

Verification of Potassium, Zinc and Boron Fertilizer on Yield of Wheat (*Triticum aestivum*) in Jamma and Meket Districts of East Amhara

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Abstract

Soil fertility map of the region developed by ATA and Ministry of Agriculture and Natural Resources indicates 100% of the Jamma and Meket district shows potassium deficiency. In addition to potassium 100% of Jamma districts and more than of 98% of Meket district also shows both NPSB and NPSBZn deficiency. This study was conducted in Eastern Amhara National, Regional State of Meket and Jamma districts in the 2017 cropping season to verify crop responses to potassium, Boron and Zinc fertilizers visa- via the soil fertility map of the districts developed by ATA and Ministry of Agriculture and Natural Resources. Five sites per district were selected for the study. The test crop was wheat (*Dinkenes*). The treatments were: NPS, NPSK, NPSBZn and NPSKBZn. Treatments were replicated three times per site and the design was RCBD. Recommended NP was used uniformly for all treatments. The collected data were subjected to analysis of variance using SAS version 9. The Result revealed that there was no statistical significance yield difference ($p > 0.05$) between potassium, boron and zinc treated plots and recommended NP plots. For all sites the finding was unrelated to the developed soil fertility map. Therefore; it is unjustified to use K, B and Zn fertilizers for the study crops and areas.

Keywords: Boron fertilizer, Potassium fertilizer, soil fertility map, Zinc fertilizer

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1. Introduction

Ethiopia is endowed with abundant agricultural resources and has diverse ecological zones. The two dominant agricultural systems in Ethiopia are the mixed agriculture of the highlands, where both crops and livestock production are integrated, and pastoralism in the lowlands. Agriculture in Ethiopia accounts for about 34.8% of the gross domestic product (GDP) (CIA World Factbook 2019). In Ethiopia there is a positive response to nitrogen and phosphorous fertilizer applications for most crops under all agro ecologies. However; there has been a lack of crop response to potassium fertilizer (Murphy, 1968; Tadele *et al*, 2010; Tadele *et al*, 2018). Against the finding of these authors 94% of the Amhara National, Regional State shows potassium deficiency, according to the soil fertility map of the region developed by ATA and Ministry of Agriculture and Natural Resources (2016) and Tena and Beyene (2011). The soil fertility map shows potassium were deficient in 100% of Jamma and Dawa-cheffa districts and also NPSBZn + NPSB were 100% deficient in Jamma and about 99% of Dawa-cheffa districts in addition to potassium (ATA and MoANR,2016).

Ethiopian soils are supposed to be rich enough to support the crop demand of potassium based on the findings of crop responses to potassium fertilizer carried out before this study (Tadele *et al*, 2018; Abebe *et al*, 2019, unpublished). Blended fertilizers which contain potassium were introduced in different ways in the country starting from 2014 as abalanced fertilizer (Brhane et al, 2017) to all areas of the region including to Jamma and Meket districts. ATA suggests to apply 100 kg of potassium fertilizer throughout the districts with out considering the crop type and agroecological zones. based on this the regional agriculture bereau forced to distribute potassium fertilizers to the farmer in addition to nitrogen and phosphorous.

Besides this the Amhara agricultural research institutes give emphasise to this new fertilizers and propose regional activities to support the soil fertility map based on crop responses. Therefore; this research was designed to verify the crop response to potassium, boron and zinc visa via the soil fertility map of the districts.

2. Material and methods

2.1. Study site

The research was conducted in a farmer's field at Meket and Jamma districts in the Eastern Amhara region in 2017/18 main rainy season. Jamma is located about 260 km away from the capital city, Addis Ababa, in the north east direction and at an altitude of 2630 meters above sea level (masl). The geographical location of the district lies between 10° 23' to 10° 27' N latitudes and 39° 07' to 39° 24' E longitudes in South Wollo Zone of the Amhara National Regional State. The dominant soil type of the district is Vertisols. The soil is characterized by poor

drainage and difficulty to work, but high potential for wheat production with proper soil management. Meket is located in the western parts of North Wollo Zone. it is bordered in the south by Wadla and Dawunt districts, in the west by Lay Gaint and Tach Gaint districts , in the northwest by Bugna district, in the north by Lasta district, in the northeast by Gidan district, and in the east by Gubalafto district. The altitude of the district reaches to 2650 meter above sea level (masl). The district receives a unimodal type of rain fall with an average annual rainfall of 1105 mm. The soil is brown in color and acidic in reaction.

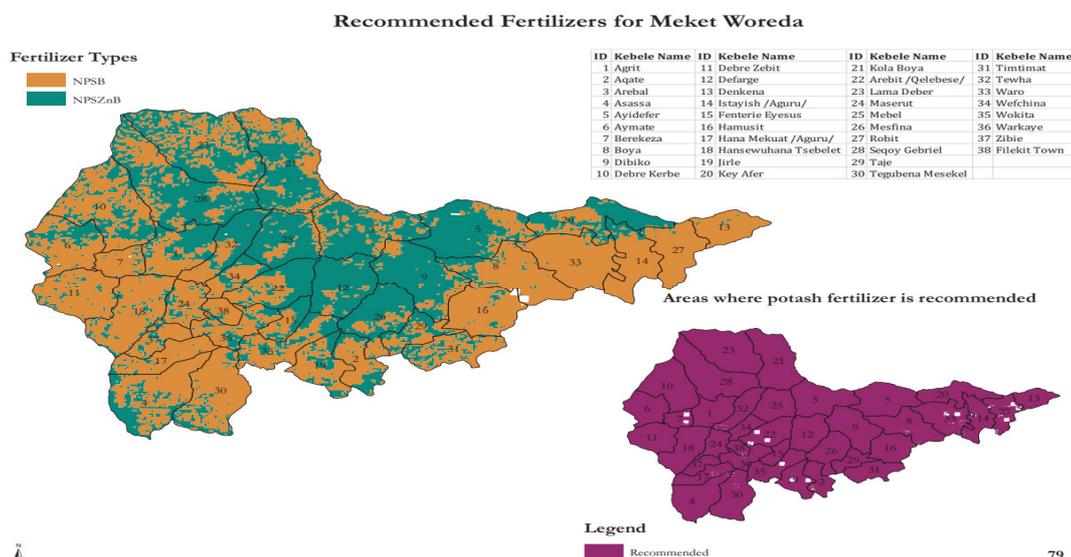
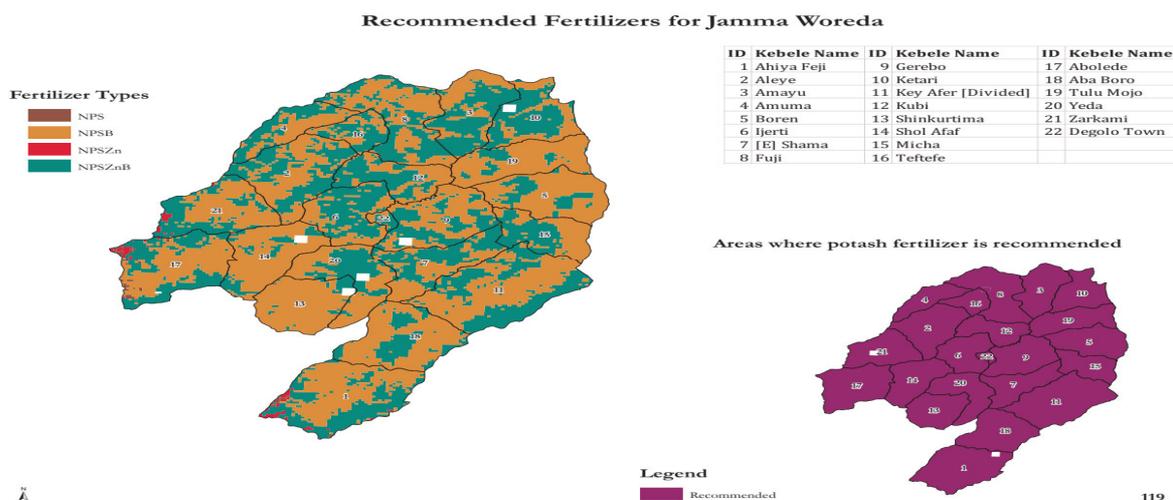


Figure 1. Fertilizer recommended areas of meket district(source,ATA and MoANR,2016).



Figure,2. Fertilizer recommended areas of Jamma district (source,ATA and MoANR,2016).

2.2 Treatment setup

The treatments used for the research were:

1. NPS
2. NPSK
3. NPSBZn
4. NPSKBZn

Treatments were replicated three times per site and the design was RCBD. Recommended NP was used uniformly for all treatments. Nitrogen, 69 kg/ha for Meket and 115kg/ha for Jamma was used. While, 69 kg/ha P₂O₅ for both districts was used. The rate of KCl was 150kg/ha. Nitrogen was applied by splitting half at planting and half at tillering. The whole rates of phosphorous and potassium chloride was applied at planting. Foliar application of B and Zn fertilizer at a rate of 1 kg/ha Borax and 1 kg/ha Zinc sulphate was used.

The plot size was 25 m² (5 m * 5m) for Meket and 24 m² (4.8 m * 5m) for Jamma. At Jamma broad bed furrow with 80cm by 40cm was used. The space between plots and replications were 0.5m and 1 m respectively. Soil and crop management were applied uniformly to all treatments. The variety was Dinkenesh with the seed rate

of 125kg/ha.

2.3 Soil Sampling and Analysis

Composite soil samples at a depth of 0-20 cm were collected from each farm at planting. Samples were air-dried and ground to pass a 2-mm sieve and 0.5 mm sieve (for total N) before analysis. Soil texture was determined by bouyoucos hydrometer method. The pH of the soils was measured in water (1: 2.5 soils to water ratio). The organic carbon content of the soil was determined following Walkley and Black procedures (1934). The total nitrogen was determined by Kjeldahl method (Bremner & Mulvaney, 1982). The available soil phosphorus was determined by the Olsen method (1954). **Exchangeable** potassium was extracted by ammonium acetate at pH 7 (sahalmedhin and Taye, 2000) and determined by Atomic absorption spectrometer.

2.4 Crop data

Plant height was measured at maturity from five random plant samples of the harvestable rows from the ground to the tip of the spike. Grain yield was collected from the central rows while, the two border rows were not included. The moisture content of the grain was collected simultaneously with the grain yield and finally adjusted to the moisture content of 12.5%.

2.5 Data analysis

Collected data were subjected to analysis of variance to evaluate the degree of variations between treatments using SAS version 9.0.

3. Results and discussion

3.1 Physico-chemical properties of the soil

The results of soil analysis showed that for both districts the soil was clay in texture. The total nitrogen ranged from 0.1% to 0.2% and 0.08% to 0.15 % for Meket and Jamma respectively, and this range is from low to medium (Tekaligne et al., 1991). The soil organic matter in Meket ranged from 1.6% to 3.8 % and for Jamma ranged from 0.67%-1.55%. The level of soil organic matter was in a category of low to medium for Meket and low to Jamma according to Berhanu (1980). The available phosphorus was ranged from 23.05ppm to 31.15ppm for Meket and from 39.4ppm to 54.8 ppm for Jamma. For both study sites the availability of phosphorous is categorized as very high (Marx *et al.*, 1999). The exchangeable potassium was 1. 703 to 5.810 meq/100g soil for Meket and 4.861 to 6.003meq/100g soil for Jamma. The level of potassium for the two districts was very high (FAO, 2006) and hence crop response to potassium is very unlikely. The soil reaction (pH) of the two districts was ranging from 5.9-6.3 and 6.4-6.77 for Meket and Jamma respectively.

3.2 Yield response

The results of the research showed that there was no statistical significance difference ($p < 0.05$) among and between treatments for both districts (Table 1,2,3 and 4). This finding is in line with previous results for refining studies of potassium, boron and zinc and for the map validation study, which was conducted in the region (Abebe *et al.*, 2019; Tadele *et al.*, 2018). The result is also supported by our soil analysis results that showed the level of potassium was above the critical limit. Adding potassium, boron and zinc fertilizers did not bring any observable yield advantages over recommended NP fertilizers.

Table 1. Effect of treatments on grain yield (kg ha^{-1}) at Jamma

Treatment	Farm 1	Farm 2	Farm 3	Farm 4	Farm5	Mean
NPS	2991	3014	3798	2834	2925	3112
NPSK	3043	3213	3565	2657	3054	3106
NPSBZn	2663	3179	3569	2922	2823	3032
NPSKBZn	2986	3186	3799	2684	3305	3192
LSD(5%)	NS	NS	NS	NS	NS	NS
CV (%)	13.1	5.66	8.4	12.88	11.02	14.0

Table 2. Effect of treatments on biomass yield (kg ha^{-1}) at Jamma

Treatment	Farm 1	Farm 2	Farm 3	Farm 4	Farm5	Mean
NPS	7722	7611	9556	7111	7889	7978
NPSK	7556	8000	8611	6778	7944	7778
NPSBZn	6833	8056	9278	7444	7444	7811
NPSKBZn	7611	7722	9222	6833	8611	8000
LSD(5%)	NS	NS	NS	NS	NS	NS
CV(%)	12.93	6.36	7.9	9.76	11.51	13.74

Table 3. Effect of treatments on grain yield (kg ha^{-1}) at Meket

Treatment	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Mean
NPS	2885	3011	3787	1943	2906	2906
NPSK	2485	3611	3979	2136	2964	3035
NPSBZn	3070	2944	3883	1877	2550	2865
NPSKBZn	2722	3033	3882	2091	2679	2881
LSD(5%)	NS	NS	NS	NS	NS	NS
CV(%)	24.32	17.62	4.88	20.12	13.79	27.74

Table 4. Effect of treatments on biomass yield (kg ha^{-1}) at Meket

Treatment	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Combined
NPS	8174	7275	10116	5159	7855	7716
NPSK	7391	8588	10652	5870	8290	8158
NPSBZn	8841	7333	9812	5696	6826	7701
NPSKBZn	8087	8529	10638	5768	7739	8152
LSD (5%)	NS	NS	NS	NS	NS	NS
CV(%)	20.8	17.45	4.42	12.5	13.52	24.59

The finding of this research did not support the soil fertility map of the districts developed by ATA and Ministry of Agriculture and Natural Resource (2016) as well as 100 kg of potassium chloride per hectare recommendations made by IPI, (2016) for all soils of Ethiopia. It was also not in line with the findings of Wassie and Tekalgn (2013) who claimed 41% yield increase over the control by using potassium fertilizer. In our case there were some cases where application of potassium as well as boron and zinc fertilizers resulted in lower yields than the control (recommended NP) even if it was insignificant. Brhane et al., (2017) also reported maximum yield of wheat from maximum input of potassium (90kg K₂O/ha) which did not bring any biological yield increment with the same rates of potassium under this research. Piri, I., (2012) reported that foliar application of micronutrient increased grain yield but it is not observed in these research.

For soils that are deficient in potassium and micronutrients including zinc and boron the yield of crops increased through proper application of the nutrients (Chaudry et al., 2007; Dash et al., 2015; Gitte et al., 2005; Nadim et al., 2012; Nataraja et al., 2006; Sultana et al., 2016). Among micronutrients, Zinc (Zn) and Boron (B) play a key role in pollination and seed set processes; so that their deficiency can cause to decrease in seed formation and subsequent yield reduction. This effect of micronutrient is not observed in this research. It is clear that the importance of potassium and other micronutrients including zinc and boron for the production of crops, however; with the current status of wheat responses for the study districts and other similar areas with similar soil and agroecological properties application of these nutrients does not give any biological benefits. The implication of our findings as witnessed by the results of soil potassium, the soil supplies sufficient amount of these nutrients for the production of wheat. Therefore; it is unwise to use these fertilizers for the production of wheat under the current situation. The government should give focus on NP fertilizers to increase agricultural production and productivity of wheat.

Application of potassium, zinc and boron fertilizers are therefore additional costs for the farmers without increasing the productivity of wheat, which is the major crop for the study areas and wheat is one of the voracious crop that could indicate any deficiency of nutrients for its optimal production. Therefore; the map developed by ATA and the ministry of agriculture and natural resource should not be used directly as it did not show any relation with potassium, boron and zinc applications.

4. Conclusion and Recommendation

The over all result of this research showed that application of K, B and Zn contained fertilizers did not bring significant yield increment over recommended NP fertilizer. This indicates application of recommended NP fertilizer without the addition of K, B and Zn fertilizers is required to increase production and productivity of wheat in the study districts. So that K, B and Zn were not potentially yield limiting nutrients in the study sites and these nutrients were sufficient to support good crop growth for wheat in both areas where these experiments were conducted.

This study confirmed that for this time no need of potassium, Zinc and Boron fertilizer in the mentioned study area. Moreover, crop response to new fertilizers and the soil fertility status must be monitored as they will be expected to be yield limiting in the future. Therefore, potassium, zinc and boron contain fertilizers should not be used for the study districts and the soil fertility map should be revised. For the future research should be done to monitor the status of potassium and micronutrients in the district.

5. References

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