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Evaluation of Potato (Solanum tuberosum L.) Varieties to Blended NPSB Fertilizer Rates on Yield, Yield Related Traits at Boneya Destrict, Northern Ethiopia

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Potato (Solanum tuberosum L.) is an important food and export crop in central highlands of Oromia region. The limiting macro and micronutrients were identified for the production of potato crops in Boneya districts. The rates of these nutrients for high potato yield and disease resistance are not yet determined. Therefore, this research was conducted to determine the effect of blended NPSB fertilizer rates on yield and yield related traits of potato varieties at Boneya Kebele, central highlands of Oromia region. The experiment was conducted as factorial combination of seven levels of blended NPSB fertilizer rates (0, 50, 100, 150, 200, 250, 300 kg ha-1) and three potato varieties (Belete, Gudane and Jalane) in Randomized Complete Block Design with three replications. The results of the study revealed that variety and blended NPSB fertilizer had significant effect on crop phenology, growth, tuber yield and yield components except proportion of medium size tubers which is not influenced by the two main factors. Blended NPSB fertilizer had nonsignificant effect on days to 50% emergence, number of main stem/hill and proportion of large size tubers. Variety and blended NPSB fertilizer interacted to influence days to 50% flowering, average tuber weight (g), average tuber number, unmarketable tuber yield, and proportion of small, medium and large size tubers. The highest marketable tuber yield (30.74 t ha-1) and total tuber yield (32.16 t ha-1) was obtained by the application of NPSB fertilizer at highest rate of 300 kg ha-1 which was followed by the application of 250 kg ha-1. Gudane (29.52 t ha-1) and Belete (29.48 t ha-1) produced significantly higher marketable tuber yield than Jalane variety. Therefore, growing of the two varieties at highest rates of blended NPSB fertilizer could be recommended in the study area for producers, because of gives higher marketable yield.

Keywords: Evaluation, Interaction and Main Effect, Marketable Yield, Variety

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1. Introduction

Potato is considered as inexpensive and nutritive food security crop, as it produces more dry matter, protein and calories per unit area and time than the major cereal crops [1]. The global annual production is about 381.7 million tons [2]. The production of potato in Ethiopia is in increasing trend where it is concentrated mostly in mid altitudes and highlands of the country. Potato ranks first among root and tuber crops in Ethiopia both in volume of production and consumption followed by cassava, sweet potato and yam where smallholder farmers are the major producers as food, and cash crop [3].

Oromia National Regional State is a leading producer where potato is used as co-staple food in some zones, such as East Hararghe, Northern region and Central highlands of Oromia region. The average yield of potato is about 19.3 t ha^{-1} [4], which is by far higher than national average yield of 12.66 t ha^{-1} in 2015 [3], but not reach to the crop potential (40 t ha^{-1}) at research centres. Soil fertility status and management are among other factors that limit the yield potential of various crops including potato [5].

The sources of plant nutrients for Ethiopian agriculture over the past five decades have been limited to Urea and Diammonium Phosphate (DAP) fertilizers which contain only nitrogen and phosphorus. Shiferaw, [6] reported that Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and development of crops. The soils in Northern part of Oromia region were identified deficient not only nitrogen and phosphorus but also sulfur and Boron [7]. This indicates that the application of nitrogen and phosphorus do not satisfy the nutrient requirements of the crops including potato. It has been also reported that the fertilizer rates used in Ethiopia are below international and regional standards. To avert the situation the Ministry of Agriculture of Ethiopia has been recently introduced a new blended NPSB fertilizer containing nitrogen, phosphorous, sulfur and Boron with the ratio of 19%N, 38% P_2O_5, 7% S and 0.1% B. This fertilizer is used as a substitute of DAP in crop production system as main source of phosphorous [8].

In the central part of Oromia region, particularly at Boneya districts, the effect of blended NPSB fertilizer rate on tuber yield and yield related traits of potato varieties resistant to late blight has not been studied. Therefore, it is necessary to conduct research in the area to assess the response of potato varieties to the newly introduced blended fertilizers and to identify rate of this fertilizer to obtain both high tuber yield and profit from the production of potato. This is because, fertilizer requirement of crops varies across locations, with soil type, fertility status, moisture amount, other climatic variables, variety, crop rotation, and crop management practices [9]. This research is therefore, initiated to achieve the following objective:

to determine the effect of blended NPS fertilizer rates on yield, yield related traits of potato varieties in the study area

2. Materials and Methods

2.1. Description of the Study Site

The experiment was conducted at Boneya district, central highlands of Oromia regional state June 2012 during cropping season. Boneya, district is part of central highlands of country which is located 124km from Addis Ababa. It is located at about $38^0$29`to $38^0$34`East longitude and $9^0$34` to $100^0$ 03`North latitude and at an elevation of 2878 m.a.s.l. receiving an annual rainfall of 900 to 1400mm. The experimental area is with mean annual minimum and maximum temperature of 15 and 22^0, with sandy loam soil and is one of the major potato producing districts.

2.2. Treatments and Experimental Design

The experiment was consisted of three potato varieties (Belete, Gudane and Jalane) and seven rates of blended NPSB fertilizer (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}). The rates of blended NPS fertilizer were arranged as the substitute of DAP fertilizer at the rate of 200 kg (92 kg P2O5) ha^{-1} that was used for potato production as recommendation of central highlands of Oromia region. The experimental design was randomized complete block design (RCBD) with three replications. Each treatment combination was assigned in one plot of each replication with the plot size of 3.60 x 4.50 meters (16.2 m2). The spacing between plants in a row and between rows was 0.3 and 0.75m, respectively, in which one plot was consists of six rows each with 12 plants and a total of 72 plants per plot. Well sprouted seed tubers of potato were planted at the spacing of 75 cm between rows and 30 cm between plants. The spacing between plots and blocks was one meter and one and half meters, respectively. Other cultural practices like weeding, earthing up, and plant protection methods are done uniformly for all experimental plots as recommendation of EIAR (2003) for the crop.

2.3. Data Analysis

All the measured parameters are subjected to analysis of variance (ANOVA) appropriate to factorial experiment in RCBD according to the General Linear Model (GLM) of Gen Stat 16th edition [10] and the interpretations was made following the procedure described by Gomez and Gomez, (1984). Least Significance Difference (LSD) test at 5% probability level was used for mean comparison following the significant differences results from the ANOVA.

2.4. Soil Sampling and Analysis

A soil sample was taken in zigzag pattern before planting randomly from the experimental site at a depth of 0-30 cm using an auger at the interval of 5-10 meters. The sample was mixed thoroughly to produce one representative composite sample. About one kilogram of composite sample was taken using polyethylene bag and was given to Soil Laboratory. The composite soil sample was analyzed for selected physicochemical properties mainly soil texture (sand, silt and clay%), soil pH, total nitrogen (N), available sulphur (S), available (B), organic carbon (OC), available phosphorus (P), Exchangeable potassium (K), Electrical conductivity and cations exchange capacity (CEC) (c mol kg^{-1}) using the appropriate laboratory procedures.

2.5. Data Collection and Measurements

Data on crop phenology, yield, and yield components was collected on plot basis while growth was collected from sample plants. The data collection and measurements was accomplished as per the procedures for standard evaluation trials of advanced potato clones established by the National Potato Research Program and International Potato Center [11]. The description of data collection and measurements for each trait is presented in subsequent sub-titles as follows.

2.5.1. Phenology and Growth Parameters

Days to 50% emergence: It was recorded when 50% of the plants in each plot sprouted and emerged.

Days to 50% flowering: It was recorded by counting the number of days from planting to 50% of the plant populations in each plot produced flowers.

Days to 50% maturity: It was recorded by counting the number of days from planting to haulms (vines) of 50% of the plant population becomes yellow or starting senescence.

Plant height (cm): The height of 10 randomly selected plants from the central rows was measured at physiological maturity stage from ground surface to the tip of the main stem and averaged to get the mean plant height.

Stem number per hill: The total numbers of main stems that arose from the ground was counted using five randomly selected plants from the central rows in each plot and the mean number of stem per hill was calculated. Only stems arising from the mother tuber was considered as main stems.

2.5.2. Yield Components and Tuber Yield

Average tuber weight (g): It was recorded by dividing total fresh weight of tubers by the total number of fresh tubers per plot.

Average tuber number per hill: Mean number of tubers produced from the middle rows, was counted at harvest and expressed as number of tubers per hill.

Marketable tuber yield (t ha^{-1}):

Mean weight of marketable tubers produced from the middle rows, was recorded at harvest by weighing tubers which were healthy and greater than 20g. The value were taken in kg/plot and converted to t ha^{-1}.

Unmarketable tuber yield (t ha^{-1}):

Mean weight of unmarketable tubers produced from middle rows was recorded at harvest and those rotten, turned green and less than 20g, were considered to determine unmarketable tuber yield, (kg/plot) and converted in to t ha^{-1}.

Total tuber yield (t ha^{-1}):

It was recorded as the sum of both marketable and unmarketable tuber yields. The total tuber yield (kg/plot) was weighed and converted to t ha^{-1}.

Tuber size grades (%):

Tuber size distribution in weight (%): it is the proportional weight of tubers size categories which was taken at harvest. All tubers from plants in the central rows of each plot were categorized into small (< 39 g); medium (40-75 g), and large (> 75 g) according to [12]. Then each of these categories was counted, and the proportion of the weight of each tuber category was expressed as a percentage.

3. Results and Discussion

3.1. Soil Physico-chemical Properties of the Experimental Site

The results of the laboratory analysis of some selected soil physical and chemical properties of the experimental site before planting are presented in Table2. The soil textural class of the experimental site was identified as clay soil with a particle size distribution of 74.8, 22.65 and 2.53% clay, silt and sand, respectively. The pH of the soil was 8.4, which could be categorized under moderate alkaline [13]. The soil of the study site had 1.4% of organic carbon (OC), which could be classified as low according to the rating of Tekalign [13], indicating low potential of the soil to supply nitrogen to plants through mineralization of organic carbon. Tekalign [13] has classified soil total N content of < 0.05 as very low, 0.05-0.12% as poor, 0.12-0.25% as moderate and > 0.25% as high. According to this classification, the soil sample of the experimental site was found to have moderate level of total N (0.23%) indicating that the nutrient to be a limiting factor for potato production in the study area.

The soil of experimental site was considered as low in available phosphorus content which was 8.8 mg kg^{-1}. The analysis for available sulfur also indicated that the experimental soil had values of 20.0 mg/kg which was low according to [14].

Table 1. *Selected soil phsico-chemical properties of the experimental site.*

Parameter	Values	Rating	Reference
Soil texture			
Clay (%)	74.82		
Silt (%)	22.65		
Sand (%)	2.53		
Textural class	Clay		
Electrical Conductivity (ds/m)	0.76		
PH (1:2.5 H_20)	8.4	Alkaline	Tekalign (1991)
Total N (%)	0.23	Medium	Tekalign (1991)
Organic carbon (%)	1.4	Low	Tekalign (1991)
CEC [Coml.(+) kg^{-1} soil]	38.4	High	London (1991)
Available phosphorus (mg/kg)	8.8	Low	Cottenie (1980)
Available Sulfur (mg/kg)	20	Low	Ethiosis (2014)
Available Boron/B/(ppm)	0.06	Low	Ethiosis (2014)

3.2. Phenology and Growth of Potato

3.2.1. Phenology

All phenology traits viz. days to 50% emergency, flowering and maturity were significantly influenced by variety, and blended NPSB fertilizer had significant effect. The interaction of variety x NPSB fertilizer significantly influenced days to 50% flowering, but the two main factors interaction had nonsignificant effect on days to 50% emergency and maturity (Table 2).

Jalane had significantly delayed days to 50% emergency and maturity. Belete also had significantly delayed days to 50% emergency as Jalane variety. The presence of significant differences among varieties for days to 50% emergency may be attributed by genetic variations of cultivars and influenced by the physiological age of the tubers, but not by external supply of nutrients. Lung'aho, C., B. *et al*. [12] stated that physiologically old tubers take relatively short times whereas physiologically young tubers take longer times to emerge from the soil. This is consistent with the suggestion of [15] that emergence depends on the soil condition and stored food in the tubers not by nutrition.

Table 2. *Effect of variety on phenology of potato crop at Boneya during 2020 cropping season.*

Variety	Days to 50% emergency	Days to 50% maturity
Gudane	12.90^{b}	87.29^{b}
Belete	13.24^{ab}	86.52^{b}
Jalane	13.81^{a}	90.19^{a}
LSD (5%)	0.602	1.063

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

The maturity of potato varieties was delayed as the varieties supplied by the increased rates of NPSB fertilizer (Table 3). The delayed days to 50% maturity (91.78 days) was observed at the highest rate of 300 kg ha^{-1} NPSB fertilizer whereas the shortest days to 50% maturity (84.78 days) was registered in plots that did not receive fertilizer. The application of 250 kg ha^{-1} NPSB fertilizer also significantly delayed the maturity of potato varieties. The growing of plants without fertilizer application and the effect of 50 and 100 kg ha^{-1} NPSB fertilizer on the maturity of potato varieties had nonsignificant difference.

The delayed days to maturity of potato varieties due to the application of NPSB fertilizer at the highest rates might be due to the three nutrients interaction and synergetic effect of the three nutrients. The result is consistent with the findings of other researchers where a crop with high nitrogen application mature later in the season than a crop with less nitrogen [16].

Table 3.*Effect of blended NPSB fertilizer on days to 50% maturity of potato varieties at Boneya during 2020cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Days to 50% maturity
0	84.78^{e}
50	85.11^{e}
100	85.89^{de}
150	87.78^{cd}
200	89.33^{bc}
250	91.33^{ab}
300	91.78^{a}
LSD (5%)	1.623

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

The three varieties in plots that did not receive fertilizer had significantly early flowering without significant difference among varieties. Jalane variety observed in plots which received 300 kg NPSB ha^{-1} showed delayed days to 50% flowering; however, the effect of this rate had nonsignificant difference with the effect of all rates of fertilizer except with the application of 50 kg NPSB ha^{-1} on the same variety. The application of lower rates (50, 100 and 150 kg NPSB ha^{-1}) had nonsignificant effect on growing of Gudane variety without fertilizer application. All rates of fertilizer had been observed in plots which received 300 kg NPSB ha^{-1}. The application of all rates of NPSB fertilizer had nonsignificant difference on days to 50% flowering of Belete which all resulted about 52 and 53 days of flowering (Table 4).

The delayed days to 50% flower of varieties towards the higher rates of NPSB fertilizer might be due to the higher rates of N supplied to plants. They further justify that high N fertilizer increased the leaf area which increases the amount of solar radiation intercepted and consequently prolongs days to flowering. [9, 17] also noted that excessive vegetative growth and delayed flowering due to the application of high rates of nitrogen. The results of the present study are generally in agreement with the findings of various researchers where increasing fertilizer rates, including NPSB prolonged days to flowering and maturity of different vegetable crops including potato in different agro-ecologies [18].

Table 4. *Interaction effect of blended NPSB fertilizer and variety on days to 50 % flowering of potato at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Variety		
	Belete	Gudane	Jalane
0	50.89 ^{h}	52^{fgh}	50.67^{gh}
50	52.67^{efg}	54^{bcdef}	53.33^{def}
100	52^{fgh}	54^{bcdef}	55^{abcde}
150	53.67^{cdef}	54^{bcdef}	56^{abc}
200	53.33^{def}	54.67^{abcde}	55^{abcde}
250	53.33^{def}	55.33^{abcd}	56.33^{ab}
300	53.33^{def}	55^{abcde}	57^{a}
LSD (5%)		1.339	

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

3.2.2. Growth Traits

The height of plants was significantly affected by variety and blended NPSB fertilizer while number of main stem/hill was significantly influenced only by variety (Table5). The interaction of variety x NPSB fertilizer had nonsignificant effect on growth (plant height and number of main stem) of potato crop. Belete had significantly highest number of main stem/hill and tallest plant height. Gudane had significantly higher number of main stem/hill than Jalane variety. The plant height of Gudane and Belete had nonsignificant differences, but the plant height of both varities was significantly highest than Jalane. This result is in agreement with the findings of [17] who reported that mineral fertilizers like nitrogen and phosphorus did not affect the number of main stem of potato crop.

Table 5. *Effect of variety on growth of potato at Boneya during 2020 cropping season.*

Variety	Plant height (cm)	Number of main stem/hill
Belete	70.14^{a}	6.75^{a}
Bubu	69.63^{a}	5.31^{b}
Shangi	66.56^{b}	3.09^{c}
LSD (5%)	2.896	0.725

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

The shortest plants were observed in plots that did not receive fertilizer whereas the tallest plants were observed in plots that received the highest rate of (300 kg ha^{-1} NPSB) fertilizer application. The height of plants without fertilizer application and the effect of 50, 100 and 150 kg ha^{-1} NPSB fertilizer had nonsignificant difference (Table 6).

Sharma, s.p *et al.* [19] reported that plant height increased with increasing fertilizer levels of nitrogen and phosphorus. This could be attributed to the enhanced availability of nutrients to the crop which may have resulted in increased photosynthetic efficiency and increased metabolic activities of the plant with an increase in fertilizer level. The results of the present study are in line with the findings of various researchers where potato plant heights and stem shoot numbers were increased with the application of sulfur containing fertilizers [26].

Table 6. *Effect of blended NPSB fertilizer on plant height of potato varieties at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Plant height (cm)
0	64.31^{c}
50	65.29^{bc}
100	68.04^{abc}
150	69.2^{abc}
200	70.96^{ab}
250	71.24^{ab}
300	72.41^{a}
LSD (5%)	4.423

Mean values followed by the same letter(s) within columns had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

3.3. Yield Components and Tuber Yield

3.3.1. Average Tuber Number and Weight

Both main effect of Variety and blended NPSB fertilizer and the interaction of the two factors were significantly influenced average tuber number and average tuber weight. Average tuber number per hill increased as the rate of blended NPSB fertilizer increased. The highest tuber number per hill was obtained from Gudane at fertilizer application of (200 kg NPSB ha^{-1}), which was (12.73) higher than the lowest tuber number (4.03) per hill produced by Jalane with fertilizer application of (150 kg of NPSB ha^{-1}) (Table 7). The increment due to increasing rates of fertilizer was not more than seven tubers per hill for all the three varieties.

The current results are similar with the findings of [28] who reported that increasing the application of nitrogen and phosphorus increased total tuber number per hill. Increased rates of blended NPS fertilizer increased average tuber weight for all varieties. The highest values for Belete and Gudane was recorded (90.64 g) and (71.82g) respectively at rate of (300 kg NPSB Kg ha^{-1}). The highest (76.65 g) value for Jalane variety was recorded at rate of (200 NPSB kg ha^{-1}) and the lowest was recorded at unfertilized plots and at lower rates of blended NPSB fertilizer application (Table 7).

The increase in average tuber weight of potato with the supply of fertilizer nutrients could be due to more luxuriant growth, more foliage and leaf area and higher supply of photosynthesis, which helped in producing bigger tubers, hence resulting in higher yields. In agreement with the present finding, [25, 17] have reported a significant increase in average tuber weight in response to nitrogen application.

Table 7. *Interaction effect of blended NPSB fertilizer and variety on average tuber number and tuber weight of potato varieties at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Average tuber number			Average tuber weight (g)		
	Variety			Variety		
	Belete	Gudane	Jalane	Belete	Gudane	Jalane
0	9^{abcd}	7.53^{abcd}	4.97^{bcd}	62.91^{cde}	42.98^{e}	60.87^{cde}
50	7.78^{abcd}	10.8^{abc}	4.93^{bcd}	61.21^{cde}	69.28^{abcd}	61.68^{cde}
100	7.93^{abcd}	10.27^{abcd}	4.6^{cd}	69.76^{abcd}	57.03^{de}	73.47^{abcd}
150	7.77^{abcd}	11.23^{ab}	4.03^{d}	82.96^{abc}	64.55^{cde}	65.07^{cde}
200	10.35^{abcd}	12.73^{a}	5^{bcd}	65.28^{cde}	71.63^{abcd}	76.65^{abcd}
250	12.27^{a}	9.53^{abcd}	5.23^{bcd}	88.44^{ab}	61.44^{cde}	68.14^{bcd}
300	9.07^{abcd}	10.43^{abc}	11.01^{ab}	90.64^{a}	71.82^{abcd}	58.39^{de}
LSD (5%)	3.393			4.199		

Mean values followed by the same letter(s) in columns and rows of each traits had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at $P < 0.05$.

3.3.2. Distribution of Tubers in Different Size Categories

The proportion of large tuber size was significantly influenced by the main effect of variety and by the interaction of two factors but not by the main effect of blended NPSB factor, and small tuber size was significantly influenced by both main effect of blended NPSB fertilizer and variety and by the interaction of the two factors. However medium tuber size was only significantly influenced by the interaction of two factors but not by both main effect of variety and blended NPSB fertilizer.

As the rate of blended NPSB rates increased, the proportion of large tuber size increased in variety Belete, Gudane and Jalane by 37.1, 9.2, and 0.1% at highest rate of (300 kg NPSB kg ha^{-1}) fertilizer application respectively as compared to unfertilized plots. Similarly as the rate of blended NPSB fertilizer increased, Jalane and Gudane variety increased the percent of medium tuber size by 6.21% and 1.46% at highest rate of (300 Kg NPSB ha^{-1}) fertilizer application respectively, than plots not received fertilizer. Whereas Belete variety decreased the percent of medium tuber size by 8.35% at (300 Kg NPSB ha^{-1}) fertilizer application than plots not received fertilizer (Table 8).

This could be due to the interaction of nutrients in blended fertilizer and remobilization of stored food from tubers because of fast growth of aboveground biomass due to increased rates of nitrogen fertilizer.

Table 8. *Interaction effect of blended NPSB fertilizer and variety on large tuber size and medium size proportion (%) at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Large tuber size (%)			Medium tuber size (%)		
	Variety			Variety		
	Belete	Gudane	Jalane	Belete	Gudane	Jalane
0	43.72^{c}	65.7^{abc}	72^{ab}	23.47^{ab}	17.84^{bcde}	13.38^{de}
50	71.53^{ab}	64.3^{abc}	76.1^{ab}	17.42^{bcde}	19.04^{abcde}	16.43^{cde}
100	68.3^{abc}	79.7^{ab}	69.7^{ab}	20.9^{abc}	13.21^{de}	15.42^{cde}
150	72.4^{ab}	76.9^{ab}	54.8^{bc}	20.69^{abc}	16.27^{cde}	19.66^{abcd}

200	86.1^{a}	78.5^{ab}	73.6^{ab}	12.28^{e}	17.66^{bcde}	24.7^{a}
250	74.4^{ab}	77.1^{ab}	73.7^{ab}	16.63^{cde}	18.34^{abcde}	20.92^{abc}
300	80.8^{a}	74.9^{ab}	72.1^{ab}	15.12^{cde}	19.3^{abcd}	19.59^{abcd}
LSD (5%)	13.44			6.765		

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

As the rate of blended NPSB fertilizer increased, the percent of small tuber size decreased by 16.77%, 15.13% and 5.74% at highest rate of (300 Kg NPSB ha^{-1}) fertilizer application for Belete, Gudane and Jalane respectively, as compared to unfertilized plots (Table 9). Generally, the present result showed that increasing the rate of blended NPSB fertilizer application decreases the proportion of small-size tubers.

The result of the present finding similar with authors, [27] who stated that increased in yield of tubers with increase in applied nitrogen was associated with increases in the number of tubers in the medium and large categories at the expense of the small ones due to increase in the weight of individual tubers.

Table 9. *Interaction effect of blended NPSB fertilizer and variety on small tuber size proportion (%) at Boneya during 2020 cropping season.*

Character	**Small tuber size (%) variety**		
Blended NPSB (kg ha^{-1})	**Belete**	**Gudane**	**Jalane**
0	20.88^{a}	19.22^{a}	10.7^{b}
50	10.3^{b}	10.3^{b}	7.48^{bcd}
100	10.48^{b}	7.18^{bcd}	9.93^{bc}
150	5.8^{bcdef}	6.54^{bcde}	6.44^{bcde}
200	1.32^{f}	3.83^{def}	1.6^{ef}
250	8.38^{bcd}	4.61^{def}	5.08^{cdef}
300	4.11^{def}	4.09^{def}	4.96^{def}
LSD (%)	2.623		

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

3.3.3. Marketable, Unmarketable and Total Tuber Yield

Marketable tuber yield and total tuber yield was significantly influenced both by main effect of blended NPSB fertilizer and variety but, not significantly influenced by interaction of the two factors. Moreover unmarketable tuber yield was significantly influenced by both main effects of variety and blended NPSB fertilizer and interaction of the two factors.

Increasing blended NPSB fertilizer application generally increased marketable tuber yields and total tuber yields of the tested potato varieties. The highest marketable tuber yield and total tuber yields of (30.74 t ha^{-1}and 32.25 t ha^{-1}) was recorded at the rate of (300 kg NPSB ha^{-1}) fertilizer application respectively. But the lowest marketable tuber yield and total tuber yield of (18.24 t ha^{-1} and 24.03 t ha^{-1}) was recorded from unfertilized plots respectively (Table10).

Results of the present study revealed that application of blended NPSB fertilizer increased marketable and total tuber yields of Potato varieties. The increased in yield of tubers with increase in applied nitrogen was associated with increases in the number of tubers in the medium and large categories at the expense of the small ones due to increase in the weight of individual tubers [27]. The varieties exhibited differential yielding ability in the study area. Belete and Bubu produced significantly higher total tuber yield (32.41 and 31.07 t ha^{-1}) than Jalane (15.98 t ha^{-1}) varities. Similarly Gudane, and Belete produced highest Marketable tuber yield (29.52, 29.48 t ha^{-1}), respectively, than Jalane (14.30 t ha^{-1}) varieties (Table 10).

The variation in total yield of potato genotypes may be due to differences in response to the growing environmental factors. This is in agreement with finding of other authors, who reported that yield differences among genotypes were attributed both to the inherent potential of genotypes and growing environment as well as to the interaction of genotype x environment [28].

Table 10. *Main effect of blended NPSB fertilizer and variety on marketable and total tuber yield at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg ha^{-1})	Marketable tuber yield (t ha^{-1})	Total tuber yield (t ha^{-1})
0	18.24^{c}	23.77^{b}
50	22.90^{bc}	24.82^{b}
100	23.31^{bc}	24.85^{b}
150	24.32^{b}	25.61^{b}
200	24.74^{b}	26.08^{b}
250	26.78^{ab}	28.10^{ab}
300	30.74^{a}	32.16^{a}
LSD (5%)	4.008	4.021
Variety		
Gudane	29.52^{a}	31.98^{a}
Belete	29.48^{a}	32.41^{a}
Jalane	14.30^{b}	15.98^{b}
LSD (5%)	2.624	2.633

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at $P < 0.05$.

The highest unmarketable tuber yield of Belete (6.70 t ha^{-1}), Jalane (5.12 t ha^{-1}) and Gudane (4.77 t ha^{-1}) was obtained from the plots that did not receive fertilizer application (Table 11). The result shows those unmarketable tuber yields were decreased significantly when the rate of blended NPSB rate was increased. This may be due to the decreased level of phosphorus, might have decreased the growth above ground biomass, tuber growth, leading to reduced tuber size and there by high unmarketable tuber yield.

Table 11. *Interaction effect of blended NPSB fertilizer and variety on unmarketable tuber yield at Boneya during 2020 cropping season.*

Blended NPSB fertilizer (kg	Variety

ha^{-1})	Belete	Gudane	Jalane
0	6.70^{a}	4.77^{b}	5.12^{b}
50	2.88^{cd}	0.64^{gh}	1.10^{fgh}
100	1.38^{fgh}	1.34^{fgh}	1.31^{fgh}
150	2.08^{cdef}	0.72^{gh}	1.09^{fgh}
200	1.79^{defg}	1.55^{efgh}	0.93^{fgh}
250	2.64^{cde}	0.56^{h}	0.78^{gh}
300	3.09^{c}	1.28^{fgh}	1.39^{fgh}
LSD (5%)	0.6514		

Mean values followed by the same letter(s) within columns (each trait) had nonsignificant difference at 5% probability level. LSD (5%) = least significant difference at P < 0.05.

4. Conclusion

Three potato varieties, Belete, Gudane and Jalane, were used with seven rates of blended NPSB fertilizers (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}). The experiment was tested in factorial arrangement in randomized block design with three replications. The experiment was conducted at Boneya district, at central highlands of Oromia region during 2020 main cropping season. The results of analysis of variance indicated that, days to 50% maturity, plant height, marketable tuber yield, and total tuber yield were significantly affected by the main effects of blended NPSB rates and potato variety. Significantly delayed 50% maturity (91.78 days) and tallest plant height (72.41cm) recorded at highest (300 NPSB kg ha^{-1}) rate of fertilizer application. The highest marketable tuber yield (30.74 t ha^{-1}) and total tuber yield (32.16 t ha^{-1}) was recorded at rate of (200 NPSB kg ha^{-1}). But Days to 50% emergency and main stem number was significantly affected only by main effect of variety. Gudane took the least days to 50% emergence (12.9 days) over the other two varieties, while Belete and Jalane took the longest days to 50% emergence (13.24 days) and (13.81days) respectively without significant difference between the latter two. Belete and Gudane produced significantly higher number of main stems (6.75, 5.31) per hill respectively than Jalane (3.09).

The interaction of blended NPSB rate and potato variety also significantly affected days to 50% flowering, average tuber number, average tuber weight, large tuber size, medium tuber size, small tuber size and unmarketable tuber yield. Significantly delayed 50% flowering of Belete (53.33 days), Gudane (55 days), and Jalane (57 days) was recorded at highest rate of fertilizer application (300NPSB kg ha^{-1}). Highest average tuber number of Belete (12.27), Gudane (12.73) and Jalane (11.01) was recorded at rate of (250, 200, 300 NPSB kg ha^{-1}) of fertilizer application without significant difference among them. The highest average tuber weight of Belete (90.64g), and Gudane (71.82g) was recorded at highest rate of fertilizer application (300 NPSB kg ha^{-1}), and (76.65g) was recorded for Jalane at rate of (200 NPSB kg ha^{-1}) fertilizer. Therefore, the growing of Gudane and as second option Belete variety with the application of highest NPSB fertilizer rate of (300 kg ha^{-1}) could be recommended in the study area according to my investigation.

5. Recommendation

However, since the experiment was conducted for one season at one location, it suggested that the experiment has to be repeated over seasons and locations using this and other improved potato varieties in order to give a comprehensive recommendation for farmers potato producer.

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