

## Validation of Blended Fertilizers Based on Ethio-Sis Soil Fertility Map to Develop Site Specific and Crop at Halaba, Southern Ethiopia

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**Abstract:** *Balanced use of inorganic fertilizers has been the important tools to overcome soil fertility problems and enhance crop production and productivity. The experiment was conducted to validate blended fertilizer to develop site and crop specific optimum rate recommendations based on Ethio-SIS soil fertility map in Halaba, southern Ethiopia, during the 2019 cropping season. The experiment consisted of six treatment levels: (1) control or unfertilized, (2) farmers' practice (100 kg ha<sup>-1</sup> of NPSB + 50 kg ha<sup>-1</sup> of Urea), (3) 100% of the recommended rates of N and P which is 138 N and 92 P, (4) 50% of the recommended rates of N and P from blended (NPSB) fertilizer and urea, (5) 100% of the recommended rates of N and P from blended (NPSB) fertilizer and urea and (6) 150% of the recommended rates of N and P from blended (NPSB) fertilizer and urea. The treatments were arranged in randomized complete block design with three replications. The result revealed that the maximum grain yield (8,240 kg ha<sup>-1</sup>), straw yield (18,435 kg ha<sup>-1</sup>) and biomass yield (25,858 kg ha<sup>-1</sup>) of maize was obtained from application of 150% of recommended rate nitrogen and phosphorus from NPSB blended fertilizer plus urea source. The economic analysis indicated that the application of 150% of recommended rate nitrogen and phosphorus from NPSB blended fertilizer and urea source gives net benefit value of (107113.50 ETB ha<sup>-1</sup>) with MRR of (9%). These results suggest that an appropriate use of balanced fertilizer based on site and crop specific not only provides enough nutrients to the soil but also improves crop production and productivity. Therefore, application of 150% of recommended rate nitrogen and phosphorus from NPSB blended fertilizer and urea source based on Ethio-SIS soil fertility map can be recommended to farmers for maize production, that with assurance of economic returns in Halaba, Southern Ethiopia and areas with similar agro-ecological and soil conditions. Finally, further investigation should be undertaken across years and different locations to confirm the current finding and for wider applicability.*

**Keywords:** *Blended fertilizer, Grain yield, Maize, NP and NPSB*

### 1. INTRODUCTION

In Ethiopia, agriculture provides an employment to 85% of the population, contributes 90% of the total export earnings, supplies over 70% of the total raw materials required by industries and accounts for 60% of the country's gross domestic product (CSA, 2016). It plays a great role in Ethiopia's economic development and will expertise the lead for many years to come. Since, Ethiopian agriculture is characterized by low production per unit. One of the major constraints for low crop productivity is low soil fertility, which is exacerbated by soil fertility depletion through nutrient removal with harvest, tillage, weeding, and losses in runoff and soil erosion, soil degradation and nutrient depletion and use of unbalanced and right amount and form fertilizer for site and crop specific (Hussain et al., 2006).

Soil fertility maintenance is a major concern in tropical Africa predominantly with the rapid population increase, which has occurred in the past few decades (Smaling and Braun, 1996). Similarly, Dagne (2016) reported that increasing crop production and soil resources in the smallholder farm sector of Africa has become a vast challenge. Inorganic fertilizers have been the important tools to overcome soil fertility problems and they are also responsible for a large part of the food production increases. The drive for higher agricultural production without balanced use of fertilizers created problems of soil fertility exhaustion and essential plant nutrient imbalances not only of major but also of secondary macronutrient and micro-nutrients. The deficiencies of secondary macro-nutrient and micro-nutrient

will arise if they are not refilled timely under intensive agriculture (Fageria and Baligar, 2008; Singh, 2011).

Recently, according to the soil fertility map Ethiopia soil analysis data revealed that the deficiencies of most of nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%), zinc (53%), potassium (7%), copper, manganese, and iron were widespread in Ethiopian soils (Ethio-SIS, 2016). Similarly, Asgelil *et al.* (2007) reported show that K, S, Ca, Mg, and micronutrients (Cu, Mn, B, Mo, and Zn) were becoming depleted and deficiency symptoms were observed in major crops in different parts of the country. Consequently, to overcome this problem of nutrient deficiency using those soil fertility maps (soil fertility atlas), district level multi-nutrient balanced fertilizers containing N, P, K, S, B and Zn in blend form have been issued to ameliorate site-specific nutrient deficiencies and thereby increase crop production and productivity in the areas. Since, experiments on validation of blended fertilizers (formulae) for major crops across different soil types have been conducted throughout the country in comparison with the previous recommended fertilizer rates.

However, blended fertilizers validation studies for major crops and soil types are still limited and information not sufficiently available for low potential parts of the country especially at Halaba district. Moreover, according to soil fertility maps (soil fertility atlas), survey report the deficiency of nitrogen, phosphorous, sulfur, and boron were widely spread in Halaba areas (Ethio-SiS, 2016). Therefore, it is necessary to improve the nutrient content of fertilizer that suits the needs and the productivity of the crop and soil. However, information on the application of rate blended fertilizer NPSB especially for maize was not determined at the study area. Therefore, these particular experiments were designed the following general and specific objectives:

#### **General Objective**

- To enhance crop productivity and contribute for food security

#### **Specific Objective**

- To validate blended fertilizer recommendations (rates) based on Ethio-SIS soil fertility map of the area
- To determine economically optimum blended fertilizer rates for maize production

## **2. MATERIALS AND METHODS**

### **2.1. Description of the Experimental Area**

The study was conducted during 2019 main cropping season in Halaba, districts of Southern Ethiopia. The geographic locations of the experimental site in Halaba lie 7°24'53.87" N and 38°6'55.54" E at an altitude of 1790 *m. a. s. l.* The major crops growing in the area were maize, wheat, sorghum, barley, tef and pepper. A minimum distance of 500 m was kept between farmers' fields to catch variability of soil conditions.

### **2.2. Experimental Set-up and Procedure**

The experiment was established in a randomized complete block design (RCBD) with three replications. It consisted of 6 treatment levels: (1) control (no input), (2) farmers' practice (100 kg ha<sup>-1</sup> of NPSB + 50 kg ha<sup>-1</sup> of Urea) for maize and tef at each district, (3) 100% of the recommended rates of N and P from TSP and urea, (4) 50% of the recommended rates of N and P from blended fertilizer and urea, (5) 100% of the recommended rates of N and P from blended fertilizer and urea and (6) 150% of the recommended rates of N and P from blended fertilizer and urea and (*BH-546 variety*) of maize was used. The trial was conducted at 2 farmers' fields and per each crop and a minimum distance of 500 m was kept between farmers' fields to catch variability of soil conditions.

The blended and phosphorus containing fertilizers from NPS and triple super phosphate (TSP), respectively were basally applied once at sowing to minimize losses and increase use efficiency. The nitrogen fertilizer from Urea was applied in the row in two times; half at sowing and the other half during the maximum growth; between the third and fourth weeks of sowing after first weeding and during light rainfall to minimize N loss All other agronomic management practices were applied as per recommendation for the variety. The necessary data were collected at right time and crop growth stage.

### 2.3. Data Collection

The crop yield and yield components collected included grain yield, total above biomass yield, straw yield. Composite soil samples per farmer field were collected at a depth of 0–20 cm prior to sowing. Soil samples were also collected immediately after harvesting at the aforementioned depth from each plot per farmers' fields for investigating the changes in soil chemical properties due to treatments application. The soil samples were air dried, grounded to pass to 2 mm sieve, and analyzed for soil texture, pH, organic matter, total nitrogen (N), total sulfur (S), available phosphorous (P), cation exchange capacity (CEC) and boron (B).

### 2.4. Economic Analysis

Economic analysis was conducted to investigate the economic feasibility of the treatments according to the procedure set by CIMMYT (1988). Partial budget, dominance and marginal analysis were carried out. The average yield was adjusted downwards by 10% to reflect the difference between the experimental plot yield and the yield farmers were expecting from the same treatment. The average open market price (Birr kg<sup>-1</sup>) for maize and the official prices of each fertilizer were used for analysis.

### 2.5. Statistical Analysis

The data were analyzed by using one-way analysis of variance (ANOVA) using Statistical Analysis Software (SAS) version 9.4, (SAS, 2014). Whenever treatments effects were significant, mean separations were made using the least significant difference (LSD) test at ( $p \leq 0.05$ ) level of probability test by one-way analysis.

## 3. RESULT AND DISCUSSION

### Soil Physicochemical Properties of the Experimental Sites Before Sowing

The soil particle size distributions of site were 63.1%, 21.3% and 15.3% sand, silt and clay, respectively (Table 1). Thus, the soil textural class of the soils of site was sandy loam (USDA, 1998). The pH value of the soil was 6.1 (1:2.5 soil: water) (Table 1). The soil pH has a vital role in determining several chemical reactions in influencing plant growth by affecting the activity of soil microorganisms and altering the solubility and availability of most of the essential plant nutrients particularly the micronutrients such as Fe, Zn, B, Cu and Mn (Sumner, 2000).

The analysis result of available P of experimental site was 11.2 ppm. According to Olsen *et al.* (1954) rating, the status of available P of site categorized under medium level (Table 1). The organic carbon and total nitrogen content of site were 1.5 % and 0.12% respectively (Table 1). According to (Tekalign, 1991; Don Ankerman, and Richard, 2015) organic carbon of the is rated as low. Likewise, total nitrogen content of site was under medium condition based on (Tekalign, 1991; Berhanu, 1980) classifications. Total sulfur of the soil was 2.8 ppm and ranged low category (Tekalign, 1991; Don Ankerman, and Richard, 2015). Cation exchange capacity of experimental soil was 12.8 meq 100g sample<sup>-1</sup> which is found at medium (London, 1991; Hazelton and Murphy, 2007) (Table 1).

**Table1.** Soil physicochemical properties at Halaba prior to sowing

Parameters	Value	Rating	Reference
Sand (%)	63.1		-
Silt (%)	21.6		
Clay (%)	15.3		
Textural class	Sandy Loam		USDA (1998)
pH (1:2.5 soil: water)	6.1		
Available P (mg kg <sup>-1</sup> )	11.2	Medium	Olsen et al. (1954)
Sulfur (mg kg <sup>-1</sup> )	2.8	Low	Don Ankerman and Richard (2015)
Total nitrogen (%)	0.12	Low	Tekalign (1991); Berhanu (1980)
Organic carbon (%)	1.5	Low	Tekalign (1991)
Cation exchange capacity (cmol (+) kg <sup>-1</sup> )	12.8	Moderate	London (1991); Hazelton and Murphy (2007)

### Effects of NPSB Fertilizer Application on the Soil Chemical Properties after Harvest

The application of NPSB blended fertilizer significantly influenced the available soil P level of the site (Table 2). The maximum available soil P was obtained from application of 100% and 150% recommended N and P from NPSB and Urea sources. The result further showed that effect of

application of fertilizers on soil reaction (pH) value, sulfur, total nitrogen, and organic matter contents of the soils of experimental site were not significant (Table 2). However, the trend showed that application of 100% and 150% RNP from NPSB and Urea sources improved the total S, total N and OC contents of soils.

**Table2.** Soil physiochemical properties after crop harvest

Treatments	pH	Av. P (ppm)	S (mg/kg)	% N	% OC
Control	5.85	12.82 <sup>b</sup>	1.81	0.12	1.18
Farmers Practice	5.57	25.88 <sup>a</sup>	2.43	0.11	2.01
100% of RNP (from TSP &Urea)	5.88	30.22 <sup>a</sup>	3.52	0.12	1.78
50% of RNP (from NPSB & Urea)	6.22	27.60 <sup>a</sup>	2.52	0.10	1.81
100% of RNP (from NPSB &Urea)	6.20	32.30 <sup>a</sup>	3.44	0.14	2.33
150% of RNP (from NPSB &Urea)	6.16	31.82 <sup>a</sup>	3.63	0.16	2.46
CV	7.2	19.8	29.4	17.1	25.5
Isd @0.05	ns	9.6	ns	ns	ns

**Effects of NPSB fertilizers on yield and yield components of maize**

The results obtained from the two farmers’ fields were consistent. Thus, combined analysis was conducted. The application of different rates of NPSB blended fertilizer significantly ( $p < 0.01$ ) influenced the measured variables including above ground biomass, grain yield, straw yield, and harvest index of maize. The above ground biomass, grain and straw yields ranged from 11,758–25,858, 3,421–8,240 and 8,337–18,435 kg ha<sup>-1</sup>, respectively (Table 3). The pooled mean analysis revealed that the maximum above ground biomass (25,858 kg ha<sup>-1</sup>), grain (8,240 kg ha<sup>-1</sup>) and straw (18,435 kg ha<sup>-1</sup>) yields were obtained from the application of 150% of recommended N and P from NPSB blended and Urea fertilizers. Statistically equivalent biomass and straw yield were also obtained from the application of 100% of recommended N and P from TSP and urea, and 100% of recommended N and P from NPSB and urea fertilizers (Table 5). The results further showed no significant difference on most yield and yield components between application of 100% of recommended N and P from TSP and Urea (which is previous recommendation) and 100% of recommended N and P from NPSB blended and Urea fertilizers (Table 3). The lowest yield and yield components were recorded at the control or unfertilized plot. The application of 150% of N and P from NPSB blended and Urea fertilizers was higher in grain yield by 36, 34 and 21% compared to the farmers’ practice, application of 100% of recommended N and P from TSP and Urea, and application of 100% of RNP from TSP and Urea fertilizers, respectively. The yield advantage relative to the control (unfertilized) treatment was 58% (Table 3) indicating the depletion of the soil and its strong response to fertilizer application. This is due to the optimum application of N, P and S, and their roles in energy provision for seed formation and grain filling. Therefore, balanced fertilizer application based on soil test-crop response is very crucial to enhance soil fertility and crop yield.

Likewise, the application of nitrogen with addition of sulfur nutrient had positive or synergetic effect (Marschner, 2002). This positive interaction could be important in boosting crop yield. Also, sulfur is essential for production of chlorophyll and utilization of phosphorus and other essential nutrients. Sulfur also, ranks equal to nitrogen for optimizing crop yield and quality (Marschner, 2002).

The maize yield depends mainly on the availability of essential plant nutrients from the application of fertilizers (Adediran, *et al.*, 2003). In agreement with the result of this experiment, Dagne (2016) also observed the maximum mean grain yield (8,400 kg ha<sup>-1</sup>), straw yield (8,553 kg ha<sup>-1</sup>) and total biomass yield (16,868 kg ha<sup>-1</sup>) from blended fertilizers, whereas the lowest from the control treatment. Similarly, Abebaw and Hirpa (2018) also reported that application of blended fertilizer at a rate of 200 kg ha<sup>-1</sup> along with 63.91 kg ha<sup>-1</sup> urea gave the maximum tef grain yield as compared to control and recommended nitrogen and phosphorous fertilizer rate.

**Table3.** Polled means value of biomass yield, straw yield, grain yield and harvest index of maize crop as influenced by different rate of NPSB fertilizer application

Treatments (kg ha <sup>-1</sup> )	AGBM (kg ha <sup>-1</sup> )	SY (kg ha <sup>-1</sup> )	GY (kg ha <sup>-1</sup> )	HI%
Control	11758.0 <sup>c</sup>	8337.0 <sup>c</sup>	3421.3 <sup>d</sup>	29.2 <sup>abc</sup>

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Farmers Practice	19900.0 <sup>b</sup>	14421.0 <sup>b</sup>	5479.2 <sup>b</sup>	27.4 <sup>abc</sup>
100% of RNP (from TSP & Urea)	23013.0 <sup>ab</sup>	16494.0 <sup>ab</sup>	6518.6 <sup>b</sup>	29.2 <sup>abc</sup>
50% of RNP (from NPSB & Urea)	15433.0 <sup>c</sup>	10196.0 <sup>c</sup>	5236.9 <sup>c</sup>	34.4 <sup>a</sup>
100% of RNP (from NPSB & Urea)	24917.0 <sup>a</sup>	17619.0 <sup>ab</sup>	6481.6 <sup>b</sup>	26.3 <sup>c</sup>
150% of RNP (from NPSB & Urea)	25858.0 <sup>a</sup>	18435.0 <sup>a</sup>	8239.5 <sup>a</sup>	32.2 <sup>ab</sup>
CV	16.7	19.1	17.1	15
Isd @0.05	3881.1 <sup>**</sup>	3395.1 <sup>**</sup>	1181.0 <sup>**</sup>	5.9 <sup>**</sup>
Famer*treatment	ns	ns	ns	ns

*Note: AGBM, SY, GY and HI; above ground biomass, straw yield, grain yield and harvest index, respectively.*

### Economic Analysis

The result of the partial budget analysis is given in (Table 4). Maize production under NPSB and Urea fertilizer management involved different costs, which affected the total production cost that varied within each treatment. According, to results suggested that all treatments were economically feasible as the net benefit values (NBV) were greater than zero (NBV>0). But the maximum net benefit value (107113.50 ETB ha<sup>-1</sup>) with MRR of 9% was obtained from that application of 150% of recommended N and P from NPSB blended fertilizer and Urea sources (Table 4) and; these could be the best rate to apply for maize in area for maize producers. However, the minimum net benefit value (44476.90 ETB ha<sup>-1</sup>) and (71229.60 ETB ha<sup>-1</sup>) of were obtained from control and followed by farmers practice respectively.

**Table4.** Economic analysis for the effect of NPSB blended and conventional NP fertilizers application on maize production at Halaba district.

Treatments	AGY (kg ha <sup>-1</sup> )	TVC (Birr)	GFB (Birr)	NB (Birr)	MRR (%)
Control	3421.3	1375.00	45851.9	44476.9	--
Farmers Practice	5479.2	3825.00	75054.6	71229.6	10.9
100% of RNP (from TSP & Urea)	6518.6	7325.00	92066.8	84741.8	3.9
50% of RNP (from NPSB & Urea)	5236.9	3911.75	71991.5	68079.7	D
100% of RNP (from NPSB & Urea)	6481.6	6448.5	90709.3	84260.8	6.4
150% of RNP (from NPSB & Urea)	8239.5	8985.25	116098.8	107113.5	9.0

*Note: (1) AGY, TVC, GFB, NB, MRR and D are adjusted grain yield, total variable costs, gross field befit, net befit and marginal rate of return (%) and dominated, respectively; (2) Price of Urea, TSP and NPSB were =15.5, 19 and 16.5 birr kg<sup>-1</sup>, respectively;(3) Price of maize grain was 13 birr kg<sup>-1</sup>*

### 4. CONCLUSION AND RECOMMENDATIONS

In Ethiopia maize production and productivity have been low mainly due to declining soil fertility, unbalanced application of fertilizer through without soil test based and crop response and use of inappropriate fertilizer recommendations. Based on the study the maximum grain yield (8,240 kg ha<sup>-1</sup>), straw yield (18,435 kg ha<sup>-1</sup>) and biomass yield (25,858 kg ha<sup>-1</sup>) of maize was obtained from application 150% of recommended rate N and P from NPSB blended fertilizer and Urea sources. The economic analysis also indicated that the application of 150% of recommended rate N and P from NPSB blended fertilizer source gives net benefit values of (107, 113.50 ETB ha<sup>-1</sup>) with MRR of 9%. Therefore, from this study I conclude that application 150% of recommended rate N and P from NPSB blended fertilizer source was significantly improved maize yield and increases soil fertility by improving some essential soil nutrients at the site. Nevertheless, this is one season result, so further study should be done for two years to confirm and for wider applicability of the current finding.

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