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Effects of Different Rates of NPS, NPSB and NPSZn Blended Fertilizers on Growth and Yields of Potato (*Solanum tuberosum* L.)

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ABSTRACT

Potato is an important food and cash crop in Ethiopia; however, the productivity of the crop is below its potential due to various constraints like unbalanced fertilizer rate and type for specific crop variety produced across the production areas. Thus, a field experiment was conducted in Lemu-Bilbilo district under rainfed condition during the 2018/19 cropping season, with the objective of evaluating the effect of different rates of NPS, NPSB and NPSZn blended fertilizers on growth and yield parameters of potato (variety Gudane). The experiment consisted of five rates (0, 50, 100, 150 and 200 kgha^{-1}) of each NPS, NPSB and NPSZn blended fertilizers as treatments. The five treatments were laid out in a Randomized Complete Block Design in three replications. Analysis of

variance revealed that number of stem, plant height, number of leaves, total tuber number per hill, marketable tuber weight, unmarketable tuber weight and total tuber weight were significantly affected by rates of each blended fertilizers (NPS, NPSB and NPSZn). The mean result of stem number per hill, plant height and number of leaves were significantly highest in the treatment received 200 kgha^{-1} rate of all the three blended fertilizers (NPS, NPSB and NPSZn) and lowest in the control. Similarly, highest total tuber numbers (27.03, 28.40 and 35.93), marketable weights (15.59, 17.20 and 24.29 tha^{-1}) and total tuber yields (17.02, 18.56 and 25.51 tha^{-1}) were obtained from the plot received 200 kgha^{-1} of NPS, NPSB and NPSZn blended fertilizers, respectively. Also, the highest mean yield of potato tubers were recorded from the treatment applied with NPSZn fertilizer type as compared to NPS and NPSB blended fertilizers. Thus, application of 200 kgha^{-1} rate of each blended fertilizers as compared to the other rates, and NPSZn as compared to NPS and NPSB fertilizer types to potato production is more productive at the study area and similar areas. However, further research is needed across season and location to draw conclusive recommendation for potato growers by including more rates and types of fertilizers.

Keywords: Blended (NPS, NPSB, NPSZN) fertilizers, Fertilizer rates, Potato growth and yield, Tuber number

1. INTRODUCTION

Ethiopia has greatest potential land for potato production; 70% of its arable land mainly in highland areas, above 1500 m.a.s.l and diverse soil types ranging from Vertisols to Nitosols, are believed to be suitable for potato (Harnet *et al*., 2014). In finding of Olango (2008), in Ethiopia, potato ranks first among the major tuber crop in volume of production and consumption and about 1,571,806 farmers are engaged in potato growing with an area of 74,935 ha per season with an annual production of 8.6 million quintals (CSA, 2013). The national average yield stands at 11.8 tha^{-1} (CSA, 2014), which is lower than the experimental yields (38 tha^{-1}) and is lower as compared to the world average (17.6 tha^{-1}) (Israel *et al*., 2012; Woldegiorgis, 2013; FAOSTAT, 2015).

The low productivity of potato is due to various contributing factors to the low yield and quality attributes of potato like substandard agronomic practices including suboptimum fertilizer amount and types of fertilizers applied, use of substandard quality tubers and shortage of improved and adaptable cultivars (Shaweno, 2017). Potato is a heavy feeder requiring various nutrients and large quantities of fertilizers to produce highest marketable tuber and total tuber yields. In the other hand low soil fertility is one of the limiting factors to sustain potato production and productivity in Ethiopia (Olango, 2008). Fertilizer recommendations made based on preliminary studies vary across diverse agro-ecologies in the country. Economically feasible fertilizer amount and type varies with soil type, fertility status, moisture amount, climatic variables, variety, crop rotation and crop management practices (Smith, 1977, Berihun and Woldegiorgis, 2012). Earlier Ethiopian agricultural Institutions generally recommends to farmers the blanket rates of 195 kgha^{-1} DAP and 165 kgha^{-1} Urea regardless of cultivar and location or soil type, which together sums up to account for 111 kg N ha^{-1} and 90 kg P_2O_5 ha^{-1} (EARO, 2004). Therefore, in most part of Ethiopia, the sources of plant nutrients for agriculture before five years have been limited to urea and Diammonium Phosphate fertilizers which contained only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops. In this regard Shiferaw (2014) and EthioSIS (2014) reported that Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and better productivity of crops including potato.

But, Ethiopian soils fertility has already declined due to continuous cropping, mono cropping, abandoning of fallowing reduce use of manure and crop rotation (Israel *et al.,* 2012). To situation, the Ministry of Agriculture of Ethiopia has been recently introduced a new blended fertilizers like (NPS), (NPSB), (NPSZn) and so no those fertilizers which containing nitrogen, phosphorous, sulfur, boron, zinc, potassium and so on (Tegbaru, 2016). However, farmers were using fertilizers without the suitable type and rates of fertilizers for each crop in the area; information is also lacking on the optimal type and rate of newly introduced blended fertilizers like NPS, NPSB, NPSZn for the area. In view of these; the study was initiated to evaluate the effect of different rates of various blended fertilizers on growth and yield parameters of potato.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in Lemu Bilbilo District; Lemu Dima peasant association. The site is located at 7^{0}32′.206′ N latitude and 39^0 15′.597 E longitude and which located 237km from Southeast of Addis Ababa and 9 km North of the Woreda town in Arsi zone of Oromia Regional State which is found at an altitude of 2816 m.a.s.l. The district has an altitude of 2600-3100 meter above sea level (high land) and has tepid to cool (Lemu-Bilbilo Woreda Agricultural office, 2018). According to some studies the soil of experimental area is clay loam with red soil having soil pH of 4.89 which is acidic according to the rating of (EthioSIS, 2014).

2.2. Treatments and Experimental Design

The experiment consisted of five treatments of each of the three types of fertilizers (NPS, NPSB and NPSZn) in which 0, 50, 100, 150 and 200 $kgha^{-1}$ rates were included. The experiment was laid out in a Randomized Complete Block design (RCBD) of five treatments in three replications each fertilizer type. Each experimental plot has been 3m wide and 3m long. The distance between replications/blocks and plots was maintained at 1.5m and 1m, respectively. The spacing between rows and plants within a row was 0.75m and 0.30m, respectively. All agricultural practice could be done according to the recommended practices and nitrogen fertilizer was supplemented in the form of urea at 92 $kgha^{-1}$, controlling of diseases and insect pest was done similarly as well as ridging done as per the recommendation of potato (MoA, 2011).

2.3. Experimental Materials

Four fertilizers types (NPS, NPSB and NPSZn) each at 0, 50, 100, 150 and 200 $kgha^{-1}$ rates were used. According to MoANR (2013) report per 100kg of NPS fertilizer contained the ratio of 19%N, 38%P_2O_5 and 7%S, NPSB fertilizer contained the ratio of 18%N, 36%P_2O_5, 7%S and 0.71%B, and NPSZn fertilizer contained the ratio of 17.7%N, 35.3%P_2O_5, 6.5%,S and 2.5%Zn.

Potato variety CIP-386423.13 (Gudane) obtained from Holeta Agricultural Research Center (HARC) was used for the experiment. The variety was released in 2006 with agronomic and morphological characteristics of the following (Table 1):

Table 1: General description of potato variety Gudene

Variety	Description
Released year	2006
Altitude	1600 – 2800 m.a.s.l.
Rain full range	Sufficient rain or irrigation over the growing season
Fertilizer rate	DAP=195 $kgha^{-1}$ and urea=165 $kgha^{-1}$
Soil type	Nitosols (Fertile and Silt loam or sandy loam texture)
Seed rate	18 - 20 $qtha^{-1}$
Spacing	30 cm and 75 cm between plant and row, respectively
Date of flowering	120 days
Tuber yield	29.17 tha^{-1} at research field

Source: MARD, 2006

2.4. Experimental Procedures

Land preparation was carried out in May, 2018. Medium size and well sprouted tubers were used for planting. Half of the N and the whole blended fertilizers rates were applied during the time of planting; and the remaining half of the N dose was applied during the first earthling-up (45 days after planting) as side dressing. Weeds were managed by hoeing and hand weeding. Earthing-up was done two times before flowering to initiate tuberization and one time after flowering to prevent exposure of tubers to direct sunlight.

2.5. Soil Sampling and Analysis

Soil analysis was conducted by taking soil samples from the production field before planting the potato tubers. Then soil analysis was conducted to know soil nutrients content. Also the soil physical and chemical components analyzed.

2.6. Data Collected

Data were collected on growth and yields parameters of potato crop as follows. Growth parameters like number of stems per hill was recorded as an average count of ten hills per plot at flowering time; the plant height was measured in centimeter from ground level to the top of the plant at 50 and 70 days after planting and the number of compound leaves per plant was recorded on randomly selected ten competitive plants in each treatment at an interval of 50 and 70 days after planting *(*Zelalem *et al.,* 2009). Yield and yield components like marketable tuber yield (tha^{-1}) was recorded from mean weight of marketable tubers produced from the middle rows at harvest by weighing tubers which were healthy and greater than 50g (the value were taken in kg/plot and converted to ton per hectare) (Zelalem *et al.*, 2009); unmarketable tuber yield (tha^{-1}) was recorded from mean weight of unmarketable tubers produced from middle rows at harvest and those may include rotted, turned to green and less than 50g weight, were considered as unmarketable tuber yield, (kg per plot) and converted into ton per hectare (Zelalem *et al.,* 2009); and

total tuber yield (tha^{-1}) was recorded as the sum of both marketable and unmarketable tuber yields and it was weighted and converted to ton per hectare (Zelalem *et al*., 2009; Mohammad *et al*., 2013).

2.7. Data Analysis

The collected data on different growth and yield parameters were subjected to analysis of variance (ANOVA) by using SAS version 9.2 statistical software (SAS, 2008). All pairs of treatment means were compared using Least Significant Difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Soil Physico-Chemical Properties of the Experimental Site

The results of laboratory analysis of the selected physico-chemical properties of the soil of the experimental site before planting are presented in Table 2. The result showed that the soil content of clay, silt and sand is 50%, 30% and 20%, respectively. As a result, the texture of the soil is clay (Bouyoucos, 1962) classification. The pH of the soil was 4.89 which is acidic according to the rating of EthioSIS (2014). According to MoA (2011) sited that Potato requires a well-drained, aerated and porous sandy loam or loamy sand soils with the pH range for potato production of from 4.5-7.5.

The CEC of the soil was 28.62 meq/100g soil. According to Murphy (2007), the experimental soil has higher CEC. The organic carbon content (OC) of the experimental field was 2.89% which is medium according to the rating of Tekalign (1991). This indicated the medium potential of the soil to supply nitrogen to plants through mineralization of organic carbon. The total nitrogen was 0.39% which is optimum according to the classification of EthioSIS (2014). The available P of the experimental soil was 20.18 ppm, which was rated as low as if it is ranged from 15 to 30 ppm according to EthioSIS (2014). Because of low efficiency of uptake by potato, phosphorus fertilizer application needs to be considerably higher than the 30-80 kgha^{-1} of P_2O_5 taken up by the crop (MoA, 2011). Also the soil analysis indicated that the available S, B and Zn were 26.88, 0.09 and 3.67 ppm, respectively.

3.2. Growth Parameters

3.2.1. Number of stems per hill

Stem number per hill was significantly ($P<0.001$) influenced by rates of the three blended fertilizer types (Table 2). The maximum stem numbers (6.90, 7.23 and 8.57 hill^{-1}) were attained at the rate of 200 kgha^{-1} of NPS, NPSB and NPSZn fertilizers applied, respectively; while the minimum stem numbers (3.57 hill^{-1}) was recorded from unfertilized plot followed by the plot treated with 50 kgha^{-1}; however, plots received both 150 and 100 kgha^{-1} significantly improved stem number per hill next to the highest result obtained from 200 kgha^{-1} than 50 kgha^{-1} and control (Table 2). This indicated that as the rates of all fertilizer types become increased from 0 to 200 kgha^{-1}; the stem numbers of potato significantly increased. This might be due to the supply of adequate amount of nutrients from the blended NPS; NPSB and NPSZn fertilizers which might have facilitated the production of main stem number and secondary branches that contributed to the production of higher tuber yield.

The three blended fertilizer types also significantly varied on potato stem growth; highest was obtained from NPSZn application than others; but NPS and NPSB was not significantly differed from each other (Table 2). The mean result of stem number per hill with the application of NPSZn was showed that significant difference from other treatments; this might be due to the effect of micro nutrient Zn importance for growth and development of crops.

Table 2. Effect of different rates of NPS, NPSB and NPSZn blended fertilizers on stem number of potato

Fertilizer rate (kgha^{-1})	Blended fertilizer types		
	NPS	NPSB	NPSZn
0	3.57^{e}	3.57^{e}	3.57^{e}
50	4.83^{d}	4.57^{d}	5.30^{d}
100	5.33^{c}	5.20^{c}	6.23^{c}
150	6.07^{b}	6.07^{b}	7.23^{b}
200	6.90^{a}	7.23^{a}	8.57^{a}
Mean	5.34	5.33	6.18
LSD(5%)	0.45	0.52	0.42
CV(%)	4.69	5.40	3.71

Numbers followed by the same latter in the same column are not significantly differed at 5% probability level

3.2.2. Plant height

Plant height was significantly (P<0.001) influenced by rates of the three blended fertilizers types applied with largest potato heights (65.50, 62.03 and 76.73 cm) recorded from the plots fertilized at the rate of 200 kgha^{-1} from all the three blended fertilizers; while, the lowest plant height (33.67cm) was recorded from unfertilized plot followed by plot fertilized with 50 kgha^{-1} rate (Table 3). However, applications of all rates of the blended fertilizers were significantly improved potato height as compared to the control plot; thus increasing rates of all fertilizer types significantly increased potato height up to the maximum rate applied which indicated that more amount of these blended fertilizers are required for better crop production (Table 3).

Also comparison of the three blended fertilizers showed that there is significant difference between them; with highest mean height obtained by application of NPSZn as compared to NPS and NPSB application. Similar to this finding Kumar *et al.* (2008a) recorded significant influence of Zn containing fertilizers even on potato plant height and LAI. The increased plant height in response to the application of the fertilizers containing more than two elements might be attributed to the synergetic influence of the nutrients contained on enhancing plant growth owing to their contribution to enhance cell division, stem elongation, promotes leaf expansion and vegetative growth of plants (Marschner, 1995; Tisdale *et al.,* 1995).

Table 3. Effect of different rates of NPS, NPSB and NPSZn blended fertilizers on plant height (cm) of potato

Fertilizer rate (kgha^{-1})	Blended fertilizer types		
	NPS	NPSB	NPSZn
0	33.67^{e}	33.67^{e}	33.67^{e}
50	42.33^{d}	44.07^{d}	50.30^{d}
100	48.37^{c}	48.73^{c}	60.47^{c}
150	55.60^{b}	53.87^{b}	69.40^{b}
200	65. 50^{a}	62.03^{a}	76.73^{a}
Mean	49.09	48.47	58.11
LSD(5%)	2.55	3.01	4.18
CV(%)	2.85	3.41	3.96

Numbers followed by the same latter in the same column are not significantly differed at 5% probability level

3.2.3. Number of leaves

The mean result of number of potato leaves was significantly (P<0.001) influenced by rates of blended fertilizers. The maximum number of leaves (329.33, 331.07 and 345.10) was recorded from plot received 200 kgha^{-1} followed by those plants fertilized with 150 and 100 kgha^{-1} of NPS, NPSB and NPSZn fertilizers, respectively; while, the lowest number of leaves (201.77) was recorded from unfertilized plot followed by plot fertilized with 50 kgha^{-1} (Table 4). Thus, the highest number of leaves recorded from plot received 200 kgha^{-1} in all fertilizer types was increased by 38.73, 39.06 and 41.53% as compared to the control plot, respectively.

The blended fertilizer types were significantly influenced potato leaf numbers with largest number obtained from NPSZn applied than those fertilized with NPS and NPSB types (Table 4). Blended fertilizers which contained Zinc played an important role in increasing number of potato leaves. In his finding Abd El *et al*., (2010) reported that, zinc fertilizer application had positive effect on vegetative growth of potato plants; that means, number of leaves, branches and leaf area per plant; so that, the results indicated that the highest values were recorded by the treatment that received 30 ppm of zinc. In agreement with this result, Rahaman *et al.* (2011) stated that, highest number of potato leaves was produced by 4kg Zn ha^{-1} followed by 3kg and 5kg Zn ha^{-l}, which was statistically significant on number of leaves per plant.

Table 4. Effect of different rates of NPS, NPSB and NPSZn blended fertilizers on leaf number of potato

Fertilizer rate (kgha^{-1})	Blended fertilizer types		
	NPS	NPSB	NPSZn
0	201.77^{e}	201.77^{e}	201.77^{e}
50	245.70^{d}	246.23^{d}	264.30^{d}
100	272.20^{c}	269.13^{c}	287.40^{c}
150	310.13^{b}	315.40^{b}	324.77^{b}
200	329.33^{a}	331.07^{a}	345.10^{a}

Mean	271.83	272.72	284.67
LSD(5%)	13.65	9.41	8.77
CV(%)	2.76	1.90	1.69

Numbers followed by the same latter in the same column are not significantly differed at 5% probability level

3.3. Yield and Yield Components

3.3.1. Tuber number per hill

The analysis of variance showed that effect of blended fertilizers rates had significantly ($p<0.001$) influenced the total potato tuber number per hill. The tuber number per hill was significantly increased with increased rates of each applied blended fertilizers (Table 5). The largest tuber numbers (27, 28 and 36) were recorded from those received 200 kgha^{-1} followed by those received 150 kgha^{-1} of blended fertilizer types (NPS, NPSB and NPSZn, respectively); while, the fewest tuber number (20.03) was recorded from unfertilized (control) plot without statistical difference from those fertilized with 50 kgha^{-1} of all fertilizer types and also with 100 kgha^{-1} of NPS and NPSB (Table 5). The increased tuber number in response to the increased rates of the blended fertilizer types might be due to more fast growth, more foliage and increased in leaf area and higher supply of more amounts of nutrients contained in those fertilizers, which might have induced formation of total tuber number thereby resulting in higher marketable tuber per hill. Also application of NPSZn significantly improved potato mean tuber number per hill as compared to those fertilized with NPS and NPSB fertilizer types. Similarly to this result the finding of Birtukan (2016) reported that, positive interaction of nitrogen, phosphorus and sulphur increased total tuber number by 60.6%. According to Jafar-Jood *et al*. (2013) report, among micronutrients, boron plays several important physiological roles in plants such as cell elongation, nucleic acid synthesis, hormone responses and membrane function. In agreement with this investigation Bari *et al*. (2001) showed that application of 1.1 kgha^{-1} Boron from borax increased potato fresh haulm weight per hill, number of tubers per hill, dry matter content of tubers and yield of tuber per hectare.

Table 5. Effect of different rates NPS, NPSB and NPSZn blended fertilizers on tuber number per hill

Fertilizer rate (kgha^{-1})	**Blended fertilizer types**		
	NPS	**NPSB**	**NPSZn**
0	20.03^{c}	20.03^{bc}	20.03^{d}
50	19.80^{c}	18.07^{c}	20.90^{cd}
100	21.10^{c}	20.37^{bc}	22.17^{c}
150	23.33^{b}	23.73^{b}	29.10^{b}
200	27.03^{a}	28.40^{a}	35.93^{a}
Mean	22.26	22.12	25.63
LSD(5%)	1.35	4.39	1.84
CV(%)	3.34	10.92	3.95

Means followed by the same letter within column are not significantly differed at 5% probability level

3.3.2. Marketable tuber weight

The analysis of variance showed that application of blended NPS, NPSB and NPSZn fertilizers at various rates had significantly ($p<0.01$) influenced marketable tuber weight of potato. Increased rates of all blended fertilizers (NPS, NPSB and NPSZn) from 0 to 200 kgha^{-1} were significantly increased marketable tuber yield from 5.61 to 15.59, 5.61 to 17.20 and 5.61 to 24.29 tha^{-1}, respectively (Table 6). The largest marketable tuber yields were obtained from plots fertilized with 200 kgha^{-1} of blended NPS, NPSB and NPSZn fertilizers; whereas, the smallest marketable yields were recorded from unfertilized plots. Application of NPS, NPSB and NPSZn fertilizers at a rate of 200 kgha^{-1} was significantly improved marketable potato weight by 64%, 67% and 77% as compared to the control plot, respectively. This increment of marketable tuber weight in the response different rates of blended NPS, NPSB and NPSZn fertilizers indicated that the importance of large amounts of blended fertilizers for growth and productivity of potato. Also plots received NPS, NPS and NPSB was statistically differed from each other. The largest mean marketable yield was obtained from plot fertilized with NPSZn as compared to those fertilized with others fertilizer types (NPS & NPSB; at par) with an improvement of 28.55% and 25.34%, respectively. This might be due to the positive interaction and complementary effect between Nitrogen, Phosphorus, Sulphur, Zinc and Boron in affecting and increasing the marketable tuber yield of potato as reported by (Tisdale *et al*., 1995).

Table 6. Effect of different rates of NPS, NPSB and NPSZn blended fertilizers on marketable tuber weight (tha^{-1})

Fertilizer rate (kgha^{-1})	Blended fertilizer types		
	NPS	NPSB	NPSZn
0	5.61^{e}	5.61^{d}	5.61^{e}
50	6.93^{d}	6.40^{d}	8.93^{d}
100	8.71^{c}	8.98^{c}	10.70^{c}
150	10.98^{b}	11.78^{b}	17.38^{b}
200	15.59^{a}	17.20^{a}	24.29^{a}
Mean	9.56	9.99	13.38
LSD(5%)	0.56	2.25	1.38
CV(%)	3.22	12.35	5.66

Means followed by the same letter within column are not significantly differed at 5% probability level

3.3.3. Unmarketable tuber weight

The analysis of variance showed that the effect of different rates of blended fertilizers were significantly ($p<0.001$) influenced unmarketable tuber weights of potato (Table 7). The heaviest unmarketable tuber weight (1.97 tha^{-1}) was recorded from unfertilized (control) plot without statistically differing from those fertilized at 50, 100 and 150 kgha^{-1} of both NPS and NPSB, and from 50 kgha^{-1} of NPSZn; whereas, the lightest unmarketable tuber weights (1.44, 1.36 and 1.22 tha^{-1}) were recorded from those fertilized at a rate of 200 kgha^{-1} of NPS, NPSB and NPSZn, respectively (Table 7). This might be due to nitrogen accelerate the growth of above ground part of plants along other nutrients, which often leads reduced tuber size and weight of the tubers become unmarketable. In consistent with this result (Fantaw *et al*., 2019) stated that, result of the two years combined analysis of the experiment done in northern part of Ethiopia showed that a minimum unmarketable tuber yield was recorded from application of 55-9.87-25.4 kgha^{-1} of blended NPS fertilizer ($N_2/S_2/P_2O_5$), while the maximum unmarketable yield was measured from unfertilized treatment. However, the mean values of unmarketable tuber weights due to fertilizer types (NPS, NPSB and NPSZn) were not statistically differed from each other.

Table 7. Effect of different rates NPS, NPSB and NPSZn blended fertilizers on unmarketable tuber weight (tha^{-1})

Fertilizer rate (kg ha^{-1})	Blended fertilizer types		
	NPS	NPSB	NPSZn
0	1.97^{a}	1.97^{a}	1.97^{a}
50	1.89^{a}	2.26^{a}	1.75^{ab}
100	1.74^{a}	1.77^{ab}	1.53^{b}
150	1.72^{a}	1.79^{ab}	1.20^{c}
200	1.44^{b}	1.36^{b}	1.22^{c}
Mean	1.75	1.83	1.54
LSD 5%	0.27	0.51	0.31
CV (%)	8.33	15.24	11.15

Means followed by the same letter within column are not significantly differed at 5% probability level

3.3.4. Total tuber weight

The analysis of variance showed that rates of the three blended fertilizers had significant ($p<0.01$) effect on total tuber weight (Table 8). The highest total tuber yields (17.02, 18.56 and 25.51 tha^{-1}) were recorded from those fertilized with 200 kgha^{-1} of NPS, NPSB and NPSZn; while, the lowest total tuber yield (7.59 tha^{-1}) was recorded from unfertilized plot, respectively. Thus, increasing the application levels of different blended fertilizers was significantly increased total tuber yield per hectare along the applied rates of each blended fertilizer. The highest tuber yield due to blended NPS, NPSB and NPSZn fertilizers application at highest rates (200 kgha^{-1}) was significantly improved potato yields by 55%, 59% and 70%, respectively as compared to the control. Also the mean yields of potato fertilized with NPSZn were significantly higher than those fertilized with NPS and NPSB, but those plots received both NPS and NPSB are at par. In the present study it was observed that total tuber yield had significantly and positively correlated

with total tuber number, marketable tuber number, plant height and main stem number. The possible reasons for the existence of this relation among the parameters are as the plant height increased the plants produce higher photosynthesis and as a result the total tuber yield was higher. This result is in consistent with that of Hammes (1985) who reported that increased in stem numbers markedly increased tuber numbers and total tuber yield per unit area of land; also plant height and total tuber yield indicating the existence of positive association between the two parameters which corroborated the findings of Yibekal (1998). In conformity with this result Minwyelet *et al*. (2017) reported that the application of blended NPS fertilizer at the rate of 272 $kgha^{-1}$ produced the highest total tuber yield (47.53 tha^{-1}); while potato crop without NPS fertilizer produced the lowest total tuber yield (17.32 tha^{-1}). In a like manner, in the finding of Mulineh (2018) stated that, highest total tuber yield (41.19 tha^{-1}) was recorded from 300 $kgha^{-1}$ NPSB applied on variety Belete which was statistically at par with variety Gudane; while, the lowest total tuber yield (15.7 tha^{-1}) was recorded from unfertilized plots on Jalene, Gudane and Belete varieties. Moreover, in other research finding it was depicted that effects of micro nutrients like Zinc have positive impacts on potato tuber yield with a maximum tuber yield (26.9 tha^{-1}) obtained from the plot received 10 $kgha^{-1}$ of zinc.

Table 8. Effect of different rates NPS, NPSB and NPSZn blended fertilizers on total tuber weight (tha^{-1})

Fertilizer rate ($kgha^{-1}$)	Blended fertilizer types		
	NPS	**NPSB**	**NPSZn**
0	7.59^{e}	7.59^{d}	7.59^{e}
50	8.82^{d}	8.65^{cd}	10.68^{d}
100	10.45^{c}	10.75^{c}	12.23^{c}
150	12.70^{b}	13.57^{b}	18.58^{b}
200	17.02^{a}	18.56^{a}	25.51^{a}
Mean	11.31	11.82	14.92
LSD(5%)	0.576	2.32	1.32
CV (%)	2.80	10.78	4.84

Means followed by the same letter within column are not significantly differed at 5% probability level

4. CONCLUSION AND RECOMMENDATIONS

Application of different blended fertilizers at different rates significantly contributed to growth and yield components of potato improvement in the study area. Based on the results of the study, from NPS, NPSB and NPSZn blended fertilizers types tested at various rates, it is possible to concluded that application of 200 $kgha^{-1}$ of each blended fertilizer, and NPSZn blended fertilizer type brought highest growth and yields which is economically and agronomical feasible for the production of potato as compared to other rates in Lemu-Bilbilo District and similar areas. However, further research study should be repeated both over locations and years in order to give complete recommendations for practical application in sustainable potato production within the producing communities by full filling all agronomic practices and incorporating different organic and inorganic fertilizers at various rates. So, using of different sources and types, and rates of fertilizers has greater value for the future to improve the production and productivity of soils and potato crop in the study area and the like.

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All data associated with this study are present in the paper.

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