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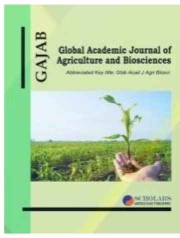

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Original Research Article

Response of Potato (*Solanum tuberosum* L) Varieties to Blended NPSZnB and Potassium Chloride Fertilizers Rates at Assosa District, Western Ethiopia

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Abstract: Potato production is constrained by a number of biotic and abiotic factors, among which poor soil fertility is the prime one. Thus, the objectives of the study were to evaluate effect of NPSZnB plus potassium chloride rates fertilizer on growth performance, yield and yield components of potato and to determine optimum fertilizer rate and economically feasible for potato production at target Assosa areas. The experiment was laid out in RCBD with split plot arrangement with three replications. Two potato varieties, Belete and Gudane were assigned to main plot whereas six blended NPSZnB with potassium chloride fertilizers rates assigned to subplots. Totally, the experiment had twelve treatments. The interaction effects of blended NPSZnB and potassium chloride fertilizers rates not significantly (P>0.05) influenced marketable yield, unmarketable yield and total tuber yield. However, the main effects of blended NPSZnB and potassium chloride fertilizers rates were highly significantly (P<0.01) affected marketable tuber yield. The partial budget analysis was revealed that highest net benefit with acceptable marginal rate of return (1027.27%) was obtained with the application of NPK (110 kg N + 90 kg P2O5 + 69 kg K2O ha^{-1}) fertilizers. We conclude that application of NPK (110 kg N + 90 kg P2O5 + 69 kg K2O ha^{-1}) fertilizers were economically feasible to recommend for potato production in the study area.

Keywords: Tuber Yield, Varieties, Potato, Partial Budget

INTRODUCTION

Potato (Solanum tuberosum L.) is the world's most important root and tuber crop worldwide. It is grown in more than 125 countries and consumed almost daily by more than a billion people. Hundreds of millions of people in developing countries depend on potatoes for their survival (Food and Agriculture Organization of the United Nations (FAO, 2009). The annual production of the world and Africa in the year of 2018 was about 368.2 and 26 million tons, respectively (FAOSTAT, 2020). It is the fourth most important crop after rice, wheat, and maize, and has historically contributed to food and nutrition security in the world (FAOSTAT, 2015; FAO, 2015).

Ethiopia is fundamentally an agrarian country where agriculture is the base for livelihood of the overwhelming majority of the population. Root crops are good sources of food, cash and foreign exchange for the majority of smallholder farmers in Ethiopia. It is playing a major role in national food and nutrition security, alleviation of poverty, generating income, and providing job opportunity in line with production, processing and marketing sub-sectors (Lung'aho *et al*., 2007). Root crops are good sources of food, cash and foreign exchange for the majority of smallholder farmers in Ethiopia. The economic and nutritional importance of root crops has been a factor for producing them both under rainfed and irrigated conditions in all potato producing regions and growing the crops more than one time in a year (Mesfin, 2009).

In the primary cropping season of Ethiopia, over 1.04 million households produced 1,141,871.7 t of potatoes on an estimated 85, 988 hectares of land. However, the productivity of this crop in the country is rather poor (13.28 t ha^{-1}) when compared to the global average yield of 19 tha^{-1} (CSA, 2021).

For example, the current rate of nitrogen fertilizer application practiced across the country is based on a blanket recommendation released by Ethiopian research centers, which means it does not take varieties, soil types, climate and associated factors into consideration (Burtukan, 2016). This blanket application can lead to excessiveness or deficiency in relation to plant nutrient requirement. When excessive nitrogen is applied, it may adversely affect crop yield; increase the cost of production and the environment can be polluted, especially soil and ground water can be highly affected due to nitrate leaching (Madramootoo *et al*., 1992; Honisch, 2002). Most Ethiopian soils lack most of the macro and micro nutrients that are required to sustain optimal growth and development of crops (Muleta *et al*., 1998).

In Ethiopia, fertilizer use has increased notably since 1990 (Haverkort *et al*., 2012). However, there is no related attainable yield increase, especially in potato (Biruk, 2018). This may be due to the fact that small scale farmers do not have the required resources to make or purchase fertilizer and/or the farmers do not apply the optimum amount of fertilizers rates and fertilizer types. Maximum yield was not obtained due to the absence of recommendation that best fit to their specific area and production system (Biruk, 2018).

Assosa area soils are deficient with nitrogen, phosphorus, sulfur, zinc, boron & potassium and fertilizers application practices in the region have been mainly based on blanket recommendations, since limited studies were carried out. There is little information on the response of the crop to blended NPSZnB and potassium chloride fertilizers rates under the conditions Assosa zone. Thus, this study was conducted with the objectives to evaluate effect of blended NPSZnB with K fertilizers rates on growth performance, yield and yield components of potato (*Solanum tuberosum* L.) and to determine optimum fertilizer rate and economically feasible for potato production at target areas (s) for potato production at Assosa area, western Ethiopia.

MATERIALS AND METHODS

The experiment was conducted at Assosa Agricultural Research Center (AsARC) in 2021 main cropping season under rain fed condition, in Benishangul Gumuz Regional State of Ethiopia. The AsARC is located from 10º 01' 25'' to 10º 02' 50'' N latitude and from 34º 33' 50'' to 34º 34' 35'' E longitude. The experimental site is located at 1553 meters above sea level, situated at 4 km east of Assosa town and at 660 km west of Addis Ababa, the capital city of Ethiopia. Assosa has unimodal rainfall pattern, which starts at the end of May and extends to mid-October, with maximum rainfall received in June to September. The total annual rainfall of Asossa is 1275 mm. The average minimum and maximum temperatures are 14.33°C and 28.43°C, respectively. The dominant soil type of Assosa area is Nitosols and Fluvisols with the soil pH ranges from 5.1 to 6.0.

Planting Material

The improved potato varieties called 'Belete (CIP-393371.58) and Gudane were used as planting materials. NPSZnB blended fertilizer was selected for Assosa area, based on Ethio SISmap (ATA, 2016). Nitrogen and Phosphorus were adjusted for the blended fertilizer from Urea and TSP source, respectively. Blended fertilizer and adjusted TSP fertilizers were applied at planting and Urea was applied twice.

The experiment was laid out in RCBD with split plot arrangement with three replications. Two potato varieties Belete and Gudane varieties were randomized as main plot whereas six rates of blended NPSZnB with potassium chloride fertilizers rates randomized as subplots. Totally, the experiment had twelve treatments. Each plot had a gross area of 9 m^2 with 3m length and 3m width. Each plot contained four rows of potato plants. Each of rows contains 10 plants per row with spacing of 0.75m and 0.30 m between rows and plants, respectively. The spacing between plots and adjacent blocks were 0.5 m and 1.5 m, respectively.

Table 1: Treatment combination and detail nutrient contents of the blended fertilizer

TN	Varieties	Fertilizer types	Rates of NPSZnB plus adjusted NPK	Nutrient contents of NPSZnB
1		Control (0)	Control (0)	0
2	Belete	100% NPK	100% NPK	110 N+90 P_2O_5+69K_2O
3		50 %NPSZnB	50 %NPSZnB+ 46.15N+27.35P_2O_5 + 34.5 K_2O	8.85N+17.65 P2O5+2.85S+0.13B+1.1Zn
4		100% NPSZnB	100% NPSZnB +92.3N+ 54.7 P_2O_5 + 69 K_2O	17.7 N + 35.3 P2O5 +7.6 S + 0.25 B -2.2 Zn
5		150% NPSZnB	150% NPSZnB + 138.45N+82.05 P_2O_5 + 103.5 K_2O	26.55N+52.95P2O5+11.4 S+0.38B+ 3.3 Zn
6		200% NPSZnB	200% NPSZnB + 184.6N+ 109.6 P_2O_5 + 138 K_2O	35.4N+70.6P2O5+15.2S+0.5B+ 4.4Zn
7	Gudane	Control (0)	Control (0)	0
8		100% NPK	100% NPK	110 N+90 P_2O_5+69K_2O
9		50 %NPSZnB	50 %NPSZnB+ 46.15N+27.35P_2O_5 + 34.5 K_2O	8.85N+17.65 P2O5+2.85S+0.13B+1.1Zn
10		100% NPSZnB	100% NPSZnB +92.3N+ 54.7 P_2O_5 + 69 K_2O	17.7 N + 35.3 P2O5 +7.6 S + 0.25 B -2.2 Zn
11		150% NPSZnB	150% NPSZnB + 138.45N+82.05 P_2O_5 + 103.5 K_2O	26.55N+52.95P2O5+11.4 S+0.38B+ 3.3 Zn
12		200% NPSZnB	200% NPSZnB + 184.6N+ 109.6 P_2O_5 + 138 K_2O	35.4N+70.6P2O5+15.2S+0.5B+ 4.4Zn

SN: Serial Number, NPSZnB; Blended N: Nitrogen, P: Phosphorus, S: Sulfur, Zn: Zinc, B: Boron

Soil Sampling

Surface soil (0-30 cm depth) samples were collected by using an auger from 10 spots of the experimental field in a zigzag pattern before planting.

Soil samples were subjected for physico-chemical analysis (soil texture, organic carbon, soil pH, total N, available P and CEC). The soil particle size distribution was determined using the hydrometer technique (Ryan and Rashid, 2001) while the soil textural class was identified from textural triangle (Motsara and Roy, 2008). The cation exchange capacity (CEC) was determined using 1N-neutral ammonium acetate method (Jackson, 1967). Soil pH was determined in a 1:2.5 soil to water ratio using a glass electrode attached to a digital pH meter (Page, 1982). Organic carbon content of the soil was determined following the wet oxidation method of Walkley and Black (1934).

Determinations of the soil physicochemical properties were carried out following standard laboratory procedures. Total nitrogen was determined according to Kjeldahl procedure (Dewis and Freitas, 1984). Available phosphorus was determined by the Olsen method (Olsen *et al*., 1954).

Data Collected

Data were collected from the three middle rows, leaving aside plants in the border rows in order to avoid border effects. Data were recorded on different growth parameters, including yield and yield components, and tuber quality parameters.

Plant Height (CM): refers to the height from the base to the apex of the plant.

Number of Main Stems per Hill: was recorded by counting the stems that originated from the tuber from 10 randomly taken hills.

Mean Tuber Weight (G): was determined at harvest by dividing the weight of all tubers obtained from randomly taken 5 plants by the total number of tubers.

Marketable Tuber Yield (t ha^{-1}): the weight of tubers, which were free from diseases, insect pests, and greater than or equal to 25 g in weight, was recorded as marketable tuber yield.

Unmarketable Tuber Yield (t ha^{-1}): the weight of tubers that are diseased and/or rotting ones and small-sized (less than 25 g in weight) was recorded.

Total Tuber Yield (t ha^{-1}): the sum of tuber yield weights of marketable and unmarketable tuber

Partial Budget Analysis

Partial budget analysis was done for each treatment. For economic evaluation, dominance analysis, cost and MRR calculated following the procedure CIMMYT (1988). Partial budget analysis was performed to investigate the economic feasibility of the treatments (fertilizer rates). The field price (10 Birr kg^{-1}) for potato tuber yield at time of harvesting and Urea (12 Birr kg^{-1}), TSP (14 Birr kg^{-1}), Potassium

Chloride (13 Birr kg^{-1}) and NPSZnB (16 Birr kg^{-1}) were used for analysis. Gross marketable tuber yield ($kgha^{-1}$): is an average yield of each treatment.

Adjusted Marketable Tuber Yield:

Is the marketable tuber yield adjusted reduced by 10% to reflect the difference between the experimental yield and yield of farmers (CIMMYT, 1988).

Adjusted marketable tuber yield = Marketable tuber yield - (Marketable tuber yield *0.1).

Gross Field Benefit (GFB): was computed by multiplying field/farm gate price that farmers received for the crop when they sale it as adjusted yield.

Total Costs That Vary:

Is the cost of fertilizers, application and transport that vary. Calculation of net benefit: this was computed as the gross field benefit less the total costs that vary.

Marginal Rate of Return (MRR %):

Was calculated by dividing change in net benefit divided by change in cost. One way of assessing this change is to divide the difference in net benefits by the difference in costs that vary (CIMMYT, 1988).

$$MRR = \frac{Change\ in\ Net\ Benefit}{Change\ in\ Total\ Cost\ that\ vary} \quad \text{Or} \quad MRR\% = \frac{Marginal\ Benefit}{Marginal\ cost} * 100$$

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) according to SAS (SAS, 2004) version 9.0 and interpretations were made following the procedure of Gomez and Gomez (1984). The treatments having significant differences were separated by using LSD (Least Significant Difference) at 5% level of significance.

RESULTS AND DISCUSSION

Selected Physicochemical Properties of the Experimental Soil before Planting

The results showed that the experimental soil was clay in textural class with strongly acidic (pH 5.2) in reaction (EthioSIS, 2014). Fageria *et al.*, (2011) stated that at optimum growth of potato was found in the soil pH range of 5.2 to 6.5.

According to the rating of EthioSIS (2014), the soil of experimental site was strongly acidic in pH (5.2). CEC was medium (21.93 (Cmol(+) kg $^{-1}$soil) (Hazelton and Murphy,2007). The experimental site was medium in organic matter (5.8%), medium in organic carbon (3.35%), low in total N (0.19%), very low in available phosphorus (6.45ppm), very low in exchangeable K content (9.98ppm), very low in sulfur (3.01ppm), low in boron (0.61ppm) and very low (0.34ppm) in zinc contents (EthioSIS, 2014). The experimental site was low in boron (Jones, 2003). Therefore, application of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates are important to increases the yield of potato at experimental site.

Table 2: Selected physicochemical properties of the experimental soil before planting

Soil physicochemical properties	Contents	Rating	Reference
pH (H_2O)	5.2	strongly acidic	EthioSIS (2014)
Sand (%)	24		
Silt (%)	22		
Clay (%)	54		
Textural Class	Clay		FAO (1990)
Organic carbon (%)	3.35	medium	EthioSIS (2014) and Tekalign (1991)
Organic matter (%)	5.8	medium	EthioSIS (2014)
CEC (Cmol(+) kg $^{-1}$soil)	21.93	medium	Hazelton and Murphy (2007)
Total nitrogen (%)	0.19	low	EthioSIS (2014)
Exchangeable potassium (ppm)	9.98	very low	EthioSIS (2014)
Available of phosphorus(mg/kg)	6.45	very low	EthioSIS (2014)
Sulfur (ppm)	3.01	very low	EthioSIS (2014)
Boron (ppm)	0.61	Low	Jones (2003)
Zinc (ppm)	0.34	very low	EthioSIS (2014)

Total Tuber Yield

The analysis of variance revealed that the interaction effects of different potato varieties and blended NPSZnB and potassium chloride fertilizers rates were not significantly ($P>0.05$) affected the total tuber yield. The main effects of blended NPSZnB and potassium chloride fertilizers rates with adjusted nitrogen, phosphorus fertilizers were highly significant ($P<0.01$) influenced the total tuber yield. The highest total tuber yield (33.12 ton ha^{-1}) was obtained by application of 200% NPSZnB+138 kg K_2O with adjusted nitrogen and phosphorus fertilizers while the lowest total tuber yield (13.8 ton per ha) was recorded by unfertilized plot.

Increasing application of 50% NPSZnB+34.5 kg K_2O with adjusted nitrogen and phosphorus to 200% NPSZnB+138 kg K_2O with adjusted nitrogen and phosphorus fertilizers increased the total tuber yield from 45.62% to 140% compared to control. This might be due to the increased photosynthetic activity and translocation of photosynthetic product to the root, which might have helped in the initiation of more stolen on potato. This result is in line with the finding of Desta *et al*., (2020) who stated that increasing the rates of blended NPSZnB fertilizer from 100% to 200%NPSZnB with adjusted nitrogen increased the total tuber yield of potato from 27.73% to 39.26% respectively, as compared to unfertilized plot. This study was harmonized with the findings of Abato and Zebire (2024) who reported that increasing blended NPSB fertilizer application generally increased total tuber yields.

Plant Height

The analysis of variance showed that the interaction effect of blended NPSZnB and potassium chloride fertilizers rates and different potato varieties not significantly (P>0.05) affected the plant height (table 3). However, the main effect of blended NPSZnB and potassium chloride fertilizers rates were highly significant (P<0.01) influenced the plant height (table3). Increasing application of blended NPSZnB and potassium chloride fertilizers rates from 50 %NPSZnB +34.5 kg K_2O to 200 % NPSZnB +138 kg K_2O with adjusted of nitrogen and phosphorus fertilizers rates increased plant height from 5.2% to 32.91% as compared to unfertilized plot. The increased potato plant height by application of NPSZnB and potassium fertilizers rates may be contributed by physiological stem elongation due to nitrogen fertilizer adjustment which is also observed by other authors (Lamessa & Zewdu, 2016; Sriom *et al*., 2017). It might be the presence of boron and sulfur in the blended fertilizer nutrient source also significantly increased plant height due to its important role in the cell division and nitrogen absorption from the soil, enhancing plant growth ultimately increased plant height. This result is similar to the findings of Gezahegn *et al*., (2020) who stated that increasing the rate of the blended fertilizer application from 0 to 300 kg NPSB ha^{-1} increased the plant height and by 18.58% as compared to unfertilized plot.

Number of Main Stem per Hill

The interaction effects of blended NPSZnB and potassium chloride fertilizers rates and different potato varieties not significantly (P>0.05) affected number of main stem per hill (table 3). The main effects of blended NPSZnB fertilizer and potato varieties were also not significantly (P>0.05) influenced number of main stem per hill.

Total Tuber Number per Hill

The analysis of variance revealed that the interaction effect of different potato varieties and blended NPSZnB and potassium chloride fertilizers rates not significantly (P>0.05) influenced number of tuber per hill (table 3). The main effect of potato varieties were also not significantly affected number of tuber per hill (table 3).

The main effect of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates were significantly affected number of tuber per hill (table3). The highest number of tuber per hill (12.17) obtained by application of 100% NPSZnB+69 kg K_2O with adjusted nitrogen and phosphorus fertilizers rates whereas the lowest number of tuber per hill (7.57) was recorded by unfertilized plot. The current results are similar to the findings of Habtamu *et al*., (2016), who reported that increasing the application of nitrogen and phosphorus increased the total tuber number per hill.

Several researchers' findings indicated that increasing application of blended fertilizer from 0 to 200 kg NPSB per ha was increased total number of tuber per hill (Desta *et al*., 2020; Gezhagn *et al*., 2020 and Abato and Zebire, 2024). The nitrogen, phosphorus and potassium fertilizers are important in tuber initiation and tuber enlargement. Because yield is dependent on photo assimilate and radiation absorption during the period of tuber initiation is one of the factors influencing the number of tubers found at harvest, and this answered by the application of both nitrogen, phosphorus and potassium.

Average Tuber Weight

The interaction effects of potato varieties and blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates not significantly (P>0.05) influenced average tuber weight (table3). Different potato varieties were not significantly (P>0.05) affected by average tuber weight (table 3).

The main effect of blended NPSZnB and potassium chloride fertilizers rates was significantly (P<0.05) influenced the average tuber weight of potato (table 3). The highest average tuber weight (112.39 g) was obtained by application of 150% NPSZnB+103.5 kg K_2O with adjusted nitrogen and phosphorus fertilizers while the lowest average tuber weight was obtained by unfertilized plot. This result in line with the findings of Gezahegn *et al*., (2020) the authors stated that the average tuber weight of potato increased as the rate of NPSB fertilizer increased. The current result is in conformity with the several researchers' work they reported an increase in blended NPSZnB, NPSB and NPS fertilizers revealed significant contribution to increased larger average tuber weight and size (Desta *et al*., 2020; Gezahegn *et al*., 2020).

The increment of average tuber weight in response to the increased supply of blended NPSZnB and potassium chloride fertilizers rates might be due to cell enlargement, more fast growth, more foliage and increase in leaf area. This is might be due to a higher supply of potassium and phosphorus containing fertilizer which may have induced the formation of bigger tubers thereby resulting in higher average tuber weight.

Marketable Tuber Yield

The analysis of variance revealed that the interaction effect of potato varieties and blended NPSZnB and potassium chloride fertilizers with adjusted nitrogen and phosphorus fertilizers were not significantly ($P>0.05$) affected marketable tuber yield (table 3). The main effects of potato varieties was not significantly ($P>0.05$) influenced marketable tuber yield (table 3).

The main effects of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates were highly significant($P<0.01$) influenced marketable tuber yield. The highest marketable tuber yield (30.19 ton per ha) was recorded by application of 200% NPSZnB+138 kg K_2O with adjusted nitrogen and phosphorus fertilizers while the lowest marketable tuber yield (11.21 ton per ha) was obtained by unfertilized treatment. Increasing application of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates from 50 %NPSZnB +34.5 kg K_2O to 200% NPSZnB+138 kg K_2O increased marketable tuber yield by 49.84% to 62.87% respectively, compared to control. This result is harmonized with the findings of Abato and Zebire, (2024) who reported that increasing the blended NPSB fertilizer levels from 100kg to 200 kg increased the marketable tuber yield. Another author stated that the marketable tuber yield increased due to increasing fertilizers from 0 to150 kg/ha NPSB + 250 kg/ha urea (Shunka, 2021). The increase in the yield of tubers with an increase in applied fertilizer was associated with increasing in the number of tubers in the medium and large categories at the expense of the small ones due to an increase in the weight of individual tubers (Sharma *et al*., 2015).

Unmarketable Tuber Yield

The interaction effects of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates and potato varieties were not significantly affected unmarketable tuber marketable yield. The main effect of blended NPSZnB fertilizers rates and potato varieties not significantly influenced unmarketable tuber yield (table 3).

Table 3: Main effects of different rates of blended NPSZnB with potassium chloride fertilizers on potato yield and yield component traits at Assosa

Varieties	**NMS**	**PH**	**TTNPH**	**ATW**	**MTY**	**UMTY**	**TTY**
Belete	2.24	69.52	11.62	109.23	26.5	2.89	29.41
Gudane	2.89	68.93	9.67	80.74	22.71	3.55	26.27
LSD	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Fertilizers							
0 (without fertilizer)	2.1	50.3d	7.57b	69.33c	11.21c	2.59	13.8c
Recommended NPK	2.6	70.77b	11.57a	102.34ab	26.94a	3	30.94a
50 % NPSZnB +34.5 kg K_2O	2.4	58.48cd	10.47ab	89.26bc	22.35b	3.03	25.38b
100% NPSZnB+69 kg K_2O	2.3	65.95bc	12.17a	96.38ab	26.88a	3.98	30.86a
150% NPSZnB+103.5 kg K_2O	2.88	75.48b	11.8a	112.39a	29.12a	3.79	32.92a
200% NPSZnB+138 kg K_2O	3.13	94.45a	10.3ab	100.21ab	30.19a	2.93	33.12a
Sig	NS	**	*	*	**	Ns	**
LSD	Ns	23.26	2.98	32.72	4.5	Ns	8.93
CV	31.16	13.45	23.27	19.36	15.19	28.91	13.03

Means followed by the same letter within a column are not significantly different at 5% level of significance; Ns = Not Significant; LSD = least significant difference; and CV= Coefficient of Variation; PH= Plant Height, NMS= Number of main stem, ATW = Average Tuber Weight (g); TTNPH= Total Tuber Number per Hill MTY=Marketable Tuber Yield (ton/ha); UMTY= Unmarketable Tuber Yield (ton/ha); TTY= Total Tuber Yield (ton/ha).

Partial Budget Analysis

When the new technology surpassed the conventional practice, it is said to be undominated (CIMMYT, 1988). Marginal rate of return measures the increase in the net income and is unnecessary when the new technology costs less than the existing farmers, technology. When the new technology yield is lower benefit, then the technology is said to be dominated. The net benefit estimates for 6 treatments are presented (Table 4). For every 1.00 Birr invested at applying recommended 50%NPSZnB+ 46.15 N +27.35 P_2O_5 + 34.5K_2O ha^{-1}, farmers can expect to recover the 1.00 Birr, and obtain an additional 25.47 Birr ha^{-1}. The results of the partial budget analysis revealed that the highest net benefit of Birr 256747.7 ha^{-1} was recorded in the treatment that received 200% NPSZnB (184.6 N+ 109.6 P_2O_5 + 138 K_2O) ha^{-1} fertilizers whereas the lowest net benefit of Birr 100890 was obtained from control treatment. Based on partial budget analysis, it is advisable to apply full 50%NPSZnB+ 46.15 N +27.35 P_2O_5 + 34.5K_2O ha^{-1} to get optimum yield of potato for Assosa area. Maximum yield and minimum cost evidently leads to high income.

Dominance Analysis

The dominant analysis revealed that the net benefit of some treatments were un-dominated. Thus, unfertilized plot, half of 50%NPSZnB, 46.15 N,27.35 P_2O_5, 34.5 K_2O and full recommended 110 kg N,90 kg P_2O_5,69 kg K_2O ha^{-1} (Table 4). This result indicated that the net benefit increased with increasing the total cost that varies. So, farmers' select un-dominated treatments compared to dominated treatments.

Table 4: Dominance analysis of blended fertilizer rates application on marketable yield of potato

Fertilizers (kg ha^{-1})	AVMTY kg ha^{-1}	10%Ad.MTY kg ha^{-1}	GB	TCV	NB	MB
0	11210	10089	100890	0	100890	0
50%NPSZnB, 46.15 N,27.35 P_2O_5, 34.5 K_2O	22350	20115	201150	3784	197366	96476
100%NPK (110 N+90 P_2O_5+69K_2O)	26940	24246	242460	7448.66	235011.3	37645.34
100%NPSZnB92.3 N+ 54.7 P_2O_5 + 69 K_2O	26880	24192	241920	7508	234412	-599.34D
150% NPSZnB (138.45 N+82.05 P_2O_5 + 103.5 K_2O)	29120	26208	262080	11232.0	250848	16435.96D
200% NPSZnB (184.6 N+ 109.6 P_2O_5 + 138 K_2O)	30190	27171	271710	14962.3	256747.7	5899.74D

AVMTY kgha^{-1} = Average Marketable Tuber Yield kg ha^{-1}, 10%Ad.MTY= Adjusted Marketable Total Yield; GB= Gross Benefit, TVC= Total Cost that Vary; NB = Net Benefit; D = Dominance, the exchange rate of 1 $ is 56.96 Ethiopian Birr.

Marginal Rate of Return

The process of calculating the marginal rates of return of alternative treatments, proceeding in steps from the least costly treatment to the most costly, and deciding if they are acceptable to farmers, which is called marginal analysis (CIMMYT, 1988). The analysis indicated that all un-dominated treatments were above minimum acceptable rate of return for farmers' recommendation. It is important to note that the acceptable minimum rate of return to farmers' recommendation is 50%-100% (CIMMYT, 1988). However, in this study application of 50%NPSZnB+ 46.15 N +27.35 P_2O_5 + 34.5 K_2O ha^{-1}) showed highest marginal rate of return but less in net benefit. So, applications of 100% NPK (110 kg N+90 kg P2O5+69 kg K2O ha-1) fertilizers are advisable for farmers at Assosa area. The best recommendation for treatments subjected to marginal rate of return is not (necessarily) based on the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation (CIMMYT, 1988).

Table 5: Marginal rate of return of un-dominated treatments as influenced by blended fertilizer rates on yield in 2020

Fertilizers kg per ha	TVC	GB	NB	MC	MB	MRR%
0	0	100890	100890	0	0	0
50%NPSZnB, 46.15 N,27.35 P_2O_5 + 34.5 K_2O	3784	201150	197366	3784	96476	2547.5
100%NPK (110 N+90 P_2O_5+69K_2O)	7448.66	242460	235011.3	3664.66	37645.34	1027.27

TCV=Total Cost that Vary, GB= Gross Benefit MC=Marginal cost, MB = Marginal Benefit NB=Net benefit, MRR= Marginal rate of return, the exchange rate of 1 $ is 56.96 Ethiopian Birr.

CONCLUSION

The present study results were revealed that the interaction effects of different potato varieties and blended NPSZnB and potassium chloride fertilizers rates were not significantly (P>0.05) influenced the total tuber yield. However, the main effects of blended NPSZnB and potassium chloride with adjusted nitrogen and phosphorus fertilizers rates were significantly ($P<0.05$) affected the plant height, marketable tuber yield, average tuber weight, total number of tuber per hill and total tuber yield. Increasing application of blended NPSZnB and potassium chloride fertilizers rates with adjusted nitrogen and phosphorus from 0% to 200% increased the yield of potato tuber linearly by about 45.63% to 58.33% over the unfertilized plot. The highest net benefit (235011.3 ETB) with acceptable minimum marginal rate of return (1027.27%) was obtained by application of 100% NPK (110 kg N+90 kg P_2O_5+69 kg K_2O per ha). On the basis of marketable tuber yield, net benefit and marginal rate of return, we recommended that application of 110 kg N, 90 kg P_2O_5 and 69 kg K_2O ha^{-1} fertilizers are economically feasible and will increases potato yield at Assosa area, western Ethiopia.

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