Journal of Horticultural Science & Ornamental Plants 13 (1): 01-14, 2021
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2021.01.14

Effects of Different Rates of Blended Fertilizers on Growth, Yields and Quality Attributes of Potato (*Solanum tuberosum* L.)

[1]*Tilaye Batu* and [2]*G. Diriba-Shiferaw*

[1]GMS/Boort Malt Ethiopia PLC in the Position of Field Advisor at Lemu-Bilbilo District
[2]Department of Horticulture and Plant Sciences, College of Agriculture and Environmental Science, Arsi University, P.O. Box: 193 Asella, Ethiopia

Abstract: Potato is an important food and cash crop in Ethiopia in general and in Lemu-Bilbilo District specifically. However, the yield of the crop is very low due to a number of constraints of which unbalanced fertilizer rate and type is the major constraint for each variety produced across the study areas. Therefore, a field experiment was conducted in Lemu-Bilbilo district, under rain fed condition during the 2018 cropping season, with the objective of evaluating the effect of different rates and types of blended NPS, NPSB and NPSZn fertilizers on growth, tuber yield and yield related traits of Gudane potato variety production in the study area. The experiment consisted of three types of fertilizers at four rates each (50, 100, 150, 200 kg ha^{-1}), recommended rate of Diammonium Phosphate (200 kg ha^{-1} (92 kg ha^{-1} P_2O_5 + 36 kg ha^{-1} N) along with the control as treatments. The 14 treatments were laid out in a Randomized Complete Block design with three replications in each. The results indicated that late germination (17.3) and 50% flowering (73.3 days) was observed in the control plot and earliest germination (10.0) and flowering (66.3 days) was observed in the plot received 200 kg ha^{-1} of NPSZn fertilizer. The effect of blended NPS, NPSB and NPSZn fertilizers significantly affected days to 50% flowering, days to 90% maturity, average tuber weight, unmarketable tuber number, marketable tuber yield and total tuber yield. On the other hand, highest marketable yield (24.3 t ha^{-1}) and total tuber yield (25.51 t ha^{-1}) was obtained from the plot fertilized with blended fertilizer type of NPSZn at rate of 200 kg ha^{-1}. Thus, application of 200 kg ha^{-1} NPSZn is more profitable at the study area and similar areas. However, further research is needed across season and location to draw conclusive recommendation for potato growers.

Key words: Blended Fertilizers · Growth · Potato Yield · Quality

INTRODUCTION

Potato (*Solanum tuberosum* L.) is belongs to the botanical species, called *solanacaae* (*Solanum tuberosum* L.); it was first domesticated in the area around Lake Titicaca, which is located 3800 meters above sea level on the border of modern-day, Bolivia and Peru, in the Andes mountain range of South America [1]. It is a crop of the world's major economic importance and number one non-grain food commodity [2]. It is the third most important food crop in consumption in the world after rice and wheat [1, 3], with a global cultivation exceeding 19.34 million hectare of land in more than 158 countries in the globe with an estimated annual production of 364 million tons [4]. According to Mondal [5] stated that, potato is one of human kind's most valuable food crops and it is a major part of the diets of more than a billion consumers worldwide. It is regarded as high-potential food security crop because, potato has an ability to provide a high yield of high-quality product per unit input with a shorter crop cycle (mostly < 120 days) than major cereal crops such as, maize; not only these but also, according to Lung'aho *et al.* [6] sited that, potato is an important food and cash crop in eastern and central Africa, playing a major role in the national food security and nutrition, poverty alleviation, income generation and provides employment in the production, processing and marketing sub-sectors.

Corresponding Author: G. Diriba-Shiferaw, Department of Horticulture and Plant Science, College of Agriculture and Environmental Science, Arsi University, P.O. Box: 193 Asella, Ethiopia.

Potato was first introduced to Ethiopia in 1858 by the German Botanist, Schemper [7]. Ethiopia has possibly the greatest potential for potato production; 70% of its arable land mainly in highland areas, above 1500 m.a.s.l, are believed to be suitable for potato. Since the highlands are also home to almost over half of Ethiopian population, the potato could play a key role in ensuring national food security [8]. In Ethiopia, potato ranks first among the major tuber crop in volume of production and consumption followed by enset, sweet potato, yam and taro. 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 [9]. It is identified as hunger breaking crop during a period when cereal crops are not ready for harvest in the highland. Potato is grown in diverse soil types ranging from Vertisols to Nitosols in the highlands of Ethiopia. The national average yield stands at 11.8 t ha^{-1} [10], which is lower than the experimental yields of over 38 t ha^{-1}, which is very low compared to the world average of 17.6 t ha^{-1} [11-13].

Potato requires a variety of plant nutrients for growth and development. Nitrogen, phosphorus, potassium and sulfur are the most important among the elements that are essential to potato [11]. In this regard, various researches have been conducted throughout Ethiopia with the objectives of determining the fertilizer requirements of potato [11]. Potato is a heavy feeder requiring large quantities of fertilizers to produce highest marketable tuber yield and total tuber yield. On the other hand low soil fertility is one of the limiting factors to sustain potato production and productivity in Ethiopia as Ethiopian soils are very diverse in terms of inherent and dynamic soil quality [14]. Even though inappropriate agronomic practices and shortage of seed tubers of improved potato varieties are among others the major constraints of potato production in the country [15]. Fertilizer recommendations made based on preliminary studies vary across diverse agro ecologies in the country. Economically feasible fertilizer amount varies with soil type, fertility status, moisture amount, climatic variables, variety, crop rotation and crop management practices [16]. In fact, the Ethiopian agricultural Institution (EIAR) generally recommends to farmers the blanket rates of 195 kg ha^{-1} DAP and 165 kg ha^{-1} Urea regardless of cultivar and location or soil type, which together sums up to account for 111 kg ha^{-1} N and 90 kg ha^{-1} P_2O_5 [17]. Therefore, in most part of Ethiopia, the sources of plant nutrients for agriculture over the past five decades have been limited to urea and Diammonium Phosphate (DAP) fertilizers which contain only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops. In this regard, Shiferaw [18] reported that Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and development of crops including potato. Similarly EthioSIS [19] reported that, Ethiopia soil data base majority of soils in Ethiopia are deficient in macronutrients (N, P and S) and micronutrients (Cu, B and Zn) because of long years frequent cultivations of staple crops thus the majority of potato growers depend on P in the form DAP and N in the form of urea [19].

This is exacerbated especially by Ethiopian fertilizer rates that are below international and regional standards. Consequently, the yield and productivity of crops including potato in Ethiopia are much lower than other countries. In addition to these soil nutrient depletion, moisture stresses, diseases and insect pests are the challenges of potato producing smallholder farmers in the country. Ethiopian soils fertility has already declined due to continuous cropping, mono cropping, abandoning of fallowing reduce use of manure and crop rotation [11]. To situation, the Ministry of Agriculture of Ethiopia has been recently introduced a new compound and blended fertilizers like (NPS), (NPSB), (NPSZn) and so no those fertilizers which containing nitrogen, phosphorous, sulfur, boron, zinc, potassium and so on Tegbaru [20]. According to ministry of agriculture report NPS fertilizer with the ratio of 19% N, 38% P_2O_5 and 7% S, (NPSB) fertilizer with the ratio of 18% N, 36% P_2O_5 and 0.71% B and (NPSZn) fertilizer with the ratio of 17.7% N, 35.3% P_2O_5, 6.5% S and 2.5% Zn. This fertilizer has been currently substituted DAP in Ethiopian crop production system as main source of phosphorous. The situation is even more challenging for the researchers and smallholder farmers to understand the effects and identify the optimum rates of the newly introduced NPS fertilizer that contains sulfur for economical production of crops including potato. Therefore the main objectives of the current study were to evaluate the response of potato to the newly introduced blended fertilizers of NPS, NPSB and NPSZn fertilizers at Arsi highland of Lemu-Bilbilo district with different level. Potato is the most important cash and food security crop grown in the highlands of Ethiopia. It is produced both under rain fed and irrigated production systems in the country. Despite its multifaceted importance, the productivity of potato generally in the country is very low which is mostly associated among others with inappropriate agronomic practices including use of improper fertilizer rates and types. Thus, development of location specific fertilizer rates and types which depend mostly on the fertility status of the soils, are paramount necessary to boost the productivity of potato and thus, the incomes and food security of the smallholder farmers in the country at large and in the study area in particular. Lemu-Bilbilo district is one of the potential potato producing areas in Arsi Zone as it has suitable soil and climatic conditions and about 4800 ha of land in the district was covered by potato with average productivity of 9.5 t ha^{-1} under irrigated condition in 2014/2015, which is very low compared to world productivity (17.67 t ha^{-1}) of potato as reported by Wereda Agricultural office of 2018. This might be due to low soil fertility including other cultural and agronomic practices in the area as much rain is available in the areas especially during rain fed production which may lead to leaching of some nutrients. However, farmers are using fertilizers without the optimum rate and type for each crop in the area; information is lacking on the optimal rate and type of blended fertilizer like NPS, NPSB, NPSZn for the area. In view of these problems this research was initiated to evaluate the effect of different rates and types of blended fertilizers on growth, yields and quality attributes of Gudane potato variety in Lemu-Bilbilo District (study area).

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in Lemu-Bilbilo District, Lemu-Dima peasant association. The site is located at 7°32'.206' N latitude and 39° 15'.597 E longitude and which located 237 km 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. Also the site was selected based on the fact that it represents potential potato production areas in the District. The District shares its boundaries with Shirka district in the East, Digelu-Tijo district in the North, Munessa district in the West and Hassasa district to the South. The district has an altitude of 2600-3100 meter above sea level (high land) and has tepid to cool as stated by Lemu-Bilbilo Woreda Agricultural office in the year of 2018. According to some studies the soil of experimental area is clay loam having soil pH of 5-6 with red soil. Production of mono-cropping deplete soil nutrient. After crop harvest there is no crop residues remain on the soil for the nutrient recycling due to the producers use the stubble for animals forage.

Treatments and Experimental Design: The experiment consisted of 14 treatments in which three types of fertilizers (NPS, NPSB and NPSZn) at four rates each (50, 100, 150, 200 kg ha^{-1}), recommended rate of DAP (200 kg ha^{-1} (92 kg ha^{-1} P_2O_5 + 36 kg ha^{-1} N) along with the control (without external fertilizer application) were included. The experiment was laid out in a Randomized Complete Block design (RCBD) of 14 treatments in three replications. Each experimental plot has been 3m wide and 3 m 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 kg ha^{-1}, controlling of disease and insect pest was done similar as well as ridging done as per the recommendation of potato [21].

Table 1: The detail fertilizer treatments

Treatment	Description
1.	Control
2.	200 kg ha^{-1} DAP
3.	50 kg ha^{-1} of NPS
4.	100 kg ha^{-1} of NPS
5.	150 kg ha^{-1} of NPS
6.	200 kg ha^{-1} of NPS
7.	50 kg ha^{-1} of NPSB
8.	100 kg ha^{-1} of NPSB
9.	150 kg ha^{-1} of NPSB
10.	200 kg ha^{-1} of NPSB
11.	50 kg ha^{-1} of NPSZn
12.	100 kg ha^{-1} of NPSZn
13.	150 kg ha^{-1} of NPSZn
14.	200 kg ha^{-1} of NPSZn

Table 2: General description of potato variety Gudene

Variety	Description
Released year	2006
Altitude	1600 – 2800
Rain full range	Sufficient rain or irrigation over the growing season
Fertilizer rate	DAP = 195 kg ha^{-1} and urea = 165 kg ha^{-1}
Soil type	Nitosols (Fertile and Silt loam or sandy loam texture
Seed rate	18 - 20 qt ha^{-1}
Spacing	30 cm between plant and 75 cm between row
Date of flowering	120 days
Tuber yield	29.17 tone ha^{-1} at research field

Source: [22]

Experimental Materials: Three fertilizers types (NPS, NPSB and NPSZn) at four rates each (50, 100, 150, 200 kg ha^{-1}), recommended rate of DAP (200 kg ha^{-1} (92 kg ha^{-1} P_2O_5 + 36 kg ha^{-1} N) were used. Potato variety CIP-386423.13 (Gudane) obtained from Holeta Agricultural Research Center (HARC) was used for the experiment. It was released in 2006 Agronomic and Morphological Characteristics of the variety is, shown in the Table 2.

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 fertilizer rate was 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 tuber bulking and one time after flowering to prevent exposure of tubers to direct sunlight.

Data Collection: To determine the effect of blended fertilizers at different rates on growths, yield and quality parameters of potato, data were collected on their specific period of the crop as follows. Growth parameters days to emergency were recorded after 10 days of planting which was recorded when 50% of the plant emerged from each plot of treatment; days to 50% flowering was recorded when the number of days taken for 50% of the plant population emerged flower from each plot [23]; number of stems per hill was recorded as an average count of ten hills per plot at flowering time, only stems arising from the mother tuber were considered as main stems for counting the number of stems; the plant height was measured in centimeter from ground level to the top of the plant at 50 and 70 days after planting; 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; and days to physiological maturity was recorded when the leaves of the crop attained 90% of the plants in the plot turn to yellowish and the plants show senescence of haulms [14].

Yield and yield components like mean number of tubers produced from ten plants of middle rows was counted at harvest and those tubers which are healthy, large sized and greater than 50g were considered as marketable tubers [24]; unmarketable tuber number per hill was recorded by counting average number of tubers of ten plants and it included rotted, diseased, insect infected and green tubers and those with less than 50g, weight as unmarketable tuber; total tuber number per hill was counted from mean number of tubers produced from the middle rows at harvest and expressed as number of tubers per hill; marketable tuber yield (t ha^{-1}) was recorded 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 per plot and converted to ton per hectare); unmarketable tuber yield (t ha^{-1}) was recorded 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 $plot^{-1}$) and converted into ton per hectare; total tuber yield (t ha^{-1}) was recorded as the sum of both marketable and unmarketable tuber yields and it was weighted and converted to ton per hectare and average tuber weight (g) was recorded by dividing total fresh weight of tubers by the total number of fresh tubers per plot [14].

Tuber quality parameters like specific gravity of tubers was measured by taking three kg of clean tubers from each plot, then the sample was weighted in air and reweighted under water method by dividing weight of tuber in the air to weight in air minus weight in water; and tuber dry matter content (%) was measured by the following method described by Zelalem *et al.* [14] by taking five healthy tubers from randomly chosen five plants per harvestable plot. Sample tubers were wash, chop and mix. Then 200g of sample was taken and pre drying at a temperature of 60°C for 15 hrs; and further dry at 105°C in an oven until constant weight attained and express in percent.

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.

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 [25]. All pairs of treatment means were compared using Least Significant Difference (LSD) test at 5% level of significance. The correlation analysis was performed to determine simple correlation coefficient between growth and yield components as affected by N and P applications.

RESULTS AND DISCUSSION

Soil Physico-Chemical Properties of 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 was 50%, 30% and 20%, respectively. As a result, the texture of the soil was clay [26]. The pH of the soil was 4.89 which is acidic according to the rating of EthioSIS [19]. According to MoA [21] 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.

Table 3: Soil physicochemical properties of the experimental site

Soil property	Value	Reference/Method
A. Physical properties		
Clay (%)	50	
Silt (%)	30	
Sand (%)	20	
Textural class	Clay	Bouyoucos Hydrometer
B. Chemical Properties		
PH (1:2.5 H2O)	4.89	ES ISO 10390: 2014
Total Nitrogen (%)	0.39	ES ISO Kjeldahl Method 2015
Available P (ppm)	10.28	Bray- II
Available S (ppm)	26.88	Mehlich -3
Available B (ppm)	0.09	Mehlich -3
Available Zn (ppm)	3.67	Mehlich -3
CEC (meq/100 g soil)	0.12	ES ISO 11265: 2015
Organic Carbon (%)	2.89	Walkely and Black

Data source: [28, 29]

Table 4: Effect of blended Fertilizer on days to 50% flowering and emergency of potato

	Parameters	
Fertilizer levels	Days to 50% Emergency	Days to 50% flowering
Control	17.3^{a}	66.3^{g}
DAP 200	12.0^{de}	70.7^{cde}
NPS 50	14.0^{b}	68.7^{f}
NPS 100	13.3^{bc}	69.3^{ef}
NPS 150	12.0^{de}	71.3^{bcd}
NPS 200	11.0^{efg}	73.3^{a}
NPSB 50	13.7^{b}	68.7^{f}
NPSB 100	12.0^{de}	70.0^{def}
NPSB 150	11.3^{def}	71.0^{bcde}
NPSB 200	10.0^{g}	72.7^{ab}
NPSZn 50	12.3^{cd}	68.7^{f}
NPSZn 100	11.7^{ed}	69.3^{ef}
NPSZn 150	10.3^{fg}	70.7^{cde}
NPSZn 200	10.0^{g}	72.0^{abc}
CV (%)	5.93	1.60
LSD (5%)	1.21	1.88

Numbers followed by the same latter in the same column are not significant difference at 5% probability level

The CEC of the site was 28.62 meq/100g soil. According to Murphy [27], the experimental soil has high CEC. Most of the time, CEC of soil describes the potential fertility of soils and indicates the soil texture, organic matter content and the dominant types of clay minerals present. The organic carbon content (OC) of the experimental field was 2.89% which is medium according to the rating of Tekalign [28]. This indicated that 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 [19]. Moreover, according to EthioSIS [19] available phosphorus from 15 to 30 ppm is low; thus, the experimental soil had low P content of 20.18 ppm. Potato needs a good supply of readily available phosphorus, since the root system is not extensive and does not readily utilize less available P forms. Because of low efficiency of uptake by potato, phosphorus fertilizer application needs to be considerably higher than the 30-80 kg ha^{-1} P_2O_5 taken up by the crop [21].

Growth Parameters

Days to Emergency: The mean result of application of both blended types and rates of fertilizer was showed that significant ($P<0.001$) on 50% days to emergency of potato. Significantly higher mean/late germination (17.3) was obtained from the control plot and the lowest/early germination mean (10.0) was observed from plot received 200 kg ha^{-1} NPSZn fertilizer rate (Table 4). Those treatments received 200 kg ha^{-1} of NPS, NPSB and NPSZn and 150 kg ha^{-1} NPSZn fertilizer rates, showed statistically at par, but it was significantly differed from unfertilized and check plots. Likewise, treatments received 100 and 50 kg ha^{-1} NPS and 50 kg ha^{-1} NPSB had no significant differences between them. Increased rates of blended fertilizers application from 0 to 200 kg ha^{-1} of NPS and NPSZn showed significant differences on the time required to attain 50% emergence of potato plants; which indicated that numerically there was decreasing trend with an increasing application rates of fertilizers (Table 4). In contrary to this result Muluneh [30] sited that, increasing the application of blended NPSB fertilizer from 0 to 350 kg ha^{-1} did not show significant differences on the time emergence of potato plants, but numerically there was decreasing trend with increasing application rate of fertilizer; variety Jalene required shortest days (21.47 days) to attain 50% emergence as compared to Gudanie (22.38 days) and Belete (22.16 days) varieties; but statistically both are the same. Similarly, De La Morena *et al*. [31] reported that, emergence of potato tuber was affected by storage conditions and physiological age of the seed tubers rather than being conditioned by the fertility status of the soil. However, Getachew [32] reported that non-significant difference between Gudane and Belete varieties for days to 50% emergence of potato plants at Mayichew, Northern Ethiopia.

Days to 50% Flowering: Mean result of days to 50% flowering of potato plant had showed that significant ($P<0.001$) differences due to the applied fertilizers types and rates. It was observed a tendency of delaying of flowering and maturity of potato, Gudane variety, as the rates of blended NPS, NPSB and NPSZn became increased as compared to the control. The earliest days to 50% flowering (66.3 days) was recorded from the control plot; while the longest days required attaining 50% flowering (73.3 days) was recorded from the plot received 200 kg ha^{-1} NPS, which is statistically at par with both plots received 200 kg ha^{-1} NPSB and NPSZn (Table 4). Increasing application of blended fertilizers NPS, NPB and NPSZn as well as DAP along the rates from 0 to 200 kg ha^{-1} became shortened the days to 50% flowering of potato from 66.3 to 73.3 days. The increment in days to 50% flower initiation, with the increasing application blended fertilizer might be attributed to the positive effect of nitrogen that stimulated growth and prolonged vegetative phase; thus, delaying the reproductive phase of plants [33]. The application of 110-19.74-50.8 (N/S/P_2O_5) kg ha^{-1} at Dabark site delayed days to flowering and maturity by 8 and 11 days, respectively as compared to unfertilized plot. Likewise in finding of Muluneh [30] reported that, the longest days required to attain 50% flowering (64.33 days) of potato is recorded from potato plant treated with 350 kg ha^{-1} NPSB from variety Gudane. While the shortest days required to attain 50% flowering (48.33 day) of potato is recorded from unfertilized treatment and variety Jalene.

In line with this result Yourtchi *et al*. [34] who reported that the earliness in flowering due to combinations of lower rates of inorganic NP and control treatments could be attributed to the enhancement of vegetative growth and storing of sufficient reserved food materials for differentiation of buds into flower buds. In agreement with this result, the effect of nitrogen and phosphorous containing fertilizers on days to flowering and days to maturity of potato has been reported by many authors. For instance, Khan *et al*. [33] and Biruk [35] reported that application of nitrogen stimulated growth of potato and enhanced the uptake of nutrients including phosphorous, but delayed the plants reproductive phase and subsequently the maturity of plants.

Number of Stems per Hill: Stem number per hill was highly significantly ($P<0.001$) influenced by both types and rates of blended fertilizers, respectively. The maximum stem number (8.57 $hill^{-1}$) was attained at the rate of 200 kg ha^{-1} NPSZn, while the minimum stem number (3.57 $hill^{-1}$) was recorded on unfertilized treatment; however, 6.27 stem number per hill was recorded from the check plot which is statistically lower as compared to those treated with 200 kg ha^{-1} NPS and NPSB as well as with 200 and 150 kg ha^{-1} NPSZn, but it is statistically at par between treatments which received 150 kg ha^{-1} NPS and NPSB and also 100 kg ha^{-1} NPSZn (Table 5). This might be due to the supply of adequate nutrients under blended NPS; NPSB and NPSZn fertilizer condition may have facilitated the production of main stem number and secondary branches which may contribute the production of higher tuber yield. The mean result of stem number per hill with the application of 200 kg ha^{-1} NPSZn was showed that highly significant difference from other treatments; this might be due to the effect of micro nutrient like B and Zn are the most important for growth and development of crops. In line with this result; according to Alemayehu and Jembere [36] pointed that, the highest number of stem shoot (10.27 $hill^{-1}$) was recorded on Belete variety on the application of 281.75 kg ha^{-1} NPS blended fertilizer; while application of 281.75 kg ha^{-1} NPS fertilizer increased the height by 35.9% and the shoot number by 24.8% from Belete variety as compared to the corresponding plants produced without NPS blended fertilizer. Similarly, in the finding of Muluneh [30] reported that, the highest stem number (6.48 $hill^{-1}$) was observed at the rate of 350 kg ha^{-1} NPSB blended fertilizer. The lowest number of main stem (4.99 $hill^{-1}$) was recorded on unfertilized treatments, but statistically non-significant with 150 kg ha^{-1} NPSB. Increasing application of nitrogen from 0 to 165 kg ha^{-1} increased main stem number per hill from 3.14 to 5.35. On the other hand the maximum main stem number (5.35) per hill was recorded at 165 kg N ha^{-1} and the minimum main stem number (3.14) per hill was obtained from the control [37].

Plant Height: The highest plant height (76.7cm) was recorded from the application of 200 kg ha^{-1} of NPSZn fertilizer while, the lowest plant height (33.7cm) was recorded from the unfertilized plot (Table 5). However, 51.9 cm of plant height was recorded from the check plot which was statistically at par with plots received 100 and 150 kg ha^{-1} NPSB as well as 50 kg ha^{-1} NPSZn; therefore, the mean result of rate of blended fertilizer of 200 kg ha^{-1} NPS statistically lower plant height, but it was significant different from the check point and unfertilized plot (Table 5). Similar to this finding Kumar *et al*. [38] 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 may be attributed to the influence of the nutrients contained on enhancing plant growth owing to their contribution to enhanced cell division, stem elongation, promotes leaf expansion and vegetative growth of plants [39, 40].

Table 5: Effect of different type and rates of blended fertilizers on plant height of potato

	Growth Parameters	
Fertilizer levels	Number of stem	Plant Height (cm)
Control	3.57[g]	33.7[j]
DAP 200	6.27[c]	51.9[fg]
NPS 50	4.83[ef]	42.3[i]
NPS 100	5.33[d]	48.4[h]
NPS 150	6.07[c]	55.6[e]
NPS 200	6.90[b]	65.5[c]
NPSB 50	4.57[f]	44.1[i]
NPSB 100	5.20[de]	48.7[gh]
NPSB 150	6.07[c]	53.9[ef]
NPSB 200	7.23[b]	62.0[d]
NPSZn 50	5.30[de]	50.3[gh]
NPSZn 100	6.23[c]	60.5[d]
NPSZn 150	7.23[b]	69.4[b]
NPSZn 200	8.57[a]	76.7[a]
CV (%)	4.76	3.60
LSD (5%)	4.74	3.30

Means followed by the same latter in the same column are not significant difference at 5% probability level

Similarly, Minwiyelet [41] pointed out that, application of blended NPS fertilizer at the rate of 227.4 kg ha^{-1} produced the highest plant height of potato (65.2cm); while the shortest plant height (40.3cm) was observed on plants grown without NPS fertilizer. Also Amin [42] reported that highest plant height (86.7cm) was recorded with treatment combination of 150 kg NPS ha^{-1} and 30 t ha^{-1} cattle manure which increased 1.86 times than the control (0 kg ha^{-1} NPS and 0 t ha^{-1} cattle manure) which was also statistically in parity with the plant height obtained with 150 kg NPS ha^{-1} and 20 t cattle manure ha^{-1}, 150 kg ha^{-1} NPS and 10 t ha^{-1} cattle manure, 100 kg ha^{-1} NPS and 30 t ha^{-1} cattle manure and 100 kg ha^{-1} NPS blended fertilizer and 20 t ha^{-1} cattle manure applied. Similarly, in conformity of this result, Alemayehu and Jembere [36] found that longest plant heights were observed from plot received 281.75 kg ha^{-1} NPS fertilizer on Belete (65.63 cm) and Gudene (65.00 cm) varieties; and application of 281.75 kgha^{-1} NPS fertilizer was increased the height of Belete variety by 35.9% as compared to plants produced without NPS fertilizer application.

Number of Leaves: The mean result of number of leaves was significantly (P<0.001) influenced by both blended rates and types of fertilizer on potato plant (Table 6). The maximum number of leaves (345.1) was recorded from treatment received 200 kg ha^{-1} NPSZn followed by 200 kg ha^{-1} NPS and NPSB, respectively. While the lowest number of leaves (201.7) was recorded from unfertilized plot. Thus, the highest number of leaves (345.1) recorded from treatment received 200 kg ha^{-1} NPSZn was increased by 41.4% and 10.1% as compared to the control and check plots, respectively. The mean result of application of blended fertilizer rates and types of 200 kg ha^{-1} NPS, 200 kg ha^{-1} NPSB and 150 kg ha^{-1} NPSZn were statistically at par, however they were highly significantly different from the unfertilized and check plots. In a like manner treatments received 150 kg ha^{-1} NPS and NPSB and 200 kg ha^{-1} DAP were statistically at par. Blended fertilizers which contained Zinc played an important role in number of leaves of potato. Increasing rates of these both blended fertilizers type and rates from 50 to 200 kg ha^{-1} of NPS to NPSZn resulted in a significant effect on the number of leaves in potato plant.

Day to Maturity: Days to maturity were significantly (P<0.001) differed due to the effect of NPS, NPSB and NPSZn blended fertilizers types and rates. Early physiological maturity (112.0 days) was recorded from the control treatment. The mean result of treatments which was received blended fertilizers of 200 kg ha^{-1} NPSZn and NPSB were at par with the check plot, respectively. Similarly, the mean results due to application of blended fertilizer types and rates at 150 kg ha^{-1} NPSB, 150 kg ha^{-1} NPSZn and 200 kg ha^{-1} NPS were statistically at par with the check plot. In a like manner the mean results due to application of blended fertilizers at 150 kg ha^{-1} NPS, 50 kg ha^{-1} NPSZn, 100 kg ha^{-1} NPS, 50 kg ha^{-1} NPS and 50 kg ha^{-1} NPSB were statistically had no significant difference between them (Table 6).

Yield and Yield Components

Marketable Tuber Number per Hill: Marketable tuber numbers hill^{-1} was significantly (P<0.001) influenced by both the blended fertilizer rates and types application. The highest marketable tuber number per hill (33.4) was obtained from 200 kg ha^{-1} NPSZn fertilizer applied and lowest (10.93) from control which was followed by check plot (22.93). Application of NPSZn fertilizer at 200 kg ha^{-1}) was significantly increased marketable tuber by 67.4% and 31.4% over the control and check treatments, respectively. In the same manner NPSZn fertilizer applied at the rate of 150 kg ha^{-1} was statistically different from those unfertilized and check treatments (Table 7). Thus, application of both blended fertilizers types (NPS to NPSZn) from 0 to 200 kgha^{-1} significantly increased number of marketable tuber per hill.

Table 6: Effect of blended fertilizers on number of leaves and 90 % maturity date of potato

	Growth parameter	
Fertilizer levels	Number of Leaves	Days of 90% Maturity
Control	210.77^{h}	112.0^{g}
DAP 200	310.23^{d}	122.3^{ab}
NPS 50	245.70^{g}	118.3^{f}
NPS 100	272.20^{f}	118.7^{ef}
NPS 150	310.13^{d}	119.7^{def}
NPS 200	329.33^{b}	121.0^{bcd}
NPSB 50	246.23^{g}	118.3^{f}
NPSB 100	269.13^{f}	120.0^{de}
NPSB 150	315.40^{cd}	121.7^{bc}
NPSB 200	331.07^{b}	123.3^{a}
NPSZn 50	264.30^{f}	118.7^{ef}
NPSZn 100	287.40^{e}	120.7^{cd}
NPSZn 150	324.77^{bc}	121.7^{bc}
NPSZn 200	345.10^{a}	122.3^{ab}
CV(%)	2.02	0.76
LSD (5%)	97.70	1.50

Table 7: The effect of different types and rates of blended fertilizers on Marketable tuber, unmarketable tuber and total tuber number per hill

	Yield Parameters		
Fertilizer levels	Marketable tuber	Unmarketable tuber	Total tuber
Control	10.93^{j}	9.10^{a}	18.07^{f}
DAP 200	22.93^{d}	3.70^{ef}	26.63^{b}
NPS 50	13.50^{hi}	6.30^{b}	19.8^{ef}
NPS 100	16.13^{fg}	4.97^{c}	21.10^{cde}
NPS 150	19.03^{e}	4.30^{cde}	23.33^{cd}
NPS 200	23.87^{cd}	3.17^{fg}	27.03^{b}
NPSB 50	12.20^{ij}	5.87^{b}	20.03^{ef}
NPSB 100	15.57^{hg}	4.80^{cd}	20.37^{ef}
NPSB 150	19.63^{e}	4.10^{de}	23.73^{c}
NPSB 200	25.53^{bc}	2.87^{g}	28.40^{b}
NPSZn 50	16.03^{fg}	4.87^{cd}	20.90^{de}
NPSZn 100	18.23^{ef}	3.93^{ef}	22.17^{cde}
NPSZn 150	26.33^{b}	2.77^{g}	29.10^{b}
NPSZn 200	33.43^{a}	2.50^{g}	35.93^{a}
CV (%)	7.42	10.22	6.85
LSD (5%)	24.2	7.7	27.5

Means followed by the same letters within column are not significantly different from each other at 5% probability level

Unmarketable Tuber Number per Hill: Unmarketable tuber number was significantly affected by rates and types of blended fertilizers application. The highest unmarketable tuber number (9.10 hill^{-1}) was obtained from the control plot and the lowest value (2.50) was recorded from potato treated with 200 kg ha^{-1} NPSZn blended fertilizer (Table 7). Similarly, treatments received 200 and 150 kg ha^{-1} NPSZn, 200 kg ha^{-1} NPSB and 200 kg ha^{-1} NPS blended fertilizers showed statistically at par and recorded the lowest unmarketable tuber number over the unfertilized and check plots. Many numbers of unmarketable tubers were obtained from the control plot. However, increment in unmarketable tuber number was observed as decreased the rates & types of blended fertilizers from 200 to 50 kg ha^{-1} and from NPSZn to NPSB and then NPS blended fertilizer applied, respectively. This indicated that as the rate of fertilizer increased the size of the tuber become increased which might be due to initiation of more vegetative growth that resulted production of more photo-assimilate to be translocated to the tubers and decreased the number and yield of unmarketable tubers [43-45].

Total Tuber Number per Hill: The analysis of variance showed that effect of blended fertilizers types and rates, (NPS, NPSB and NPSZn) had significantly ($p<0.001$) affected the total number of potato tuber per hill. The total tuber number per hill^{-1} was significantly increased with an increased rates and types of the blended fertilizers (Table 7). The most tuber number (35.9) was recorded from those received 200 kg ha^{-1} NPSZn blended fertilizer followed by 200 kg ha^{-1} NPSB and 200 kg ha^{-1} NPS; while the fewest tuber number (18.1) was recorded from the unfertilized (control) plot. Even though medium (26.6) tuber number per hill was recorded from the check plot; it was statistically at par with treatments received blended fertilizers at 200 kg ha^{-1} from NPS and NPSB, as well as 150 kgha^{-1} NPSZn, respectively. In a similar manner the mean result of treatments those received 100 and 150 kg ha^{-1} NPS, 150 kg ha^{-1} NPSB, 100 and 50 kg ha^{-1} NPSZn and 150 kg ha^{-1} NPS had no significant differences between them (Table 7). The increment in total tuber number in response to the increased supply of blended fertilizer types and rates might be due to more growth, more foliage and increased leaf area and higher supply of phosphorous containing fertilizer, which may have induced formation of total tuber number thereby resulting in higher marketable tuber per hill. Similarly, Birtukan [37] reported that, interaction of highest level of nitrogen and phosphorus increased total tuber number by 60.6%; the maximum total tuber number was recorded from the combination of 165 kg N and 135 kg ha^{-1} P (13.7 tuber hill^{-1}) and the minimum (8.53 tuber hill^{-1}) was obtained from the control. According to Jafar-Jood *et al*. [46] report, among micronutrients, boron play several important physiological roles in plants such as, in cell elongation, nucleic acid synthesis, hormone responses and membrane function. In agreement with this investigation Bari *et al*. [47] showed that application of

1.1 kg B ha^{-1} 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.

Marketable Tuber Yield: The analysis of variance showed that application of blended NPS, NPSB and NPSZn fertilizers had significantly ($p<0.001$) influenced marketable tuber yield (Table 8). The application of blended fertilizers significantly increased potato marketable tuber yield (t ha^{-1}) as compared to those grown without fertilizer application. Increased rates of blended fertilizers (NPS, NPSB and NPSZn) from 0 to 200 kg ha^{-1} was significantly increased marketable tuber yield (24.3, 17.2 and 15.6 t ha^{-1}), respectively. The highest marketable yield (24.3 t ha^{-1}) was obtained from plot fertilized with blended fertilizer of NPSZn at rate of 200 kg ha^{-1}; whereas, the lowest marketable yield (5.6 t ha^{-1}) was recorded from the unfertilized plot, but it was statistically at par with those treated with 50 kg ha^{-1} NPSB and NPS. The highest marketable yield (24.3 t ha^{-1}) recorded from those treated with 200 kg ha^{-1} NPSZn was increased by 77% and 39.1% over the control and check plots, respectively. In a like manner, those received 200 kg ha^{-1} NPSB improved potato yield by 67.4%, 14.9% and 9.3% over the control, check and treatment received 200 kg ha^{-1} NPS, respectively; while its yield is lower than treatment received 200 kg ha^{-1} NPSZn by 29.2%.

Likewise plot which received 150 kg ha^{-1} NPSZn was statistically same with plot received 200 kg ha^{-1} NPSB (Table 8). The plot which received 200 kg ha^{-1} DAP (check) had recorded low yield (14.8 t ha^{-1}) as compared with those plots received 200 and 150 kg ha^{-1} NPSZn as well as 200 kg ha^{-1} NPSB; but it was statistically at par with the rate of 200 kg ha^{-1} NPS (Table 8). 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. This increment of marketable yield in the response to increasing rate and type of blended NPS, NPSB and NPSZn fertilizers indicated that the importance of blended fertilizers for growth and productivity of potato. On the other hand the difference in yield among those blended NPS, NPSB and NPSZn fertilizers might be related to genetic makeup of the potato variety in the efficient utilization of inputs like nutrients, which is one of the four major categories of the level (rate) that affecting yields (soil, climatic, genetic and management practices) as reported by Tisdale *et al.* [40]. In line with this result Amin [42] pointed that, highest marketable tuber yield (39.79 t ha^{-1}) was recorded from the application of 150 kg ha^{-1} NPS blended fertilizer + 30 t ha^{-1} cattle manure followed by 150 kg ha^{-1} NPS blended fertilizer + 20 t ha^{-1} cattle manure and 100 kg ha^{-1} NPS blended fertilizer + 30 t ha^{-1} cattle manure with marketable tuber yield of 37.98 and 37.95 t ha^{-1}, respectively; which were also statistically at par with this highest marketable tuber yield. However, the lowest marketable tuber yield (9.59 t ha^{-1}) was recorded from the control, which is less by 33.82% as compared to the highest yield obtained with 150 kg ha^{-1} NPS blended fertilizer + 30 t ha^{-1} CM.

Table 8: The effect of blended NPS, NPSB and NPSZn fertilizer types and rates on marketable, unmarketable and total tuber yield of potato

	Yield Parameters (t ha^{-1})		
Fertilizer levels	Marketable tuber yield	Unmarketable yield	Total tuber yield (tha^{-1})
Control	5.6^{f}	2.26^{a}	7.59^{h}
DAP 200	14.8^{c}	1.06^{e}	15.90^{d}
NPS 50	6.9^{f}	1.89^{b}	8.82^{h}
NPS 100	8.7^{e}	1.74^{bc}	10.45^{g}
NPS 150	11.0^{d}	1.72^{bc}	12.70^{e}
NPS 200	15.6^{c}	1.44^{dc}	17.02^{cd}
NPSB 50	6.4^{f}	1.97^{ab}	8.65^{h}
NPSB 100	9.0^{e}	1.77^{bc}	10.75^{fg}
NPSB 150	11.8^{d}	1.79^{bc}	13.57^{e}
NPSB 200	17.2^{b}	1.36^{de}	18.55^{bc}
NPSZn 50	8.9^{e}	1.75^{bc}	10.68^{g}
NPSZn 100	10.7^{d}	1.53^{dc}	12.23^{ef}
NPSZn 150	17.4^{b}	1.20^{de}	18.58^{b}
NPSZn 200	24.3^{a}	1.23^{de}	25.51^{a}
CV(%)	7.59	13.08	6.80
LSD (5%)	15.3	35.5	15.51

Means followed by the same letters within columns are not significantly different from each other at 5% level

The highest percentage of large size tuber (43.46%) was recorded from the application of 350 kg ha^{-1} and it was statistically at par with 200, 250, 300 kg ha^{-1} NPSB; while the lowest percentage of large size tuber (22.90%) was recorded from the unfertilized plot, but it is par with 150 kg ha^{-1} [30]. Likewise in the finding of Minwyelet [41], application of NPS blended fertilizer at the rate of 272 kg ha^{-1} produced the highest marketable tuber yield (47.02 t ha^{-1}); while the lowest marketable tuber yield (14.85 t ha^{-1}) was obtained on potato plants without NPS fertilizer. Similarly, Alemayehu and Jembere [36] pointed that, highest marketable tuber yield of Belete (55.37 t ha^{-1}) variety was recorded in location I by the application of 283.75 kg ha^{-1} NPS fertilizer which was statistically similar with yield recorded in location II. Similarly, the highest marketable tuber yield of Gudene (46.83 t ha^{-1}) variety was recorded in location I by application of 283.75 kg ha^{-1} NPS fertilizer which was statistically similar with those yields recorded with 181.60 and 272.0 kg ha^{-1} NPS fertilizer application.

Unmarketable Tuber Yield: The analysis of variance showed that the effect of blended NPSB, NPS and NPSZn fertilizers significantly ($p<0.001$) influenced unmarketable tuber yield (Table 8). Increasing blended fertilizers from 0 to 200 kg ha^{-1} NPS, NPSB and NPSZn as well as DAP was decreased unmarketable tuber yield from 2.26 to 1.06 t ha^{-1} (Table 8). The highest unmarketable tuber yield (2.26 t ha^{-1}) was recorded from unfertilized (control) plot; whereas the lowest unmarketable tuber yield (1.06 t ha^{-1}) was recorded from the application of 200 kg ha^{-1} DAP (check plot) which is at par with treatments received 200 and 150 kg ha^{-1} NPSZn and 200 kg ha^{-1} NPSB (Table 8). This might be due to nitrogen accelerated the growth of above ground part of plants, which often leads reduced tuber size and weight of the tubers become unmarketable. On the other hand increased unmarketable tuber yields of potato plants were also observed with the decreased applied fertilizer rates. This indicated that as the rate of fertilizer increased the size of the tuber became increased which might be due to initiation of more vegetative growth that resulted production of more photo-assimilate. Two years combined analysis of the experiment done in northern part of Ethiopia showed that a minimum unmarketable tuber yield was recorded from an application of 55-9.87-25.4 kg ha^{-1} of blended NPS fertilizer; while the maximum unmarketable yield was measured from unfertilized treatment.

Total Tuber Yield: The analysis of variance showed that both rates and types of blended NPS, NPSB and NPSZn fertilizers had significant ($p<0.01$) effect on total tuber yield (Table 8). The highest total tuber yield (25.51 t ha^{-1}) was recorded from those applied with 200 kg NPSZn ha^{-1}; while, the lowest total tuber yield (7.59 t ha^{-1}) was recorded from unfertilized plot and it was statistically at par with treatments which was received 50 kg ha^{-1} NPS and NPSB blended fertilizers, respectively (Table 8). Lowest yields were recorded from 50 kg ha^{-1} application of each fertilizer type and control; however, check plot gave similar result (15.90 t ha^{-1}) with those fertilized by 200 kg ha^{-1} NPS blended fertilizer. Thus, increased application rates of blended fertilizers from 0 to 200 kg ha^{-1} significantly increased total tuber yield. The highest tuber yield at the highest blended NPSZn fertilizer application (200 kg ha^{-1}) followed by highest rates of NPSB and NPS were significantly improved potato yields by 70%, 59% and 55%, respectively as compared to the control. Similarly, highest level of each fertilizer applied was significantly improved potato yield as compared to those fertilized with DAP (Table 8).

In the present study it was observed that total tuber yield had highly significant and positive 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 [48] who reported that increased in stem numbers markedly increased tuber numbers and total tuber yield per unit area of land and also plant height and total tuber yield indicating the existence of positive association between the two parameters which corroborated the findings of Yibekal [49]. In conformity with this result, Minwyelet *et al*. [41] reported that the application of blended NPS fertilizer at the rate of 272 kg ha^{-1} produced the highest total tuber yield (47.53 t ha^{-1}); while potato plants without NPS fertilizer produced the lowest total tuber yield (17.32 t ha^{-1}). Likewise according to Alemayehu and Jemberie [36] report increasing NPS application rates in both experimental locations generally increased marketable yields of the tested potato varieties. The highest marketable yield of Belete (55.37 t ha^{-1}) variety was recorded in location I by the application of 283.75 kg ha^{-1} NPS fertilizer which was statistically similar with yield recorded in location II. Similarly, the highest marketable yield of Gudene (46.83 t ha^{-1}) variety was recorded in location I by application of 283.75 kg ha^{-1} NPS fertilizer which was statistically similar with those yields recorded with 181.60 and 272.0 kg ha^{-1} NPS fertilizer application rates.

In a like manner, the finding of Muluneh [36] stated that, highest total tuber yield (41.19 t ha^{-1}) was recorded from 300 kg ha^{-1} NPSB applied on variety Belete and it was statistically at par with variety Gudane and Belete at 250 to 350 kg ha^{-1}; while, the lowest total tuber yield (15.7 t ha^{-1}) was recorded from unfertilized plot from variety Jalene which was statistically at par with verities of Gudane and Belete on the control plot. Moreover in different researchers reports stated that effect of micronutrients had impact on yield of potato crop by increasing zinc level. Maximum tuber yield (26.9 t ha^{-1}) was recorded when zinc was treated at 10 kg ha^{-1}. However, statistically similar results were obtained from both 5 kg ha^{-1} Zn (26.0 tha^{-1}) application and the control plot (0 kg ha^{-1} Zn) (24.1 t ha^{-1}).

Tuber Quality Parameters

Specific Gravity of the Tuber: The mean result of analysis of variance due to the effect of blended types and rates of

Table 9: The effect of blended fertilizers on specific gravity and tuber dry matter of potato

	Tuber quality parameters	
Fertilizer levels	Specific gravity of tuber (%)	Tuber dry matter (%)
Control	1.06^{b}	22.18^{c}
DAP 200	1.142^{a}	25.93^{ab}
NPS 50	1.06^{b}	22.21^{5c}
NPS 100	1.09^{b}	23.36^{b}
NPS 150	1.100^{ab}	24.86^{ab}
NPS 200	1.154^{a}	26.47^{a}
NPSB 50	1.07^{b}	22.97^{bc}
NPSB 100	1.08^{b}	23.35^{b}
NPSB 150	1.133^{a}	27.28^{a}
NPSB 200	1.163^{a}	23.51^{b}
NPSZn 50	1.06^{b}	22.84^{bc}
NPSZn 100	1.100^{ab}	24.54^{abc}
NPSZn 150	1.123^{a}	24.92^{abc}
NPSZn 200	1.154^{a}	26.04^{a}
CV (%)	2.05	2.05
LSD (5%)	1.22	0.70

Means followed by the same letters within column are not significantly different from each other at 5% probability level

NPS, NPSB and NPSZn fertilizers showed significant differences on specific gravity of the tuber (Table 9). The application of blended type and rates of fertilizers in the rate of 200 and 150 kg ha^{-1} of NPSZn, NPSB and NPS fertilizers and DAP at 200 kg ha^{-1} produced higher results as compared other treatments and control plot (Table 9). The highest value (1.163) was recorded from plot received 200 kg ha^{-1} NPSB, which is at par with the rate of 200 kg ha^{-1} NPSZn, 200 kg ha^{-1} NPS, 150 kg ha^{-1} NPSB, 150 kg ha^{-1} NPSZn and the check plot, respectively (Table 9). In line with this result Simret *et al.* [50] found that, the application of nitrogen had no significant effect on specific gravity of potato. Similarly, Desta [51] reported that specific gravity was not significantly affected by application of blended NPSB fertilizer. In the same manner Rytel *et al*. [52] reported that quality of potato tubers and their chemical composition is influenced by genetics, soil fertility, weather conditions and chemical treatments that are applied.

Dry Matter Contain of Potato Tuber: The effect of both blended fertilizer type and rates showed significant ($p<0.01$) effect on dry matter content of potato. However, the highest dry matter content (27.28%) was observed from the plot received 150 kg ha^{-1} NPSB; but it was statistically at par with the treatments of 200, 150 and 100 kg ha^{-1} of NPS, NPSB and NPSZn, respectively (Table 9). While the lowest value (22.18%) was recorded from the unfertilized plot; but it was statistically at par with the treatments of 50, 100 and 150 kg ha^{-1} of NPS, NPSB and NPSZn blended fertilizers, respectively (Table 9). This might be due to the qualities of vegetables depending upon genetic, climatic, biotic, edaphic, chemical and other factors as well as combinations of these factors [53]. In line with the result, Alemayehu and Jembere [36] stated that, highest tuber dry matter contents of 39.13, 37.13 and 32.85% were recorded from Belete, Gudene and local varieties, respectively when the crop was applied with 283.75 kg ha^{-1} NPS. In consistent with this result, Tai and Coleman [54] reported that dry matter content is subjected to the influence of both the environment and genotypes.

CONCLUSION AND RECOMMENDATIONS

Application of different fertilizers significantly contributed to yield and yield components and qualities of potato improvement in the study area. Based on the results of the present study, it can be concluded that NPSZn blended fertilizer at the rate of 200 kg ha^{-1} is agronomical and economically feasible for the production of potato in Lemu-Bilbilo woreda and similar areas. However, further research study should be repeated both over locations and years in order to give concrete recommendations for practical application in sustainable potato production within the producing communities by full filling agronomic practices and incorporating different organic and inorganic fertilizers. So, using of different sources and rates of blended fertilizers has greater value for the future to improve the production and productivity of soil and potato in the study area and the like.

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