Journal of Scientific and Innovative Research 2022; 11(4): 80-83
Available online at: www.jsirjournal.com

Research Article

ISSN 2320-4818
JSIR 2022; 11(4): 80-83

Received: 17-10-2022
Accepted: 01-12-2022

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Evaluation of blended fertilizer rate for better production of maize at Siltie Zone Sankura Woreda

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DOI: 10.31254/jsir.2022.11404

Abstract

For sustainable crop production, the use of right fertilizer type at right amount based on crop need has a substantial significance. A field experiment was conducted for two consecutive years (2018 and 2019) to identify the best fertilizers formulae and rate for production of maize at Silte Zone Sankura Woreda. Nine different fertilizer types and rates were laid out in randomized complete block design (RCBD) replicated three times. Treatments were fixed based on limiting nutrients (NPSB) of the area identified by Ethiosis. The treatments are; Control (no fertilizer), 150 kg NPSB+41 kg urea-top dress/ha, 2 00 kg NPSB+72 kg urea-top dress/ha, 250 kg NPSB+102 kg urea-top dress/ha ,100 kg NPSB + 260 kg urea top dressing, 150 kg NPSB+41 kg urea-top dress/ha+ Cu foliar application, 200 kg NPSB+72 kg urea-top dress/ha + Cu (FA) ,250 kg NPSB+102 kg urea-top dress/ha) + Cu (FA) ,100 kg NPSB + 260 kg urea top dressing + Cu (FA). Statistically significant effects ($P<0.05$) were observed on yield parameters studied due to applied fertilizers while growth parameters were not significantly affected. The highest grain yield (6689 kg/ha) was obtained from treatment application of 100 kg NPSB + 260 kg urea top dressing + Cu. The economic analysis also revealed that application of 100kg NPSB+260kg urea top dressed + Cu resulted with the highest net return of 43344.5 Eth-birr ha^{-1} with MRR having lowest total cost compared to others. Therefore, based on yield response and economic analysis application of 100kg NPSB+260kg urea top dressed + Cu is recommended for Sankura Woreda.

Keywords: Blended fertilizer, Maize yield, Net return.

INTRODUCTION

Ethiopia's economy is based on agriculture, which accounts for 40% of the gross domestic product (GDP) and 85% of the employment [1]. However, the sector has been characterized by low productivity, mainly caused by low soil fertility and absence of balanced fertilization and relevant soil management practices. Maize is first in productivity and second in area coverage after teff in the country [2]. In spite of large area coverage, the national average grain yield is about 3.67 t ha^{-1} [3]. This yield is below world's average which is about 5.6 t ha^{-1} [2]. It is widely produced in southern Ethiopia particularly Siltie Zone Sankura Woreda [3]. However, yield amount gained by small scale farmers remained low despite the availability of improved varieties [4].

The major cause for this contradiction is the low use of external inputs which led to negative balances for major nutrients [5] and it might have worse the depletion of K, S, Zn and B nutrients in soils as identified by EthioiSIS. Application of micronutrients (Zn and B) in combination with macronutrients (NPK) has highly significant effect to improve nutrient concentration and uptake [6]. However, major impediment to increase fertilizer use efficiency in the country has been lack of information about the fertility status of the agricultural land.

Applying fertilizers based on initial soil fertility status and crop requirement leads to economic and efficient use. Recommendation of site and crop specific fertilizers to increase agricultural production and productivity of Ethiopian farmers was not based on adequate knowledge of nutrient status of the agricultural soils [7]. The problem has been recognized by the government and a national land resource and soil fertility mapping work has been undertaken by the EthioSIS project of the Agricultural Transformation Agency (ATA). The major blended fertilizer recommendations by MOA and ATA for Sankura Woreda are NPS, NPSB, NPSZnB and NPSBCu [7]. Although the types of blended fertilizers in general are identified for the South Nations Nationalities and Peoples Regional State (SNNPRS), the atlas doesn't contain information about recommended fertilizer application rates for specific crops, agro ecologies and soil types. Therefore, the current study was conducted to identify the best fertilizer formulae and rate for production of maize at Sankura Woreda.

MATERIALS AND METHODS

An experiment was conducted at Sankura woreda of SNNPRS during 2018/19 and 2019/20 under rain fed condition. The research site is situated at 7º 33′10.4" N and 38º 10′38" E latitude and longitude, respectively and at an altitude of 1876 m.a.s.l. In 2018 and 2019 cropping seasons, the area received annual rainfall of 1760.4 and 1252 mm, respectively and its distribution pattern is bi-modal. The annual mean maximum temperatures of the two years were 28.12 and 27.2 ^{0}C while the mean minimum temperatures are 8.2 and 7.4^{0}C, respectively.

The experimental design and treatments

The experiment was arranged in randomized complete block design and replicated three times on farmers training center (FTC). The experimental site was prepared using standard cultivation practices and was plowed using Oxen four times before planting. The experiment consisted of nine treatments including control treatment. The blended fertilizer rates consisted of eight levels of NPSB (100,150, 200, and 250 kg ha^{-1}) with and without addition of copper. N content of blended fertilizer of NPSB is small thus, N rates were adjusted to recommended rate using urea. The full dose of blended fertilizer was applied at planting close to seed while urea was applied in splits; 1/3 of the total at planting and the rest after 35 days of planting. Copper was applied as copper sulfate by foliar application 650 gm/ha base. The plot size was 4 m × 4.5 m (18 m^2) and the spacing between rows and plants were 0.75 and 0.3 cm, respectively. Improved maize variety, *Shone*, seeds were sown between last week of August and first week of May by drilling along the rows at a seed rate of 30 kg ha^{-1}. Other agronomic practices were done as per the recommendation of the crop.

Table 1: Treatment arrangement

Treatments (kg ha^{-1})	Nutrient rates per hectare				
	N	P_2O_5	S	B	Cu
Control	0	0	0	0	0
150 kg NPSB (F2)+ 41 kg urea TD	69	54	10	1.07	0
200 kg NPSB (F2) + 72 kg urea TD	92	72	13	1.4	0
250 kg NPSB (F2) + 102 kg urea TD	115	90	17	1.7	0
100 kg NPSB (F2) + 260 kg urea TD	138	36	10	1.07	0
150 kg NPSB (F2) + 41 kg urea TD + Cu (FA)	69	54	10	1.07	
200 kg NPSB (F2) + 72 kg urea TD + Cu (FA)	92	72	13	1.4	
250 kg NPSB (F2) +102 kg urea TD + Cu (FA)	115	90	17	1.7	
100 kg NPSB (F2) + + 260 kg urea TD + Cu (FA)	138	36	10	1.07	

While TD= top dressing, FA= foliar application

Soil sampling and analysis

Soil samples of the study site were collected from 0-20 cm depth to make a composite sample before planting and analysed for selected physicochemical properties at laboratory of Areka Agricultural Research Center. Soil particle size distribution was determined using the Bouyoucos hydrometer method [8]. The pH of the soil was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter as described by [9]. Organic carbon (%) was determined by wet oxidation method as described by [10]. Available P was analysed by Olsen method [11] and total nitrogen was measured using Kjedahl method as described by [12]. Exchangeable K^+ was determined following Mehlich-3 extraction method as described by [13].

Crop Data collection and analysis

Agronomic data collected were plant height (cm), number of seed per cob, number of cob per plant, biomass yield (kg ha^{-1}) and grain yield (kg ha^{-1}). Yield and yield related parameters collected on plot basis were converted to ha^{-1} and subjected to statistical analysis of variance (ANOVA) using SAS version of 9.0 [14]. Significant difference between and among treatment means were assessed using the least significant difference (LSD) at 0.05 level of probability.

Economic Analysis

To estimate the economic feasibility of blended fertilizers, partial budget analysis was performed based on the field price of the grain. The actual yield gained from the experimental plot was adjusted downward to 10 % to assess the expected yield at farmers' fields with farmer's practices [15]. All costs that vary were included. The market cost of maize was 8.15 Ethiopian Birr (ETB) kg in 2020. The fertilizer cost was calculated for each fertilizers, Urea (12.90 Birr kg^{-1}), NPSB (14.14 Birr kg^{-1}) and copper sulfate was 22.50 Birr kg^{-1}. Cost of land preparation to post-harvest, and others were assumed to remain the same among the treatments. Analysis of marginal rate of return (MRR %) was carried out for non-dominated treatments, and the MRRs were compared to a minimum acceptable rate of return (MRR) of 100% in order to select the optimum treatment [15]. The net benefit per hectare for each treatment is the difference between the gross benefit and the total Variable costs.

RESULT AND DISCUSION

Physo-chemical properties of soil at the experimental site

The experimental soils were clay loam in texture with average proportion of sand, silt and clay (22, 40 and 38% respectively), which is a good textural class for maize [16]. The average pH (H_2O) value was 5.93 showing that the soil is moderately acidic according to [17]. Soil having pH value above 5 is suitable for availability of essential nutrients [18] thus the experimental soil pH was right for maize production without adding any amendments. The organic carbon content of the experimental soil (2.92%) is low in accordance with [19]; the total nitrogen content (0.2%) of the experimental soil was medium according to [17]. Available P of the experimental site was 7.25 mg kg^{-1} and could be considered as medium according to [19], On the other hand, according to [20] the K status of the soil is in the range of low.

Table 2: Characteristics of experimental soils before planting at depth of 0–20 cm

Soil properties								
pH	OC%	TN %	P(mg kg^{-1})	Exc. K(mg kg^{-1})	Texture	Clay	Sand	Silt
5.93	2.92	0.2	7.25	94.81	clay loam	38	22	40

Growth parameters

Analysis of variance showed that application of different rates of blended fertilizer had significant influence (P <0.01) on plant height, number of cop per plant and cop length (Table 3). The highest plant height (2.74m) was obtained from application of 250 NPSB + 102 urea Kg ha^{-1}. The lowest plant height was recorded from application of NPSB at a rate of 150 kg ha^{-1} with and without copper, and no significant difference was observed with the control plot. Increment in plant height might be due to increase in vegetative growth and cell elongation attributed to applied nutrient via the blended fertilizer. Especially nitrogen plays a great role in plant growth. This result is also in agreement with that of [21] who mentioned significant increment of plant height due to application of blended fertilizers and blanket NP recommendation as compared to the control. However, supplementation of Cu with blended fertilizer did not bring a significant difference in plant height. This result is in line with [22] who reported non-significant effect on plant height of addition of Cu and Zn. The highest number of cop per plant (1.33) was obtained from application of 250 NPSB + 102 urea Kg ha^{-1}. The maximum (29.93 cm) and minimum ear length were obtained from application 100 NPSB + 260 urea kg ha^{-1} and the control, respectively (Table 3). The effect of blended fertilizer application significantly (P ≤0.01) affected ear length of maize. However, there was no significant difference in ear length among plots treated with different blended fertilizer rates with and without Cu application.

Yield and yield components

The analysis of variance showed that application of different rates of blended fertilizer had significant influence (P <0.01) on above ground biomass. Significantly higher biomass yields were recorded in all plots treated with blended fertilizers compared to the control. As a result, maximum above ground biomass (16318 Kg ha^{-1}) was recorded from application of 100 NPSB+260 urea kg ha^{-1} + Cu fertilizer and the lowest result recorded from the control. The second lower result was recorded from application of 150 NPSB+41 urea kg ha^{-1} with and without copper. On the other hand, these rates had higher yields compared to the control plots. Statistically similar result was recorded among plots that received blended fertilizer of 100, 200 and 250 kg ha^{-1} with and without copper application. This might be due to the fact that maize enormous requirement of nitrogen compared to all other essential nutrients. Therefore, the low result in unfertilized plots might have been due to smaller radiation interception because of reduced leaf area development which also limits the efficiency in the conversion of solar radiation to continue efficient photosynthesis. In line with the present result, [21] obtained significantly lowest biomass yield of maize crop when no fertilizer is applied.

Analysis of variance indicated that grain yield of maize was highly significantly (P <0.01) affected by blended fertilizer rates (Table 3). The control plot had significantly lower yield (2058.4 kg ha $^{-1}$) as compared with the eight rates of NPSB with and without copper application. But, there was no significant variation recorded among four rates of blended fertilizer; 200, 250, 100 kg ha^{-1} NPSB without copper and 100 kg ha^{-1} NPSB with copper. Accordingly, the highest grain yield (6689 kg ha^{-1}) was obtained from application of 100 kg NPSB + 260 kg urea + Cu) ; and the lowest from the control. This result is in line with [21] who found that application of 300 kg NPSZnB ha^{-1} resulted in maximum yield, but, statistically comparable with others due to Nitrogen adjustment to 64 kg N ha^{-1} for all treatments. [22] also verified that application of blended fertilizer in maize crop brought significantly highest grain yield as compared to unfertilized plot. However, the result also revealed that application of copper had no significant effect on yield, thus plots treated with same blended fertilizer rate with and without copper were not significantly different from each another. Thus, it is possible to say that soil of the area is not deficient in copper.

Table 3: Growth and yield parameters of maize crop under the effect of different blended fertilizer rates.

Treatment	Ph (m)	Cp	Cl (cm)	Bm (Kg ha^{-1})	Yl (Kg ha^{-1})
Control	2.63ab	1.03c	28.46b	11243c	3065e
150KgNPSB+41kgurea TD	2.62b	1.00c	29.56ab	13298b	5292d
200KgNPSB +72 Kg urea TD	2.65ab	1.06bc	29.9a	15394a	6114ab
250 kg NPSB +102Kg urea TD	2.74a	1.33a	29.70ab	15440a	6405ab
100kg NPSB+260kg urea TD	2.71ab	1.26ab	29.60ab	15902a	6579ab
150 Kg NPSB + 41 Kg urea TD + Cu	2.62b	1.03c	29.50ab	13517b	5460cd
200Kg NPSB +72 kg urea TD + Cu	2.68ab	1.16abc	28.6ab	16112a	6005bc
250 kg NPSB+102 kg urea TD + Cu	2.66ab	1.3a	29.86a	14809ab	6052bc
100 kg NPSB + 260 kg urea TD + Cu	2.64ab	1.2abc	29.93a	16318a	6689a
Lsd	0.11	0.2	1.35	1602	617
Cv	3.7	14,90	3.92	9.31	9.16

Mean values followed by the same letters in each column and treatment showed no significant difference not significantly different at p≤5% level of significance; Lsd: least significant difference at 5 % level ,CV; Coefficient of variation, TD; top dressing, Cu; copper, Ph; plant height, Cp; cop per plant, Cl; cop length, Bm; above ground biomass, Gy; grain yield.

Economic Analysis

The market price of maize grain and fertilizer were calculated while the cost of other production practices like seed and weeding were assumed to remain the same or comparable among the treatments. The highest net return of 43733.41 Eth-birr with MRR value of (334.04 %) was obtained from plot treated with 100kg NPSB+260kg urea top dressed, making it economically superior and more profitable than the rest of the treatments (Table 2). It is fair to anticipate that farmers would be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return (100 %).

Table 4: Dominance analysis of Maize experiment influenced by different blended fertilizers Types and Rate

Treatments	Av. Yield	Adj. yield	GB (EB/ha)	TCV (EB/ha)	NB (EB/ha)	MRR (%)
1.control	3065	2758.5	22481.8	0	22481.8	----
2.150KgNPSB+41kgurea TD	5292	4762.8	38816.8	2649.7	36167.1	516.48
6.150 Kg NPSB + 41 Kg urea TD +Cu	5460	4914	40049.1	3212.24	36836.8	D
3.200KgNPSB +72 Kg urea TD	6114	5502.6	44846.2	3755.4	41090.8	783.18

7.200Kg NPSB +72 kg urea TD +Cu	6005	5404.5	44046.7	4319.07	39727.6	D
5.100kg NPSB+260kg urea TD	6579	5921.1	48256.9	4767.87	43489.1	838.13
4.250 kg NPSB +102Kg urea TD	6405	5764.5	46980.7	4850.47	42130.2	D
9.100 kg NPSB + 260 kg urea TD + Cu	6689	6020.1	49063.8	5330.41	43733.4	334.04
8.250 kg NPSB+102 kg urea TD + Cu	6052	5446.8	44391.4	5413.08	38978.41	D

Av. G= average yield, Adj. G= adjusted yield kg ha^{-1}, TVC= Total Variable Cost, MRR%: marginal rate of return, D= dominated

CONCLUSION AND RECOMMENDATION

For sustainable crop production, the use of right fertilizer type at right amount based on crop need has a substantial significance. The experiment was done to evaluate the effect of different rates of blended fertilizer on yield and yield component of maize in Siltie zone at Sankura district. The finding of the experiment showed that the yield and yield component of maize respond positively on the application of blended fertilizer. The maximum yield (6689Kg ha^{-1}) was obtained from application of 100 NPSB + 260 urea kg ha^{-1}. In addition, the highest net benefit (43733.41Eth.birr ha^{-1}) with a marginal rate of return (334.04 %) was obtained from application of 100 NPSB+260kg ha^{-1}urea. Therefore application of 100 NPSB+260kg ha^{-1} urea is recommended for maize production in Sankura Woreda.

Conflict of interest

None declared.

Financial support

None declared.

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