Effects of Blended NPSB Fertilizer Rates on Selected Soil Properties at Banshure Kebele, in Bedele District, South Western Ethiopia.

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Abstract
Balanced fertilizer application is an important management practice to improve soil fertility and quality in the agricultural lands. In present study, we examined the effects of nine different rates of blended NPSB fertilizer rates on soil pH, soil organic carbon (SOC), total nitrogen, available sulphur (ava.S), available boron (ava.B) and available phosphorus (ava.P) in the plowed layer (0-20cm). The results obtained from this study indicated that, the values of soil pH obtained from all treatments are lower than that of soil pH before fertilizer application. The application of fertilizer have remarkably improved soil organic carbon (SOC) and total nitrogen (TN) values compared with soil organic carbon (SOC) and total nitrogen (TN) recorded before fertilization. Except soil total nitrogen (TN) and soil organic carbon (SOC), application of different rates of blended NPSB fertilizer were highly significantly affected the values of soil pH, available phosphorus (ava.P), available sulphur (ava.S), and available boron (ava.B). The highest values of available phosphorus (ava.P), available sulphur (ava.S), and available boron (ava.B) were obtained from the plot treated with the highest (300kg/ha) fertilizer rate, were as the lowest was recorded from the control plot. Unlike available phosphorus (ava.P), available sulphur (ava.S), and available boron (ava.B), the values of soil pH recorded after fertilizer application becomes declined as the rate of fertilizer applied to the soil is increased dramatically. Thus, these indicated that, as the rate of blended NPSB fertilizer increased soil acidity becomes increased due to the presence of soil acidifying compounds such as nitrate, sulphate and boric acid in blended form.
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1. Introduction

Know a day; soil quality has gained attention as a result of environmental issue related to soil degradation and production sustainability under different farming systems (Galantini J, 2006). It has been considered by previous researches that the concentration of soil nutrients such as organic carbon, nitrogen and phosphorous are good indicator of soil quality and productivity because of their favorable effects on the physical, chemical and biological properties of soil (Han X, 2011). More over it has been recognized that soil available nutrients such as total nitrogen (TN), available phosphorus (ava.P), available sulphur (ava.S), and available boron (ava.B) are coming from mineralization and available components of fertilizer, can be directly absorbed by plants contributing greatly to the soil fertility (Schnug E, 2009).

In recent years, due to the rapid population growth and a continuous decline in the amount of cultivating land area, the rate of fertilizer application keeps on rising in the country in order to obtain high crop production in agriculture (Li DC, 2010). Never the less, instead of improving the soil structure and soil fertility, the long-term inappropriate fertilization has caused severe degradation of soil, characterized by high acidity, low nutrients and a disturbed, unbalanced ecosystem (Wang KR, 2009).

Introduction of inorganic fertilizer in the early to mid-20 century was responsible for massive increases in what individual farmers could produce. The major problem was the result of too much application. A plant can only utilize so much during its cycle of growth; the leftovers have the tendency to pollute the environment causing problems. When using inorganic fertilizer, nutrients are immediately available to plants and the exact amount of a given element can be measured before feeding plants; however, commercial fertilizer, particularly nitrogen is easily leached out by rain or irrigation.

Inorganic fertilizers are designed to address the tendency of soils nutrient, which is a very common problem in farms. One distinctive advantage of inorganic fertilizer is it contains all the 3 major nutrients, nitrogen, phosphorus and potassium. Additionally, this type of fertilizer can provide plants with immediate nutrients supply when the need arises, unlike organic fertilizer that only have a slow release capacity. The main disadvantage of inorganic fertilizers is that they have acidic content. Acids that is present in inorganic fertilizers such as hydrochloric acid and sulfuric acid leads to high level of soil acidity that could in turn have a destructive effect on nitrogen fixing bacteria.

However in Buno Bedele Zone in general and Bedele district specifically the farmers are using only inorganic fertilizer throughout the year to enhance the amount of the yield obtained from their farm lands. But the problems rising from excessive use of the blended NPSB fertilizer in this high rain fall areas were not yet done. Therefore this study was conducted for one cropping season with the following objectives:-

To determine the effects of blended NPSB fertilizer rates on selected soil physico-chemical propertied and

To recommend the possible solution for the problems arising from the using of inorganic fertilizer

2. MATERIALS AND METHODS

2.1. Description of the Study Area

2.1.1. Location

Field experiments were conducted at two sites of Banshure Kebele, in Bedele district of Buno Bedele Zone, South Western Ethiopia in 2021 main cropping season. Bedele district is located between 8 o 14'30" and 8 o 37'53"N, and 36o 13'17" and 36o 35'05"E (Figure 1). The district is located at 483 km away from Addis Ababa on the road to Mettu.

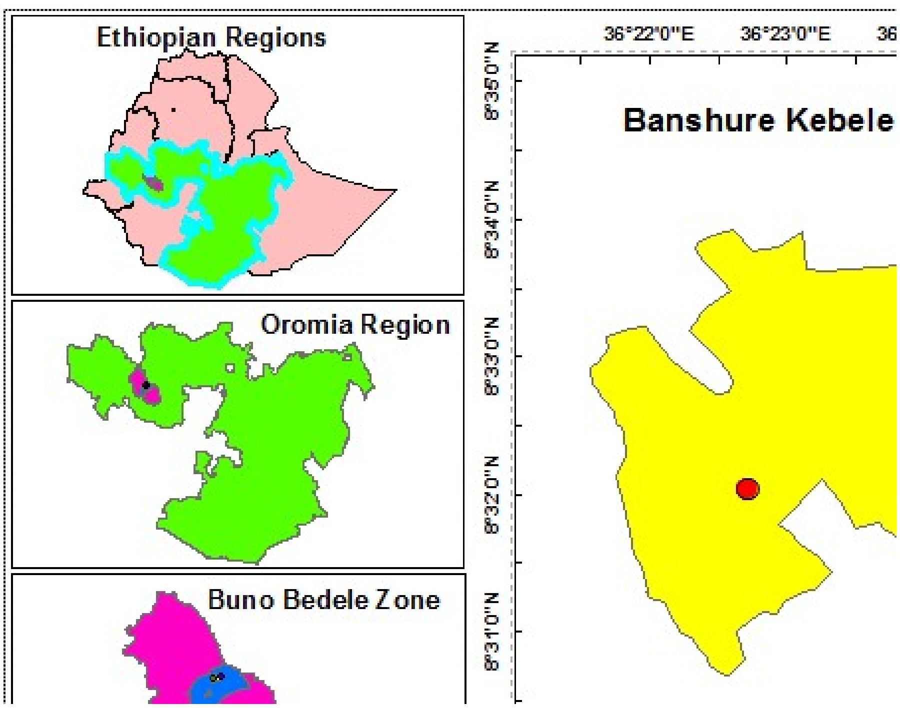

Figure 1: Location map of the study area and experimental sites (Alle and Abu)

2.1.2. Climate

According to the sixteen-year (2005-2021) climate data recorded at Bedele Meteorological Station, the mean annual rainfall of the study area is 1942 mm and the mean monthly minimum and maximum temperature are 13 and 26^0C, respectively. The rainy season extends from April to October with the maximum rains in the months of May, June, July, August and September (Figure 2), whereby the mean monthly rainfall exceeds 301mm (BMES, 2021).

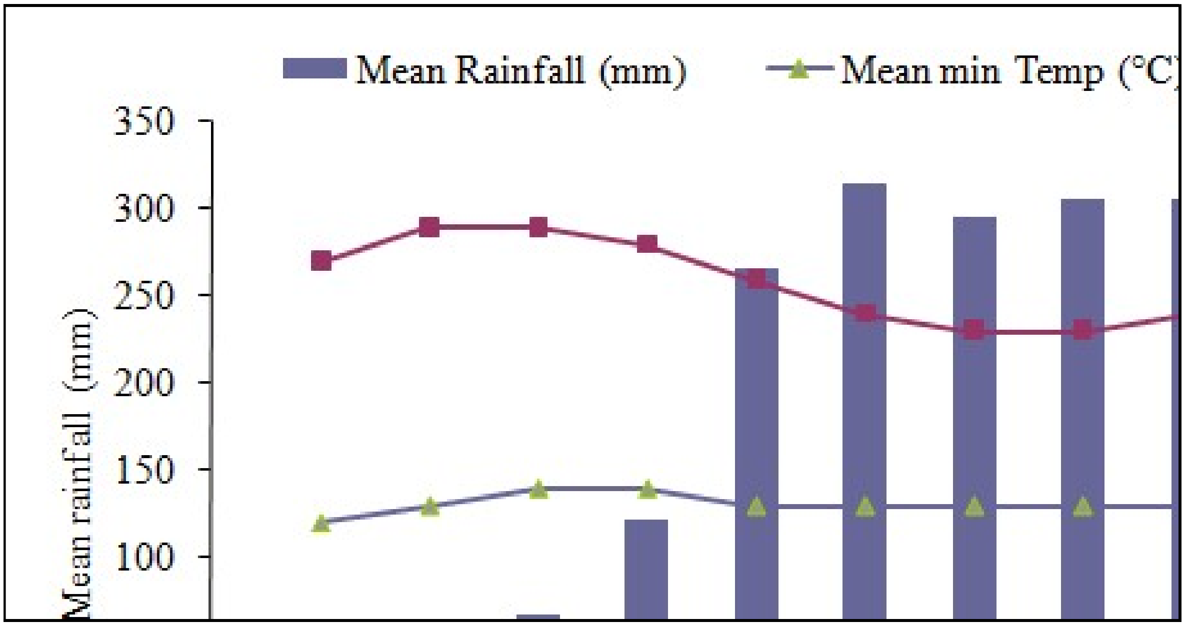

Figure 2. Mean monthly rainfall and maximum and minimum temperature of Bedele district (2021)

2.1.3. Soil type and topography

According to Alemayehu (2015), the soil type of the study area belongs to the reference soil group of Nitisols. The soils are generally deep, well-drained and red tropical soils with diffuse horizon boundaries and a clay-rich nitic subsurface horizon (Driessen *et al*., 2001). Nitosols are predominantly derived from basic parent rocks through strong weathering, which are more fertile than most other red tropical soils (FAO-WRB, 2006). The area is characterized by undulating topographically. In general, Bedele district is characterized by lowland and midland, having an altitude ranging from 1013 to 2390 meters above sea level with humid climatic condition (BDAO, 2021).

2.1.4. Vegetation and Farming systems

Subsistence farming is the main livelihood of the community. Mixed crop-livestock farming system is predominant in the agricultural production of Bedele district. Most of the residents in the area are dependent on agriculture (LDMA, 2010), and crop and livestock are the important sources of income for all relatively wealthy community members (CSA, 2018).
The concentrated common vegetation in the district is Bamboo, Gravilia robista, Cordia Africana and acacia species. The crops grown by smallholder farmers of the area include maize (*Zea mays*), teff (*Eragrostistef*), sorghum (*Sorghum bicolor*), barley (*Hordeumvulgare*), wheat (*Triticum spp*), rice (*Oryza sativa*) and different pulse crops, finger millet (*Eleusinecoracana*), fruits, different types of vegetables and spices.

Farmers in the district are using traditional plough drawn by oxen and maize is rotated with legume crops such as bean for maintaining soil fertility of cultivated lands and chemical fertilizers such as DAP and urea at the rates of 46 kg P_2O_5 ha^{-1} and 46 kg N ha^{-1} are applied for all types of crops grown in the district annually since 1995 when extension package program was launched around Bedele (BDAO, 2021). However, the yields are still low due to declining soil fertility and limited information on the right fertilizers with the right rates for the major crops grown in the district.

2.2. Experimental Site Selection

Bedele district was selected purposively for the experiment, because maize is the major crop grown widely in the district. Two specific experimental sites Alle and Abu were selected from model farmers in maize production based on the willingness of the farmers to provide their farmland for experimental purpose.

2.3. Soil Sampling and Analysis

After the experimental sites were identified, soil samples were collected from the experimental fields following zigzag pattern to increase precision (ICARDA, 2013). From each experimental field 15 disturbed soil samples were collected at depth of 0-20cm by using auger. For each site, one composite sample was prepared from the bulk samples for the determination of soil physicochemical properties of the soil before planting. Two undisturbed soil samples from both experimental sites for bulk density determination were taken by using core sampler following Jamison *et al*. (1950) method. Soil bulk density (ρb) was measured and determined by measuring the volume of undisturbed soil sample collected using a core sampler and the sample was weighed after oven-dried at a temperature of 105^{o}C. Then, the result was calculated by the formula as described by Jamison *et al.* (1950).

$$\rho b = \frac{\text{Mass of soil in gram}}{\text{Volume of soil in cm}^3} \quad (1)$$

The composite soil samples were air dried, ground using a pestle and mortar and allowed to pass through a 2 mm sieve for all parameters except organic carbon and total nitrogen and through a 0.5 mm sieve for organic carbon and total nitrogen. The collected samples were analyzed for selected physicochemical properties mainly for soil texture, soil pH, exchangeable basic cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+), cation exchange capacity (CEC), organic carbon (OC), total N, available P, available S, and available B at Bedele Agricultural Research Center Laboratory. Soil texture was determined using the Bouyoucos hydrometer method (Bouyoucos, 1962). Soil pH was determined in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter (Rhoades, 1982). Organic carbon was determined as described by Walkely and Black (1934). Exchangeable basic cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were extracted with 1M ammonium acetate at pH 7, then 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 with flame photometer (Rowell, 1994). To determine the cation exchange capacity (cmol(+) kg^{-1} soil), the soil sample first was leached using 1 M ammonium acetate, 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 Na (Sahlemedhin and Taye, 2000). Percent base saturation was calculated by dividing the sum of the base forming cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+)) by CEC of the soil and multiplying by 100.

$$\text{PBS (\%)} = \frac{\text{Sum of exchangeable bases (Ca, Mg, Na and K)}}{CEC} * 100 \quad (2)$$

Available phosphorus in soil was determined by the Bray-II (Bray and Kurtz, 1945) extraction method. Total nitrogen was analyzed by Kjedahl method as described by Bremner and Mulvaney (1982). Available S was determined by KH_2PO_4 extractant (Johnson and Fixen, 1990). Available B was estimated by hot water extraction method (Havlin *et al*., 1999).

2.4. Experimental Design and Treatments

The experiment was laid out in randomized complete block design (RCBD) with three replications. Treatments were nine levels of blended NPSB fertilizer rates, (0, 25, 50, 75, 100, 150, 200, 250 and 300 kg ha^{-1}) with 92 kg ha^{-1} of nitrogen which was recommended for maize production in Bedele district (Dagne, 2015). The treatment was decided standing from blanket recommendation 100 kg ha^{-1} which is commonly used by the farmers in the district for all types of crops. Urea was used as a supplementary source of nitrogen for all treatments.

2.5. Post-Harvest Soil Sampling and Analysis

After harvesting, soil samples were taken from each plot at the depth of 0-20cm, whereby four soil samples were collected from each plot and one composite sample prepared. Accordingly, 54 composite samples were prepared for analysis of selected soil properties after harvest. The composite samples were air-dried, ground and passed through 2.0 mm and 0.5 mm diameter sieves before analysis. Analysis of the selected soil chemical properties were carried out for soil pH, organic carbon, total nitrogen, available phosphorus, available sulfur and boron as described under Section 2.3.

2.6. Statistical Data Analysis

After harvesting the soil data collected from both sites were pulled together and subjected to statistical analysis of variance (ANOVA) using SAS version of 9.3 (SAS, 2004). Significant difference between and among treatment means were assessed using Duncan's multiple range taste (DMRT) at 0.05 level of probability (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSIONS

3.1. Selected Soil Physical Properties of Experimental Sites

3.1.1. Texture (Particle size distribution)

Soil texture analysis results of both sites were clay dominated and had the particles size distribution of 20% sand, 25% silt and 55% clay for Alle, and 19% sand, 22% silt and 59% clay for Abu (Table 1). Based on Bouyoucos (1962) classification, the textural classes of the soil of both Alle and Abu were clay. The high clay content may indicate presence of high weathering activity due to high rainfall and warm temperature.

Steward *et al*. (1970) also stated that, high clay content may be due to high weathering which arises from the prolonged action or strong intensity of the weathering agents such as high rainfall and warm temperature, as a result of which the oxide of Al and Fe are formed. To improve the limitations that may occur due to the prevalence of such soil minerals, addition of adequate organic matter resources into the soil may improve the nutrient retention and availability for sustainable crop production.

3.1.2. Bulk density

Bulk densities of the experimental sites were 1.4 and 1.3 g cm^{-3} for Alle and Abu, respectively (Table 1) which is ideal for crop root penetration and aeration (Tekalign, 1991). This recorded bulk density was rated as medium and low for Alle and Abu respectively, based on the rating of bulk density by Hazelton and Murphy (2007) (Appendix Table 1). The medium to low bulk density might be due to the medium organic matter content of the experimental sites. Thus, the topsoil of the experimental sites seems to be well aggregated and without compaction problem that affect root growth, air and water movement in the soil and conducive for crop production.

White (2013) also stated that, values of top soil bulk density <1 g cm^{-3} for soils high in organic matter and 1.0 to 1.4 g cm^{-3} for well-aggregated mineral soils, are conducive for crop production. Likewise, Hunt and Gilkes (1992) stated that, for an optimal movement of air and water through the soil, low bulk density values of <1.5 gm cm^{-3} are desirable. Generally, according to Lal (1997) top soil bulk density value in the range of 0.7-1.84 g cm^{-3} is normal in relation to plant growth.

Table 1. Particle size distribution and bulk density values of soil of the experimental sites.

Parameters	Values	
	Alle	Abu
Sand (%)	20	19
Silt (%)	25	22
Clay (%)	55	59
Texture Class	Clay	Clay
Bulk density(gcm^{-3})	1.4	1.3

3.2. Selected Soil Chemical Properties

3.2.1. Soil pH

The pH values were 5.48 and 5.47 for Alle and Abu respectively (Table 2). According to FAO (2006) classification, the soil reaction of both sites was moderately acidic (Appendix Table 1). This might be due to climatic factors such as warm temperature and prolonged rainfall responsible for leaching of basic cations from the soil surface and may also be responsible for increment of soil acidity in the study area. The normal soil pH for maize is from 5 to 8, with a pH of 6-7 probably being an optimal for most varieties (Martins *et al*., 2017). Likewise, FAO (2006) reported that the preferable pH range for most crops and productive soils are 4 to 8. Sahlemdhin (1999) also reported the pH of the soil between 5 and 7.55 is within a suitable range for crop production. Based on this evidences the topsoil reaction of the experimental sites can be considered as conducive for maize production.

3.2.2. Organic carbon

The results obtained from soil laboratory analysis indicated that, the soil organic carbon contents were 2.04 and 2.12% for Alle and Abu respectively (Table 2). According to Walkely and Black (1934) classification, the organic carbon contents of soil of both experimental sites were categorized as a medium (Appendix Table 2). The medium organic carbon contents of the surface soil could be related to organic matter addition due to crop residue decomposition in the soil surface, which are commonly left on the field.

3.2.3. Total nitrogen

The total nitrogen contents of the experimental sites were 0.17 and 0.18% for Alle and Abu, respectively (Table 2). According to FAO (2006) classification, the experimental soil contains low total nitrogen (Appendix Table 2). Indicating that, total nitrogen is a limiting factor for optimum crop growth and yields. This might be due to unbalanced application of N containing fertilizer and continuous cultivation of land resulting in the reduction of soil organic matter contents and total nitrogen. Likewise, Wakene and Heluf (2003) reported that, continuous cultivation reduced soil organic matter and total nitrogen content. Therefore, nitrogen containing fertilizers should be applied to supplement the nitrogen requirement of crop.

3.2.4. Available phosphorus

The laboratory analysis results of available phosphorus were 1.67 and 1.77 mg kg^{-1} for Alle and Abu, respectively (Table 2). According to Manjula and John (2012) rating, the soils of experimental area contains low available phosphorus (Appendix Table 3). Specifically, type and rate of organic and inorganic fertilizer utilized in cultivating land and P fixation is also the reason for low availability of phosphorous in the soil. This is in line with the research findings of Abera and Kefyalew (2017) who reported low amount of phosphorous content on soils that are cultivated repeatedly and due to removal of exchangeable basic cations through leaching in high rainfall areas which causes phosphorous fixation problem. Ethio-SIS (2014) suggests optimum phosphorus content for most Ethiopian soil as 15 mg kg^{-1} of soil. Based on this evidence, the available phosphorus in the soil of experimental sites is low and needs additional application of phosphorus containing fertilizer.

3.2.5. Available boron

Soil laboratory analyses results reveal that hot water available boron, which are considered as available to plants were 0.3 and 0.36 mg kg^{-1} for Alle and Abu, respectively (Table 2). According to the rating of Jones (2003), the available boron content of soil of the experimental sites was low (Appendix Table 3). This showed that, the soil of the study area is deficient in boron content; this might be due to crop uptake, leaching and continuous application of fertilizers not containing boron. Similarly, Khadka et al. (2018) reported deficient available boron due to intense cultivation of crops without application of boron containing fertilizer. According to Ethio-SIS (2014), the critical boron value for most Ethiopian soils is 0.8 mg kg^{-1} of soil and the results from the study area were below the critical value. So application of fertilizers containing boron is necessary to increase the boron content of the soil to the optimum level and to increase the productivity of the soil.

3.2.6. Available sulfur

The available sulfur content of the experimental soil had value of 9.26 mg kg^{-1} of sulfur for both Alle and Abu (Table 2). According to Ethio-SIS (2014) soil sulfur content rating, the sulfur content of soil of the experimental sites were very low (Appendix Table 3). Thus, the soils of experimental sites were considered as deficient in available sulfur content, which is unsatisfactory for optimum maize growth and yield. This might be due to crop uptake and continuous application of inorganic fertilizer not containing sulfur. Likewise, Khadka et al. (2018) reported intense cultivation of crops without application of sulfur containing fertilizer might be the cause of deficient status of available sulfur in the field. Thus, it is mandatory to apply sulfur containing fertilizer to improve soil fertility, crop growth and yield (FAO, 2008).

Table 2. Soil pH, organic carbon, total nitrogen, available phosphorus, available boron and available sulfur contents of the experimental sites

Parameters	Values	
	Alle	Abu
pH (1: 2.5 soil to water ratio)	5.48	5.47
Organic Carbon (%)	2.04	2.12
Total nitrogen (%)	0.17	0.18
Available phosphorus (mg kg^{-1})	1.67	1.77
Available Boron (mg kg^{-1})	0.3	0.36
Available Sulfur (mg kg^{-1})	9.26	9.26

3.2.7. Cation exchange capacity

The CEC of experimental soils were 20.94 and 22.64 cmol (+) kg^{-1} of soil for Alle and Abu, respectively (Table 3). The results obtained from both Alle and Abu were under medium range (Appendix Table 2). According to London *et al*. (1991), soil having CEC of 15 to 25 cmol (+) kg^{-1} of soil are categorized under medium range. The medium CEC of the soil might be due to high clay content of the soil, because the soil texture of the experimental sites was dominated by clay.

3.2.8. Exchangeable bases and percentage base saturation

The contents of basic cations (Ca, Mg, K and Na) in the soil were 1.26, 1.52, 0.59 and 0.16 cmol (+) kg^{-1} of soil for Alle, respectively and 1.39, 1.52, 0.6 and 0.18 cmol (+) kg^{-1} of soil for Abu, respectively (Table 3). As per the rating set by FAO (2006), the basic cations of the study area are classified as very low for Ca, medium for Mg and K and low for Na for both Alle and Abu sites (Appendix Table 4). The very low, low and medium values of basic cations at both study sites might be attributed to crop uptake and leaching of appreciable amounts of exchangeable basic cations like (Ca), Magnesium (Mg), potassium (K) and Sodium (Na) from the surface soil as the result of the high annual rainfall of the area. Similarly, Kidanu and Achalu (2018) also reported leaching of appreciable amounts of exchangeable basic cations from surface soil by excessive rainfall in soils of Wayu Tuka district, East Wolega Zone, Ethiopia.

Percent of base saturation of the soils of the experimental sites were 16.85 and 16.29 for Alle and Abu respectively (Table 3). The results were very low according to FAO (2006) classification. It is directly related with the exchangeable Ca, Mg, Na and K as described by Hazelton and Murphy (2007). Percent base saturation is closely related to soil pH as soil pH increases with base saturation, whereby base saturation of 70% to 80% represents generally soil with pH > 6.0 (Hazelthon and Murphy, 2007).

Table 3. CEC, exchangeable bases and PBS of soil of experimental sites

Parameters	Values	
	Alle	Abu
Cation exchange capacity cmol (+) kg^{-1}	20.94	22.64
Exchangeable Mg cmol (+) kg^{-1}	1.52	1.52
Exchangeable Ca cmol (+) kg^{-1}	1.26	1.39
Exchangeable K cmol (+) kg^{-1}	0.59	0.6
Exchangeable Na cmol (+) kg^{-1}	0.16	0.18
Percentage of base saturation (%)	16.85	16.29

3.3. Post Harvest Selected Soil Properties

3.3.1. Soil pH

The ANOVA analysis revealed that, application of different rates of blended NPSB fertilizer significantly ($P<0.01$) affected the pH values of the soil. The highest mean value of pH (5.3) was recorded from the control plot, whereas the lowest value of pH (5.12) was recorded from the plot that received the highest rate of (300 kg ha^{-1}) blended NPSB fertilizer (Table 4). The result indicated that, as the rate of blended NPSB increased the pH of the soil slightly declined, which may be due to acid forming property of blended NPSB fertilizer incorporated to the soil. This result is in agreement with that of Melkamu (2020) who reported that pH of the soil decreased as the rate of blended NPSB and Urea applied to the soil is increased. To solve this problem, the use of combined application of lime along with blended NPSB fertilizer may be considered to increase soil pH to the optimum level in improving the soil richness status and to raise maize crop yield.

3.3.2. Organic carbon

Application of different rates of blended NPSB fertilizer did not significantly ($P >0.05$) affect the organic carbon content of the soil, but only numerical change was observed. The highest organic carbon content (3.85%) was recorded from the plot treated with highest fertilizer (300 kg ha^{-1}) rate, whereas the lowest organic carbon content (3.5%) was recorded from the control plot (Table 4). These results indicated that, application of blended NPSB fertilizer rates influenced the percentage of soil organic carbon content. In line with this study, Melkamu (2020) reported the highest value of soil organic carbon from the plot that received the highest blended NPSB fertilizer rate and the lowest from the control plots. Similarly, Zeleke *et al*. (2020) reported that the highest (2.16%) net increase of organic carbon was recorded from the plot treated with 200 kg ha^{-1} of blended NPSB fertilizer supplemented with 46 kg ha^{-1} of nitrogen and (0.71%) loss from the control plot.

3.3.3. Total nitrogen content

Total nitrogen content after harvest was not significantly ($p>0.05$) affected by application of different rates of blended NPSB fertilizer. This might be because nitrogen containing fertilizer is equally adjusted to all plots. However the mean values of total nitrogen recorded from all plots after trial was higher than the total nitrogen recorded before trials. This may be due to the residual effect of nitrogen containing fertilizer applied to the soil. In line with this study, Saha *et al*. (2003) stated that the nutrients added to the soil in the form of fertilizers are not being removed or utilized fully by the crops in one season. Moreover, Zeleke *et al*. (2020) reported the highest (0.066%) net increase of total nitrogen after application of 200 kg ha^{-1} blended NPSB fertilizer supplied with 46 kg ha^{-1} of nitrogen and a loss from the control plot.

3.3.4. Available phosphorus

The result obtained from this study revealed that, application of different rates of blended NPSB fertilizer highly significantly ($p<0.01$) affected the available phosphorus content of the soil. The highest residual phosphorus (4.81 mg kg^{-1}) was obtained from the plot that received the highest (300 kg ha^{-1}) NPSB fertilizer rate, whereas the lowest residual phosphorus (1.53 mg kg^{-1}) was recorded from the control plot (0 kg ha^{-1} NPSB) (Table 4). Except the control plot, the values of available phosphorus obtained after trial were higher than those recorded before the trial. This may be due to residual effect of phosphorus containing fertilizer applied, since phosphorus has low mobility and hence might have remained in the soil in appreciable amounts. The result recorded from this study agree with that of Tewolde *et al*. (2020), who obtained the highest residual soil phosphorus (8.3 mg kg^{-1}) from the plot supplied with 300 kg ha^{-1} of blended NPSB fertilizer rate. Similarly, Melkamu (2020) also reported the highest residual soil phosphorus from the plot supplied with the highest rate (250 kg ha^{-1}) of blended NPSB fertilizer and the lowest from the control plot.

3.3.5. Available sulfur

Application of different rates of blended NPSB fertilizer significantly (P<0.01) increased the available sulfur content of the soil. The maximum mean available sulfur (14.38 mg kg^{-1}) of the soil was recorded on plot that received the highest (300 kg ha^{-1}) blended NPSB fertilizer rate, whereas the lowest mean value of available sulfur (9 mg kg^{-1}) was recorded on the control plot (0 NPSB kg ha^{-1}) of fertilizer rate (Table 4). Except the control plot, all values of available sulfur obtained from this study after harvest was higher than the available sulfur content of the soil before the experiment was conducted. This study indicated that application of blended NPSB fertilizer rates brought changes in available sulfur content of the soil. This result is in line with that of Tewolde *et al*. (2020), who recorded the highest available sulfur on the plot that received 300 kg ha^{-1} of blended NPSB fertilizer rate supplemented with 46 kg ha^{-1} of N, whereas the lowest from the control plot. Moreover, Saha *et al*. (2003) reported that nutrients applied to the soil in the form of fertilizers are not removed or utilized fully by the crops in one season, so that the residual nutrients that remained from erosion, leaching and crop up take can be used for crop growth in the next cropping season.

According to Ethio-SIS (2014) soil classification for sulfur values, the results obtained from this study were in the low range and very low for the control plot (Appendix Table 3). It can be concluded that the present NPSB blended fertilizer rates can't meet sulfur requirements for the next cropping season, suggesting that additional application of sulfur containing fertilizer is necessary for best crop production.

3.3.6. Available boron

Application of different rates of blended NPSB fertilizer significantly (p<0.01) increased the available boron content of the soil. The maximum mean of available boron (0.77 mg kg^{-1}) of soil were recorded on the plot received 300 kg ha^{-1} of blended NPSB fertilizer rate, whereas the lowest (0.08 mg kg^{-1}) of available boron were recorded from the control plot (0 NPSB kg ha^{-1}) of fertilizer rate (Table 4). Generally the increasing trends were observed in case of available boron content of the soil from T1 to T9 as the rate of blended NPSB fertilizer rate increased upward.

According to Jones (2003) classification, the residual available boron content of the soil after harvesting was under low range except the control plot and the plot that received 25 kg ha^{-1} of blended NPSB fertilizer rate, which were under very low range (Appendix Table 3). This might be due to residual effect of boron containing blended fertilizer applied to the soil. According to Ethio-SIS (2014) critical boron value for most Ethiopian soils is 0.8 mg kg^{-1}of soil. Hence, available boron content of the soil after harvest was in low range, so that additional applications of boron containing fertilizer seems to be necessary to fulfill boron requirements of the crops in the next cropping season.

The result obtained from this study agreed with that of Tewolde *et al.* (2020), who reported the highest (0.334 mg kg^{-1}) residual Available boron from the plot that received the highest (300 kg ha^{-1}) blended NPSB fertilizer rate and the lowest (0.05 mg kg^{-1}) of available boron from the control plot. Likewise, Zeleke *et al*. (2020) reported the highest (0.2 mg kg^{-1}) net increase of available boron as a result of 200 kg ha^{-1} of blended NPSB +100 kg of Urea and the lowest (0.01 mg kg^{-1}) of available boron on the plot with 50 kg ha^{-1} of blended NPSB +100 Urea.

Table 4. Effects of blended NPSB fertilizer rates on selected soil properties

NPSB fertilizer rates (kg ha^{-1})	pH	OC (%)	TN (%)	Ava.P (mg kg^{-1})	Ava.S (mg kg^{-1})	Ava.B (mg kg^{-1})
0	5.30^{a}	3.50^{a}	0.30^{a}	1.52^{d}	9^{d}	0.08^{e}
25	5.29^{a}	3.57^{a}	0.30^{a}	1.83^{cd}	10.96^{c}	0.17^{de}
50	5.28^{a}	3.62^{a}	0.31^{a}	1.90^{bcd}	11.07^{c}	0.23^{d}
75	5.27^{ab}	3.73^{a}	0.32^{a}	2.12^{bcd}	11.31^{c}	0.41^{c}
100	5.26^{ab}	3.73^{a}	0.32^{a}	2.63^{bc}	11.46^{c}	0.48^{c}
150	5.25^{ab}	3.75^{a}	0.32^{a}	2.72^{bc}	11.89^{bc}	0.58^{b}
200	5.24^{ab}	3.77^{a}	0.32^{a}	2.86^{b}	12.60^{b}	0.61^{b}
250	5.18^{bc}	3.83^{a}	0.33^{a}	4.30^{a}	12.89^{b}	0.71^{a}
300	5.12^{c}	3.85^{a}	0.33^{a}	4.81^{a}	14.38^{a}	0.77^{a}
LSD(0.05)	0.09	0.70	0.06	0.98	1.13	0.09
CV (%)	1.52	16.23	16.11	30.71	8.34	17.50

pH=power of hydrogen, OC=Organic carbon, TN=Total nitrogen, Ava.P=Available phosphorus, Ava.B=Available boron, Ava.S=Available sulfur, CV=Coefficient of variance; LSD= Least significant difference at 5% level

4. Summary and Conclusion

Blended NPSB fertilizer is a newly released fertilizer for the stake holder of the Bedele district, however the optimum rate of this fertilizer for major crop and their impact on selected soil property is not done by any institutions for this district. Therefore the study was conducted at two sites of Banshure kebele in Bedele distric. The result revealed that, there is significant difference among different rates of blended NPSB fertilizer. The excessive application of chemical fertilizer reduced soil pH values recorded after one year application. Therefore care should be taken during inorganic fertilizer application or soil test based fertilizer application is mandatory and incorporation of organic fertilizer and lime is mandatory to reduce the drawback of inorganic fertilizer on soil properties and environmental health. However the trial is conducted only for one cropping season, for strong recommendation further study is mandatory.

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