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Effects of NPSB Blended and Urea Fertilizer Rates on Yield and Yield Components of Maize and Economic Productivity Under Andisols and Chernozemssoil Types

Melkamu Hordofa Sigaye*, Ashenafi Nigussei and Abreham Yacob

Ethiopian Institute of Agricultural Research Institute, Wondo Genet Agri. Research Center P. O. Box 198, Shashemane, Ethiopia

**Corresponding author*

Abstract

Site-specific fertilization is indispensable to boost agricultural productivity. The field experiments were conducted on Andisols and Chernozems to determine the optimum combination of NPS-B and Urea fertilizer rate. The treatments were: (150 kg ha^{-1} NPSB + 150 kg ha^{-1} Urea), (200 kg ha^{-1} NPSB + 150 kg ha^{-1} Urea), (250 kg ha^{-1} NPSB + 150 kg ha^{-1} Urea), (300 kg ha^{-1} NPSB + 150 kg ha^{-1} Urea), (150 kg ha^{-1} NPSB + 250 kg ha^{-1} Urea), (200 kg ha^{-1} NPSB + 250 kg ha^{-1} Urea), (250 kg ha^{-1} NPSB + 250 kg ha^{-1} Urea), (300 kg ha^{-1} NPSB + 250 kg ha^{-1} Urea), (150 kg ha^{-1} NPSB + 350 kg ha^{-1} Urea), (200 kg ha^{-1} NPSB + 350 kg ha^{-1} Urea), (250 kg ha^{-1} NPSB + 350 kg ha^{-1} Urea), (300 kg ha^{-1} NPSB + 350 kg ha^{-1} Urea), control and R NP (92 kg N 69 kg P_2O_5). The treatments were arranged in a randomized complete block design and replicated three times. The application of 200 kg ha-1 NPS-B blended fertilizer plus 250 kg ha^{-1} Urea resulted in the highest aboveground biomass (16,839.0 kg ha-1) and grain yield (6545.3 kg ha-1) in Dore Bafano. The application of 200 kg ha^{-1} NPS-B blended fertilizer plus 250 kg ha^{-1} Urea at Meskan resulted in the highest aboveground biomass (15,113.9 kg ha-1) and grain yield (6495.6 kg ha-1). However, the unfertilized plots at both locations yielded the lowest values of above-ground biomass and grain yield. The application of 200 kg ha^{-1} NPSB blended fertilizer coupled with 250 kg ha-1 Urea yielded a maximum net benefit value of (82511.9 ETB ha-1) with a marginal rate of return of (14%). Similarly, the application of 200 kg ha^{-1} NPSB blended fertilizer + 250 kg ha^{-1} Urea at Meskan resulted in a higher net benefit of (81902.5 ETB ha-1) with a marginal rate of return of 40.6%. *However,* the minimum net benefit was recorded from the control plot at both locations. Therefore, the application of 200 kg ha^{-1} NPS-B blended fertilizer with 250 kg ha^{-1} Urea should be recommended for Meskan (Chernozemes) and Dore Bafano (Andisols).

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Grain yield, Maize, NPSB, and Urea fertilizers.

Introduction

Maize (*Zea mays* L.) is the most widely cultivated cereal crop and source of cash in Ethiopia with area coverage (17%) and production (26%) with about 6.5 million tons of production in (CSA, 2019). The estimated average yields of maize for smallholder farmers in Ethiopia are about 4.2 t ha^{-1} (CSA, 2019), which is much lower than the world's average yield of 5.8 t ha^{-1}. However, low soil fertility and low levels of input use are some of the major crop production constraints in Ethiopia (Abreha *et al.*, 2013). Tropical smallholder farming systems including

Ethiopia lack sustainability, mainly due to nutrient losses by soil erosion, lack of soil fertility restoring input, and unbalanced nutrient mining (Hirpa *et al.*, 2009). Thus, the potential maize productivity in the country has not yet been exploited. To alleviate the soil fertility problems different research activities have been undertaken on maize production using various fertilizer sources in different parts of the country. Achieving a high maize yield requires an adequate and balanced supply of nutrients as declining soil fertility is a prominent constraint for maize production (Barbieri *et al.*, 2012).

Inorganic fertilizers have been an important tool to overcome soil fertility problems and are also responsible for a large part of the food production increases. The drive for higher agricultural production without balanced use of fertilizers created problems of soil fertility exhaustion and plant nutrient imbalances not only of major but also of secondary macronutrient and micronutrients. The deficiencies of secondary macronutrients and micronutrients will arise if they are not replenished timely under intensive agriculture (Fageria *et al.*, 2011 and Singh *et al.*, 2011). However, the nationwide fertilizer trials with cereals have indicated that more than 50% of the soils are highly responsive to the addition of nitrogen, 25% to phosphorus, and very few to potassium.

Recently, according to the soil fertility map Ethiopia soil analysis data revealed that the deficiencies of most of the nutrients such as nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%), zinc (53%), potassium (7%), copper, manganese, and iron were widespread in Ethiopian soils (Ethio-SIS, 2016). Similarly, Asgelil *et al.*, (2007) found that the soil analyses and site-specific studies also indicated that elements such as K, S, Ca, Mg, and micronutrients (Cu, Mn, B, Mo, and Zn) were becoming depleted and deficiency symptoms were observed in major crops in different parts of the country. Furthermore, the above-listed nutrient deficiencies were widely spread at Dore-bafano (*Hawassa zuriya*) and Meskan (Ethio-SiS, 2016). Consequently, to overcome this problem, multi-nutrient balanced fertilizers containing N, P, K, S, B, and Zn in blended form have been issued to ameliorate site-specific nutrient deficiencies and thereby increase crop production and productivity.

To alleviate the problems of soil fertility and crop yield in the area, the office of the ministry of agricultural and natural resources was introduced affordable technologies. Which is blended chemical fertilizer with NPSB fertilizer which contains nutrients (18.9% N, 37.7% P_2O_5, 6.95% S, and 0.1% B) in each district and is currently being used by the farmers in the study areas (EthioSIS, 2016).

However, the NPSB fertilizer rate which is being used by farmers is blanket recommendation (100kg ha^{-1}) along with 46 kg N ha^{-1} through urea in the districts. This fertilizer (blended NPSB) may or may not be sufficient to meet the crop requirement in the areas. Nevertheless, the current blended fertilizer (NPSB) contains a small amount of nitrogen as compared to the recommended nitrogen fertilizer rate for economical maize production.

Thus, there is a need to test the blended NPSB fertilizer by supplementing it with nitrogen-containing fertilizer sources such as Urea for optimum productivity of maize. And, there is limited information on the effect of blended fertilizer application rate by supplementing nitrogen from Urea on yield and yield components of maize.

Therefore, this particular experiment was designed to determine the response maize yield and yield components to NPSB blended by supplementing nitrogen fertilizer rates. And to determine the economically best and optimum rate of NPSB blended and nitrogen fertilizer rates for maize production in each district.

Materials and Methods

Description of experimental sites

The study was executed on farmer fields across soil types and agro-ecologies separately in two locations for two consecutive (2020-2021) cropping seasons situated at Dore Bafano and Meskan. Dore Bafano (Sidama region) is geographically located at (6^o 57' N and 38^0 15' E to 7^0 10') with altitudes ranging from 1850 to 1934 *m.a.s.l.* The mean annual rainfall ranges 800 -1100 mm; the peak rainy months are April, July, August, and September.

The mean annual minimum and maximum temperatures are 12 and 26.7^0C, respectively. The dominant soil type of the district is Andosols. While Meskan (Southern region) site lies at (08°05'N and 38°26.9' E) with an altitude of 1908 *m.a.s.l.*

The mean annual rainfall is 1062 mm. The mean annual minimum and maximum temperatures are 10 and 24 ^{0}C, respectively. The dominant soil type of the district is vertisols. Major crops produced in the districts include maize, haricot bean, vegetables, and other cereal crops.

Experimental Design and Treatments

The study was laid out in a randomized complete block design (RCBD) with three replications. The experiment comprised 14 treatments using a combination of NPSB and Urea, with their levels listed below (Table 1). The improved maize variety (BH-546) was sown in a row with 75 cm between rows and 30 cm between rows. Blended NPSB and phosphorus-containing fertilizers triple superphosphate (TSP) was given once at sowing. Nitrogen-containing Urea, on the other hand, was applied in a split form according to the treatment (1/3 at planting and the remaining 2/3 at knee-high stage). As per recommendations, all-important field management procedures were implemented.

Crop harvest, soil sampling, and analyses

At physiological maturity, plant height was measured from the central rows in randomly taken 10 plants, using a measuring stick and their mean was used for computation. From the net plot area ($3m^2$), maize was manually harvested to determine, the above-ground biomass, grain yield, straw yield, and 1000 kernels weight. The grain yield was adjusted to a 12.5% moisture content. Composite soil samples were sampled at random across all experimental at a depth of 0-20 cm before treatment application and after harvesting the crop soil samples were also collected immediately from each experimental unit to investigate the changes in soil chemical properties due to treatment application. The soil samples were air-dried, were processed, and analyzed for soil texture, pH, organic matter, total nitrogen, available phosphorous, total sulfur, and cation exchange capacity were analyzed following the standard procedures outlines.

Economic Analysis

The marginal rate of return (MRR) was performed following the CIMMYT partial budget analysis (CIMMYT 1988). The variable costs associated with labor and fertilizer purchase were compared using partial budgeting, which included only costs that varied from the control, i.e., costs of variable inputs (fertilizer and labor). The grain yield was down adjusted by 10% with the assumption of variation in crop management, postharvest loss in farmer-managed experiments compared to experiments managed by researchers. The income from grain was calculated by multiplying the total yield per ha with the farm gate price. A price of grain 18.05 birr per kg. The net benefit was calculated as the difference between the gross benefit (ETB ha^{-1}) and the total costs (ETB ha^{-1}). Following the CIMMYT partial budget analysis method, total variable costs (TVC), gross benefits (GB), and net benefits (NB) were calculated. Then treatments were arranged in an increasing TVC order and dominance analysis was performed to exclude dominated treatments from the marginal rate of return (MRR) analysis. A treatment is dominated if it has a higher TVC than the treatment which has a lower TVC next to it but has a lower net benefit. A treatment that is non-dominated and hasan MRR of greater or equal to 100% and the highest net benefit is said to be economically profitable (CIMMYT 1988). The Benefit-cost ratio was calculated by dividing gross benefit by total cost.

Statistical Analysis

The data were analyzed by using a two-way analysis of variance (ANOVA) using statistical analysis software (SAS) version 9.4, (SAS, 2014). Whenever the treatment effects were significant, mean separations were made using the least significant difference (LSD) test at ($p \leq 0.05$) level of probability test by proc-mixed analysis (Gomez and Gomez, 1984).

Results and Discussion

Physicochemical properties of the experimental field soil

The initial soil results indicated that particle size distributions sand silt and clay were 41, 33, and 26% for Dore Bafano and 20, 34, and 46% for Meskan, respectively (Table 2). Based on FAO-WRB (1998) soil textural classification the textural classes of the soil of the sites were loam and clay, respectively. The soil in water pH (1:2.5) analysis shows slightly acidic (6.45) and neutral (7.1) for Dore Bafano and Meskan sites, respectively (Table 2). Tekalign (1991) reported that when the soil pH ranges from 6.7-7.3 rates as neutral. The analysis result shows that the available P contents of Dore Bafano and Meskan sites were 6.45 and 22.4 mg kg^{-1}, respectively; (Table 2) which is rated as medium and very high according to Cottenie (1980). The total nitrogen contents were 0.26 and 0.35% for Dore Bafeno and Meskan sites, respectively; which was ranged from medium to a high level according to Tekalign (1991). Similarly, organic carbon contents were 3.51 and 4.49 for Dore Bafeno and Meskan site, respectively, and rated as high level according to Tekalign (1991). The cation exchange capacity (CEC) of the soils was 20 cmol (+)

kg^{-1} for Dore Bafeno and 60 cmol (+) $kg^{-1}$for the Meskan site. Hazelton and Murphy (2007) classified that the CEC values less than 12 cmol (+) kg^{-1} low, 12-25 cmol (+) kg^{-1} moderate, and greater than 40 cmol (+) kg^{-1} very high and thus the experimental soils rated as moderate and very high for Dore Bafeno and Meskan, respectively (Table 2).

Effects of NPSB and Urea Fertilizer on Yield and Yield and Yield Components of maize at Dore bafano and Meskan

Dore bafano Site

As shown in Table (3) maize yield and yield components were significantly (p<0.01) influenced by the application of different levels of NPSB blended fertilizer and nitrogen fertilizers. The pooled means analysis show that the tallest plant height (224.2cm) was obtained from application of 250 kg ha^{-1} NPSB blended fertilize plus 350 kg ha^{-1} of Urea (Table 3). Whereas the shortest plant height was obtained from the unfertilized or control plot. This increment in plant height might be due to an increase in cell elongation and more vegetative growth attributed to the different nutrient content of micronutrients. Thus, the result indicated that blended fertilizers application has enhanced the maize vegetative growth. This result is in agreement with that of Bakala (2018); Tekle and Wassie (2018) and Kinfe *et al.,* (2019) who found that application of blended fertilizers significantly increased maize and tef plant heights as compared to the control.

The analysis of variance depicted that above-ground biomass, stover, and grain yield were significantly influenced by the application of different fertilizer treatments. The combined addition of 200 kg ha^{-1} NPSB blended fertilize with 250 kg ha^{-1} Urea resulted in the significantly highest above-ground biomass (16,839.0 kg ha^{-1}), stover yield (10259.1 kg ha^{-1}), and grain yield (6545.3 kg ha^{-1}).

However, the minimum values of above-ground biomass, stover, and grain yields were obtained from the unfertilized plots(Table 3). The increase in maize yield could be due to the better contributing character of the blended fertilizers and the good interaction of nutrients. In addition, Jafer (2018); Mekuannet and Kiya, (2020); Tagesse and Alemayehu (2020) found that using mixed fertilizer produced higher grain yields than using recommended NP fertilizer or leaving the plot unfertilized. Likewise, Tekle and Wassie (2018) found that grain yield of tef was found highest in blended fertilizers as compared to control treatment and recommended NP fertilizers.

Meskan Site

Like Dore Bafeno, the application of different fertilizer treatments brought significant variation on aboveground biomass, stover, and grain yields (Table 3). The highest grain (6,495.6 kg ha^{-1}) and above-ground biomass (15,113.9 kg ha^{-1}) were obtained from plots treated with 200 kg ha^{-1} NPSB blended fertilize plus 250 kg ha^{-1} Urea, which was closely followed by 150 kg ha^{-1} NPSB blended fertilize plus 250 kg ha^{-1} Urea. However, the minimum values were obtained in control or unfertilized plots (Table 3). The maximum grain yield at the highest NPSB rate might have resulted from improved root growth and increased uptake of nutrients and better growth due to the synergistic effect of the four nutrients which enhanced yield components and yield. Nitrogen enhances the vegetative growth as well as yield whereas phosphorus plays a fundamental role in metabolism and the energy-producing reaction thus resulting in enhanced grain yield (Mengel and Kirby, 2001). This result is in mark with Dassalegn *et al.,* (2018) reported that significantly higher biomass yield of maize at the rate of 46 kg N ha^{-1} under blended fertilizer of PKSZnB as compared to the negative control, standard control (92 N, 69 P_2O_5) kg ha^{-1} and 222 kg N ha^{-1} at N treatments under blended arranged from 0, 46, 92, 138, 176 and 222 kg N ha. Likewise, Kinfe *et al.,* (2019) blended 250 kg NPSZnB ha^{-1} fertilizer gave a higher dry biomass yield of maize. Similarly, Adane *et al.,* (2020) was found the highest mean grain yield (7592 and 5329 kg ha^{-1}) during two cropping seasons by application of 350 kg ha^{-1} NPSZnB plus 200 Urea kg ha^{-1}.

Effects of NPSB Blended and Urea fertilizer rate on Economic Feasibility of Maize Production

The economic analysis revealed that the highest net benefit of (82511.9 ETB ha^{-1}) with (14 %) marginal rate of return was obtained from the application of 200 kg ha^{-1} NPSB blended fertilizer plus 250 kg ha^{-1} Urea at Dore bafano. Similarly, at Meskan the combined application of 200 kg ha^{-1} NPSB blended fertilizer and 250 kg ha^{-1} Urea brought the maximum net benefit of (81902.5 ETB ha^{-1}) with (40.6 %) marginal rate of return. In both sites, however, the minimum net benefit was recorded in unfertilized plots. Therefore, the application of 200 kg ha^{-1} NPSB blended fertilizer with 250 kg ha^{-1}Urea could be economical for both sites.

Table.1 Details of treatment combination and set-up

Treat	Urea (kg ha^{-1})	NPSB (kg ha^{-1})	N from urea	N from blended	Total N	P_2O_5	S	B
1	Control							
2	RNP		200	150	92	69	0	0
3	150	150	69	27.15	96.15	54.15	10.05	1.07
4	150	200	69	36.2	105.20	72.20	13.40	1.42
5	150	250	69	45.25	114.25	90.25	16.75	1.78
6	150	300	69	54.3	123.30	108.30	20.10	2.13
7	250	150	115	27.15	142.15	54.15	10.05	1.07
8	250	200	115	36.2	151.20	72.20	13.40	1.42
9	250	250	115	45.25	160.25	90.25	16.75	1.78
10	250	300	115	54.3	169.30	108.30	20.10	2.13
11	350	150	161	27.15	188.15	54.15	10.05	1.07
12	350	200	161	36.2	197.20	72.20	13.40	1.42
13	350	250	161	45.25	206.25	90.25	16.75	1.78
14	350	300	161	54.3	215.30	108.30	20.10	2.13

Note: the nutrient amounts in 100 kg of NPSB: 18.9% N, 37.7% P_2O_5, 6.95% S, and 0.1% B

Table.2 Some physic-chemical properties of the experiment fields

Parameters	Location	
	Dore Bafano	Meskan
Texture	Level	
Sand	41	20
Silt	33	34
Clay	26	46
Textural Class	Loam	Clay
pH H_2O (1:2.5)	6.45	7.1
Available P (mg kg^{-1})	4.52	22.4
% Total Nitrogen	0.26	0.35
Organic Carbon %	3.51	4.49
CEC (cmol ($^+$) kg^{-1})	21	58
Ca (cmol ($^+$) kg^{-1})	6.01	38.3
Mg (cmol ($^+$) kg^{-1})	0.38	7.28
K (cmol ($^+$) kg^{-1})	2.13	1.13
Na (cmol ($^+$) kg^{-1})	5.15	2.03

Table.3 Pulled Mean values of yield and yield components of maize as affected by different rates of NPSB and Urea at Dore and Meskan

Treatments NPS + Urea (kg ha^{-1})	Dore						Meskan					
	PH (cm)	BM (kg ha^{-1})	SY (kg ha^{-1})	GY (kg ha^{-1})	1000 KW (gm)	HI (%)	PH (cm)	BM (kg ha^{-1})	SY (kg ha^{-1})	GY (kg ha^{-1})	1000 KW (gm)	HI (%)
Control	101.2^{f}	10691.0^{e}	7726.9^{b}	2929.3^{g}	204.0^{e}	27.5^{e}	80.0^{c}	7612.0^{g}	5268.0^{g}	2514.8^{g}	190.2^{cdef}	33.4^{cd}
R-NP	205.7	15469.0^{abcd}	9717.6^{a}	5716.4^{abc}	252.1^{abc}	37.2	192.3^{ab}	14019.4^{abc}	8849.8^{abc}	5340.4^{bc}	228.3^{abc}	38.4^{abc}
150 NPSB +150 Urea	198.1^{e}	14783.0^{bcd}	9682.2^{a}	5066.6^{cd}	240.9^{abcd}	34.8^{abc}	160.0^{c}	9463.1^{f}	5691.8^{fg}	3942.1^{ef}	194.4	42.1^{abc}
200 NPSB +150 Urea	217.9^{ab}	15521.0^{abcd}	10410.6^{a}	5076.4^{cd}	218.5^{cde}	32.7^{ab}	184.6^{b}	10112.0^{ef}	6160.8^{efg}	4122.0^{ef}	217.3^{abcde}	40.9^{abc}
250 NPSB +150 Urea	206.7^{bcd}	16209.0^{abc}	10464.7^{a}	5710.1^{abc}	240.4^{abc}	34.8^{abc}	198.0^{ab}	10945.4^{def}	6738.4^{defg}	4377.8^{def}	225.1^{abcd}	40.1^{abc}
300 NPSB +150 Urea	198.7^{de}	15283.0^{abcd}	9596.0^{ab}	5652.8^{abc}	239.8^{abc}	37.6^{ab}	194.1^{ab}	12500.9^{cd}	7470.3^{bcdef}	5201.4^{cd}	232.8^{abc}	41.8^{abc}
150 NPSB +250 Urea	205.7^{bcde}	16394.0^{ab}	10143.8^{a}	6216.1^{ab}	258.3^{ab}	38.0^{ab}	196.9^{ab}	14500.9^{ab}	8915.1^{ab}	6423.3^{a}	234.6^{ab}	42.8^{ab}
200 NPSB +250 Urea	215.5^{abc}	16839.0^{a}	10259.1^{a}	6545.3^{a}	264.5^{a}	38.9^{ab}	203.6^{ab}	15113.9^{a}	8489.0^{abcd}	6495.6^{a}	224.9^{abcd}	43.2^{ab}
250 NPSB +250 Urea	202.9^{bcde}	14987.0^{abcd}	9502.8^{ab}	5449.7^{bcd}	252.7^{abc}	36.8^{ab}	197.3^{ab}	13447.2^{bc}	7711.0^{bcde}	6207.1^{ab}	238.6^{a}	46.2^{a}
300 NPSB +250 Urea	200.2^{cde}	14802.0^{bcd}	8916.3^{ab}	5851.1^{abc}	223.9^{bcde}	39.9^{a}	196.8^{ab}	11156.5^{de}	6901.8^{defg}	4425.5^{cde}	184.9^{def}	40.7^{abc}
150 NPSB+350 Urea	196.9^{de}	14217.0^{cd}	9533.9^{ab}	4648.2^{de}	200.6^{e}	32.8^{bcd}	197.3^{ab}	10149.1^{ef}	6493.0^{efg}	3826.9^{ef}	200.5^{abcdef}	37.7^{abc}
200 NPSB +350 Urea	210.4^{abcd}	15248.0^{abcd}	10688.5^{a}	4525.1^{def}	209.1^{de}	30.4^{cde}	190.1^{ab}	10575.0^{ef}	7060.7^{bcdefg}	3685.1^{ef}	178.7^{ef}	35.9^{abc}
250 NPSB+350 Urea	200.6^{cde}	14394.0^{bcd}	10713.2^{a}	3646.8^{fg}	208.3^{de}	25.6^{e}	193.4^{ab}	11408.3^{de}	7009.4^{cdefg}	4569.8^{cde}	200.8^{abcdef}	40.4^{abc}
300 NPSB+350 Urea	224.2^{a}	13728.0^{d}	9708.7^{a}	3984.6^{ef}	190.7^{e}	29.0^{cde}	206.9^{a}	14519.4^{ab}	9722.4^{a}	3467.8^{f}	166.4^{e}	27.6^{d}
CV	8.9	12.3	16.1	18.3	13.4	16.0	17.7	19.3	22.2	17.2	18.1	20.1
LSD@0.05	17.0**	2013.8**	1896.1*	966.3**	35.4*	6.3	19.1*	1601.5**	1873.5*	916.8*	43.1*	8.9*
Year*Treatment	Ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Mean values followed by the same letter in the same column are not significantly different at 5% probability level; Where-Plant height, AGBM- above-ground biomass, SY-straw yield, GY-grain yield, KW-kernels weight, and HI-harvest index.

Table.4 Effects of NPSB blended and urea fertilizer rates on the economic feasibility of maize production at Dore bafano.

Ttr	NPSB	Urea	GY	GB	TVC	NB	MRR%
	(kg ha^{-1})			(EHB ha^{-1})			
1	Control		2636.4	40863.7	0.0	40863.7	
3	150	150	4559.9	70679.1	5910.0	64769.1	4.0
2	RNP 200	150	5144.8	79743.8	6825.0	72918.8	8.9
4	150	200	4568.8	70815.8	6965.0	63850.8	d
7	250	150	5594.5	86714.6	7740.0	78974.6	19.5
5	150	250	5139.1	79655.9	8020.0	71635.9	d
8	250	200	5890.8	91306.9	8795.0	82511.9	14.0
6	150	300	5087.5	78856.6	9075.0	69781.6	d
11	350	150	4183.4	64842.4	9570.0	55272.4	d
9	250	250	4904.7	76023.3	9850.0	66173.3	38.9
12	350	200	4072.6	63125.1	10625.0	52500.1	d
10	250	300	5266.0	81622.8	10905.0	70717.8	65.1
13	350	250	3282.1	50872.9	11680.0	39192.9	d
14	350	300	3586.1	55585.2	12735.0	42850.2	3.5

Where: ETB = Ethiopian Birr (currency); TCV = Total cost that vary; NB = Net benefit; MRR = GB=Growth benefit, Marginal rate of return; Price for Urea, NPS, TSP and Maize grain; 18.58, 21.75, 21.75, 15.5 Eth- birr kg^{-1} respectively.

Table.5 Effects of NPSB blended and urea fertilizer rates on the economic feasibility of maize production at Maskan

Treat	NPSB	Urea	GY	GB	TVC	NB	MRR%
	(kg ha^{-1})			(EHB ha^{-1})			
1	Control		2263.3	35081.5	0.0	35081.5	
2	RNP 200	150	3547.9	54992.3	5881.5	49110.8	2.4
3	150	150	4806.4	74498.6	6792.0	67706.6	20.4
4	150	200	3709.8	57501.9	6931.5	50570.4	d
8	250	200	5781.0	89605.0	7702.5	81902.5	40.6
7	250	150	3940.0	61070.3	7981.5	53088.8	d
6	150	300	5846.0	90613.6	8752.5	81861.1	37.3
5	150	250	4681.3	72559.5	9031.5	63528.0	d
12	350	200	3444.2	53385.3	9523.5	43861.8	d
11	350	150	5586.4	86589.0	9802.5	76786.5	118.0
10	250	300	3316.6	51407.1	10573.5	40833.6	d
9	250	250	3983.0	61735.7	10852.5	50883.2	36.0
13	350	250	4112.8	63748.7	11623.5	52125.2	1.6
14	350	300	3121.0	48375.8	12673.5	35702.3	d

Where: ETB = Ethiopian Birr (currency); TCV = Total cost that vary; NB = Net benefit; MRR = GB=Growth benefit, Marginal rate of return; Price for Urea, NPS, TSP and Maize grain; 18.58, 21.75, 21.75, 15.5 Eth- birr kg^{-1} respectively.

Recommendation

In conclusion, the application of 200 kg ha^{-1} NPSB blended fertilizer plus 250 kg ha^{-1} Urea resulted in the highest aboveground biomass (16,839.0 kg ha^{-1}) and grain yield (6545.3 kg ha^{-1}) in Dore Bafano. The application of 200 kg ha^{-1} NPSB blended fertilizer plus 250 kg ha^{-1} Urea at Meskan resulted in the highest aboveground biomass (15,113.9 kg ha^{-1}) and grain yield (6495.6 kg ha^{-1}). However, the unfertilized plots at both locations yielded the lowest values of above-ground biomass and grain yield. The application of 200 kg ha^{-1} NPSB blended fertilizer coupled with 250 kg ha-1 Urea yielded a maximum net benefit value of (82511.9 ETB ha^{-1}) with a marginal rate of return of (14%). Similarly, the application of 200 kg ha^{-1} NPSB blended fertilizer + 250 kg ha^{-1} Urea at Meskan resulted in a higher net benefit of (81902.5 ETB ha^{-1}) with a marginal rate of return of 40.6%. However, the minimum net benefit was recorded from the control plot at both locations. The study also found a substantial yield advantage from the newly introduced blended fertilizer (NPS+B) compared to the conventionally used DAP fertilizer or recommended NP. Therefore, the application of 200 kg ha^{-1} NPSB blended fertilizer with 250 kg ha^{-1} Urea should be recommended for Meskan (Chernozemes) and Dore Bafano (Andisols).

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