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International Journal of Agricultural Research and Review
Abbreviated Key Title: Int. J. Agric. Res Rev.
ISSN: 2360-7971 (Print) & Open Access
DOI: 10.54978/ijarr.2023. Vol. 13, Issue 1, Pp.: 1-138

OPEN ACCESS

IJARR
INTERNATIONAL JOURNAL OF AGRICULTURAL RESEARCH AND REVIEW

Soil Fertility Characterization and Response of Maize (Zea mays L.) to Application of Blended Fertilizer Types and Rates from Asossa, Western Ethiopia

Bakala Anbessa

Ethiopia Institute of Agricultural Research, Assosa Agricultural Research Centre
Corresponding author email: - anbessa2004@gmail.com

ABSTRACT

Soil fertility depletion and soil acidity are critical problems for crop production in western Ethiopia. Therefore, a field experiment was conducted on the Nitisols of the Asossa Agricultural Research Centre to characterise the soil fertility status of the farm and investigate the response of yield and yield components of maize (Zea mays L.) to different blended fertiliser rates and types. The treatments consists of: control, three rates of N and P combined (92/46, 115/57 and 138/69 N/P2O5 kg ha-1 and two formula of blended fertilizers with different rates, formula 2 consists of 100 kg NPSB+ 73.9 N,150 kg NPSB +110.8 N and 200 kg NPSB + 147.8 N kg ha-1 and formula 4 consists of 100 kg NPSZnB + 75.1 N, 150 kg NPSZnB + 112.6 N 1 and 200 kg NPSZnB +150.2 N kg ha-1. The treatments were laid out as a randomised complete block design with three replications. To characterise the experimental area soil, two pedons were opened from cultivated and uncultivated adjacent plots. The experimental soil was strongly acid to moderately acidic in pH, had vcarbon, was mediumrganic carbon, to very low in total nitrogen, was below the critical level of available P (Olsen extractable), and had high CEC. Application of blended fertilisers (NPSB, NPSZnB) hastened days to tasseling, silking, and maturity by 10, 7, and 15 days, respectively, as compared to combined N and P rates. Application of blended fertiliser significantly (p < 0.01) increases the plant height, cob weight, ear length, 100 kernels weight, number of kernels per row, and ear height as compared to combined N and P and the control. The analysis of variance revealed that fertiliser types and rates significantly (P < 0.01) affected biomass yield, grain yield, straw yield, and harvest index. However, there was no significant difference between the two blended fertiliser types. Maximum grain yield (7056.2 kg ha-1) was recorded with 200 kg NPSZnB + 150.2 N kg ha-1 application, while minimum grain yield (2996.0 kg ha-1) was recorded from the control treatment. The application of 150 kg NPSB + 110.8 N kg ha-1 had the highest marginal rate of return (MRR%) and net benefit. Therefore, we recommended the treatment (150 kg NPSB + 110.8 N kg ha $^{-1}$) since it produced a high marginal rate of return, a high net benefit, and a relatively small total cost of production for maize production in the Asossa area.

Keywords; Blended, pedons, yield, uptake, efficiency, recovery, net benefit
Accepted 27th December, 2024

INTRODUCTION

Soil is the most important resource required for agricultural production (Khanif, 2010). Soils have many variables, which have multiple types of characteristics. The variables influence not only pedogenesis and development but also the use and productivity of soils. Therefore, in order to understand the similarities, dissimilarities, and relationships among different soil types, it is important to study the physico-chemical properties of soils under land use. The existence of various types of soils in different parts of Ethiopia is related to the variability of soil-forming factors in type, degree, and intensity. Soil types and characteristics show substantial variations across the various regions of Ethiopia. However, there isn't a lot of information available about the soils of the research farm in the studied area or the Asossa Wereda as a whole, even though understanding the physical and chemical properties of the soil is important for long-term production and productivity in agriculture and for research in the area.

Among cereals, maize (Zea mays L.) is an important crop that ranks third after wheat and rice in the world (Rasheed et al., 2004). It is one of the important cereal crops used in the human diet in large parts of the world, and besides serving as an important feed component for livestock. In terms of total world production, maize outranked paddy rice (Oryza sativa) and wheat (Triticum aestivum) (Rasheed et al., 2004). Low soil fertility is one of the bottlenecks to sustaining agricultural production and productivity in Ethiopia. Thus, maize is one of the heaviest feeders of nutrients, producing high-quality yields among cereals. This is due to its ability to produce higher grain and straw yields compared to other cereals. The application of balanced fertilisers is the basis for producing more crop output from existing land under cultivation, and crops' nutrient needs are according to their physiological requirements and expected yields (Ryan, 2008). Most research works focus on N and P requirements of crops; limited information is available on various sources of nuas K,nts such as S, Zn, B, and other micronutrients.

The application of fertilisers in relation to initial soil fertility status and crop requirements leads to the economic and judicious use of fertilizers. Nutrient mining due to suboptimal fertiliser use on one hand and unbalanced fertiliser use on the other has favoured the emergence of multi-nutrient deficiency in thiopia. Several studies show that nutrients like K, S, Ca, Mg, and all micronutrients except Fe are running out. Major crops in different parts of the country are showing signs of deficiency (Wassie et al., 2009). According to Bekabil et al. (2011), the lack of appropriate fertiliser blends and lack of micronutrients in fertiliser blends are the national problems that are major constraints to crop productivity. Improving productivity and other desirable traits is important. This can be done by using better production management techniques and adding nutrients from sources other than urea and DAP. These should include sources of potassium, sulphur, and other micronutrients (CSA, 2011). Therefore, the present study was designed to assess the effects of different types and rates of nutrients on maize production in Asossa.

MATERIALS AND METHODS

Description of the Study Sites

The experiment was conducted in Benishangul Gumuz Regional State, at the Asossa Agricultural Research Centre (AARC) research farm, in the 2016/17 main cropping season under rain-fed field conditions. Benishangul Gumuz Regional State is geographically located at 9O30' to 11O39'' N latitude and 34O 20' to 36O 30'' E longitude, covering a total land area of 50,000 square kilometres. The study site is located at 10° 02' 05'' N latitude and 34° 34' 09'' E longitude. The study area lies approximately 4 km east of Asossa town and 660 km west of Addis Ababa, respectively. Asossa has a unimodal rainfall pattern, which starts at the end of April and extends to mid-November, with maximum rainfall received in June to October. The total annual average rainfall for Asossa is 1275 mm. The minimum and maximum temperatures are 16.750C and 27.920C, respectively. The dominant soil type of the Asossa area is Nitosols, with the soil pH ranging from 5.0 to 6.0.

Treatments and Experimental Design

The treatments were laid out in a randomised complete block design with three replications. Hybrid maize variety (BH546) was used as the test crop. The ten treatments, which include a control, three rates of nitrogen and phosphorus (92N & 46 P2O5, 115N P2O5, and.5 P2O5 138 N & 69 P2O5 kg ha-1), and two different 2 consists of 100 kg NPSB + 73.9N 1, 150 kg NPSB + 110.8N, and 200 kg NPSB + 147.8 N kg ha-1, andrmulas of blended fertilisers with rates, formula formula 4 consists of 100 kg NPSZnB + 75.1 N, 150 kg NPSZnB + 112.6 N 1, and 200 kg NPSZnB + 150.2 N kg ha-1-based Map-recommended fertilisers were used as treatments. Blended fertilisers and TSP were basal applied at planting, and urea was top dressed twice (at knee height and tasseling). The plot size of 4.5 m x 5.1 m (22.95 m^2) was used. The crop was planted in rows with recommended spacing (75 x 30 cm) between the rows and plants, respectively. The other crop management practices were applied uniformly for all plots as per the recommendation for the crop.

The treatments include:

Table 1. Fertilizer rates based on recommended N and P, and blended fertilizer types and rates applied.

Trt.No	Rate (kg/ha)	Compound fertilizers' mineral contents (%)
T1	Control(no fertilizer)	0
T2	200kg Urea &100 kg TSP	92N & 46 P_2O_5
T3	250 kg Urea & 125 kg TSP	115N & 57.5 P_2O_5
T4	300 kg Urea & 150 kg TSP	138 N & 69 P_2O_5
T5	100 kg NPSB +73.9 N	18.1 N - 36.1 P_2O_5 – 0.0 K_2O + 6.7 S + 0.0 Zn + 0.71 B
T6	150 kg NPSB + 110.8 N	27.15 N – 54.15 P_2O_5 – 0.0 k_2O + 10.05 S + 0 Zn + 1.07B
T7	200 kg NPSB + 147.8 N	36.2 N – 72.2 P_2O_5 – 0.0 k_2O + 13.4 S + Zn + 1.42B
T8	100 kg NPSZnB +75.1 N	16.9 N – 33.8 P_2O_5 – 0.0 k_2O + 7.3 S + 2.23 Zn + 0.67B
T9	150 kg NPSZnB + 112.6 N	25.35 N – 50.7 P_2O_5 – 0.0 k_2O + 10.95 S + 3.35 Zn + 1.01B
T10	200 kg NPSZnB +150.2 N	33.8 N – 67.6 P_2O_5 – 0.0 k_2O + 14.6 S + 4.46 Zn + 1.34B

Soil Sampling and Analysis

The soil pedon samples were analysed for selected agriculturally relevant soil physicochemical properties at the Regional Soil Laboratory in Benishan-gul, Gumuz, following the standard analytical procedures. Two soil pedons were opened (uncultivated and cultivated land) from representative landforms to characterise and classify the soil of the study area. Field observation, pedon opening, horizon designations, pedon description, and sampling of freshly opened soil pedons were carried out using the procedures of FAO (1990) guidelines. Finally, the soil profile samples were analysed for physicochemical properties at the Benshal-gul Gumuz Soil Laboratory using standard analytical procedures.

We looked at the chemical properties of both pedons's all horizons. These properties included pH, CEC, exchangeable acidity, exchangeable bases (Ca, Mg, Na, K), organic carbon, total nitrogen, and available P. Soil pH was determined using a pH meter with a combined glass electrode in water (H_2O) at a 1:2.5 soil:water ratio as described by Carter (1993). Organic carbon was determined by oxidising carbon with potassium dichromate in sulphuric acid solution following the Walkley and Black method (1934). Finally, the organic matter content of the soil was calculated by multiplying the organic carbon percentage by 1.724. The total nitrogen contents in soils were determined using the Kjeldahl procedure by oxidising the organic matter with sulphuric acid and converting NH_4^+ nitrogen into NH_4 as ammonium sulphate (Sahlemedhin and Taye, 2000). Exchangeable acidity was determined by saturating the soil samples with potassium chloride solution and titrated with sodium hydroxide as described by McLean (1965). Available phosphorus was determined in Olsen methods. In the Olsen procedure, the soil samples were shaken with 0.5M sodium bicarbonate at nearly constant pH of 8.5 in a 1:20 soil-to-solution ratio for half an hour, and the extract was obtained by filtering the suspension as indicated by Olsen *et al.* (1954).

Exchangeable bases (Ca, Mg, K, and Na) in the soil were estimated by the ammonium acetate (1M NH_4OAc at pH 7) extraction method. The soil samples were extracted with NH4OAc and more NH4 solution than needed. An atomic absorption spectrophotometer was used to measure the amount of Ca and Mg in the extracts, and a flame photometer was used to measure the amount of exchangeable K and Na, following the steps outlined by Rowell (1994). Soil cation exchange capacity (CEC) was measured after leaching the ammonium acetate-extracted (ammonium ion standard) soil samples with 10% sodium chloride solution.

Statistical Data Analysis

Analyses of variances for the data were recorded and conducted using the SAS GLM procedure (SAS 1998). Least significant difference (LSD) test at 5% probability is used for mean separation when the analyses of variance indicate the presence of significant differences.

Economic Analysis

Mean grain yield of the selected treatment was used in partial budget analysis (CIMMTY, 1988). Economic analysis was performed to investigate the economic feasibility of the treatments (fertiliser rates). A partial budget, dominance, and marginal analysis were used. The average open market price (Birr kg-1) for maize and the official prices of blended, urea, and TSP fertilisers were used for economic analysis. The dominance analysis procedure as detailed in CIMMYT (1988) was used to select potentially profitable treatments from the range that was tested. The selected and discarded treatments using this technique are referred to as undominated and dominated' treatments, respectively. The undominated treatments were ranked from the lowest (the farmers' practice) to the highest cost treatment. For each pair of ranked treatments, a % marginal rate of return (MRR) was calculated. The % MRR between any pair of undominated treatments denotes the return per unit of investment in fertiliser expressed as a percentage.

RESULTS AND DISCUSSION

Soil Chemical Properties of Pedons

Soil reaction, exchangeable acidity, and exchangeable Al+3

As you went deeper into the soils of both pedons, the pH value went up in a way that wasn't straight up (Table 5). The higher pH of the soil on the surface may be because it has a higher capacity to exchange cations, a lower capacity to exchange acids, and a lower capacity to exchange Al+3 than the soil below the surface in the area that was studied. EthioSIS (2014) classified pH values into five classes: strongly acidic < 5.5, moderately acidic 5.6 - 6.5, neutral 6.6 - 7.3, slightly alkaline 7.3 - 8.4, and highly alkaline > 8.4. The soils in the study area had pH values of 5.2 (strongly acidic) to 5.7 (moderately acidic) in the subsurface and surface horizons, respectively (Table 5). The most favourable pH for the availability of most plant nutrients corresponds roughly with the optimum range of 6 to 7 (Brook, 1983). The range of soil reactions at the experimental site may limit crop production by influencing the availability of important plant nutrients.

The top layer of pedon 2 had less exchangeable acidity and Al than the soil below it. This could be because straw and fertiliser added organic matter that increased yield, and the top layer of soil had a high capacity to exchange cations. The uncultivated pedon 1, on the other hand, had low exchangeable acidity and Al levels across all horizons. This could be because grass straw and litter fall added organic matter, and the uncultivated pedon 1 had higher CEC than the cultivated one. Exchangeable acidity consists of any aluminium or iron, as well as any exchangeable H that may be present in the exchange sites (Bohn *et al*., 2001).

Table 2. Soil pH, organic carbon, organic matter, total nitrogen and available phosphorous.

Horizon	Depth (cm)	pH	Exch. acidity	Exch. Al^{+3}	OC%	OM%	TN%	C/N	Available P mg/kg
Pedon 1									
A	0-20	5.7	0.16	0.24	3.3	5.7	0.28	11.78	3.22
AB	20-35	5.6	0.56	0.48	2.7	4.65	0.23	11.73	3.22
Bt_1	35-100	5.4	0.48	0.24	1.1	1.89	0.06	13.00	3.18
Bt_2	100-200	5.6	0.56	0.56	0.58	1.0	0.05	11.60	3.08
Pedon 2									
Ap	0-20	5.6	0.72	0.48	3.0	5.17	0.26	11.53	3.94
BA	20-45	5.2	1.2	2.8	1.9	3.3	0.16	11.87	3.26
Bt	45-120	5.3	4.0	3.92	1.1	1.9	0.09	12.22	3.11

Where pH = soil reaction with water (1:2.5), Exch. = exchangeable, OC = organic carbon, OM = organic matter, TN = total nitrogen, C/N carbon to nitrogen ratio, P = phosphorous.

Organic carbon, total nitrogen and available phosphorous

The little information we had showed that the soil organic carbon was slightly different between pedon 1 that had not been farmed and pedon 2 that had, and it went down as you dug deeper into the ground. *It's similar to what Bahilu et al. (2014) found: in the Delta Sub-watershed of Southwestern Ethiopia, land use and slope had a big effect on the organic carbon of the soil.* The high organic carbon content of surface soil could be related to organic matter content due to litter fall, crop residue, etc., of the soil surface. Total nitrogen contents of the soils also showed the same trend as soil organic carbon. *Mohammed et al. (2005) did research in Ethiopia that shows how much organic carbon is in the soil depends on how the land has been used in the past. Generally, cultivated soils will have less organic carbon than the same amount of land that has been left fallow.*

The carbon-to-nitrogen (C/N) ratio is an index of nutrient mineralisation and immobilisation; a low C/N ratio indicates a higher rate of mineralisation, and a higher C/N ratio indicates a greater rate of immobilisation. This study found no significant differences in the C/N ratio between land use systems or between cultivated and uncultivated land. According to Yihenew (2002), the optimum range of the C:N ratio is about 10:1 to 12:1 that provides nitrogen in excess of microbial needs. This meant that the C:N results for both peons showed the best range for microbes to break down and mineralise organic matter, except for peon 1's Bt1 horizon, which had not been grown for that reason.

Soil organic carbon was determined to estimate the amount of organic matter in the soil. Organic matter has an important influence on soil's physical and chemical characteristics, fertility status, plant nutrition, and biological activity (Brady and Weil, 2002). The highest value of soil organic matter was recorded at the surface soil layers, and it decreased with an increase in soil depth. In all of the profiles that were looked at, the amount of organic matter dropped sharply with depth. This suggests that there were more decomposable organic materials near the surface. Yihenew (2002) reported that most cultivated land soils of Ethiopia are poor in their organic matter content due to low amounts of organic materials applied to the soil and complete removal of the biomass from the field.

According to Landon (1991), available (Olsen-extractable) soil P levels of less than 5 mg kg^{-1} are rated as low, 5–15 mg kg^{-1} are rated as medium, and greater than 15 mg kg^{-1} are rated as high. Thus, the available (Olsen-extractable) P throughout the studied soils (Table 1) was below the critical level. Available P showed almost constant distribution with depth of the studied soil pedons. The low P content of the soils could be related to P fixation by Al and Fe. So, the soils' low available P could be one of the main things that stops them from being fertile in the study area and other similar places in the Asossa district. *There wasn't much phosphorus available in most places in Asossa Wereda in the Benshagul-Gumuz Region (Getahun et al., 2016a; Bray II extractable).*

Cation exchange capacity and percent base saturation

According to Landon (1991), CEC of the soils greater than 40 cmol (+) kg-1 are rated as very high and 25-40 cmol (+) kg-1 as high, and CEC of soil from 15-25, 5-15, and < 5 cmol (+) kg-1 of soil are classified as medium, low, and very low, respectively. According to Landon (1991), the CEC soil of the studied area ranges from 25.8 cmol (+) kg-1 depth to 34.5 cmol (+) kg-1 that high**,** implying it is good for agricultural purposes. Furthermore, such a high CEC value provides the soil with high buffering capacity so that one can apply the required amount of fertiliser dosage without any immediate negative effects on the soils. CEC values generally showed declining trends with depth of both pedons. The cation exchange capacity of a soil could then relate with the organic matter content of a soil (Brady and Weil, 2002).

Table 3. Exchangeable cation, CEC and percent base saturation

Horizon	Depth (cm)	Exchangeable cation (cmol(+) kg^{-1}soil)				Ca/Mg	K/Mg	CEC (cmol(+) kg^{-1}
		Ca	Mg	K	Na			
Pedon1								
A	0-20	6	2	0.1	0.4	3	0.05	38.0
AB	20-35	4	2	0.1	0.5	2	0.05	34.5
Bt$_1$	35-100	3	1	0.1	0.3	3	0.1	29.9
Bt$_2$	100-200	2	2	0.1	0.6	1	0.05	25.8
Pedon 2								
Ap	0-20	5	3	0.1	0.5	1.7	0.03	35.7
BA	20-45	2	2	0.1	0.4	1	0.05	31.5
Bt	45-120	2	2	0.1	0.3	1	0.05	27.6

Where, Ca = cacium; Mg = magnisium; K= potasium; Na = sodium; CEC = cation exchangeaable capacity; PBS = percent of base saturation.

It was found that exchangeable Ca made up most of the exchange complex of the soil particles in both of the soils that were studied (Table 6). Landon (1991) categorised Ca as <2.0 Cmol (+) kg-1 soil as very low, 2.0 to 5.0 Cmol (+) kg-1 as low, 5.1 to 10.0 Cmol (+) kg-1 as medium, 10.1-20.0 as high, and >20.0 Cmol (+) kg-1 as very high. Based on this categorisation, the level of Ca in the tested soils ranges from low to medium in the subsurface and surface horizons, respectively. According to Mesfin (1998), most Nitisols profiles show Ca and Mg higher in the surface horizon than in the horizon below; this can be attributed to recycling through leaf fall and decay.

The amounts of the basic cations that are exchangeable for K and Na were much lower than the amounts of the basic cations that are exchangeable for Ca and Mg in both the soil pedons and the soil horizons inside the apedon. However, exchangeable Na was relatively higher than K in all soil horizons. Exchangeable K in studied soils had 0.1 Cmol (+) kg-1 through all horizons as given in Table 6. This was very low, according to Landon's (1991) rating. The soils in the study area had very low K, indicating that these soils have no adequate levels of K for crop production. The result disagrees with the common idea that Ethiopian soils are rich in K. But it agrees with Belay (1996) and Wakene (2001), who reported K deficiency in Eutric Vertisols of Melbe (Tigray) and Dystric Nitisols of the Bako area, respectively.

Effect of Blended Fertilizer Types and Rates on Yield Components of Maize

Ear length, hundred kernels weight, number of kernels per row and number of kernel row per cob

The mean value and analysis of variance of treatment on ear length, 100 kernels weight, and number of kernels per row revealed a highly significant difference ($P \leq 0.01$) among blended fertiliser types and rates (Table 10 and Appendix Table 3). However, the application of fertiliser treatments had non-significant ($P \geq 0.05$) effects on the number of kernel rows per cob (Table 10). Blended fertiliser rates and types had highlP < 0.01significant ($P \leq$) effects on ear length of maize (Table 10). However, there were no significant differences between the two formula types. Blended fertiliser that contains B improved cob weight. These results agree with the finding of Mozafar (1989), who reported that applying B fertiliser to maize production encourages good cob development.

The largest ear length (16.10 cm) was obtained under the application of 200 kg NPSZnB + 150.2 N (T10), while the shortest ear length of maize (11.57 cm) was recorded under the control. The two types of blended fertiliser formulas (NPSZnB and NPSB) gave similar responses to these parameters. The application of blended fertiliser had a highly significant ($p \leq 0.01$) influence on 100 kernels weight (Table 10); however, there were no significant differences between the two blended fertiliser formulas. The maximum number of 100 kernels weight (48.85 g) was obtained under T9, while it was at par with T5, T6, T7, and T10. On the other hand, the minimum number of 100 kernels weighed (40.96 g) was recorded under the control.

Comparing the 100 kernels weight showed that 150 kg NPSZnB + 112.6 N kg ha-1 application resulted in 20.05% and 15.15% more 100 kernels weight as compared to the control treatment and recommended N and P, respectively (Table 10). The mean analysis of variance of treatment on the number of kernels per row revealed a highly significant ($P \leq 0.01$) difference among fertiliser rates and types. However, there were no significant differences between the two blended fertiliser formulas (Table 10). Both blended fertiliser types (NPSZnB and NPSZnB) gave more response to the number of kernels per row than recommended N and P and the control. The maximum number of kernels per row (37.10) was obtained under application of (T10), while the minimum number of kernels per row (24.23) was recorded under the control plants.

Table 4. Ear length, hundred kernels weight, number of kernels per row and number of kernel row per cob of maize as influenced by blended fertilizer types and rates.

Treatments	Ear length(cm)	100 kernels weight(g)	Number of kernels per row	Number of kernel row per cob
Control	11.57e	40.69d	24.23d	14.567
100 Kg TSP&200 Kg Urea	14.13abcd	42.42cd	30.700bc	14.567
125 Kg TSP & 250 Kg Urea	13.067cde	40.83d	30.50bc	14.467
150 Kg TSP & 300 Kg Urea	12.100de	42.92cd	29.100cd	14.933
100 Kg NPSB Kg +73.9 N	14.47abc	46.60abc	34.63ab	15.067
150 Kg NPSB Kg + 110.8N	15.53ab	46.61abc	35.67ab	15.167
200 Kg NPSB Kg + 147.8 N	14.20abc	46.59abc	32.70abc	14.900
100 Kg NPSZnB + 75.1 N	13.933bcd	43.32bcd	31.43bc	15.433
150 Kg NPSZnB + 112.6 N	13.36cde	48.850a	33.17abc	15.067
200 Kg NPSZnB + 150.2 N	16.10a	47.303 ab	37.10a	15.100
LSD(0.05)	2.04**	4.26**	5.42**	-
CV	8.61	5.66	9.90	2.95

Mean value of followed the same letter(s) are non-significant difference at LSD 5%; LSD(0.05) least significant probability level: CV = coefficient variation

The analysed data of the number of kernel rows per cob indicated that a non-significant difference was observed among fertiliser rates tested. Application of blended fertiliser (T10) increases the number of kernels per row by 53.11% over the control plot. As compared to the recommended N and P, the mean value of the number of kernels per row increased by 20.84% for T10. The longest ear, heaviest kernel, and most kernels per row were all seen when blended fertiliser was used. This may be because it contained nutrients like N, P, S, Zn, and B, which may have helped plants grow and develop more than when only N and P were used or when no fertiliser was used. Data regarding the number of kernel rows per cob for various treatments are indicated in (Appendix table 5). The mean value and analysis of variance of treatment on the number of kernels per row revealed a non-significant ($P \geq 0.05$) difference among fertiliser rates and types. The maximum number of kernel rows per cob (15.43) was obtained under application T8 (100 kg NPSZnB + 75.1 N), while this treatment was at par with all other treatments.

Influence of Blended Fertilizer Types and Rates on Grain Yield , Straw Yield, Biological Yield and Harvest Index of Maize.

Grain yield

The analysis of variance among blended fertiliser rates, types, and recommended N and P on grain yield revealed highly significant ($P \leq 0.01$) differences; however, there were no significant differences between the two blended fertiliser types (Appendix table 6). The two types of blended fertiliser had significantly improved grain yield. The grain yield increment from the plot that was treated with blended fertiliser might be the contribution of balanced nutrients (macro- and micro-nutrients) present in blended fertiliser as compared to recommended N and P and control. The low yield of maize under application of recommended N and P might be due to the absence of macronutrients like K and S and other micronutrients (Zn, B). A similar trend was observed withal. (2012).*Oorboori et al.*

Comparing the grain yield, T10 resulted in 135.5% and 111.1% increases as compared to T1 and T2, respectively. *The same thing was seen by Singh et al. (2009) in wheat crops. They said that 100% NP plus a single spray of micronutrients worked best compared to other methods.* Grain yield increments with the blended fertiliser, which contained S, B, and Zn, indicated the need to supplement the element for maize production. Finally, it was found that adding micronutrients, especially boron and zinc, to cereals increased their yield and yield components (Majid et al., 2012). The increase in grain yield could be attributed to the beneficial influence of yield-contributing characters and the positive interaction of nutrients in the blended fertiliser (Dagne, 2016). Strong relationships were found between grain yield and ear length, grain yield and 100 kernels weight, and number of kernels per row and between grain yields. Therefore, those three yield attributes are the most important components directly related to grain yield in maize.

Table 5. biomass yield, grain yield, straw yield and harvest index of maize as influenced by blended fertilizer types and rates at Asossa district.

Treatments	Grain yield (kg)	Straw yield (kg)	Biological yield(kg)	Harvest index
Control	2996.0e	4400.9e	7397e	0.41bcd
100 Kg TSP&200 Kg Urea	3342.5de	5119.8de	8462de	0.40cd
125 Kg TSP & 250 Kg Urea	3569.3de	5337.7de	8907d	0.40cd
150 Kg TSP & 300 Kg Urea	3958.9d	5882.4cd	9841d	0.40cd
100 Kg NPSB Kg +73.9 N	5789.8bc	6971.7ab	12761bc	0.46ab
150 Kg NPSB Kg + 110.8N	6863.4a	7886.7a	14750a	0.47a
200 Kg NPSB Kg + 147.8 N	6563.8a	6971.7ab	13536ab	0.48a
100 Kg NPSZnB + 75.1 N	5473.3c	6644.9bc	12118c	0.45abc
150 Kg NPSZnB + 112.6 N	6538.7ab	7124.2ab	13663ab	0.48a
200 Kg NPSZnB + 150.2 N	7056.2a	7559.9ab	14616a	0.49a
LSD(0.05)	758.71**	1065.4**	1396.3**	0.05**
CV	8.48	9.72	7.01	6.95

Mean value of followed the same letter(s) are non-significant difference at LSD 5%; LSD(0.05) least significant probability level: CV = coefficient variation

As the rate of N and P increases, the grain yield was also increased. Therefore, grain yield obtained from recommended N and P was slightly superior to the control. The low yield *on unfertilised plots might have been due to reduced leaf area development, resulting in less radiation interception and, consequently, low* *efficiency in the conversion of solar radiation (Sallah et al., 1998).* The yield advantage of blended fertilisers over recommended N and P might be due to the presence of macronutrients like S and micronutrients like Zn and B. If levels of these nutrients are too low, it can lead to poor plant growth, reduced uptake, inhibited cell division, respiration, and nitrogen mobilisation, as well as inefficient plant water use.

Straw yield

The mean value and analysis of variance of treatment on straw yield revealed highly significant ($P \leq 0.01$) differences among fertiliser types and rates. However, there were no significant differences between the two blended fertiliser types. Nitrogen increases shoot dry matter, which is positively associated with grain yield in cereals and legumes (Fageria, 2007). The maximum maize straw was recorded with T6 (7886.7 kg ha-1), while the minimum value (4400.9 kg ha-1) was recorded with the control treatment. Comparing the straw yield showed that T6 resulted in 79.21% more biomass yield as compared to the control treatment (Table 11). Compared to the recommended N and P, the mean value of straw yield was increased by 54.04% when T6 was applied. Nitrogen application increases stover yield, and this might be due to the fact that N increases leaves per plant, leaf area, and stem diameter (Kaur *et al*., 2012).

Biological yield

The analysis of variance among blended fertiliser types and rates of biological yield revealed a highly significant ($P \leq 0.01$) difference. The two types of blended fertiliser had significantly improved biological yield over recommended N and P. These results were in conformity with the findings of Sharma *et al*. (2011), who stated that the application of micronutrient combinations with macronutrients gave the highest biological yield, as grain yield was also influenced, which might be attributed to the additional availability of nutrients.

The maximum amount of biological yield (14750 kg ha-1) was obtained under the application of 150 kg NPSB Kg + 110.8N (T6). However, it was non-significantly different from other treatments T7, T9, and T10. This might be due to the basal application of nitrogen fertiliser in addition to the blended fertilizers. In agreement with the results of this study, Abera (2013 unpublished) reported significantly higher biological yield at higher N rates. The minimum amount of biological yield (7397 kg ha-1) was obtained from the control plot, while this treatment is statistically on par with the recommended N and P. Comparing the biological yield showed that T6 resulted in 99.4% more biological yield compared to the control plants (Table 11). On the other hand, compared to the recommended N and P, the mean value of biological yield increased by 74.3% for the application of blended fertiliser via nitrogen (150 kg NPSB + 110.8 N).

The increase in biological yield could be because of micronutrients that help with photosynthesis, early growth, and nitrogen fixation. Zn and other important nutrients were found in the multi-nutrient solution (Azhar et al., 2011). As the rate of N and P increases, the biological yield was also non-significantly increased. This increase in biological value with the blended fertiliser showed that both macro- and micro-plant nutrients were deficient in the study area. Also, maize had a higher biological yield when blended fertiliser was used instead of the control and recommended N and P. This might be because it has the right amount of both macro and micronutrients.

Harvest Index

The physiological ability of maize to convert total dry matter into grain yield is determined by its harvest index (HI). The analysis of variance revealed that fertiliser rates and types had a highly significant ($P \leq 0.01$) influence on harvest index. However, there were no significant differences between the two blended fertiliser types (Appendix table 6). Both blended fertiliser types (NPSZnB and NPSZnB) gave more response to harvest index than recommended N and P and the control. Nevertheless, a non-significant difference between recommended N and P and control was observed with regard to harvest index. The highest harvest index (0.49) was found when 200 kg of NPSZnB and 150.2 kg of N were applied to an area of 10 hectares (T10). The lowest harvest index (0.40) was found when the recommended amounts of N and P were used.

The increase in the harvest index due to micronutrients may be attributed to its influences in enhancing theparts. osynthesis process and translocation of photosynthetic products to economic part.Comparing the harvest index showed that 200 kg NPSZnB + 150.2 N kg ha^{-1} application resulted in a 19.51% higher harvest index as compared to the control treatment (Table 11). Compared to the recommended N and P, the mean value of the harvest index increased by 22.50% for the application of blended fertiliser (200 kg NPSZnB + 150.2 N kg ha^{-1}). The higher harvest index was expressed because of the physiological potential for converting dry matter into grain yield.

Dominance analysis and marginal rate of return

The highest net benefits from the application of inputs for the crop's production might not be sufficient for the farmers to accept as good practices. In most cases, farmers prefer the highest profit (with low cost and high income). For this purpose it is necessary to conduct a dominated treatment analysis (CIMMITY, 1988). The %

MRR between any pair of undominated treatments denotes the return per unit of investment in fertiliser expressed as a percentage. A dominated treatment is any treatment that has net benefits that are less than those of a treatment with lower costs that vary (Stephen and Nicky, 2007).

Table 6. Dominance analysis of blended fertilizer and recommended N and P application in Asossa district during 2016/17.

Treatments (Nutrient ha^{-1})	**VC**(ETB ha^{-1})	**NB**(ETB ha^{-1})	**MRR%**	**B:C ratio**
Control	0	16080	0	0
100 Kg NPSB +73.9 N	2721.3	27945.7	436.0	10.3
100 Kg NPSZnB + 75.1 N	2825.6	26170.4	D	9.3
100 Kg TSP& 200 Kg Urea	3,073	14891.0	D	4.8
125 Kg TSP & 250 Kg Urea	3622.5	15528.5	D	4.3
150 Kg NPSB + 110.8N	3937.6	32321.4	5329.4	8.2
150 Kg NPSZnB + 112.6 N	3971.9	30478.1	D	7.7
150 Kg TSP & 300 Kg Urea	4639.5	16595.5	D	3.6
200 Kg NPSB + 147.8 N	5106.5	29430.5	D	5.8
200 Kg NPSZnB + 150.2 N	5293.4	31845.6	D	6.0

Where VC = variable cost, NB = net benefit, MRR% = marginal rate of return, D = dominated, B:C ratio = benefit cost ratio.

The dominance analysis showed that the net benefit of all treatments was dominated except for the application of 100 kg NPSB + 73.9 N kg ha^{-1} and 150 kg NPSB + 110.8 N kg ha^{-1} (Table 20). This result indicated that the net benefit was decreased as the total cost that varies increased beyond undominated fertiliser treatment applications. Therefore, no farmer may choose other dominated treatments in comparison with the undominated treatments. This also helps to avoid the dominated treatment in further estimates of marginal rates of return.

Economic analysis revealed that the maximum marginal rate of return was recorded with the application of 150 kg NPSB + 110.8 N kg ha-1 (5329.4%), followed by 100 kg NPSB + 73.9 N kg ha-1 (436.0%). The marginal rates of those treatments were well above the 100% minimum (CIMMYT, 1988). In the present study, the treatments that had above 100% marginal rate return were recommended for the farmers, with treatments that had a small number of variable costs. This treatment was 150 kg NPSB + 110.8 N kg ha-1. Accordingly, the study revealed that application of 150 kg NPSB + 110.8N kg ha-1 was considered as the best for recommendation. The best recommendation for treatments subjected to marginal rates of return is not necessarily based on the highest marginal rate; rather, it is based on the minimum acceptable marginal rate of return, and the treatment with the highest net benefit and relatively low variable cost, together with an acceptable MRR, becomes the tentative recommendation (CIMMYT, 1988).

SUMMARY AND RECOMMENDATION

In recent years, crop productivity in Ethiopia in general and in the Benshal-gul Gumuz region in particular has shown a declining trend, in spite of the best use of improved varieties. The most likely causes of this decline are soil fertility depletion and the continued use of traditional fertilisers, which have a limited number of essential plant nutrients. In addition, due to high rainfall, soil erosion is a severe problem in sloping areas where vegetative cover is very low. So, the study's goal was to find out how the soil in the Asossa district affects the growth and yield components of maize (Zea mays L.) when it is fertilised with different amounts and types of blended fertiliser. The present study was conducted in Benishangul Gumuz Regional State, at the Asossa Agricultural Research Centre station.

Application of blended fertiliser had significantly affected the plant height and ear height as compared to N and P combined supply and the control. The application of blended fertiliser increases the cob weight by 128.2% over the control plot, while a non-significant difference was observed between the blended fertiliser formulas. The analysis of variance of treatment on ear length, 100 kernels weight, and number of kernels per row revealed higtypes. gnificant ($P \leq 0.01$) differences among fertiliser rates and types.The fertiliser rates and types on biological yield, grain yield, straw yield, and harvest index revealed highly significant differences ($P \leq 0.01$); however, there were no significant differences between the two blended fertiliser types. Maximum grain yield, 7056.2 kg ha^{-1}, was recorded with T10 (200 kg NPSZnB + 150.2 N), while minimum grain yield, 2996.0 kg ha^{-1}, was recorded from the control treatment. This maximum grain yield was followed by T6, T7, and T9 with corresponding grain yields of 6863.4, 6563.8, and 6538.7 kg ha^{-1}, respectively, where these treatments were statistically at par with each other. The maximum maize straw was recorded with T6 (7886.7 kg ha-1), while the minimum value (4400.9 kg ha-1) was recorded with the control treatment. Accordingly, the study revealed that application of 150 kg NPSB + 110.8 N kg ha^{-1} and 150 kg NPSZnB + 112.6 N kg ha^{-1} are the best rates recommended for maize production in the Assosa area.

The profitability of the study showed that the application of 150 kg NPSB + 110.8 N and 150 kg NPSZnB + 112.6 N kg, which provided relatively high net benefits (32,321.4 and 30,478.1 ETB), was the best rate to apply. The marginal rate of analysis from undominated treatments indicated that for each one birr invested in the purchase or production of fertilisers, it was possible to recover one birr plus an extra 4.36 birr ha-1 and 53.29 birr ha-1 as the fertiliser application changed from unfertilised plot to 100 kg NPSB + 73.9 N kg ha-1 and 150 kg NPSB + 110.8 N kg ha-1, respectively. Therefore, we recommend the treatments (150 kg NPSB + 110.8N kg ha-1) that have a high marginal rate of return, a high net benefit, and a relatively small total cost of production for maize production in the Asossa zone. The rate of sulphur in the blended fertiliser was less than the requirement for cereal crops, and the blending fertiliser company must work toward balancing the ratio of sulphur with other cronutrients. The exchangeable potassium of the Asossa area is below the critical level and will be corrected only by the application of potassium fertiliser, so potash fertilisers are needed to address the key nutrient deficiencies in the tested soils.

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Citation: Bakala A: *Soil Fertility Characterization and Response of Maize (Zea mays L.) to Application of Blended Fertilizer Types and Rates from Asossa, Western Ethiopia* Int. J. Res. Rev. 13(1) Pp.1-11, 2025