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Optimum Rate of Blended Fertilizer and Urea Determination for Potato Production under Irrigation Condition in Holetta Research Center, West Showa, Ethiopia

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Abstract

Potato is an important food and cash crop in Ethiopia, especially in the high and mid-altitude areas. Lack of scientific recommendation of fertilizer rate to popular varieties limited crop yield, especially under irrigation potential. The research was conducted in Holetta Agricultural Research Center, under irrigation during 2019-2020 off-season to find and recommend the NPSB blended fertilizer and urea rates for potato using rates of blended NPSB + urea (0, 150 + 150, 200 + 150, 250 + 150, 300 + 150, 150 + 250, 200 + 250, 250 + 250, 300 + 250, 150 + 350, 200 + 350, 250 + 350, 300 + 350) kg/ha and recommended 195 kg/ha DAP + 165 kg/ha urea fertilizer and two varieties Belete and Gudenie. The treatment combinations were arranged in randomized complete block design in factorial arrangement with three replications. The results showed that the rates, variety and interactions were found highly significant for total and marketable tuber yield t/ha, total and marketable tuber number, average tuber number and weight, stem number and height. From these results, it can be concluded that the responses of potato varieties Belete and Gudenie to NPSB+ urea were highly significant on yield and yield components. Even though, it needs location replication with growing season to offer responsible recommendation, it is better to apply 300 kg/ha NPSB + 150kg/ha urea to the Belete potato variety and 150 kg/ha NPSB + 250 kg/ha urea to Gudenie potato variety for high yield and high economic return in Holetta and areas with similar soil type and agro-ecologies under irrigationie.

Keywords

Recommended Urea and DAP, NPSB, Belete and Gudenie potato varieties

1. Introduction

Potato (solanum tuberosu L.) is an important crop in many parts of Ethiopia and it ranks first among root and tuber crops in volume of production and consumed followed by Cassava, Sweet potato and Yam [1]. According to [2], potato is a high potential food security crop in Ethiopia because of its high yielding potential, nutritional quality, short growing period and wider adaptability. Based on area coverage it is second crop in Ethiopia next to Enset (Ensete ventricosum L.) [3]. Potato is an important food and cash crop in central highlands of Ethiopia. The potential attainable average yields of the crop on research and farmers' fields are 45 and 25 tons/ha, respectively, while the national average production is limited to about 12.3 tons/ha [4, 1]. Potato is an important food and cash crop in Ethiopia, especially in the high and mid altitude areas. It plays good role in improving the quality of the basic diet in both rural and urban areas of the country [5].

Potato cropping systems help to improve resilience especially among smallholder farmers by providing direct access to nutritious food, increasing household incomes and reducing their liability to food price instability [6]. In Ethiopia, its 'meher' season production area has reached about 66, 926 ha, total production of 921,403.2 ton cultivated by over 1.2 million households [1]. On the other hand, the productivity of this crop in the country is very low (13.8 t ha^{-1}) compared to the world's average yield of 19 t ha^{-1} [1]. Utilization of different cropping seasons with in a year especially, irrigation and belg production season was one problem among production declining factors for potato crop. In addition, supporting these two diseases free (late blight) excusing production seasons have double importance for farmers by increasing yield and decreasing cost spent for chemicals to control late blight diseases. Less attention was given from the government and research centers to develop appropriate technology that best go with such growing conditions accompanied by water shortages. These conditions require both short maturing crops and drought tolerant varieties.

Optimal crop production and good quality product is a result of balanced fertilization. In balanced fertilization, soil nutrient content and crop requirement should meet each other. The amount of nutrient depleted per year should be balanced with the amount of fertilizers applied in the year. Use of balanced fertilizers in deficient soils can improve fertilizer-use efficiency and crop profitability. Fertilizer determination research works carried earlier have been limited to the two common macro nutrients (N and P) and hence the effects of blended fertilizers have not been studied. The ratio of NPSB in blended fertilizer is N: 18.9 P: 37.7, S: 6.95, B: 0.1 [7].

New fertilizer materials with value addition and fortification with secondary and micro nutrients would be required to ensure balanced fertilizer use involving most of the nutrients required by crops [8]. Optimum management of water resources at the farm level is needed in view of increasing water demands, limited resources, and aquifer contamination [9]. When irrigation is required there are many available methods and management strategies. The selection of the method and approach depends on factors such as water availability, crop type, soil characteristics, land topography and associated cost [10]. Furrow irrigation is one of the most frequently used surface irrigation methods in the world [11]. This irrigation method is used mainly to irrigate row crops and orchards. Nowadays, furrow irrigation's importance was gaining attention because of the high cost of energy in pressurized irrigation methods and the incorporation of automation in its operation [10].

The formulation blending fertilizers based on actual need is determined by the combination of crop requirement and soil test level. Lack of appropriate fertilizer blends micro nutrients in fertilizer blends is a national problem constituting a major constraint to crop productivity. The recent completed research and soil tests through the Ethiopian Soil Information System Project, revealed that Ethiopian soils are deficient in various other nutrients that are not provided by DAP and urea [12]. This research was conducted because of lack of research recommendation to the newly formulated fertilizers NPSB (18.9% N, 37.7% P_2O_5, 6.95% S, and 0.1% B) to overcome soil nutrient deficiencies. Scientific recommendation of fertilizer rate to popular varieties was limited especially under irrigation potential. Poor soil fertility and lack of appropriate fertilizer blends recommendations of micronutrients are the major constrains to crop production. Therefore, this research was conducted to identify and recommend the optimum rate of NPSB blended fertilizer + urea for potato cultivars under irrigation in Holetta Research Center.

2. Materials and Methods

The research was conducted in Holetta Agricultural Research Center during 2019-2020 off-seasons comprising two factors; improved potato varieties (Gudenie, Belete) and fertilizer treatments NPSB + Urea fertilizer [0, 300 + 150, 200 + 250, 300 + 350, 200 + 150, 250 + 250, recommended DAP (195) and Urea (165), 300 + 250, 150 + 350, 150 + 150, 250 + 150, control, 200 + 350, 250 + 350, 150 + 250] kg /ha. The blended NPSB contains 18.9% N, 37.7% P_2O_5, 6.95% S and 0.1% B while DAP contains 46 % P and 18 % N. But, urea contains 46% N. The treatment combinations were arranged in randomized complete block design in three replications. Each plot had 4.5 meter width and 3 m length which forms a block holding 28 treatment or plot. The distance between block was 1.5 meter and between consecutive plots was 1 meter.

2.1. Experimental procedures

The land was prepared well by tractor plowing three times until fine tilth was achieved in similar ways of land preparation rule for potato fields in Holetta research center. Sprouted medium-sized seed tubers were planted according to the specified treatments in 75 cm distance between rows and 30 cm between plants. Cultivation, weeding and harvesting was done at the appropriate time according to the research recommendations. The soil analyses were done before planting, taking soil samples from a depth of 20-30 cm.

2.2. Fertilizer application, Harvesting and other cultural practice

Application of blended NPSB and half urea fertilizers at specified rates was done by banding the granules of fertilizers at depth of 5-10 cm and 5 cm away from the seed tuber at planting time while half remaining urea applied at 45 days after planting. The experimental field was irrigated before and after planting. After planting, irrigation was done every seven days to field capacity in all the experimental plots by furrow irrigation method. Ten days before harvesting, the haulms of the potato plants were removed using a sickle. Tuber harvesting were done once at proper physiological maturity attainment (70% leaves withering) as described by [13].

2.3. Data collections

Number of main stem /hill, plant height (cm), average tuber number/hill, average tuber weight/ hill, total and marketable tuber number per plot, total and marketable tuber yield t/ha were collected.

2.4. Statistical Data Analysis

Data were subjected to analysis of variance (ANOVA) for Randomized Complete Block Design in factorial arrangement by using GLM (general linear model) procedure of SAS 9.2 software [14]. All significant pairs of treatment were compared with the Least Significant Difference (LSD) at 5% significance level and the partial budget analysis was conducted for the fertilizer rates.

2.5. Economic Analysis

Simple partial budget analysis was employed for economic analysis of fertilizer application and it was carried out for average marketable tuber yield data. The possible response of the crop towards the added fertilizer and price of fertilizer during planting finally determines the economic feasibility of fertilizer application [15].

3. Result

3.1. Soil Physico-Chemical properties of Experimental Site

The result of laboratory analysis selected physico-chemical properties of the soil of excremental site was presented in Table 1. The pH of the soil before planting was 5.08. The cation exchange capacity (CEC) of the experimental site was 21.54 meq/100 g soils. The analysis of available P, total N, S and B indicated the experimental soil had value of 8.641 ppm, 0.11%, 3.9% and 0.36 mg/kg, respectively. Based on soil analysis result, the experimental site had clay 53.5%, silt 36.5% and sand 10% and categorized as clay loam textural classes.

Table 1. Soil Physical properties of the experimental site before planting

Result /Parameters tested	Value	Physical properties	Values
pH	5.08.	% Clay	53.5
CEC (meq/100g)	21.54	% Silt	36.5
P ppm	8.641	% Sand	10
N (%)	0.11	Texture class	Clay loam
S (%)	3.9		
Av. B (mg/kg)	0.36		

3.2. Number of main Stems Per hill

The analysis of variance showed that the growing year, fertilizer rates, variety and interaction of fertilizer rates and variety highly significantly affected ($P<0.001$) the number of stem number (Table 2 and Table 3). The highest (4.55 stem number was recorded from 300 NPSB + 150 urea the fertilizer treatment while the lowest (3.18) stem number was recorded from 300 NPSB +250 urea kg/ha. The recommended DAP and Urea provided SN (4.03) which was significantly different from the highest SN scored from (300 NPSB + 150 urea). The highest (3.98) stem number/hill was recorded from Gudenie variety while the lowest (3.07) stem number was recorded from Belete. Significantly higher stem number (4.7) per hill was produced in 2019 than 2020 (2.35). In the interaction effect of NPSB + urea and varieties, this highest (4.05) stem number was recorded from Gudenie variety, the highest (5.05) stem number was produced at 300 NPSB+150 urea fertilizer treatment, while the lowest (3.43) was recorded from 300 NPSB + 250 urea.

3.3. Plant Height

The analysis of variance showed that the NPSB + urea fertilizer rates, variety and growing year as well as the interactions of fertilizer rate and variety were highly significant in affecting ($P<0.001$) the plant height (Table 2 and Table 3). The highest plant height (87.75 cm) was recorded in 200 NPSB + 250 urea kg/ha followed by 86.52 cm and 85.5 cm at 300 NPSB +350 urea kg/ha and 200 NPB+350 urea kg/ha, respectively while the lowest plant height (64.26 cm) was recorded from control treatment. The recommended DAP and urea's plant height was significantly lower than the highest result mentioned above. The taller plant height was produced by Gudanie and 2020 production year. In the interaction, the highest plant height (90.43 cm) was recorded from variety Belete at 300 NPSB + 150 urea kg/ha fertilizer treatment while the lowest plant height (65.50 cm) produced from control. The recommended DAP and urea provided significantly lower plant height than the highest plant height mentioned above. Variety Gudenie produced the highest (87.81 cm) plant height at 300 NPSB + 350 urea fertilizer treatments while the lowest (63.03 cm) one was recorded from control. Recommended DAP and urea gave significantly lower plant height (73.38 cm) with Gudenie variety than the highest plant height mentioned for Gudenie.

Table 2. Effect of fertilizer rates, variety and growing season on stem number, plant height, yield and yield component

Fertilizer NPSB+Urea kg/ha	SN	PH	ATN	ATW	TTN	MTY t/ha	TTY t/ha	MTN
0	3.37cdefg	64.26h	6.62g	0.61g	154.83h	22.96h	28.25h	100.42g
300+150	4.55a	77.75defg	9.54bc	0.92bc	271.92a	36.36b	42.27b	180.54a
200+250	3.64c	87.75a	8.10f	0.77f	233.83efg	29.85g	34.01g	157.83ef
300+350	3.36cdefg	86.52a	8.77d	0.82e	242.92de	32.95ef	37.07ef	175.50abc
200+150	3.63c	78.60def	9.39bc	0.91bc	240.08def	35.74bc	39.27d	168.00cd
250+250	3.49cde	83.03c	9.12cd	0.84e	262.58ab	33.74de	37.38e	178.50ab
195 DAP+165urea	4.03b	75.53g	8.21f	0.85de	240.42def	33.06ef	37.43e	171.75bc
300+250	3.09g	83.71bc	9.61b	0.91bc	269.00a	34.92cd	40.60c	151.67f
150+350	3.18efg	76.31fg	8.23ef	0.85e	225.92g	33.84de	35.88f	161.17de
150+150	3.46cdef	79.02de	8.69de	0.82e	239.58def	31.74f	36.47ef	155.67ef
250+150	3.67c	76.80efg	10.27a	0.93b	256.25bc	34.73cd	41.94b	162.25de
200+350	3.23defg	80.06d	9.15bcd	0.89bcd	246.83cd	34.54cd	39.49cd	158.08ef
250+350	3.54cd	85.50ab	8.73d	0.89bcd	232.00fg	34.75cd	39.24d	159.42ef
150+250	3.14fg	77.44efg	8.81d	0.98a	232.83efg	38.44a	43.63a	176.17abc
LSD	0.3486	2.4252	0.4732	0.0385	10.147	1.3552	1.2935	8.4976
P-VALUE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Variety								
Belete	3.07b	81.92a	9.00a	1.00a	237.30b	38.79a	44.38a	160.71
Gudenie	3.98a	76.98b	8.61b	0.72b	241.13a	28.00b	31.75b	161.71
LSD	0.1318	0.9166	0.1789	0.0146		0.5122	0.4889	
P-value	<0.0001	<0.0001	<0.0001	<0.0001	NS	<0.0001	<0.0001	NS
Growing year								
2019	4.70a	60.14b	8.91a	0.70b	205.35b	24.48b	31.47b	105.02b
2020	2.35b	98.76a	8.70b	1.02a	273.08a	42.32a	44.67a	217.41a
LSD	0.1318	0.9166	0.1789	0.0146	3.8351	0.5122	0.4889	3.2118
P-value	<0.0001	<0.0001	0.0271	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
CV	12.22	3.77	6.643	5.55	5.24	5.01	4.00	6.52

SN = stem number, PH = plant height in cm, ATN = Average tuber number per plant, ATW = Average tuber number per hill in kg, TTN = Total tuber number per plot, MTN = Marketable tuber number per plot, TTY t/ha = Total tuber yield ton per hectare, and MTY t/ha = marketable tuber number ton per hectare.

3.4. Average Tuber Number (ATN)

The analysis of variance showed that effect of blended fertilizer NPSB, varieties and the interaction of variety and fertilizer rates were highly significant in affecting ($P<0.001$) average tuber number (Table 2 and Table 3) while the growing year effect was significant. The highest average tuber (ATN) number (10.27) and the lowest ATN (6.62) was recorded at fertilizer rates of 250 NPSB + 150 urea kg/ha and control consecutively. The recommended urea and DAP provided ATN (8.21) which was significantly highest ATN from control and lower from the highest average tuber number. The highest (9.00) average tuber number (ATN) was recorded from Belete variety while the lowest (8.61) average tuber number (ATN) was recorded from variety Gudenie not received fertilizers. In their interaction, the highest (10.36/hill) average tuber number was recorded from variety Belete at 200 NPSB + 150 urea kg/ha treatment and the lowest

(7.00/hill) average tuber number produced from Belete variety grown without fertilizers while Gudenie provided the highest 10.83 ATN/ hill at 300 NPSB + 150 urea kg/ha and lowest 6.24 ATN/hill at control treatment.

3.5. Average Tuber Weight (ATW)

Average tuber weight was highly significantly affected by blended fertilizer NPSB, variety, growing year and the interaction of NPSB and variety (p<0.001) (Table 2 and Table 3). The highest ATW 0.98 kg/hill observed on fertilizer rate 150 NPSB + 250 urea kg/ha and the lowest ATW 0.61 kg/hill was seen in control. The recommended urea and DAP provided 0.85kg/hill ATW which was significantly different from the highest average tuber weight scored from150 NPSB + 250 urea kg/ha. The highest 1.00 kg/hill average tuber weight was recorded from variety Belete while lowest 0.72 kg/hill average tuber weight was recorded from variety Gudenie. In the interaction, the highest 1.14 kg/hill average tuber weight was recorded from variety Belete at 250 NPSB + 150 urea kg/ha fertilizer treatment followed by 1.08 kg/hill at 300 NPSB kg/ha+150 kg/ha urea and 300 NPSB kg/ha and 250 kg/ha urea while the lowest 0.70 kg/hill average tuber weight obtained from control treatment. In line with this Gudenie provided its own highest 0.84 kg/hill ATW at 150 NPSB kg/ha+250 kg/ha urea and 300 kg/ha NPSB+150 kg/ha urea while the lowest for Gudenie was produced at control treatment.

3.6. Total Tuber Number (TTN)

The results of the analysis of variance showed that the effect of blended fertilizer NPSB, growing year, and the interaction of rates and variety were highly significant (P<0.001) (Table 2 and Table 3) while the variety was not significant. The highest TTN (271.92) was recorded at 300 NPSB + 150urea kg/ha followed by 269 TTN at 300 kg/ha NPSB + 250 kg/ha urea and 262.58 TTN at 250 kg/ha NPSB + 250 kg/ha urea while the lowest 154.58 TTN was recorded in control. The recommended DAP and urea provided 240.42 TTN which was significantly different from the highest TTN scored from 300 NPSB + 150 urea kg/ha. The application of blended fertilizer 300 NPSB kg/ha + 150 kg /ha urea increased total tuber number from 154.58 to 271.92 which could be calculated to 76 % increase. In 2020, the higher tuber number 273.08 was produced while in 2019 lower TTN 205.35 was harvested.

In interaction cases, the highest 270.17 total tuber number was recorded from Belete variety at 150 kg/ha NPSB + 150 kg/ha urea followed by 167. 50 TTN produced at 300 kg/ha NPSB + 150 kg/ha urea while Belete variety's lowest TTN 149.33 was produced from plots not treated with fertilizers. Gudenie provided its highest 284.50 TTN at 250 kg/ha NPSB + 150 kg/ha urea followed by 276.33 at 300 kg/ha NPSB + 150 kg/ha urea and 300 kg/ha NPSB + 250 kg/ha urea while lowest 160.33 total tuber number was recorded from control. Gudenie's highest 284.50 TTN was higher than Belete's highest TTN (267.17).

3.7. Marketable Tuber Number (MTN)

Based on the analysis of variance, the effect of blended fertilizer NPSB, growing year and the interaction of fertilizer rates and variety were highly significant (P<0.001) (Table 2 and Table 3). The highest 180.54 marketable tuber number was recorded from 300 kg/ ha NPSB +150 kg/ ha urea treatment and par with the treatments that received 250 kg/ha NPSB + 250 kg/ha urea (178.50/plot), 300 kg/ha NPSB + 350 kg/ha urea (176.17/plot) and 300 kg/ha NPSB + 350 kg/ha urea while the lowest 100.42 MTN was recorded from not fertilized plot. Applying 300 kg/ha NPSB + 150 kg/ha urea fertilizer increased MTN from 100.42 to 180.54 by 84 %. The recommended urea and DAP provided 171.75 MTN which was significantly lower than the highest MTN but, in par with MTN recorded at 250 kg/ha NPSB +250 kg/ha urea (178.50/plot), 300 kg/ha NPSB+350 kg/ha urea (176.17/plot) and 300 kg/ha NPSB+350kg/ha urea. Significantly higher 217.41 MTN was produced in 2020 while lower 105.02 MTN harvested from 2019 production season. The highest 190.83/plot marketable tuber number was recorded from Belete variety at 150 kg/ha NPSB+250 kg/ha urea followed by 187.00 which harvested from 150 kg/ha NPSB+ 150 kg/ha urea while the lowest 88.33/plot marketable tuber number was recorded from control. Gudenie gave its highest 208.00 MTN at recommended urea and DAP followed by 200.17 MTN at 300 kg/ha NPSB+ 350 kg/ ha urea while its lowest 112.50 MTN was harvested from control treatment. Application of 150 kg/ha NPSB+250 kg/ha urea to Belete Gave an advantage of increasing MTN from 88.33 to 190.83 which was 116%.

3.8. Total Tuber Yield (TTY t/ha)

The analysis of variance showed that the response of blended NPSB fertilizer, varieties, growing year, and the interactions of variety and rates were highly significantly affected (P<0.001) total tuber yield (Table 2 and Table 3). The maximum total tuber yield of 43.63 t/ha was produced on the application of 150 NPSB + 250 urea kg/ha while the lowest 28.25 t/ha total tuber yield (TTY) was recorded from control. It showed a 54.44% difference from control. Belete gave significantly higher 44.38 t/ha TTY while Gudenie produced 31.75 t/ha. Significantly higher 44.67 t/ha TTY was harvested in 2020 than in 2019(31.47 t/ha).

In the interaction of variety and rates, Belete gave its maximum 51.16 t/ha tuber yield at 300 kg/ha NPSB + 150 kg/ha urea followed by 49.92 t/ha at 150 kg/ha NSB+250 kg/ha urea while the lowest 33.26 t/ha tuber yield was recorded from control. Application of 250 NPSB + 150 urea kg/ ha to Gudenie triggered to produce maximum yield 39.09 kg/ha followed by 150 kg/ha NPSB + 250 kg/ha urea while the lowest yield 23.25 t/ha was obtained from control. Belete variety showed tuber yield increment from 33.26 to 51.16 t/ha as a result of increasing fertilizers from 0-300NPSB + 150 urea kg/ ha which is 54% while Gudenie provided the advantage of 68.13% tuber yield increase due to increasing fertilizers from 0 to150 kg/ha NPSB + 250 kg/ha urea.

Table 3. The interaction effect of fertilizer rates and variety on plant height, yield and yield component of Belete and Gudenie variety

Variety	Fertilizer NPSB+Urea kg/ha	**SN**	**PH(cm)**	**ATN/ plant**	**ATW (kg/ plant)**	**TTN/ plot**	**MTN/ plot**	**TTY t/ha**	**MTY t/ha**
Belete	0	**2.48**	**65.50**	**7.00**	**0.70**	**149.33**	**88.33**	**33.26**	**25.81**
	300+150	**4.05**	**79.99**	**9.27**	**1.08**	**267.50**	**176.33**	**51.16**	**44.33**
	200+250	**3.63**	**88.03**	**8.38**	**0.84**	**239.83**	**167.83**	**37.34**	**33.36**
	300+350	**2.65**	**85.23**	**7.88**	**0.94**	**214.17**	**150.83**	**42.94**	**37.21**
	200+150	**3.15**	**82.83**	**10.36**	**1.14**	**242.83**	**172.00**	**47.46**	**43.36**
	250+250	**3.05**	**80.68**	**9.03**	**1.04**	**252.50**	**184.33**	**46.23**	**40.83**
	195DAP +165urea	**3.58**	**77.68**	**7.93**	**0.93**	**224.50**	**135.50**	**40.31**	**34.84**
	300+250	**2.75**	**90.43**	**9.84**	**1.08**	**261.67**	**177.67**	**47.82**	**40.10**
	150+350	**2.91**	**74.71**	**8.79**	**0.93**	**245.33**	**163.83**	**41.53**	**39.86**
	150+150	**2.63**	**84.21**	**9.56**	**1.03**	**270.17**	**187.00**	**45.51**	**40.90**
	250+150	**3.03**	**82.13**	**9.71**	**1.01**	**228.00**	**141.33**	**44.79**	**35.71**
	200+350	**2.87**	**86.01**	**9.27**	**1.05**	**222.17**	**142.33**	**46.39**	**40.49**
	250+350	**3.40**	**87.79**	**9.37**	**1.05**	**241.33**	**171.83**	**46.75**	**41.58**
	150+250	**2.83**	**81.71**	**9.57**	**1.12**	**262.83**	**190.83**	**49.92**	**44.76**
Gudenie	0	**4.26**	**63.03**	**6.24**	**0.53**	**160.33**	**112.50**	**23.25**	**20.11**
	300+150	**5.05**	**75.52**	**9.81**	**0.77**	**276.33**	**184.75**	**33.39**	**28.40**
	200+250	**3.65**	**87.48**	**7.82**	**0.71**	**227.83**	**147.83**	**30.69**	**26.35**
	300+350	**4.08**	**87.81**	**9.66**	**0.70**	**271.67**	**200.17**	**31.20**	**28.68**
	200+150	**4.12**	**74.38**	**8.42**	**0.68**	**237.33**	**164.00**	**31.08**	**28.12**
	250+250	**3.93**	**85.38**	**9.22**	**0.64**	**272.67**	**172.67**	**28.54**	**26.65**
	195 DAP +165urea	**4.48**	**73.38**	**8.49**	**0.78**	**256.33**	**208.00**	**34.56**	**31.27**
	300+250	**3.43**	**77.00**	**9.39**	**0.75**	**276.33**	**125.67**	**33.39**	**29.74**
	150+350	**3.45**	**77.91**	**7.68**	**0.76**	**206.50**	**158.50**	**30.24**	**27.83**
	150+150	**4.29**	**73.83**	**7.82**	**0.62**	**209.00**	**124.33**	**27.43**	**22.59**
	250+150	**4.31**	**71.47**	**10.83**	**0.84**	**284.50**	**183.17**	**39.09**	**33.75**
	200+350	**3.60**	**74.12**	**9.02**	**0.73**	**271.50**	**173.83**	**32.59**	**28.59**
	250+350	**3.68**	**83.20**	**8.10**	**0.72**	**222.67**	**147.00**	**31.73**	**27.92**
	150+250	**3.45**	**73.18**	**8.06**	**0.84**	**202.83**	**161.50**	**37.34**	**32.12**
CV		12.22	3.77	3.77	5.55	5.24	6.52	6.52	5.01
P-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

SN = stem number, PH = plant height in cm, ATN = Average tuber number per plant, ATW = Average tuber number per hill in kg, TTN = Total tuber number per plot, MTN = Marketable tuber number per plot, TTY t/ha = Total tuber yield ton per hectare, and MTY t/ha = marketable tuber number ton per hectare.

3.9. Marketable Tuber Yield (MTY)

Marketable tuber yield was highly significantly affected by the blended NPSB fertilizer, varieties, growing year, and the interactions of variety and rates (Table 2 and Table 3). The highest 38.44 t/ha marketable tuber yield (MTY) was recorded from 150 NPSB + 250 urea kg/ha while the lowest 22.96 t/ha MTY was harvested from control. Belete variety provided significantly higher 38.79 t/ha MTY while Gudenie produced 28.00 t/ha lower MTY. In 2020, significantly higher 42.32 t/ha MTY was harvested while lower 24.48 t/ha MTY was recorded in the 2019 cropping season.

The blended fertilizer 150 NPSB+250 Urea kg/ ha applied on Belete resulted in the production of Belete's maximum 44.76 t/ha MTY followed by application of 300 kg/ha NPSB + 150 kg/ha urea, 44.33 t/ha MTY. 33.75 t/ha MTY was the maximum MTY of Gudenie harvested at the application of 250 kg/ha NPSB+150 kg/ha urea. Plot not received fertilizers gave the lowest MTY of 25.81 t/ha and 20.11 t/ha with Belete and Gudenie varieties respectively. When compared with control Belete variety showed a 73.42% MTY increase while Gudenie showed 68%.

3.10. Partial budget analysis

Table 4. Partial Budget analysis

NPSB	Urea	Variable Costs ETB	Maximum Cost ETB	Grows yield t/ha	Adjusted yield t/ha	Grows Benefit ETB	Net benefit ETB	Maximum Benefit ETB	Maximum Rate of Return%
				Belete					
0	0	0		25.81	23.23	232,290.00	232,290.00		
150	150	4,050	4,050	40.9	36.81	368,100.00	364,050.00	131,760.00	3,253.33
200	150	4,750	700	43.36	39.02	390,240.00	385,490.00	21,440.00	3,062.86
150	250	5,350	600	44.76	40.28	402,840.00	397,490.00	12,000.00	2,000.00
250	150	5,450	100	35.71	32.14	321,390.00	315,940.00		
243	165	5,547	97	34.84	31.36	313,560.00	308,013.00		
200	250	6,050	503	33.36	30.02	300,240.00	294,190.00		
300	150	6,150	100	44.33	39.90	398,970.00	392,820.00	98,630.00	98,630.00
150	350	6,650	500	39.86	35.87	358,740.00	352,090.00		
250	250	6,750	100	40.83	36.75	367,470.00	360,720.00	8,630.00	8,630.00
200	350	7,350	600	40.49	36.44	364,410.00	357,060.00		
300	250	7,450	100	40.1	36.09	360,900.00	353,450.00		
250	350	8,050	600	41.58	37.42	374,220.00	366,170.00	12,720.00	2,120.00
300	350	8,750	700	37.21	33.49	334,890.00	326,140.00		
				Gudenie					
0	0	0		20.11	18.10	180,990.00	180,990.00		
150	150	4,050	4,050	22.59	20.33	203,310.00	199,260.00	18,270.00	451.11
200	150	4,750	700	28.12	25.31	253,080.00	248,330.00	49,070.00	7,010.00
150	250`	5,350	600	32.12	28.91	289,080.00	283,730.00	35,400.00	5,900.00
250	150	5,450	100	33.75	30.38	303,750.00	298,300.00	14,570.00	14,570.00
243	165	5,547	97	31.27	28.14	281,430.00	275,883.00		
200	250	6,050	503	26.35	23.72	237,150.00	231,100.00		
300	150	6,150	100	28.4	25.56	255,600.00	249,450.00	18,350.00	18,350.00
150	350	6,650	500	27.83	25.05	250,470.00	243,820.00		
250	250	6,750	100	26.65	23.99	239,850.00	233,100.00		
200	350	7,350	600	28.59	25.73	257,310.00	249,960.00	16,860.00	2,810.00
300	250	7,450	100	29.74	26.77	267,660.00	260,210.00	10,250.00	10,250.00
250	350	8,050	600	27.92	25.13	251,280.00	243,230.00		
300	350	8,750	700	28.68	25.81	258,120.00	249,370.00	6,140.00	877.14

Price for 1kg potato was 8ETB and yield adjustment factor 10%.

The highest net benefit (397,490.00ETB) was gained from 150 kg/ha NPSB + 2,500 kg/ha urea followed by 300kg/ha on Belete variety (Table 4). The highest 98,630% maximum rate of return obtained from 300 kg/ha NPSB+150 kg/ha urea while the lowest 2,000% maximum rate of return was gained from 150 kg/ha NPSB + 2,500 kg/ha urea among undominated treatments (Table 4). This means, the investment return increased by 98,630.00% at an application rate of 300 kg/ha NPSB + 150 kg/ha urea. The highest 298,300.00 ETB net benefit from Gudenie variety was obtained at 250 kg/ha NPSB + 150 kg/ha urea whiles the lowest 18,0990.00 ETB net benefit gained from the control treatment (Table 4). The highest 18,350.00% maximum rate of return was gained from 300 kg/ha NPSB + 150 kg/ha urea while the lowest 451.11 % maximum rate of return was from 150 kg/ha NPSB + 150 kg/ha urea among un dominated treatment.

4. Discussions

The pH of the soil was 5.08 which is highly acidic according to the rating of [16]. The pH of the soil between 5.00 and 7.55 is found within a suitable range for crop Production [17]. According to [18] report, the pH range of most crops was 4-8 because of the variable optimum pH requirement of different crops. Potato requires the pH range for production is 4.5-7.5 [19]. Thus, the pH of the experimental soil is almost within the range for productive soils for the potato crop. The soil of experimental land was containing low level of available P [20] and total nitrogen [16]. Its particle size distribution was in clay loam class as each category was 53.5 % clay, 36.5 % silt, and 10 % sand. The Sulfur and Boron range was very low [16]. The soil was in general, in the low level of available macro nutrient p, total nitrogen, sulfur, and micronutrient boron. The potato grown under irrigation in the soils of Holetta Research Center requires higher addition of these lacking nutrient for the intended yield increase and soil nutrient balance.

Stem number was highly significantly affected by fertilizer rates, variety, and growing year. With growing fertilizer rates the stem number grew and reached a maximum at 300 kg/ha NPSB and 150 kg/ha urea. In agreement with the result, [21] reported that increasing the rates of blended fertilizers significantly increased the number of stem per hill. This author also indicated variability in stem numbers between varieties. In line with the result, [22] indicated that Belete and Gudenie produced a significantly higher number of main stems per hill (6.52 and 6.89), respectively. Similarly, [23] average main stem number per hill was significantly ($p < 0.01$) influenced by the interaction of the genotype and growing environment. The current study is again confirmed with the report of [24, 25] the number of stems per plant (hill) influenced by variety.

Similarly, plant height was also highly significantly affected by fertilizer rated, variety, growing environment, and interaction of rates and variety. In this result, the highest plant height (87.75 cm) was recorded in 200 NPSB + 250 urea kg/ha which is on par with 86.52cm and 85.5 cm at 300 NPSB + 350 urea kg/ha and 200 NPB + 350 urea kg/ha, respectively while the lowest plant height (64.26cm) was recorded from the control treatment. These results were in agreement with the finding of [21] who reported the highest plant height 65.9cm at the application of 350 kg NPSB/ha fertilizer while the lowest plant height 54.85 cm was recorded from unfertilized treatment. According to the report of [26], the tallest potato plants were observed in response to increasing the rate of NPS application to 272 and 281.75 kg/ha. Report of [27] also showed that maximum plant height of 92.66 cm was recorded against the application of 150 kg N/ha which was statistically higher than the rest of the treatments and the minimum 54.08 cm was found in the application of 0 kg N/ha. In line with this, the report of [28] also indicated increasing nitrogen 0 to 168 kg /ha increased the height of potato plants from 34.00 to 88.67 cm. In agreement with the report of [26] the longest plant height was observed on variety Belete supplied with 281.75 kg/ha NPS fertilizer. These results were in conformity with the following findings [23, 29, 30].

The average tuber number and weight were highly significantly affected by rates, variety, and interaction of variety and rates. The highest average tuber number and weight were recorded at 250 kg/ha NPSB+150 kg/ha urea and 150 kg NPSB + 250 kg/ha urea respectively while the lowest was harvested from an unfertilized plot. These results were in agreement with [27] finding that mentioned increasing the rate of nitrogen increase total tuber yield/plot, average tuber weight, marketable tuber weight, unmarketable tuber weight, and total tuber number/ plant. The present study is in line with the finding of [31] increasing the application of N increased highly significantly total tuber number per hill from 8.44 to 9.84. [23] also indicated that the number of tubers initiated by a particular cultivar could be influenced by the growing condition. [32] observed a considerable variation in tuber number among four cultivars. The report of [33] mentioned increasing application of blended fertilizers from 100% NPSB to 200% NPSB with N adjustment increased mean tuber weight of potato crop by about 11% and 16%, respectively over the control treatment. The present study is in agreement with the finding of [31] application of N and P significantly increased average tuber weight (ATW). The report of [30] pointed out increasing phosphorous rate resulted in increases in marketable tuber numbers, total tuber numbers, and average tuber weight. Similarly, [8] reported that potato planted in the highest rate of blended NPSZnB fertilizer (199 kg ha-1) recorded the highest average tuber weight.

According to the report of [21], the increment of average tuber weight is in response to the increased supply of blended NPSB fertilizer might be due to more fast growth, more foliage and increase in leaf area and higher supply of phosphorous-containing fertilizer, which may have induced formation of bigger tubers thereby resulting in higher average tuber weight. Boron does have a direct influence on yield or related attributes as it plays a great role in root development through which, it facilitates more nutrient-up take and more stolen development used to produce more tubers. This result is in agreement with [34] in which B fertilization significantly increased tuber number and yield, as well as Boron-up take in addition to available nitrogen and Boron in the soil after harvest. Boron plays role in tuber bulking through reverting plant vegetative growth to root growth by hormonal control and facilitating carbohydrate transport to root (https://levitycropscience.com/b-is-for-bulking-using-boron-to-increase-potato-yield/). Boron stabilizes calcium in the cell wall and acts in synergy with calcium to improve plant resistance to disease, pest, and environmental stresses [35]. Boron was reported as increasing tuber yield applied with sulfur [36]. In agreement with the finding of [21] the application of blended NPSB fertilizer increased the weight of tuber in all potato varieties as compared to growing of varieties without fertilizer application (control). In line with the finding, [22] variety Belete had about 30.3 and 29.75% higher tuber weight than Bubu. The present study is in agreement with the idea of different researchers like [37, 23, 38] yield differences among genotypes were attributed both by the inherent yield potential of genotypes and the growing environment as well as the interaction of genotype x environment.

The present study is in line with the finding of [31] increasing the level of applied N from 0 to 165 kg N/ha, increased total tuber yield by 94.14%. Similarly, the finding of [27] indicated that increasing the rate of nitrogen increase total tuber yield per plot, average tuber weight, marketable tuber weight, unmarketable tuber weight, total tuber number/plant, and small tuber size.

[30] also reported that as Phosphorous rate increases marketable tubers, total tuber numbers, average tuber weight were highly increased as result of responsiveness of potato as compared to other tuber crops. Similarly, [39] reported that the interaction of nitrogen and phosphorous were significantly affected the marketable tuber. According to the report of [8] increasing blended NPSZnB fertilizer rate from 0 to 199 kg/ha increased marketable tuber number from 4.16 to 5.89/hill with non significant effect on unmarketable tuber number. In agreement with these, the report of [26] increasing NPS application rates marketable tuber yield of potato was highly significantly affected the main effect of NPS rate and potato variety.

5. Conclusion

This study revealed that there was a significant difference among the yields and yield components due to fertilizer rates. There was an interaction effect due to fertilizer rates and variety for any parameter considered. From this, it can be concluded that the fertilizer rates of NPSB + urea highly significantly affected the yield and yield component of potato under irrigation. Therefore, it is better to apply 300 kg/ha NPSB + 150kg/ha urea to the Belete potato variety and 150 kg/ha NPSB + 250 kg/ha urea to Gudenie potato variety for high yield and high economic return in Holetta and areas with similar soe il type and agro-ecologies under irrigation for both Belete and Gudenie.

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