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Effects of Blended NPSB and N Fertilizer Rates on Maize (*Zea mays* L.) Grain Yield and Yield Components in Chora District, Buno Bedele Zone, South Western Ethiopia

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Abstract: Maize is a significant cereal crop in Ethiopia. However, the yield of this crop is declined from time to time due to continuous use of DAP and urea for a long season, which resulted in deficiency of other important nutrients and due to absence of the right fertilizer with the right rate at the right time. Therefore, a field experiment was conducted at chora district during the 2021 main cropping season to assess the effect of blended NPSB fertilizer rates supplemented with inorganic N fertilizer on maize grain yield and yield components and to determine the economically optimum levels of blended NPSB and N required to give higher yield of maize. The treatment consisted of factorial combination of five levels of blended NPSB (0, 50, 100, 150 and 200kg/ha) and four levels of N (0, 23, 46 and 69kg/ha) fertilizer rates. The experiment was laid out in randomized complete block design (RCBD) with three replications. Analysis of the results revealed that, plant height (PH), above ground dry biomass (AGDB kg/ha), grain yield (GY kg/ha) and stalk yield (SY kg/ha) were highly significantly affected by main effect of blended NPSB and N rates, as well as by their interaction, while number of cob per plot (NCPP), cob length (CL), number of grains per cob (NGPC), thousand kernel weight (TKW gm) and harvest index (HI%) were significantly affected by main effect of blended NPSB and N rates, as well as by their interaction. Only number of rows per cob (NRPC) was not significantly affected by both main effects of blended NPSB and N rates, as well as their interaction. The result showed that, the highest grain yield (7026.4kg/ha) and net benefit (89020 ETB/ha) with an acceptable marginal rate of return (1010.9%) was obtained from the plot treated with 200kg/ha of NPSB and 69kg/ha of N fertilizer rates. Therefore, based on the result obtained from this study, application of 200kg/ha of blended fertilizer supplemented with 69 kg/ha of N fertilizer can be suggested as profitable for production of maize at the study area and their similar soil conditions and agro-ecologies.

Keywords: Blended NPSB Fertilizer, N Fertilizer, Grain Yield, Maize

1. Introduction

Maize is a member of grass family, poaceae. It is believed that the crop was originated in mexico and introduced to west Africa in the early 1500s by Portuguese traders [14]. It was brought to Ethiopia in the 1600s to 1700s [21]. In Ethiopian agriculture maize is one of the pillar cereal crops ranking first in total production and productivity, and second next to teff in area coverage [18]. Maize in Ethiopia is used directly for human consumption as food and raw materials for local drinks. In addition maize leaves and stalks are used to feed animals [2].

The estimated average yield of maize for small holder farmers in Ethiopia are about 4.2t/ha, which is much lower than the yield recorded under demonstration plot which was 50 to 60 kg/ha [9]. The low yield of maize in Ethiopia is due to several factors such as poor crop management practices, unbalanced nutrient application, disease and insect pest [36]. Poor soil fertility highly negatively affects the growth and development of maize as compared to other cereal crops. As a result, it is often said “maize speaks” implying that maize cannot supply maximum grain yields unless ample amount of nutrients are applied to the growing media [12].

Di-ammonium phosphate (DAP) and urea have been the only chemical fertilizers used for crop production with initial understanding that nitrogen and phosphorus are the major limiting nutrients of Ethiopian soils [5]. However, in addition to nitrogen and phosphorus, sulfur, boron and zink deficiencies are wide spread in Ethiopian soils [16]. Therefore, different fertilizer materials would be required to ensure balanced fertilizer use involving all or most of nutrients required by crops. Sulfur is required for the synthesis of sulfur containing amino acids such as cystine and methionine. Sulfur addition showed increase nitrogen uptake when sulfur was applied at the highest nitrogen rate, indicating a synergism between both nutrients [17]. Boron is also an essential element for better utilization of photo-assimilates from source to sink during growth period [3].

When the soil does not supply ample amount of nutrients for normal plant growth, addition of supplemental nutrients are required. Better matching of fertilizer application to local climate, soil and management practices help to ensure that production can be intensified cost effectively and sustainably [11]. Hence, understanding the plant nutrients requirement of a given area has vital role in increasing crop production and productivity on sustainable basis. Currently several combination of blended fertilizer which include most deficient elements in the soil such as nitrogen, phosphorus, sulfur, boron, potassium, zink, copper and iron are fabricated for different agro-ecologies of the country [16].

Among different types of blended fertilizer fabricated, the blended fertilizer containing nitrogen, phosphorus, sulfur and boron are distribute to chora district. However there is limited information on the optimum of blended fertilizer application rate for the production of maize. Therefore there is a need to develop location and agro-ecology based fertilizer rate recommendation to increase the productivity of maize. Therefore, this study was under taken to determine the effect blended NPSB and N rates on yield and yield components of maize.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted in chora district on farmer's field during the 2021 main cropping season. The district is located 503 km away from Addis Ababa and 20km from BunoBedele Zone on the way to Metu in western direction. According to the sixteen (2005-2021) year meteorological data, the mean annual rain fall of the study area is 1942mm and the mean monthly minimum and maximum temperature are 13 and 16°C respectively. The rainy season extends from April to October and the maximum rain is received in the months of May, June, July, August and September with mean monthly rain fall exceeding 301mm [4].

The major soil type of the study area is Nitosols [33]; topographically the area is characterized by mountainous and gentle sloping landscape. The soil is characterized as deep, well drained, red, diffuse horizon boundaries and clay rich nitic sub-surface horizon [15]. The major crop grown in the area is maize (Zea mays L.), teff (Eragrotisteff), Sorghum (sorghum bicolor), barley (Hordeumvulgare), wheat (triticumspp), different pulse crops, vegetable and spices. Most of the resident in the area are dependent on agrarian activities to a greater or lesser extent [29], and crop as well as livestock's are the important sources of income for all wealth groups [10].

2.2. Experimental Materials

2.2.1. Planting Materials

The maize variety named (BH-661) which was released by Bako agricultural research center in 2011 was used as a test crop. Maize variety (BH-661) is adapted to the agro ecology of the study area and it is now popular in the study area.

Table 1. *Description of maize variety (BH-661) used for the study.*

No	Description	Agronomic characteristic
1	Altitude (m.a.s.l)	1600-2200
2	Rain fall (mm)	1000-1500
3	Year of release	2011 E.C
4	Seed rate (seeds/ha)	50,000
5	Grain yield on station (kg/ha)	95-120
6	Grain yield on farmers field (kg/ha)	65-85

Source: BARC, 2011.

2.2.2. Fertilizer Materials

Urea (46%N) and blended NPSB (18.9%N, 37.7P_2O_5, 6.95%S and 0.1%B) were used as a source of nutrient.

2.3. Soil Sampling and Analysis

The soil samples were collected randomly from the surface (0-20cm) using auger in zigzag pattern before planting and composited into one sample. The composited samples were mixed properly and one kg of the sample was taken from the composited soil. The sample was transported to soil laboratory of Bedele Agricultural Research Center and placed on shelf in soil sample drying room. Air dried soil sample was ground using pestle and mortar under shading. Before test, the sample was sieved through a 2mm diameter sieve mesh. The soil test was done for soil textural class, soil pH, organic carbon, total nitrogen, available phosphorus, CEC, exchangeable bases, available sulfur and boron. The soil tests were made at the soil laboratory of Bedele agricultural research institute.

The soil texture was determined by Bouyoucos hydrometer method [6]. Soil pH was determined in 1:2.5 soils: water ratio using a glass electrode attached to a digital pH meter [47]. Organic carbon was estimated by wet digestion method [47] after air dried soil was ground to pass a 0.5mm diameter of sieve. To determine the cat ion exchange capacity (cmol(+)/kg) of soil, the soil sample was first leached by 1M ammonium acetate, second washed with ethanol and the adsorbed ammonium was replaced by sodium (Na). Then, the CEC was determined titrimetrically by distillation of ammonia that was displaced by sodium [41]. Exchangeable basic cat ions (Ca^{2+}, mg^{2+}, k^+ and Na^+) were extracted with 1m of ammonium acetate at pH 7. Exchangeable Ca^{2+} and mg^{2+} were determined from the extracted solution with atomic absorption spectroscopy (AAS) method, whereas exchangeable k^+ and Na^+ were determined from extracted solution with flame photometer [40].

Total nitrogen (%) was also determined from the soil sample that passes through 0.5mm diameter using the Kjedhal method [24]. Available phosphorus in soil was determined by the Bray II [7] extraction method. Available sulfur (meq/L SO_4^{2-}) was determined by mono-calcium phosphate extraction method [23], and available boron was determined using hot water method [22].

2.4. Treatments and Experimental Design

The treatments consisted of factorial combination of four levels of N (0, 23, 46 and 69 kg/ha) and five levels of blended NPSB (0, 50, 100, 150 and 200kg/ha) fertilizer rates.

Table 2. *Fertilizer compositions of the experimental treatments.*

No	Treatments		Total composition of fertilizer in the treatment (kg ha-1)			
	Nitrogen rate (kg ha-1)	Blended NPSB rate (kg ha-1)	N	P_2O_5	S	B
1	0	0	0	0	0	0
2	0	50	9.45	18.85	3.48	0.05
3	0	100	18.9	37.7	6.95	0.1
4	0	150	28.35	56.55	10.43	0.15
5	0	200	37.8	75.4	13.91	0.2
6	23	0	23	0	0	0
7	23	50	32.45	18.85	3.48	0.05
8	23	100	41.9	37.7	6.95	0.1
9	23	150	51.35	56.55	10.43	0.15
10	23	200	83.8	75.4	13.91	0.2
11	46	0	46	0	0	0
12	46	50	55.45	18.85	3.48	0.05
13	46	100	64.9	37.7	6.95	0.1
14	46	150	74.35	56.55	10.43	0.15
15	46	200	129.8	75.4	13.91	0.2
16	69	0	69	0	0	0
17	69	50	78.45	18.85	3.48	0.05
18	69	100	87.9	37.7	6.95	0.1
19	69	150	97.35	56.55	10.43	0.15
20	69	200	175.8	75.4	13.91	0.2

The experiment was laid out in randomized complete block design (RCBD) with three replications.

2.5. Experimental Procedure and Management

The experimental field was prepared according to the local practice. Thus, the land was ploughed two times using oxen before planting and third ploughing was done before planting to make it ready for planting. In accordance with the specifications of the design, a field layout was prepared. The size of each experimental plot was 3m*4m (12m^2). The blocks were separated by 1m wide open spaces, whereas the plots within a block were 0.5m apart from each other. After layout, five rows were prepared by keeping the distance 0.8m between rows and 0.5m between plants. Each treatment was assigned randomly to the experimental plots within a block.

The maize variety (BH-661) was planted at the rate of 50,000 seeds/ha in rows of 0.5m apart, thus, there were five rows in each plot. The full dose of blended NPSB fertilizer was applied as per the treatments at planting time, whereas nitrogen was applied in two splits (1/2 at planting and ½ 30 days after planting) through application of urea. The outer most two rows from each side of a plot of each row were considered as border and were not included for recording the data. Thus, the net plot was 2.4m*3m (7.2m^2). Harvesting was done on the 20th of November 2021 at maturity stage. The total above ground dry biomass yield was harvested from the three central rows and measured by using spring balance before maize cobs are harvested from maize stalk.

From each treatment 1kg of biomass was taken and dried at sample drying room and measured by using sensitive balance to calculate the total above ground dry biomass yield. Threshing was done manually by hand in a sack. After threshing, the grain yield was weighed using sensitive digital balance for each treatment and converted to kg/ha.

2.6. Data Collected

2.6.1. Growth Parameters

Plant height was measured during physiological maturity from the three central rows from ground level to the apex of each plant and an average was used for analysis. The cob length also measured from three selected cobs and an average was used for analysis.

2.6.2. Yield Components

The number of grains per cob was determined from three cobs and the average value was considered for analysis. Total above-ground dry biomass yield (kg/ha) was calculated by taking the total weight of the harvest including seeds from three central rows and sun drying the biomass to constant weight and converted to kg/ha. Stalk yield was calculated by subtracting the grain yield from the total above ground dry biomass yield. Thousand seed weight (gm) was weighed by counting thousand seeds obtained from three cobs using sensitive balance.

2.6.3. Grain Yield

Three central rows per plot were harvested, sundried and threshed. The grain yield obtained from each plot was weighed using an electronic balance and converted to kg/ha. Harvest index (HI%) was computed as the ratio of grain yield to total above ground dry biomass yield [13].

$$\text{HI (\%)} = \frac{\text{Grain yield (kg/ha)}}{\text{Above ground dry biomass (kg/ha)}} * 100$$

2.6.4. Statistical Analysis

The collected samples were subjected to analysis of variance (ANOVA) for appropriate to factorial experiment in a randomized complete block design (RCBD) using SAS software program version 9.3 [42]. Means between and among treatments were separated using least significance difference (LSD) test at 5% level of significance.

2.6.5. Economic Analysis

The cost of management and materials like seed, weeding, harvesting and threshing were assumed to remain the same or insignificant among the treatments. So for economic analysis of this study only the cost of blended NPSB and urea were considered. Analysis of (MRR%) was carried out for non dominated treatments and MRRs were compared to a minimum acceptable rate of return (MARR) of 100% to select optimum treatments [8]. The net benefit is calculated by subtracting the total variable cost from gross field benefit. The average yield was adjusted downward by 10% to reflect the difference between the experimental field and the expected yield at farmer's fields and with farmer practices from the same treatments.

3. Results and Discussion

3.1. Physicochemical Properties of Experimental Soil Before Planting

The physicochemical properties: The result obtained from laboratory analysis indicated that, clay particles dominated silt and sand. Thus, 51 (%) clay, 27 (%) sand and 22 (%) silt (Table 3). The textural class of the study area was classified as clay according to Bouyoucos [6] classification. The pH of the study area was 5.48, according to FAO; the pH of the study area was categorized as moderately acidic [19]. This value fall in the pH range that is very conducive for maize production as normal soil pH for maize is recorded to be from 5-8, with the pH of 6-7 probably being an optimal for most varieties [31].

Regarding organic carbon content, the soil sample collected from the study area contain (2.38%) of organic carbon (Table 3). According to FAO classification, the soil of the study area contains low organic carbon [19]. The CEC value of the study area was (21.43 cmol(+)/kg) of soil (Table 3). According to FAO, the CEC value of the study area was rated as medium [19]. The medium value of CEC is related clay dominated soil of the study area; because clay dominated soil contain high CEC due to high surface area of the soil. The other nutrient tested for the soil before planting was available phosphorus (p). The available phosphorus recorded from experimental area was (1.29mg/kg) of soil, which was categorized as low [30]. This is may be due to high phosphorus fixation of clay soil. This result link with soil with high clay content has high phosphorus fixation capacity, because clay particles have high surface area per unit volume which can absorb phosphorus easily [39]. However, maize being a high phosphorus demanding crop, the level of available phosphorus value would not meet phosphorus requirement, therefore addition of blended fertilizers containing phosphorus nutrient is mandatory to obtain the optimum grain yield.

Regarding the exchangeable bases, the values recorded from the study area for potassium (K^+), Sodium (Na^+), Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) was 2, 0.2, 1.29 and 1.47 cmol(+)/kg of soil respectively (Table 3). As per the rating set by FAO, the basic cat ions recorded from the study area was classified as very high for potassium (K^+), low for sodium (Na^+), very low for calcium (Ca^{2+}) and medium for magnesium (Mg^{2+}) [19]. The low, very low and medium amount of sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) of the study area might be due to leaching of surface soils by excessive rain fall. Similarly, Kidanu and Achalu reported the leaching of appreciable amount of exchangeable basic cat ions like calcium, magnesium and sodium from surface soil by excessive rain fall [27]. On the other hand very high amount of exchangeable potassium was recorded from study area. This result is agree with Murphy, who reported that Ethiopian soils contains sufficient amount of potassium nutrient [34]. The percentage base saturation (PBS) of the study area was 23.14%, according to FAO, the percentage base saturation (PBS) of the study area was rated as low range [19]. This might be due to deficiency of exchangeable basic cat ions and the exchange sites on soil colloids are dominated by acidic ions.

Total nitrogen content of the study area was (0.20%) (Table 3). According to EthioSIS interpretation, the total nitrogen content of the soil within the ranges of <0.1, 0.1-0.15, 0.15-0.3, 0.3-0.5 and >0.5 was rated as very low, low, medium, high and very high respectively [16]. Regarding on this range, total nitrogen content of the study area falls under medium range. Accordingly, the soil analysis result of experimental site indicated that total nitrogen is limiting factor for the production of maize. Therefore, nitrogen containing fertilizer should be applied to supplement the nitrogen requirements of the crop.

The available sulfur recorded from experimental field was (10mg/kg) of soil, which was grouped under medium range [16]. This medium sulfur content of the soil might be due to lack of organic matter application to the soil and continuous use of DAP and urea that do not contain sulfur for crop production. Therefore, to intensify the crop production, application of sulfur containing fertilizer to the study area is mandatory. Regarding the available boron, available boron content of the experimental area was (0.44mg/kg) of soil (Table 3). This value indicated that, the available boron content of experimental field was low [26]. According to Jones interpretation, available boron <0.2 considered as very low, 0.3-1 as low, 1.1-2 as medium, 2.1-4 as high and >4.1 as very high [26]. Generally the value recorded from laboratory indicated that, the available boron content was insufficient for crop production and application of blended fertilizer containing boron to the study area is necessary to increase crop production and boron content of the soil.

Table 3. *Laboratory analysis result of the study area before planting.*

Physical parameters	Value	Rating	Source
Soil texture			
Sand (%)	27		
Silt (%)	22		
Clay (%)	51		
Textural class	Clay		
Chemical parameters			
pH	5.48	Moderately acidic	FAO, 2006
Total nitrogen (%)	0.20	Medium	Ethiosis, 2013
Available phosphorus (mg/kg) of soil	1.29	Low	Manjula., 2012
Available sulfur (mg/kg) of soil	10.0	Low	Ethiosis, 2013
Available boron (mg/kg) of soil	0.44	Low	Jones, 2003
Organic carbon (%)	2.32	Low	FAO, 2006
CEC (cmol(+)/kg) of soil	21.43	Medium	FAO, 2006
Exchangeable calcium (cmol(+)/kg) of soil	1.29	Very low	FAO, 2006
Exchangeable magnesium (cmol(+)/kg) of soil	1.47	Medium	FAO, 2006
Exchangeable sodium (cmol(+)/kg) of soil	0.2	Low	FAO, 2006
Exchangeable potassium (cmol(+)/kg) of soil	2	Very high	FAO, 2006
PBS (%)	23.14	Very low	FAO, 2006

3.2. Effects of NPSB and N Rates on Growth Parameters of Maize

3.2.1. Effects of NPSB and N Rates on Plant Height

The result recorded from analysis of variance indicated that, there was highly significant ($p<0.01$) difference in plant height due to main effects of blended NPSB, N rates and their interaction effect. Significantly tallest (2.28m) plant height was recorded from the plot treated with 200kg/ha of blended NPSB supplemented with 69kg/ha of N, whereas the shortest plant height (1.5m) was recorded from the control plot. Thus, the mean height of plants grown at the rate of 200kg/ha of blended NPSB and 69kg/ha of N was significantly taller than all other plots treated with different rates of inorganic fertilizers.

In general this result showed that, an increase in plant height as the level of blended NPSB and N rate increases, similarly in their interaction effect (Table 4). The increment in plant height might be due to an increase in cell elongation and more vegetative growth attribute to different nutrient. This result agree with Kinfe et al. who reported that, plant growth and development reduced significantly if any of the nutrient element is less than its threshold value in the growing media or not adequately balanced with other nutrient elements [28]. Similarly, Osman and Mohammed reported that, plant height of maize increase with increased level of nitrogen (N) and phosphorus (P) [37]. The result obtained from this study also agree with the finding of Tenaw, who declare the beneficial role of nitrogen and phosphorus in cell division and elongation as well as root growth and dry matter of plants [44].

Table 4. *Mean plant height (m) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	BlendedNPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	1.50^{g}	1.55^{fg}	1.67^{efg}	1.77^{def}	2.14^{ab}
23	1.63^{fg}	1.88^{cde}	2.05^{abc}	2.14^{ab}	2.28^{a}
46	1.76^{ef}	1.80^{def}	1.87^{cde}	2.10^{abc}	2.28^{a}
69	1.7^{ef}	1.79^{def}	2.02^{bcd}	2.16^{ab}	2.28^{a}
LSD (5%)	0.24				
CV (%)	7.78				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.2. Effects of NPSB and N Rates on Above Ground Dry Biomass Yield

Analysis of variance indicated that, the main effects of blended NPSB and N rates, as well as their interaction showed a highly significant ($p<0.01$) effect on above ground dry biomass yield. The outmost above ground dry biomass (18088kg/ha) yield was recorded from the plots treated with 200kg/ha of blended NPSB and 69kg/ha of N, whereas the lowest above ground dry biomass (2915.1kg/ha) was recorded from the control (unfertilized) plot (Table 5). This might be due to the beneficial effects of the right fertilizer with the right rate. The result obtained from this study is in line with Mekuanent and Kiya who reported a significance difference in biomass yield of maize due to blended NPSB fertilizer rate and the higher blended fertilizer level was gave higher above ground dry biomass yield, whereas the lowest above ground biomass yield was recorded from the control plot [32].

Similarly, Teng and Timmer declare that, combined application of nitrogen and phosphorus increased above ground dry biomass yield of maize [45]. Tripathia also reported that, the combination of nitrogen and phosphorus leads to an increase in dry matter accumulation [46].

Table 5. *Mean above ground dry biomass yield (kg/ha) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	2915.1^{j}	4730.9^{ij}	5658.6^{i}	5992.1^{hi}	7698.9^{gh}
23	4456.0^{ij}	9264.2^{fg}	9320.0^{fg}	10981.0^{ef}	14854.0^{bc}
46	5658.6^{i}	10553.1^{ef}	12280.3^{de}	11829.7^{de}	15707.3^{b}
69	9581.9^{fg}	11017.8^{ef}	10886.0^{ef}	13332.4^{cd}	18088.0^{a}
LSD (5%)	2003.9				
CV (%)	12.43				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.3. Effects of NPSB and N Rates on Number of Cobs Per Plot

The result obtained from this study indicated that, main effect of blended NPSB and N rate, as well as their interaction significantly ($p<0.05$) affected the number of cobs per plot. The highest mean (38.33) number of cobs was recorded from the plot treated with 200kg/ha of blended NPSB and 69kg/ha of N, whereas the lowest (17) number of cobs per plot were recorded from the control plot (Table 6). This might be due to beneficial effect of sufficient blended fertilizer rate applied with appropriate amount of nitrogen containing fertilizer, which can capacitate the plants to hold two or more number of cobs per plot. This result in line with Fufa et al. who reported the highest number of cobs from the net plot treated with 150kg/ha of blended NPSB and the lowest from the control plot [20].

Table 6. *Mean number of cobs per plot of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	17.00^{g}	21.00^{fg}	23.00^{defg}	24.00^{cdefg}	34.33^{ab}
23	19.00^{fg}	21.66^{efg}	23.33^{cdefg}	31.00^{abcde}	32.66^{abc}
46	23.00^{defg}	25.00^{bcdefg}	28.00^{bcdef}	32.00^{abcd}	38.33^{a}
69	27.33^{bcdef}	25.00^{bcdefg}	28.00^{bcdef}	32.00^{abcd}	38.33^{a}
LSD (5%)	9.34				
CV (%)	20				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.4. Effects of NPSB and N Rates on Cob Length

Regarding cob length, main effect of blended NPSB and N rates, as well as their interaction effect significantly ($p<0.05$) affected the cob length. The longest (19.44cm) cob length were obtained from the plot that received the 200kg/ha of NPSB and 69kg/ha of N fertilizer rates, whereas the shortest cob length (12.89cm) were recorded from control (unfertilized) plot (Table 7). This is due to beneficial effect of sufficient blended NPSB fertilizer supplemented with enough amount of N containing fertilizer, and they play great role in cell elongation of plants as a result maize cobs also enlarged and capacitated to hold sufficient amounts of grains. This study was in agreement with Rouf and Ali who reported that, the amount of fertilizer increased the length of the cob also increase than the control [38].

Table 7. *Mean cob length (cm) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	12.89^{h}	14.83^{fgh}	15.66^{efg}	15.99^{defg}	17.44^{abcde}
23	13.11^{h}	15.00^{fgh}	16.77^{bcdefg}	16.89^{bcdef}	18.55^{abc}
46	14.55^{gh}	16.33^{cdefg}	17.33^{abcde}	18.00^{abcd}	19.00^{ab}
69	16.89^{bcdef}	16.77^{bcdefg}	17.44^{abcde}	18.77^{ab}	19.44^{a}
LSD (5%)	2.23				
CV (%)	8.15				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.5. Effects of NPSB and N Rates on Number of Grains Per Cob

The analysis in the current study revealed that, the main effect of NPSB and N fertilizer rates, as well as their interaction effect significantly ($p<0.05$) affected the number of grains per cob. The highest mean number of grains (585.33) was recorded from the plot treated with highest blended NPSB and N rate. The lowest (298) number of grains were recorded from the control plot (Table 8). This might be due to positive effect of balanced nutrient that capacitated the plant to vigorous growth and resulted in longest cob which helps the cobs to hold much number of grains. Similarly this study agreed with Fufa et al. who reported that, the plant that were provided with sufficient NPSB fertilizer has higher capability to utilize nutrients and facilitate to use other nutrients from the soil and produce bigger cobs that produces more number of grains per cob [20].

Table 8. *Mean number of grains per cob of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	298.00^{k}	445.00^{hi}	482.00^{defghi}	503.00^{bcdefgh}	516.67^{bcdef}
23	380.00^{j}	445.00^{hi}	485.33^{cdefghi}	530.67^{abcde}	542.33^{abc}
46	432.33^{ij}	451.00^{ghi}	504.67^{bcdefg}	544.33^{ab}	548.00^{ab}
69	459.33^{fghi}	475.67^{efghi}	539.33^{abcd}	577.33^{a}	585.33^{a}
LSD (5%)	58.49				
CV (%)	7.26				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.6. Effects of NPSB and N Rates on Number of Rows Per Cob

Statistical analysis showed that, the main effect of NPSB and N fertilizer rates, as well as their interaction effect did not significantly ($p>0.05$) affected the number of rows per cobs. This result was agreed with the result reported by Rouf and Ali who declare that, application of additional fertilizer did not significantly change number of rows per cob [38]. This might be due to the fact that rows per cob in maize are formed at the early growth stage of maize when there is no much competition among plants for nutrients for growth and development.

Table 9. *Mean number of rows per cob of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	12.00^{a}	12.00^{a}	12.66^{a}	12.66^{a}	12.66^{a}
23	12.66^{a}	12.00^{a}	12.00^{a}	12.00^{a}	12.66^{a}
46	12.20^{a}	12.00^{a}	12.66^{a}	12.00^{a}	12.66^{a}
69	12.66^{a}	12.00^{a}	12.66^{a}	12.66^{a}	12.00^{a}
LSD (5%)	1.37				
CV (%)	6.71				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.7. Effects of NPSB and N Rates on Thousand Kernels Weight (TKW)

The main effect of NPSB and N rates, as well as their interaction effects significantly ($p<0.05$) affected thousand kernels weight. The highest thousand kernels weight (40.58gm) were recorded from the plot treated with 200kg/ha and 69kg/ha of blended NPSB and N rates respectively, although the lowest thousand grains weight (19.18gm) were recorded from the control plot (Table 10). The highest thousand weight is observed due to the balanced nutrient supplied in the form of inorganic fertilizer, those play great role in grain filling of maize and as a result increase the grains weight of maize, while the lowest thousand kernel weight is recorded from the control plot due to deficiency of appropriate amounts of nutrients in the growing media.

Similar to this study Singh and Daoudi reported that, there was significant difference among fertilizer rate on thousand kernels weight of maize at East Wollega Zone of Oromia region [43]. Onasanya et al. also justified that, the lowest thousand seed weight was recorded from zero blended fertilizer application with compared to fertilizer application [35].

Table 10. *Mean TKW (gm) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	19.18^{k}	26.44^{ij}	30.80^{efghi}	33.20^{cdefg}	33.62^{cdefg}
23	22.46^{jk}	29.15^{ghi}	30.46^{fghi}	33.23^{cdefg}	35.65^{bcd}
46	27.07^{hij}	31.54^{defgh}	33.16^{cdefg}	35.49^{bcde}	40.00^{ab}
69	30.39^{fghi}	34.76^{cdef}	37.72^{abc}	40.00^{ab}	40.58^{a}
LSD (5%)	4.74				
CV (%)	8.90				

Where, TKW=Thousand kernel weight; LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.8. Effects of NPSB and N Rates on Maize Grain Yield (kg/ha)

The main effects of blended NPSB and N rates, as well as their interaction showed a highly significant ($p<0.01$) effect on maize grain yields. As the application rate of blended NPSB and N containing fertilizer is increased from zero to upwards, there was increasing trends in mean grain yield though all increases are not statistically different. The highest grain yield (7026.4kg/ha) of maize was obtained at the highest rate of 200kg/ha and 69kg/ha of blended NPSB and N respectively, while the lowest grain yield (513.9kg/ha) was recorded from control (unfertilized) plot (Table 11). The highest grain yield at highest blended NPSB and N rate might have resulted from improved root growth resulting in increased photosynthetic product and increased uptake of nutrients favoring increased growth which enhanced yield components and yield of maize.

In line with this study Mekuannet and Kiya reported that, grain yield of maize increased at fertilizer application levels with compared to without fertilizer application [32]. Similarly Dagne reported that, grain yield of maize varieties was increased as fertilizer levels increased up to certain level [11]. Likewise Jafer reported better grain yield of maize from application of blended fertilizer in contrast to recommended NP fertilizer and control (unfertilized) plot [25].

Table 11. *Mean grain yield (kg/ha) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	513.9^{i}	1055.6^{h}	2041.7^{g}	3486.1^{f}	4930.6^{d}
23	680.6^{hi}	2041.7^{g}	3375.0^{f}	4333.3^{e}	5819.2^{c}
46	2143.1^{g}	4319.4^{e}	4696.8^{de}	4909.6^{d}	6887.5^{a}
69	3522.2^{f}	4942.3^{d}	5492.9^{c}	6319.4^{b}	7026.4^{a}
LSD (5%)	464.19				
CV (%)	7.15				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.9. Effects of NPSB and N Rates on Harvest Index (HI%)

The harvest index is a measure of the physiological productivity potential of a variety. It is used to estimate how much a crop can convert the dry matter into economic yield. The main effect of blended NPSB and N fertilizer rates, as well as their interaction significantly ($p<0.05$) affected harvest index of maize. The maximum harvest index (64.06%) were recorded from the plot treated with 200kg/ha and 69kg/ha of blended NPSB and N rates respectively, while the minimum harvest index (15.28%) were recorded from the control (unfertilized) plot (Table 12). The increment in harvest index at higher rate of blended NPSB with supplemental nitrogen might be attributed to greater photo assimilate production and its ultimate partitioning into grain yield. This result in line with Orkaido who reported that, different rates of inorganic fertilizer levels had a significant effect on maize harvest index [36]. Similarly Zeidan et al. reported that, the harvest index in corn increases when N rates increases [48].

Table 12. *Mean harvest index (%) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	BlendedNPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	15.28^{j}	22.34^{hij}	35.23^{fghi}	39.75^{defgh}	44.71^{bcdef}
23	17.82^{ij}	23.83^{ghij}	35.70^{fghi}	40.15^{cdefgh}	57.83^{abcd}
46	35.64^{fghi}	40.99^{cdrfg}	37.67^{efgh}	42.09^{cdefg}	58.47^{abc}
69	37.89^{efgh}	55.70^{abcde}	38.93^{efgh}	60.84^{ab}	64.06^{a}
LSD (5%)	18.57				
CV (%)	17.91				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.2.10. Effects of NPSB and N Rates on Stalk Yield (kg/ha)

Statistical analysis of current study indicated that, mean stalk yield of maize was highly significantly ($p<0.01$) affected by main effect of blended NPSB and N rates, as well as their interaction effect. The highest stalk yield (8820kg/ha) was recorded from the plot treated with the highest NPSB and N rate, whereas the lowest stalk yield (2401kg/ha) was recorded from the control (unfertilized) plot (Table 13). This might be due to the fact that, crop supplied with adequate nutrients have more vegetative growth, longer linear growth rate and more dry matter accumulation with directly related to an increase in stalk yield [1].

Table 13. *Mean stalk yield (kg/ha) of maize as affected by the interaction of blended NPSB and N fertilizer rates.*

N(kg/ha) fertilizer rates	Blended NPSB (kg/ha) fertilizer rates				
	0	50	100	150	200
0	2401^{g}	3675^{defg}	3752^{cdefg}	2506^{fg}	2768^{fg}
23	3775cd^{efg}	4628^{cdefg}	5754^{bcde}	5981^{abcde}	7701^{ab}
46	3516ef^{g}	5471^{bcdef}	5889^{abcde}	6698^{abc}	7728^{ab}
69	4510^{cdefg}	6393^{abcde}	6612^{abcd}	7756^{ab}	8820^{a}
LSD (5%)	2983.1				
CV (%)	23.94				

Where, LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

Table 14. *Mean PH, AGDB, NCPP, CL and NRPCs of maize as influenced by application of blended NPSB and N fertilizer rates.*

Treatment Blended NPSB rate (kg/ha)	PH(m)	AGDB (kg/ha)	NCPP	CL (cm)	NRPC
0	1.70^{b}	10000^{b}	23.917	12.83^{b}	12.21
50	1.91^{ab}	11013^{ab}	26.667	16.27^{a}	12.50
100	1.96^{a}	12068^{ab}	28.583	16.91^{a}	12.66
150	1.99^{a}	13857^{ab}	28.917	17.26^{a}	12.33
200	1.99^{a}	14325^{a}	29.167	17.52^{a}	12.58
LSD (5%)	0.25	4104.1	NS	2.78	NS
N rate (kg/ha)					
0	1.60^{b}	10028^{c}	26.333	10.76^{b}	12.26
23	1.95^{a}	10482^{bc}	27.267	17.00^{a}	12.33
46	1.95^{a}	13830^{ab}	27.733	17.13^{a}	12.44
69	1.96^{a}	15322^{a}	28.467	17.15^{a}	12.80
LSD (5%)	0.22	3670.8	NS	2.49	NS
CV (%)	15.76	19.9	21.1	20.09	14.66

Where, PH=Plant height; AGDB=Above ground dry biomass; NCPP=Number of cobs per plot; CL=Cob length; NRPC=Number of rows per cob; LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

Table 15. *Mean NGPC, TKW, GY, HI and SYs of maize as influenced by application of blended NPSB and N fertilizer rates.*

Treatment Blended NPSB rate (kg/ha)	NGPC	TKW (gm)	GY (kg/ha)	HI (%)	SY (kg/ha)
0	348.58^{b}	29.503	1625.6^{b}	24.16^{b}	4020^{b}
50	445.92^{ab}	29.915	3832.2^{a}	37.90^{a}	6960^{a}
100	481.83^{a}	31.127	4076.0^{a}	38.16^{a}	7029^{a}
150	513.33^{a}	31.272	5012.1^{a}	38.95^{a}	7723^{a}
200	518.50^{a}	33.082	5227.0^{a}	44.30^{a}	8678^{a}
LSD (5%)	100.16	NS	1909.1	12.74	2806.1
N rate (kg/ha)					
0	353.20^{b}	29.493	1707.6^{b}	32.559^{b}	5305^{b}
23	488.20^{a}	30.407	4603.8^{a}	34.860^{b}	5807^{b}
46	491.53^{a}	31.783	4623.4^{a}	40.091^{ab}	8900^{a}
69	499.20^{a}	32.236	4843.5^{a}	47.285^{a}	9277^{a}
LSD (5%)	89.59	NS	1707.6	11.39	2509.8
CV (%)	15.09	18.79	22.5	19.83	16.37

Where, NGPC=Number of grains per cob; TKW=Thousand kernel weight; GY=Grain yield; HI=Harvest index; SY=Stalk yield; LSD=List significance difference at 5% level; CV=Coefficient of variation; Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance.

3.3. Partial Budget Analysis

During partial budget analysis the price of maize 15ETB/kg, NPSB 17.182ETB/kg and Urea 16ETB/kg was considered. Based on those prices, the partial budget analysis showed that, the maximum net benefit (89020ETB/ha) with an acceptable rate of return (ARR) was obtained from 200kg/ha of blended NPSB and 69kg/ha of N fertilizer, whereas the lowest net benefit (8388.1ETB/ha) among fertilized treatments was obtained from the plot received 23kg/ha of N with 0 blended NPSB fertilizer. But the lowest net benefit (6937.55ETB/ha) obtained from the control plot was lower than all plots included in this experiment (Table 16). The application of 200kg/ha of blended NPSB + 69kg/ha of N resulted in above the maximum acceptable rate of return, i.e. 1010.9% rate of return. This implies that for each 1ETB invested in maize production, the producer can get additional 10.1ETB for treatment with 200kg/ha and 69kg/ha of blended NPSB and N fertilizer rate.

In conclusion, the maximum net benefit (89020ETB/ha) was gained by the use of BH-661 maize variety with rates of 200kg/ha +69kg/ha of blended NPSB and N fertilizer was found to be better than the net benefit (60088.6ETB/ha) obtained from blanket recommendation (100kg/ha of NPSB +46kg/ha of N). Therefore, the net positive benefit obtained with application of 200kg/ha of blended NPSB + 69kg/ha to maize production are economically profitable and can be recommended for farmers in study area and other areas with similar agro-ecological conditions.

Table 16. *Partial budget analysis.*

Treatments		Average yield	Adjusted grain	Total revenue	Total variable	Net benefit	Marginal rate
N (kg/ha)	NPSB (kg/ha)	(kg/ha)	yield (kg/ha)	(ETB/ha)	cost (ETB/ha)	(ETB/ha)	of return (%)
0	0	513.9	462.51	6937.65	0	6937.65	0
0	50	1055.6	950.04	14250.6	859.1	13391.5	751
0	100	2041.7	1837.53	27562.95	1718.2	25844.75	1449.6
0	150	3486.1	3137.49	47062.35	2577.3	44485.05	2169.7
0	200	4930.6	4437.54	66563.1	3436.4	63126.7	2169.9
23	0	680.6	612.54	9188.1	800	8388.1	D
23	50	2041.7	1837.53	27562.95	1659.1	25903.85	2038.8
23	100	3375.0	3037.5	45562.5	2518.2	43044.3	1995.1
23	150	4333.3	3899.97	58499.55	3377.3	55122.25	1405.9
23	200	5819.2	5237.28	78559.2	4236.4	74322.8	2234.9
46	0	2143.1	1928.79	28931.85	1600	27331.85	D
46	50	4319.4	3887.46	58311.9	2459.1	55852.8	3320
46	100	4696.8	4227.12	63406.8	3318.2	60088.6	493
46	150	4909.6	4418.64	66279.6	4177.3	62102.3	234.4
46	200	6887.5	6198.75	92981.25	5036.4	87944.85	3008
69	0	3522.2	3169.98	47549.7	2400	45149.7	D
69	50	4942.3	4448.07	66721.05	3259.1	63461.95	2132
69	100	5492.9	4943.61	74154.15	4118.2	70035.95	765.2
69	150	6319.4	5687.46	85311.9	4977.3	80334.6	1199
69	200	7026.4	6323.76	94856.4	5836.4	89020	1010.9

Where, ETB=Ethiopian birr, ha=hectare, D=dominant.

4. Summary and Conclusion

The result of soil laboratory analysis revealed that, most of chemical properties of the experimental site indicated low fertility status. Thus, chemical properties of the soil such as organic carbon (OC %), available phosphorus (P mg/kg) of soil and exchangeable calcium (exch Ca) were found to be low. The result of the field experiment revealed that all parameters were significantly affected by main effect of NPSB and N levels, except number of row per cob. Similarly, interaction effects of blended NPSB and N levels also brought highly significant effect on plant height (PH m), above ground dry biomass yield (AGDBY kg/ha), grain yield (GY kg/ha) and stalk yield (SY kg/ha).

The highest grain yield (7026.4kg/a) was recorded due to application of 200kg of blended NPSB supplemented with 69kg/ha of nitrogen, whereas the lowest grain yield (513.9kg/ha) was obtained from control plot. Then it can be concluded that, the result obtained from this study revealed that the use of the right fertilizer (NPSB and N) with the right rates (200kg/ha NPSB +69kg/ha N) are the realistic approach to address the problem of low productivity of maize in the study area. In general, combination of (200kg NPSB +69kg N) produced maximum grain yield to gather with the best economic benefit.

Therefore, 200kg/ha of blended NPSB with 69kg/ha of N could be recommended for farmers in study area, instead of using blanket recommendation of (100kg/ha of NPSB + 46kg/ha of N). So this study is conducted for one cropping season on only one farmers field, further study is needed to recommend agronomic ally optimum and economically feasible levels of NPSB and N fertilizer for study area before giving conclusive recommendation.

Competing Interest

The authors declare that they have no conflict of interest.

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References

[1] Abebaw Tadele and Hirpa Legese, 2018. Effects of fertilizer rate (blended) and sowing methods on yield of bread wheat (triticumaestivum) and its economic profitability in western Ethiopia. 5 (7): 9.

[2] Akalu T. 2015. On-farm Evaluation of Improved Maize Varieties in Ethiopia. https://www.researchgate.net/publication/237309549.

[3] Ali, M. A., Tariq, N. H., Ahmed, N., Abid, M. and Rahim, A. 2013. Response of Wheat (Triticumaestivum L.) to Soil Applied Boron and Zinc Fertilizers Under Irrigated Conditions. Pak. J. Agri., Agril. Engg., Vet. Sci., 29 (2): 114–125.

[4] Bedele meteorological substation, 2021.

[5] Bekabil Fufa and Hassan Rashid. 2006. Determinants of fertilizer use on maize in eastern Ethiopia: A weighted endogenous sampling analysis of the extent and intensity of adoption, 45 (1): 38-49.

[6] Bouyoucos J (1962). Hydrometer method improved for making particle size analysis of soil. Agronomy Journals 54: 464-465.

[7] Bray, H. R. and Kurtz L. T., 1945. Determination of organic and available forms of phosphorus in soils. Soil Science (9): 39-46.

[8] CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo/International Maize and Wheat Improvement Center). (1988). From agronomic data to farmer's recommendations: an economics training manual. Completely revised edition, CIMMYT, Mexico. D. F. 79 pp.

[9] CSA(Central Statistical Agency). 2020. Report on area and production of crops(private peasant holdings 'Meher' season) 2016/2017. Addis Ababa Ethiopia, the FDRE statistical bulletin, Vol. I. Statistical Bulletin 584, Addis Ababa Ethiopia, April 2017. Pp. 1-12.

[10] CSA. 2018. Livestock Population of Ethiopian, Central Statistical Authority, Addis Ababa, Ethiopia.

[11] Dagne Chimdessa. 2016. Blended Fertilizers Effects on Maize Yield and Yield components of Western Oromia, Ethiopia. *Agriculture, Forestry and Fisheries*, 5 (5): 151-162.

[12] Delorite, R. J. and H. L. Ahlgren. 1967. Crop production. 3rd(ed.). Prentice Hall, Inc., Englewood Cliffs, New Jersey.

[13] Donald C. M., 1962. In search of yield. Journal of Australian Institute of Agricultural Science, 28: 171-178. Egbe O., Alibo S. and Nwueze I. 2010. Evaluation of some extra-early and early maturing cowpea varieties for intercropping with maize in Southern Guinea Savanna of Nigeria. Agriculture and Biology Journal, 1: 845-458.

[14] Dowswell, C. R, R. L Paliwal and R. P. Cantrell 1999. Maize in 3rd World. West Views press, Inc. Colorado, USA.

[15] Driessen, p., Deckers, j., Spaargaren, O. and Natchtergaele, F. 2001. Lecture notes on the major soils of the world: World Soil Resource Reports 94. FAO, Rome.

[16] Ethiopian Soil Information System (EthioSIS). 2013. Soil analysis report. Agricultural Transformation Agency.

[17] Fernando S, Julio M, Miralles CDJ and Hugo MP. 2009. Sulfur fertilization improves nitrogen use efficiency in wheat by increasing nitrogen uptake. Field Crops Research, 113 (2): 170–177.

[18] Food and Agriculture Organization Corporate Statistical Database (FAOSTAT). 2017. Statistical databases and data-sets of the Food and Agriculture Organization of the United Nations. http://faostat.fao.org/default.aspx

[19] Food and Agriculture Organization of the United Nations Rome, 2006.

[20] Fufa Anbessa, Thomas Abraham and Habtamu Ashagre. 2019. Influence of Plant Population and NPSB Blended Fertilizer Rates on Yield Parameters and Yield of Maize (Zea mays L.) in Bako, Ethiopia. P. 348.

[21] Haffanaghel, H. P. 1961. Agriculture in Ethiopia. FAO, Rome.

[22] Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson, W. L. 1999. Soil fertility and fertilizer: an introduction to nutrient management Prentice Hall, New York, 499p.

[23] Hoeft, R. G., Walsh, L. M. and Keeney, D. R. 1973. Soil Science Society of America, Proceeding, 37: 400-404.

[24] Jackson, M. L. 1974. Soil Chemical Analysis. Printice Hall. Ind, Englewood, Chiffs N. J. USA. 284p.

[25] Jafer Dawid, 2018. Validation of blended fertilizer for maize production under limed condition of acid soil. Journal of Natural Sciences Research 8 (23): 52-58.

[26] Jones, D. I., Dennis, P. G., Owen, A. G. and van Hee, P. A. W. 2003. Organic acid behavior in soils -misconceptions and knowledge gaps. Plant and Soil, 248 (2): 31- 41.

[27] Kidanu Motuma and Achalu Chimdi, 2018. Availability of Boron, Sulfur and Zinc and Status of other Selected Soil Properties under Acidic Soils of Different Land Use Types: The Case of Wayu Tuka District, East Wollega Zone. Journal of Agriculture and Environmental Science, 18, 17-22.

[28] Kinfe Tekulu, Tsadik Tadele, Tewolde Berhe, Weldegebreal Gebrehiwot, Gebresemaeti Kahsu, Solomon Mebrahtom and Goitom Aregawi. 2019. Evaluation of NPSZnB fertilizer levels on yield and yield component of maize (Zea mays L.) at Laelay Adiyabo and Medebay Zana districts, Western Tigray, Ethiopia. Journal of Cereals and Oilseeds. Vol. 10 (2), pp. 54- 63.

[29] Livestock Development and Marketing Agency(LDMA). 2010. Annual Progress Report, Livestock Development and Marketing Agency, Oromia, Ethiopia.

[30] Manjula V. Nathan John Stecker A. and Yichang Sun, 2012. University Extension Division of Plant Sciences, College of Agriculture, Food and Natural Resources University of Missouri Revised 1/2012 Soil Testing A Guide for Conducting Soil Tests in Missouri.

[31] Martins, Karla V, Durval Dourado-neto, Klaus Reichardt, and Jose L Favarin. 2017. "Maize dry matter production and macronutrient extraction model as a new approach for fertilizer rate estimation" 89: 705–16.

[32] Mekuannet Belay and Kiya Adare (2020). Response of growth, yield components, and yield of hybrid maize (Zea mays L.) varieties to newly introduce blended NPS and N fertilizer rates at Haramaya, Eastern Ethiopia. Cogent Food & Agriculture. 6: 1771115. https://doi.org/10.1080/23311932.2020.1771115

[33] Mesfin,. A. 1998. Nature and management of Ethiopian soils, Alemaya University of Agriculture, Ethiopia. 272p.

[34] Murphy HF. 1968. A report on fertility status and other data on some soils of Ethiopia. Experimental station bulletin no. 44. Hailesilassie College of Agriculture, Oklahoma State University.

[35] Onasanya, R. O., Aiyelari, O. P., Onasanya, A. S., Oikeh, F. E., & Oyelakin, O. O.(2009). Growth and yield response of maize (Zea mays L.) to different rates of nitrogen and phosphorus fertilizers in Southern Nigeria. IDOSI Publications, 5 (4), 400–407.

[36] Orkaido Olte (2004) Effects of Nitrogen and Phosphorus Fertilizers on Yield And Yield Components of Maize (Zea Mays L.) on Black Soil of Regede Konso Alemaya University at Konso special wereda, southern Ethiopia. M.Sc. Thesis Presented to Haramaya University, Ethiopia.

[37] Osman, A. M. and Mohamed, Z. M. 1981. Yield and yield component of wheat and their inter relationships as influenced by N and seed rate in Sudan. Journal of Agricultural Science, Cambridge. 97: 611-618.

[38] Raouf, S. and Ali, N. 2016. Effects of time and rate of nitrogen application on phenology and some agronomical traits of maize (Zea mays L.), BIOLOGIJA. 62 (1): 35–45.

[39] Rishid P., 2019. Understanding phosphorus forms and their cycling in the soil. ANR-2535.

[40] Rowell, and D. L., 1994. Soil science: Methods and applications. Addison Wesley Longman Limited. England. 350.

[41] Sahlemedhin S. and Taye B. 2000. Procedures for Soil and Plant Analysis. National Soil Research Center Technical. Paper 74. NFIA, Addis Ababa, Ethiopia.

[42] SAS (Statistical Analysis System). 2008. Statistical Analysis System. SAS institute version 9.20 Cary, NC, USA.

[43] Singh, R., & Daoudi, M. (2017). Effect of nitrogen and Sulphur on growth and yield of hybrid maize (Zea mays L.). International Journal of Current Microbiology and Applied Sciences, 6 (6), 1930–1935 https://doi.org/10.20546/ijcmas.2017.606.22

[44] Tenaw Workayehu. 1977. Effect of nitrogen fertilizer rates and plant densities on grain yield of maize. African Crop Sci. J. 8: 273-282.

[45] Teng Y. and Timmer V. R. 1994. Nitrogen and phosphorus interactions in an intensively managed nursery soil plant system. American Journal of Soil Science Society, 58: 232-238.

[46] Tripathi, S. B. and V. P. Singh. 1982. Relationship between dry matter accumulation and nutrient composition at different stages at Kisan composite maize. Indian Journal of Agricultural Research 16: 149-152.

[47] Walkley A, Black IA. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science 37 (1): 29-38.

[48] Zeidan MS, Amany A, El-Kramany MF. Effect of N-fertilizer and plant density on yield and quality of maize in sandy soil. Res J AgricBiol Sci. 2006; 2 (4): 156–61.