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EFFECTS OF POTASSIUM FERTILIZER ON THE YIELD COMPONENTS AND TUBER YIELD OF IRISH POTATO (*Solanum tuberosum* L.) IN WOLAITA ZONE, SOUTHERN ETHIOPIA

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ABSTRACT

Irish potato (*Solanum tuberosum* L.) is cultivated for food and cash in Ethiopia. However, its productivity is limited by various constraints among which are particularly high demands of potassium (K) fertilizer for growth and development coupled with low soil fertility. Further studies need to be done to prove the emerging research evidences that Potassium (K) is becoming a limiting nutrient in some Ethiopian soils. A field experiment was conducted to determine effects of K-fertilizer (KF) on yield components (YC) and yield of potato in Abota-Ulto (Loc-1) and Gututo-Ampokosha (Loc-2) locations, Southern Ethiopia. Treatments included different rates of potassium fertilizer: 0, 30, 60, 90, 120, 150 and 180 kgha^{-1}. The experiment was laid out in RCBD (randomized complete block design) with three replications. Results revealed that YC and yield of potato were significantly affected by both main and interaction effects of KF rates and locations. Marketable tuber yield (MTY) was significantly increased from 15.6mtha^{-1} in the control to 33.6mtha^{-1} with KF (potassium fertilizer) rate 150 kgha^{-1}. Significantly higher MTY was obtained in Loc-1 than Loc-2. K-fertilizer rates by location interaction effects were significant on YC and yield of potato. In Loc-1 the highest MTY was obtained with KF applied at150 kgha^{-1} whereas in Loc-2 the highest MTY was obtained with KF applied at120 kgha^{-1}. Results of partial budget analyses showed that in Loc-1, the highest net benefit (Ethiopian Birr 96060ha^{-1}) with marginal rate of return was 1102% with KF applied at 150 kgha^{-1}. In Loc-2, the highest net benefit (Ethiopian Birr 73312.8 ha^{-1}) with marginal rate of return was 910% with KF applied at120 kgha^{-1}. It was concluded that potato significantly responded to KF indicating insufficient amount of K content in the soils of both locations for optimum potato production. Application of potassium fertilizer is economically feasible in both locations.

Key words: K- Fertilizer application, Potato production, Marketable yield, Economic feasibility, Locations

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INTRODUCTION

Potassium (K) is one of the most important essential nutrients required for plant growth and development. It plays a crucial role in activation of enzymes, osmoregulation, photosynthesis, nitrated degradation and starch synthesis and sugar degradation. Especially, K enables plants to tolerate various types of stress such as drought, frost damage, diseases and insect pests [1]. Thus, due to its multiple functions, there must be sufficient supply of K in particular soils to ensure optimum growth and production of crops. Otherwise, K deficiency causes serious crop yield reduction and crops growing on soils with K deficiency become susceptible to diseases and insect pests, damage by frost and will produce low yield and poor quality [2]. Consequently, in K deficient soils, K should be applied in the form of fertilizer for high quality and optimum crop production.

In Ethiopia, soils were thought to be rich in K contents and hence it was not part of the fertilizer program in Ethiopian agriculture [3]. But with time, with increasing soil degradation caused by soil erosion, continuous cultivation, heavy leaching due to torrential rainfall in the highlands, inadequate application of organic matter, among others, it is likely that recently, K could be depleted in Ethiopian soils limiting crop productivity. In this line, emerging research evidences few decades back in Ethiopia are showing that indeed K is becoming a limiting nutrient in some Ethiopian soils. For instance, Abiye *et al.* [4] studied the response of wheat to K fertilizer grown on a vertisol in Chefe-Donsa district, central Ethiopia and reported that application significantly increased the grain and straw yield of wheat. Similarly, the response of potato to different K fertilizer levels was studied for two years (2007-2008) on acidic soils of Chencha, southern Ethiopia.

The result revealed that the tuber yield of potato was significantly increased with increasing levels of K and the highest tuber yield of potato was obtained with K applied at150 kgha^{-1}. Potassium applied at this rate increased the total tuber yield at18 tha^{-1} in the control treatment to53 tha^{-1} [5]. In Hagere-Selam district of southern Ethiopia, Wassie and Shiferaw [6] studied the response of Irish potato to K fertilizer in 2007/08 cropping season on farmers' fields and found that K applied at 100 kgha^{-1} significantly increased the total and marketable yield of potato by 208 and 252%, respectively, over the untreated control, indicating insufficient K in the soil of study area for potato production. In central Ethiopia, in a location known as Moretena-Jiru, Eyasu *et al*. [7] studied the effects of K-fertilizer application on tef and found significant response of the crop to K fertilizer application. These are only a few examples whereby responses of different crops to K-fertilizer application were reported. Otherwise, there are a good number of published works indicating significant crop responses to K fertilizer application across locations in Ethiopia.

The overall implication of all these findings is that K is becoming a limiting nutrient in some Ethiopia soils against long standing claim that Ethiopian soils are rich in K and thus, there was no need to apply K fertilizer. However, still there is a need for further studies on responses of diverse crops involving different soil types and locations to further prove that indeed K has become a limiting nutrient in Ethiopian soils. In this line, there is little or no information on soil K status and the responses of crops to K fertilizer application in Wolaita zone, southern Ethiopia. Consequently, this experiment was conducted in two districts of Wolaita zone to evaluate the effects of K fertilizer on yield components and yield of potato and to determine economic feasibility of K fertilizer for potato production in the study areas.

MATERIALS AND METHODS

Brief descriptions of study sites

The experiment was conducted on farmers' fields on two sites/locations called Abota-Ulto and Gututo-Ampokoysha. Abota-Ulto site is found in Damot Pulassa district, Wolaita zone, southern Ethiopia. Geographically it is located between 07°02'33" and 07°03'43" N and 037°87'80"and 037°90'01" E. It is situated at an altitude ranging from 1884-1930 meters above sea level. Its mean monthly minimum and maximum temperatures are 16.27 and 21.68^{o}c, respectively and receives mean annual rainfall of 1403.94 mm. Whereas, Gututo-Amphokoysha site is found in Humbo district, Wolaita zone, southern Ethiopia. It is located between 06° 72' 02" and 06° 76' 18"N and 37° 77'10" and 37° 77'79"E. It has an altitude ranging from 1804-1836 meters above sea level. Its mean monthly minimum and maximum temperatures are 19.4^{o}C and 22.5^{o}C, respectively and receives a mean annual rainfall of 1267.5mm.

Pre-planting soil sampling and analysis

After selecting the exact fields at which the experiment was to be conducted, in both sites, soil samples from each field were collected from 15 spots within the field at fixed intervals by walking in a zigzag manner from a depth of 0-20cm by using a soil augur. The collected samples were composited in one big plastic bag and from a thoroughly mixed sample, a kg of soil sample was taken and brought to the laboratory. In the laboratory, the soil sample was processed following standard procedures and analyzed for selected physicochemical properties. Soil texture was determined by Bouyoucos hydrometer method [8]. Soil pH was determined in 1:2.5 soil-water suspensions by using pH meter [9]. Soil organic carbon (OC) content was determined by wet digestion method [10]. Available phosphorus (AvP) was determined by Olsen's method using sodium bicarbonate (0.5M NaHCO3) as extraction solution [11], and total nitrogen by Kjeldhal method following procedures outlined by Bremner [12]. Exchangeable bases (calcium, magnesium, potassium and sodium) and CEC (cation exchange capacity) were determined by the ammonium acetate (1M NH4OAc at pH 7) extraction method [13].

Treatments, design and experimental procedures

Treatments with K fertilizer rates were; 0, 30, 60, 90, 120, 150 and 180 kgha^{-1} and the experiments were laid out in RCBD (randomized complete block design) with three replications. Improved potato variety Gudenie, common among farmers of both sites, was planted in a plot size 2.1 x 3.75m in rows with intra and inter row spacings of 30 and 75cm, respectively. Plots were separated by 0.5cm spacing and blocks were separated by 1m space apart from each other. The whole dose of K fertilizer was basal applied just before planting in the form of potassium chloride (KCl) as per the treatment. Blended fertilizer of nitrogen, phosphorus, sulfur and boron (NPSB) was also basically applied uniformly to all plots at rate 100 kgha^{-1}. The recommended amount of N fertilizer; 46 kgha^{-1} for potato production at the study area was applied in the form of Urea. The N fertilizer was split applied in which one half of the recommended dose was applied at planting and the remaining half dose was applied one and half month after planting of potato just after first weeding of the experimental plots. Agronomic management of the experiment was done as per recommendations for potato production in Ethiopia described in the Crop Technologies Guideline (EIAR) [14].

Data collection and measurements

Data on specific gravity (Spr), number of marketable tubers per plot (NMTPP), number unmarketable per plot (NUMTPP) and average tuber weight per tuber (ATWPT) were taken and recorded. At physiological maturity of the test crop, data on marketable tuber yield (MTY), unmarketable tuber yield (UMTY) and total tuber yield (TTY) were also collected and recorded. Total tuber yield (TTY) was collected from middle three rows in each plot and tuber yields from each plot was weighed in 25 kg capacity balance, and the resulting data were recorded as TTY in kg per plot. Then, the TTY of each plot was sorted into MTY and UMTY weighed and recorded in kg per plot. Those tuber yields which were free from damage by diseases and insect pests and weighing equal or greater than 25g were sorted as MTY. Those tuber yields which were rotten and/or damaged by diseases and insect pests and weighed 25g were considered as UMTY. Finally, the various components of tuber yield data collected from each plot were converted from kg per plot into metric tons per hectare (mtha^{-1}) for the purposes of analyses and reporting.

Statistical data analysis

Data on specific gravity (Spr), average tuber weight per tuber (ATWPT) number of marketable tubers per plot (NMTPP), number of unmarketable tubers per plot (NUMTPP), marketable tuber yield (MTY), unmarketable tuber yield (UMTY) and total tuber yield (TTY) were subjected to analysis of variance (ANOVA) using statistical analysis software (SAS) version 9.0 [15]. For those parameters whose ANOVA tested to be significant, further mean separation was done using least significance difference (LSD) at 0.05 probability level by using the same software.

Partial budget analysis of treatment effects

Partial budget analysis of treatment effects was done following procedures described by International Maize and Wheat Improvement Center (CIMMYT) [16] to determine economic feasibility of treatments (K fertilizer rates) for potato production in the study areas. The partial budget analysis was done for each of the two study areas due to the fact that the K fertilizer rates' effect on potato tuber yield of both sites was statistically significant. In doing so, mean marketable tuber yield of potato obtained in response to each treatment was used to calculate the partial budget of treatment effects in both locations. Moreover, the tuber yield data were adjusted down by 10% to compromise for crop management practice differences which are employed by researchers and farmers.

Price of variable cost, which is the price of K fertilizer, was taken to be Ethiopian Birr (ETB) 40.00 kg^{-1} or (US$ = 0.314). The market price of potato in the nearby local markets of each location was taken. Accordingly, at the time of crop harvest, prices of potato tuber yield in the local markets of Abota-Ulto and Gututo-Ampokosha were ETB 3.00 and 2.85 per kg of tuber yield, respectively.

Gross benefit (GBT) from each treatment was calculated as a product of mean marketable tuber yield ($kgha^{-1}$) and the market price of tuber yield ($ETBkg^{-1}$). Net benefit (NBT) obtained from each treatment was calculated as the difference between GBT and variable cost of each treatment. Marginal rate of return was calculated as the ratio of the difference between NBTS of successive treatments and the difference between the variable costs of corresponding successive treatment and was expressed in percentage. Treatments with MMR values greater than 100% were considered as economically viable ones.

RESULTS AND DISCUSSION

Pre-planting selected soil physicochemical properties of the study locations

Some of the physicochemical properties of soils of the study locations analyzed before planting of the experiment are summarized in Table 1. Accordingly, the soil reactions were in slightly acidic range in both locations based on the ratings described by Jones [17]. The soil organic matter and total nitrogen contents were in the medium category in Abota-Ulto location and in low category in the Gututo-Ampokosha as per the ratings described by Landon [18]. Soil available phosphorus (AvP) content of the former location was higher than found in the soil of the later location. However, in both locations the AvP contents were below soil critical P level established for some Ethiopian soils which is 8.0$mgkg^{-1}$ [19]. The exchangeable K contents of soils of both locations were found to be below critical levels required for optimum growth and production of potato [20].

Effects of K-fertilizer rates on the yield components of and yield of potato
Effects of K-fertilizer rates

Main effects of K-fertilizer rates and location on the yield components of potato are shown in Table 2. The NMTPPs were significantly increased with increasing rates of K-fertilizer over locations and the lowest and highest NMTPPs were recorded in the control and K-fertilizer rate of 150kgha^{-1}, respectively. On the contrary, the highest and lowest NUMTPPs were recorded in the control treatment and K-fertilizer rate of 150 kgha^{-1} treatments, respectively. The current finding is in agreement with Miressa and Yohannes [21] who reported that the number of tubers per hill increased with increasing rates of K-fertilizer and the highest number of tubers was obtained with K-fertilizer applied at150 kgha^{-1}. The current result is also in line with Niguse *et al*. [22] who reported that the number of tubers per hill gradually increases with increasing rates of K-fertilizer application. Furthermore, Chala [23] studied the responses of two potato varieties in Bale Highland of Ethiopia to different rates of K fertilizer and reported that number of marketable tubers per hill of two varieties had been significantly increased with increasing levels of K-fertilizer application whereas no significant difference in the number of unmarketable tubers per hill was observed due to K-fertilizer application.

Number of marketable tubers per plot (NMTPP) and Number of un-marketable tubers per plot NUMTPP were also significantly affected by location. Higher NMTPP was obtained in Abota-Ulto than in Gututo-Ampokosha whereas higher NUMTPP was recorded in the later than former location. This could be due to better site quality and adaptability of potato variety in the former than later location.

Average tuber weight per tuber (ATWPT) was also significantly affected by main effects of K-fertilizer and location (Table 2). It was significantly increased with increasing rates of K-fertilizer from 45.2g in the control to 81.7g for which K-fertilizer was applied at150 kgha^{-1}. Average tuber weight per tuber is one of the most important yield components of potato which significantly responded in K-deficient soils. In line with current finding, Egata *et al*. [24] studied the effects of K fertilizer sources along with nitrogen and phosphorus on potato in four locations in Ethiopia and reported that ATWPT was significantly increased with K-fertilizer. A significantly higher ATWPT of potato was obtained in the Abota-Ulto than in Gututo-Ampokosha location.

Main effects of K-fertilizer rates and location on specific gravity of potato are shown in Table 2. Specific gravity (Spr) was significantly increased with increasing rates of K-fertilizer and the highest superior Spr (1.087) was obtained with K-fertilizer applied at150 kgha^{-1}. Specific gravity is one of the most important quality parameters of potato tuber and tubers with Spr are needed for the purpose of processing potato tubers into chips [25] and it is one of quality indices improved by K nutrition. It is due to this fact that Spr was significantly improved by K-fertilizer application in this study. In a similar study, Miressa and Yohannes [21] and Yohannes *et al.* [26] reported that application of K in Wachamo site, Hadya zone southern Ethiopia in the form of KCl has significantly increased Spr of potato tubers.

Effects of K-fertilizer rates on the tuber yield of potato

Both marketable tuber yield (MTY) and total tuber yield (TTY) were significantly affected by main effects of K-fertilizer rates (Table 3). They were increased significantly with increasing rates of K-fertilizer rates and the highest values of these parameters were obtained from K-fertilizer applied at 150 kgha^{-1}. It increased MTY and TTY of potato by 116 and 113%, respectively over the control. The result is in agreement with the finding of Wassie and Shiferaw [6] who reported that application of K fertilizer has significantly increased the tuber yield of potato at Hagere-Selam district southern Ethiopia. Furthermore, the result of similar study reported by Wassie [5] indicated that application of K fertilizer has significantly increased the tuber yield of potato in Chencha district, southern Ethiopia which is some 150 km away from the current study location. According to these authors, K-fertilizer applied at 150 kgha^{-1} increased the total tuber yield of potato from 18tha^{-1} in the control plot to 53tha^{-1} in the treated plot which was a very impressive response to K fertilizer application. Moreover, Miressa and Yohannes [21] studied the response of potato to K-fertilizer application in Wachamo, Southern Ethiopia and found that application of 150 kgha^{-1} KCl increased MTY and TTY by 22 and 11%, respectively, over that obtained from unfertilized control treatment which is in line with present finding. Yohannes *et al.* [26] studied the response of potato K-fertilizer and reported that TTY was increased from 22.84 tonha^{-1} obtained in the control treatment to 39.2 tonha^{-1} due to application of K-fertilizer applied at 200 kgha^{-1} in the form of K_2O. The result of the current study signified insufficient or low level of K in the soils of the study locations for optimum production potato. This was confirmed by the low level of exchangeable K content in soils of both locations as was revealed by results of pre-planting soil analyses data shown in Table 1.

The tuber yield of potato was also significantly affected by locations and higher tuber yield was obtained in Abota-Ulto location than in Gututo-Ampokosha (Table 3). This could be due to better site quality especially in terms of selected soil physicochemical properties in the former than in the later location.

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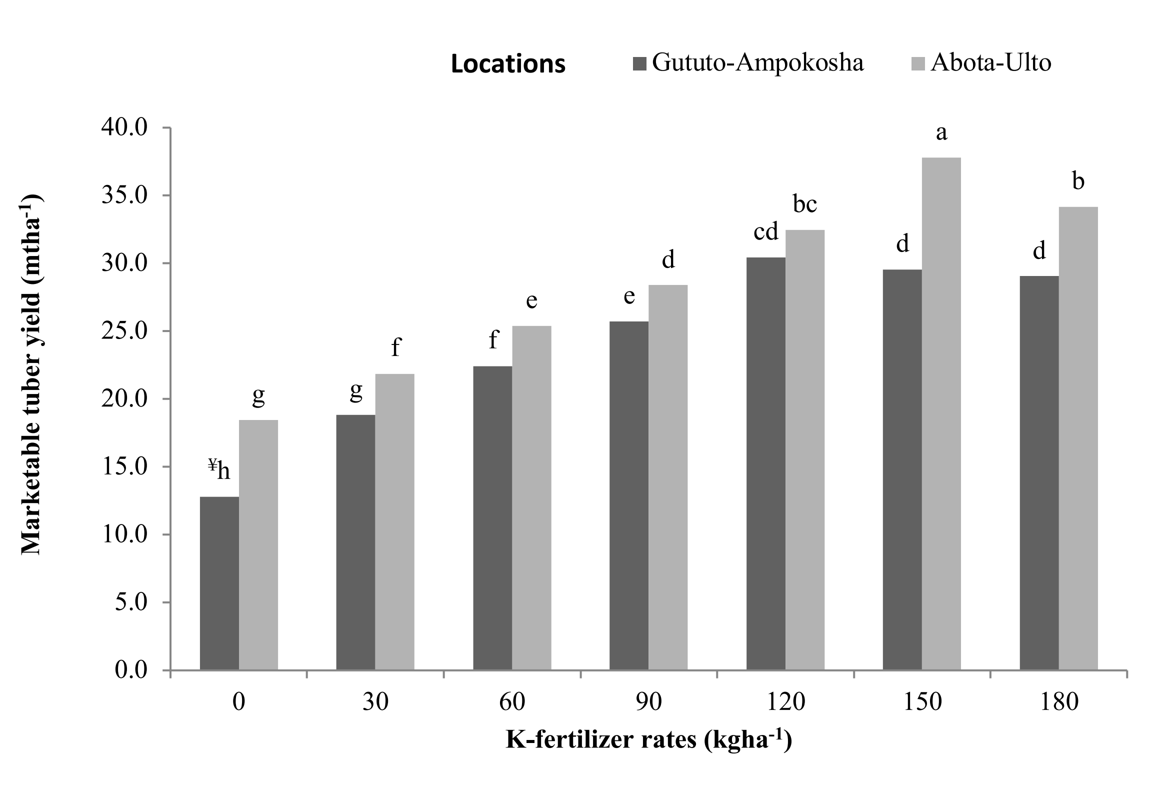

Figure 1: Interaction effect of K fertilizer rates and locations on the marketable tuber yield of potato grown in two locations in Wolaita zone, southern Ethiopia

¥Bars followed by the same letter (s) is not statistically different from each other at 0.05 probability level

Marketable tuber yield (MTY) of potato was significantly affected by interaction effect of K-fertilizer rates and locations (Fig.1). In Gututo-Ampokosha location, MTY was significantly increased with increasing levels of K-fertilizer and the highest MTY (30.5mtha^{-1}) was obtained at K-fertilizer rate applied as 120 kgha^{-1}. There was no further increase in MTY of potato obtained with further increase in K-fertilizer rates. But in the Abota-Ulto location, the highest MYL (37.8 mtha^{-1}) was obtained with K-fertilizer applied at 150 kgha^{-1}. The interaction effect of K-fertilizer rates and locations on TTY of potato is shown in Fig 2. Total tuber yield (TTY) was also significantly affected by interaction effect of K-fertilizer rates and locations. In Gututo-Ampokosha, TTY gains ranged from 13.4mtha^{-1} in the control to 31.2mtha^{-1} in plots applied with K-fertilizer at 120 kgha^{-1} whereas it ranged from 18.9 mtha^{-1} to 39.0 mtha^{-1} in plot treated with 150 kgha^{-1} K-fertilizer in Abota-Ulto. These results imply that potato variety, Gudinie used in this study better responds to K-fertilizer in Abota-Ulto than Gututo-Ampokosha location. This could be attributed to better adaptability of the test variety of potato in the former than in the latter location. In line with this study the effects of different fertilizers including K-fertilizer on potato studied in four

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locations of central Ethiopia and the result revealed that MTY and TTY of potato were significantly and widely varied across locations [27].

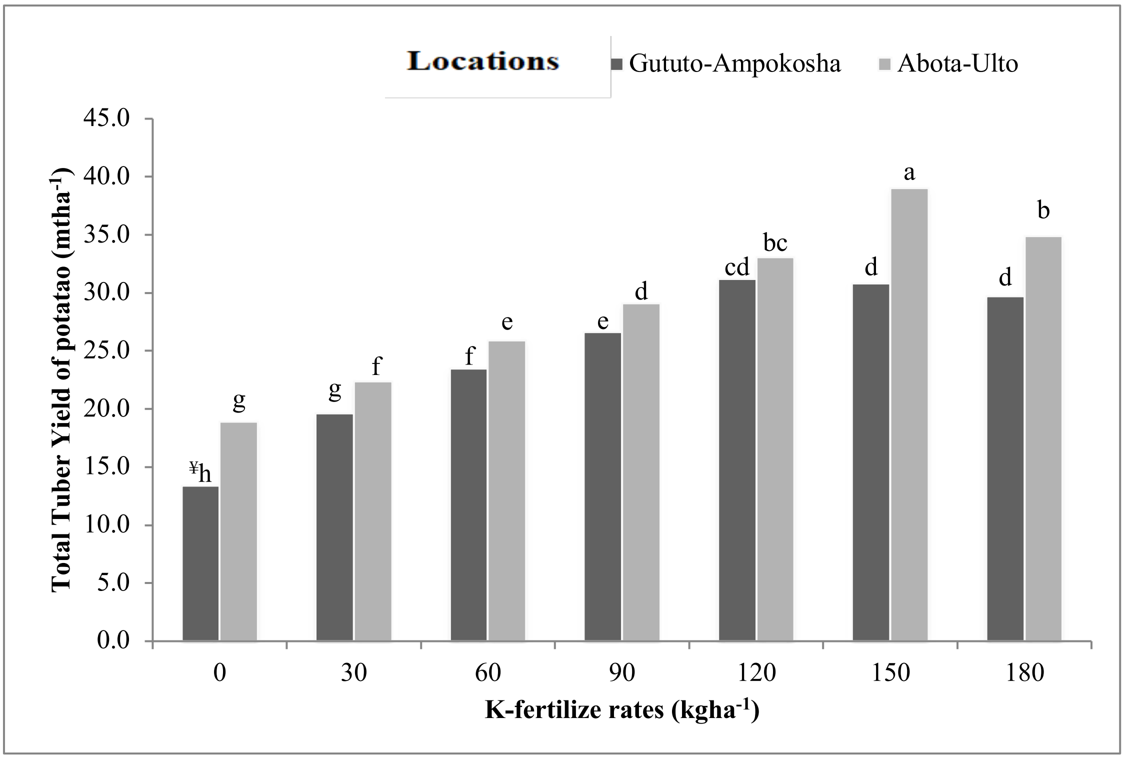

Figure 2: Interaction effect of K-fertilizer rates and locations on the total tuber yield of potato grown in two locations in Wolaita Zone, Southern Ethiopia

¥Bars followed by the same letter (s) is not statistically different from each other at 0.05 probability level

Partial budget Analysis of K-fertilizer rates

The result of partial budget analysis data of Abota-Ulto location is summarized in Table 4. All rates of K-fertilizer produced net benefits much higher than that produced by untreated control treatment and the highest net benefit was obtained from K-fertilizer applied at150 kgha^{-1}. Similarly, all K-rates produced marginal rate of return (MMR) greater than 100% implying that application of K-fertilizer was economically feasible in this location. However, the highest MMR (1102%) was obtained with K-fertilizer applied at150 kgha^{-1} making it the most economically feasible rate to use it for potato production in the study location.

Application of K-fertilizer has also produced much higher NBT than that produced with untreated control treatment in Gututo-Ampokosh (Table 5). The highest NBTha^{-1} (ETB73312.8) was produced from K-fertilizer applied at 120 kgha^{-1} indicating K-fertilizer application is economically feasible in Gututo-Ampokosha. The highest MMR was obtained from K-fertilizer applied at 30 kgha^{-1}, but this treatment produced the lowest value of NBT compared to other K-fertilizer rates. The next highest MRR was K-fertilizer applied at 120 kgha^{-1} thus; as this treatment produced the highest amount of NBTha^{-1}, it stands to be the most economical K-fertilizer rate for potato production in the study area stated above. In agreement with the current result, in addition to significantly improving the biological yield of potato, application of K-fertilizer was found to be economically feasible by some authors [5, 6, 23].

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Application of K fertilizer significantly increased the yield components and tuber yield of potato grown in Abota-Ulto and Gututo-Ampokosha locations of Wolaita zone, southern Ethiopia, indicating insufficient amount of K in the soils of both locations. This was proved by below critical soil test K values in soils from both locations. Significantly higher tuber yield of potato was found in Abota-Ulto than Gututo-Ampokosha location implying better adaptability and/or better site quality in the former than in the latter location, which suggests that location variation had also significant effect on optimum potassium fertilizer application for boosted potato productions. Consequently, the highest tuber yield of potato was obtained with K-fertilizer rates at 120 and 150 kgha^{-1} on Gututo-Ampokosh and Abota-Ulto site, respectively. The results of partial budget analysis revealed that all K-fertilizer rates produced higher net benefits and marginal rate of returns than that produced by the untreated control treatment in both locations, indicating that K-fertilizer application is economically feasible for potato production in both locations.

Application of 120 and 150 kgha^{-1} of K fertilizer is recommended for the improved production of potato in Gututo-Ampopokosha and Abota-Ulto locations, respectively. However, further verification of these K-fertilizer rates in several famers' fields in the respective locations is required.

Data Availability

Data that supports the findings stated in this study are available from the corresponding author on the request.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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Table 1: Pre-planting selected physicochemical properties of the soil of the study locations

Locations	Texture	DB (gcm^{-3})	pH	OM %	TN	AvP (mgkg^{-1})	CEC Cmol(+)kg^{-1}	Ca^{2+}	Mg^{2+}	K^+	Na^+
Abota-Ulto		1.07	6.10	2.62		5.75	17.3	12.09	4.29	0.49	0.15
Gututo-Ampokosha		1.09	6.18	2.12		2.13	16.6	12.37	3.20	0.51	0.16

Table 2: Main effects of K-fertilizer rates and locations on yield components of potato

Treatments	µNMTPP	NUMTPP	ATWPT (g)	Spr
K-fertilizer rates (kgha^{-1})				
0	230.7c†	19.2a	45.2d	1.059e
30	239.3bc	18.3ab	55.1cd	1.072d
60	251.3bc	17.7ab	66.4bc	1.075cd
90	273.0ab	16.3ab	68.5b	1.076c
120	272.7ab	16.2b	70.6ab	1.080b
150	294.5a	15.5b	81.7a	1.087a
180	276.3ab	16.0b	73.8ab	1.082a
LSD (0.05)	**40.4**	**3.99**	**12.5**	**0.0029**
Locations				
Abota-Ulto	316a	14.7b	68.7a	1.077
Gututo-Ampokosha	208b	19.9a	63.2b	1.075
LSD (0.05)	**21**	**1.6**	**2.5**	**0.0016**
K-fertilizer rates	**	**ns**	**	**
Locations	**	**	*	*
K-fertilizer rates x Location	**	**ns**	**ns**	*
CV (%)	**13.0**	**14.6**	**16.0**	**23**

µNMTPP = Number of marketable tubers per plot, NUMTPP = Number of unmarketable tubes per plot, ATWPT = Average tuber weight per tuber, Spr = Specific gravity *, ** = Statistically Significant, highly significant at 0.05 and 0.01 probability levels respectively, ns= non- Significant. †Mean within column(s) followed by the same letter(s) are not statistically different from each other at 0.05 probability level

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Table 3: Main effects of K fertilizer rates and locations on tuber yield of potato in Woalita zone, southern Ethiopia

Treatments	µMTY	UMTY	TTY
		mtha^{-1}	
K-fertilizer rates (kgha^{-1})			
0	15.55f	0.60	16.16f
30	20.34e	0.62	20.96e
60	23.90d	0.81	24.72d
90	27.01c	0.77	27.82c
120	31.45b	0.71	32.17b
150	33.67a	1.21	34.88a
180	31.59b	0.69	32.29b
LSD (0.05)	**1.57**	**Ns**	**1.62**
Locations			
Abota Ulto	28.33a	0.71	29.04a
Gututo-Ampokosha	24.12b	0.84	24.95b
LSD (0.05)	**0.84**	**ns**	**0.87**
K-fertilizer rates	**	**ns**	**
Locations	**	**ns**	**
K- fertilizer rates x Locations	**	**ns**	**
CV (%)	**10.16**	**19.0**	**16.9**

µMTY = Marketable tuber yield, UMTY = Unmarketable tuber yield, TTY = Total tuber yield *, **= Statistically significant and highly significant a t 0.05 and 0.01 probability levels respectively, ns= non-Significant

Table 4: Partial budget analysis of K-fertilizer rates for Abota-Ulto location

K-fertilizer rates (kgha^{-1})	*MTY	Adjusted MTY	GBT	TVC	NBT	MMR (%)
	kgha^{-1}			ETB ha^{-1}		
0	18437	16593	49779	0	49779	0
30	21860	19674	59022	1200	57822	670
60	25390	22851	68553	2400	66153	694
90	28383	25545	76635	3600	73035	573
120	32457	29211	87633	4800	82833	816
150	37800	34020	102060	6000	96060	1102
180	34150	30735	92205	7200	85005	D**

*MTY = Marketable tuber yield, GBT = gross benefit, TVC = total variable cost, NBT = net benefit, MRR = marginal rate of return **D = Dominated

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Table 5: Partial budget analysis of K-fertilizer rates for Gututo-Ampokosha location

K-fertilizer rates (kgha^{-1})	MTY	Adjusted MTY	GBT	TVC	NBT	MRR (%)
	kgha^{-1}		EBha^{-1}			
0	12810.0	11529	32857.65	0	32857.65	0
30	18813.3	16932	48256.2	1200	47056.2	1183
60	22420.0	20178	57507.3	2400	55107.3	670
90	25726.7	23154	65988.9	3600	62388.9	606
120	30453.3	27408	78112.8	4800	73312.8	910
150	29546.7	26592	75787.2	6000	69787.2	D**
180	29043.3	26139	74496.15	7200	67296.15	D

*MTY = Marketable tuber yield, GBT = gross benefit, TVC = total variable cost, NBT = net benefit, MRR = marginal rate of return **D = Dominated

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