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Potato yield response to tillage practices and inorganic potassium application in South Western Uganda

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Abstract. This study examined the effects of minimum and conventional tillage practices and potassium levels on potato yield in South Western Uganda. Researcher and farmer managed trials were set at KaZARDI and Kariko for three seasons. Varying rates of potassium fertilizer (100, 150, 200, 250, and 300 kg ha^{-1}) were applied in a split plot arrangement with tillage practices as main plots and K rates as the subplots of a randomized complete block design with three replications. Potato growth and yield data was analysed using R-studio version 4.2.0. The findings were that application of 200 kg K ha^{-1} significantly ($P < 0.001$) increased plant height, the number of tubers per plant, and overall yield per hectare by 12.5%, 27.5% and 21.7%%, respectively. The highest marketable tuber yield achieved was 26.4 t/ha under conventional tillage, compared to 23.3 t/ha under minimum tillage. The interaction between tillage practices and potassium levels was statistically significant, with traditional tillage showing a stronger response to fertilizer application than minimum tillage. Although minimum tillage resulted in a lower yield, it is cost-effective, with a benefit-cost ratio of 3.1.

Keywords: Potato, Tillage practices, Potassium levels, Yield, and Profitability.

Introduction

The potato (Solanum tuberosum L.) is a versatile crop, with a global production reaching nearly 375 million tons (FAOSTAT, 2023). Emphasized by the Food and Agriculture Organization (FAO) as a key food security crop amidst global food supply challenges, population growth, and escalating food demands, potatoes are a dietary staple for billions of individuals (Devaux, 2014). Their short growing cycle of3 months and high nutritional value, packed with carbohydrates, proteins, fibres, vitamin C, and beneficial phytonutrients such as carotenoids and flavonoids, make potatoes an important crop (Lutaladio & Castaldi, 2009; Singh *et al.*, 2020).

Globally, China leads in potato production with an annual output surpassing 99 million tons, representing around 25% of the total global potato production (Bvenura *et al*., 2022) while in Africa, particularly Uganda holds the ninth position in potato production, yielding approximately 188,000 tons annually from around 39,000 hectares (FAOSTAT, 2014). The primary production regions in Uganda encompass the highlands of Kigezi contributing about 60% to the national output and the Eastern region on the slopes of Mt. Elgon, the north-western part of the country, and Central Uganda in districts of Mubende, Rakai, and Masaka (Namugga *et al*., 2017). Potato holds the 5th position among the sixteen strategic food crops identified and prioritized by the Government of Uganda to promote food security and income generation (UBOS, 2018). Despite its significance, potato yields have stagnated at 7 tons per hectare far below the potential optimal yield of 20-40 t/ha (FAO, 2022). The suboptimal yields are attributed to a myriad of biotic and abiotic factors, including diminishing soil fertility, substandard planting materials, intermittent droughts within the growing season, infestations of pests and diseases, and inadequate knowledge regarding appropriate fertilizer types and application rates for the crop (Schulte-Geldermann, 2013; Muthoni *et al.,* 2013).

Potato requires substantial nutrient inputs for sustainable productivity and quality tubers. To ensure the quantity and quality of potato tubers, rational use of mineral fertilizers is necessary (Navarre *et al.,* 2014) and the sufficient supply of the most important nutrients: nitrogen (N), phosphorus (P) and potassium (K), is paramount (Harris, 1992).

Potassium (K) specifically plays a crucial role in promoting optimal growth and development in plants, and is required in adequate amounts to support various physiological and metabolic functions (Oosterhuis et al., 2014). Its significance in potato cultivation is underscored by its essential roles in photosynthesis, starch synthesis, and carbohydrate translocation (Singh et al., 1996). Additionally, potassium plays a vital role in enhancing tuber quality and quantity while aiding the potato plant in overcoming environmental stressors such as drought, insect pests, and diseases (Brady and Weil, 2008). Potassium also enhances the storage quality and shelf life of potatoes by potentially reducing the severity of black spot bruising in tubers (Ebert, 2009).

In South-western Uganda, farmers commonly apply NPK fertilizers (17:17:17) at a rate of 100 kg per hectare for potato cultivation (Priegnitz *et al*., 2019). Research shows that potato crops have a high potassium demand, typically ranging from 170 to 230 kg of Kha^{-1}, emphasizing the responsiveness of potato crop to potassium application (Grewal and Trehan, 1993). Furthermore, Muzira *et al.* (2018) highlighted soil potassium as a major constraint affecting potato productivity in South-western Uganda, while Kayuki *et al.* (2017) reported potassium imbalances in the region due to nutrient depletion during crop harvests and losses from runoff and soil erosion. Therefore, the common practice of applying NPK fertilizers at a rate of 100 kg per hectare for potato cultivation may not meet the high potassium demand of potato crops suggesting the need for further research into optimizing potassium levels in potato production.

On the other hand, proper soil and water management in potatoes are essential to assure optimal crop growth and development and therefore, tillage practices are adopted to create a conducive environment for potato growth and yield (Djaman *et al.,* 2022). Tillage at various planting and growth stages is necessary to prepare the seed bed and control of weeds. Several practices during potato production such as cultivation, planting, disking, hilling, and harvesting disturb the soil environment exposing it to high soil erosion risks (Yang *et al*., 2009; Rees *et al*., 2011).

Appropriate tillage systems that improve root growth, nutrient uptake, aeration and water transmission should therefore be considered to ensure sustainable potato production (Djaman et al., 2022).Conventional potato farming methods in commercial production utilize heavy machinery for various tasks like cultivation, herbicide and pesticide application, and harvesting, leading to soil compaction (Djaman *et al*., 2022). Compaction before and during planting can thwart root and shoot development (Stalham *et al*., 2007; Djaman *et al*., 2021a; Huntenburg *et al*., 2021) leading to delayed emergence, reduced rooting density and deep rooting and diminished canopy cover, affecting tuber yield negatively (Stalham *et al*., 2007; Huntenburg *et al*., 2021). Conversely, small scale farmers such those in south western Uganda use hand hoes for seed bed preparation, weeding, hilling and harvesting and the greatest percentage practice conventional tillage that involves first and second digging for seed bed preparation (Kayuki *et al*., 2017). Many potato producers believe deep ploughing is essential to achieve the optimal soil tilth necessary for optimal tuber formation and quality (Ivany et al., 2007). However, this intensive soil preparation can be detrimental to soil structure and promote soil erosion (Drakopoulos et al., 2016). Numerous studies have highlighted the potential benefits of reduced tillage in potato production systems to enhance soil quality, reduce production costs and time, and sustain potato yields (Singh et al., 1996; Grant and Epstein, 1973; Wallace and Bellinder, 1989; Pierce and Burpee, 1995; Holmstrom et al., 2006). Nevertheless, certain studies have shown that implementing minimum tillage practices can lead to decreased potato tuber yields. For example, Yaroson et al. (2019) investigated different soil management methods, including ridges tillage, mound tillage, flat tillage, and zero tillage, to assess their effects on potato tuber yield. Among the techniques examined, zero tillage was found to yield the lowest amount of tubers.

The contradictory information on effects of tillage methods on potato growth, yield, and tuber quality could be attributed to numerous factors such as soil types, climate variations, and specific cropping systems. Over all, the current research focuses on investigating the most effective tillage practice and potassium fertilizer doses to improve resource utilization efficiency and boost both growth and tuber yield of potatoes in South-western Uganda.

Materials and methods

Soil samples

Soil samples from depths of 0 to 30 cm were collected at the two experimental sites at Kachwekano (on-station) and Kariko (on-farm) in Kabale district. The samples were sent to National Research Laboratories for analysis of, Soil pH, Extractable P, exchangeable K, and Ca, total nitrogen (N) and soil texture using the soil analytical procedures described by Okalebo *et al*., 2002).

Design

The experiment followed a randomized complete block design with split plots and three replications. The experiment was run for three seasons (September 2020 season B, March 2021 season A, and September 2021 season B). The Main plots were conventional and minimum tillage, and the subplots consisted of fertilizer levels. Plots that had rested at least for four seasons were selected. In conventional tillage, the land was ploughed two times before planting, and in minimum tillage, the land was ploughed once and then planted.

NPK fertilizer was used, maintaining N and P constant at 100 kgs/ha and varying potassium levels at 100, 150 (Grain pulse), 200, 250, and 300 kgs ha^{-1}. Grain pulse, a new NPK fertilizer blend for potatoes on the market, was included and applied at its recommended rate (150K kgs/ha). The N was applied as urea, P as triple super phosphate (TSP), and K as MOP. All the fertilizers were basal broadcasted in appropriate plots and then incorporated into the soil using a hand hoe. A spacing of 75 cm between rows and 30cm within rows was adopted, and one potato tuber of NAROPOT4 variety was planted per hole. NAROPOT4 (also known as Rwangume) is a widely cultivated variety suitable for most potato growing environments, has high market demand and good culinary attributes (Namugga *et al.,* 2017). Plots were weeded, and pests and diseases were controlled with appropriate chemicals. At maturity, five plants from the two middle rows were randomly selected, the number of haulms was counted per plant, and measurements were taken for plant height. Plants were harvested to collect data on number of small tubers, number of medium tubers and number large tubers. In doing this, two middle rows were selected and the number of harvested plants in those rows noted. The weight for all tuber grade sizes was determined and final tuber weight computed. Using R studio, analysis of variance was determined and significant means separated using Turkey LSD test.

Benefit-Cost Ratio analysis

Data on all relevant costs associated with potato production was gathered/recorded, including expenses on seeds, fertilizers, pesticides, labour, equipment, land, water, and any other inputs, as well as fixed costs. Potato yield per hectare for each treatment was recorded. The data above was then used to calculate the total production costs, Estimate the total revenue based on the prevailing market prices, compute the net profit and calculate the benefit-cost ratio (BCR) by dividing the total discounted benefits by the total discounted costs. A BCR greater than 1 indicated a potentially viable investment. All calculations were done in excel.

Results and Discussion

Table 1. Soil analysis

	Soil pH	SOM	Total N	Extractable P	K	Mg	Ca	Sand	Clay	silt	Textural Class
	(1:2H_2O)	*%*	*gkg^{-1}*		*ppm*				*%*		
Kachwekano	5.3	0.2	2.6	0.6	87	114	2056	40	30	29	Clay loam
Kariko	5.1	0.1	1.8	3.4	69	137	1552	56	22	21	Sandy clay loam
Critical Values	5.5	3		15-30	150-200						

The soil analytical results indicate moderately acidic soil conditions with low levels of inherent essential plant nutrients (NPK) shown by the low levels of soil organic matter as a major source and sink of soil nutrients. The field conditions thus require adequate fertilization either through organic, inorganic or a combination necessitating addition of external potassium sources to enhance potato productivity. The results revealed that, the pH of samples ranged from 5.1 to 5.3 which was within the critical value of 5.2. The soil samples contains low levels of soil organic matter since it is less than 3%. Available phosphorous and K levels are generally low, for all the soil samples, implying that application of organic manure or inorganic fertilizers will be required for soil fertility sustainability.

Growth and growth components

Plant height and haulm numbers

Potassium application rates and tillage practices influenced both plant height and haulm numbers significantly ($p< 0.001$), highlighting the importance of addition of external potassium sources and tillage in potato cultivation. Maximum plant height (50.8 cm) and maximum haulm counts were obtained with addition of 200 kg K/ha and 250 kg K/ha rates of application respectively. (Table 2). The phenomenon on plant height trend with potassium can be explained by potassium's regulatory role in cell expansion, stomatal function, enzyme activation, and stress resistance that contribute to improved plant growth (Wang et al., 2013; Oosterhuis et al., 2014; Abd El-Latif et al., 2011). The study results align with the findings of Asmaa and Magda (2010), Khan et al. (2012), and Singh and Singh (1996), where plant height increased with potassium application from 200 kg/ha up to 285 kg/ha. In contrast, our findings contradict the study by Zelelew et al. (2016), who observed that potassium application exceeding 150 kg K/ha led to a decrease in plant height. Similar findings with the number of haulms and K treatments were reported by Abay and Sheleme (2011), where the number of haulms produced by potato plants was influenced by K fertilizer. This could be due to the role of K in enzymatic actions for energy utilization, starch formation, and respiration (Wang et al., 2013). However, it should be noted that stem number per plant can also be influenced by the number of eyes on the seed tuber planted (Iritani et al., 1983). In disagreement with the current findings, Al-Moshileh and Errebi (2004) reported that potassium treatment did not significantly affect the number of haulms per plant.

Table 2. Effect of tillage practice and K levels on plant height and haulm numbers

	Plant height (cm)			Haulm Numbers		
Potassium Level(K)(kgs/ha)	Tillage Practice(T)			Tillage		
	Conventional	*Min.*	*Mean*	*Conventional*	*Min.*	*Mean*
100	46.3	43.8	45.1b	2.7	3.1	2.9c
150 (Grain pulse)	48.8	45.9	47.3b	2.6	2.7	2.7d
200	53.4	48.1	50.75a	3.5	3.1	3.3a
250	53.6	48.1	50.8a	3.5	3.25	3.4a
300	53.3	48.1	50.7a	3.2	3.15	3.2b
Mean	51.1a	46.8b		3.1a	3.1a	
	K	T	K	K	T	K*T
LSD (0.05)	2.4	1.8	4	0.1	ns	ns

Conventional tillage resulted in taller plants and more haulm counts compared to minimum tillage (Table 2). The increase in plant height and haulm numbers with conventional tillage could be due to the reduction in the soil's compaction layer, reduced weed infestation in early stages of crop growth, and the convenient supply of water, air, and mineral nutrients (Wang et al., 2013). The better soil physical properties exhibited by the clay loam and sandy clay loam soil textural classes could have enhanced the development of the roots and shoots system, enabling increased photosynthesis (Ati et al., 2015).

Yield and Yield Components

Table 3. Tuber yield for on-station and farmer managed sites

Potassium Level	Kachwekano site	Kariko site

(K) kgs/ha	Tillage Practice(T)			Tillage Practice(T)		
	Conventional	*Min.*	*Mean*	*Conventional*	*Min.*	*Mean*
100	20.863	20.521	20.692c	17.178	13.475	15.326c
150	21.263	21.611	21.437c	17.643	13.426	15.534c
200	28.012	24.747	26.379a	24.483	17.558	21.02a
250	28.092	23.869	25.981a	24.057	17.951	21.004a
300	27.852	19.499	23.676b	23.462	14.175	18.819b
Mean	25.217a	22.05b		21.364a	15.317b	
	K	T	K*T	K	T	K*T
LSD	1.3	0.7	1.7	1.8	1.9	ns

P>0.05, Different letters indicated significant differences within columns and rows

At both study sites, potato tuber yields were highest with application of 200kg/ha K and 250kg/ha K under conventional tillage than minimum tillage practices (Table 3). This can be explained by the critical role of soil structure in determining the availability and movement of water and nutrients for plant growth. Under conventional tillage practices, the soil structure is typically loose, allowing for easy water and nutrient movement and uptake by plant roots (Kumar *et al.*, 2018). In contrast, minimal tillage practices tend to result in a tighter soil structure, which can limit the movement of water and nutrients along the soil profile (Kumar *et al.*, 2018).

Total yield (t/ha)

In general, potato tuber yield significantly ($p < 0.001$), increased with increasing potassium levels and the highest yields (26.4 t/ha and 26.0) were obtained with application of 200 kg/ha K and 250 kg/ha K respectively, (Table 4). The observed increase in yield is due to the importance of potassium in the formation and translocation of assimilates to the tubers which increases tuber bulking capacity, biomass and yield (Van der Zaag, 1981; Moinuddin et al., 2005). According to Trehan et al. (2001), potassium (K) plays a critical role in activating enzymes essential for photosynthesis, carbohydrate metabolism, protein synthesis, and facilitating the translocation of carbohydrates from leaves to tubers. These processes contribute to an increase in tuber size. Consistent with the current results, Abd El-Latif *et al.* (2011) reported a significant increase in total tuber yield when K was applied at 285 kg/ ha K. Similarly, Zelelew *et al.* (2016), Haile (2009), and Chapman *et al.* (1992) reported potato yield increase with increasing potassium levels, whereas excessive K addition was unnecessary for tuber weight enhancement. Excessive potassium in soil is toxic and may create competition with other nutrients and can impair nutrient assimilation processes, hamper overall plant growth, and negatively impact productivity (Malvi et al., 2011). This is in confirmation with our findings where Potato tuber yield reduced (from 26t/ha to 23t/ha) with addition of 300kg/ha K.

The tillage practices investigated also showed significant ($P < 0.001$) differences in tuber yield (Tables 3 and 4). Conventional tillage gave a significantly higher tuber yield (25.8t/ha) than minimum tillage (22.9t/ha). The increased tuber yield observed in Conventional tillage may be attributed to the breakdown of compacted soil layers, enhanced water infiltration, improved root penetration, and decreased weed competition. These factors collectively promote better nutrient absorption by plants, as highlighted by Torabian et al. (2021). The conducive environment for root development and nutrient uptake fosters vigorous shoot growth, leading to enhanced photosynthesis and the accumulation of substantial carbohydrate reserves in the tubers (Barakat et al., 2020; Al-Hamed et al., 2016). Similar results were reported by Drakopoulos (2016), where standard tillage gave higher total tuber yield compared to reduced tillage. However in his study, Alva et al. (2009), found no significant effects of tillage practices on total tuber yield under different Nitrogen management practices. The contradictory findings in literature about the contribution of tillage practices on potato growth and tuber yield could be as a result of various factors such soil type, the climatic conditions and crop rotation practices prevailing in a specific area of study (Cooper et al., 2016). On the other hand, minimum tillage practices involve minimal soil disturbance, aiming to preserve soil structure and organic matter. While this approach helps reduce soil erosion and maintains soil biodiversity (Djaman et al., 2021), it may lead to uneven crop emergence, poor root development, and increased vulnerability to drought stress (Drakopoulos et al., 2016).

Table 4. Effect of K, tillage practices and their interaction on tuber numbers and tuber yield

Treatments	Yield per tuber category t/ha					Tuber number per plant			
Tillage (T)	*Small*	*Medium*	*Large*	*Marketable*	*Total*	*Small*	*Medium*	*Large*	*Total*
Conventional	1.6a	17.6a	6.1a	23.7a	25.3a	2.2a	9.1a	0.88a	12.2a
Minimum	1.4a	14.7b	5.9a	20.6b	22b	2.06a	7.9b	0.96a	10.1b
LSD(P=0.05)		0.5		0.7	0.7		0.43		0.5
Significance	ns	***	ns	***	***	ns	***	ns	***
Potassium Level(K)(Kgs/ha)									
100	1.3a	14.4c	5bc	19.4c	21.7c	1.9a	7.7c	0.8ab	10.3c
150(Grain pulse)	1.6a	15.4bc	4.5c	19.9c	21.5c	2.2a	8.1bc	0.71b	11.1bc
200	1.5a	17.8a	7.1a	24.9a	26.4a	2.1a	9.4aa	1.04a	12.6a
250	1.5a	17.3a	7.1a	24.4a	26.0a	2.2a	9.1	0.96ab	12.3a
300	1.5a	15.8b	6.3ab	22.1b	23.6b	2.2a	8.3b	0.83ab	11.3b
LSD5%		1.6		1.2	2.6	0.3	0.6		0.7
Significance	ns	**	ns	***	**	ns	**	ns	***
Interaction of Potassium levels and Tillage (K*T)									
250kg/ha: conventional	1.5ab	18.2b	8.4a	26.6a	28.1a	2.1abc	9.6ab	1.1a	12.8ab
200kgs/ha: conventional	1.6ab	19.4a	7.1abc	26.5a	28a	2.2abc	10.2a	1ab	13.4a
300kgs/ha: conventional	1.7a	18.6ab	7.6ab	26.1a	27.9a	2.4ab	9.6ab	1abc	12.9ab
200kgs/ha: minimum	1.5ab	16.2c	7.1abc	23.3b	24.8b	2.1abc	8.6c	1.1ab	11.7bc
250kgs/ha: minimum	1.6ab	16.4c	5.9cd	22.3b	23.9b	2.3abc	8.7bc	0.8bcd	11.8bc
150kg/ha: minimum	1.4ab	14.9d	5.4d	20.2c	21.6c	2.0abc	8.0cd	0.8abcd	10.9cd
150kg/ha: conventional	1.7a	15.9cd	3.6e	19.6cd	21.3c	2.5a	8.2c	0.6d	11.2c
100kgs/ha: conventional	1.3b	15.7cd	3.9e	19.6cd	20.9cd	1.8c	8.3c	0.6d	10.75cd
100kgs/ha: minimum	1.3b	13.1e	6.1bcd	19.2cd	20.5cd	2abc	7.0e	1abc	9.95d
300kg/ha: minimum	1.3b	13.1e	5de	18.2d	19.5d	1.9bc	7.1de	0.7cd	9.7d
LSD5%	0.3	1.1	1.4		1.7	0.4	0.9	0.3	
Significance	ns	**	*	***	***	ns	*	*	ns

P>0.05, Different letters indicated significant differences within columns

Effect of tillage practices and K on average number of tubers per plant

The number of tubers per plant showed a gradual and significant ($p < 0.001$) increase with increasing potassium levels (table 4). The highest tuber number per plant (12.6) was produced from the application of 200kg K/ha, followed by 250 kg K (12.3) and the lowest (10.3) was obtained from 100kg K/ha. In similar studies by Adhikary and Karki (2006) and Wibowo et al. (2014), adding K_2SO4 fertilizer increased the number of tubers produced. This could be due to the substantial role of potassium in photosynthesis, helping in timely and appropriate nutrient translocation and water absorption by roots (Bergmann, 1992).

Tillage practices had a significant impact on the average number of tubers per plant ($p = 0.0009$). Plants grown under conventional tillage displayed a higher tuber count (12.2) per plant compared to the 10 tubers per plant obtained under minimum tillage (Table 4). The increase in tuber numbers with conventional tillage can be attributed to improved soil structure and physical characteristics, fostering enhanced root and shoot growth that supports photosynthesis. This finding is consistent with the study results of Haider et al. (2016), which also emphasized a notable interaction between tillage depth and tuber quantity.

Interaction effect of potassium levels and tillage practices on potato yield and growth parameters

An investigation into the interaction between potassium levels and tillage practices revealed a notable impact on total tuber yield (Table 4 (T*K)). Potassium levels of 200 kg and 250 kg combined with conventional tillage resulted in significantly higher tuber yields (28.0, 28.1, and 27.9 t/ha). However, a significant decrease in yield (27.9 t/ha) was observed when potassium was applied at 300 kg/ha under conventional tillage and 19.5 t/ha under minimum tillage, lower than that achieved with 100 kg K per hectare (20.5kg/ha) (Table 4). The lower yields obtained with higher K levels could mean that some of the residues retained and incorporated may be contributing to K supply especially for minimum tillage and higher doses become toxic to the crop (Lv et al., 2023). Notably, excessive potassium concentrations disrupt the balance of nutrients within the plant and antagonize the uptake of other nutrients such as magnesium, calcium, and phosphorus, leading to nutrient imbalances that negatively impact plant growth and development (Hasanuzzaman et al., 2018). Moreover, excessive potassium may create osmotic stress within the plant cells that alters the water balance within the plant, affecting water uptake and movement, which can lead to wilting, reduced cell expansion, and overall plant dehydration which compromise growth and yield potential (Pervez *et al.*, 2013).

Correlation matrix among growth and Yield parameters of Potato.

Correlation analysis indicated a significant and positive relationship between plant height and number of tubers per plant ($r = 0.57$), tuber weight per plant ($r = 0.782$), and total tuber yield ($r = 0.74$). Examination of the number of stems and the yield parameters revealed positive and significant correlations with tuber weight per plant ($r = 0.35$), tuber number per plant ($r = 0.49$), plant height ($r = 0.44$), and total tuber yield ($r = 0.5$). Biniam et al. (2016) also observed a similar positive correlation between primary stem number and plant height, as well as tuber numbers, attributing it to enhanced ground cover leading to taller plants in search of more sunlight. Taller plants tend to produce more leaves that favour photosynthesis helping the plant to make bigger tuber size and hence higher total tuber yield (Zelelew et al., 2016). Contrary to the current findings, Iritani et al. (1983) reported that a higher number of stems per plant results in reduced yield because they lead to the increased formation of small tubers.

In this study, a significant and positive correlation was observed between tuber number per plant and tuber weight per plant (r = 0.713) as well as total tuber yield (r = 0.834). This relationship arises from the fact that an increase in the number of tubers formed on a plant leads to higher total tuber weight and overall tuber yield. However, Van der Zaag (1992) reported that tuber size decreases as the number of tubers per square meter increases. The positive correlation (0.45) between total tuber yield and potassium application highlights the essential role of potassium in carbohydrate synthesis and the transport of starch from potato leaves to tubers, as emphasized by Van der Zaag (1981).

Cost-benefit analysis

It was noted that the gross margin increased because of increasing K application rates and the use of conventional tillage. Maximum gross margin (20,236,914 UGX/ha) was obtained from 200 kg K/ha under conventional tillage. The increase in gross margin from the crops for the addition of potassium could be due to the positive yield responses of NAROPOT4.

Table 5. Cost benefits analysis

Item	MT/100kg K/ha	MT/200kg K/ha	MT/250kg K/ha	CT/100kg K/ha	CT/200kg K/ha	CT/250kg K/ha
Cost of herbicide	125,000	125,000	125,000	125,000	125,000	125,000
Cost of seed potato	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Cost of fertilizer	416000	832000	1,040,000	416000	832000	1,040,000
Herbicide application	200,000	200,000	200,000	200,000	200,000	200,000
1st Digging	500,000	500,000	500,000	500,000	500,000	500,000
2nd Digging	0	0	0	500,000	500,000	500,000
Labour for Planting	300,000	300,000	300,000	300,000	300,000	300,000
1st weeding	300,000	300,000	300,000	300,000	300,000	300,000
2nd weeding	300,000	300,000	300,000	300,000	300,000	300,000
cost of contact fungicide	75,000	75,000	75,000	75,000	75,000	75,000
cost of systemic fungicide	360,000	360,000	360,000	360,000	360,000	360,000
labour for spraying	375,000	375,000	375,000	375,000	375,000	375,000
Total Variable Cost	7,951,000	8,367,000	8,575,000	8,451,000	8,867,000	9,075,000
Marketable Yield (kgs/ha)	19,179	23,300	22,285	19,575	26,458	26,602
Cost per kg	1,100	1,100	1,100	1,100	1,100	1,100
Gross Benefit	21,096,574	25,630,446	24,513,886	21,532,492	29,103,914	29,262,200
Marginal return	13,145,574	17,263,446	15,938,886	13,081,492	20,236,914	20,187,200
benefit cost ratio GB\TVC	2.7	3.1	2.9	2.5	3.3	3.2

Conclusion

This research aimed at investigating the effect of tillage practices and potassium levels in NPK fertilizers on the growth and tuber yield of potatoes in South-western Uganda. Based on the results, enhancing potassium levels in NPK fertilizer to 200kg ha-1 and implementing conventional tillage practices in potato farming enhances potato yields and results in a higher return on investment. While there were yield discrepancies noted between minimum tillage and conventional tillage at the 200kg K application rate, minimum tillage is a viable option and had a comparable benefit-cost ratio to conventional tillage (Table 5).

Minimum tillage is especially beneficial for farmers in erosion-prone regions or those with limited resources and time for extensive digging. Thus, both tillage approaches can be considered depending on the specific circumstances and socio-economic conditions of the farmers.

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