



Evaluation of Blended Fertilizer Formulas under Limed Condition of Acid Soil on Soybean (*Glycine max*) at Asossa District of Benishal-gul Gumuz Regional State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Purpose: To evaluate the blended fertilizer formulas types, under unlimed limed condition of Asossa acid soil on soybean in Benishagul Gumuz of Ethiopia.

Methods: Two factorial RCB design with three replications was used in the investigation. Five types of blended fertilizer formulas were tested under limed and unlimed condition in Factorial Randomized Complete Block Design. Lime and blended fertilizer types were used as factor. The amount of lime that was applied at each location was calculated on the basis of the exchangeable acidity, bulk density and 15 cm depth of the soil. One mole of exchangeable acidity would be neutralized by an equivalent mole of CaCO₃. Accordingly, the amount of lime for this particular activity would be uniformly applied for all plots at 1.5 times of the exchangeable acidity (Equation 1) and incorporated in to the soil a month before seed sowing.

Results: The effects of applied lime (CaCO₃) and fertilizer types on growth and yield components of soybean were non-significantly (P>0.05) influenced except 100 seed weight, whereas the lime by blended fertilizer types interaction effects were not-significantly (P>0.05) affect all growth and yield components of soybean (Table 2). The highest plant height (71.58 cm) was obtained from

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NPKSZnB (Formula 5 modified) fertilizer type, however statistically non-significant from the other treatments.

Conclusion: The partial budget analysis indicated that, it was not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the high net benefit, relatively low variable cost together with an acceptable MRR becomes the tentative recommendation. Therefore we recommend the treatments (100 kg /ha NPSB) that have acceptable marginal rate of return, relatively high net benefit and relatively small total cost of production for soybean production in Asossa zone.

Keywords: Lime; blended; yield; budget; fertilizer.

1. BACKGROUND

Soybean (*Glycine max* L.) is one of the grain legumes and native to East Asia, perhaps in North and Central China [1] and it is grown for its edible bean, an important source of inexpensive and high quality protein (40%) and oil (20%) around the world. In Ethiopia, soybean is an important food crop widely produced in the west and southwestern parts. Its production is highly concentrated in high rainfall areas of Ethiopia like Asossa, Wollega and Jimma areas. It was recently integrated into the cropping systems of smallholder farmers in Asossa areas and serves as a cash crop for farmers [2].

Soybean is grown on 10⁴ million hectares of land on five continents with annual total production of 241 million tons and productivity of 2.0 ton ha⁻¹ [3]. In Ethiopia, the area allocated for soybean and the corresponding total annual production has been 31,876 ha and 63,653 tons, respectively, with the productivity less than 2 ton ha⁻¹ [4], while the potential soybean yield has been estimated to be in the range of 6 – 8 tons ha⁻¹ in USA [5].

About 50 countries worldwide grow soybean [6]. The United States of America (USA) accounted for 40 to 45% of the world's total soybean production in 2003 [6]. Egypt, the largest producer of soybean in Africa, produces about 180,000 tons annually [7]. Soybean improves soil fertility by fixing nitrogen from the atmosphere [8]. Soybeans are sensitive to low pH. In acid soils, liming is essential to raise the pH to 6.0 or 6.5 for optimum yield production. Soils in Africa are typically highly variable in fertility and how they respond to application of inputs [9]. Soil nutrient depletion, nutrient mining and degradation have been considered serious threats to agricultural productivity and have been identified as major causes of decreased crop yields and per capita food production in sub-Saharan Africa [10].

The fertility status of Ethiopian soils has also declined and continued to decline posing a challenge to crop production. This is due to, continuous cropping (abandoning of fallowing), reduced manure application, removal of crop residues and animal dung for fuel wood and erosion coupled with low inherent fertility of the soils [11]. The nutrient mining of Ethiopian soils might be caused by the losses of soil organic matter, macronutrient, and micronutrient depletion; topsoil erosion; acidity; salinity; and deterioration of other soil physical properties. Declining soil fertility particularly low soil nitrogen availability is often the major factor resulting in decreased crop plant yields and recognized as a major problem to continue cereal cropping in soils of Ethiopia, specifically in soils of Assosa area [12]. The study in western parts of Ethiopia had revealed soil acidity problems (Abebe, 2007). In these areas, 67% of soils had pH values less than 6 that range from strongly to very strongly acidic conditions. Of these, 2.2% were extremely acidic (pH<4.5), 34% were very strongly acidic (pH = 4.5 to 5.0), 32.8% were strongly acidic (pH = 5.1 to 5.5.) and 27% were moderately acidic with pH range of 5.6 to 6.0 (Abebe, 2007).

In order to speed up agricultural growth, the government of Ethiopia has established Agricultural Transformation Agency (ATA) by federal regulation to handle initiatives of helping to achieve its goal of boosting agricultural productivity under the Agricultural Growth Plan [13]. The ATA, in partnership with the MoA and other federal and regional stakeholders, launched Ethiopian Soil Information System (EhioSIS) in 2011 with the major purpose of mapping the soil fertility status of the country's agricultural land targeted at woreda (administrative district) level. Based on this information the initial mapping work conducted on 162 woredas showed that, in addition to nitrogen and phosphorus, sulfur, potassium, boron and zinc nutrients are deficient in many

areas. This data indicated that one compound fertilizer (NPS) and three blended fertilizers (NPSB, NPSZnB, and NPSZn) plus or minus potash fertilizer are needed to address the key nutrient deficiencies in the tested soils in Ethiopia [14].

Application of fertilizers in relation to initial soil fertility status and crop requirement leads to economic and judicious use of fertilizers. Experiments conducted by different researchers to decide rate of fertilizer under different research stations and their surrounding on-farm resulted in different rates of recommendations in terms of both N and P [15]. 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. Different research reports indicate that nutrients like K, S, Ca, Mg and all micro-nutrients except Fe are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country [16]. Recently acquired soil inventory data from EthioSIS (Ethiopian Soil Information System) also revealed that in addition to N and P, nutrients such as S, B, Zn are widespread in Ethiopian soils. EthioSIS (Ethiopian Soil Information System) indicated that, the soils of Asossa area also deficient in, sulphur, boron and zinc in addition to phosphorous and nitrogen, which all potentially hold back crop productivity despite continued use of N and P fertilizer as per the blanket recommendation. Therefore, the present study was designed to assess the effects of different fertilizer types under lime and unlimed on soybean production in Asossa District.

2. MATERIALS AND METHODS

2.1 Description of the Study Sites

The experiment was conducted in Benishangul Gumuz Regional State, at Asossa Agricultural Research Center (AARC) research farm in 2016/17 main cropping season under rain fed field condition. Benishangul Gumuz Regional State is geographically located at 9°30' to 11°39' N latitude and 34° 20' to 36° 30"E longitude covering a total land area of 50,000 square kilometer. The study site is located at 10° 02' 05" N latitude and 34° 34' 09" E longitudes. The study area is situated east of Asossa town and west of Addis Ababa about 4 km and 660 km distance, respectively. Asossa has 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 of Asossa is 1275 mm. The minimum and maximum temperatures are 16.75°C and 27.92°C, respectively. The dominant soil type of Asossa area is Nitosols with the soil pH ranges from 5.0 to 6.0.

2.2 Treatments and Experimental Design

Two factorial RCB design with three replications was used in the investigation. The treatment arrangements and application modes was conducted according to specific blended fertilizer formulation for Asossa area.

1. Control
2. Recommended NP (39 kg/ha Urea + 100 kg/ha TSP(N=18, P₂O₅=46)
3. Formula 2: 100 kg/ha (18.1 N - 36.1 P₂O₅ - 0.0 k₂O + 6.7 S + 0.0 Zn + 0.71 B)
4. Formula 4: 100 kg/ha (16.9 N - 33.8 P₂O₅ - 0.0 k₂O + 7.3 S + 2.23 Zn + 0.67B)
5. Formula 4 modified: 100 kg /ha (17.5 N - 34.9 P₂O₅ - 0.0 k₂O + 7.6 S + 2.23Zn + 0.25B)
6. Formula 5 modified: 100 kg/ ha (13 N - 26.1 P₂O₅ - 14.8 k₂O + 5.6 S + 1.72Zn + 0.25B)
7. Recommended NP (39 kg/ha Urea + 100 kg/ha TSP (N=18, P₂O₅=46) + lime
8. Formula 2: 100 kg/ha (18.1 N - 36.1 P₂O₅ - 0.0 k₂O + 6.7 S + 0.0 Zn + 0.71 B) + lime
9. Formula 4: 100 kg/ha (16.9 N - 33.8 P₂O₅ - 0.0 k₂O + 7.3 S + 2.23 Zn + 0.67B) + lime
10. Formula 4 modified: 100 kg /ha (17.5 N - 34.9 P₂O₅ - 0.0 k₂O + 7.6 S + 2.23Zn + 0.25B) + lime
11. Formula 5 modified: 100kg /ha (13 N - 26.1 P₂O₅ - 14.8 k₂O + 5.6 S + 1.72Zn + 0.25B) + lime

The amount of lime that was applied at each location was calculated on the basis of the exchangeable acidity, bulk density and 15 cm depth of the soil. One mole of exchangeable acidity would be neutralized by an equivalent mole of CaCO₃. Accordingly, the amount of lime for this particular activity would be uniformly applied for all plots at 1.5 times of the exchangeable acidity (Equation 1) and incorporated in to the soil a month before seed sowing.

$$LR, CaCO_3 (kg / ha) = \frac{cmolEA / kg \text{ of soil} * 0.15 m * 10^4 m^2 * B.D. (Mg / m^3) * 1000}{2000} \quad (1)$$

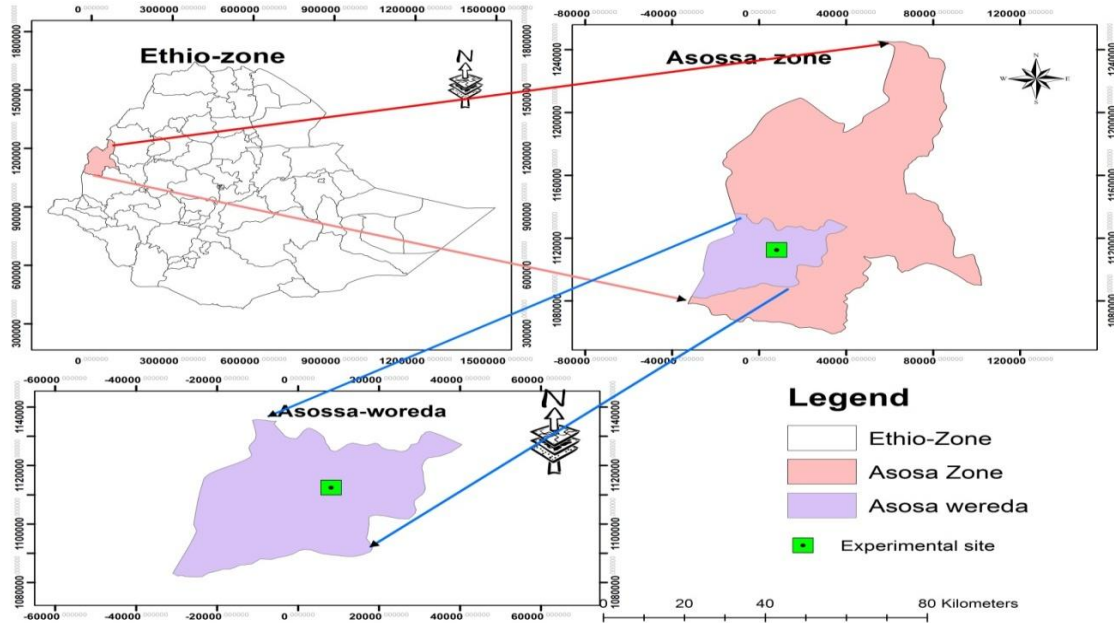


Fig. 1. Map showing the study location in District of Benshal-gul Gumuz Regional State

2.3 Soil Sampling and Analysis

Before the commencement of the experiment, a composite soil sample was taken from the upper 0-20 cm of the experimental field and analyzed for selected physical and chemical properties. Soil pH was determined using a pH meter with combined glass electrode in water (H₂O) at 1:2.5 soil: water ratio as described by Carter (1993). Organic carbon, was determined by oxidizing carbon with potassium dichromate in sulfuric acid solution following the Walkley and Black method (1934). The total nitrogen contents in soils were determined using the Kjeldahl procedure by oxidizing the organic matter with sulfuric acid and converting the nitrogen into NH₄⁺ as ammonium sulfate (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 0.5 M sodium bicarbonate at nearly constant pH of 8.5 in 1:20 of soil to solution ratio for half an hour and the extract was obtained by filtering the suspension as indicated by Olsen et al. (1954).

Finally exchangeable bases (Ca, Mg, K and Na) in the soil were estimated by the ammonium acetate (1M NH₄OAc at pH 7) extraction method. In this procedure, the soil samples were extracted with excess of NH₄OAc solution, and Ca and Mg in the extracts were determined by atomic absorption spectrophotometer, while flame photometer was used to determine the contents of exchangeable K and Na as described by Rowell (1994).

2.4 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 used for mean separation when the analyses of variance indicate the presence of significant differences.

2.5 Economic Analysis

Mean grain yield of the selected treatment was used in partial budget analysis [17]. 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 open market

price (Birr kg⁻¹) for maize and the official prices of blended, Urea and TSP fertilizers were used for economic analysis. The dominance analysis procedure as detailed in CIMMYT [17] 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.

3. RESULTS AND DISCUSSION

3.1 Soil Chemical and Physical Properties of the Studied Area

EthioSIS (2014), classified pH values into five classes, strongly acidic < 5.5, moderately acidic 5.6 - 6.5, neutral 6.6 - 7.3, moderately alkaline 7.3 - 8.4 and strongly alkaline > 8.4. Accordingly the soils in the studied area had 5.2 which were strongly acid. The most favorable pH for availability of most plant nutrients correspond roughly with the optimum range of 6 to 7 [18]. The range of soil reaction in experimental site may limit crop production by influencing the availability of important plant nutrients. According to Landon [19], Soil pH value below 5.5 could be an indication of presence of appreciable amount of exchangeable acidity and exchangeable Al³⁺ and removal of exchangeable cations, such as calcium and magnesium. The same as the exchangeable acidity of the studied area was high, and might be restrict the growth of plant roots. Exchangeable acidity consists of any aluminum or iron, as well as any exchangeable H that may be present in the exchange sites [20]. According to Miller and Donahue (1997), for good plant growth, bulk densities should be below 1.4 g cm⁻³ and 1.6 g cm⁻³ for clay and sand soils, respectively. So the bulk density values observed in these soils were within the normal range for mineral soils.

Exchangeable Ca was found to pre dominate the exchange complex of the soil colloidal particles in the soil of the studied area (Table 1). Landon [19] categorized Ca as <2.0 Cmol (+) kg⁻¹ soil very low, 2.0 to 5.0 Cmol (+) kg⁻¹ low, 5.1 to 10.0 Cmol (+) kg⁻¹ medium, 10.1-20.0 high and >20.0 Cmol (+) kg⁻¹ as very high. Based on this categorization, the status of Ca in tested soil is

low in range. The concentrations of the monovalent basic cations (exchangeable K and Na) were far lower than the concentrations of the divalent basic cation (exchangeable Ca and Mg) in the soil of experimental area. This was very low according to Landon, [19] rating. Landon, [19] categorized the exchangeable K in soils as <0.2 very low, 0.2 to 0.4 Cmol (+) kg⁻¹ low, 0.41-1.2 medium, 1.21-2.00 high and >2.00 Cmol (+) kg⁻¹ as very high. Accordingly the exchangeable K studied area is medium in rating. The soils in the study area had, low in exchangeable Ca and medium in exchangeable K, indicating that these soils have no adequate levels of basic cations for crop production. The amounts of organic carbon content recorded can be categorized very low (< 2%) Landon [19]. Similarly the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status as indicated by Landon [19]. Therefore, the experimental soils qualify for low in total N. According to Landon [19], available (Olsen extractable) soil P level of less than 5 mg kg⁻¹ is rated as low, 5-15 mg kg⁻¹ as medium and greater than 15 mg kg⁻¹ is rated as high. Thus, the available (Olsen extractable) P soils was of studied area is below the critical level.

3.2 The Main Effect of Lime and Fertilizer Types on Growth and Yield Components of Soybean

The effects of applied lime (CaCO₃) and fertilizer types on growth and yield components of soybean were non-significantly (P>0.05) influenced except 100 seed weight, whereas the lime by blended fertilizer types interaction effects were not-significantly (P>0.05) affect all growth and yield components of soybean (Table 2). The highest plant height (71.58 cm) was obtained from NPKSZnB (Formula 5 modified) fertilizer type, however statistically non-significant from the other treatments. This indicated that the addition of other macronutrient and micronutrient (S, K, Zn and B) to recommended N and P had no significant contribution for soybean production in Asossa area. Similarly the application of lime to the low soil pH of studied area had no significant (p>0.05) different from the unlimed one except 100 seed weight. Plot treated with lime resulted with significantly (p <0.05) increased 100 seed weight of soybean plant than the unlimed. This result is line with [21] who found that lime plus balanced fertilizer had the highest values of 100-seed weight as compared with the rest of treatments.

Table 1. Soil chemical and physical properties of the experimental area

PH	Exchangeable acidity	Bulk density	Mg	Ca	K	Na	OC	TN	Ava. P
5.02	2.14	1.36	0.58	3.5	1.03	0.213	1.73%	0.16	5.53

Table 2. The main effect of lime and fertilizer type on growth and yield components of soybean

Treatments	Plant height (cm)	Number of pod/plant	Number of seed/pod	100 seed weight (g)
Lime				
Unlimed	65.907	18.820	2.4800	11.0 ^B
Limed	67.393	19.267	2.4000	12.5 ^A
LSD	-	-	-	1.5
Fertilizer types				
Control	43.25	12.04	2.02	10.1
NP	64.000	17.9	2.46	11.50
NPSB (Formula 2)	67.600	19.50	2.50	10.50
NPSZnB (Formula 4)	62.7	17.48	2.43	11.67
NPSZnB (Formula 4 modified)	67.417	19.96	2.43	12.0
NPKSZnB (Formula 5 modified)	71.58	20.36	2.37	13.17
LSD	-	-	-	-
CV%	8.74	24.99	7.54	17.05

The analysis of variance of among the main effect and interaction of blended fertilizer types and lime on number of pod per plant and number of seed per pod had revealed non-significant ($P>0.05$) difference. However maximum number of pod per plant (20.36) and seed per pod (2.50) were recorded from NPKSZnB (Formula 5 modified) and NPSB (Formula 2) respectively (Table 2). The application of treatments indicated that the addition of K, S, Zn and B over recommended N and P had no any significant effect for both those yield components. The less responsive growth and yield components of soybean to blended fertilizer might be due to blow requirement level of K, S, Zn and B in blended (balanced) fertilizer for crops productivity.

3.3 Grain Yield, Straw Yield, Biological Yield and Harvest Index of Soybean

The analysis of variance of treatment on seed yield revealed the main and interaction effect of treatment had non-significant ($P\leq 0.01$) difference among limed and unlimed (Table 3). Similarly the fertilizer types had no significant effect on seed yield of soybean. However the highest seed yield (2558.3) of soybean had obtained from the balanced fertilizer type (NPKSZnB Formula5 modified), which contain N, P, K, S, Zn and B nutrients. On the other hand the addition of K, S, Zn and B nutrients to recommended N and P had no any significant effect on the seed yield of soybean (Table 3).

This is might be due to the blow the requirement level K, S, Zn and B nutrients in blended fertilizer.

The main effect of lime application had highly significant ($p<0.01$) effects on Straw yield, Biological yield and Harvest index of soybean (Table 3). However there is no significant ($P>0.05$) difference between the interaction effect of lime and fertilizer types. The higher straw yield (3869.6 kg/ha) of soybean was obtained from the limed compared to the unlimed (Fig. 2). Comparing the straw yield, lime application (1.5*EA) resulted in 29.4% more straw yield compared to unlimed. This is might be due the amelioration soil with lime (CaCO_3) precipitate the Al^{3+} and H^+ cation in acid soil and the availability of plant nutrient become increased after limed. Similarly the application of lime had improved the biological yield and harvest index of soybean as compared to unlimed. The higher biological yield (6255.6 kg/ha) and harvest index (0.42%) were recorded under limed as compared to unlimed. The mean value and analysis of variance of treatment on seed yield, straw yield and harvest index revealed non-significant difference ($P\geq 0.05$) among the main blended fertilizer types, and interaction effect of blended fertilizer types and lime (Table 3). On the other hand the application of treatment indicated that the blended fertilizer types had significant ($P>0.05$) effects on biological yield of soybean (Table 3). The highest biological yield (6333.3 kg/ha) was

obtained from NPKSZnB (Formula 5 modified), followed by NPSB (Formula 2) and recommended N and P which also had (6138.9 kg/ha) and (5611.1 kg/ha) respectively.

3.4 Partial Budget Analysis

The application of 100 kg NPKSZnB kg ha⁻¹ had the highest net-benefit of 22,768.45 ETB, followed by 100 kg NPSB, recommended 100 kg DAP and 100 kg NPKSZnB + 3.3 t/ha lime which also had a total of 20,793.07, 20,170.4 and 18,824.45 ETB net benefit respectively. The lowest net benefit was obtained by the application of the control with total of 9,094.46 ETB followed by 100 kg NPSZnB(Modified

formula 4) + 3.3 t /ha with net benefit of 13,837.15 ETB. Furthermore 100 kg NPSZnB + 3.3 t/ha also had lower net benefit of 14,583.57 ETB. The increased production of the crop due to the application of inputs might or might not be beneficiary to farmers [17]. Therefore, partial budget analysis [17] was employed to estimate the net benefit, dominance analysis and marginal rate of return that could be obtained from various alternative treatments [17]. The profitability of the study showed that application of 100 kg NPKSZnB kg /ha, 100 kg NPSB kg /ha and 100 kg DAP which provided the relatively high net benefit (22,768.45, 20,793.07 and 20,170.4 ETB) respectively, was the peak to apply fertilizers.

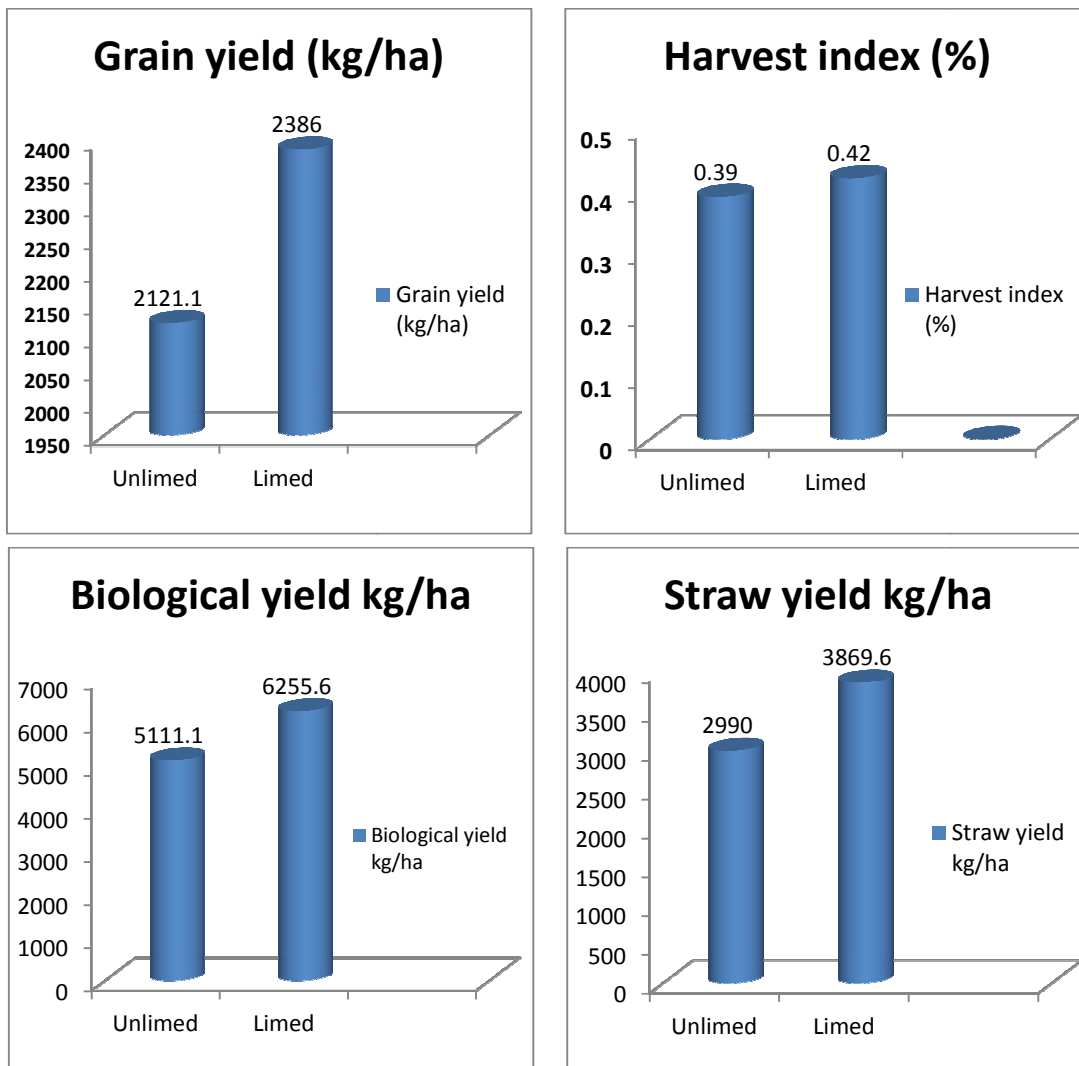


Fig. 2. The effect of limed and unlimed on grain yield, straw yield, biological yield and harvest index

Table 3. Effect of different blended fertilizer formulas on yield and yield attributes of soybean

Treatments	Grain yield (kg/ha)	Straw yield kg/ha	Biological yield kg/ha	Harvest index
Lime				
Unlimed	2121.1	2990.0 ^B	5111.1 ^B	0.39 ^B
Limed	2386.0	3869.6 ^A	6255.6 ^A	0.42 ^A
LSD	-	493.75 ^{**}	586.28 ^{**}	0.05 ^{**}
Fertilizer types				
Control	954.6	2012.24	3322.1	0.31
NP	2261.9	3349.2	5611.1 ^{ABC}	0.41
NPSB (Formula 2)	2326.9	3811.9	6138.9 ^{AB}	0.39
NPSZnB (Formula 4)	2107.5	2920.3	5027.8 ^C	0.42
NPSZnB (Formula 4 modified)	2013.1	3292.5	5305.6 ^{BC}	0.3817
NPKSZnB (Formula 5 modified)	2558.3	3775.0	6333.3 ^A	0.4017
LSD	-	-	926.99 [*]	-
CV%	18.02	18.77	13.45	14.74

3.5 Dominance Analysis and Marginal Rate of Return

The highest net benefits from the application of inputs for the production of the crop 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 dominated treatment analysis [17]. The % MRR between any pair of undominated treatments denotes the return per unit of investment in fertilizer 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 [22]. The dominance analysis showed that the net benefit of all treatments was dominated except application of 100 kg NPSB and 100 kg NPKSZnB (Table 5). This result indicated that the net benefit was decreased as the total cost that varies increased beyond undominated fertilizer treatments application. Therefore, no farmer may choose other dominated treatments in comparison with the undominated treatments. This also helps to avoid the dominated treatment in further estimate of marginal rates of return.

Economic analysis revealed that maximum marginal rate of return was recorded with application of 100 kg /ha NPKSZnB (249.87%), followed by 100 kg NPSB (172.04%). The marginal rates of those treatments were well above the 100% minimum [17]. According to CIMMYT [17] experience and empirical evidence, for the majority of situations indicated that the

minimum rate of return acceptable to farmers would be between 50 and 100%. In the present study the treatments that had above 100% marginal rate return was recommended for the farmers, with treatments that had small number of variable cost. This treatment was 100 kg /ha NPSB.

The % MRR between any pair of undominated treatments denotes the return per unit of investment in fertilizer expressed as a percentage. The results of undominated treatments indicated that for each one birr invested in purchase or production of fertilizers that was possible to recover one birr plus an extra of 2.50 birr ha⁻¹ and 1.72 birr ha⁻¹ as the fertilizer application changed from unfertilized plot to 100 kg/ha NPKSZnB and 100 kg/ha NPSB respectively. Passing from the first treatment that had the lowest costs that vary to the end treatment which had the highest cost that vary, the marginal rate of return obtained was above the minimum acceptable marginal rate of return. In this study, 100% was considered as minimum acceptable rate of return for farmers" recommendation. Accordingly, the study revealed that application of 100 kg NPKSZnB was considered as the best for recommendation. The best recommendation for treatments subjected to marginal rate of return is not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit, relatively low variable cost together with an acceptable MRR becomes the tentative recommendation [17].

Table 4. Partial budget analysis of blended fertilizer application types and lime on soybean at Asossa Zone

Lime t/ha	Fertilizer type in kg/ha	Variable cost (ETB ha ⁻¹)	GR (ETB ha ⁻¹) from		Total GR (ETB ha ⁻¹)	NB (ETBha ⁻¹)
			Straw	Grain		
0	Control	0	503.06	8,591.40	9,094.46	9,094.46
0	100 kg DAP	1,024	837.30	20,357.10	21,194.40	20,170.4
0	100kg NPSB	1,102.00	952.97	20,942.10	21,895.07	20,793.07
0	100kgNPSZnB	1,170.00	730.08	18,967.50	19,697.58	18,527.58
0	100 kg NPSZnB (modified formula 4)	1,180.00	823.13	18118.00	18,941.13	17,761.13
0	100 kg NPKSZnB	1,200.00	943.75	23,024.70	23,968.45	22,768.45
3.3	100 kg DAP	7,572	1,057.20	22,741.2	23,798.40	16,226.4
3.3	100kg NPSB	7,650	1,172.87	23,326.20	24,499.07	16,849.07
3.3	100 kg NPSZnB	7,718	949.97	21,351.60	22,301.57	14,583.57
3.3	100 kg NPSZnB(Modified formula 4)	7,728	1,043.05	20,522.10	21,565.15	13,837.15
3.3	100 kg NPKSZnB	7,748	1,163.65	25,408.80	26,572.45	18,824.45

N. B: Prices - Urea= 8.24 birr/kg, NPSB = 11.02 , NPSZnB = 11.7, NPSZnB = 12.00, TSP=12.75 birr/kg, Price of soybean=9 birr/kg, Price of straw= 0.25 birr/kg, Seed=10 birr/kg & Labor cost =30 birr/ person/day for 8 hours, TC=Total cost, Gross return (Return from Grain &straw yield) =price /kg yield in kg and Net return = gross return – Total cost, VC = variable cost, GR= growth return, TGR = total growth return from straw and grain, NB = net benefit*

Table 51. Dominance analysis and marginal rate of return of blended fertilizer types and lime application for maize in Asossa district during 2015/17

Lime t/ha	Fertilizer types kg/ha	Variable cost (ETB ha ⁻¹)	NB (ETBha ⁻¹)	Dominance analysis	MRR%
0	Control	0	9,094.46	0	0
0	100 kg NPSB	1,102.00	20,793.07	UD	172.04
0	1024 kg DAP	1,024	20,170.4	D	-
0	100 kgNPSZnB	1,170.00	18,527.58	D	-
0	100 kg NPSZnB (modified)	1,180.00	17,771.13	D	-
0	100 kg NPKSZnB	1,200.00	22,768.45	UD	249.87
3.3	100 kg DAP	7,572	19,598.00	D	-
3.3	100 kg NPSB	7650	16849.07	D	-
3.3	100 kg NPSZnB	7718	14583.57	D	-
3.3	100 kg NPSZnB(Modified)	7728	13837.15	D	-
3.3	100 kg NPKSZnB	7748	18824.45	D	-

Where D= Dominated and UD = Undominated

4. SUMMARY AND CONCLUSIONS

In recent years, crop productivity in Ethiopia in general and in Benshal-gul Gumuz region in particular has shown a declining trend, in spite of the best use of improved varieties. The most possible causes of this decline is soil fertility depletion and the continuous use of the traditional fertilizer, which have limited number of essential plant nutrient. The present study was conducted in Benishangul Gumuz Regional State, at Asossa Agricultural Research Center station in the 2015/2016 to 2016/2017 main cropping season under rain fed field conditions.

The experimental soil was strongly acid in pH, very low organic carbon, low in total nitrogen, below the critical level of available P (Olsen extractable), and low to medium in basic cation. The bulk density values observed in these soils were within the normal range for mineral soils. Application of blended fertilizer types had no significant effect on yield and yield components of soybean except biological yield, however lime application had significant effect on 100 seed weight, biological yield, straw yield and harvest index of soybean.

The profitability of the study showed that application of 100 kg NPKSZnB kg /ha and 100 kg NPSB kg /ha which provided the relatively high net benefit (22,768.45 and 20,793.07 ETB) respectively, was the peak to apply fertilizers. The results of undominated treatments indicated that for each one birr invested in purchase or production of fertilizers that was possible to

recover one birr plus an extra of 2.50 birr ha⁻¹ and 1.72 birr ha⁻¹ as the fertilizer application changed from unfertilized plot to 100 kg/ha NPKSZnB and 100 kg/ha NPSB respectively. The best recommendation for treatments subjected to marginal rate of return is not necessarily based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the high net benefit, relatively low variable cost together with an acceptable MRR becomes the tentative recommendation. Therefore we recommend the treatments (100 kg /ha NPKSZnB) that have acceptable marginal rate of return, relatively high net benefit and relatively small total cost of production for soybean production in Asossa zone. But based on yield data, net benefit and relatively small total cost of production the farmer of Asossa district can also use 100 kg NPSB when NPKSZnB formula were not available on the market.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Laswai HS, Mpagalile JJ, Silayo VCK, Ballegu WR. Use of soybeans in food formulation in Tanzania. In: Myaka F.A., Kirenga, G. & Malema, B (Eds.). Proceedings of the First National Soybean Stakeholders Workshop, 10th-11th November, Morogoro, Tanzania. 2005;52–59.
2. Nigussie M, Girma A, Anchala C, Kirub A, (Eds.). Improved technologies and resource management for Ethiopian agriculture. A training manual. RCBP-MoARD, Addis Ababa, Ethiopia; 2009.
3. Food and Agriculture Organization (FAO). United Nations Food and Agricultural Organization, FAOSTAT Agricultural Database; 2012.
4. Central Statistical Authority (CSA). Agricultural Sample Survey. Ethiopia: Addis Ababa. 2008/9 Report on Area and Production for Major Crops (Private Peasant Holdings, Main Season); 2013.
5. Specht JE, Hume DJ, Kumudini SV. Soybean yield potential—a genetic and physiological perspective. *Crop Sci.* 1999;39:1560–1570.
6. Boerme RH, Specht JE, (Eds). Soybeans: Improvement, production and uses. Third Edition, No. 16 in the Series Agronomy, ASA, CSSA, and SSSA, Madison; 2004.
7. USDA-ERS. Foreign Agriculture Service-Commodity Intelligence Report; 2009. Available:<http://www.pecad.fas.usda.gov/>
8. Sanginga N, Dashiell K, Diels J, Vanlauwe B, Lyasse O, Carsky RJ, Tarawali S, Asafo-Adjei B, Menkir A, Schulz S, Singh BB, Chikoye D, Keatinge D, Rodomiro O. Sustainable resource management coupled to resilient germplasm to provide new intensive cereal-grain legume-livestock systems in the dry savanna. *Agriculture, Ecosystems and Environment.* 2003;100:305-314.
9. AGRA. Alliance for a Green Revolution in Africa: AGRA at work; 2007. Available:www.agra-alliance.org/work/
10. Henao J, Baanante C. Agricultural production and soil nutrient mining in Africa: Implication for resource conservation and policy development. IFDC Technology Bulletin. International Fertilizer Development Center. Muscle Shoals, A. L. USA; 2006.
11. Tilahun Amede. Restoring soil fertility in the highlands of East Africa through participatory research. International Center for Research in Agroforestry. Brief No. A1; 2003.
12. Zerihun G, Girma A, Shelame B. Effects of sulfur fertilization and *Bradyrhizobium* inoculation on nitrogen fixation, yield and yield components of two soybean (*Glycine max* L.) varieties in acidic soils of Assosa Area. M.Sc Thesis, Hawasa University, Hawasas, Ethiopia; 2015.
13. MoFED (Ministry of Finance and Economic Development). Growth and Transformation Plan (GTP) from 2010/11 – 2014/15, Draft. Addis Ababa. Ethiopia; 2010.
14. ATA (Agricultural Transformation Agency). Soil fertility status and fertilizer recommendation Atlas for Tigray Regional State, Ethiopia. Ethiopian Agricultural Transformation Agency (ATA), A.A., Ethiopia; 2014.
15. Kelsa Kena, Tadesse Yoannes, Tesfa Bogale. Influence of fertilizer and its management practices on maize grain yields in major maize producing areas of Ethiopia. In: Proceedings of the First National Maize Work Shop of Ethiopia. IAR (Institute of Agricultural Research), Ethiopia; 1992.
16. Wassie Haile, Shiferaw Boke, Kelsa Kena. Integrated soil fertility management options for sustainable crop production: Review of research findings from Southern Regional State of Ethiopia. In: Improved Natural Resource Management Technologies for Food Security, Poverty Reduction and Sustainable Development. Proceedings of the 10th Conference of the Ethiopian Society of Soil Science, 25-27 March 2009, EIAR, Addis Ababa, Ethiopia. 2009;163-175.
17. CIMMYT (International Maize and Wheat Improvement Center). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely Revised Edition. Mexico, DF. 1988;79.
18. Brook RH. International course on soil and plant analysis: Lecture notes. Service Laboratory for Soil, Plant and Water Analysis, Soil Science Department, Faculty of Agriculture, Minia University, Egypt; 1983.
19. Landon JR. Booker tropical soil manual, a hand book for soil survey and agricultural land evaluation in the tropics and subtropics. Longman, Booker. 1991;474.

20. Bohn HL, McNeal BL, O'Connor GA. Soil Chemistry, 3rd Ed.; 2001.
21. Wafula E, George C, Nancy K. Response of soybean (*Glycine max* L.) to application of inorganic fertilizers, cattle manure and lime in Western Kenya. M.Sc Thesis, Nairobi University, Nairobi, Kenya; 2013.
22. Stephen K, Nicky M. In-service training on partial budgeting techniques. Mount Makulu, Lusaka, Zambia; 2007.

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