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Evaluation of various blended fertilizer types and rates for better maize (*Zea mays*) crop production in Yeki woreda, Sheka Zone, South West Ethiopia

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ABSTRACT

Appropriate fertilization methods for a particular crop based on real limiting nutrients and crop demands are cost-effective and wise utilization of fertilizers for long-term agricultural productivity. An experiment was done to assess alternative fertilizer types and rates for better maize production during main cropping season of 2018 and 2019. The fertilizers were set depending on the study area's limiting nutrients, which include NPS and NPSB at various rates. There are seven treatments in the experiment: (1)no fertilizer; (2) NPS: 69N, $54P_2O_5$, 10S; (3) NPS: 92N, $72P_2O_5$, 13S; (4) NPS: 115N, $90P_2O_5$, 17S; (5) 69N, $54P_2O_5$, 10S, 1.05B NPSB; (6) 92N, $72P_2O_5$, 13S, 1.4B NPSB and (7) 115N, $90P_2O_5$, 17S, 1.7B NPSB. Treatments were placed out in a randomized complete block design and replicated three times on two farmers' fields. The study showed that using NPS mixed fertilizer had a substantial impact on maize output when compared to the control. Treatment 2 (NPS; 69N, 54p205, 10S) yielded significantly greater maize yield over control at ($P<0.05$). Similarly, with an appropriate marginal rate of return (128.2%), treatment 2 (NPS; 69N, $54P_2O_5$, 10S) had the largest net benefit (30908.5 ETB/ha). As a result, maize producers in the area of study should use NPS with the nutrient ratios of 69N, $54P_2O_5$ and 10S.

Keywords: Blended fertilizer, Fertilizer types, Fertilizer rate, Maize yield, Productivity, Economic feasibility

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Introduction

Maize (*Zea mays* L.) is one of the most significant food crops cultivated worldwide and it is Ethiopia's most important food crop in terms of volume and productivity. It is grown in almost every corner of the world under a wide range of conditions (Mandefro *et al*., 2002). Annual maize coverage in Ethiopia is at 2.11 million hectares (CSA, 2015). Despite the large areas are under cultivation in maize, the national average yield is around 3.2 t ha^{-1} (CSA, 2014). This yield is considerably lower than the global average yield of 5.21 t ha^{-1} (FAO, 2011).

It is becoming increasingly clear that site-specific fertilizer prescriptions are required. Fertilizer trials employing multi-nutrient blends that contain micronutrients, are uncommon. Moreover, there has been no investigation or justification of yield response to multi-nutrient fertilization. EIAR and RARIs have recently developed soil test-based fertilizer recommendations and calibration efforts, but only for a limited number of locations and crop varieties. The depletion of other nutrients such as K, Mg, Ca, S, and micronutrients may be increased by such unbalanced application of plant nutrients. Deficiency symptoms have been detected on main crops in several parts of the country. The use of low levels of N and P fertilizers on maize and beans was also identified to be the leading cause of nutrient depletion in eastern Uganda (Wortmann and Kaizzi, 1998).

In Ethiopia, in general, and in the SNNPRS in particular, there is no detailed investigation on soil nutrient losses; replenishment and balance have been conducted. This is considered to be the source of greatest gap between potential and actual yield. According to the findings of new study on Ethiopian soil maps, there is widespread nutrient deficiency (Ethio-SIS, 2016). A number of formulas containing these nutrients are available for different regions of the country. The main deficit nutrients suggested for SNNPR in general and in the research area in particular are NPSB and NPS. As a result, the purpose of this study was to evaluate how different types and rates of blended (NPS and NPSB) fertilizers affect yield and yield components of Maize.

Materials and Methods

The study was carried out by the Bonga Agricultural Research Centre in Southwest Ethiopia. Yeki District is situated in Southwest Ethiopia State, at an elevation of 1200 meters above sea level, in a latitude of 7°10′54.5′′ and a longitude of 35°25′04.3′′ East of Ethiopia, around 611 kilometers southwest of Addis Ababa. The area's mean annual rainfall is 1559 mm, and it has a hot to moderate humid lowland agro-ecology with maximum and minimum temperatures of 29.7°C and 15.5°C, respectively, and it is dominated by Nitisols (IFPRI, 2010). The experiment was based on the area's nutrient shortage, as shown on an Ethiopian soil fertility map created by the Ethiopian soil information system (Ethio-SIS, 2016). As a result, different rates of two types of blended fertilizers (NPS & NPSB) were used.

Experimental layout

The experiment includes seven treatments: no fertilizer, 150 kg NPS + 75 kg urea, 200 kg NPS + 125 kg urea, 250 kg NPS + 175 kg urea, 150 kg NPSB + 75 kg urea, 200 kg NPSB + 125 kg urea, 250 kg NPSB + 175 kg urea and these were replicated three times in RCBD arrangement. The plot was 3m by 3m in size. The blocks and plots were separated by 1.0 and 0.5 m pathways, respectively, to avoid treatment mixing. At planting time, all doses of NPS, NPSB and 60 K2O fertilizers were applied and a half dose of urea as a nitrogen source was top-dressed 40 days later. SHONE, an improved maize variety was planted in rows with all agronomic procedures as recommended for the crop.

Agronomic and economic analysis

Agronomic data for maize were collected, including plant height, cob length, total biomass, grain yield and 100 seed weight. Proc GLM methods in SAS 9.3 was used to do variance analysis on all data (SAS Institute Inc., Cary, NC USA). To determine the significance of differences between means, the least significant difference (LSD) at the 5% probability level was used.

The economic feasibility of the two fertilizer types (NPS and NPSB) for maize production was investigated using an economic analysis. The partial budget, dominance, and marginal rate of return were computed. For partial budget analysis, average yield was modified downwards by 10%, expecting that farmers would get 10% less output than on an experimental site. The study employed the average open market price for maize (5 Ethiopian Birr (ETB)/kg) and the official prices for NPS (11.12 ETB/kg), NPSB (12 ETB/kg), and N as Urea (10 ETB/kg). The lowest acceptable marginal rate of return for a treatment to be considered a good alternative for farmers should be more than 50% (CIMMYT, 1988). However, Gorfuet *al.* (1991) suggested that a minimum acceptable rate of return be 100%. As a result, the study's minimum allowable marginal rate of return is 100 percent.

Results and Discussion

Soil Physico-chemical properties of the experimental site before sowing

The site's textural class was clay, with a particle size distribution of 12.5% sand, 23.4 percent silt, and 63.9 percent clay. According to Tekalign (1991), the experimental site of the study area was moderately acidic with a pH value of 5.8 (Table 1). The pH of the soil between (5.8 -7.2) was found within the suitable range for crop production (Sahlemedhin and Taye, 2000). So that the pH level of the study site is found within a suitable range for maize production. The site's cation exchange capacity was very high (42.95 meq/100mg) (Landon, 1991). It is known that soils with heavy clay texture are high in cation exchange capacity. The experimental site was medium in total nitrogen and low in organic carbon (Landon, 1991). According to Landon (1991), available phosphorus of the site was medium and this medium phosphorus content of the site might be due to the moderate acidic condition of the site. Exchangeable potassium of the experimental site was very high (Landon, 1991) and optimum available sulfur (64.6 Mg S/Kg) according to Ethio-SIS (2016).

Table 1. Soil Physico-chemical properties of the experimental site before sowing.

Soil parameters	Unit	Value	Rates
Particle size distribution			
%sand	12.5	--	--
% silt	23.4	--	--
%clay	63.9	---	---
Textural class	Clay		
pH(H_2O)		5.80	Moderately acidic
Organic carbon	%	1.30	Low
CEC	Meq/100mg	42.95	Very high
Total nitrogen	%	0.18	medium
Available phosphorus	Mg P_2O_5/Kg	20.68	medium
Exchangeable K	(cmol $_{(+)}$ kg^{-1})	0.69	high
Available sulphur (Av.S)	Mg S/Kg	64.60	optimum

Mean yield and yield components of maize

The result of this study revealed that application of both fertilizer type and rates significantly ($p<0.05$) improves all measured parameters in comparison to control. The rate of NPS blended fertilizers had a significant ($p <0.05$) effect on maize grain and biomass yield. The application of NPSB blended fertilizer at the rate of 115N, 90P_2O_5, 17S, 1.7B (250 kilogram NPSB +175 kg urea ha^{-1} top dressed) and the control (unfertilized) yielded the highest (8259 kg ha^{-1}) and least (4963 kg ha^{-1}) average grain yields, respectively. The mean grain yield rose by 66.8 percent as compared to the control. This increase suggests an insufficient degree of soil fertility in the study area for maize production. This is consistent with the results of Tollesa *et al.* (1993), who stated that while the adoption of new varieties, particularly maize hybrids, is accelerating in Ethiopia, fertilizer management techniques needed to supplement the varieties' existing potential. Additionally, biomass yield is increasing in the same manner as grain yield when the rate of NPS fertilizer was raised from 0 to 150 kg ha^{-1}, cobe length raise by 13.7%. Increasing the NPS or NPSB fertilizer rate above this level had no effect on this parameter (Table 2).

Plant height was significantly affected by the rate of NPS blended fertilizer as compared to the control (unfertilized). The highest Plant height (2.5 meter) was obtained from plots treated with treatment 2 (69N, 54P_2O_5, 10S) but the lowest is (2.1 meter) was from unfertilized. The lowest plant height in unfertilized plots might be attributed to the research area's poor soil fertility level. Similar to this, Tekle and Wasse's (2018) research revealed that applying blended fertilizer significantly improves plant height compared to control

Plant growth and development may be substantially reduced if any of the nutrient elements is less than its threshold level in the soil or is not appropriately balanced with other nutrient elements, according to the findings of this study (Landon, 1991). This indicates that the application of NPS blended fertilizer has enhanced maize vegetative growth. The rate of NPS fertilizers had a significant ($p < 0.05$) effect on 100 seed weight, according to the results of the analysis of variance. The 100 seed weight rose from 38.3g to 41.4g when the NPS rate increased from 0 to 69N, 54P_2O_5, 10S kg ha^{-1}. This finding is consistent with Tekulu *et al.* (2019), who discovered that blended fertilizer rates had a substantial impact on maize seed weight when compared to the control. For the rate of (blended) NPS fertilizer applied above this level, this parameter was unaffected.

Table 2. Mean yield and yield components of blended fertilizer evaluation on maize.

Treatment	Plant height	Cobe length	TSW(g)	BM(kg ha^{-1})	GY(kg ha^{-1})
T1. No fertilizer	2.1b	16.7b	38.3b	1459.07c	4963.0c
T2. NPS = (69,54,10)	2.5a	19.0a	41.4a	16452.0b	7407.0b
T3. NPS = (92,72,13)	2.5 a	19.3a	41.8a	16674.7b	7777.8ab
T4. NPS = (115,90,17)	2.5 a	19.3a	40.9a	16780.0b	7740.8ab
T5. NPSB =(69,54,10,1.07)	2.5 a	19.4a	41.0a	17896.0a	7889.0ab
T6. NPSB = (92,72,13,1.4)	2.6 a	19.7a	41.1a	18226.7a	7814.0ab
T7. NPSB= (115,90,17,1.7)	2.5 a	20.3a	40.9a	18488.0a	8259.0a
Mean	2.4	19.1	40.7	17016.5	7407.0
C.V (%)	4.7	9.2	5.1	2.5	6.0
LSD	0.2	1.6	1.9	697.0	721.0

N.B: TSW- Thousand seed weight BM-biomass, GY-grain yield

Economic analysis

According to a partial budget analysis, applying NPSB blended fertilizer at a rate of 150 kg NPSB + 75 kg urea ha^{-1} top dressing gave maximum net benefit (32950.5 ETB/ha) followed by treatment 2 (NPS 150 kg +75 kg urea) with the net benefit (30908.5 ETB ha^{-1}) with acceptable marginal rate of return. However, the least net benefit (22333.5 ETB) was obtained from control/unfertilized. The dominance analysis found that, with the exception of treatments 2 and 5, all treatments were cost dominated (Table 3).

Thus, NPSB blended fertilizer at a rate of 150 kg + 75 kg urea per hectare is a cost-effective rate for maize production in the study area. In addition, application of NPS blended fertilizer at the rate of 150 kg + 75 kg urea ha^{-1} could be optionally used since it is the second highest net benefit with acceptable MRR.

Table 3. Economic (partial budget and dominance) analysis of fertilizers on maize at Yeki woreda.

	Treatments	Av. yield kg ha^{-1}	Adj. yield kg ha^{-1}	Gross benefit	Tvc	Net Benefit	MRR %
1	Control	4963	4467	22333.5	0	22333.5	
2	150 kg NPS + 75 kg urea	7407	6666	33331.5	2423	30908.5	128.2
5	150 kg NPSB + 75 kg urea	7889	7100	35500.5	2550	32950.5	106.2
3	200 kg NPS + 125 kg urea	7778	7000	35000.1	3480	31520.1	D
6	200 kg NPSB + 125 kg urea	7814	7033	35163.0	3650	31513.0	D
4	250 kg NPS + 175 kg urea	7741	6967	34833.6	4538	30295.6	D
7	250 kg NPSB + 175 kg urea	8259	7433	37165.5	4750	32415.5	D

Conclusion and Recommendation

The experimental site is clay in texture and moderately acidic with 5.8 pH value. In addition, it is medium in total nitrogen and available phosphorus. This research revealed that applying deficient soil nutrients nitrogen, phosphorus, and sulfur indicated in the area's soil fertility map (Yeki) increased maize yield. According to the findings of the study, the application of different blended fertilizer rates had a significant effect on all measured parameters. Plots received NPSB blended fertilizer 150 kg + 75 kg urea to dressing per hectare gave significantly higher maize yield (7889 kg ha^{-1}) compared to control. In addition, plots treated with NPSB (150 kg + 75 kg urea top-dressed) gave the highest net benefit (32950.5 ETB ha^{-1}) with an acceptable marginal rate of return (106.2%), which was greater than the experiment's minimum acceptable marginal rate of return (MRR) (100 %).

As a result, NPSB in the ratios of 69N, 54P2O5, 10S, and 1.07B (150 kg NPSB + 75 kg urea top dressing ha^{-1}) is advised as the optimum alternative for maize production near Yekiworeda (Beko and Hibret fire kebele). In addition, NPS 69N, 54P2O5, and 10S and (150 kg NPS and 75 kg urea top-dressed ha^{-1}) can be utilized as alternatives.

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Conflict of interest

The authors declare that the publishing of this paper does not include any conflicts of interest.

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