Evaluation Of Effects Of Phosphate Fertilizers On Growth And Yields Of Four Sweet Potato Varieties In Kericho County

Samson Kirui, Peter Kamau, David Mushimiyimana

School Science and Technology, Department of Agriculture.
Kenya Methodist University, P.O Box 267 – 60200 Meru, Kenya
Email: kiruisam08@yahoo.com

School Science and Technology, Department of Agriculture.
Kenya Methodist University, P.O Box 267 – 60200 Meru, Kenya
Email: Pakamau52@gmail.com

School Science and Technology, Department of Agriculture.
Kenya Methodist University, P.O Box 267 – 60200 Meru, Kenya
Email: David.Mushimiyimana@kemu.ac.ke

ABSTRACT: Sweet potato (ipomoea batatas (L) Lam) is among the most important root and tuber food crops in the world, ranked seventh (based on production) and per capita consumption is 24 kg per year in Kenya. Sweet potato tubers are rich in vitamin A, B and C and Minerals such as K, Na, Cl, P & C and therefore Production of orange flesh sweet potato is important particularly for children and pregnant mothers in Sub Saharan Africa who are often exposed to vitamin A desiciency. Production of sweet potato is constraints by inadequate knowledge on type of fertilizer and rates, low yielding varieties with low dry matter content and varietal suitability to higher altitudes. Availability of planting materials of sweet potato suitable for high agro-ecological zones remains a major constraint in promotion of high yielding orange flesh sweet potato in Soin/Sigowet Sub County, Kericho County. In order to address this challenges a study was conducted to find out varietal performance of four Orange flesh sweet potatoes under different phosphate levels in the medium altitudes areas of Kericho. The main objective of the study was to determine the yield performance of the Four Orange Sweet potato varieties under three phosphate fertilizer levels. The Four Orange flesh Sweet potato varieties were Ken spots 1, 3, 4, and 5 while the three Phosphate levels were 0 kg P_2O_5kg/ha, 30 kg P_2O_5kg/ha and 60 kg P_2O_5kg/ha) . Randomized completed block design was used with three replicates. All Growth parameters(vine length, Number of vines per plant) and yield components (marketable and non marketable storage roots per plant, root yield per hectare, and Level of Dry matter content) for the four sweet varieties, (%) were significant ($p < 0.05$). In terms of production per hectare, Ken Spot 1 produced significantly higher root yield per hectare than all the other three varieties and recommended for medium altitudes zones of Soin/Sigowet Sub County of Kericho County. Overall, Ken Spot 1 produced significantly higher root yield per hectare than all the other three varieties

Keywords: Orange flesh sweet potato, Phosphate levels, Sweet Potato Varieties, weather, Yield performance.

1.0 INTRODUCTION

Back ground Information

In Sub-Saharan Africa Sweet potato is rated as one of the most important roots and tuber crop in terms of its domestic as well as industrial uses. The nutritional value of this important root and tuber crop far exceeds Yam, Cassava and Cocoyam (Onwuene, 1978). In terms of food security, over 100 developing countries cultivates sweet potato and at global level, it is one of the most important food crops and ranked among the six most important food crops in the world after Wheat, Rice, Maize, Irish potato and cassava. Sweet potato is ranked second in the world's root and tuber crop following Irish Potato in production and third after Irish potato and cassava in consumption in several parts of tropical Africa (Lene, 1981). Over 7 million tons (5% of global production) is produced annually in Africa (Kapinga et al., 2003,). At present, it is cultivated throughout the tropics, however the largest plantings of sweet potato are found in China and other countries of Asia (Huaman, 1992). The production in Africa is quite low estimated at 4 to 5 tons per hectare, about a third of the Asian yields. This indicates a huge potential for future yield increase of sweet potato in Africa. It is a food security crop grown in many parts of the poorest region of the world mainly by women for household consumption and source of family cash income (Aritua & Gibson, 2002; Scott et al., 2000). Kericho County has about 600 ha of sweet potatoes with total Production of 6,700 tonnes. There are 11,200 households growing sweet potatoes and majority of them growing as food security crop in their gardens. In Africa, Kenya is rated seventh largest Africa sweet potato producer. The potential production of Kenya is 50 tons/ha while production achieved so far is 8.2 tons/ha (FAO, 2002). The importance of sweet potato as food security crop cannot be underestimated as it plays a vital nutritional role and used as a source of starch, alcohol and animal feeds (Mwololo, Mburu & Muturi, 2012). Though the important role of sweet potato is mainly in food security, it has shown a great potential as an income source for resource poor farmers (Rees et al., 2001). In Zambia and other countries in Southern Africa sweet potato is an important secondary food crop and very useful crop in addressing food security (Kapinga et al., 2005). The main challenges of Sweet potato production are non application of artificial fertilizer by farmers in Sigowet Sub County of Kericho County. Farmers used to plant Sweet potato without fertilizer Applications and the yield performance was good but land fragmentation has resulted in continuous planting of sweet potato in same field leading to declining yields hence the need of plant nutrition through fertilizer application to supplement high nutrients mining. Also inadequate information on phosphate fertilizer use and rates is another challenge faced in the region. Phosphorus as nutrient is very important and performs several functions in crops and these functions are only specific to this nutrient. Due to its importance, adequate supply of Phosphorus is required for optimum growth and reproduction. Since Phosphorus is mostly deficient for crop production and its requirements by crops are relatively in large amounts, phosphorus is therefore classified as major nutrient. In Sub-Saharan Africa, many farmers who are resource-poor grow Sweet Potato without applying any artificial fertilizer. This is in contrast with developing Nations of the world where fertilizer use and applications rates has been considered of great importance for increased and sustained crops yields as high growth rate is dependent on optimum nutrition(Akinrinde,2006).

2.0 MATERIALS AND METHODS

2.1 Climatology and Soils

The experiment was carried out at two sites at Kiptere Free Pentecostal church and Gladys Letting's farm near Kiptere market during the October-March 2016/2017 cropping season in Sigowet/Soin Sub County, in Kericho County. The two experimental sites are at an elevation of 1810 m above sea level. The area experiences a bimodal relief type of rainfall with the long rains occurring from March to June and the short rains occurring in October to November. The area receives an annual average rainfall of 1800 mm and is reliable in nature, however due to climate change, there have been changes in rain fall pattern. The area has nitisols type of soil with a pH ranges from strongly acid (4.78) to slightly alkaline (6.5) which is favorably for production of Sweet potatoes. Also the soil organic matter content ranges from low (1.42% total organic carbon (TOC) to adequate (3.5% TOC). (Farm mgt handbook of Kenya, 2010) The experiment was established in the short rains October-November 2016 cropping season.

2.2 Treatments and Plot Layout

There were two treatments, phosphate levels (F) and Sweet potato varieties (V). Three phosphate levels; No fertilizer level (F1), Medium fertilizer levels (30 P_2O_5 kg/ha) and (F3)-High fertilizer levels (60 P_2O_5 kg/ha). Four sweet potato (ipomoea batatas (L) Lam) varieties Ken spot 1 (V1), Ken spot 3 (V2), Ken spot 4 (V3) and Ken spot 5 (V4) were tested. Each sweet potato varieties were grown under the three different phosphate levels.

***Table 1** Treatment Combinations*

Phosphate Levels	Sweet Potato Varieties			
	KEN SPOT 1	KEN SPOT 3	KEN SPOT 4	KEN SPOT 5
0 P_2O_5 kg/ha	F1V1	F1V2	F1V3	F1V4
30 P_2O_5 kg/ha	F2V1	F2V2	F2V3	F2V4
60 P_2O_5 kg/ha	F3V1	F3V2	F2V3	F2V4

Table 1 shows the treatment combinations used in this study in the field. The experiment was arranged on a randomized complete block design (RCBD) and replicated three times. The plots measured 6 m by 3 m with 1 m wide paths between plots and 2 m wide path between blocks

2.3 Land preparation, fertilizer application and planting

The plot was ploughed with a tractor after it was cleared of any bushes and latter properly prepared to fine tilt using jembes and raking to remove large clods. Laying of soil conservation structures was done and structures implemented to avoid soil erosion. Soil samples were taken for analysis to determine the position of availability and adequacy of nutrients for plant performance. Field layout was done after demarcation and pegging out. Ridges were made to the recommended spacing and fertilizers rates applied per treatment and sweet potato vines planted to the right depth. Four varieties of sweet potato materials were sourced from University of Kabianga which is one of the Multiplication centres of Kenya Agricultural and Livestock Organization (KALRO) Njoro regional centre.

2.4 Data Collection

The research population comprised all the sweet potato plants in all the treatments and correlated to the sweet potato population in the replications. The representative units were selected by random sampling using transects in the experimental units to give the research sample. An equal number of subjects (10) were sampled in each treatment. During the growing period, quantitative data on growth performance and yield parameters was collected and recorded. The measurements were taken at 90 days and 150 days after planting and at maturity. Yield and yield components were estimated from the total storage roots harvested from the plot. Total storage root yield (t/ha) and marketable and unmarketable storage root yield (t/ha) was estimated by multiplying average yield per plant by the population density per hectare. The parameters monitored were; Vine length per plant, Number of vines per plant, Average number of the storage roots per plant, Marketable storage root number/plant, Unmarketable storage roots number/plant, Total storage root yield (t/ha), Marketable storage root yield(t/ha), Unmarketable storage root yield(t/ha), Dry matter content (%): The dry matter content (%) of the sweet potato was calculated by using the loss weight and the fresh sample weight according to the following formula.

$$Dry\ matter\ content\,(\%) = \frac{Dry\ Weight X100}{Fresh\ Weight}$$

2.5 Data Analysis

The collected data were summarized in ms excel for statistical analysis. The data collected were analyzed statistically using analysis of variance technique with the help of SPSS version 22.0 and Post Hoc tests using least significance difference (LSD) test at 5% probability level was employed where necessary to compare the differences among treatment means (Steel and Torrie, 1984).

3. RESULTS AND DISCUSSIONS

3.1 Vine Length

The mean vine length were recorded 90 days and 150 days after planting and the results are given in table 2

Table 2: *Mean Vine Length of Sweet Potato Varieties*

Period	Statistic	Sweet Potato Varieties				Treatment(Kg P_2O_5/ha)		
		Ken Spot 1	Ken Spot 3	Ken Spot 4	Ken Spot 5	0	30	60
90 Days After Planting	Mean	140.044	119.400	114.578	102.089	92.733	131.300	133.050
	Std. Error	12.036	12.036	12.036	12.036	10.423	10.423	10.423
150 Days After Planting	Mean	177.133	152.778	148.956	144.378	113.267	165.217	188.950
	Std. Error	17.293	17.293	17.293	17.293	14.976	14.976	14.976

From data in table 2 ,Sweet potato Variety Ken Spot 1 had the highest mean vine length (140.0cm) while Variety Ken Spot 5 had the lowest mean vine length (102.09cm) 90 days after planting. Likewise, Variety Ken Spot 1 had the highest mean vine length of 177.13cm after 150 days while Ken Spot 5 exhibited the lowest mean vine length over the same growth period. Analysis of variance results showed that vine length of sweet potatoes differed significantly by fertilization method ($p<0.05$) both at 90 and 150 days after planting. Application of Phosphate fertilizers significantly affected vine length of the four varieties of sweet potatoes, with mean vine length being significantly shorter in the 0 kg P_2O_5 /ha /ha fertilizer treatment compared to 30 kg P_2O_5/ha and 60 kg P_2O_5 Kg/ha and at both sampling intervals as revealed by post-hoc Least Significant Difference (LSD) test results. The mean vine lengths were not found to be significantly different between the four varieties at both sampling intervals ($p>0.05$). Blocking also had no effect on vine length of the sweet potatoes. Pairwise comparisons showed that significant mean differences occurred between Varieties Ken Spot 1 and Ken Spot 4 (89.33cm) and Ken Spot 1 and Ken Spot 5 (96.27cm) under 0 kg P_2O_5 /ha fertilizer application. These results could mean that sweet potato Variety Ken Spot 1 produces longer vines under low fertilizer conditions than Varieties Ken Spot 4 and Ken Spot 5. Ken spot 1 therefore because of the longer vines under low fertilizer application can be used as a good source of vines especially in the multiplication of clean planting materials since it produces longer vines under low fertilizer application. The vines can too be useful as livestock feeds particularly feeding ruminants animals since sweet potato vines are rich in proteins and minerals contents enriching livestock feeds and lowering cost of production in dairy farming (Ahmed et al., 2012). The current results are in agreement with the findings of Wariboko & Ogidi (2014) whose results showed that the treatments (varieties) of sweet potatoes were significantly different in growth parameters.

3.2 Number of Vines per Plant

The mean number of vines at 90 days and 150 days after planting were recorded and results are given in table 3

Table 3: *Mean number of vines of sweet potato varieties.*

Period	Statistic	Sweet Potato Varieties				Treatment		
		Ken Spot 1	Ken Spot 3	Ken Spot 4	Ken Spot 5	0Kg P_2O_5/ ha	30Kg P_2O_5 /ha	60Kg P_2O_5/ ha
90 Days After Planting	Mean	14.667	14.444	13.489	13.000	9.067	16.100	16.533
	Std. Error	.868	.868	.868	.868	.752	.752	.752
150 Days After Planting	Mean	17.089	16.333	14.778	15.000	11.083	18.133	18.183
	Std. Error	1.024	1.024	1.024	1.024	.887	.887	.887

The results in table 3 show that the highest overall mean number of vines 90 days after planting (16.53) was obtained in sweet potatoes planted under 60 kg P_2O_5 /ha followed by an average of 16.1 branches from sweet potatoes planted with fertilizer rate of 30 kg P_2O_5 /ha. However, the lowest mean number of vines 90 days after planting was obtained in sweet potatoes planted without fertilizer. This trend repeated itself 150 days after planting where the mean number of vines was 18.18, 18.13 and 11.08 respectively under 60Kg P_2O_5 /ha, 30 kg P_2O_5 /ha and 0 kg P_2O_5 /ha fertilizer application as seen in table 3. Sweet potato Variety Ken Spot 1 had the highest mean number of vines at both sampling intervals 14.67 and 17.09 respectively for 90 and 150 days after planting. Whilst the lowest mean number of vines 90 days after planting was noted in Variety Ken Spot 5 (13.0). Ken Spot 4 produced the lowest mean number of vines 150 days after planting (14.78). Application of Phosphate fertilizer significantly affected the number of vines in sweet potatoes at $p<0.05$ at both sampling intervals of 90 days and 150 days after planting. The mean number of vines was significantly lower in sweet potatoes planted with 0 kg P_2O_5 /ha fertilizer compared to 30 kg P_2O_5 /ha and 60 kg P_2O_5 /ha in both samples collected 90 and 150 days after planting as shown post-hoc LSD test results in table 4 and Table 5 90 days and 150 days after planting respectively.

Table 4.: *LSD on Effect of fertilizers on the mean number of vines 90 days*

kg P_2O_5 /ha	0	30	60
0		-7.0333*	-7.4667*
30			-.4333
60			

*. The mean difference is significant at the .05 level

Table 5: *LSD on Effect of fertilizers on number of vines 150 days*

kg P_2O_5 /ha	0	30	60
0		-7.0500*	-7.1000*
30			-.0500
60			

*. The mean difference is significant at the .05 level.

The number of vines of sweet potatoes at both sampling periods neither was nor significantly affected by blocking, sweet potato variety and the effects between Phosphate fertilizer application and sweet potato varieties. This study therefore means that Ken spot 1 with the highest number of vines is recommended for vine multiplication.

3.3 Number of Non- marketable and Marketable Roots.

The mean number of non-marketable roots at harvest was counted per plant were recorded and results given in Table 6

***Table 6:** Mean number of non-marketable and marketable roots of SP*

Category of Roots	Statistic	Sweet Potato Varieties				Treatment(Kg P_2O_5/ha)		
		Ken Spot 1	Ken Spot 3	Ken Spot 4	Ken Spot 5	0	30	60
Non-Marketable Number	Mean	5.667	5.222	10.667	21.000	5.167	13.083	13.667
	Std. Error	1.701	1.701	1.701	1.701	1.473	1.473	1.473
Marketable Number	Mean	42.333	38.056	44.000	44.222	34.250	45.625	46.583
	Std. Error	3.141	3.141	3.141	3.141	2.720	2.720	2.720

From the results in Table 4, the highest mean number of marketable roots was observed in sweet potatoes planted using 60 kg P_2O_5 /ha (46.58) while the lowest mean was realized in sweet potatoes planted with 0 kg P_2O_5Kg/ha fertilizer (34.25). Similarly, the highest mean number of non-marketable roots was associated with sweet potatoes planted under 60kg P_2O_5 /ha (13.67) while the lowest mean was associated with the treatment of 0 kg P_2O_5 /ha set up (5.17). Among the four sweet potato varieties, Ken Spot 5 had the highest mean number of marketable roots (44.22) followed by Ken Spot 4(44.0) and then Ken Spot 1(42.33), while Ken Spot 3 had the lowest number of marketable roots (38.06). In a similar fashion, the highest numbers of non-marketable roots were associated with Variety Ken Spot 5 (21.0) while Ken Spot 3 had the lowest number of non-marketable roots (5.22). Phosphorus fertilizer effects on number of marketable roots was examined using F-Test (ANOVA) which the results showed that the response of sweet potatoes to the different levels of phosphorus fertilizer for the number of marketable roots exhibited significant differences since it has P-Value less than 0.05 with the highest mean marketable numbers of roots being realized under 60 kg P_2O_5 /ha and 30kg P_2O_5 /ha compared to sweet potatoes planted with 0 kg P_2O_5 /ha fertilizer application . The response of sweet potato to the different level of phosphorus fertilizer for the number of marketable roots showed significant differences, in which the highest mean number of marketable roots (46.583) was produced by the 60 kg P_2O /ha treatment and this was significantly higher than the 0 kg P_2O /ha treatments. The findings of this study agree with that of Gibrilla et al, (2016) who found that fertilizer application significantly affected mean number of marketable roots of sweet potato and application at 60 kg P_2O /ha gave significantly more marketable roots than that of 0 kg P_2O /ha treatments. In addition, the number of non-marketable roots differed significantly at $p<0.05$ with the highest mean non-marketable numbers of roots being realized under 60kg P_2O_5 /ha and 30 kg P_2O_5 /ha compared to those produced planted with 0 kg P_2O_5 /ha fertilizer application. However, there were no significant differences in the numbers of both marketable and non-marketable roots of sweet potatoes planted with 30kg P_2O_5 /ha and 60 kg P_2O_5 /ha . The results on the mean number of non-marketable roots contradicts those of Gibrilla et al, (2016) who concluded in his findings that there was no significant difference for Phosphate fertilizer application. Variety of the sweet potatoes did not significantly affect the mean numbers of marketable roots. However, the number of non-marketable roots differed significantly by sweet potato variety ($p<0.05$), where Variety Ken Spot 5 had significantly higher mean number of non-marketable roots than all the other three Varieties. The mean number of non-marketable roots differed significantly between varieties Ken Spot 3, 4 and Ken spot 5 while there was no significant difference between Ken spot 1 and 3 .

3.4 Non-Marketable and Marketable Root yields Per Plant.

The Non-marketable and marketable root yield per plant was weight at harvest and results summarized in table 7.

***Table 7:** Mean non-marketable and marketable root yield per plant sweet potatoes*

Category of Roots	Statistic	Sweet Potato Varieties				Treatment (Kg P_2O_5/ha)		
		Ken Spot 1	Ken Spot 3	Ken Spot 4	Ken Spot 5	0	30	60
Non-Marketable Root Yield	Mean	.057	.044	.077	.144	.040	.109	.093
	Std. Error	.015	.015	.015	.015	.013	.013	.013
Marketable Root Yield	Mean	.928	.756	.814	.700	.588	.915	.896
	Std. Error	.039	.039	.039	.039	.034	.034	.034

It can be found in table 5 that based on fertilizer treatment, the mean marketable root yield was highest in sweet potatoes planted using 30 kg P_2O_5/ha (0.915kg), closely followed by the mean of sweet potatoes planted under 60 kg P_2O_5/ha (0.896kg) while the lowest mean (0.588kg) was associated with those planted with 0 kg P_2O_5/ha fertilizer set up. Similarly, the highest numerical mean non-marketable root yield was associated with sweet potatoes planted with 30 kg P_2O_5/ha (0.109 kg) while the lowest mean (0.040kg) was realized from sweet potatoes planted 0 kg P_2O_5/ha fertilizer. This finding were in contrast with the findings of Gibrilla et al. (2016) who found that different level of phosphorus fertilizer for marketable root yield showed significant differences, in which the highest marketable yield was produced by the 60 kg P_2O_5/ha treatment and this was significantly higher than the treatment planted with 0 kg P_2O_5/ha fertilizer and 30 kg P_2O_5/ha treatments. Based on sweet potato variety, the highest mean marketable root yield was obtained from Ken Spot 1 (0.928kg) while the lowest was obtained from Ken Spot 5 (0.700kg). On the other hand, the highest mean non-marketable root yield was realized from Ken Spot 5 (0.144kg) and the lowest root yield was associated with Ken Spot 3 (0.044kg). This finding agreed well with Mwololo et al. (2012) who found that a number of marketable and non-marketable roots varied significantly among varieties. The differences in mean of both marketable and non-marketable root yield of sweet potatoes were significant ($p<0.05$) for fertilizer treatment. Marketable root yield per plant was significantly higher under both 60kg

P_2O_5/ha and 30kg P_2O_5/ha compared to the 0 kg P_2O_5 /ha, which was also reflected in non-marketable root yield per plant. However, no significant differences in root yield per plant were noted between 60 kg P_2O_5/ha and30 kg P_2O_5/ha fertilizer treatments. Marketable and non-marketable root yields were also significantly affected by sweet potato variety (p<0.05), where Ken Spot 5 had consistently and significantly higher mean non-marketable root yield than then other three varieties. For marketable root yield, Variety Ken Spot 1 produced significantly higher yields than Ken Spot 3 and Ken Spot 5.

3.5 Root Yield per Hectare

The mean root yield per plant was recorded at harvests and the data was multiplied by the plant population per hectare to get root yield per hectare and the results are given in Figure

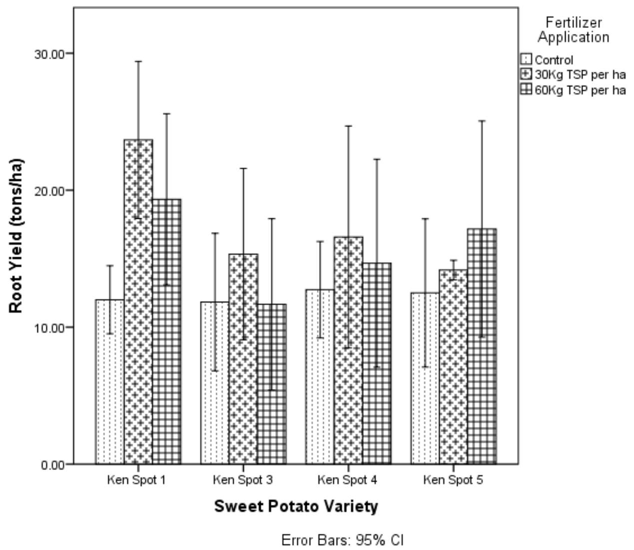

***Figure 1:** Effects of Fertilizers and Varieties on Root Yield per Hectare*

From the results in figure 1 the highest mean root yield per hectare of sweet potatoes was associated with 30kg P_2O_5/ha (17.44tons/ha) followed by 15.71tons/ha harvested from sweet potatoes planted with 60kg P_2O_5/ha. The lowest mean root yield was associated with sweet potatoes planted with 0 kg P_2O_5/ha fertilizer application (12.27tons/ha). Variety Ken Spot 1 produced the highest root yield per hectare (18.33tons/ha), followed by Ken Spot 4 (14.66tons/ha) and Ken Spot 5 (14.61tons/ha). Ken Spot 3 produced the lowest mean root yield of 12.94tons/ha. Sweet potato root yield per hectare was significantly affected by phosphorus fertilizer rates (P<0.05). Phosphorus fertilizer rate of both 30kg P_2O_5/ha and 60kg P_2O_5/ha produced significantly higher root yields per hectare than planting with 0 kg P_2O_5/ha. However, root yields produced from sweet potatoes planted with 30 kg P_2O_5/ha and 60kg P_2O_5/ha were not significantly different despite 30kg P_2O_5/ha producing numerically marginal higher mean than 60kg P_2O_5/ha. Variety of the sweet potatoes also significantly affected root yield per hectare (P<0.05) as shown by LSD results. Variety Ken Spot 1 produced significantly higher root yield per hectare than all the other three varieties. These results of the current study were in line with results gotten by Karanja et al, (2013) in which Ken spot 1 produced consistently higher yields per hectare than all the other three varieties. However, in term of fertilizer application, Gibrilla et al. (2016) concluded that fertilizer rate of 60 kg P_2O_5/ha produced significantly higher yield per ha than 30 kg P_2O_5/ha and 0 kg P_2O_5/ha which were in contrast of the findings of this study where 30 kg P_2O_5/ha produced numerically higher yield than 60 kg P_2O_5/ha kg P_2O_5/ha.

3.6 Dry Matter Content of Sweet Potatoes.

The dry matter content (%) was calculated by using the lost weight and the fresh sample weight according to the following formula.

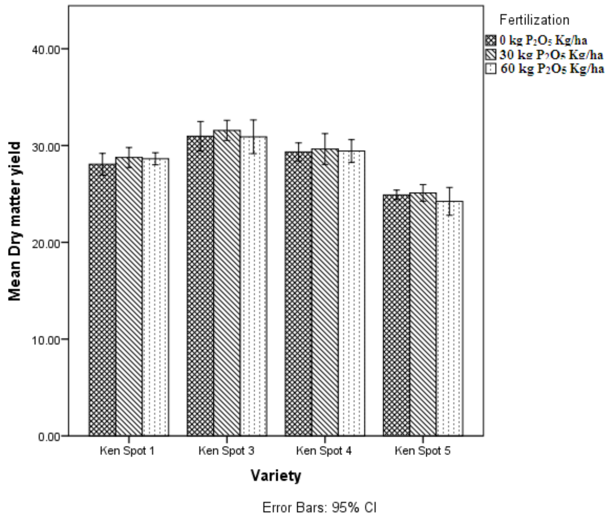

***Figure 2.** Effects fertilizer and sweet potato varieties on Dm Content (%)*

The dry matter content of sweet potato was determined from a representative 10g sliced sweet potato samples for each treatment. The slices were weighed immediately after slicing and kept for 5 days in open air then the samples were oven dried at 80c for 24 hours in laboratory and results were tabulated in figure 2 The results in figure 2 show that application of phosphate fertilizer at the rate of 30 kg P_2O_5/ha produced the highest mean DM (28.77 %) of sweet potatoes followed planted with 0 kg P_2O_5/ha set up at 28.31% and 60 kg P_2O_5/ha at 28.30 %. With respect to variety, the highest mean DM content was realized from Ken Spot 3 (31.44 %) while the lowest mean DM content was associated with Ken Spot 1 (28.49 %). Varieties Ken Spot 4 and Ken Spot 5 had almost the same DM content. Analysis of variance revealed that DM content was significantly affected by both variety and application of phosphorus fertilizer rates (P<0.05). Phosphorus fertilizer at the rate of 30 kg P_2O_5/ha produced significantly higher DM content than 60 kg P_2O_5/ha and 0 kg P_2O_5/ha. Variety of the sweet potatoes also significantly affected DM content (P<0.05) as the results of LSD statistical test, variety Ken Spot 3 had

$$Dry\ matter\ content\,(\%) = \frac{Dry\ WeightX100}{Fresh\ Weight}$$

significantly higher DM content than all the other three varieties, while Variety Ken Spot 1 had consistently lower DM content compared to the rest.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

First, the results of this study have shown and it is consequently concluded that application of phosphates fertilizer at the rates of 30 kg P_2O_5/ha and 60 kg P_2O_5/ha significantly affected growth of sweet potatoes in terms of the vine length and number of vines as well as yields in terms of number of marketable and non-marketable roots, marketable and non-marketable root yields in kilograms and root yield per hectare. No significant differences manifested in yield and growth components of sweet potatoes at both fertilizer application rates. Secondly, the results showed that growth components vine length and the number of vines were not significantly affected by sweet potato variety. Although the numbers of marketable roots were not affected by variety, the number of non-marketable roots by sweet potato variety with here Ken Spot 5 having a significantly higher number of non-marketable roots than all the other varieties. Optimum marketable root yields per hectare were obtained from Ken Spot 1 variety of sweet potatoes. Finally, it is concluded that the effect between fertilizer treatment and sweet potato variety significantly affected growth and yields of sweet potatoes. Optimum root yield per hectare, as a result, differed significantly because of the effect between phosphate fertilizers and variety. Ken Spot 1 produced significantly higher root yields per hectare than the other three varieties with phosphate fertilizer at the rate of 30 kg P_2O_5/ha.

4.2 Recommendations

First, the findings arising from the analysis of the effect of phosphate fertilizer application on sweet potato growth and yields inform the recommendation hereto, that farmers in similar agro-iconological zones may use phosphate fertilizers at the rate of 30 kg P_2O_5/ha. Which gives optimum yields of sweet potatoes provided that other growth and crop production and management practices are kept constant. Secondly, sweet potato farmers are strongly advised to use Ken Spot 1 variety if they are to obtain economically marketable root yields. This is based on the assumption that the taste and nutritional components of this variety are acceptable to the targeted consumer. Finally, use of Ken Spot 1 variety in combination with 30 kg P_2O_5/ha is highly recommended given that the current study established that optimum economic root yield per hectare as a result of phosphate fertilizers was realized in Ken Spot 1that produced significantly maximum root yield per hectare.

REFERENCES

[1] Ahmed, M., R.Nigussie-Dechassa and B.Abebie. (2012) Effects of planting methods and vine harvesting on shoot and tuberous root yield of Sweet potato (ipomoea batatas (L) Lam) in the region of Ethiopia .AffrJ.aGNC. Retrieved from www.haramaya.edu.et/wp.../law.../HLR_Policies_Guidelines%20and%20Structures.pd.

[2] Akinrinde, E.A. (2006) .Phosphorus fertilization effect on dry matter production and biomass partitioning in sweet potato (Ipomoea batatas) grown on an acidic loamy-sand Alfisol.Retrieved from agris.fao.org/agris-search/search.do?recordID=FI2016100434

[3] Aritua, V. and Gibson, R.W.(2002).The perspective of Sweet potato Chlorotic Stunt Virus in sweet potato production in Africa: A review. In: Africa Crop Science Journal 10 (4): 281-310.Better Crops/Vol. 83 (1999, No. 1) 7.Functions of Phosphorus in Plants. Retrieved from erepository.uonbi.ac.ke/.../Muturi_Participatory%20Evaluation%20Of%20Sweet%20P.

[4] District Agriculture Officer (2014) Kericho District Annual Report Ministry of Agriculture. Nairobi.

[5] FAO (2002): Food and Agricultural Organization of United Nations ,Rome,2002 http://www.fao.org/docrep/004/y6000e/y6000e00.htm

[6] FAO (2003): Food and Agricultural Organization Available at <http://apps.fao.org/>, accessed on 8th, June, 20013. .

[7] Farm Management Handbook of Kenya vol. 11 Natural Conditions and Farm Management Information, Part B Central Kenya, (2010)

[8] Gibrilla D, J. Sarkodie-Addo, M. A. Daramy and M. Jalloh. (2016) Growth and yield of sweet potato to different tillage methods and phosphorus fertilizer rates in Ghana. Journal of Experimental Biology and Agricultural Sciences ISSN No. 2320 – 8694. Retrieved from www.jebas.org/Jou.Exp.Bio.Agr.Sci/.../10.18006_2016.4(5).475.483

[9] Huaman, Z. (1992) Systematic Botany and morphology of the sweet potato plant. Technical information Bulletin 25.International potato center, Lima peru.22p

[10] J.K. Mwololo, M.W.K.Mburu, P.W, Muturi .(2012).Performance of sweet potato varieties across environments in Kenya. International Journal of Agronomy and Agricultural Research vol, 2 No 10, p.1-11. Retrieved from www.pu.ac.ke/.../sweet%20potato%20varieties%20across%20environments

[11] Kapinga, R., Lemaga, B., Ewell, P., Zhang, D., Tumwegamiire, S., Agili, S., Nsumba, J.(2003). Increased promotion and utilization of orange-fleshed sweet potato as part of the food based approaches to combat vitamin A deficiency in sub-Saharan Africa. Food Africa, 5-9 May 2003, Cameroon. Abstract accepted for Food, Nutrition and Health theme.

[12] Kapinga, R., S. Tumwegamire, B. Lemaga, M. Andrade, R. Mwanga,…… B. Serwadda.(2005.) Development of farmer based seed systems for healthy planting materials and increased sweet potato production in East and Southern Africa. In African Crop Science Conference Proceedings, Vol. 7, pp. 1169–1173. November5–9, 2005. Kampala, Uganda.

Retrieved from jambo.africa.kyoto-u.ac.jp/kiroku/asm_normal/abstracts/pdf/34-2/34-2-4.pdf

[13] Lene. J.M. (1991). Diseases and pests of sweet potato: South East Asia, the pacific and East Africa. Natural resources Institutes. Bulletin 46(7):116 Retrieved from nla.gov.au/anbd.bib-an13450128

[14] Onwuene I.C. (1978) .Cultivation, harvesting and storage. The Tropical Root Crops; Yam, cassava, sweet potato and cocoyam. University Ife, lie-Ife Nigeria pp.176-183.

[15] Rees, D., R. Kapinga, K. Mtunda, D. Chilosa, E. Rwiza, M. Kilima, H. Kiozya & R. Munisi .(2001). Effect of damage on market value and shelf-life of sweet potato in urban markets ofTanzania. Tropical Science, 41: 1–9.

[16] Scott, G.J., Rosegrant, M.W. and Ringler, C. (2000). Roots and tubers for the 21st century: trends, projections and policy options 2020 Brief 66: a 2020 vision for food, agriculture and the environment. International Food Policy Research Institute.

[17] Steel R.G.D. and TorrieJ.H. (1984). Principles and Procedures of Statistics. Biometric Approach.2nd Ed., pp: 172–7. McGraw Hill Book Co., Singapore

[18] Wariboko,C. and Ogidi,I.(2014) Evaluation of performance of improved sweet potato (Ipomoea batatas (L) Lam varieties in Bayelsa state ,Nigeria.Afr.J.Environ.Sci.Technolo.,8;48.53. Retrieved from https://www.ajol.info/index.php/ajest/article/download/99551/88834

AUTHOR PROFILE

Samson Kirui has a Diploma and BSc in Agriculture from Egerton University, Kenya and is currently pursuing an MSc. In Agricultural and Rural Development from Kenya Methodist University. He works with County Government of Kericho seconded to Kenya Climate Smart Agriculture Project as Monitoring and Evaluation Officer since December 2017. He has worked with Ministry of Agriculture in Extension management, coordinating and planning and has implement agricultural and rural development projects In Rift valley and Nyanza Kenya for over 28 years