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Research Article

Investigation of Response of Upland Rice (*Oryza sativa* L.) to Blended NPSB Fertilizer in Fogera and Libo Kemkem Districts of Amhara Region

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Abstract

A field experiment was conducted for three years to evaluate and determine economic optimum rate of NPSB blended + urea fertilizers for upland rice production in Fogera and Libokemkem districts of Amhara Region. Blended NPSB fertilizer rates of 100, 150, 200 and 250 kg ha^{-1} were factorially combined with 100, 150, 200 and 250 kg urea ha^{-1}. Zero fertilizer as control treatment and recommended NP as a reference treatment were included in the study. The treatments were laid in a randomized complete block design with three replications. The results show that, in Libokemikem district, the maximum grain yield of 4.9 t ha^{-1} was obtained from 200 kg NPSB + 250 kg Urea ha^{-1}, while the maximum dry biomass yield of 10.2 t ha^{-1} was recorded from 250 kg NPSB + 250 kg Urea ha^{-1}. In Fogera district, the maximum grain and biomass yields of 6.1 and 15 t ha^{-1}, respectively were obtained from 250 kg NPSB + 200 kg Urea ha^{-1}. The partial budget analysis of the pooled data indicate that at Libokemikem district, the maximum net economic return (NER) of Ethiopian birr (Birr) 48,529.70 with marginal rate of return (MRR) of 1284.9% was obtained from 200 kg NPSB + 250 kg urea ha^{-1}. At Fogera district, the maximum NER of Birr 62,323.60 with MRR of 959.7% was obtained from 100 kg NPSB + 250 kg urea ha^{-1}. However, it is not possible to draw conclusions that the significant yield increment recorded was due to the contribution of S and B blends in the NPSB blended fertilizer. Because, there were confounding effects of N and P nutrients in the NPSB blended fertilizer. As it is revealed in the results, the significant yield response recorded, however, was due to the increasing levels of N. Therefore, we recommend further investigation of the response of NERICA-4 (upland rice) to each nutrient (P, S and B) through nutrient omission studies.

Keywords

Yield Limiting, Blended Fertilizer, Upland Rice

1. Introduction

Studies show that the use of chemical fertilizers in Ethiopia has made a contribution to crop yield growth to date [4, 20] although there is a potential for further improvement. Fertilizer is applied by less than 45% of farmers, on about 40% of area under crop, and most likely at below optimal dosage levels [10]. However, recent study reports indicated that nutrients like potassium (K), sulfur (S), calcium (Ca), magnesium (Mg) and all micro-nutrients except iron (Fe) are

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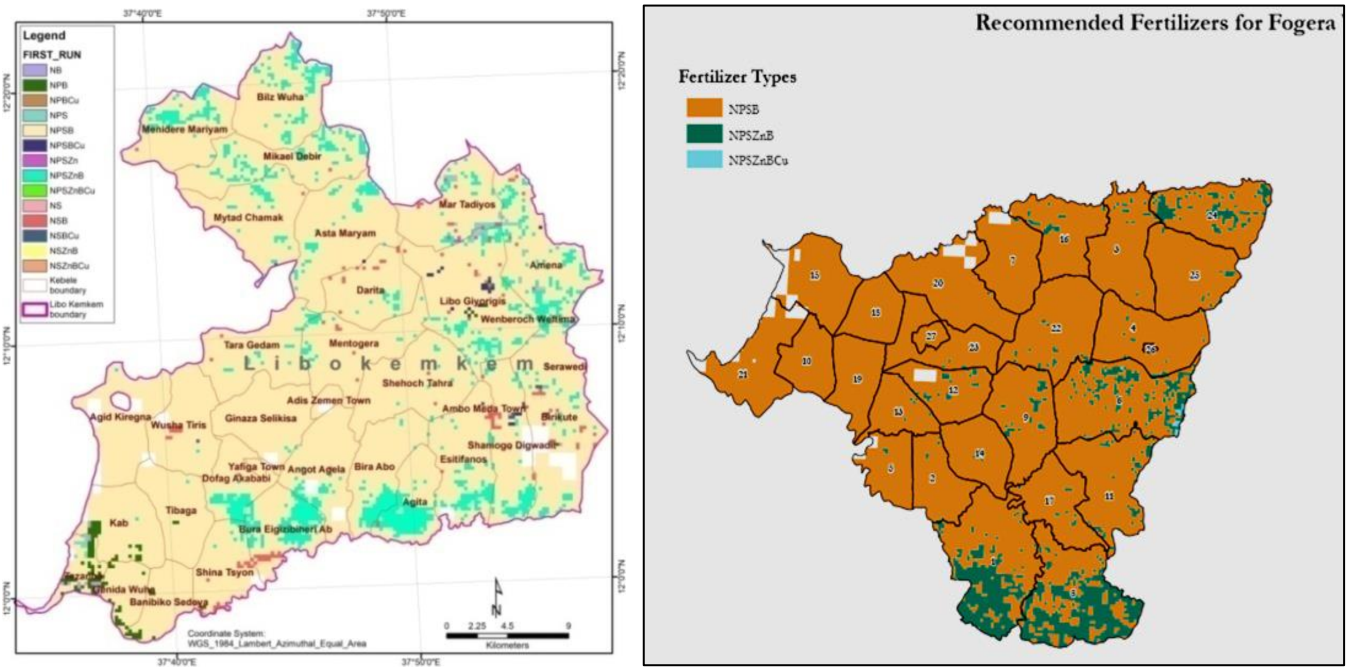
becoming depleted. Deficiency symptoms are reported on major crops in different areas of the country [2, 3, 23]. Recently acquired soil inventory data from EthioSIS (Ethiopian Soil Information System) revealed that in addition to nitrogen (N) and phosphorus (P), S, born (B), zinc (Zn) and K deficiencies are widespread which all potentially limit crop productivity despite continued use of N and P fertilizer as per the recommendation [11]. Studies indicated that nutrient mining due to sub-optimal fertilizer use on one hand and unbalanced fertilizer uses on other hand have favored the emergence of multi nutrient deficiency in Ethiopian soils that in part may have contributed to fertilizer factor productivity decline experienced over recent past [2, 23]. Hence, following an extensive soil fertility assessment survey in the country, district and kebele-based blended fertilizer recommendations have been developed by EthioSIS [11].

Two blended fertilizer types, NPSB and NPSZnB, are recommended almost for entire areas of Fogera and Libokemkem Districts in South Gondar Zone of Amhara Region (Figure 1). However, fertilizer trials involving multi-nutrient blends that include micronutrients are rare in Ethiopia. Although there is general perception that the new fertilizer blends are better than the conventional fertilizer recommendation (Urea and DAP), their economic and agrnomic advantages are not examined and understood under various production environments.

Rice (*Oryza sativa* L.) production is a recent phenomenon in Ethiopia, as compared to other cereals crops. However, rice production has brought a significant change in the livelihood of farmers and created job opportunities for a number of citizens in different areas of the country. Currently, Amhara, Southern Nations, Nationalities and Peoples Region (SNNPR), Oromiya, Somali, Gambella, Benishangul Gumuz, and Tigray regions are rice producing areas in Ethiopia [17]. The Amhara region takes the lion's share of rice production in the country and accounted for 65-81% of the area coverage and 78-85% of the production in the years 2016-2018 [6-8]. At present, Fogera and Libokemkem Districts are the two major rice growing districts in Amhara Region. The area coverage in rice production has increased considerably linked with expansion of production in the wetland and upland areas with the introduction of suitable rice varieties for the different agro-ecologies. Even though there is huge potential and increasing demand of the crop, lack of high yielding varieties, terminal moisture stress and low soil fertility, disease and cold effect are the constraints that hinder the expansion and productivity of the crop [1]. This study was therefore conducted with the objectives of determining optimum NPSB blended fertilizer rates for rice and assessing economic feasibility of the recommended blended fertilizer rates.



a) b)

Figure 1. *Blended fertilizer recommendation maps of a) Libokemikem district and b) Fogera District of Amhara Region (EthioSIS, 2015).*

2. Materials and Methods

2.1. Site Description

The experiment was executed from 2017-2019 in Fogera plain on two districts, Fogera and Libokemkem districts of Amhara Region in Ethiopia. It was conducted on farmers' fields and on a research station at Fogera National Rice Research and Training Center (FNRRTC) in Amhara Region. Fogera plain, which covers Fogera district and part of Libokemkem district, is an extended wetland area around Lake Tana and is situated between latitude 11°49'55" N and longitude 37° 37′ 40" E at an altitude of 1815 meters above sea level (Figure 2). The dominant soil type of the study area is classified as Pellic Vertisol. Rainfall of the area is unimodal, usually occurring from June to September, and its average annual total rainfall is 1363.7 mm. The mean minimum and maximum temperature of the study area is 12.7°C and 27.4°C, respectively. The ecology and type of rice cultivation practiced in Fogera and Libokemkem districts is categorized as rain-fed lowland and rain-fed upland rice culture.

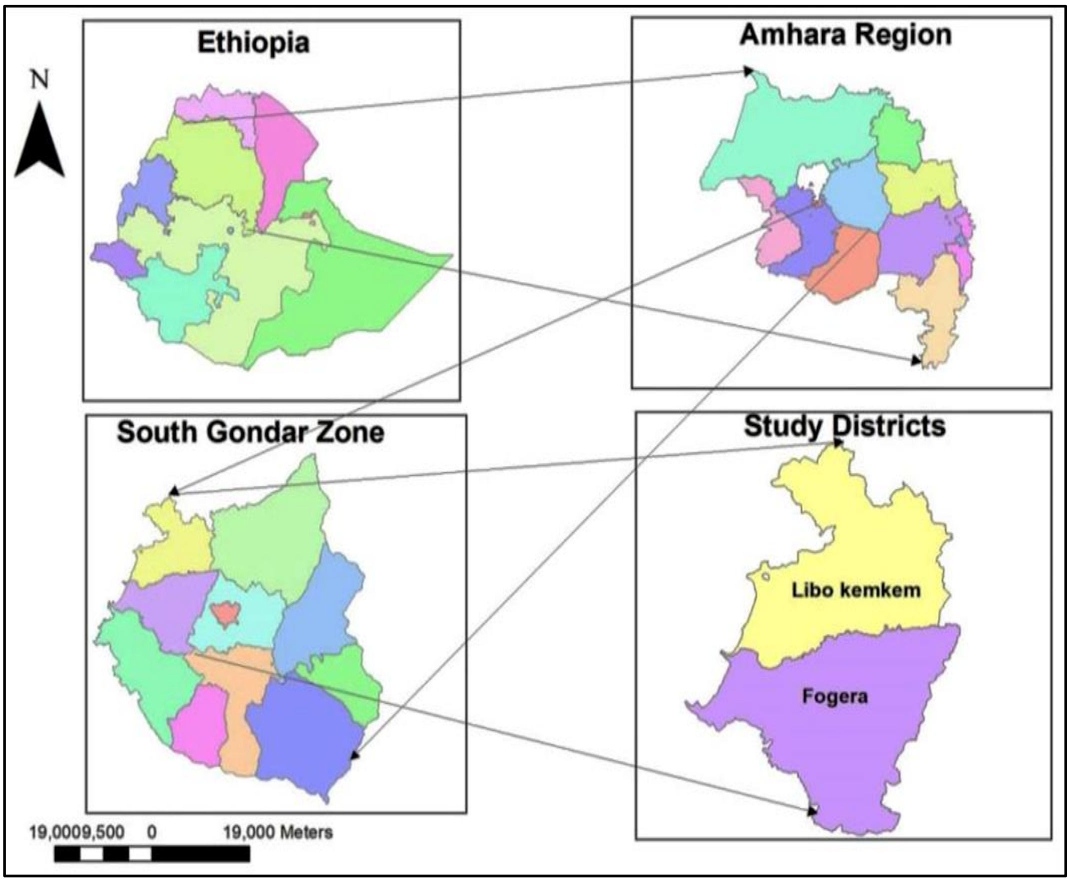


Figure 2. Location map of the study Districts (Fogera and Libo kemkem Districts).

Treatments and Experimental Design

Four rates of NPSB blend fertilizer (100, 150, 200 and 250 kg ha^{-1}) and four rates of urea (100, 150, 200 and 250 kg ha^{-1}) were factorially combined. In the first year, 17 (seventeen) treatments including control treatment (without fertilizer) were evaluated; while in the second year, the previous recommended NP (69/23 N/P_2O_5 kg ha^{-1}) was included to form eighteen (18) treatments (Table 1). The treatments were laid in a randomized complete block design with three replications. The blended fertilizer was band-applied as basal and N fertilizer was applied in split; 1/3 at planting, 1/3 at mid-tillering and 1/3 at panicle initiation stages. Upland rice variety NERICA-4 was planted with 20 cm spacing at seed rate of 100 kg ha^{-1}. The gross and net plot sizes were 2 m * 3 m and 1.2 m * 3 m, respectively. The other crop management practices were applied uniformly for all plots as per the recommendations.

Table 1. *Treatment set up.*

Treatment	2017		2018 & 2019		N, P_2O_5, S, B (kg ha^{-1})
	NPSB (kg ha^{-1})	Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Urea (kg ha^{-1})	
1	0	0	0	0	0, 0, 0, 0
2	100	100	100	100	64.1, 36.1, 6.7, 0.7
3	100	150	100	150	87.1, 36.1, 6.7, 0.7
4	100	200	100	200	110.1, 36.1, 6.7, 0.7
5	100	250	100	250	133.1, 36.1, 6.7, 0.7
6	150	100	150	100	73.15, 54.15, 10.05, 1.05
7	150	150	150	150	96.15, 54.15, 10.05, 1.05
8	150	200	150	200	119.15, 54.15, 10.05, 1.05
9	150	250	150	250	142.15, 54.15, 10.05, 1.05
10	200	100	200	100	82.2, 72.2, 13.4, 1.4
11	200	150	200	150	105.2, 72.2, 13.4, 1.4
12	200	200	200	200	128.2, 72.2, 13.4, 1.4
13	200	250	200	250	151.2, 72.2, 13.4, 1.4
14	250	100	250	100	91.25, 90.25, 16.75, 1.75
15	250	150	250	150	114.25, 90.25, 16.75, 1.75
16	250	200	250	200	137.25, 90.25, 16.75, 1.75
17	250	250	250	250	160.25, 90.25, 16.75, 1.75
18	-	-	50 kg DAP	150	69, 23, 0, 0

2.2. Soil Sampling and Analysis

One composite surface soil sample by taking five sub-samples at a depth of 0-20 cm was collected before planting from each testing site. The collected soil samples were analyzed for texture, pH, Electrical conductivity, organic carbon, total nitrogen, available phosphorus, exchangeable potassium, extractable zinc and cation exchange capacity (CEC) following the standard soil analysis procedure.

2.3. Data Collection

Rice plants were harvested above ground level from net plot area to determine biomass and grain yields. Biomass yield of rice was weighed with graduated balance after sun drying of harvested plants and each plot biomass yield was converted into hectare basis. After sun drying and threshing, grains of each plot were sorted out from straw and debris, and weighted with sensitive balance. Rice grain yield obtained from each net plot area was adjusted to 14% moisture content and converted into hectare basis.

2.4. Data Analysis

The collected data were subjected to analysis of variance (GLM procedure) using SAS software version 9.00 (SAS, 2004). The mixed model procedure was used for the combined analysis over the testing sites and years with treatments as a fixed variable and with site, replication and year as random variables. Treatment means separation was done with Duncan's Multiple Range test (DMRT) at $P \leq 0.05$. The farm-gate prices of Ethiopian Birr (ETB) 12.50, 15.62 and 16.66 per kg for variable factors; paddy rice, Urea fertilizer and NPSB blended fertilizer, respectively, were used for partial budget analysis following the CIMMYT procedure [5]. The other factors were constant as they were applied uniform to all treatments. The mean grain yields used in the partial budget analysis were adjusted to 90% of the measured yield.

3. Results and Discussion

3.1. Soil Physico-Chemical Characteristics of the Study Sites

The physico-chemical characteristics of surface soil (0-20 cm) of the study sites are presented in Table 2 below. The surface soil of the study sites had moderately acidic to neutral soil reaction [15], non-saline (James et. al., 1982), low to medium organic carbon, medium total N [21], very low to very high available P [15], high to very high CEC [13], high exchangeable potassium [12], medium extractable zinc (Jones, 2003) and clay to heavy clay soil texture.

Table 2. Physico-chemical properties of the composite surface (0-20 cm) soil samples collected from the study sites before planting in 2017 and 2019.

Soil parameter	2017		2019	
	Libokemikem	Fogera	Libokemikem	Fogera
pH (H_2O)	6.20	5.98	6.65	5.08
Electrical conductivity (ds m^{-1})	0.059	0.067	0.141	0.112
Organic carbon (%)	1.60	1.95	0.66	1.25
Total nitrogen (%)	0.13	0.16	0.11	0.16
Available phosphorus (mg kg^{-1})	7.80	2.08	17.2	48.5
Exchangeable potassium ($Cmol_c$ kg^{-1})	Nd	Nd	0.63	0.67
Extractable zinc (mg kg^{-1})	Nd	Nd	0.74	0.41
Cation Exchange Capacity ($Cmol_c$ kg^{-1})	50.0	36.0	Nd	Nd
Texture				
Sand (%)	7	13	12	18
Silt (%)	15	20	16	30
Clay (%)	78	62	72	52

Nd: Not determined.

3.2. Effect of NPSB Blended and Urea Fertilizer on the Yield of Upland Rice

The data analysis shows that there was a significant ($p<0.05$) effect of the combined use of the NPSB blended and urea fertilizer on the grain and biomass yields of upland rice in Fogera and Libokemkem districts (Tables 3, 4 and 5). At Libokemikem district, the data analysis in the first experimental year (2017) and the pooled analysis over the second and third experimental years (2018 and 2019) show that the highest grain yield was obtained from 200 kg NPSB + 250 kg urea ha^{-1} (151.2N, 72.2P_2O_5, 13.4S, 1.4B kg ha^{-1}) (Tables 3 and 4). However, the highest biomass yield was recorded from 250 kg NPSB + 250 kg urea ha^{-1} (160.25N, 90.25P_2O_5, 16.75S, 1.75B kg ha^{-1}) with no significant difference from the biomass yield recorded from 200 kg NPSB + 250 kg urea ha^{-1} (151.2N, 72.2P_2O_5, 13.4S, 1.4B kg ha^{-1}).

At Fogera district, in the first experimental year (2017), the highest grain yield was recorded from 150 kg NPSB + 150 kg urea ha^{-1} (96.15N, 54.15P_2O_5, 10.05S, 1.05B kg ha^{-1}) (Table 3). But, the pooled analysis over the second and third experimental years (2018 and 2019) show that the highest grain and biomass yields were recorded from 250 kg NPSB + 200 kg urea ha^{-1} (137.25N, 90.25P_2O_5, 16.75S, 1.75B kg ha^{-1}) with no significant difference from the grain yield recorded from 100 kg NPSB + 200 kg urea ha^{-1} (110.1N, 36.1P_2O_5, 6.7S, 0.7B kg ha^{-1}) (Table 5).

In line with the result of the present study, [19] showed that 300 and 200 kg NPSB ha^{-1} blended fertilizers along with the recommended NP fertilizers gave the highest wheat yield. Application of different blended NPSB fertilizer rates were reported to significantly affect crop phonology, yield and yield components of tef [22, 18] reported that application of K, S, Zn, Mg and B significantly increased yield of bread wheat as compared to the control (no fertilizer). According to [16], blended fertilizers had a significant effect on the aboveground biomass, grain yield and straw yield of food barley. [14] also reported that supplementation by S, Zn, B and K nutrients increased maize yields by 40% over the standard NP fertilizer recommendation. Similar study indicated that maximum grain, stover, and total biomass yields of maize were obtained by applying blended fertilizers [9].

However, in the present study and in the other studies mentioned above, there was a confounding effect of increasing levels of N and P as the level of the NPSB blended fertilizer were increasing. Thus, with all the aforementioned studies including the present study, it is hardly possible to identify which nutrients had significant effect for the recorded higher yields. Therefore, yield response studies to each nutrient should be investigated through nutrient omission trials.

Table 3. *Mean table of effect of the combined use of NPSB blended and urea fertilizer on the grain and biomass yield (kg ha^{-1}) of upland rice in Libokemikem and Fogera districts in 2017.*

NPSB-blended + Urea (kg ha^{-1})	N, P_2O_5, S, B (kg ha^{-1})	Libokemikem		Fogera	
		Grain yield	Biomass yield	Grain yield	Biomass yield
0 + 0	0, 0, 0, 0	1088g	2977h	1637c	4804f
100 + 100	64.1, 36.1, 6.7, 0.7	1683f	5285g	3575ab	11033abc
100 + 150	87.1, 36.1, 6.7, 0.7	1868def	5757efg	3015ab	8210de
100 + 200	110.1, 36.1, 6.7, 0.7	1863def	6400def	3427ab	10362abcd
100 + 250	133.1, 36.1, 6.7, 0.7	2352bc	7157cd	3567ab	11104abc
150 + 100	73.15, 54.15, 10.05, 1.05	1754ef	5551fg	2889ab	6800ef
150 + 150	96.15, 54.15, 10.05, 1.05	1834def	5741efg	3888a	11027abc
150 + 200	119.15, 54.15, 10.05, 1.05	2105cde	7059cd	3041ab	11078abc
150 + 250	142.15, 54.15, 10.05, 1.05	2183cd	7877bc	3251ab	10529abcd
200 + 100	82.2, 72.2, 13.4, 1.4	1876def	5756efg	3853a	10164bcd
200 + 150	105.2, 72.2, 13.4, 1.4	2016cdef	6655de	2884ab	8300de
200 + 200	128.2, 72.2, 13.4, 1.4	2225bcd	7346cd	3478ab	11376abc
200 + 250	151.2, 72.2, 13.4, 1.4	2733a	8443ab	3117ab	11830ab
250 + 100	91.25, 90.25, 16.75, 1.75	2113cde	7335cd	3166ab	9045cde
250 + 150	114.25, 90.25, 16.75, 1.75	1967cdef	6858d	2988ab	7642e
250 + 200	137.25, 90.25, 16.75, 1.75	2868a	8645ab	3555ab	11102abc
250 + 250	160.25, 90.25, 16.75, 1.75	2575ab	9029a	2703b	12721a
Rec. NP	69, 23, 0, 0	-	-	-	-
Mean		2056.6	6772.7	3181.7	10001.7
CV (%)		9.5	7.6	15.3	12.1

Means followed by the same letter are not significantly different at 5% probability level. Rec. NP = Recommended nitrogen and phosphorus fertilizer.

Table 4. Mean table of effect of the combined use of NPSB blended and urea fertilizer on the grain and biomass yield (kg ha^{-1}) of upland rice at Burah testing site in Libokemikem district in 2018 and 2019.

NPSB-blended + Urea (kg ha^{-1})	N, P_2O_5, S, B (kg ha^{-1})	2018		2019		Pooled over two years	
		Grain yield	Biomass yield	Grain yield	Biomass yield	Grain yield	Biomass yield
0 + 0	0, 0, 0, 0	1396i	3393h	1426f	3241j	1411i	3317i
100 + 100	64.1, 36.1, 6.7, 0.7	4010g	6574fg	1902def	3981ij	3167defgh	5278h
100 + 150	87.1, 36.1, 6.7, 0.7	3992g	8152e	2120bcdef	4907ghi	3056fgh	6530fg
100 + 200	110.1, 36.1, 6.7, 0.7	4807cdefg	10107d	2278abcde	5000ghi	3542cdefg	7554cdef
100 + 250	133.1, 36.1, 6.7, 0.7	5260bcdef	10024d	2694abc	7037bc	3977c	8531bc
150 + 100	73.15, 54.15, 10.05, 1.05	3974g	7929ef	2364abcde	5463efgh	3169defgh	6696efg
150 + 150	96.15, 54.15, 10.05, 1.05	4029g	8292e	2347abcde	5185fgh	3188defgh	6739efg
150 + 200	119.15, 54.15, 10.05, 1.05	4986cdefg	10704cd	2595abcd	6296bcdef	3790cde	8059bcd
150 + 250	142.15, 54.15, 10.05, 1.05	5439abcde	11040bcd	2258abcde	5648efgh	3849cd	7805cde
200 + 100	82.2, 72.2, 13.4, 1.4	4207fg	8319e	1684ef	5139fgh	2945gh	7047def
200 + 150	105.2, 72.2, 13.4, 1.4	4673defg	10820bcd	2001cdef	5000ghi	3070fgh	7328def
200 + 200	128.2, 72.2, 13.4, 1.4	5769abcd	11889bc	2338abcde	6018cdefg	3710cdef	8954b
200 + 250	151.2, 72.2, 13.4, 1.4	6301ab	14560a	2942a	6944bcd	4957a	10752a
250 + 100	91.25, 90.25, 16.75, 1.75	4566efg	9801d	1842def	4815hi	3204defgh	7308def
250 + 150	114.25, 90.25, 16.75, 1.75	4074g	10137d	2199abcde	6389bcde	3137efgh	8638bc
250 + 200	137.25, 90.25, 16.75, 1.75	5859abc	12252b	2417abcde	8148a	4138bc	10200a
250 + 250	160.25, 90.25, 16.75, 1.75	6534a	14295a	2813ab	7407ab	4674ab	10851a
Rec. NP	69, 23, 0, 0	2637h	5670g	2516abcd	5833defgh	2576h	5735gh
Mean		4570.1	9594.4	2255.3	5686.3	3412.7	7640.3
CV (%)		12.6	8.3	16.8	10.3	14.4	10.9

Means followed by the same letter are not significantly different at 5% probability level. Rec. NP = Recommended nitrogen and phosphorus fertilizer.

Table 5. Mean table of effect of the combined use of NPSB blended and urea fertilizer on the grain and biomass yield (kg ha^{-1}) of upland rice at the research station in Fogera district in 2018 and 2019.

NPSB-blended + Urea (kg ha^{-1})	N, P_2O_5, S, B (kg ha^{-1})	2018		2019		Pooled over two years	
		Grain yield	Biomass yield	Grain yield	Biomass yield	Grain yield	Biomass yield
0 + 0	0, 0, 0, 0	3979g	6116h	1783h	3611f	3101g	4863h
100 + 100	64.1, 36.1, 6.7, 0.7	5423f	9500g	3586cdefg	10000bc	4505ef	9750fg
100 + 150	87.1, 36.1, 6.7, 0.7	5938cdef	12216gf	3556cdefg	6852de	4747def	9534fg
100 + 200	110.1, 36.1, 6.7, 0.7	6558abcde	13590cdef	4220abcdefg	8426cd	5389abcd	11008def
100 + 250	133.1, 36.1, 6.7, 0.7	7137ab	15853abcd	4933ab	12130ab	6035a	13991ab
150 + 100	73.15, 54.15, 10.05, 1.05	5650ef	12682ef	2932g	5556ef	4291f	8406g

NPSB-blended + Urea (kg ha^{-1})	N, P_2O_5, S, B (kg ha^{-1})	2018		2019		Pooled over two years	
		Grain yield	Biomass yield	Grain yield	Biomass yield	Grain yield	Biomass yield
150 + 150	96.15, 54.15, 10.05, 1.05	5996bcdef	11774fg	3922abcdefg	6296de	4959bcdef	9035fg
150 + 200	119.15, 54.15, 10.05, 1.05	7083abc	16880ab	3407defg	6852de	5245abcde	10863ef
150 + 250	142.15, 54.15, 10.05, 1.05	6956abcd	18263a	4279abcdef	7685cde	5617abc	12974bc
200 + 100	82.2, 72.2, 13.4, 1.4	5875def	11840fg	3744abcdefg	5556ef	4810cdef	8698g
200 + 150	105.2, 72.2, 13.4, 1.4	6718abcde	14730bcdef	3705bcdefg	5278ef	5211abcde	10004fg
200 + 200	128.2, 72.2, 13.4, 1.4	6853abcd	15547abcde	4655abcd	10000bc	5754ab	12773bcd
200 + 250	151.2, 72.2, 13.4, 1.4	7140ab	17982a	4239abcdefg	7778cde	5690ab	12880bcd
250 + 100	91.25, 90.25, 16.75, 1.75	6357bcdef	13060def	3288efg	6019def	4823cdef	9539fg
250 + 150	114.25, 90.25, 16.75, 1.75	6708abcde	15559abcde	5051a	6667de	5879a	12002cde
250 + 200	137.25, 90.25, 16.75, 1.75	6904abcd	16252abc	4873abc	13056a	6092a	14973a
250 + 250	160.25, 90.25, 16.75, 1.75	7697a	18489a	4457abcde	8704cd	6077a	13596abc
Rec. NP	69, 23, 0, 0	7102ab	12303fg	2991fg	7361cde	4636def	10326efg
Mean		6436.3	14254.4	3888.8	7607.7	5174.7	10964.6
CV (%)		9.1	10.7	17.1	17.5	12.3	13.2

Means followed by the same letter are not significantly different at 5% probability level. Rec. NP = Recommended nitrogen and phosphorus fertilizer.

3.3. Yield Response Curve to N at Different Levels of P, S and B

The trend of the two years pooled grain yield responses to N at uniform levels of P_2O_5, S and B, as shown on the graphs below, indicate that there were significant grain yield responses to the increasing levels of N. At Libokemikem district (Graph 1a), the maximum grain yield was obtained from N level 5 (151.2 kg N ha^{-1}) with 72.2 kg P_2O_5 + 13.4 kg S + 1.4 kg B ha^{-1}. At Fogera district, the maximum grain yield was obtained from N level 4 (137.3 kg N ha^{-1}) with 90.3 kg P_2O_5 + 16.8 kg S + 1.75 kg B ha^{-1} (Graph 1b.). This indicates, irrespective of the amount of the blended fertilizer (PSB), the yield was increasing as the level of N increased, which imply the increasing yield response was only due to the increasing levels of N.

Table 6. Level of N from NPSB.

N levels (kg ha^{-1})	Levels of P_2O_5/S/B in kg ha^{-1}			
	36.1/6.7/0.7	54.1/10.0/1.05	72.2/13.4/1.4	90.2/16.7/1.75
1	0	0	0	0
2	64.1	73.15	82.2	91.25
3	87.1	96.15	105.2	114.25
4	110.1	119.15	128.2	137.25
5	133.1	142.15	151.2	160.25

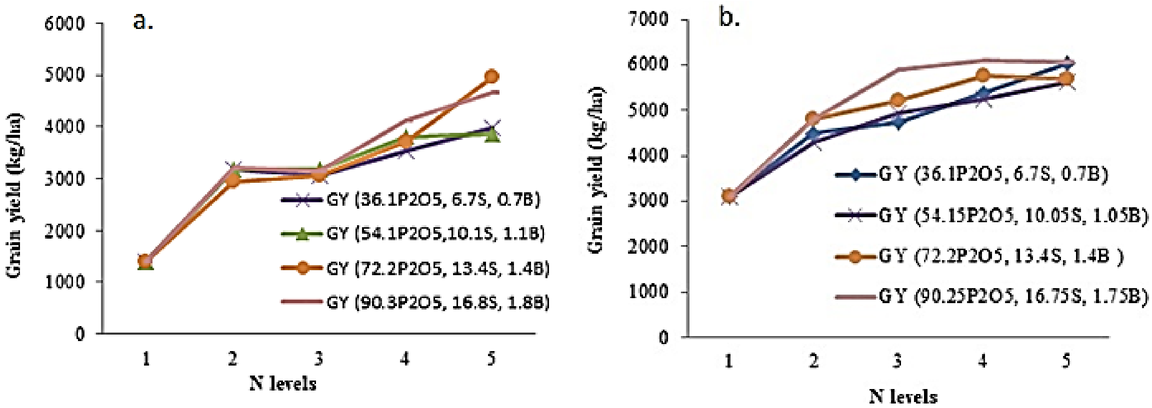


Figure 3. *Pooled grain yield response curves to N at different levels of P, S and B at a. Libokemikem district and b. Fogera district.*

3.4. Yield Responses to Different Levels of NPSB Blended Fertilizer

The bar graphs, shown below, indicate that the significant yield difference obtained at both districts was not due to the effect of NPSB blended fertilizer (Graph 2a. and 2b.). Because, as the bar graphs reveal, the yield responses to different levels of the blended fertilizer at different levels of N was almost similar except at N level 5 in Libokemikem district and at N level 3 in Fogera district where there were some yield differences to the different levels of the blended fertilizer. Instead, the bar graphs reveal a significant yield raise as the level on N increased from level 1 to 5.

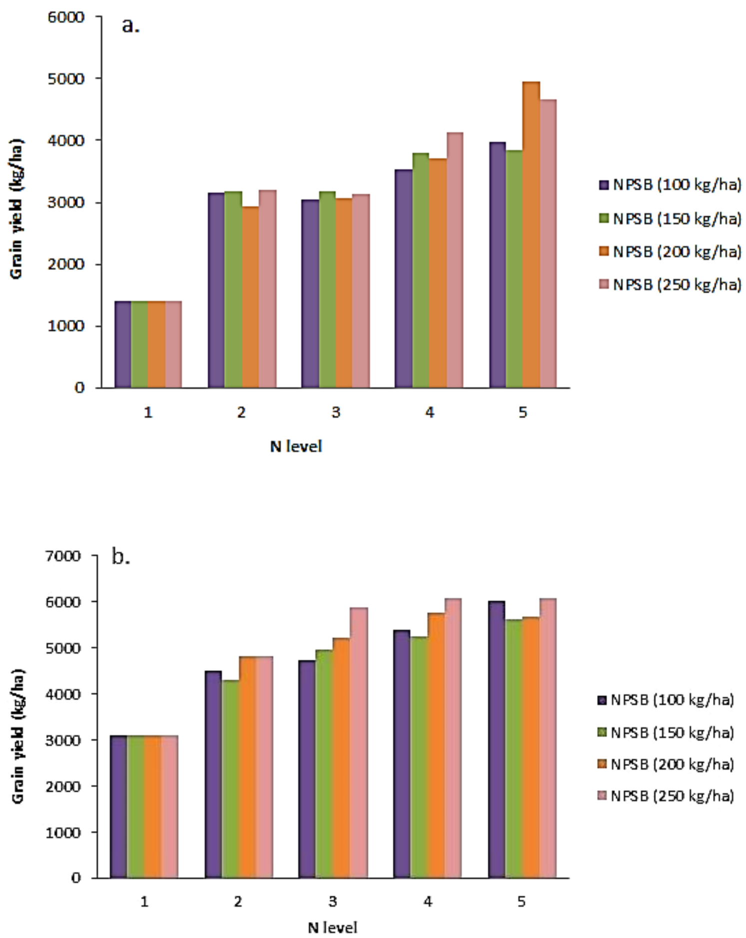


Figure 4. *Effect of NPSB blended and N fertilizer on the pooled grain yield of upland rice at a. Libokemikem district and b. Fogera district.*

3.5. Partial Budget Analysis

The partial budget analysis result at Libokemikem district indicates that the maximum net economic return of Ethiopian birr (Birr) 48,529.70 with marginal rate of return (MRR) of 1284.9% was obtained from 200 kg NPSB + 250 kg urea ha^{-1}. The other treatments are dominated (Table 7). At Fogera district, the maximum net economic return of Birr 62,323.60 with MRR of 959.7% was obtained from 100 kg NPSB + 250 kg urea ha^{-1} (Table 8).

Table 7. Partial budget analysis of the combined use of the NPSB blended fertilizer with urea for the grain yield of upland rice (pooled over 2018 and 2019) at Libokemikem district.

NPSB + Urea (kg ha^{-1})	Adj. Yield (kg ha^{-1})	Gross return	Cost of NPSB/DAP /100 kg	Cost of Urea /100 kg	Total ferti-lizer Cost	Net return	MRR (%)
0 + 0	1269.9	15873.7	0	0	0	15873.8	-
Rec. NP (50DAP+134.4Urea)	2318.4	28980.0	830.7	2092	2923.1	26056.9	348.4
100 + 100	2850.3	35628.7	1666.3	1562	3227.9	32400.9	2081.7
100 + 150	2750.4	34380.0	1666.3	2342	4008.6	30371.4	D
150 + 100	2852.1	35651.2	2499.5	1562	4061.1	31590.2	D
100 + 200	3187.8	39847.5	1666.3	3123	4789.4	35058.1	364.8
150 + 150	2869.2	35865.0	2499.5	2342	4841.8	31023.2	D
200 + 100	2650.5	33131.2	3332.7	1562	4894.2	28237.0	D
100 + 250	3579.3	44741.2	1666.3	3904	5570.2	39171.1	608.5
150 + 200	3411.0	42637.5	2499.5	3123	5622.6	37014.9	D
200 + 150	2763.0	34537.5	3332.7	2342	5675.0	28862.5	D
250 + 100	2883.6	36045.0	4165.9	1562	5727.4	30317.6	D
150 + 250	3464.1	43301.2	2499.5	3904	6403.3	36897.9	D
200 + 200	3339.0	41737.5	3332.7	3123	6455.8	35281.7	D
250 + 150	2823.3	35291.2	4165.9	2342	6508.2	28783.1	D
200 + 250	4461.3	55766.2	3332.7	3904	7236.5	48529.7	1284.9
250 + 200	3724.2	46552.5	4165.9	3123	7288.9	39263.6	D
250 + 250	4206.6	52582.5	4165.9	3904	8069.7	44512.8	D

All the cots are in Ethiopian Birr. Adj: Adjusted yield, D: Dominated, MRR: Marginal Rate of Return, Rec.NP: Recommended nitrogen and phosphorus fertilizers.

Table 8. Partial budget analysis of the combined use of the NPSB blended fertilizer with urea for the grain yield of upland rice (pooled over 2018 and 2019) at Fogera district

NPSB + Urea (kg ha^{-1})	Adj. Yield (kg ha^{-1})	Gross return	Cost of NPSB/DAP/100 kg	Cost of Urea/100 kg	Total Ferti-lizer Cost	Net return	MRR (%)
0 + 0	2790.9	34886.2	0	0	0	34886.3	
Rec. NP (50DAP+134.4Urea)	4172.4	52155.0	833.2	2092	2925.6	49229.4	490.3
100 + 100	4054.5	50681.2	1666.3	1562	3227.9	47453.4	D
100 + 150	4272.3	53403.7	1666.3	2342	4008.6	49395.1	21.2
150 + 100	3861.9	48273.7	2499.5	1562	4061.1	44212.7	D

NPSB + Urea (kg ha^{-1})	Adj. Yield (kg ha^{-1})	Gross return	Cost of NPSB/DAP/100 kg	Cost of Urea/100 kg	Total Fertilizer Cost	Net return	MRR (%)
100 + 200	4850.1	60626.2	1666.3	3123	4789.4	55836.8	884.4
150 + 150	4463.1	55788.7	2499.5	2342	4841.8	50946.9	D
200 + 100	4329.0	54112.5	3332.7	1562	4894.2	49218.3	D
100 + 250	5431.5	67893.7	1666.3	3904	5570.2	62323.6	959.7
150 + 200	4720.5	59006.2	2499.5	3123	5622.6	53383.7	D
200 + 150	4689.9	58623.7	3332.7	2342	5675.0	52948.8	D
250 + 100	4340.7	54258.7	4165.9	1562	5727.4	48531.3	D
150 + 250	5055.3	63191.2	2499.5	3904	6403.3	56787.9	D
200 + 200	5178.6	64732.5	3332.7	3123	6455.8	58276.7	D
250 + 150	5291.1	66138.7	4165.9	2342	6508.2	59630.6	D
200 + 250	5121.0	64012.5	3332.7	3904	7236.5	56776.0	D
250 + 200	5482.8	68535.0	4165.9	3123	7288.9	61246.1	D
250 + 250	5469.3	68366.2	4165.9	3904	8069.7	60296.6	D

All the cots are in Ethiopian Birr. Adj: Adjusted yield, D: Dominated, MRR: Marginal Rate of Return, Rec.NP: Recommended nitrogen and phosphorus fertilizers.

4. Conclusion

The study revealed that the grain and biomass yield of upland rice were significantly affected by the combined use of NPSB blended fertilizer with urea. At Libokemikem district, the highest yield and the maximum net economic benefit were obtained from the combined use of 200 kg NPSB + 250 kg urea ha^{-1} (151.2N, 72.2P_2O_5, 13.4S and 1.4B kg ha^{-1}). At Fogera district, the highest yield was recorded from the combined use of 250 kg NPSB + 200 kg urea ha^{-1} (137.25N, 90.25P_2O_5, 16.75S and 1.75B kg ha^{-1}). But, the maximum net economic benefit was obtained from the combined use of 100 kg NPSB + 250 kg urea ha^{-1} (133.1N, 36.1P_2O_5, 6.7S and 0.7B kg ha^{-1}). However, it is not possible to conclude the significant yield differences obtained in this study were due -to the effect of the S and B blends in the NPSB blended fertilizer. Because, there were confounding effects of N and P nutrients in the NPSB blended fertilizer. As it is revealed in the results and discussion, the significant yield response recorded, however, was due to the increasing levels of N nutrient. Therefore, we recommend further investigation of the response of NERICA-4 (upland rice) to each nutrient (P, S and B) through nutrient omission studies.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Abebaw Dessie, 2018. Cereal crops research achievements and challenges in Ethiopia International Journal of Research & Review (www.ijrrjournal.com) Vol. 5; Issue: 9; September 2018.

[2] Abiye Astatke, Tekalign Mamo, Peden, D. and M. Diedhiou, 2003. Participatory On-farm conservation tillage trial in Ethiopian highland vertisols: The impact of potassium application on crop yield. Experimental Agriculture 40: 369-379.

[3] Asgelil Debebe, Taye Bekele, Yesuf Assen, 2007. The status of micro-nutrients in Nitisols, Vertisols, Cambisols and Fluvisols in major maize, wheat, teff and citrus growing areas of Ethiopia. In: Proceedings of Agricultural Research Fund Research Projects Completion Workshop held on 1-2 February 2007 at EIAR, Addis Ababa, Ethiopia. pp 77-96.

[4] Asnakew Woldeab, Tekalign Mamo, Mengesha Bekele and Tefera Ajamo, 1991. Soil fertility management studies on wheat in Ethiopia. pp. 137-172. In: Hailu Gebremariam, D. G. Tanner and Mengistu Hulluka (eds.). Wheat Research in Ethiopia: A historical perspective. Addis Ababa, IAR/CIMMYT.

[5] CIMMYT (International Maize and Wheat Improvement Center), 1988. From Agronomic data to Farmers Recommendations: An economic training manual. Revised Edition. Mexico, D. F. 200p.

[6] CSA (Central Statistical Agency), 2017. Report on Areaand Production of Major Crops (Private Peasant Holdings, Meher Season) The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey Volume I, 2017/18 (2010 E. C.) April, 2018. ADDIS ABABA, Ethiopia.

[7] CSA (Central Statistical Agency), 2018. Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season) The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey, Volume I, 2018/19. April, 2019. ADDIS ABABA, Ethiopia.

[8] CSA (Central Statistical Agency), 2019. Report on area and production of major crops (private peasant holdings, meher season). The federal democratic republic of Ethiopia central statistical agency agricultural sample survey 2018/19. Volume i. Statistical bulletin 589.

[9] Dagne Chimdesa, 2016. Blended fertilizer effects on maize yield and yield components of Western Oromia, Ethiopia. Journal of Agriculture, Forestry and Fisheries. 5(5): 151-162.

[10] Dercon, S. and R. V. Hill, 2009. Growth from agriculture in Ethiopia. Identifying key Constraints. Paper prepared as part of a study on agriculture and growth in Ethiopia. DFID, UK.

[11] EthioSIS (Ethiopian Soil Information System), 2015. Fertilizer Recommendation Atlas of the Amhara Regional State. pp.

[12] FAO (Food and Agriculture Organization), 2006. Plant nutrition for food security: A guide for integrated nutrient management. FAO, Fertilizer and Plant Nutrition Bulletin 16, Rome, Italy.

[13] Hazelton P. and B. Murphy, 2007. Interpreting soil test results: What do all the numbers mean? 2nd Edition. CSIRO Publishing. 152p.

[14] John l. H. E. Mayorga, E. Tsamakis, M. E. McClain, A, Aufdenkampe, P. Quay, and J. E. Richey, 2000. Organic matter in Bolivian tributaries of the Amazon River: A comparison to the lower mainstream, Limnol. Oceanogr., 45(7) 1449-1466, American Society of Limnology and Oceanography, Inc., Washington NCS. 1992. Ethiopia nation.

[15] Jones J. B., 2003. Agronomic Handbook: Management of Crops, Soils, and Their Fertility. CRC Press LLC, Boca Raton, Florida, USA. 482p.

[16] Melkamu Hordofa, Gashaw Meteke, Wassie Haile, 2019. Effects of Different blended fertilizers on yield and yield components of food barley (Hordeum *vulgar* L.) on nitisols at Hulla District, Southern Ethiopia. Acad. Res. J. Agri. Sci. Res. 7(1): 49-56.

[17] MoARD (Ministry of Agricultural and Rural Development), 2010. National Rice Research and Development Strategy of Ethiopia. The Federal Democratic Republic of Ethiopia, Ministry of Agriculture and Rural development, Addis Ababa, Ethiopia. 48 pp.

[18] Mulugeta Eshetu, Shure Sebboka, Tilahun Chibsa, Chala Chimdesa, Negash Bedessa, 2017. Optimization of Fertilizer Recommendation for Bread Wheat at Sinana District of Bale Zone, Southeastern Oromia, Ethiopia. Int. J. Sci. Qualitative Analysis 3(6): 55-60.

[19] Rut Duga, Diriba Shiferaw and Wogayehu W. 2019. Effects of blended Fertilizer Rates on Bread Wheat (triticumaestivum L.) Varieties on Growth and Yield Attributes. J. Ecol. And Nat. Resour. 3(3): 000170.

[20] Tekalign Mamo and M. A. Mohamed-Saleem. 2001. Joint Vertisols Project as A Model for Agricultural Research and Development. Proceedings of the international symposium on Vertisols management. In: Advances in Vertisol Management in the Ethiopian Highlands. pp. 13-18, DebreZeit, Ethiopia.

[21] Tekalign Tadese, 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa, Ethiopia.

[22] Tewolde Berhe, Gebreyohannes Girmay and Abrha Kidanemariam, 2020. Validation of blended NPSB fertilizer rates on yield, yield components of Teff [Eragrostis tef (Zuccagni) Trotter] at vertisols of Hatsebo, Central Tigray, Ethiopia. Journal of Soil Science and Environmental Management. 11(2): 75-86.

[23] Wassie Haile and Shiferaw Boke, 2011. Response of Irish Potato (*Solanum tuberosum*) to the Application of Potassium at Acidic Soils of Chencha, Southern Ethiopia. International Journal of Agricultural Biology 13: 595–598.