Comparative evaluation and validation of soil fertility map based fertilizer recommendation for bread wheat and food barley

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Abstract

Site-specific fertilizer rate recommendation is mainly projected for N and P in Ethiopia. In recent times, the Ministry of Agriculture and Natural Resources (MoANR) in coordination with the Agricultural Transformation Agency (ATA) recommended eight new fertilizer types for Amhara National Regional State (ANRS). As a result, in the region, seven soil nutrients (N, P, K, S, Zn, B, and Cu) are found to be deficient in the developed soil fertility map. However, the comparative advantages of recommended fertilizer types were not examined and understood under various production environments. Then this trial was conducted to validate the response of wheat and barley to soil fertility map based on various balanced fertilizer recommendations under Debark district. Four and six fertilizer formulations on barley (recommended NP, NPSB, NPSZnB and modified NPSZnB) and wheat respectively (recommended NP, NPSB, NPSZnB, modified NPSZnB, NPKSZnB, and modified NPKSZnB) were used for validation of soil fertility map based fertilizer recommendation at Debark district. The result of this experiment revealed that addition of S, K, Zn and B to wheat; and addition of S, Zn and B to barley did not show significant difference in above-ground biomass and grain yield over the application of recommended NP alone. Hence, application of additional plant nutrients (K, Zn and B) besides the current fertilizer recommendations (NP) for wheat and barley is not recommended in the study areas and similar agroecologies.

Keywords: Boron, Nitrogen, Phosphorus, Potassium, Sulfur, Zinc

Introduction

The need for site-specific NP fertilizer recommendations is familiar in Ethiopia; however, fertilizer trials involving multi-nutrient blends that include micronutrients are rare. The Ministry of Agriculture and Natural Resources (MoANR) in coordination with the Agricultural Transformation Agency (ATA) launched a new national fertilizer blending program on February 12, 2013. It aims to popularize new high-yield blended fertilizers and to create Ethiopia's first in-country blended fertilizer production facilities (Ethio SIS, 2014). Accordingly, ATA and MoANR (2016) have been developed eight fertilizer types: NPS, NPSB, NPSZn, NPSZnB, NPSBCu, NPSZnBCu, Muriate of Potash (MoP) and urea to solve site-specific nutrient deficiencies of nitrogen, phosphorus, potassium, sulfur, zinc, boron and copper in the Amhara National Regional State (ANRS).

In the past field experimentations, nitrogen is deficient in almost all soils and phosphorus is also deficient in about 70% of the Ethiopia soils (Tekalign *et al*., 2001). These low availabilities of nitrogen and phosphorus have been demonstrated to be a major constraint to cereal production. This is due to soil erosion, continuous crop cultivation without fallow, unbalanced nutrient supply during crop cultivation, low organic matter and absence of nutrient recycling. On the other hand, most of the area used for grain production, especially tef, wheat and barley fall under the low fertility soils (Hailu *et al*., 2015). Although there is a general perception that the new fertilizer blends provide better crop production than the traditional fertilizer recommendations (urea and DAP), their comparative advantages are not yet clearly examined and understood under various production environments.

Then, soil fertility research teams drawn from Ethiopian Institute of Agricultural Research, Amhara Regional Agricultural Research Institute (ARARI), Oromia Regional Agricultural Research Institute (ORARI), Tigray Regional Agricultural Research Institute (TRARI) and Southern Regional Agricultural Research Institute (SARI)were designed experiments to validate blended fertilizer formulas that were recommended based on soil fertility maps. The validation of new recommended blended fertilizer types by field experiments on the response of different crops therefore, avoids unnecessary use of fertilizers by smallholder farmers or confirm the recommendations by Ministry of Agriculture and Natural Resources (MoANR) in coordination with the Agricultural Transformation Agency (ATA)

Objectives

- ✓ To validate the response of wheat and barley to different soil fertility map based blended fertilizer recommendations under Debark district
- ✓ To quantify their comparative advantage over the traditional fertilizer recommendation

Materials and methods

This study was conducted on farmers' fields for two consecutive years (2015 and 2016) at Debark woreda; 5 sites for wheat (Digalu variety) and 5 sites for barley (HB1307 variety) in each year. The selected physico-chemical properties of soil of the experimental sites in 20 cm depth indicated that textural classes are dominated by loam and clay loam. The soil pH of the experimental sites ranged 5.58-5.74, which is moderately acidic (Hazelton and Murphy, 2016). The range of organic carbon percentage is 1.43-2.53, percentage of total nitrogen is 0.21-0.28, available (olsen) P is ranged 14.37-56.24 ppm, and Cation Exchange Capacity (CEC) is ranged 35.82-45.30 cmol (+) kg^{-1} of soil.

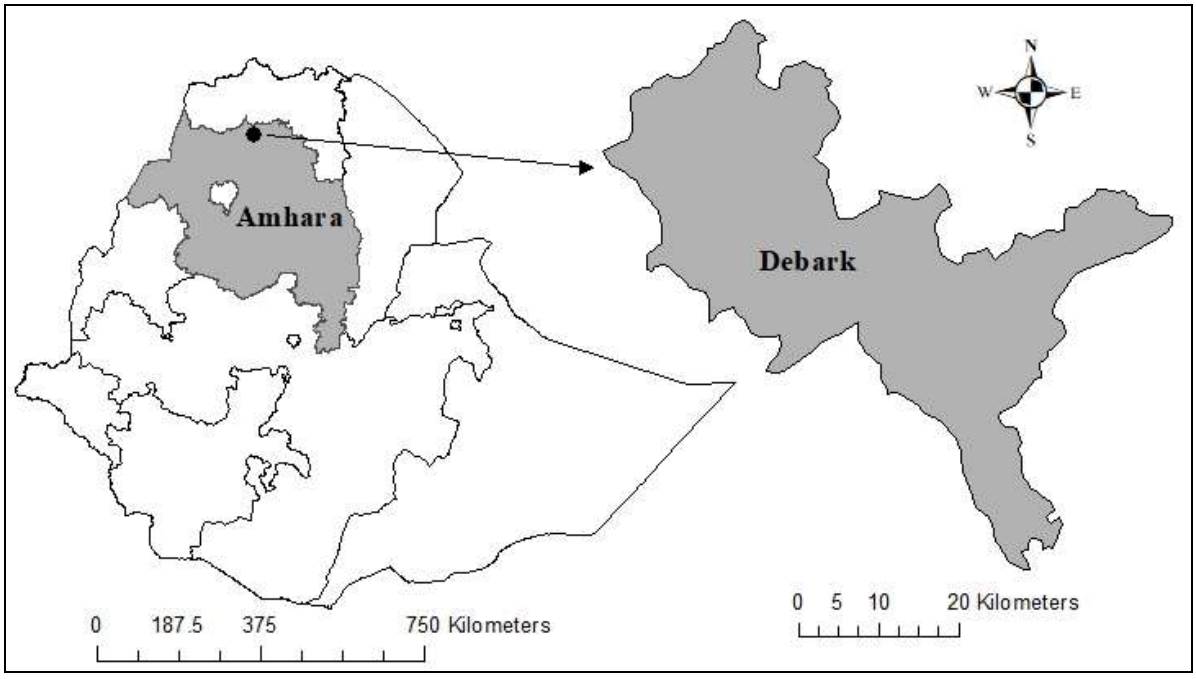

Figure 1: Location map of Debark district

The area was received an annual rainfall of 1152.63 mm, a minimum temperature of 16.01° C and a maximum temperature of 28.64° C during the year 2015. It was also received an annual rainfall of 1814.2 mm, a minimum temperature of 15.34° C and a maximum temperature of

27.54° C in 2016. The area received the highest rainfall in August 2015 (416.81 mm) and July 2016 (656.31 mm) cropping seasons (Figure 2).

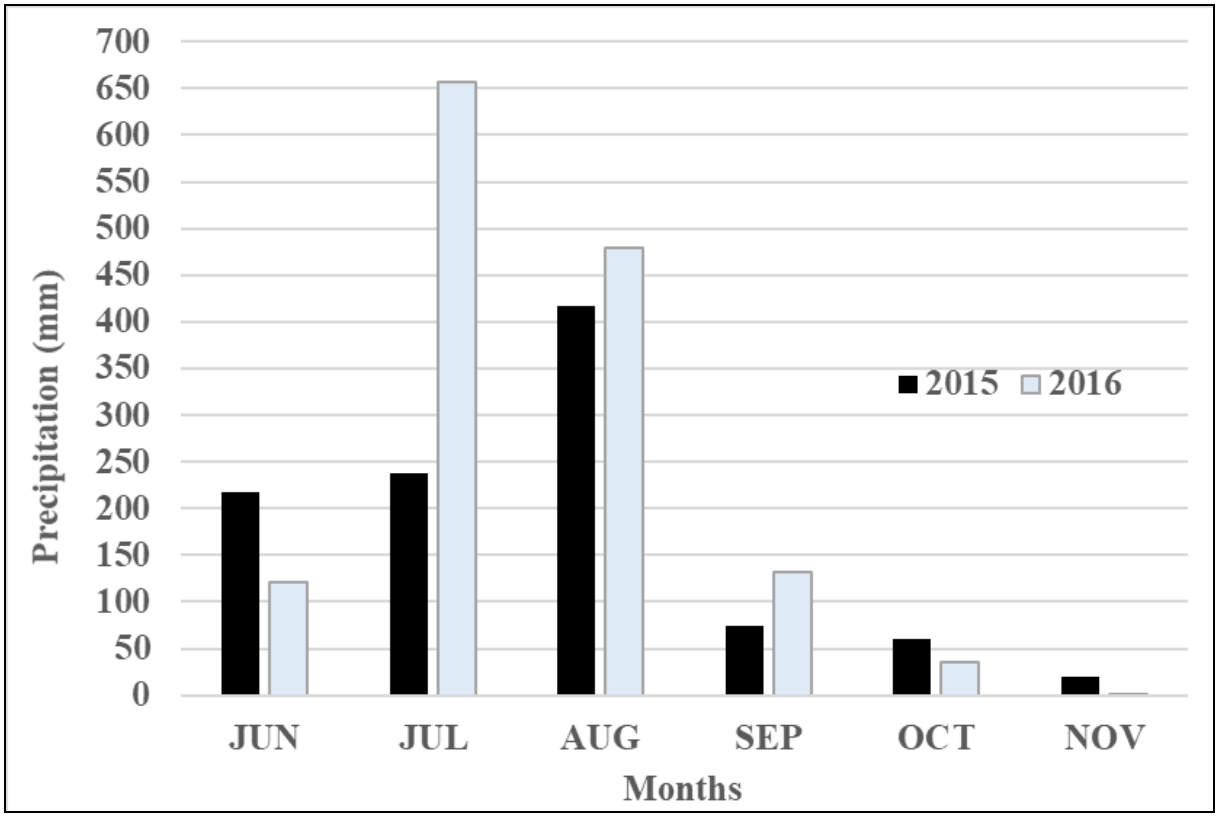

Figure 2. Rainfall in 2014 and 2015 cropping season at Debark district (Source: https://power.larc.nasa.gov)

Based on the soil information data of EthioSIS (2014), critical values for each limiting nutrients identified were compared among each other and against the blanket recommended N and P from DAP and Urea fertilizers. Blended fertilizers and DAP were basal applied at planting for wheat and barley. Urea was top-dressed 30 to 45 days after planting. The test crops were planted in rows. The plot size was 4m*3m for both barley and wheat. It was planted with 20 cm between rows. The seed rate was 125 kg/ha and 100 kg/ha for wheat and barley respectively.The other crop management practices were applied as per the recommendation for each crop. The detailed treatment set-up for each location and crop type is indicated in Table 1 and 2.

Table 1. Fertlilizer formulations tested on food barley

Treatments for barley	N	P_2O_5	K	S	Zn	B
T1= Recommended NP (50 kg/ha Urea + 100 kg/ha DAP)	41	46	0	0	0	0
T2= Formula 2: 100 kg/ha + 50 kg/ha urea top dressed	41	36	0	6.7	0	0.71
T3= Formula 4: 100 kg/ha + 50 kg/ha urea top dressed	41	34	0	6.3	2.23	0.67
T4= formula 4 modified: 150 kg /ha + 35 kg/ha urea top dressed	42	51	0	10.95	3.36	1.01

Table 2. Fertilizer formulations tested on bread wheat.

Treatments for wheat	N	P_2O_5	K	S	Zn	B
T1= Recommended NP (140 kg/ha Urea + 150 kg/ha DAP)	91	69	0	0	0	0
T2= Formula 2: 150 kg/ha + 140 kg/ha urea top dressed	92	54	0	10.1	0	1.07
T3= Formula 4: 150 kg/ha + 150 kg/ha urea top dressed	94	51	0	11	3.35	1.01
T4 =formula 4 modified: 200 kg/ha + 124 kg /ha urea top dressed	92	70	0	15.2	4.46	0.5
T5 = formula 5: 150 kg/ ha + 156 kg/ha urea top dressed	91	39	21	8.4	2.58	0.77
T6 = Formula 5 modified: 250 kg/ha + 128 kg /ha urea top dressed	90	65	37	14	4.3	0.63

Results and Discussion

Both food barley and bread wheat crops were grown well in the area as shown in figure 3, but there is no treatment difference across the study sites in both growing seasons. But, the productivity of the crops was highly varied on the experimental sites.

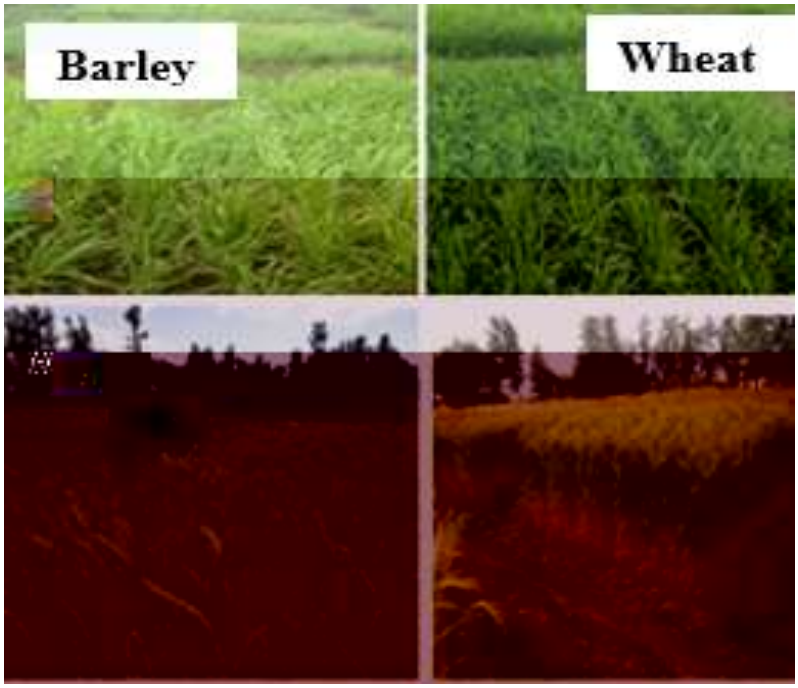

Figure 3: Pictures for barley and wheat trials at early and maturity stages

The second year crop performance was better than the first year in most locations. Growing seasons and experimental sites did not change the response of those crops to fertilizer formulations. Above-ground biomass and grain yield of bread wheat and food barley were none significantly responded to fertilizer formulations or treatments (Table 3). The result showed that the application of recommended NP compared to the additional nutrients such as S, K, Zn and B did not show significant difference in the above-ground biomass and grain yield of bread wheat; likewise, application of recommended NP fertilizer compared to addition of S, Zn and B did not show significant difference in the above-ground biomass and grain yield of barley.

As a result, it is possible to prove that there is no need to apply new plant nutrients (K, S, B and Zn) other than nitrogen and phosphorus for both crops in the district. Similar findings by Tadele *et al.* (2018) reported that the addition of fertilizers including potassium, zinc and boron under different districts for maize, wheat and tef did not show any significant yield advantage over NPS alone. Hence from this finding, it can be justified that the

recommendations made by MOA in collaboration with ATA might not be feasible and an aproparaite site specific NP nutrient recommendations has to be strengthend.

Table 3. Effect of different fertilizer formulations on yield of barley and wheat at Debark

Types of fertilizer applied	BW(kg/ha)	GY(kg/ha)	Types of fertilizer applied	BW(kg/ha)	GY(kg/ha)

The present result proved that the importance of each new blended fertilizer to increase the yield of wheat and barley was insignificant as compared to the two major nutrients (N and P) in the district (Table 3). The present finding was harmony with the study of fertilizer rate determination on late-maturing local food barley cultivar, which is evaluated at Wogera in the highlands of North Gondar. According to this result, the most profitable fertilizer rates for food barley production were 69 kg ha^{-1} N and 20 kg ha^{-1} P (Mulatu and Grando, 2011).

Conclusion and Recommendation

This study disproved that the general perception suggesting new blend fertilizers may provide better wheat and barley grain and biomass yield than the traditional fertilizer recommendations (urea and DAP) at Debark and similar agro-ecologies and soil types. At Debark and similar environments, the application of various blend fertilizers that included sulfur, potassium, boron and zinc did not showed significant yield and biomass advantage as compared to recommended NP fertilizer. Therefore, it is recommended that the application of NP fertilizers will be beneficial until further studies in the future provide evidence-based wheat and barley yield advantage as compared to recommended NP fertilizers.

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