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EFFECT OF PHOSPHORUS APPLICATION ON YIELD OF SWEET POTATOES IN EMBU WEST SUB-COUNTY, KENYA

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ABSTRACT: *Sweet potato is a crop that plays a great role in food security in Kenya since it is a drought resistant crop, takes a short time to mature and is highly flexible. The main economic activity in Embu West Sub County is agriculture, which is the economic pillar of Embu County with most farmers there being small scale farmers and depending on this sector for their livelihood. Phosphorus as a plant nutrient is a key component of several chemical compounds necessary for metabolic activities, flowering, and root development; hence, it is essential for proper plants growth including sweet potatoes. This study purposed to evaluate how P application affects yield of three sweet potato varieties in Embu West Sub County. The sweet potato varieties used were SPK004 (V1), Kenspot 3 (V2) and Kenspot 4 (V3). The P fertilizer levels used were 0 kg/ha (P1), 25 kg/ha (P2), 50 kg/ha (P3), and 75 kg/ha (P4). Data on two specific yield parameters was collected at harvest; the collected data was summarized using excel. Analysis of variance of the data was done using SPSS version 23, at α=0.05. For treatment means that were significantly different, LSD as Post hoc test was used to separate them. The study showed significant yield potential difference in the yield parameters among the three sweet potato varieties with Kenspot 4 being the highest producer of both total and marketable tubers yield. The study showed that the amount of P applied significantly affected yield of sweet potatoes with a P level of 50 kg/ha producing significantly higher yields.*

Keywords: P-levels, P-application, Varieties, Significant, Yield

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INTRODUCTION

Sweet potato farmers are faced with many challenges, among which include inadequate research and development, low production of propagation materials of good quality, low yields, poor research extension and farmers' interactions, weak value addition and processing, poor framework of markets, inadequate financing and money lending services and ineffective implementation of produce and product standards. New technologies are still being adopted and disseminated poorly, and an unfavorable and ineffective regulatory framework exists. Soil fertilization has been the biggest hindrance in the production of sweet potatoes in Africa, and this is more pronounced in Kenya because of a lack of adequate knowledge on the same. These challenges have negatively affected the performance of tubers crops industries in Kenya (GoK, 2010). In Embu County, the studies conducted on sweet potato production have looked at varieties for farmer preference (Ngoroi et al., 2013).

This study focused on fertilization of sweet potatoes, especially the application of phosphorous. Sweet potato is the main root and tuber crop grown in Embu County. Phosphorus element is required by many plant species including sweet potatoes. It is essential for many metabolic processes (El Sayed et al., 2011). Most farmers apply phosphatic fertilizers, but the quantity that plants can access is not enough because it is transformed to an unavailable form after reacting with constituents of the soil (El-Morsy et al., 2002; Hassan et al., 2005). According to Hassan et al. (2005), application of P-fertilizers increases sweet potatoes production compared with the untreated control. Since P is a key element necessary for plant growth, including *Ipomea batatas*, the proposed research is aimed at comparing the levels of P and sweet potato yield.

There are persistent variations in yield responses of sweet potatoes to fertilizers (N, P, and K) application. Nitrogen at very high levels promotes yield (Hartemink et al., 2000; Taranet et al., 2017), and overabundances of vegetative growth at the expense of storing roots. Some studies have indicated that sweet potato do not respond to phosphorus fertilizer application and that pre-existing levels of P in the soil are adequate while others have shown positive responses of sweet potato to P fertilizer, but only at very high levels, varying between cultivars. Potassium studies consistently reported increased growth and storage root production as K rates increased (Bailey et al., 2009; Byju & George, 2005).

According to Kareem (2011), sweet potato yields were not significantly affected by the P level applied. However, El-Sayed et al. (2011) reported significant yield responses with increased P application. This study tried to address the gap of what exactly the phosphorous requirements in sweet potato production are, whether P is even useful in the yield production of sweet potato and if so, whether it is useful to the soils in Embu West Sub-County. This study therefore aims to:

- Determine the yield potential of three sweet potato varieties.
- Determine the effect of 4 phosphorus levels on the yield of three sweet potato varieties.

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MATERIALS AND METHODS

Location of the Study

The research was carried out at KARLO, Embu which is in Kangaru, Embu West Sub County, central division, Embu district in Embu County, Kenya. Embu County has two distinct rainy seasons. Rainfall quantity received is an average of 1250mm per annum with a mean temperature of 21^0C.

Experimental Procedure

Land was cleared, dug and harrowed to fine tilth manually. Using split RCBD, land was divided into three blocks. Each block had twelve plots each measuring three meters by three meters. There were three replications. Each plot received a combination of two treatments, that is, sweet potato variety and a specific level of P. Treatments were randomly assigned on the experimental units. Sweet potatoes were propagated by use of vines which were sourced from KARLO Embu. The vines were planted in holes made on the prepared land. The phosphate fertilizer used was TSP which was in granular form. The granules were placed in the planting holes and the thoroughly mixed with soil before placing the vine in the soil. Length of the vines planted was 30cm. 20cm of this was buried under the ground during planting. The vines were planted at a spacing of 100 × 50cm. Weeds, pests and diseases were controlled throughout the growing period. Harvesting was done at the end of growing period.

Treatment Combinations

Treatments used three sweet potato varieties which were SPK 004 (V1), Kenspot 3 (V2) and Kenspot 4 (V3), and four P levels which were 0 kg/ha (P1), 25 kg/ha (P2), 50 kg/ha (P3), and 75 kg/ha (P4). These treatments were combined as follows: P1V1, P1V2, P1V3, P2V1, P2V2, P2V3, P3V1, P3V2, P3V3, P4V1, P4V2, P4V3.

Data Collection and Analysis

Each plot had 4 rows and each row had 7 plants. Two inner rows from each plot were sampled; then two plants from both the right and left end of each row were not sampled; the remaining 3 plants from each of the inner 2 rows were selected and tagged. Data on yield parameters of the sweet potato tubers from the six tagged plants was collected and recorded.

Collected data was first summarized using excel; then ANOVA was done using SPSS version 23 at α=0.05. For treatment means that were significantly different, LSD as post hoc test was used to separate them.

RESULTS AND DISCUSSION

Total Tubers Yield

Tubers from each tagged plant were weighed separately using a weighing balance. The total yield of the six plants was multiplied by 20,000 which is the plant population per hectare then divided by six (the six sampled plants) to convert yield into total tuber yield per hectare. The results obtained are represented in Figure 1, which shows that Kenspot 4 produced the highest

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tuber yield compared to Kenspot 3 and SPK 004. All varieties produced the highest tuber yield at P level of 50 kg/ha. Total tuber yield increased with an increase in the amount of P applied but decreased at the highest level of P application (75 kg/ha). At 0 kg/ha of P application, Kenspot 4 produced the highest total tuber yield. To find out if the treatments had significant effect on total tuber yield, ANOVA was carried out and the ANOVA summary is shown in Table 2.

ANOVA summary (Table 2) reveals that the total yield of tubers differed significantly between the three sweet potato cultivars ($p<0.5$). To separate variety and P level means, LSD test was conducted and the results are as exhibited in Tables 3 and 4 respectively. According to Table 3, Kenspot 4 produced significantly higher total tubers yields than Kenspot 3. Kenspot 4 produced higher total tubers yields than SPK 004 but the difference was not significant. SPK 004 produced higher total tubers yields than Kenspot 3 but the difference was not significant. The high genetic diversity in Kenyan sweet potato genotypes, as shown by Karuri et al. (2010) who reported significant difference between genotypes in aerial and storage root characteristics, can explain the considerable yield differences among the three varieties. The results from this research agree with those of Mwololo et al. (2012) who reported a significant difference in total tuber weight among the varieties. Other sweet potato trials have also reported significant differences in yield due to the varied genetic makeup among genotypes (Kathabwalika et al., 2013; Nedunchezhiyan et al., 2007) as well as other crops such as common beans *(Phaseolus vulgaris*) (Mwale et al., 2008; Mwale et al., 2009; Chataika et al., 2010).

According to Table 4, applying 50kg P/ha produced a significantly higher total tubers yield than 0 kg/ha. Application of 50 kg/ha of P also produced a significantly higher total tubers yield than 75 kg/ha. Application of 50kg/ha of P produced higher yields than 25kg/ha but the difference was not significant. There was no significant difference between the yields produced by 0 kg/ha of P and 25 kg/ha of P. This means that increasing the P level from 0 to 25 kg did not significantly increase the yield but increasing it to 50 kg/ha did. Table 4 also shows that increasing the P level further from 50 kg/ha to 75 kg per ha significantly reduced the total tuber weight; hence, higher levels of P should be avoided. These results agree with those of Hassan et al. (2005) who reported a significant effect of P on yield. Dumbuya et al. (2016) also reported that yield components increased from 0 kg/ha P_2O_5 to 60 kg P_2O_5 /ha but decreased with application of levels above 60kg P_20_5 /ha. The increase in total tuber yield with increase in amount of P applied could also be as a result of low levels of P in soil as shown from soil analysis results (Table 1). The decrease in tuber yield when 75 kg/ha P is applied may be because high P levels in soil suppressed tuber development of sweet potatoes and other root and tuber crops. This decrease in total tuber yield could be attributed to the nutrient imbalance that resulted from additional P nutrition through fertilizer application (Kareem et al., 2020).

Marketable Tubers Yield

After harvesting each of the tagged plants from each plot, marketable tubers (those with a middle diameter of more than 3cm and not longer than 30cm) were weighed using a weighing scale and their weight recorded. Weight from the six tagged plants from each plot was multiplied by 20000 which is the plant population per hectare and then divided by six (the six sampled plants) to get the yield of marketable tubers per hectare. The results obtained are as shown in Figure 2. According to Figure 2, the marketable yield from each variety increased with an increase in the amount of P applied up to a level of 50 kg/ha. Kenspot 4 produced the

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highest marketable tubers yield at each level of P application while 50kg/ha produced the highest marketable tubers yields in each variety. At P level of 0kg/ha, Kenspot 4 produced the highest marketable yield of tubers, hence can be the most appropriate variety to use for those farmers who do not want to apply fertilizers on their farm. To find out if the treatments had any significant effect on marketable tubers yield, ANOVA was carried out and the ANOVA summary is shown in Table 5. According to Table 5, the yield of marketable tubers differed significantly among the three varieties used ($p<0.05$). There was a significantly different yield of marketable tuber produced by the 4 different p levels applied ($p<0.05$). To separate the variety and P level means, LSD test was carried out and the results are presented in Tables 6 and 7 respectively.

Table 6 shows that Kenspot 4 produced significantly higher marketable tubers yield than Kenspot 3. Kenspot 4 produced higher marketable tubers yield than SPK 004 but the difference was not significant. SPK 004 produced higher marketable tubers yields than Kenspot 3 but the difference was not significant. These results agree with those of Kirui et al. (2018) and Mwololo et al. (2012) who found that the yield of marketable and non-marketable roots varied significantly among varieties.

According to Table 4.11, 50 kg/ha of P applied produced significantly higher yields than 0 kg/ha. 50 kg/ha phosphorus produced significantly higher yield than 75 kg/ha. 25 kg/ha produced higher yields than 0 kg/ha though the difference was not significant. 50 kg/ha produced higher yields than 25 kg/ha though the difference was not significant. Increasing the P level from 50kg to 75kg per ha led to a decrease in yield of marketable tubers. These results agree with Dumbuya et al. (2016) and Hassan et al. (2005) who both reported significant effects of P fertilizer on sweet potato components of yield. They reported that the low quantity of accessible native phosphorus in the soil may have contributed to the significant influence of P fertilizer on sweet potato yield components. This low quantity of native phosphorus was noted in the soils where this study was carried out, as seen in Table 1. The results also agree with those of Kirui et al. (2018) who reported significant effect of P fertilizer treatments on the mean of both marketable and non-marketable root yield of sweet potatoes. According to Hameda et al. (2011), the increase in marketable tuber yield with increase in P application can be explained in that one of the most important nutrients for many plant species including sweet potato is phosphorus, which acts as an important part of many organic compounds in plants that are essential for metabolic processes, blooming and root development. In spite of P fixation, several authors including Hassan et al. (2005) have observed a favorable response of sweet potato to the application of P fertilizer. The results from this study also agree with those reported by El-Morsy et al. (2002) and Hassan et al. (2005) who found that fertilization of sweet potato plants with P fertilizer caused significant increases in total and marketable yield. Results from this study agree with those of Boru et al. (2017) who reported that the main effects of FYM, P and the interaction of the two factors were significant ($P<0.05$).

RECOMMENDATIONS

Based on the results of this study, Kenspot 4 and SPK 004 are significantly better for yield parameters compared to Kenspot 3; hence, they are recommended for farmers in Embu West Sub County. Kenspot 4 is good in production of both total and marketable tubers yield and it can be a good commercial variety. Kenspot 4 produced the highest yield without phosphorus

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application (0 kg/ha); hence, it is also recommended for farmers who may be unable to afford fertilizers. A P level of 50 kg/ha is recommended for farmers in Embu West Sub County since it produced significantly higher yields than the control and other P levels in the two yield parameters. High phosphorus levels should be avoided since they tend to lower the growth and yield of sweet potato as shown by P level of 75 kg/ha in this study.

Acknowledgement

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Abbreviations:

P Phosphorus

GoK Government of Kenya

ANOVA Analysis of variance

SPSS Statistical Package for Social Sciences

LSD Least Significant Difference

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APPENDIX

TABLES

Table 1: Soil Analysis Report

	Soil Analytical Data							
Lab. No/2017	952							
Soil depth cm	Top							
Fertility results	Value	Class	Value	Class	Value	Class	Value	Class
* Soil pH	5.04	medium acid						
Exch. Acidity me%	0.3	adequate						
* Total Nitrogen %	0.21	adequate						
* Total Org. Carbon %	2.26	moderate						
Phosphorus ppm	10	low						
Potassium me%	0.86	adequate						
Calcium me%	4.8	adequate						
Magnesium me%	2.13	adequate						
Manganese me%	1.11	adequate						
Copper ppm	4.20	adequate						
Iron ppm	24.8	adequate						
Zinc ppm	22.4	adequate						
Sodium me%	0.57	adequate						

Table 2: ANOVA Effect of Variety and P levels on Total Tubers Yield

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
SEASON	253.5	1	253.5	18.62	0
BLOCK	147.053	2	73.526	5.401	0.007
VARIETY	102.889	2	51.445	3.779	0.029
P LEVEL	121.073	3	40.358	2.964	0.04
Error	776.028	57	13.615		
Total	1480.449	71			

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Table 3: LSD Effect of Variety on Total Tubers Yield

	SPK 004	Kenspot 3	Kenspot 4
SPK 004		0.79833	-2.04063
Kenspot 3			
Kenspot 4		2.8396*	

The mean difference is significant at 0.05 level.

Table 4: LSD Effect of P level on Total Tubers Yield

	0 kg/ha	25 kg/ha	50 kg/ha	75 kg/ha
0 kg/ha		-1.2742	-3.35417*	-0.3922
25 kg/ha			-2.08	0.88194
50 kg/ha				2.96194*
75 kg/ha				

The mean difference at the level 0.05 is significant.

Table 5: ANOVA Effect of Variety and P level on Marketable Tubers Yield

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
SEASON	207.194	1	207.194	16.254	0
BLOCK	118.788	2	59.394	4.659	0.075
VARIETY	94.746	2	47.373	3.716	0.03
P LEVEL	94.061	3	31.354	2.46	0.013
Error	726.57	57	12.747		
Total	**1330.931**	**71**			

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Table 6: LSD Effect of Variety on Marketable Tubers Yield

	SPK004	Kenspot 3	Kenspot 4
SPK 004		1.10697	-1.68321
Kenspot 3			-2.79013*
Kenspot 4			

The mean difference at level 0.05 is significant.

Table 7: LSD Effect of P Levels on Yield of Marketable Tubers

	0 $kgha^{-1}$	25 $kgha^{-1}$	50 $kgha^{-1}$	75 $kgha^{-1}$
0 $kgha^{-1}$		-1.4137	-2.99411*	-0.47689
25 $kgha^{-1}$			-1.58039	0.93683
50 $kgha^{-1}$				2.51722*
75 $kgha^{-1}$				

The mean difference at the level 0.05 is significant.

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FIGURES

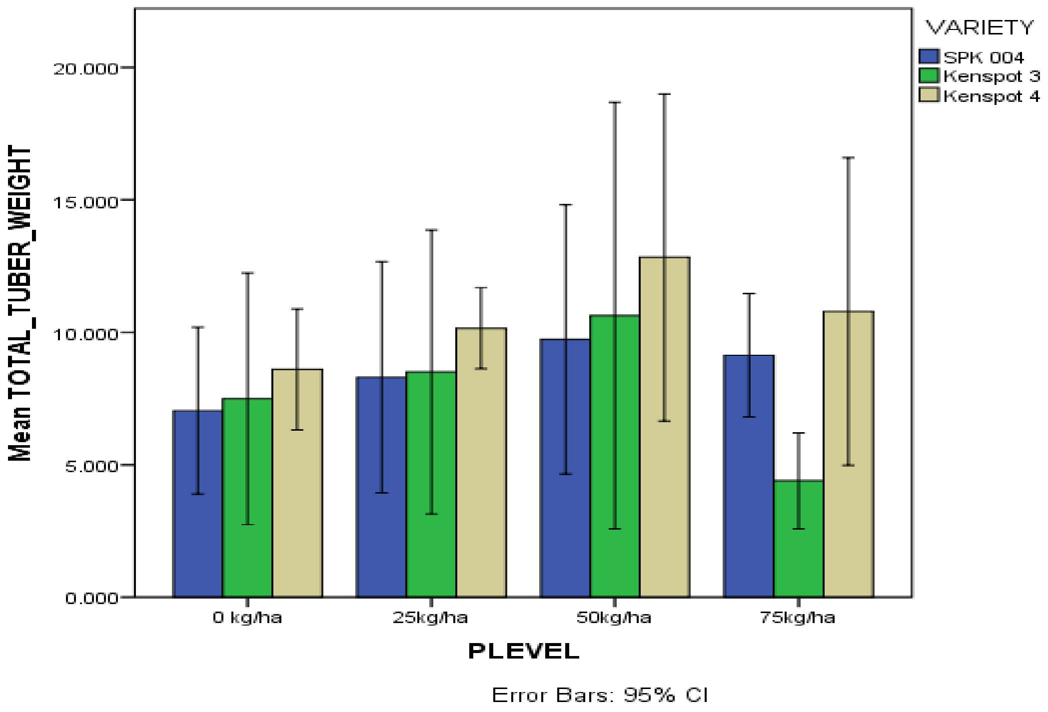

Figure 1: Effect of variety and P level on total tubers yield

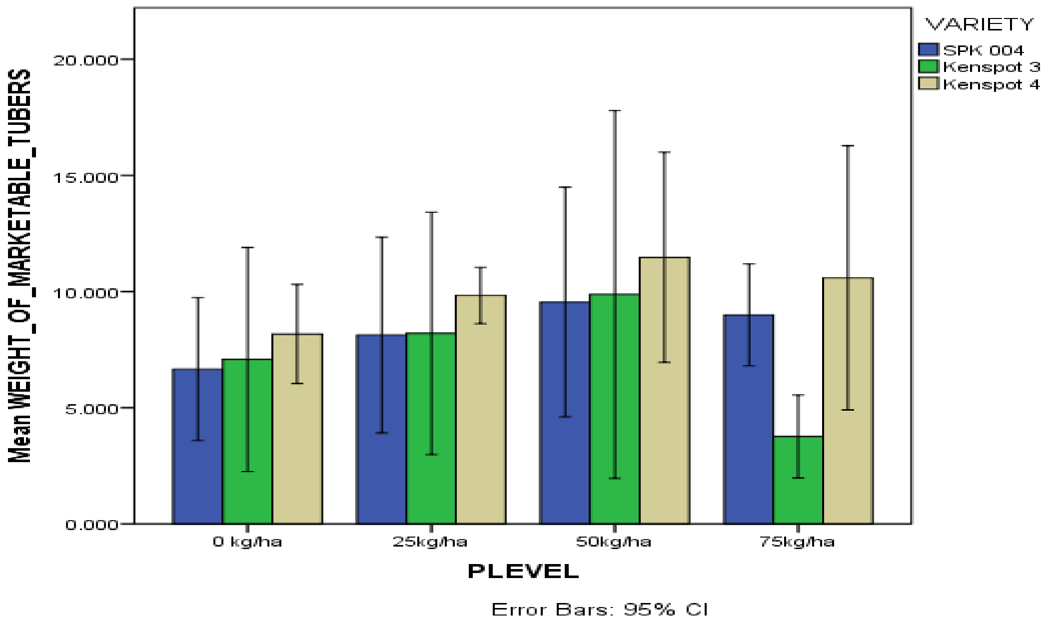

Figure 2: Effect of variety and P level on marketable tubers weight

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