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Blended fertilizers validation based on Ethio-sis soil fertility map at Halaba, Southern Ethiopia

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ABSTRACT

The drive for higher agricultural production without balanced use of fertilizers created problems of soil fertility exhaustion. Inorganic fertilizers have been the important tools to overcome soil fertility problems and also responsible for a large part of the food production increases. The experiment was conducted validate blended fertilizer to develop site and crop specific optimum rate recommendations based on Ethio-SIS soil fertility map in Halaba districts of southern Ethiopia, during the 2019 cropping season. The experiments were consisted of six treatments levels: (1) control, (2) farmers' practice (100 kg ha^{-1} of NPSB + 50 kg ha^{-1} of Urea), (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 arranged in randomized complete block design (RCBD) with three replications. Based on the study the result revealed that the grain yield, straw yield and biomass yield of maize was significantly ($p \leq 0.05$) affected by application of NPSB blended fertilizer rates. The maximum grain yield (8,240 kg ha^{-1}), straw yield (18,435 kg ha^{-1}) and biomass yield (25,858 kg ha^{-1}) of maize was obtained from application 150% of recommended rate nitrogen and phosphorous from NPSB blended fertilizer source. The economic analysis indicated that the application of 150% of recommended rate nitrogen and phosphorous from NPSB blended fertilizer source gives net benefit of 107113.50 Eth birr ha^{-1} with MRR of 9%. Therefore, application of NPSB blended fertilizer source was significantly improved maize yield and yield component and increases soil fertility by improving some essential soil nutrients at site.

Keywords: maize, grin yield and blended fertilizer

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 growth and will command the lead for many years to come. Since the Ethiopian agriculture is characterized by low production per unit area and poor agricultural practices, the country is facing a serious and chronic problem of food shortage. 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 appropriate amount and form fertilizer for site specific and crop (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). Improving food production and soil resources in the smallholder farm sector of Africa has become an enormous challenge (Dagne, 2016). Consequently, to restore soil fertility first, other efforts to increase crop production would end up with little success (Brady, *et al.* 2002) 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 plant nutrient imbalances not only of major but also of secondary macronutrient and micronutrients. The deficiencies of secondary macronutrient and micronutrient will arise if they are not replenished 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) found that the soil analyses and site-specific studies also indicated that elements such as 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 then, 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 areas 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 the 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 agronomic and economic optimum blended fertilizer rates for maize

MATERIALS AND METHODS

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.

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^{-1} of NPSB + 50 kg ha^{-1} 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.

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).

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^{-1}) for maize and the official prices of each fertilizer were used for analysis.

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.

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 soil 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 $sample^{-1}$ which is found at medium (London, 1991; Hazelton and Murphy, 2007) (Table 1).

Table 1. Soil physiochemical 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^{-1})	11.2	Medium	Olsen et al. (1954)
Sulfur (mg kg^{-1})	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^{-1})	12.8	Moderate	London (1991); Hazelton and Murphy (2007)

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

Table 2. Soil physiochemical properties after crop harvest

Treatments	pH	Av. P (ppm)	S (mg/kg)	% N	% OC
Control	5.85	12.82[b]	1.81	0.12	1.18
Farmers Practice	5.57	25.88[a]	2.43	0.11	2.01
100% of RNP (from TSP &Urea)	5.88	30.22[a]	3.52	0.12	1.78
50% of RNP (from NPSB & Urea)	6.22	27.60[a]	2.52	0.10	1.81
100% of RNP (from NPSB &Urea)	6.20	32.30[a]	3.44	0.14	2.33
150% of RNP (from NPSB &Urea)	6.16	31.82[a]	3.63	0.16	2.46
CV	7.2	19.8	29.4	17.1	25.5
lsd @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 ($p\leq0.01$) 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^{-1}, respectively (Table 3). The polled mean analysis revealed that the maximum above ground biomass (25,858 kg ha^{-1}), grain (8,240 kg ha^{-1}) and straw (18,435 kg ha^{-1}) 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, 34and 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 required for production of chlorophyll and utilization of phosphorus and other essential nutrients. Sulfur 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^{-1}), straw yield (8,553 kg ha^{-1}) and total biomass yield (16,868 kg ha^{-1}) from blended fertilizers, whereas the lowest from the control treatment. Abebaw and Hirpa (2018) also reported that application of blended fertilizer at a rate of 200 kg ha^{-1} along with 63.91 kg ha^{-1} urea gave the maximum tef grain yield as compared to control and recommended nitrogen and phosphorous fertilizer rate.

Table 3. Pooled 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^{-1})	AGBM (kg ha^{-1})	SY (kg ha^{-1})	GY (kg ha^{-1})	HI%
Control	11758.0^{c}	8337.0^{c}	3421.3^{d}	29.2^{abc}
Farmers Practice	19900.0^{b}	14421.0^{b}	5479.2b^{c}	27.4^{abc}
100% of RNP (from TSP &Urea)	23013.0^{ab}	16494.0^{ab}	6518.6^{b}	29.2^{abc}
50% of RNP (from NPSB & Urea)	15433.0^{c}	10196.0^{c}	5236.9^{c}	34.4^{a}
100% of RNP (from NPSB &Urea)	24917.0^{a}	17619.0^{ab}	6481.6^{b}	26.3^{c}
150% of RNP (from NPSB &Urea)	25858.0^{a}	18435.0^{a}	8239.5^{a}	32.2^{ab}
CV	16.7	19.1	17.1	15
lsd @0.05	3881.1	3395.1	1181.0	5.9
Site*treatment	ns	Ns	ns	ns

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

Economic Analysis

The economic analysis showed that application of 150% of recommended N and P from NPSB blended fertilizer and Urea provided relatively high net benefit and hence these could be the best rate to apply for maize in districts, respectively (Table 4). The highest economic return in maize production was provided from the farmers practice followed by application of 150% of recommended N and P from NPSB fertilizer (Table 4). According to economic analysis application of 150% of recommended rate nitrogen and phosphorous from NPSB blended fertilizer source gives maximum net benefit of 107113.50 Eth birr ha^{-1} with MRR of 9%. However, the minimum net benefit of were obtained from control and followed by farmers practice of the area.

Table 4. Economic analysis for the effect of NPSB blended and conventional NP fertilizers application on maize production at Halaba district.

Treatments	AGY (kg ha^{-1})	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^{-1}, respectively;(3) Price of maize grain was 13 birr kg^{-1}*

CONCLUSION

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^{-1}), straw yield (18,435 kg ha^{-1}) and biomass yield (25,858 kg ha^{-1}) of maize was obtained from application 150% of recommended rate N and P from NPSB blended fertilizer source at Halaba districts. The economic analysis also indicated that the application of 150% of recommended rate N and P from NPSB blended fertilizer source gives net benefit of 107, 113.50 Et birr ha^{-1} with MRR of 9% in maize production in Halaba area.

Therefore, 150% of recommended rate N and P from NPSB blended fertilizer source could be recommended for different wealthy groups of farmers. Thus, from this study I conclude that application of 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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REFERENCES

Abebaw Tadele Alem and Hirpa Legese. 20118. Effects of fertilizer rate (blended) and sowing methods on yield of bread wheat (*Triticum aestivum*) and its economic profitability in western Ethiopia**.** *Int. J. Compr. Res. Biol. Sci. (2018).5(7):1-14.*

Adediran, J. A. and J. O. Kogbe, 2003. Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savanna zone of Nigeria. *African J. Biotech*. 2: 345-349.

Asgelil D., Taye B., and Yesuf A. 2007. The status of Micro-nutrients in Nitisols, Vertisols, Cambisols, and FLuvisolss in major Maize, Wheat, Teff and Citrus growing areas of Ethiopia. In Proceedings of Agricultural Research Fund. pp 77-96.

Berhanu Debele, 1980. The physical criteria and their rating proposed for land evaluation in the highland region of Ethiopia. Land Use Planning and Regulatory Department, Ministry of Agriculture, Addis Ababa, Ethiopia.

Brady, N.C. and Weil, R.R. 2002. The Nature and Properties of Soils.13th edition. Pearson Education Ltd, USA.

CIMMYT. 1988. From agronomic data to farmer's recommendations: economics training manual. Completely revised edition, CIMMYT, Mexico. D.F. 79 pp.

CSA (Central Statistical Agency). 2016. Agricultural Sample Survey for the crop season. Vol. 5 report on Area and production Statistical Bulletin 578. FDRE/CSA, A.A, Ethiopia.

Dagne C. 2016. Blended fertilizers effects on maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries 5(5):151-162. doi: 10.11648/j.aff.20160505.13.

Don Ankerman, B.S. and Richard Large, *2015* Agronomy Hand book. Soil and Plant Analysis Midwest Laboratories, Inc pp,35.

Ethio-SIS (Ethiopia Soil Fertility Status). 2016. Fertilizer Recommendation Atlas of the Southern Nations, Nationalities and Peoples' Regional State, Ethiopia. pp 81.

Fageria, N. K. and V. C. Baligar. 2001. Improving nutrient use efficiency of annual crops in Brazilian acid soils for sustainable crop production. Commun. Soil Sci. Plant Anal. 32:1303–1319.

Hazelton, P., and B. Murphy, 2007. Interpreting soil test results: What do all the numbers mean 2nd Edition. CSIRO Publishing. 152p.

Hussain N, Khan M.A and Javed M.A. 2006. Effect of foliar application of plant micronutrient mixture on growth and yield of wheat (*Triticum aestivum L*.). Pak. J. Bio. Sci. 8:1096-1099.

Landon, J.R. 1991. Booker tropical soil manual Hand Book for soil survey and agricultural land evaluation in the tropical and sub tropics. Long man scientific and technical, ESSXEX, New York.474p.

Marschner H. 2002. Mineral nutrition of higher plants .2nd ed. Academic Press: London.674p.

SAS (Statistical Analysis System Institute). 2014. SAS Version 9.4 © 2002-2012. SAS Institute, Inc., Cary, North Carolina, USA.

Singh J, Bisen S, Bora DK, Kumar R, Bera B (2011). Comparative study of organic, inorganic and integrated plant nutrient supply on the yield of Darjeeling tea and soil health. Field Crop Research 58:58-61. Singh NI, Chauhan JS (2009). Response of French bean (Phaseolus Vulgaris L.) to organic manures and inorganic fertilizer on growth and yield parameters under irrigated condition. Natural Science 7(5):1-3.

Smaling, E. M. and A. R. Braun, 1996. Soil fertility research in sub-Saharan Africa: new dimensions, new challenges. Commun. Soil Sci. and Plant Anal. J. 27: 365-386.

Sumner, M.E. 2000. Handbook of Soil Science, CRC Press, Boca Raton, FL.

Tekalign Tadese. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa, Ethiopia.