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Effect of NPS Fertilizer Rates on Yield and Yield Components of Potato (*Solanum Tuberosum L.*) on the Highlands of Bale, South Eastern-Ethiopia

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Abstract

Potato *(Solanum tuberosum L.)* is one of the most widely grown tuber crops in the highlands of Bale. However, the productivity is low due to poor agronomic practices, diseases, insect pests and other biotic and abiotic factors. Therefore, an on-farm experiment was conducted to determine the effect of NPS fertilizer rates on yield components and yield of potato and to recommend the most economically feasible rate of NPS fertilizer for potato production. Analysis of variance revealed that days required to reach 50% of flowering and 90% of physiological maturity were significantly affected by the main effects of NPS fertilizer and varieties while plant height, number of stems per hill, number of marketable tubers per plot, number of unmarketable tubers per plot, marketable tuber yield, unmarketable tuber yield and total tuber yield were highly significantly affected by the application of NPS fertilizer. The maximum plant height was recorded from 250 kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}). The highest number of marketable tubers and unmarketable tubers per plant marketable tuber yield and unmarketable tuber yield were obtained from 200 kg NPS $ha^{-1}$and prior recommended rate of UREA (165 N kg ha^{-1}). The highest total tuber yield (34.77 t ha^{-1}) was obtained from 200 kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}). Partial budget analysis also revealed that the highest net benefit (62576 ETB ha^{-1}) with marginal rate of return (114.5 %) was gained from application of 200 Kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}). Therefore, based on the results of the yield, yield parameters and Paritial Budget Analysis, the application of 200 Kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}) can be recommended for potato production on the highlands of Bale.

Keywords: Potato; Marketable tuber; NPS fertilizer; Tuber yield

Introduction

Potato (*Solanum tuberosum* L.) belongs to the family *Solanaceae* and genus *Solanum* [18]. On a global scale, in volume of production potato ranks the fourth most cultivated food crop after wheat, rice, and maize, with an estimated area of 19 million hectares [6]. In Ethiopia, among root and tuber crops potato ranks first in volume of production and consumption followed by sweet potato, enset, yam and taro [4]. The potato tuber is well known to supply carbohydrate, high quality protein, essential vitamins, minerals and trace elements. Potato is a plant that consumes large quantities of nutrients and capitalizes better mineral and organic fertilizers applied. It demands high levels of soil nutrients due to its relatively poorly developed, coarse, and shallow root system [19]. It also produces much more dry matter in a shorter life cycle that results in large amounts of nutrients removed per unit time [10].

Nitrogen is the one most often limiting nutrient for potato growth by increasing the proportion of larger-sized tubers. Phosphorus has various effects on tuber quality, since it functions in cell division and synthesis and storage of starch in the tubers and increases the size and percentage of dry matter of the tubers. Sulfurplays an important role in chlorophyll formation and therefore helps to give plants their green color. Sulfur is known to take part in many reactions in all living cells [16]. Potato is one of the most important and widely produced tuber crops on the highlands of Bale. However, its yield is limited by a number of biotic and abiotic factors, including decline in soil fertility, use of low yielding varieties, poor agronomic practices as well as diseases and other pests.

There is little information on the impact of different types of fertilizers except nitrogen and phosphorous on the yield and other traits of potato on the highlands of Bale. According to the soil fertility map made over 124 Woradas of Oromia, most soils lack about seven nutrients (N, P, K, S, Cu, Zn and B) (EthioSIS, 2014). Based on the EthioSIS (Ethiopian soil Information System) soil analysis report of 2014, the soils of Sinana and Sinja areas of Bale lacks S in addition to the N and P. Therefore, the objective of the study was:

Therefore, the objectives of the study were;

- To determine the effect of NPS fertilizer rates on yield and yield components of potato varieties and recommend the best and economically feasible rate of NPS fertilizer.

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Materials and Methods

Description of Study Area

The experiment was conducted at Sinana (station) and Sinja during 'Gena' cropping season for three years from 2020/21-2021/22. Sinana is located 07o 07'10.837" N latitude and 040o 13'32.933" E longitude; and (2400 m a.s.l.) and it is found 463 km south east of Finfinnee and 33km East of Robe, the capital of Bale zone. Its annual rain fall is 860 mm, maximum tempireture is 21°C and minimum temperature is 9°C. Sinja is located 50km away from Sinana and about 10km from Robe in the Southwest direction and it is about 2650 m.a.s.l. Its annual rainfall is 940 mm and maximum temperature is 20°C and minimum temperature is 7°C. Both areas have Vertisols type. All the locations have bimodal rainfall patterns. The major crops grown widely at those locations are cereals (wheat, barley, maize and *tef*, pulses (chickpea, field pea, faba bean, and lentil) and vegetables (onion, garlic, potato and tomato).

Treatments and Experimental Design

The treatments consisted of factorial combination of two potato varieties (Ararsa and Moti) and six NPS fertilizer rates (0, 50, 100, 150, 200 and 250 kg ha^{-1}) and was laid out in Randomized Complete Block Designs (RCBD) with three replications. The recommended rate of UREA (165kg ha^{-1}) was uniformly applied to all plots except the control one. The blended NPS (19% N, 38% P_2O_5 and 7% S) was used as the sources of fertilizer.

Experimental Procedure and Field Management

The experimental field was ploughed and disked by tractor and pulverized to a fine tilth by hand digging. The gross plot size of 3 m × 3 m (9 m^2) which contained four rows and the tubers were planted at a spacing of 75 cm and 30 cm between rows and plants, respectively. The two middle rows were used for data collection. The Land preparation, planting and other management practices were applied as per the recommendations for the crop in the area.

Table 1: Selected soil physico-chemical properties of the experimental sites before planting.

Properties	Sinana Result	Sinana Rating	Sinja Result	Sinja Rating	References
1. Physical properties					
Sand (%)	20		22		-
Silt (%)	26		27		-
Clay (%)	54		51		-
Textural Class	Clay		clay		-
2. Chemical properties					
pH (1: 2.5 H_2O)	6.82	Neutral	6.01	neutral	Tekalign (1991)
Organic Carbon / OC/ (%)	1.18	Low	1.32	medium	Tekalign (1991)
Total nitrogen / TN/ (%)	0.16	Medium	0.12	low	Tekalign (1991))
Available phosphorus /P/ (ppm)	10.23	Medium	4.2	low	Roy *et al* (2006)

Data to be Collected and Measurements

Soil Sampling and Analysis

Before sowing, soil samples (0-30 cm depth) were collected diagonally from five spots from the entire experimental field and mixed to have one composite sample. The composite sample was air-dried, ground using a pestle and a mortar and allowed to pass through a 2-mm sieve. Working samples were obtained from submitted bulk samples and taken to Sinana Agricultural Research Centre Soil Testing Laboratory for analysis of major physicochemical properties - soil PH, soil texture, organic carbon, total N, available P and organic matter.

Agronomic and Yield data

Agronomic and yield data such as days to 50% flowering, days to 90% physiological maturity, plant height, number of stems per hill, number of marketable tubers per plot, number of unmarketable tubers per plot, marketable tuber yield, unmarketable tuber yield and total tuber yield were collected.

Statistical Data Analysis

The collected data were subjected to Analysis of Variance (ANOVA) procedure using GenStat 16th edition software. Comparisons among treatment means with significant difference for measured characters were done by using Fisher's protected Least Significant Difference (LSD) test at 5% level of significance.

Economic Analysis

Yield from experimental plots was adjusted downward by 10% for management difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment. Accordingly, the mean seed yields for NPS treatment combinations were subjected to a discrete economic analysis using the procedure recommended by CIMMYT (1988).

Average Yield (AY) (kg ha^{-1}): It is an average yield of each treatment converted to kg ha^{-1}.

Adjusted Yield (AJY): The adjusted yield for a treatment is the average yield adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same treatment. AJY = AY - (AY × 0.10).

Gross field benefit (GFB): The gross field benefit for each treatment was calculated by multiplying field/farm gate price that farmers receive for the crop when they sale it as adjusted yield. GFB = AJY x field/farm gate price of a crop.

Total Variable Costs (TVC): This is the sum of all the costs that vary for a particular treatment. The total costs that varied included the cost of NPS fertilizer and the application cost of the fertilizer to the

Table 2: Mean squares of ANOVA for phenological parameters and yield of potato as affected by NPS fertilizer.

Source	df	Mean squares								
		DF	DM	PH	NSPH	NMTPP	NUMTPP	MTY	UMTY	TTY
Block	2	20.86	14.11	81.29	0.14	34.7	101.9	1.61	1.29	0.06
NPS	5	37.89**	8.49**	60.74**	0.68^{ns}	330.2**	663.2^{ns}	12.85**	1.55**	20.43**
V	1	46.69*	56.25**	1492.53^{ns}	82.81^{ns}	169.0^{ns}	164.7 ^{ns}	1.71^{ns}	1.03ns	0.09^{ns}
NPS × V	5	2.83^{ns}	1.65^{ns}	57.88^{ns}	1.18^{ns}	188.0^{ns}	582.4 ^{ns}	1.33 ^{ns}	0.06 ns	0.95 ^{ns}
Error	22	9.26	1.66	18.20	0.79	197.2	652.3	1.33	0.27	1.763
CV (%)		**5.4**	**1.1**	**10.5**	**20.4**	**10.6**	**16.3**	**4.2**	**10.0**	**4.1**

Where; V: Varieties; df: Degree of Freedom; DF: Date of Flowering; DM: Date to Maturity; PH: Plant Height; NSPH: Number of Stems Per Hill; NMTPP: Number of Marketable Tubers Per Plot; NUMTPP: Number of Unmarketable Tubers Per Plot; WMTY: Weight of Marketable Tuber Yield; WUMTY: Weight of Unmarketable Tuber Yield; TTY: Total Tuber *= Significant; ** = Highly Significant crop. To estimate economic parameters, potato tuber yield was valued at average open price of 200 t^{-1} and the mean current prices of NPS and wages were 40.00 Birr kg^{-1} and 300 Birr/ person/ day, respectively.

Net Benefit (NB): This was calculated by subtracting the total variable costs from the gross field benefit for each treatment. **NB = GFB – TVC**

Dominance analysis (D): This was carried out by first listing the treatments in order of increasing costs that vary. Any treatment that has net benefit that are less or equal to those of a treatment with lower costs that vary were considered as dominated.

Marginal Rate of Return (MRR): This was computed by dividing the marginal net benefit (i.e., the change in net benefits) with the marginal cost (*i.e*., the change in costs) multiplied by hundred and expressed as a percentage.

$$MRR = \frac{Chnge\ in\ NB}{Change\ TVC} \times 100$$

Where, NB= change in net benefit, TVC= change in total variable cost, MRR= Marginal rate of return. Thus, MRR of 100% implies a return of one Birr on every Birr of expenditure in the given variable input.

Finally, among the non-dominated treatments, the treatment which gave the highest net return and a marginal rate of return greater than the minimum considered acceptable to farmers (100%) was considered for recommendation.

Results and Discussion

Soil Physico-Chemical Properties of the Experimental Site

Selected physico-chemical properties of the soil were determined for composite soil (0-30 cm depth) samples collected before sowing (Table 1). Accordingly, the texture of the soil of the experimental site is dominated by the clay fraction. The pH of both experimental sites is neutral. The Organic carbon low, Total nitrogen medium and available phosphorus medium for Sinana location while for Sinja location Organic carbon medium, Total nitrogen low and available phosphorus low (Table 1). The results of pre planting soil analysis indicated that it needs external application of nutrients or amendments of the experimental sites to grow potato.

Days to 50% of Flowering

The analysis of variance indicated that the number of days required to reach 50% flowering was significantly ($p<0.01$) and ($p<0.05$) affected by main effect of NPS fertilizer and varieties, respectively while the interaction of NPS and varieties had no significant effect on the number of days required to reach 50% flowering (Table 2).

The shortest period (53.17 days) required to reach days to 50% flowering was observed without application of fertilizers while the longest days (60.17) required to reach days to 50% flowering was recorded from the application of 250 kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) (Table 3). Variety Ararsa was earlier to reach flowering than Moti.

The increment in days to 50% flower initiation, with the increasing application of blended fertilizer might be attributed to the positive effect of nitrogen that stimulated growth and vegetative phase; thus, delaying the reproductive phase of potato. The effect of nitrogen and phosphorous containing fertilizers on days to flowering of potato has been studied by many authors. In related studies, Zelalem *et al.* (2009) and Biruk *et al.* (2015) reported that application of N and P fertilizers delayed flowering and prolonged the days required to attain physiological maturity of potato.

Table 3: Mean effects of NPS fertilizer and varieties on flowering, date of maturity, plant height and number of stems per hill of potato.

Treatment	Days to 50% flowering	Days to 90% maturity	Plant Height	Number Stems Per Hill
Rate of NPS (kg ha^{-1})				
0	53.17 c	116.8 a	35.33 b	3.90 a
50	54.50 bc	116.7 a	39.07 ab	4.10 a
100	56.83 abc	116.5 ab	40.97 ab	4.47 a
150	57.67 ab	115.7 ab	41.33 a	4.30 a
200	57.83 ab	114.3 b	42.63 a	4.57 a
250	60.17 a	114.2 c	44.57 a	4.83 a
LSD (0.05)	**3.643**	**1.54**	**5.11**	**NS**
Variety				
Ararsa	57.83 a	116.94 a	45.21	4.84
Moti	55.56 b	114.44 b	47.09	4.88
LSD (0.05)	**2.10**	**0.89**	**NS**	**NS**
CV (%)	**5.4**	**1.1**	**10.5**	**20.4**

Means followed by the same letter(s) in the table are not significantly different at 5% level of significance; LSD=Least significance difference at 5% probability level; CV=Coefficient of variation.

Days to 90% of Physiological Maturity

The analysis of variance showed that the number of days required to reach 90% of physiological maturity was highly significantly ($p<0.01$) affected by main effects of NPS fertilizer and varieties while the interaction of NPS and varieties did not significantly influence the number of days required to reach 90% physiological maturity (Table 2). Variety Ararsa was earlier to mature than Moti.

In response to increasing rates of NPS fertilizer application, the number of days required for potato maturity was decreased. The decreased number of days required to reach physiological maturity in response to increased rates of NPS fertilizer may be attributed to the enhanced availability of the nutrient in the soil and its increased uptake by the potato plants, which might have resulted in a more luxurious vegetative growth that resulted in delayed maturity. The result indicated that increasing the rate of NPS delayed time of maturity of potato which may be attributed to the role that nutrient play's significant role in promoting vegetative growth before the start of tuberous root development as nitrogen promotes vegetative growth thereby delaying plant maturity.

This result of this study is in agreement with the findings of various researchers who found out that increasing fertilizer rates, including NPS prolonged days required to reach flowering and maturity of different vegetable crops including potato in different agro-ecologies [8,11].

Plant Height

Plant height was highly significantly ($p<0.01$) influenced by the main effect of NPS fertilizer. However, neither the main effect ofvariety nor the interaction effect of NPS and variety significantly influenced this parameter (Table 2).The highest plant height (44.57 cm) was recorded from the application of 250 kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) which, however, was statistically at par with the plant heights attained by applying 200 and 150 kg NPS ha^{-1} while the lowest plant height (35.33 cm) was recorded from the treatment without application of NPS fertilizer (Table 3).

Table 4: Main effects of NPS and varieties on NMTPP, NUMTPP, MTY, UMTY and TTY of potato.

Treatment	Number of marketable tubers per plot	Number of unmarketable tubers per plot	Marketable tuber Yield (t ha^{-1})	Unmarketable tuber Yield (t ha^{-1})	Total tuber yield (t ha^{-1})
Rate of NPS (kg ha^{-1})					
0	119.2 b	26.83 a	25.53 b	4.42 c	29.95 d
50	130.5 ab	27.33 a	25.98 b	4.71 bc	30.69 cd
100	132.5 ab	42.00 a	26.40 b	5.11 ab	31.93 bc
150	136.2 ab	41.33 a	27.90 a	5.49 ab	33.30 ab
200	140.5 a	50.50 a	29.27 a	5.69 a	34.77 a
250	136.5 ab	50.17 a	28.19 a	5.53 a	33.60 a
LSD (0.05)	**16.82**	**NS**	**1.40**	**0.62**	**1.59**
Variety					
Ararsa	130.4 a	41.8 a	26.99 a	5.33 a	32.32 a
Moti	134.7 a	37.6 a	27.43 a	4.99 a	32.42 a
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**10.6**	**16.3**	**4.2**	**10.0**	**4.1**

Means followed by the same letter(s) in the table are not significantly different at 5% level of significance; LSD: Least Significance Difference at 5% probability level; CV: Coefficient of Variation.

The increase in plant height might be due to the enhanced availability of nutrients to the crop which might have resulted in increased photosynthetic efficiency and increased metabolic activities of the plant with an increase in fertilizer level.

This result is in line with the reports of Mulubrhan (2004) and Zelalem *et al.* (2009) who reported that increasing the application rate of nitrogen and phosphorus highly significantly increased the height of potato plants.

Number of Stems per Hill

The main effects of NPS, varieties and the interaction between NPS fertilizer and varieties did not show significant effect on number of stems per hill of potato (Table 2).

Number of Marketable Tubers per plot

The number of marketable tubers per plot was highly significantly ($p<0.01$) influenced by the main effect of NPS fertilizer. However, neither the main effect of variety nor the interaction effect of NPS and variety did significantly influence this parameter (Table 2).The maximum number of marketable tubers per plot (140.5) was recorded from the application of 200 kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) which, however, was statistically at par with the application rate of 250,150,100 and 50 kg NPS ha^{-1}; the minimum number of marketable tubers per plot (119.2) was obtained from the plot without NPS fertilization (Table 3).The increment in marketable tuber number in response to an increased supply of NPS fertilizer 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.

Number of Unmarketable Tubers per plot

The difference in number of marketable tubers per plot was observed to be non-significant for main effects of NPS and varieties. Similarly, significant variation was also not observed by the interactions of the two factors (Table 2).

Marketable Tuber Yield

The analysis of variance showed that the main effect of NPS fertilizer was highly significant ($p<0.01$) on marketable yield of potato while the main effect of varieties nor their interaction with NPS fertilizer did not influence this parameter (Table 2). The highest marketable tuber yield (29.27 t ha^{-1}) was obtained from the application of 200kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) which is statistically at par with the treatments the received 250 and 150 kg NPS ha^{-1}whereas the lowest marketable tuber yield (25.23 t ha^{-1}) was obtained from no application of NPS fertilizer on potato (Table 4).

This increment of marketable yield in the response to increasing rate NPS, NPSB fertilizer indicated that the importance of NPS fertilizers for growth and productivity of potato. In line with this result Amin (2018) reported that, the highest marketable tuber yield (39.79 t ha^{-1}) was recorded from the application of 150 kg NPS ha^{-1}.

Unmarketable Tuber Yield

Analysis of variance indicated that the main effect of NPS fertilizer was highly significant ($p<0.01$) on unmarketable yield of potato while the main effect of varieties nor their interaction with NPS fertilizer did not influence this parameter (Table 2). The highest unmarketable tuber yield (5.69t ha^{-1}) was obtained from the application of 200kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) which is statistically at par with treatments that received 250 and 150 kg NPS ha^{-1}; the lowest marketable tuber yield (4.42 t ha^{-1}) was obtained from no application of NPS fertilizer on potato (Table 4).This might be due to the fact that nitrogen accelerated the growth of the above ground part of plants, which often leads reduced tuber size and weight of the tubers becoming unmarketable.In agreement with the result of this study, Habtam *et al.* (2012) reported that further increasing the rate of the nutrient from 100 to 200 kg KCl ha^{-1} increased the unmarketable tuber yield of potato.

Total Tuber yield

Analysis of variance revealed that the main effect of NPS fertilizer was highly significant ($p<0.01$) on total yield of potato while neither of the main effect of varieties nor their interaction with NPS fertilizer did not influence this parameter (Table 2). The maximum total tuber yield (34.77 t ha^{-1}) was obtained from 200kg NPS $ha^{-1}$and recommended rate of UREA (165 N kg ha^{-1}) which is statistically at par with treatments received 250 and 150 kg NPS ha^{-1} whereas the lowest marketable tuber yield (29.95t ha^{-1}) was obtained from no application of NPS fertilizer on potato (Table 4). Increasing in total tuber yield with increasing rates of blended NPS fertilizer was due to the positive effect of nitrogen, phosphorus and sulfur on total tuber weight.

This result is in agreement with the findings of Firew (2016) and Israel *et al.* (2012) who reported that total tuber yield was highly significantly influenced by nitrogen and phosphorus application. Similarly, Minwyelet (2017) and Melkamu *et al.* (2018) reported that

Table 5: Partial budget analysis result for NPS fertilizer rate on potato production.

NPS (Kg ha^{-1})	Aver yield (t ha^{-1})	Adjusted yield by 10% down (t ha^{-1})	GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
0	29.95	26.96	53910	0	53910	
50	30.69	27.6	55242	2300	55239	D
100	31.93	28.74	57474	4600	57469	77.26
150	33.30	29.97	59940	6900	59933	107.4
200	34.77	31.29	62586	9200	62576	114.5
250	33.60	30.24	60480	11500	60468	-91.2

Where GFB: Gross Field Benefit; TVC: Total Variable Costs; NB: Net Benefit, MRR: Marginal Rate of Return; ETB ha^{-1}: Ethiopian Birr per hectare; D: Dominated Treatments; Cost of NPS 4000.00 Birr 100 kg^{-1}; Labour cost for NPS fertilizer application = 1,2,3,4,5 persons to apply NPS 50,100,150,200,250 kg ha^{-1} day^{-1} at 300 ETB per day respectively; sale price of potato 200 Birr per 1 t during harvest on farm.

the application of 272 kg NPS ha^{-1} resulted in the production of the highest total tuber yield (47.53 t ha^{-1}) while application of no NPS fertilizer produced the lowest total tuber yield (17.32 t ha^{-1}).

Economic Evaluation

Partial budget analysis revealed that the highest net benefit (62576 ETB ha^{-1}) with marginal rate of return (114.5%) was gained from application200 Kg NPS ha^{-1}and recommended rate of UREA (165 N kg ha^{-1}) (Table 5). The dominated treatments according to the dominance analysis were eliminated from further economic analysis. To identify treatments with the optimum return to the farmer's investment, marginal analysis was performed on non-dominated treatments. For a treatment to be considered as a worthwhile option to farmers, the Marginal Rates of Return (MRR) need to be at least between 50% and 100% [3]. Thus, to draw farmers' recommendations from marginal analysis in this study, 100% return to the investment is reasonable minimum acceptable rate of return. Accordingly, application of 200 Kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}) with marginal rate of returns (114.5%) for potato production was above the minimum acceptable rate of return.

Conclusion and Recommendation

Analysis of variance revealed that days required to reach 50% of flowering and 90% of physiological maturity were significantly affected by the main effects of NPS fertilizer and varieties while plant height, number of stems per hill, number of marketable tubers per plot, number of unmarketable tubers per plot, marketable tuber yield, unmarketable tuber yield and total tuber yield were highly significantly affected by the application of NPS fertilizer.

Plots treated with NPS fertilizer required the longest period to reach 50% flowering and 90% of physiological maturity. Ararsa variety was earlier to flowering and maturity than Moti variety. The maximum plant height was recorded from 250 kg NPS ha^{-1}and recommended rate of UREA (165 N kg ha^{-1}) while the minimum plant height was recorded from plots without fertilization. The highest number of marketable tubers and un marketable tubers marketable tuber yield, and unmarketable tuber yield were obtained from200 kg NPS ha^{-1}and recommended rate of UREA (165 N kg ha^{-1}) while the lowest number of marketable tubers, un marketable tubers, marketable tuber yield and unmarketable tuber yield were recorded from plots without fertilization. The maximum total tuber yield (34.77 t ha^{-1}) was obtained from the application of 200kg NPS ha^{-1}and recommended rate of UREA (165 N kg ha^{-1}) whereas the lowest marketable tuber yield (29.95t ha^{-1}) was obtained from no application of NPS fertilizer on potato. Partial budget analysis also revealed that the highest net benefit (62576 ETB ha^{-1}) with marginal rate of return (114.5 %) was gained from the application of 200 Kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}).

Therefore, based on the results of the growth, yield, yield related parameters and economic analysis, the application of 200 Kg NPS ha^{-1} and recommended rate of UREA (165 N kg ha^{-1}) were recommended for potato production on the highlands of Bale.

Author Statements

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