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Determining the Rate of Blended Fertilizers and Urea for Potato Production Under Rain Fed Condition in Kersa Malima, South West Showa, Ethiopia

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Abstract
This experiment was conducted on Belete and Gudenie potato verities reaction to fertilizer rates Control, 150 kg/ha NPSB+80 kg/ha urea, 250 kg/ha NPSB+80 kg/ha urea, 350 kg/ha NPSB+80 kg/ha urea, 150 kg/ha NPSB+140 urea, 250 kg/ha NPSB+140 kg/ha urea, 350 kg/ha NPSB+140 kg/ha urea, 150 kg/ha NPSB +200 kg/ha urea, 250 kg/ha NPSB +200 kg/ha urea and 350 kg/ha N+200 kg/ha urea in Kersa Malima district in 2018-2019 main cropping seasons (June-August) using completely randomized block design arrangement in three replications. The analysis was done using SAS 9.2. This study revealed that there was highly significant difference among the yield and yield components due to main effect fertilizer rates. The interaction did not affect any parameter considered. The highest total and marketable yield (38.75 t/ha and 36.51 t/ha) respectively were harvested from 350 kg/ha NPSB+140 kg/ha urea followed by total and marketable yield of 250 kg/ha NPSB+200kg/ ha urea (37.57 and 35.66 t/ha), respectively. The partial budget analysis indicated that the highest benefit (108,426.5ETB) was fetched from 350kg/ha NPSB+140kg/ha urea followed by 250kg/ha NPSB+200kg/ha urea (106,429ETB). But, the marginal rate of return indicated that highest investment return increment of 24,391.25% was recorded from 250kg/ha NPSB+200kg/ha followed by 150 kg/ha NPSB+80kg/ha urea (3.004.231%). From this it can be concluded that the NPSB+urea rates highly significantly affected the yield and yield component of potato. It is better to apply 250 kg/ha urea+200 kg/ha urea to potato for high yield and high economic return in Kersa Malima district. It is better to repeat the experiment with more replication and higher rates including planting time as the farmer were planting starting from March.
Keywords: NPSB, urea, yield and yield components, Belete and Gudenie potato varieties
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1. Introduction

Irish potato (*Solanum tubserosum* L.*)* is a peak vegetable crop in Ethiopia (Amin, 2018). It is a high potential food security crop for closely populated highland areas (Hirpa *et al*., 2010). Potato is one of the most suiting crops to high lands areas of Ethiopian, which can produce higher yield per unit time and land. In spite of most favorable growing condition in Ethiopia, its average productivity is low when compared with world and other African countries. This is due to cultivation with low or no fertilizer in Ethiopian farmers (Gezu, 2015). As indicated in Chillot and Hassan (2010) the other productivity problem is lower levels of fertilizer use and/or inappropriate type of fertilizers application. Inappropriate soil fertility management is cause of food shortage and malnutrition of tremendous peoples in the country (Gete *et al*., 2010*)*.

For longer years Ethiopian soil was only added phosphorus and nitrogen fertilizers which found from di-ammonium phosphate (DAP) and urea in most cases. Recent production strategies and soil tests indicated that shortage of S and B (Asefa et al., 2015) is one of the yield limiting factors. Crop yield decline is a result of inappropriate cropping systems, mono cropping, nutrient mining, unbalanced nutrient application, removal of crop residues and inadequate resupply (Nyamangara et al., 2001). In central and western Ethiopia, soil fertility declining is basic problem of smallholder crop growers (Tolera et al., 2009). Improper cropping system like continuous monocultures of cereals is also contributed ununder mineable contribution to yield reduction and soil nutrients depletion (Zerihun et al., 2013 and Kombiok et al., 2008). According to Fassil and Charle (2009) soil degradation and nutrient depletion have been gradually increasing and increasing; now become a serious problem to agricultural productivity in Ethiopia. Shortage of plant nutrients like N, P, K, S, Zn, B and Cu was observed on major crops in different areas of the country (ATA, 2016). Most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014). This experiment was conducted to determine and recommend the rates of blended fertilizes for potato growers of *Kersa Malima* districts of Oromia region using Gudenie and Belete potato varieties.

1.1 Materials and Methods

This experiment was conducted comprising Belete and Gudenie potato verities; and ten fertilizer treatments in *Kersa Malima* district in 2018-2019 main cropping seasons (June-August) using completely randomized block design arrangement with three replications. The fertilizer treatments were Control, 150 kg/ha blended fertilizer+80 kg/ha urea, 250 kg/ha blended fertilizer+80 kg/ha urea, 350 kg/ha blended fertilizer+80 kg/ha urea, 150 kg/ha blended fertilizer+140urea, 250 kg/ha blended fertilizer+140 kg/ha urea, 350 kg/ha blended fertilizer+140 kg/ha urea, 150 kg/ha blended fertilizer +200 kg/ha urea, 250 kg/ha blended fertilizer+200 kg/ha urea and 350 kg/ha blended fertilizer+200 kg/ha urea. The blended fertilizers types were NPSB (N=18.9%, P=37.7%, S=6.95%, B=0.1% content*)* and urea*.* The soil sample was taken from 0-30cm depth for analysis and the result was found in Table 1.

The land was prepared well by plowing 3-4times until fine tilth was achieved in similar ways of land preparation rule for potato fields in Holleta research center. Tubers used for planting was similar size for the varieties. The sprouted tubers were planted in 10 cm depth with 75cm distance between rows and 30cm between plants on 4.5mx3m plot size. The distance between block was 1.0m and plot was 0.5m. All Blended NPSB fertilizer treatments and half amount urea was applied during planting while remaining half of urea applied during start of flowering. All cultural practices except fertilizer treatment was done in the same practice as Holleta research center recommended practice for potato production. Tuber harvesting was done once at proper physiological maturity (70% leaves withering). A tuber dry matter was measured after drying sample biomass in oven dry at 75^0C until constant weight had achieved.

1.1.1 Data Collection

During harvesting tubers were categorized in to marketable and un-marketable yields. Marketable tubers were tubers which were greater than 20mm in diameter and free of cracking, diseases, insect and mechanical damage. The tuber dry matter was prepared from 300gm sample tubers by drying it in oven at 75^0c temperature until constant dry weight was achieved. The data collected were total and marketable tuber number per plot, total tuber and marketable yields in ton/ha, average tuber number/plant and weight/ tuber, tuber dry weight in %, plant height and main stem number.

1.1.2 Data Analysis

Data were subjected to analysis of variance using proc GLM (general linear model) procedure of SAS 9.2 software (SAS Institute Inc. 2009). The means were compared with Least Significant
Difference (LSD) at 5% significance level and the partial budget analysis was conducted.

1.2 Result

1.2.1 Soil analysis result before planting

The soil had average PH of 6.57, phosphorus ppm of 7.71, total nitrogen of 0.15 %, 1.45 % organic carbon and CEC (meq/100g), Clay, Silt and sand % tage of 42.55, 34.17, 35.00 and 30.83, respectively. The textural class of soil was generally clay loam.

1.2.2. Plant height

There was highly significant difference among plant heights due to the impact of fertilizer treatments applied (Table 2). The highest plant height (59.76cm) was recorded at fertilizer application rate of 350 kg/ha NPSB and 200 kg/ha urea even though not significantly different from 350 kg/ha NPSB and 140 kg/ha urea plant height (59.40cm) while the lowest plant height was registered from control (35.61cm) (Table 2). Variety was highly significant in affecting plant height (Table 3). Significantly higher plant height (39.53cm) was obtained from Belete while Gudenie provided lower plant height (37.67cm) (Table 3). The growing year did not significantly affect plant height (Table 3).

1.2.3 Stem number

The main stem number was not significantly affected by fertilizer rates (Table 2). Both growing year and variety affected main stem number highly significantly (Table 3). The higher 3.48 and 3.34 main stem numbers were observed from 2019 growing year and Gudenie variety, respectively (Table 3).

1.2.4 Dry matter

The tuber dry matter in percent was not significantly affected by fertilizer rates variety and interactions (Table 2). Not significantly different the highest dry matter (24.08%) was observed at control treatment followed by the dry matter (23.74%) of 150 kg/ ha NPSB + 200 kg / ha urea; and not significantly different lowest dry matter were observed at 150 kg /ha NPSB + 200 kg/ha urea (23.57%) (Table 2). Tuber dry matter was highly significantly affected by growing year (Table 3). The higher 23.53% tuber dry matter was produced during 2018 growing year while the lower 21.40 % was produced during 2019 growing season.

1.2.5. Average tuber number and weight

The average tuber number per plant and weight per tuber were highly significantly affected by the fertilizer rates, variety and growing season (Table 2). The highest average tuber number (12.23 tuber/plant) was recorded from 350 kg/ha NPSB with 140 kg/ha urea followed by 350 kg/ha NPSB with 80 kg/ha urea (11.92 tubers /plant) and

250 kg/ha NPSB with 200 kg/ha urea(11.61 tubers /plant) while the lowest was recorded at control(6.81 tubers /plant) (Table 2). The maximum average tuber weight per tuber (74.52g) was obtained from 350 kg/ha NPSB with 200 kg/ha urea followed by 250 kg/ha NPSB with 200 kg/ha urea (72.91 g), 150 kg/ha NPSB with 200 kg/ha urea (72.25 g) as well as 350 kg/ha NPSB with 140 kg/ha urea (70.26 g) while the lowest (55.82 g) was recorded at control (Table 2). The growing year highly significantly affected both average tuber number and weight (Table 3). The higher average tuber number (12.82tubers /plant) and the higher average tuber weight (76.46 g) was recorded from 2019 while lowest was from 2018. Variety was highly significant in affecting both average tuber number and weight (table 3). The higher average tuber number was obtained from Gudenie variety while Belete variety produced higher average tuber weight (72.83g).

1.2.6 Total and marketable tuber number

The fertilizer treatments, variety and growing season were highly significant in affecting the total and marketable yield (<0.01) (Table 2). The highest marketable tuber number (253, 252.235) were produced by 350 kg/ha NPSB and 140 kg/ha urea followed by 250 kg/ha NPSB and 200 kg/ha urea; and 350 kg/ha NPSB and 200 kg/ha urea while the lowest was recorded at control (123), respectively (Table 2). The higher 302.54 and 265.17 total and marketable tuber numbers were observed during 2019 growing season, respectively. Higher total and marketable tuber number was obtained from Gudenie variety (Table 3).

1.2.7 Total and marketable tuber yield t/ha

The fertilizer treatments, variety and growing year were highly significant in affecting the total and marketable tuber yield (Figure 1, Table 2). The highest total and marketable yield (38.75 t/ha and 36.51 t/ha) were harvested from 350 kg/ha NPSB+140 kg/ha urea followed by total 37.57 t/ha) and marketable yield (35.66) of 250 kg/ha NPSB+200kg/ ha while the lowest total and marketable yield was obtained from control (16.75 t/ha and 15.5 t/ha), respectively (Figure 1). The higher total and marketable tuber yield (44.31 t/ha and 42.13 t/ha) was produced during 2019 growing year, respectively. The higher 34.10 t/ha and 32.09 t/ha total and marketable tuber yield respectively were provided by Belete variety. Increasing NPSB blended fertilizer from 0-150 kg /ha resulted in marketable yield increase of 89.38% while further increase from 150-250 kg/ha and 250-350 kg/ha increase 21.76% and 10.21%, respectively. In other words increasing 0-150, 0-250 and 0-350 kg/ha resulted in marketable yield increment of 89.38%, 111.14% and 121.35%, respectively. On the other hand, increasing urea fertilizer from 0-80 kg /ha resulted in marketable yield increase of 91.85% while further increase from 80-140 kg/ha and 140-200 kg/ha increase 22.00% and 2.32%, respectively. In other words increasing 0-80, 0-140 and 0-200 kg/ha resulted in marketable yield increment of 91.85%, 113.85% and 116.17%, respectively.

The highest benefit (108,426.5TB) was gained from 350 kg/ha NPSB +140 kg/ha urea followed by 250kg/ha NPSB + 200 kg/ha urea (106,429ETB) while the lowest benefit was obtained from control (Table 4). The highest marginal rate of return (24,391.25%) obtained from 250 kg/ha NPSB+200 kg/ha urea (Table 4). This means, the investment return increment rate was highest at application rate of 250 kg/ha NPSB+200 kg/ha urea. At this application the income was 24,391.25% times of the cost of fertilizer and this income was the highest income in relation to the other rates.

1.3 Discussion

The average pH value before planting was general 6.37 which is moderately acidic soil reaction (Herrera, 2005) with pH values ranging 5.69 – 6.98. This pH rage is good for nutrient uptake by the plants (Warren, 2004). The pH value reported for the experimental soil does not have toxicity of aluminum, manganese and hydrogen; rather than abundance of cations like K^{+1}, Ca^{+2} and Mg^{+2}(Fall, 1998). EthioSIS(2013) soil pH classification supports the result as it was moderatesoil pH level. The pH of the soil between 5.00 and 7.55 are found within the suitable range for crop Production (Sahlemdhin, 1999). According to FAO (2006) report, pH range of most crops was 4-8 because of variable optimum pH requirement of different crops. Thus, the pH of the experimental soil is almost within the range for productive soils for potato crop. The soil particle size percentage of the soil of production land was *34.17*% for clay, *35.00*% for slit and *30.83*% for sand that forms clay loam soil class. The soil textural class of the experimental site was not far of the ideal soil textural class requirement of potato as it is sandy loam. The available phosphorus content of the growing location soil was 7.15ppm, 6.79ppm, 9.18 for replications I, II, and III respectively and the average was 7.71ppm which were all in general in the low range of available phosphorus according to Tekalign (1991).

The average soil total nitrogen of the site before planting was 0.15% which is in the low range according to rating of Havlin *et al*. (1999) as rated total nitrogen below 0.1% very low, 0.1 to 0.15 % low, 0.15 to 0.25 % medium, and high > 0.25 %. EthioSIS(2014) total nitrogen content rating confirms this result was in the low range of nitrogen level.

According to Tekalign (1991) rating the average organic carbon content of the soil before planting was medium as the result indicated 1.45% organic carbon content. Soil organic carbon percentages of < 0.60, 0.6- 1.0, 1.0 - 1.80, 1.80 -3.0, and >3 as very low, low, medium, high and very high, respectively (EthioSIS, 2013). The cation exchange capacity of the experimental area before planting was *42.55* which is a very high cation exchange capacity value according to Hazelton and Murphy(2007). In line with this, Landon (1991) report also in conformity with the result as he also rated CEC of greater than 40 cmol kg-1 is very high level. From the results, the problem of growing soils of Keresa Malima district was low available phosphorus and nitrogen which require higher application of the plant nutrient to get reasonable yield.

There was highly significant difference among plant heights due to the impact of fertilizer treatments applied and variety. The highest plant height (59.76 cm) was recorded at highest fertilizer application rate of 350 kg/ha NPSB and 200 kg/ha urea followed by 350 kg/ha NPSB+140 kg/ha urea(59.04 cm) while the lowest plant height was registered from control(35.61 cm). This is probably due to the crop nutrient need satisfaction and growing condition favorability of growing location that make the crop to take up the applied nutrient and use it for more plant height growth due to applied Boron as it assists the root to absorb more nutrient (Diriba et al., 2019). This result was in agreement with Melkamu et al. (2019) as they reported highest plant height at the highest fertilizer applied. It is also in conformity with Mulugeta et al. (2019). Significantly higher plant height (39.53cm) was obtained from Belete while Gudenie provided lower plant height (37.67cm). This is due to genetic potential difference of the two varieties. Main stem number was not significantly affected by fertilizer rates. Both growing year and variety affected main stem number highly significantly. These results are in conformity with reports of some researchers in that stem number is not influenced by mineral fertilizers but affected by physiological age of the seed tuber (Asiedu *et al*., 2003), storage condition of tubers, number of viable sprouts at planting, sprout damage at the time of planting and growing conditions (Firman and Allen, 2007), variety and tuber size (Park *et al*., 2009).

The yield and yield components were highly significantly affected by main effect fertilizer rates and variety. The highest average tuber number and weight, total and marketable number and weight were recorded from the highest fertilizer applied while the lowest were from the control (non-fertilized treatments). These results are in agreement with those of Singh et al. (2016) that reported application of nitrogen, phosphorus and sulfur fertilizer resulted in significantly increased in marketable and total tuber yield. This could be probably due to the fact that tuber number and size increases at higher nitrogen rate because nitrogen can promote the vegetative growth for more photo-assimilate production while phosphorous improved the development of roots for nutrient uptake and stolen for more tuber production. Israel et al. (2012) indicated that increase in nitrogen and phosphorus application from 0 -165 kg /ha and 0 - 60 kg/ ha were resulted in marketable tuber number increase by 56.36 and 19.2% respectively compared to control. Similarly, Singh et al. (2016) reported that application of 180 kg/ha nitrogen with 50 kg/ha sulfur, increased the number of tuber by 43%. Application of phosphorus fertilizer had significant contribution to increase in total tuber yield and total number of tubers per plant as compared to unfertilized (Rosen and Bierman, 2008). The current result is in consistency with Israel et al. (2012) who reported an increase in total tuber yield and average tuber weight with increased nitrogen and phosphorous fertilizer application. Sulfur fertilizer application is reported for significant increase of potato tuber yield by enlarging tuber sizes (Barczak et al., 2013). According to the report of Mahmoodabad et al. (2010) and Sharma and Arora (1987), increment of nitrogen fertilizer rate resulted in more tuber yield but excessive rate of nitrogen (250 kg ha-1) decreased the total number of tubers per unit area and yield. Similarly, Sharma et al. (2011) reported that application of sulfur fertilizer resulted significant differences on yield and raising the level 0 to 45kg/ha increased total tuber yield per plant by 32.55%. Also, similar report of response of potato with application of nitrogen and phosphorous fertilizers was mentioned in. Zelalem et al. (2009).

1.4 Conclusion

This study revealed that there was significant difference among the yield and yield components due to fertilizer rates. The interaction did not affect any parameter considered. The highest total and marketable yield (38.75 t/ha and 36.51 t/ha) respectively were harvested from 350 kg/ha NPSB+140 kg/ha urea followed by total and marketable yield of 250 kg/ha NPSB+200kg/ ha urea (37.57 and 35.66 t/ha), respectively. The variety was also highly significant in affecting all parameter considered except total and marketable tuber number as well as average tuber number. The highest benefit (108,426.5TB) was gained from 350 kg/ha NPSB +140 kg/ha urea followed by 250kg/ha NPSB + 200 kg/ha urea (106,429ETB) while the lowest benefit was obtained from control (Table 4). The highest marginal rate of return (24,391.25%) obtained from 250 kg/ha NPSB+200 kg/ha urea (Table 4). This means, the investment return increment rate was highest at application rate of 250 kg/ha NPSB+200 kg/ha urea. At this application the income was 24,391.25% times of the cost of fertilizer and this income was the highest income in relation to the other rates. From this it can be concluded that the fertilizer rates NPSB+urea highly significantly affected the yield and yield component of potato. It is better to apply 250 kg/ha urea+200kg/ha urea to potato for high yield and high economic return in Kersa Malima district.

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Table 1: Soil analysis before planting for the growing location

Replication	*PH*	*Avi. P ppm*	*N (%)*	*OC %*	*CEC (meq/100g)*	*Texture %*		
						Clay	*Silt*	*Sand*
1	*6.73*	7.15	*0.13*	*1.26*	*41.92*	*35*	*35*	*30*
2	*6.63*	6.79	*0.20*	*1.18*	*43.42*	*35*	*37.5*	*27.5*
3	*6.22*	9.18	*0.13*	*1.92*	*42.3*	*32.5*	*32.5*	*35*
Average	*6.53*	7.71	*0.15*	*1.45*	*42.55*	*34.17*	*35.00*	*30.83*

Available phosphorus in parts per mole, total nitrogen in percentage, Organic matter in percentage, Cation exchange capacity in meqper 100g.

Table 2: Effect of NPSB and Urea fertilizers on potato dry matter, height, stem number, yield and yield component

NPSB+ Urea kg/ha	PH(cm)	SN	DM %	ATN/ plant	ATW/ tuber in g	MTN/ plot	TTN/ plot
350+200	59.76a	4.78a	23.48	10.82cde	74.52a	235ab	283bcd
350+140	59.40ab	4.57a	23.44	12.23a	70.26abc	253a	306a
350+80	49.71f	4.43a	23.48	11.92ab	65.00def	233b	287abc
250+200	53.20de	4.42a	23.57	11.61abc	72.91ab	252a	297ab
150+200	55.93cd	4.75a	23.74	10.40de	72.25ab	212c	264de
250+140	56.60bc	4.42a	23.37	11.21bcd	69.60bcd	233b	280bcd
250+80	51.51ef	4.67a	23.34	11.04bcd	63.03ef	223bc	276cde
150+140	56.03cd	4.76a	22.97	10.49de	67.50cde	219bc	267cde
150+80	53.53de	4.65a	23.14	9.98e	62.74f	206c	258e
Control	35.61g	3.75b	24.08	6.81f	55.82g	123d	159f
LSD	2.8934	0.3751		0.90	4.69	19.00	20.00
CV	11.73	17.87	6.71	18.13	15.00	18.93	16.45
P-value	<.0001	<.0001	NS	<.0001	<.0001	<.0001	<.0001

PH (cm) =plant height in cm, SN=stem number, DM %= tuber dry matter in percent, ATN/plant= Average tuber number per plant, ATW/ tuber(g)= Average tuber number per tuber in g, TTN/plot= Total tuber number per plot, MTN/plot=Marketable tuber number per plot.

Table 3: Effect of year and variety on potato dry matter, height, stems number, yield and yield Component

Year	PH(cm)	SN	DM (%)	ATN/ plant	ATW/ tuber	MTN/ plot	TTN/ plot	TTY t/ha	MTY t/ha
2018	42.25b	3.72b	23.53a	8.48b	55.27b	172.32b	232.66b	29.73b	18.50b
2019	64.00a	5.32a	21.40b	12.82a	79.46a	265.17a	302.54a	44.13a	42.44a
LSD	1.29	0.17	0.33	0.40	2.10	8.60	9.14	1.30	1.29
P-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.002	<.0001
				Variety					
Belete	54.56a	4.18b	23.56	10.35b	72.83a	210.93b	254.94b	34.10a	32.09a
Gudenie	51.70b	4.86a	23.36	10.95a	61.90b	226.56a	280.27a	30.76b	28.85b
LSD	1.29	0.17		0.40	2.10	8.60	9.14	1.30	1.29
CV	11.73	17.87	6.71	18.13	15.00	18.93	16.45	19.32	20.35
P-value	<.0001	<.0001	NS	0.0032	<.0001	0.0004	<.0001	<.0001	<.0001

PH (cm)=plant height in cm, SN=stem number, DM %= tuber dry matter in percent, ATN/plant= Average tuber number per plant, ATW/tuber(g)= Average tuber number per tuber in g, TTN/plot= Total tuber number per plot, MTN/plot=Marketable tuber number per plot, TTY t/ha= Total tuber yield ton per hectare, MTY t/ha= marketable tuber number ton per hectare.

Table 4: Partial Budget analysis

Fertilizer rates kg/ha NPSB+Urea	Variable cost ETB	Marginal cost ETB	Gross benefit ETB	Net Benefit ETB	Marginal Benefit ETB	Marginal rate of return %
control	0		48,825	48,825		
150+80	1170	1170	85,144.5	83,974.5	35,149.5	3,004.231
150+140	1890	720	94,626	92,736	8,761.5	1,216.875
150+200	2610	720	97,618.5	95,008.5	2,272.5	315.625
250+80	4460	1850	93,334.5	88,874.5		
250+140	5180	720	103,603.5	98,423.5	9,549	1,326.25
350+80	5860	680	102,532.5	96,672.5		
250+200	5900	40	112,329	106,429	9,756.5	24,391.25
350+140	6580	680	115,006.5	108,426.5	1,997.5	293.75
350+200	7300	720	106,690.5	99,390.5		

Price for 100kg potato was 400ETB and yield adjustment factor 10%

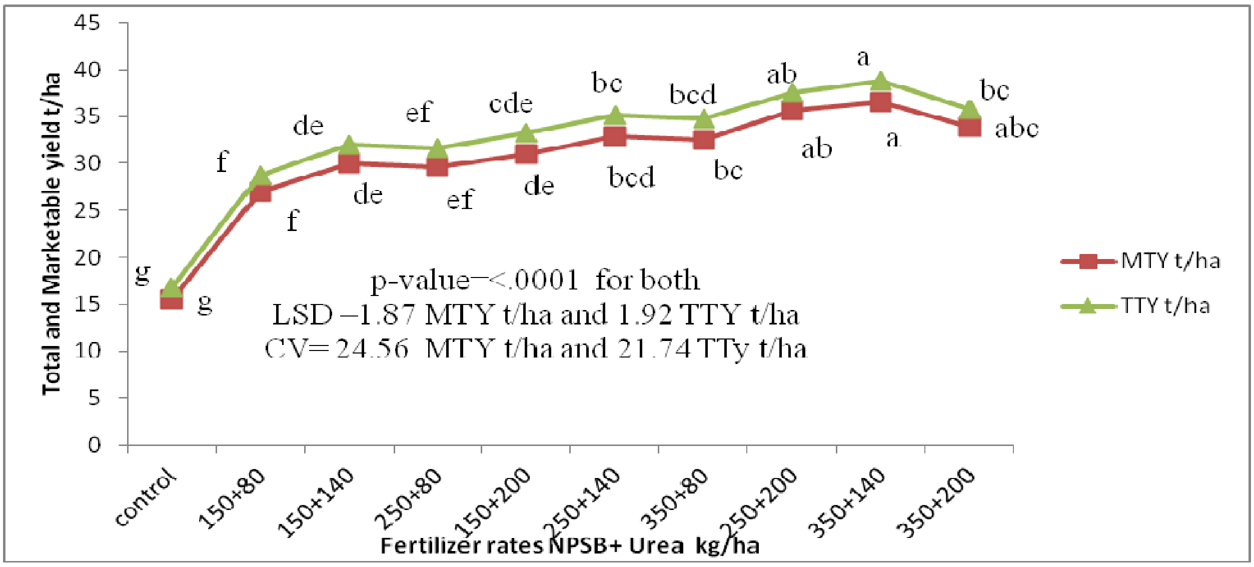

Figure 2: Effect of NPSB +Urea kg/ha on Total and marketable tuber yield at Kersa Malima Growing condition