Agronomic performance of regional local popular orange-fleshed sweetpotato cultivars in Kenya

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Abstract

Vitamin A deficiency is a major nutritional problem in Kenya, leading to night blindness and high mortality rate in infants. Worldwide, an estimated 3-million preschool-age children have visible eye damage due to vitamin A deficiency (VAD), and annually over 300,000 children die within a few months after getting blind. Consumption of orange-fleshed sweetpotato (OFSP) that is high in provitamin A (β-carotene), can improve body stores of vitamin A, hence reducing the risk of deficiency. Most of the high -carotene content varieties in Kenya have low root dry matter contents while consumers prefer varieties with dry and floury roots. Fourteen local OFSP cultivars selected by the East and Central African (ECA) countries were evaluated at KARI-KARI-Kakamega, Kabete Campus of the University of Nairobi, KARI-KARI-Mtwapa and KARI-KARI-Katumani between 2006 and 2008 to assess their performance in different sweetpotato growing zones in Kenya. Farmers from the neighboring communities evaluated and ranked the cultivars based on field performance and quality of cooked roots. Varieties 199062.1, Ukerewe, Mayai, and Ejumula consistently gave high yields over four locations. Yields were highest at KARI-KARI-Kakamega and lowest at KARI-Mtwapa while virus infection was highest at KARI-KARI-Kakamega. The overall ranking of cultivars by farmers was not consistent with the root yields. At Kabete and KARI-Mtwapa, cultivars Ukerewe and Pipi were ranked high. Farmers at KARI-Kakamega ranked SPK004 highest followed by Ukerewe, Ejumula, Carrot C, Mayai, and 199062.1. Mayai, K135, SPK004 and Pipi were ranked high at KARI-Katumani.

Keywords: b-carotene, yield, dry matter, virus infection.

Introduction

Sweetpotato (*Ipomoea batatas* (L) Lam.) is one of the most important staple crops in the densely populated parts of eastern and Central Africa. It is one of the world's highest yielding crops in terms of production per unit area, exceeding that of major cereals such as rice, and with higher food value (Woolfe, 1992). In Kenya swetpotato is widely grown by the small scale farmers, mainly women, and is a key livelihood resource for food supply and cash income. Moreover, its value adding potential is now increasingly recognized, given the crops' rapidly expanding industrial and commercial applications. Sweetpotato vines and roots are also used as animal feed particularly in the expanding zero grazing livestock systems in Kenya. Compared to many other crops, sweetpotato requires few inputs and relatively less labour, making it suitable for the resource poor households. Its ability to produce relatively good yields under marginal conditions, its flexible planting and harvesting times, makes it a "classic" food security crop. Sweetpotato is grown in Kenya in nearly all agro-ecologies with the highest concentration in the Lower Midland and Upper Midland zones (Ndolo et. al., 2001).

A part from the contribution of sweetpotato to food security and cash income generation, it is also a major source of carbohydrates, providing essential nutrients in diets, particularly β-carotene used for the control Vitamin A deficiency (Low *et al*. 1996). Vitamin A deficiency remains a major nutritional problem in Kenya, significantly leading to night blindness and mortality of infants. An estimated 3-million preschool-age children worldwide have visible eye damage due to vitamin A deficiency (VAD). In women, VAD results in reproductive disorders, increases the risk of pregnancy mortality, as well as giving birth to underweight children. Strategies to control vitamin A deficiency include utilization of -Carotene-rich crops, such as orange-fleshed sweetpotato (OFSP) (Ruel, 2001). Daily consumption of the beta carotene dense orange-fleshed variety provides about 2.5 times the vitamin A requirements for 4 to 8-year-old children, and improved liver vitamin A stores (van Jarsveld et al. 2005).

The Kenya Agricultural Research Institute (KARI) in collaboration with the International Potato Centre (CIP) and the Sweetpotato Regional Network (PRAPACE) has identified some β-carotene (pro-vitamin A) rich OFSP varieties. Most of these varieties have not been well taken up by farmers because of their poor adaptability (especially for the introductions), and low root dry matter contents. The diverse nature of agro-ecologies where sweetpotato grows, and the widespread need to combat vitamin A deficiency, makes the need to develop more OFSP varieties. A number of popular local OFSP varieties from the East and central African countries were introduced into Kenya through CIP. The objective of this study was to evaluate these varieties in different sweetpotato growing zones in Kenya and identify adapted and acceptable varieties for dissemination to farmers.

Material and methods

Fourteen varieties (Table 1) identified were evaluated at KARI-KARI-Kakamega (mid altitude, high virus pressure), Kabete Campus of the University of Nairobi (High altitude, low virus pressure) KARI-KARI-Mtwapa (coastal lowlands) and KARI-KARI-Katumani (drought and high weevil infestation) between 2006 and 2008. These locations represent the major sweetpotato growing areas of Kenya. The climatic characteristics of the sites as described by Jaetzold and Schmidt (1983) are given in Table 2. Vine tip cuttings, 25 to 30 cm long were used as planting material. Each plot was planted in 5 rows, 1 m apart, 5.1 m long, and 0.3 m between plants (33,300 plants ha^{-1}) in a randomized complete block with three replications. The OFSP variety SPK004 was included in all locations as a check for dry matter content while NASPOT 1 was used as a check for high yield. Plants were harvested after 150-180 days of growth. The two middle rows in each plot were used for data collection. At harvest, the foliage was cut at a height of 10 cm from the ground level and weighed. The storage roots were separated into marketable and unmarketable roots, counted and weighed. Marketable roots included all those with a cross-sectional diameter of at least 3 cm. Data were also collected on virus infection and root dry matter (DM) content. The DM was determined by oven drying 200g of chopped root samples at 70^0 C for 48 hours. Virus damage was assessed by visual scoring for virus damage on leaves, 90 days after planting, using a score of 1-5 per plot where: 1 = no apparent virus symptoms; 2 = mild symptoms on a few plants; 3 = mild symptoms on many plants, some stunting; 4 = mild symptoms on many plants, stunting of many plants; 5 = most plants stunted.Standard data sheets developed by CIP were used for data collection.

Table 1. Characteristics of popular orange-fleshed clones used in the study

Clone	Country of Origin	Remarks
1. Carrot C	Tanzania	Local collection, deep orange
2. K135	Kenya	Local collection, orange
3. Zambezi	Zambia	Local collection, deep orange
4. Mayai	Tanzania	Local collection, deep orange
5. K566632	Kenya	Local collection
6. Gweri	Uganda	Local collection
7. Pipi	Kenya	Local collection
8. K 118	Kenya	Local collection
9. Ukerewe	Tanzania	Local collection
10. 199062.1	CIP	Breeding material
11. Ejumula	Uganda	Standard local check- orange, released in Uganda
12. SPK004 (KARI-Kakamega 4)	Kenya	Standard local improved check-Released in Kenya and Uganda
13. Naspot1	Uganda	Standard check for high yields
14. Resisto	USA	Standard check for high beta-carotene

Table 2. Climatic characteristics of the sweetpotato testing sites in Kenya

Site	AEZ*	Mean temperaturas (°C)	Annual rainfall (mm)	Altitude (m)	Soil types
KARI-Kakamega	UM1	20.6-22.8	1900	1585	Humic nitosols
Kabete	UM3	19.5-19.9	1046	1800	Humic nitosols
KARI-Mtwapa	CL3	24.0-26.6	1200	15	Orthic ferralsols
KARI-Katumani	UM4	13.9-24.7	717	1600	Rhodic/orthic ferralsols

Source - Jaetzold and Schmidt (1983)

*Agro-ecological zones: UM = upper midlands; LM = lower midlands; CL3 Coastal lowlands

Farmers from the adjacent communities were invited to the trial sites on the day of harvest sites to evaluate varieties based on the field performance and cooked roots attributes. Field performance attributes considered were foliage production, tolerance to drought, virus resistance, and tolerance to weevil, size and shape of roots, number of mature roots, root skin colour, root flesh colour and general acceptability. Attributes of cooked roots were appearance, taste, smell/flavor, flouriness /starchiness, fibrousness and general appreciation. Each farmer was asked to assign bean seeds to represent the appreciation of the variety's performance in each particular attribute under consideration. The number of seeds ranged from one to five whereby**:** one seed means very bad, two seeds = bad, three seeds = moderate, four seeds = good and five seeds = very good. Pre-labeled bags bearing variety name, replication and criterion being assessed were placed in each plot in all the replications. Evaluation was done by considering one attribute at a time. Farmers were asked to place one to five seeds in each bag and move through the entire field. When the attribute had been assessed for all the varieties in the entire field, bags were collected and bundled together. The process was repeated for other attributes until completed. The total number of seeds placed by all participants in each bag for a particular attribute was recorded. The number of seeds assigned to all attributes in all replications for a particular variety was summed up. The variety with the highest number of seeds for all the field performance attributes was ranked first for field performance. Root sample of each variety from one replication was cooked and evaluated in a similar way as for field performance. The overall ranking of the clones was done by adding all the seeds assigned to each clone for field and cooked root attributes and the clone with the highest sum ranked first. Overall ranks for each variety at three sites were summed up to get the rank sum. The rank sums were ranked again such that a variety with the lowest rank sum was assigned rank one and that with the greatest rank sum ranked last.

Data analysis was carried out using SAS software (SAS, 2001). Analysis of variance was conducted for each location to assess variation within location and among locations for all the traits measured. Mean separation for each trait was done by calculating LSD values. All location-year and season combinations were treated as individual environments. Stability assessment of varieties was done using Finlay and Wilkinson (1963) regression coefficient (b1). Combined analysis of variance was done to verify G x E interactions across environments.

Results and discusion

Highly significant variety, environment and variety x environment interactions were observed for all traits measured (Table 3). Environment x variety interactions suggested that the ranking of clones at each environment was not constant. Significant interaction was expected because experimental sites differed in soil types, mean temperature and annual rainfall (Table 2). The genotypes also originated from a genetically diverse background. Mean yield of the varieties was highest at KARI-KARI-Kakamega and KARI-Katumani and lowest at KARI-Mtwapa. The high yield at KARI-KARI-Kakamega was expected as the area received higher rainfall and has deeper soils than the other locations. Low root yield at KARI-Mtwapa was attributed to the low rainfall received during the trial period and shallow sandy soils which restricted root expansion. Only one single observation was made at KARI-Katumani because the other two trials failed to reach the harvesting stage because of inadequate moisture. Unexpectedly, the single season when cropping was successful realized high yields due to the unusually high rainfall. There may be need to conduct more trials at this site to make conclusive recommendations. Variety199062.1 consistently gave high root yield across all sites, while variety K118 produced the lowest. Although 199062.1 had the highest root yield, its root dry matter content was low which may affect its promotion among the Kenyan adult consumers who prefer varieties with high root DM content.

This variety will, however, be ideal for processing and consumption by the children who tend to prefer roots with low root dry matter contents. The highest yielding varieties at KARI-Kakamega were 199062.1 (26.0 tons/ha) followed with Mayai (21.9 tons/ha), Ukerewe (20.2 tons/ha) and K566632 (20.2 tons/ha) while the lowest was Resisto (11.2 tons/ha). The crop yield at KARI-Kakamega was affected by the sweetpotato virus and the hailstones which hit the crop at the early stages of root bulking during the 2007 long rain season. The highest yielding varieties at KARI-Mtwapa were 199062.1, Mayai and the local check SPK004. Ejumula and K118 which performed moderately well at KARI-Kakamega had the lowest yield at this site. Similarly 199062.1, K566632 and Mayai were the best clones in terms of root yield at Kabete. Two varieties K135 and Resisto which had low yields at KARI-Kakamega outperformed other varieties in KARI-Katumani. These were followed by Mayai, Ukerewe and 199062.1.

Table 3. Mean root yield and virus infection of local orange-fleshed sweetpotato varieties at four experimental sites in Kenya

Variety	Sites							
	KARI-Kakamega		KARI-Mtwapa		Kabete		KARI-Katumani	
	Total root yield t/ha	Virus infection (1-5)	Total root yield t/ha	Virus infection (1-5)	Total root yield t/ha	Virus infection (1-5)	Total root yield t/ha	Virus infection (1-5)
Resisto	11.2	3.3	6.7	1.7	8.3	2.3	19.2	1.3
Carrot C	17.1	4.3	6.0	2.0	8.4	2.3	11.0	1.7
Naspot 1	14.2	3.3	10.8	1.0	15.0	2.0	18.0	1.3
Gweri	12.6	2.9	8.6	1.0	5.8	2.0	10.0	1.0
Ejumula	18.8	3.8	4.9	2.0	9.6	2.0	16.2	1.7
SPK004	12.6	3.0	13.6	1.3	10.5	2.0	11.9	1.7
K118	14.8	4.1	4.3	2.3	7.4	1.7	14.4	2.0
K135	13.7	4.0	8.5	1.7	8.8	1.7	21.3	2.0
199062.1	26.0	3.1	18.0	1.3	15.4	1.7	14.6	3.0
Ukerewe	20.2	3.3	11.6	1.3	11.7	1.7	15.2	1.7
Pipi	13.9	3.9	11.6	1.0	9.9	1.3	11.3	1.0
Mayai	21.9	4.3	13.3	2.0	12.0	1.3	20.0	1.3
K566632	20.2	4.7	6.2	2.3	12.5	1.3	9.7	1.7
Zambezi	12.5	4.4	10.2	2.3	10.7	1.0	11.3	2.0
Mean	**16.6**	**3.8**	**9.6**	**1.7**	**10.4**	**1.7**	**14.4**	**1.6**
LSD (0.05)	**8.8**	**0.7**	**4.8**	**0.9**	**4.2**	**0.9**	**7.0**	**1.1**
CV%	**448.7**	**19.6**	**26.6**	**30.8**	**35.3**	**36.6**	**29.1**	**36.5**

The mean yield of marketable roots constituted 87.0 % of the mean total root yield (Table 4). High marketable root yield is important to the farmer since this is most important commercial part of the plant. The mean number of roots per plant ranged between 2.9 and 5.4. The number of roots per plant is important in sweetpotato production since it is positively correlated to the root yield (Whyte, 1992). It is also an important selection criterion for farmers practicing piecemeal harvesting since the presence of many small roots at harvesting may indicate that there is conditioned potential for production hence a longer production period (Ndolo et. al., 1995). Varieties 199062.1, Ukerewe, K566632 and Mayai which gave high root yield in most sites produced more than 4 roots per plant. These results suggest a negative correlation between root and foliage yield in these varieties. Most of the high yielding varieties except for Ukerewe had low vine production.

Farmer variety assessment results for Kabete, KARI-Mtwapa and KARI-Kakamega are given in Table 5. Naspot 1, Ukerewe, Pipi, SPK004 and 19962.1 were ranked high by farmers at KARI-Mtwapa and Kabete on the basis of field performance and quality of the cooked roots. Farmers at Kakamega ranked SPK004 highest followed by Ukerewe, Ejumula, Carrot C, Mayai, K135, K118 and 199062.1. The combined overall ranking of the varieties indicated that the two check varieties SPK004 and Naspot one were the best. The other best ranked orange-fleshed sweetpotato varieties were Ukerewe, 199062.1 and Mayai. These varieties were also the most outstanding varieties in terms of root yield.

Table 4. Aggregated data for root yield, number of roots per plant, foliage yield, virus infection, dry matter and taste test score content of 14 sweetpotato varieties planted at 4 locations in Kenya

Variety	Marketable root yield (t/ha)	Total root yield (t/ha)	% Marketable roots	No. of roots/plant	Foliage weight (t/ha)	Virus score (1-5)	DM%
K56663	12.1	14.8	81.8	5.4	16.7	3.1	26.8
Carrot C	10.4	12.4	83.9	4.7	20.0	2.9	31.0
K118	9.7	11.3	85.8	3.5	24.9	2.8	32.9
Mayai	15.6	17.8	87.6	4.6	18.0	2.8	29.0
199062.1	18.4	20.5	89.8	4.8	16.2	2.7	22.3
Zambezi	9.2	11.5	80.0	5.0	16.7	2.7	30.2
K135	10.6	12.3	86.2	3.9	26.0	2.6	29.8
Ejumula	12.3	13.8	89.1	4.0	16.7	2.6	29.9
Ukerewe	14.0	15.7	89.2	5.0	20.2	2.5	30.0
Pipi	10.8	12.2	88.5	4.0	27.4	2.5	29.7
Resisto	9.1	10.8	84.3	5.0	15.7	2.4	21.0
SPK004	10.8	12.0	90.0	3.2	22.9	2.3	28.9
Gweri	9.0	9.9	90.9	3.5	34.8	2.1	30.0
Naspot 1	13.1	14.5	90.3	2.9	20.9	2.0	29.9
Mean	11.8	13.6	87.0	4.2	21.3	2.6	28.7
LSD (0.05)	2.8	2.9	6.9	0.9	4.7	0.4	4.8
CV%	39.3	35.6	23.8	33.6	36.6	25.2	18.08

Table 5. Overall ranking of sweetpotato varieties at three trial sites in Kenya based on attributes for field performance and quality of cooked roots

Variety	Kabete	Mtwapa	Kakamega	Rank sum	Overall rank
K135	7	6	7	20	7
Pipi	3	3	12	18	6
Naspot1	1	1	9	11	2
Gweri	12	9	8	29	11
Ukerewe	2	8	2	12	3
Ejumula	9	12	3	24	8
Carrot C	10	11	4	25	9
K118	10	14	6	30	12
Mayai	6	4	5	15	4
Zambezi	8	8	10	26	10
199062.1	5	5	7	17	5
SPK004	4	1	1	6	1
Resisto	13	13	14	40	14
K566632	14	10	13	37	13

Table 6 gives the means and stability parameters based on Finlay and Wilkinson b-value (Finlay and Wilkinson, 1963) coefficient of determination (R^2). The varieties used in the study vary in their reaction to environments and this variation is often linear. Significant linear were found between the yields measured and location indices, location index being the mean value for a characteristic of all varieties tested. The regressions accounted for most of the variations in the variety x environment interactions. Varieties 199062.1, Mayai, K566632 and Ukarewe with yields greater than the variety mean and b-values significantly greater than unity were considered generally not adaptable or stable and may be recommended for favourable environments. Only variety K118 and K135 were stable but had yields below the environmental mean. Such varieties can recommend for poor environments.

Table 6. Variety mean, b-value Standard deviation and R^2 of popular orange-fleshed sweetpotato varieties planted in seven environments in Kenya

Variety	Total root wt. t/ha)	b-value	R^2
199062.1	19.9	1.22	0.67
Carrot C	11.8	1.27	0.85
Ejumula	12.8	1.65	0.90
Gweri	9.5	0.73	0.60
K118	10.9	1.10	0.84
K135	12.1	0.70	0.50
K566632	14.1	1.39	0.80
Mayai	17.4	0.89	0.37
Naspot 1	13.8	1.97	0.40
Pipi	11.9	0.73	0.60
Resisto	10.8	1.86	0.80
SPK004	11.7	0.32	0.43
Ukerewe	15.3	1.20	0.90
Zambezi	11.3	0.42	0.67

The significant root yield differences among the varieties in the four sites suggest the need to focus on only the best varieties within these sites. Since sweetpotato varieties are affected by the variability of the ecological conditions, it is important for varieties to be tested across zones before they are released to farmers for production. The varieties 199062.1, Ukerewe, and Mayai, which performed well in most locations and had acceptable root yields, will be recommended for release to farmers. there will be need for further evaluation of these varieties at KARI-Mtwapa and KARI-Katumani where only one season data were obtained to gain confidence in the results.

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