserite in general performed similar to POLY4 indicating the significance of sulphur nutrient in corn grain yields**
- **Comprehensive research including tissue and post- harvest soil nutrient analysis is essential for confirming, explaining the reasons and mechanisms of the observed results**

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