Advanced Techniques in Biology & Medicine

Tamene et al., Adv Tech Biol Med 2018, 6:1
DOI: 10.4172/2379-1764.1000253

Research Article Open Access

Refining Fertilizer Rate Recommendation for Maize Production Systems in Assosa, North Western Ethiopia

Dessalegn Tamene, Bekele Anbessa, Tigist Adisu Legesse* and Getahun Dereje

Ethiopian Institute of Agricultural Research, Soil Science, Benshangul Gumuze Regional State, Assosa, Ethiopia

***Corresponding author:** Tigist Adisu Legesse, Ethiopian Institute of Agricultural Research, Soil Science, Benshangul Gumuze Regional State, Assosa, Ethiopia, Tel: 251+09 13043518; Asst: 09 12 7707 75; E-mail: wowtigistadisu@gmail.com

Received date: December 26, 2017; **Accepted date:** January 15, 2018; **Published date:** January 22, 2018

Copyright: © 2018 Tamene D, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Maize growers need balanced crop nutrition to maximize its yield potential and get the most out of their fertilizer investment. In practice, this requires making all of the required nutrients available to the maize crop by the right amount or rate. The objectives of this study was to determine optimum N, P, K and S response curve under balanced fertilization and to establish economic mixes blended fertilizers and determine soil, crop specific optimum N, P, K and S fertilizers rates for maize crop grown in Assosa areas. The experiment was conducted using randomized complete block design (RCBD) with three replications consisting of a total of 8 treatments for N, P, K and 10 treatments for S. Therefore; the result revised that the N level was highly significant (P<0.05) on grain yield. The highest grain yield (7292.5 kg ha^{-1}) was obtained at the lowest nitrogen rate with balanced fertilizer of 46 kg N ha^{-1}+PKSZnB while significantly the lowest grain yield (3298.6 kg ha^{-1}) was records from control. The application of 69 kg ha^{-1} P resulted in grain yield increases, aboveground biomass yield was also affected in the same amount of P with balanced fertilizers having increased biomass yield with P application. Even if the ANOVA results shows significant difference on that of treated with K fertilizer, there was slight variation within treatments except the highest rates of K fertilizer. Across the S rate studies, all S rates with balanced fertilizers had a statistically significant yield increment from the control and Recommended NP. From the across-treatment yield increase, treatment 10 Kg S ha^{-1}+NPKZnB gives maximum yield (6717.7 kg ha^{-1}). Analyzed across S rate, the economic optimum S rate was also 10 Kg S ha^{-1} for the clay textured soils of Assosa.

Keywords: Blended fertilizer; N, P, K and S rate; Maize production

Introduction

Maize is one of the most important cereals cultivated in Ethiopia. It ranks second after tef in area coverage and first in total production. The results of the year 2015/2016, Meher season post-harvest crop production survey indicate that total land areas of about 12,486,270.87 hectares were covered by grain crops. Out of the total grain crop areas, 79.88% (9,974,316.28 hectares) was under cereals. Of this maize covered 21.17% (about 2,111,518.23 hectares) and gave 71,508,354.11 ton of grain yields (CSA, 2015/2016) [1,2].

Despite the large area under maize, the national average yield of maize is about 3.39 t ha^{-1} (CSA, 2016). This is by far below the world's average yield which is about 4.77 t ha^{-1} (FAO, 2011) [3].

The low productivity of maize is due to inappropriate cropping systems, mono-cropping, nutrient mining, unbalanced nutrient application, removal of crop residues from the fields and inadequate re-supplies of nutrients have contributed to decline in crop yields [1]. One of the major problems constraining the development of an economically successful agriculture is nutrient deficiency [2]. It is estimated that some 30 to 50% of the increase in world food production since 1950s is attributable to fertilizer use.

Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer uses on other have favored the emergence of multi nutrient deficiency in Ethiopian soils that in part may contributed to fertilizer factor productivity decline experienced over recent past.

Current fertilizer recommendation in Ethiopia is based on very general crop specific guidelines or more often, a single recommendation for all crops (100 kg DAP (18-46-0) and 100 kg Urea (46-0-0). This blanket recommendation often fails to take into consideration differences in resource endowment (soil type, labor capacity, climate risk) or make allowances for dramatic changes in input/output price ratio, thereby discouraging farmers from fertilizer application. Moreover, the nutrients in the blanket recommendation are not well balanced agronomically and its continued use will gradually exhaust soil nutrient reserves. Therefore neither yields nor profits can be sustained using imbalanced application of fertilizers, as the practice results in accelerating deficiencies of other soil nutrients. Since absence of one or more nutrients besides N and P can depress yield significantly. This could explain, in part, the modest crop yield improvements observed over the last few decades in contrast to significant increases in fertilizer use and investment made in the country. Today, in addition to N and P, S, B and Zn deficiencies are widespread in Ethiopian soils, while some soils are also deficient in K, Cu, Mn and Fe.

To overcome the constraint of low nutrient recovery and optimize fertilizer use, there is need to replace such general and over-simplistic fertilizer recommendations with those that are rationally differentiated according to agro-ecological zones (soils and climate), crop types, nutrient uptake requirements and socio-economic circumstances of farmers. Better matching fertilizer application recommendations to local climate, soil, and management practices helps ensure that production can be intensified in a cost-effective and sustainable way and, thereby, enhance regional food security.

The concept of balanced fertilization paves the way for optimum plant nutrient supply to realize full yield potential of crop. However, continuous use of imbalance fertilizers causes decline in soil fertility and yield reduction. Keeping these points in view, the present study was undertaken to investigate the effect of N, P, K and S fertilizers under balanced fertilization for higher yield of maize and soil fertility in Assosa soil type of Nitisols, which is one of the major maize growing soils in Benishangul Gumuz of Assosa area.

Materials and Methodology

Description of the study area

Field experiment was conducted at Assosa Agricultural Research Center (AsARC), on Assosa District during main cropping season (April to December for three consecutive years (2014-2016). AsARC is found at 680 km far from Addis Ababa to the North West direction. Geographically, it is located at 10°02'468"N Latitude and 34°34'266"E Longitude with an altitude of 1560 m above sea level. Agro-climatically, it has been characterized by hot to warm moist lowland plain with uni-modal rainfall distribution pattern. Average annual rainfalls of maximum were 1358 mm and minimum 1128.5 mm received between May and October during the cropping season [4].

Treatments and experimental design

The fertilizer treatments considered in the study was consist of different levels of N, P, K & S fertilizers under balanced fertilization with recommended NP as a positive control. The experiment was conducted using randomized complete block design (RCBD) with three replications consisting of a total of 8 treatments for N, P, K and 10 treatments for S. Plot sizes of $5.1^*3.75$ m were used.

The experimental fields were prepared by using oxen plow in accordance with conventional farming practices followed by the farming community in the area where, the fields were plowed three times. The gross plot size was 19.125 m^2 (5.1 m × 3.75 m) that accommodated seven maize plants per rows as an experimental unit with $4.75^*3.6$ m net plot. Hybrid maize (BH 546) which was high yielder as compared to other improved maize varieties in the study areas was used as a test crop on all sites that were planted in rows with spacing of 75 cm between rows and 30 cm among plants within a row. Planting was done on May 30, 2014 and the same on 2015 and 2016. Two seeds of maize were planted per hill and after emergence; thinned to one plant per hill. Blended fertilizers (NPSZnB) were applied at planting. Urea and triple super phosphate was used as the source of N and P, respectively. Application of urea was in two split, while the entire rate of phosphorus was applied at sowing in band. The quantities of fertilizers applied were determined by calculating the equivalent amount required by 1 ha of land (standard measurement).

During the different growth stages of the crop, all the necessary field management practices were carried out as per the practices. In order to avoided boarder effects, both ends of the rows and row length of a plot were left. Hence, 13.2 m^2 (4 m × 3.3 m) of net plot size was used for the data collection. Important agronomic practices like hoeing and weeding were uniformly applied to all experimental plots as often as required.

Soil sampling and laboratory analyses

Soil samples were randomly collected from surface layer of the experimental field (i.e., 0-30 cm soil depth) to form composite before sowing and analyzed for the soil texture, pH, available P, total N and OC (Organic Carbon).

The soil samples were air-dried and ground to pass 2 and 0.5 mm sieves (for total N). All samples were analyzed following standard laboratory procedures. Organic carbon and total N contents of the soil were determined following the wet combustion method of Walkley and Black and wet digestion procedure of Kjeldahl method, respectively. The available P content of the soil was determined following bray II method. Soil texture was analyzed by Bouyoucos hydrometer method. The pH (1:2.5 solid:liquid ratio) of the soils was measured in water using pH meter with glass-calomel combination electrode.

Plant data collection and analysis

Central plants were used for data collection. Growth indicating parameters such as plant height, ear length and grain yield was collected. The plant height (cm) was measured from the base of the plant to upper top most leaves of the plant. The data was taken from five randomly selected plants. The data was taken from five randomly plants and the average value was computed. The grain yield from the middle was recorded and adjusted by the standard formulae to grain yield per hectare basis.

Statistical analysis

Analysis of variance was carried out for the yield studied following statistical procedures appropriate for the experimental design using SAS computer software. Whenever treatment effects was significant, the means was separated using the least significant difference (LSD) procedures test at 5% level of significance [4].

Economic data collection and analysis

Economic analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). A partial budget, dominance and marginal analysis were used. The average yield was adjusted downwards 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 [5].

Results and Discussion

Soil physic-chemical characterization

Selected Physic-chemical properties of soil samples prior to the field experiment were presented in Table 1. Soil of experimental fields were clay in textural class (60.4% clay, 30% sand and 9% silt) based on soil textural triangle 1.36 g/cm^3 Bulk density which was some too compact for Agricultural clay soil and rating as moderate have 48.68% of Total porosity. Accordingly, the experimental soil is moderately acidic in reaction (pH (H_2O)=5.8) and rating as low to (0.28%) total N which was high in reference to moderate organic carbon (2.46%); available phosphorous (P=3.48 mg Kg^{-1} soil) which was very low. K=0.14 low according to FAO 2006 [3]. CEC of the soil was 22.6 CEC (Cmol kg^{-1}), which is again very low. Generally, the fertility status of the study site was low to medium (Table 1).

Citation: Tamene D, Anbessa B, Legesse TA, Dereje G (2018) Refining Fertilizer Rate Recommendation for Maize Production Systems in Assosa, North Western Ethiopia. Adv Tech Biol Med 6: 253. doi:10.4172/2379-1764.1000253

Soil Parameters	Value	Remark
Soil pH (by 1:2.5 soil water ratio	5.8	Moderately Acidic
Total Nitrogen (%)	0.28	High
Organic matter content (%)	2.46	Moderate
Available phosphorous (ppm)	3.47	Very Low
Cation exchange capacity (Cmol (+) kg^{-1})	22.6	Very Low
Exchangeable potassium (Meq/100 g soil)	0.14	Low
Soil texture		
Clay (%)	60.4	
Sand (%)	30	
Silt (%)	9.1	
Textural class	Clay	Clay

Table 1: Selected soil physico-chemical characterization before planting of Assosa area.

Effect of nitrogen fertilizer under balanced fertilization on biomass yield, grain yield and yield components of maize

The effect of nitrogen fertilizer application rate significantly ($P \leq 0.05$) affected ear length of maize. Ear length increased significantly when the rate of N was increased from 0 to 46 kg N ha^{-1}. Increasing the rate of nitrogen application beyond this level of N supply did not affect this parameter. Maximum ear length (17.4167 cm) was recorded at application of 176 kg N ha^{-1} and minimum ear length (14.0833 cm) was at the control treatment (Table 2). Comparing the ear length showed that 130.5 kg N ha^{-1} application resulted in 18.36 % more ears length compared to the control treatment. Generally, the trend showed that decrease in ear length occurred with decrease in nitrogen rate. Similar to this finding, Sharifi and Taghizadeh reported that the length of ears per plant was significantly affected by N application rate in which the maximum length of ear was produced in response to applying 176 kg N ha^{-1}, where the longest ear (17.4167 cm) and the shortest was produced at control treatment (14.0833 cm) [6].

Treatment Arrangement	Ear length (cm)	Plant height (cm)	Bio-mass (kg ha^{-1})	Grain yields (Kg ha^{-1})
Control (no fertilizer)	14.0833^{B}	174.417^{C}	4282.6^{C}	3298.6^{C}
Rem'd NP (92, N 69 kg P_2O_5 ha^{-1})	15^{B}	188.917^{B}	6214.6^{CB}	4401.1^{CB}
0 kg N ha^{-1}+PKSZnB	16.4167^{A}	211^{A}	9156^{A}	6666.4^{A}
46 kg N ha^{-1}+PKSZnB	17.25^{A}	212.25^{A}	9991.2^{A}	7292.5^{A}
92 kg N ha^{-1}+PKSZnB	16.75^{A}	211.083^{A}	9291.1^{A}	6914.5^{A}
138 kg N ha^{-1}+PKSZnB	17.1667^{A}	213.583^{A}	9240^{A}	6860.1^{A}
176 kg N ha^{-1}+PKSZnB	17.4167^{A}	214.833^{A}	9316.5^{A}	6763.6^{A}
222 kg N ha^{-1}+PKSZnB	16.5^{A}	217.833^{A}	6745.2^{B}	5156.2^{B}
LSD (0.05)	1.0514	12	1981.3	1478
CV	7.88	7.15	30.21	30.69

Table 2: Combined analysis on effects of N rate under balanced fertilization on grain yield (kg ha^{-1}) and yield components of maize of three years data (LSD: Least Significance Difference; CV: Coefficient of Variance; Rem'd: Recommended Rate).

The effect of N rate was highly significant effect ($P<0.05$) on plant height (Table 2). Plant height increased significantly with the increase in the rate of nitrogen application. When the rate of nitrogen was increased from 0 to 46 kg ha^{-1}, plant height was increased from 174.41 to 211 cm, respectively. The increases in plant height with respect to increased N application rate could be due to the maximum vegetative growth of the plants under higher N availability. It was reported that maize plant height was increased by 6% when the rate of nitrogen was increased from 0 to 46 N ha^{-1}.

The results of the analysis of variance showed that biological yield (BY) of maize was significantly ($P \leq 0.05$) influenced by the effect of nitrogen rates. When the rate of nitrogen was increased from 0 to 46 kg N ha^{-1}+PKSZnB biological yield of maize was significantly affected, biological yield of the crop increased by 57.13%. When the rate of nitrogen was increased more, biological yield was unaffected. The increase in biological yield with increase in rate of N might be due to better crop growth rate, leaf area index and accumulation of photo assimilate due to maximum days to maturity by the crop, which ultimately produced more biological yield. The result is consistent with the findings in which biological yields of 14.70 t ha^{-1} were attained in maize in response to the N application at the rate of 180 kg ha^{-1}. From this result, it is evident that N availability must be adequate at the vegetative stage of growth to ensure the maximum biological yield [7].

The analysis of variance showed that the N level was highly significant ($P<0.05$) on grain yield Table 2. The highest grain yield (7292.5 kg ha^{-1}) was obtained at the lowest nitrogen rate with balanced fertilizer of 46 kg N ha^{-1}+PKSZnB while significantly the lowest grain yield (3298.6 kg ha^{-1}) was recorded on the no nitrogen application (control) Table 2. Increased application of N fertilizer was accompanied with linear increase in grain yield of maize as reported by many researchers. confirming that N is the principal factor in controlling the growth and development of the crop. Consistent with these results, it was also reported that a greater yield response was obtained for maize with increasing N application under adequate soil moisture condition.

Economic analysis: The result of this study revealed that except 2nd, 3rd and 4th treatments all the other treatments were dominated. Because these treatments have net benefits less than treatments with lower variable costs. Such dominated treatments were dropped from economic analysis. As a result only marginal rate of return (MRR) of the three treatments were computed (Table 3).

According to CIMMYT, experience and empirical evidence, for the majority of situations indicated that the minimum rate of return acceptable to farmers would be between 50-100%. That is the treatment with the highest net benefit per hectare and a marginal rate of return greater than the minimum acceptable rate of return. Therefore, it is unlikely that a rate of return below 50% will be accepted. Accordingly, the highest MRR% (116.67) was recorded from treatment application of 46 Kg/ha N with balanced fertilizers (SPKZnB) when compared to the other for this specific area to get more profit as described in Table 3.

Fertilizer rate	Total variable cost	Total income	Net benefit	Marginal increase in net benefit	Marginal increase in variable cost (Birr ha^{-1})	Dominance	MRR%
Control (no fertilizer)	0	17993.28	17993.28			D	
Recd NP (92+69 P_2O_5 ha^{-1})	4944.69	24725.28	19780.59	1787.31	4944.69		36.14
0 kg N ha^{-1}+PKSZnB	8783.75	31998.72	23214.97	3434.38	3839.06		89.46
46 kg N ha^{-1}+PKSZnB	10170.75	35004	24833.25	1618.28	1387		116.67
92 kg N ha^{-1}+PKSZnB	11557.75	33189.6	21631.85			D	
138 kg N ha^{-1}+PKSZnB	12944.75	32928.48	19983.73			D	
176 kg N ha^{-1}+PKSZnB	14090.41	32465.28	18374.87			D	
222 kg N ha^{-1}+PKSZnB	15477.55	24749.76	9272.21			D	

Table 3: Economic analysis on grain yield of maize crop.

Treatments	Plant height (cm)	Ear length (cm)	Bio-mass yield (Kg ha^{-1})	Grain Yield (Kg ha^{-1})
Control (no fertilizer)	149.333^{C}	14.3333^{C}	6555.8^{D}	2945.8^{E}
Red.NP (92+69 kg P_2O_5 ha^{-1})	182.083^{B}	16.5833^{B}	7634.6^{CD}	5206.3^{D}
0 kg P_2O_5 ha^{-1}+NKSZnB	212^{A}	18^{A}	9734.4^{B}	6752.1^{B}
23 kg P_2O_5 ha^{-1}+NKSZnB	207.417^{A}	17^{BA}	10088.5^{B}	6927.3^{B}
46 kg P_2O_5 ha^{-1}+NKSZnB	210.333^{A}	17.6667^{BA}	12648^{A}	8206.1^{A}
69 kg P_2O_5 ha^{-1}+NKSZnB	216.917^{A}	17.8333^{A}	10300.9^{B}	7073^{B}
92 kg P_2O_5 ha^{-1}+NKSZnB	210.083^{A}	17^{BA}	9371.5^{B}	6388.6^{CB}
115 kg P_2O_5 ha^{-1}+NKSZnB	215.5^{A}	17.9167^{A}	8883.6^{CB}	5661.7^{CD}
LSD (0.05)	15.852	1.1359	1428.7	1075.6
CV	9.68	8.16	18.6	21.51
Sig.	**	**	**	**

Table 4: Effects of P-rate under balanced fertilization on grain yield and yield components of maize (LSD: Least Significance Difference; CV: Coefficient of Variance; Red: Recommended Rate).

Citation: Tamene D, Anbessa B, Legesse TA, Dereje G (2018) Refining Fertilizer Rate Recommendation for Maize Production Systems in Assosa, North Western Ethiopia. Adv Tech Biol Med 6: 253. doi:10.4172/2379-1764.1000253

Effect of phosphorus fertilizer under balanced fertilization on bio-mass yield, grain yield and other yield components of maize

The application of 46 kg ha^{-1} P resulted in grain yield increases, aboveground biomass yield was also affected in the same amount of P with balanced fertilizers having increased biomass yield with P application. The mean P effect on grain and biomass yield over all site per years was significant at (p=0.05).

As observed from the graph as variable cost increases the net benefit also goes to increase to some extent. But maximum net benefit was obtained at 46 kg N ha^{-1} application. To conclude as it is best to recommend the treatment it needs partial budget analysis (Figure 1).

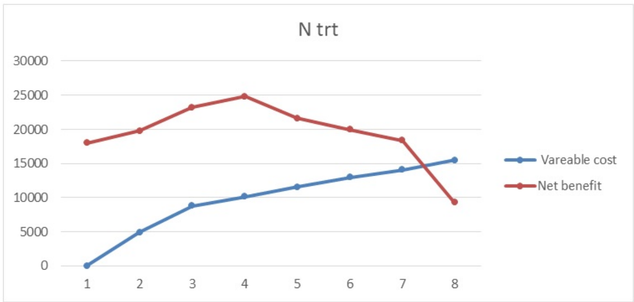

Figure 1: Trends of variable cost and net profit.

Application of an additional 23 kg ha^{-1} P resulted in significant yield increases but the highest yield was recorded by the application of 46 kg ha^{-1} P. Yield response to applied P was associated with increased other yield components such as biomass yield by P application.

Levels of P application had significant effects on ear length of maize. The longest ears (17.9167 cm) were produced with highest P level as compared with 17 cm produced with the lowest P level (Table 4). Ear length showed positive response to increasing levels. Some researchers reported that ear length increased with increasing P level. The longest ears (17.9167 cm) were recorded in plots that received P at 115 kg P_2O_5 ha^{-1}+NKSZnB compared to 17 cm ears length noted in plots applied with P at 23 kg P_2O_5 ha^{-1}+NKSZnB. The increase in ear length of maize with the application of P under balanced fertilization probably may be due to the increase in number of leaves per plant and mean leaf area [8].

The analysis of variance showed that significant deference on biomass yields among treatments applied on those plots especially from the control treatment. The yield grows to 35% from the control to the first rate of P fertilizer. Furthermore, application of P fertilizer was found to significantly increase in dry matter accumulation in maize.

The analysis of variance indicated highly significant (P<0.05) effects on grain yield of maize. 46 P kg ha^{-1} with balanced fertilizers (NKSZnB) gave significantly highest grain yield (8206.1 kg ha^{-1}) (Table 4). On the other hand, the lowest grain yield of 2945.8 kg ha^{-1} was recorded the control plot. The lower grain yield in the absence or lower P rate indicates higher demand for P fertilizer. It was suggested that P deficiency is a common crop growth and yield-limiting factor, especially in soils which reduces P solubility. Phosphorus application at the rate of 46 kg P_2O_5 ha^{-1}+NKSZnB resulted in a marked increase in grain yield. The increased grain yield might be due to availability supply of P with essential balanced nutrients. Phosphorus might be involved in vital plant functions to increase yield and yield related traits. The data on grain yield of maize showed that by increasing the P fertilizer up to 69 Kg ha^{-1} levels grain yield increased, but significantly decline at the maximum rate of P. Therefore, 46 kg ha^{-1} P with balanced fertilizers (NKSZnB) could be the optimum level for producing potential yield of maize. The results suggested that fertilizer up to the level of 46 P kg ha^{-1} was efficiently utilized by the crop or this P level enabled the crop to make use of available resources efficiently.

Fertilizer rate	Total variable cost	Total income	Net benefit	Marginal increase in net benefit	Marginal increase in variable cost (Birr ha^{-1})	Dominance	MRR%
Control (no fertilizer)	0	14139.84	14139.8			D	
Red NP (92+69 kg P_2O_5 ha^{-1})	4221	24990.24	20769.2			D	
0 kg N ha^{-1}+PKSZnB	9387.062	32410.08	23023	2253.78	7419.84		30.37
23 kg N ha^{-1}+PKSZnB	10110.42	33251.04	23140.6	117.6047	840.96		13.98
46 kg N ha^{-1}+PKSZnB	10834.062	39389.28	28555.2	5414.5953	6138.24		88.211
92 kg N ha^{-1}+PKSZnB	11556.98	33950.4	22393.4			D	
138 kg N ha^{-1}+PKSZnB	12280.34	30665.28	18384.9			D	
176 kg N ha^{-1}+PKSZnB	13003.55	27176.16	14172.6			D	

Table 5: Economic analysis on grain yield of maize crop.

Effect of potassium fertilizer under balanced fertilization on biomass yield, grain yield and yield components of maize

Economic analysis: In the result of present study, the costs of fertilizers (Inputs) were varied while other costs were constant for each treatment. In order to recommend the present result for producers, it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain. Based on partial budget analysis, with 10% increase in input price and with 10% decrease in output price, the highest net benefit 28555.22 Birr ha^{-1} was obtained from treatment 46 kg P_2O_5 ha^{-1} with balanced fertilizers for maize variety BH-546. This means that for every 1.00 birr invested for 46 kg

P_2O_5 ha^{-1} for maize in the field, producers can expect to recover the 1.00 Birr and obtain an additional of 0.88 Birr (Table 5).

According to CIMMYT, the minimum acceptable marginal rate of return (MRR %) should be between 50 and 100%. The present study indicated that MRR much greater than 100%. Therefore, the most attractive P_2O_5 fertilize application rate for farmers with higher benefits in this study was 46 P_2O_5 kg ha^{-1} fertilizer application rate with balanced fertilizer.

Effect of potassium: As ANOVA indicates the application potassium treatment had significant yield difference at (P=0.05 probability level) as compared from the control.

Application of K fertilizer at minimum rate has also significantly increased grain yield of maize by 23% over that produced by local control treatment. Suggests low level soil K content in the study area for optimum production of maize. However, the highest grain yield was produced by 120 kg K ha-1+NPSZnB treatment. It increased grain yield by 30% over that produced by recommended NP treatment. This shows the importance of balanced applications of fertilizers containing all the other nutrients for enhancing productivity of maize at Assosa district.

Treatments	Ear length (cm)	Plant height (cm)	Bio-mass yield (Kg ha^{-1})	Grain Yield (Kg ha^{-1})
Control (no fertilizer)	16.66	200.33^{c}	4500.4^{f}	5240.7^{c}
Recm'd. NP (92 kg N+69 kg P_2O_5 ha^{-1})	17.17	204.25^{b}	5780^{e}	5428.9^{bc}
0 kg K ha^{-1}+NPSZnB	16.68	218.083^{a}	8379^{bcd}	6544.8^{abc}
24 kg K ha^{-1}+NPSZnB	17	221.05^{a}	8178.1^{cd}	6393.8^{abc}
48 kg K ha^{-1}+NPSZnB	17.18	216.417^{ab}	8465^{bc}	6399.2^{abc}
72 kg K ha^{-1}+NPSZnB	16.68	215.483^{ab}	9368.8^{ba}	7275.5^{a}
96 kg K ha^{-1}+NPSZnB	17.58	223.917^{a}	9555.5^{a}	7235.5^{a}
120 kg K ha^{-1}+NPSZnB	16.43	213.667^{ab}	9744.3^{a}	6530.2^{abc}
144 kg K ha^{-1}+NPSZnB	16.56	223.75^{a}	8373.5^{bcd}	6622.7^{ab}
168 kg K ha^{-1}+NPSZnB	16.94	220.45^{a}	7402.9^{d}	5600^{bc}
CV	8.15	7.54	16.05	26.25
LSD	1.11	13.24	1041.2	1344.1

Table 6: The effects of K-rate under balanced fertilization on grain yield and yield components of maize.

Ear length (cm): 24 kg K ha^{-1}+NPSZnB but the increment was not consistent in line with the rate. 96 kg K ha^{-1}+NPSZnB17.5896 kg K ha^{-1}+NPSZnB16.43 120 kg K ha^{-1}+NPSZnB

Plant height (cm): The mean of plant height and the analysis of variance are shown in Table 6. Here were significant variations ($p \leq 0.05$) among the fertilizers rates on maize height at three sites per each year. Application of balanced fertilizers with K significantly increased plant height as compared to the recommended NP fertilizers and the control. Similarly, the recommended NP fertilizers also significantly increased plant height as compared to the control.

However, there was a slight significant difference and not consistence with increasing K rates. The highest plant height was recorded from 96 kg K ha^{-1}+NPSZnB but non-significant variation with (24 kg K ha^{-1}+NPSZnB) which was the minimum k rate (Table 6). This increment in plant height might be due to increase in cell elongation and more vegetative growth attributed to different nutrient content of balanced fertilizer. On the other hand the least plant height in unfertilized plots might have been due to low soil fertility level in the study area. In conformity with the results obtained from this study, Plant growth and development may be retarded significantly if any of nutrient elements less than its threshold value in the soil or not adequately balanced with other nutrient elements by Landon. Thus, the results indicate that balanced fertilizers application has enhanced the maize vegetative growth.

Grain yield: Grain yield of maize showed significant differences ($P \leq 0.05$) among K fertilizer rates used at both years and sites Table 6. Application of K fertilizer was significantly higher than control and recommended NP.

The highest maize grain yield was obtained from 72 kg ha^{-1} of K however, no significance variation with 96 kg of K (Table 6). The magnitude of increment was 27.56% and 25% above the control and recommended NP fertilize respectively. This increment in grain yield with the balanced fertilizer which contained both macro and micro plant nutrients were an indicator of low soil fertility level in the study area for maize production. This in line with agreement which states that, although adoption of new varieties especially maize hybrid is moving fast in Ethiopia, fertilizer management techniques need to supplement the existing potential of the varieties. This showed that low soil fertility is among the greatest constraints to maize production in Ethiopia.

It was reported that many soils of the tropical regions are unable to supply sufficient K+ to field crops. Hence, application of this element in adequate amount is essential for obtaining optimal crop yields. Many other researchers also have reported that application of potassium fertilizer increased maize yield. The increase in grain yield could be attributed to beneficial influence of yield contributing characters and positive interaction of nutrients in the balanced fertilizer.

Economic analysis: The primary objective of producers in applying fertilizer is to make profit. The extent to which their use of fertilizers contributes to this objective depends not only upon the kinds and upon amounts of fertilizer they apply and the yield, but also upon the cost of fertilizer and price of yields. Both the physical and economic realities must be recognized. Here the economic analysis revealed that the gross return and net return were maximum with application of 120 Kg ha^{-1}+NPSZnB followed by application of 200 Kg/ha KCl+SPNZnB. Application of 120 Kg ha^{-1} KCl+NPSZnB was well above the 100% minimum. But investing on additional fertilizer rate gave less MRR. According to CIMMYT, experience and empirical evidence, for the majority of situations indicated that the minimum rate of return acceptable to farmers would be between 50-100%. But, the treatments that have highest Marginal rate of return (MRR %), obtained from application of 120 Kg ha^{-1} KCl+NPSZnB for Maize production in Assosa area is the same with that of receiving higher and lower K rates and hence it is better to use 120 Kg ha^{-1} KCl+NPSZnB and 48 Kg ha^{-1} KCl+NPSZnB rather than using maximum K rates (Table 7).

Fertilizer rate	Total variable cost	Total income	Net benefit	Marginal increase in net benefit	Marginal increase in variable cost (Birr ha^{-1})	Dominance	MRR%
Control (no fertilizer)	0	19532.16	19532.16				
Recommended NP (92, 69)	4944.69	24862.08	19917.39			D	
0 kg K ha^{-1}+NPSZnB	9741.75	32911.2	23169.45	3252.06	4797.06		67.79
24 kg K ha^{-1}+NPSZnB	10104.95	32315.04	22210.09			D	
48 kg K ha^{-1}+NPSZnB	10468.15	33527.52	23059.37	849.28	363.2		233.83
72 kg K ha^{-1}+NPSZnB	10831.35	34975.68	24144.33	1084.96	363.2		298.7
96 kg K ha^{-1}+NPSZnB	11194.55	34838.4	23643.85			D	
120 kg K ha^{-1}+NPSZnB	11557.75	35680.8	24123.05	479.2	363.2		131.94
144 kg K ha^{-1}+NPSZnB	11920.95	29149.44	17228.49			D	
168 kg K ha^{-1}+NPSZnB	12284.15	25909.44	13625.29			D	

Table 7: Economic analysis of grain yield of maize crop.

Treatments	Ear length (cm)	Plant height (cm)	Bio-mass yield (Kg ha^{-1})	Grain Yield (Kg ha^{-1})
Control (no fertilizer)	149.083^{C}	14.6667^{C}	4188.7^{C}	2987.6^{B}
Recommended NP (92+69 kg P_2O_5 ha^{-1})	161.167^{C}	16.25^{BA}	5044.3^{C}	3655.4^{B}
0 Kg S ha-1+NPKZnB	210.667^{BA}	16.5^{BA}	8917.3^{BA}	6404.6^{A}
10 Kg S ha-1+NPKZnB	207.417^{BA}	16.1667^{BA}	9413^{A}	6717.7^{A}
20 Kg S ha-1+NPKZnB	198.5^{B}	16^{B}	8927.3^{BA}	6289.7^{A}
30 Kg S ha-1+NPKZnB	214.25^{A}	16.4167^{BA}	8648.1^{BA}	6122.6^{A}
40 Kg S ha-1+NPKZnB	216.333^{A}	17.0833^{A}	8746.8^{BA}	6122.5^{A}
50 Kg S ha-1+NPKZnB	207.833^{BA}	16.75^{BA}	8350.1^{B}	5997.2^{A}
LSD (0.05)	13.465	0.9774	999.25	735.77
CV	8.42	7.37	15.72	16.33
Sig.	**	**	**	**

Table 8: Effect of sulfur fertilizer on yield and yield components of maize.

Effect of sulfur fertilizer under balanced fertilization on biomass yield, grain yield and yield components of maize

Grain yield and yield component parameters: Sulfur (S) is an important part of balanced fertilizer to crop nutrition plan. S rate have response significantly on plant height. Height is one of yield component parameters which contribute highly to the yield of maize. Minimum height was attained (149.083 cm) on the control plot.

The ANOVA result indicates that the application of S at lower rates responds more in grain and biomass yield of maize. Maize grain yield increase to S fertilization has occurred with lower rates. Also, the magnitude of yield increase has been large.

Grain yields: Grain, yield of maize showed significant differences ($P \leq 0.05$) among sulfur fertilizers rates used at Assosa (Table 8). Application of S with balanced fertilizer was significantly higher than control. The recommended NP fertilizer did not bring about a significant change in maize yield from the control. The highest (6717.7 kg ha^{-1}) and lowest (2987.6 kg ha^{-1}) grain yields were obtained with the application of 10 Kg S ha^{-1} fertilizer with balanced fertilizers, and the control (without fertilizers), respectively. The fact that many workers in soil, and reported that only this rate increased maize fertility have recognized as the promising rate 20 to 30 g kg S content.

Cost benefit analysis: Partial budget analysis is a method of organizing experimental data about the cost benefit of some changes. It calculates income and expenses based on variable cost. Partial budget averaged of the 8 treatments is presented in Table 9. From the final experimental data, the gross yield for 8 treatments was obtained. Costs and benefits were calculated for each treatment. The cost of Urea, TSP, KCl, $CaSO_4$, and B fertilizer was Birr 13.87, 14.47, 9.08, 26.9 and 11.12 kg^{-1}, respectively. The selling price of maize at the local market at Assosa area was taken as Birr 4.8 kg^{-1} for grain yield. Variable costs were summed up and subtracted from gross benefits which were taken as net benefit. The highest net benefit of 23850.66 Birr ha^{-1} was obtained from the application of 10 Kg S ha^{-1}+NPKZnB with balanced fertilizer while the lowest net benefit of Birr 12601.23 ha^{-1} was from the control. According to CIMMYT, experience and empirical evidence, for the majority of situations indicated that the minimum rate of return acceptable to farmers would be between 50-100%. Therefore, the treatments that have highest Marginal rate of return (MRR %), which was application of 10 Kg S ha^{-1}+NPKZnB kg ha^{-1} for Maize production in Assosa area is recommended.

Fertilizer rate	Total variable cost	Total income	Net benefit	Marginal increase in net benefit	Marginal increase in variable cost (Birr ha^{-1})	Dominance	MRR%
Control (no fertilizer)	0	12601.23	12601.23			D	
Rec'd NP (92+ 69)	4944.68	17545.92	14340.48			D	
0 Kg S ha^{-1}+NPKZnB	6810.69	30742.08	20001.39	5660.9	1866		303.37
10 Kg S ha^{-1}+NPKZnB	8394.29	32244.96	23850.66	3849.27	1583.6		243.07
20 Kg S ha^{-1}+NPKZnB	9975.2	30190.56	20215.35			D	
30 Kg S ha^{-1}+NPKZnB	11561.5	29388.48	17826.98			D	
40 Kg S ha^{-1}+NPKZnB	13145.1	29388	16242.9			D	
50 Kg S ha^{-1}+NPKZnB	14728.97	28786.56	14057.58			D	

Table 9: Economic analysis of grain yield of maize crop.

Conclusion and Recommendation

Effect of nitrogen fertilizer under balanced fertilization on biomass yield, grain yield and yield components of maize

As the ANOVA of combined analysis of three years data results indicates that significant deference at ($P<0.05$) observed between treatments both in grain and biomass yields of maize at Assosa areas. Maximum grain yield was obtained on plots treated with 46 kg N ha^{-1} with balanced fertilizers which were applied on all plots except on the control plots. When the recommended of nitrogen was applied as NP (92 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}) alone grain yield of maize was increased by 37.4%. However, the rate of nitrogen was applied at 46 kg N ha^{-1}+PKSZnB (with balanced fertilizers), grain yield of the crop increased by 94.5% which was the maximum of all.

Grain yield was highly significantly ($P<0.05$) affected by the treatment effect of N level with balanced fertilization. The lowest grain yield (3298.6 kg ha^{-1} was at the control and the highest was (7292.5 kg ha^{-1}) at 46 kg N ha^{-1}+PKSZnB (with balanced fertilizers). The highest economic benefit (24833.25 birr ha^{-1}) and higher acceptable MRR (116.67%) was obtained from the application of 46 kg Nha^{-1}+PKSZnB while the lowest economic benefit were (9272.21 Birr ha^{-1}) was from 222 kg N ha^{-1}+PKSZnB and lowest MRR % (36.14%) was from Recommended NP (92 kg N ha^{-1}+69 kg P_2O_5 ha^{-1}). Therefore, based on the results of this experiment 46 kg N ha^{-1} with balanced fertilizer could be used to increase the productivity of the maize hybrid variety (BH-546) in the study area [7].

Effect of phosphorus fertilizer under balanced fertilization on bio-mass yield, grain yield and other yield components of maize

The effects of P rates were highly significantly ($P<0.05$) effect on grain yield. Maize at the P rate of 46 kg ha^{-1} with balanced fertilizer gave the highest grain yield of (8206.1 kg ha^{-1}) while the control gave the lowest grain yield of (2945.8 kg ha^{-1}).

The economic analysis revealed that highest net return of Birr 28555.22 ha^{-1} was recorded in the treatment that received 46 P kg ha^{-1} and highest marginal rate of return (MRR) 88.211% obtained. In general, the results of the present study indicated that P at the rate of 46 kg ha^{-1} plus balanced fertilizers could be recommended for the study area.

Effect of potassium fertilizer under balanced fertilization on biomass yield, grain yield and yield components of maize

The low yield was recorded from control treatments. This might have been due to reduced leaf area development resulting in lesser radiation interception and, consequently, low efficiency in the conversion of solar radiation. Compared to the recommended NP fertilizers, mean grain yield was increased by 3.5% from the control. As the K rates increase in some instance grain yield also increase but it bends down above the optimal points. Finally even if the ANOVA result shows significantly different plots that were treated with K fertilizer was almost the same except the highest rate of K fertilizer.

References

1. McDonald AH, Nicol JM (2005) Nematode parasites of cereals. In: Luc M, Sikora RA, Bridge J (eds) Plant parasitic nematodes in subtropical and tropical agriculture. CABI Publishing, Wallingford, pp: 131-191.
2. Balasubrananiyan P, Palaniappan SP (2001) Field crops: An overview. Principles and Practices of Agronomy. Agrobios (India), p: 47.
3. (2011) FAO (Food and Agriculture Organization). Plant nutrition for food security: A guide for integrated nutrient management. FAO, Fertilizer and Plant Nutrition Bulletin, Rome 16.
4. Nyamangara J, Mudhara M, Giller KE (2005) Effectiveness of cattle manure and nitrogen fertilizer application on the agronomic and economic performance of maize. S Afr J Plant Soil 22: 59-63.
5. Fageria NK, Baligar VC (2005) Enhancing nitrogen use efficiency in crop plants. Adv Agron 88: 97-185.
6. Wassie F, Yewhalaw D, Steurbaut W, Spanoghe P, Van Bortel W, et al. (2011) Multiple insecticide resistance: An impediment to insecticide-based malaria vector control program. PLoS One 6: e16066.
7. Chaudhary AR (1983) Maize in Pakistan. Punjab Agriculture Research. Cord. Board, University of Agriculture. Faisalabad, Pakistan, pp: 312-317.
8. (2015-2016) CSA (Central Statics Agency). Reports on estimate of area, production and yield of crops for 2014/2015 and 2015/2016, meher season. Centeral Stastical Authority, Ethiopia.