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Participatory evaluation methods of cassava varieties preferred in the mid-altitude tropical climate conditions of western Kenya

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The advantage of farmers' participation in breeding programmes depends on the effectiveness of the evaluation methods used. There is scarce information on the farmers' evaluation methods and their effectiveness as compared to the breeder's methods. Three districts representing the different agro-ecologies, inhabiting ethnic communities, cassava production and utilization niches were selected. Focused group discussion was used to determine the variety evaluation methods. The effectiveness of farmers and breeders evaluation methods were tested by evaluating cassava trials consisting of 15 varieties planted in the three districts. High storage roots yields, resistance to diseases and pests were the most preferred traits across the districts. Preference for traits related to plant type and storage roots quality, and variety ranking differed between districts indicating the differences in agro-ecologies, production and utilization niches. Farmers' and breeder's evaluation methods significantly correlated for related traits and elicited differences between varieties for most traits evaluated. Though low cyanide content was among the farmers' preferred traits, their evaluation method did not either elicit genotypic differences between varieties or correlate with the breeder's evaluation. The breeder lacked evaluation method for taste of boiled storage roots despite it being preferred by farmers. Despite the differences in traits preferences and variety ranking between farmers and the breeder and between districts, farmers and the breeder have effective evaluation methods. However, both evaluation methods have deficiency in evaluation of some of the preferred traits indicate the need for participatory variety selection.

Key words: Farmer preferred traits, farmers' qualitative evaluation method, breeder's quantitative evaluation method, participatory variety selection (PVS), variety ranking.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a clonally propagated crop grown in diverse environments for diverse utilization within the tropics by small scale farmers mainly for subsistence (El-Sharkawy, 2004). The

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diversity in production environments and utilization methods lead to diversity in variety preferences. These diversities render centralised conventional cassava breeding approach ineffective and the need for target farmers' participation in cassava breeding (Manu-Aduening et al., 2006).

Farmers’ participation in breeding programmes gives them an opportunity to select varieties that perform well in their environments with preferred traits (Almekinders and Elings, 2001). Unlike breeders who use quantitative scientific methods, farmers use qualitative indigenous method to evaluate varieties. Breeders therefore are able to identify and accurately measure traits based on their scientific knowledge.

However, some of the farmer preferred traits are not known to breeders or even if known, breeders more often lack the skills and scientific methods to evaluate them (Morris and Bellon, 2004). Farmer’s participation in cassava breeding can only enhance efficiency if they have effective quantitative methods of variety evaluation for preferred traits. Similarly, the breeder’s input can enhances the breeding efficiency if the quantitative methods used can effectively evaluate farmer preferred traits.

This study aims at generating information on; the qualitative methods used by farmers to evaluate cassava varieties, the effectiveness the farmers’ qualitative and the breeder’s qualitative methods of evaluating cassava varieties for preferred traits.

MATERIALS AND METHODS

The study was conducted in three purposefully selected districts in the major cassava growing region of western Kenya. The three districts; Mumias, Teso and Busia were purposefully selected to represent different cassava production systems and utilization methods.

From each district, one active farmer group whose members have long experience in cassava production and utilization was identified. Mumias district was represented by the Development Association Foundation (DAF) farmer group with membership of 33 (14 men, 19 women).

Farmers in this district grow cassava under mixed cropping system and use cassava storage roots after boiling. Naako-Aterait women group with membership of 29 (three men and 26 women) represented Teso district Farmers in Teso district grow cassava as a mono-crop and use storage roots after processing to flour. The flour is used to make; a local brew known as '*Busaa'*, porridge or local dish (stiff porridge) known as ‘*Ugali*’. Busia district was represented by Agro-farmer group with membership of 31 (19 men and 12 women). Farmers in Busia district grow cassava under both mixed and mono-cropping systems. Both cassava utilization methods; eating after boiling and processing to flour are equally popular in Busia district.

A total of 10 (six landraces and four improved) cassava varieties were used in this study. The varieties were selected and collected from farmers’ fields inform of cuttings based on their popularity across the three study districts. Popularity, which was based on secondary data from district agricultural crops production records, knowledge of extension staff and farmers was assumed to indicate the presence of farmer preferred traits and adaptation to the region.

Farmer's selection criteria and indigenous technical knowledge (ITK) methods of evaluating of cassava varieties

Focused group discussion (FGD) involving a total of 222 (73 men and 149 women) farmers, 96 (38 men and 57 women) members of farmer groups and the rest none farmer group members were conducted. During the discussion, farmers enlisted preferred cassava traits and ITK method they use to evaluate them. Farmers’ selection criteria were determined by ranking the preferred cassava traits using pairwise ranking method. Farmers also described and defined the ITK method(s) they use to evaluate each preferred traits. Farmers were asked to rank the varieties directly by observing all plants in a plot, both uprooted and none-uprooted plants without considering the scores they awarded for the traits. A correlation analysis between direct variety ranking and traits scores was carried out to confirm the selection criteria.

Farmers’ and breeder's variety evaluation

The 15 popular cassava varieties collected were planted under concealed identity by each farmer group in each of the three study districts using 5 x 9 α-Lattice design with three replications. Each plot consisted of three rows of five plants each spaced at 1 x 1 m. The trials were managed by group members. No fertilizer was applied since farmers commonly don’t use fertilizers on cassava. At harvest, 12 months after planting (MAP), the 10 varieties were evaluated by farmers and the breeder separately. Only the middle row in each plot was carefully uprooted leaving all storage roots intact and attached to the plant. The uprooted plants were left in their position in the plot for evaluation.

Farmers’ variety evaluation

In order to make it easier for farmers’ evaluation, the trial plots were blocked into three blocks. Each block comprised of all the 15 varieties. Farmers evaluated each plot for; storage roots yield, disease and pest resistance, plant height, internode length, branching level, cyanide content, taste of boiled storage roots and height to first branching using ITK methods. The farmers scored for each trait on a scale of 0 (trait absent from the variety) to 5 (variety has the trait to farmers’ satisfactory level). The farmers were asked to award scores like marks based on how satisfied they were with performance of the variety for each trait. Taste of boiled storage roots was evaluated after cooking two storage roots from each variety.

The storage roots were peeled, chopped into small pieces of 4 to 5 cm long, washed, placed in transparent plastic bags and boiled in a large cooking pot for about 45 min using local cooking methods. The boiled pieces were put on labelled plates on tables for evaluation. Mean scores were computed per site and standardized (Steel and Torrie, 1960). A selection index (SI) formula was developed by weighting the preferred traits based on farmer traits ranking. The standardized mean scores were used in the in SI formula to compute the SI value of each variety. The computed variety SI value was used to rank the varieties. The farmers were also asked to rank the varieties directly without considering the trait scores.

Breeders evaluation

The breeder collected data using scientific qualitative technique in all the three districts on; disease resistance on a score scale of 1 = resistant and 5 = susceptible taken on monthly basis starting 3 MAP and scored per plot; plant height (PT) and height to first branching (HB) (m), dry matter content (DM %) determined by the formula:

Table 1. Farmer preferred traits and their ranking in Teso, Busia and Mumias districts.

Trait	Preferred form	Rank			
		T	B	M	Mean
Yield of storage roots	High number and size of tubers	1	1	1	1.0 (1)
Cleanliness of plants	Healthy clean leaves and stems	2	2	2	2.0 (2)
Height of plants	Tall plants	3	4	4	3.7 (3)
Bitterness of storage roots	Sweet taste	8	3	3	4.7 (4)
Bushiness of plants	Many branches per plant	4	6	6	5.3 (5)
Length between eyes	Short length between eyes	5	5	7	5.7 (6)
Storage roots taste	Sweet, soft and friable	7	7	5	6.3 (7)
Spearman's rank correlation coefficients between Mumias		-0.2	0.8	-	-
Spearman's rank correlation coefficients between Busia		0.1	-	-	-

T, B and M = Teso, Busia and Mumias district, respectively.

$$DM (\%) = \{[Wa/(Wa - Ww)] \times 158.3\} - 142$$

Where; Wa is the mass of roots in air and Ww is the mass of roots in water, cyanide content (PC) taken using picrate score method on a score scale of 1 = low and 9 = high cyanide content, number of storage roots per plant (NR) taken by counting total number of storage roots per plant and fresh storage root yield (t ha^{-1}) (RY) taken by weighing all storage roots per plant, averaged per plot and converted to yield per hectare.

Data were analysed using residual maximum likelihood (REML) procedure in GENSTAT 14th Edition (Payne et al., 2011). Analysis was conducted per site independently and then tested for homogeneity of variance between sites using Bartlett's test before a combined analysis across sites detect variability in performance between genotypes, environments and their interaction.

Variety ranking by the breeder was based on a selection index (SI) formula recommended by Ceballos et al. (2004) with a few modifications. The SI was computed using standardized trait means. The SI formula used was:

$$SI = 10 (RY) – 8 (CMD + PC) + 8(NR + DM) + 3(PT) - 3(HB)$$

Where; SI is selection index; RY = fresh storage roots yield; CMD = cassava mosaic disease reaction score; PC = picrate score; NR = number of storage roots per plant; DR = dry matter content; PT = plant height and HB = height to first branching.

The breeder's and farmers' variety ranking were compared between and within districts using Spearman's rank correlation analysis using farmers' trait mean scores and the related mean agronomic qualitative measurement taken by the breeders.

RESULTS

Farmer's preferred traits and selection criteria

High storage roots yields and clean plants were the most preferred traits in all the three districts ranked first and second, respectively (Table 1). The other traits which can generally be considered as plant and storage roots quality related traits were inconsistently ranked in all districts. Farmer preferences in Mumias and Busia districts highly correlated (Spearman's rank correlation (rs) of 0.77) where as farmers preferences in Busia and Mumias to Teso districts with rs = 0.61 and 0.54, respectively. Tall plant and high branching level are more preferred by farmers from Teso district, ranked third and fourth respectively, as compared to farmers from Busia and Mumias districts where they were ranked fourth and sixth respectively. Low cyanide content was important in Busia and Mumias districts ranked third, as compared to Teso district where it was ranked last (position eight).

Farmers' indigenous variety evaluation technical knowledge (ITK)

During FGD, farmers described and listed the ITK methods they use to evaluate preferred cassava traits. In this study, the following ITK methods that farmers use to evaluate different cassava preferred traits were revealed:-

i. High yield of storage roots: Is evaluated before and at harvest stages.

a) Before harvest yield evaluation is either by observing soil cracking around the plant and/or stem thickness at the crown. Large deep cracks radiating from the crown of plant indicate and/or thick stems at the crown indicate high yields and are preferred.

b) At harvest stage, storage roots yield is evaluation by considering the number and size of storage roots. Many and large storage roots indicate high yields and are preferred.

ii. Cleanliness of plants: Is evaluated by observing the health of the leaves. Plants with deformed, few, discoloured small leaves are considered susceptible and undesirable. Despite the region being a hot spot for many cassava foliar diseases and pests, most farmers could not identify any of them. They believe the poor health of plants expressed as yellowing, curling and dropping-off of leaves, stunted growth of plants and drying of stems are due to poor soils fertility (soil exhaustion), water stress,

Table 2. Between districts mean square and within districts Kruskal-Wallis H-values for cassava mean scores evaluated by farmers in Mumias, Teso, and Busia districts.

Source	Mumias n = 33	Teso n = 29	Busia n = 31	Between districts (MS)
Soil cracking (SC)	77.6**	106.0**	60.7**	1.9^{ns}
Storage roots number (RN)	19.3*	62.2**	12.3**	1.1^{ns}
Storage roots size (RS)	57.4**	23.7**	43.6**	2.7^{ns}
Stem thickness (ST)	84.5*	41.7**	34.7*	1.5^{ns}
Cleanliness of plants (DR)	66.8**	65.5**	33.2**	0.5^{ns}
Height of plant (PT)	76.2**	12.9*	49.1**	1.3^{ns}
Bitterness of storage roots (PC)	27.7*	5.7^{ns}	21.6ns	6.3**
Bushiness of plants (BL)	95.1**	52.9**	36.1**	0.9^{ns}
Length between 'eyes' (IL)	30.2*	34.6**	24.4*	3.3**
Taste of boiled storage roots (TR)	34.7**	62.3**	29.2**	3.9**

ns, * and ** = not significant, significant at P ≤ 0.05 and 0.01, respectively; n = number of participating farmers; MS = mean square.

bad environmental conditions, bad omen or witchcraft.

iii. Bitterness of fresh storage roots: Is evaluated by tasting the storage root. Varieties with bitter storage roots are considered to have high cyanide content and are not preferred for chewing raw or boiling. Such varieties are used after drying and processing the storage roots to flour.

iv. Height of plant, length between 'eyes', and bushiness of plant: Are evaluated by direct counting and/or observing the plants.

v. Taste of boiled storage roots: Evaluated by tasting the boiled storage roots.

Farmers' variety evaluation using ITK

The Kruskal-Wallis H-values for trait scores were significant (P < 0.05) for all traits evaluated in all districts except for cyanide content in Teso and Busia districts (Table 2). Significant Kruskal-Wallis H-values indicate significant genotypic differences between varieties and thus the ability of farmers using their qualitative ITK methods to elicit different between varieties. The between districts mean squares (MS) for trait score were significant (P < 0.05) only for cyanide content, internode length and taste of storage roots. The significant MS show either the presence of genotype x environment interaction effect or between districts differences in farmer preferences for these traits.

Due to the differences observed in traits preferences and scoring by farmers between districts (Table 2), selection index (SI) formula was developed for each district separately. Weighting of traits in the SI formula were based on trait ranking by farmers during the FGD. For example out of the seven traits, high storage roots yield (RY) and low cyanide content (PC) were the most and least preferred traits respectively by farmers in Teso district. The SI formula for Teso district, RY and PC are given weightings of 7 and 1, respectively. The SI formula used for each district was:

Teso:- $SI_{ft} = 7(SC+RN+RS+ST)/4 + 6(DR) + 5(PT) + 1(PC) + 4(BL) + 3(IL) + 2(TR)$

Busia:- $SI_{fb} = 7(SC+RN+RS+ST)/4 + 6(DR) + 4(PT) + 5(PC) + 2(BL) + 3(IL) + 1(TR)$

Mumias:- $SI_{fm} = 7(SC+RN+RS+ST)/4 + 6(DR) + 4(PT) + 5(PC) + 2(BL) + 1(IL) + 3(TR)$

Where: Storage root yield (RY) mean score was considered as a function of soil cracking (SC), storage roots number (RN), storage root size (RS) and stem thickness (ST) mean scores. The SI for each variety in each district was computed using the standardized mean scores.

Farmers' variety ranking

Ebwanatereka in Teso and Mercury, in Mumias and Busia were ranked top by farmers using SI method. Migyera in Teso, Bumba in Mumias and MM96/1871 in Busia were ranked first by farmers using direct ranking method (Table 3). Variety ranking using SI and direct ranking methods correlated significantly (P < 0.05) in all districts with Spearman's' rank correlation coefficient (r_s) of 0.7, 0.6 and 0.8 in Busia, Mumias and Teso district, respectively (Table 4). Significant correlation in variety ranking using the two methods in all the study districts imply either ranking by use of SI or direct ranking can be used. There were no significant (P < 0.05) correlation in variety ranking by farmers between districts except between Mumias using SI method with Busia using both methods with r_s = 0.7 and between Mumias' using direct ranking with Teso using both methods with r_s = 0.5. Lack of significant correlation in variety ranking by farmers between districts indicates differences in either variety preferences, environmental, and/or genotype x environment interaction effects.

Table 3. Cassava variety ranking by farmers and the breeder in Mumias, Busia and Teso districts.

Variety	Mumias			Busia			Teso			Across districts			Overall mean
	Farmer		Breeder	Farmer		Breeder	Farmer		Breeder	Farmer		Breeder	
	SI	DT		SI	DT		SI	DT		SI	DT		
Migyera (I)	3	3	1	5	8	1	3	1	2	3.7(2)	4.0(1)	1.3(1)	1.3(1)
Sudhe (L)	6	7	12	2	4	11	2	2	3	3.3 (1)	4.3(3)	8.7(8)	4.0(2)
MM96/1871 (I)	4	2	3	3	1	2	12	14	5	6.3(5)	5.7(5)	3.3(3)	4.3(3)
Mercury (L)	1	5	8	1	3	3	9	8	10	3.7(2)	5.3(4)	7.0(7)	4.3(3)
SS4 (I)	9	6	4	7	2	4	10	9	1	8.7(9)	5.7(5)	3.0(2)	5.3(5)
Bumba (L)	2	1	13	12	9	7	5	3	13	6.3(5)	4.0(1)	11.0(11)	5.7(6)
Nambukaya (L)	7	10	5	4	7	8	8	4	7	6.3(5)	7.0(8)	6.7(6)	6.3(7)
MM96/4684 (I)	10	4	2	8	10	6	4	6	11	7.3(8)	6.7(7)	6.3(5)	6.7(8)
Ebwanatereka (L)	8	9	14	6	5	10	1	7	4	5.0(4)	7.0(8)	9.3(9)	7.0(9)
MM96/3972 (I)	12	11	6	10	14	5	11	13	6	11.0(12)	12.7(14)	5.7(4)	10.0(10)
CK9 (L)	11	12	7	9	15	13	7	10	9	9.0(10)	12.3(13)	9.7(10)	11.0(11)
Kaleso (L)	15	14	9	15	11	12	15	11	12	15.0(15)	12.0(11)	11.0(11)	12.3(12)
Opongi (L)	14	8	15	14	12	14	6	5	8	11.3(13)	8.3(10)	12.3(14)	12.3(12)
Sifros (L)	5	15	11	11	6	15	14	15	15	10.0(11)	12.0(11)	13.7(15)	12.3(12)
Serere (L)	13	13	10	13	13	9	13	12	14	13.0(14)	12.7(14)	11.0(11)	13.0(15)

L, landraces; I, improved varieties; SI and DT, farmers' ranking using selection index and direct ranking, respectively.

Breeder's evaluation

Variety MS were significant ($P < 0.01$) for the traits evaluated by the breeder (Table 5) indicating significant genotypic differences between the varieties. MS for districts and variety x district interaction effects were significant ($P < 0.01$) for all traits except for resistance to foliar diseases and number of storage roots per plant. These imply there are significant differences in test environments and the presence of significant genotype x environment interaction effect, respectively for all traits except resistance foliar diseases and number of storage roots per plant.

Migyera in Mumias and Busia districts, SS4 in Teso district were ranked first while MM96/4684, MM96/1871 and Migyera were ranked second in Mumias, Busia and Teso district, respectively by the breeder (Table 3). Generally, all the varieties ranked top by the breeder are improved varieties. There were no significant ($P < 0.05$) correlation in breeder's variety ranking between districts except between Mumias and Busia districts ($r_s = 0.70$) indicating differences in environments and the presence of cross-over effects resulting from genotype x environment interaction effect.

Farmers' qualitative versus breeder's quantitative evaluation

There were significant ($P < 0.05$) correlation between qualitative scoring by farmers for preferred traits and quantitative data taken by the breeder on all related agronomic traits taken except picrate content score versus bitterness taste scores, number of storage roots per plant versus stem thickness and storage roots yield versus size of storage roots taken by the breeder and farmers respectively in all districts (Table 6). There was negative correlation between the breeder's disease score and farmers score for cleanliness of the plant implying farmers awarded high scores for plants that the breeder had low scores and vice-versa. This means farmers preferred varieties resistant to foliar diseases. Correlation between branching level taken by the breeder and bushiness of the plants scored by

Table 4. Spearman's rank correlation coefficients between farmers variety ranking using selection index (SI), direct ranking and the breeder's ranking in Teso, Busia and Mumias.

	BB	BFD	BFS	MB	MFD	MFS	TB	TFD
BFD	0.40	1.00						
BFS	0.55*	0.70**	1.00					
MB	0.70**	0.13	0.39	1.00				
MFD	0.70**	0.46	0.48	0.30	1.00			
MFS	0.49	0.66**	0.67**	0.15	0.61*	1.00		
TB	0.45	0.43	0.59*	0.33	0.39	0.14	1.00	
TFD	0.15	0.07	0.27	-0.06	0.54*	0.30	0.34	1.00
TFS	0.09	0.09	0.39	-0.12	0.51*	0.28	0.26	0.81**

BB, MB and TB, breeder's ranking in Busia, Mumias and Teso district respectively; BFD, MFD and TFD, farmers' direct ranking in Busia, Mumias and Teso district, respectively; BFS, MFS and TFS, farmers ranking using selection index in Busia, Mumias and Teso district, respectively.

Table 5. Mean square values of important agronomic and farmer preferred traits evaluated by the breeder across three districts, Mumias, Busia and Teso.

Source of variation	df	DR	DM (%)	BL	PC	PT (m)	NR	RY (t ha^{-1})
Variety (V)	14	8.3**	45.4**	9.2**	5.5**	3310.9**	37.6**	8.6**
District (D)	2	0.5^{ns}	102.6**	2.8**	1.0**	100061.9**	4.4^{ns}	6.6**
V x D	28	0.4^{ns}	42.8**	0.8**	3.6**	1628.9**	4.3^{ns}	2.2**

df, degrees of freedom; DR, foliar disease resistance scored on a 1= Resistant to 5 = susceptible; DM, dry matter content (%); BL, branching levels PC, picrate score on a 1 = no cyanide to 9 = high levels of cyanide; PT, plant height (m); NR, number of storage roots per plant; RY, fresh storage roots yields (t ha^{-1}); *, Significant at P ≥ 0.05; **, Significant at P ≥ 0.01; ns, non-significant.

Table 6. Correlation coefficients between qualitative and quantitative evaluation of cassava varieties by farmers and the breeder for related traits in Mumias, Teso and Busia districts.

Traits correlated	District		
	Mumias	Teso	Busia
DR by breeder vs DR by farmers	-0.8**	-0.8**	-0.5*
B L by breeder vs BL by farmers	-	-0.6**	0.4*
IL by breeder vs IL by farmers	-0.8**	-0.9**	-0.7**
PC by breeder vs PC by farmers	-0.1	0.2	-0.2
PT by breeder vs PT by farmers	0.6**	0.4*	0.3*
NR by breeder vs NR by farmers	0.4*	0.4*	0.8**
NR by breeder vs RS by farmers	-0.3	-0.6**	-0.4*
NR by breeder vs ST by farmers	0.2	-0.3	0.1
RY by breeder vs NR by farmers	0.4*	0.2	0.8**
RY by breeder vs RS by famers	0.1	0.2	0.3
RY by breeder vs ST by famers	-0.3	0.4*	0.2

farmers correlated negatively in Teso but positively in Busia. These imply farmers in Teso prefer plants that branch at a lower height while farmers in Busia prefer plants that branch at high heights. This may reflect the differences in cropping systems used in Teso and Busia.

There were no significant (P < 0.05) correlation between the breeder's and farmers' variety ranking using both in all districts except in Busia district between the breeder and farmers' using direct ranking method (rs = 0.55) (Table 6). Three out of the top 5 ranked varieties by the breeder were improved varieties in all districts (Table 5). This ranking is opposite to farmers ranking where at least 3 out of the top 5 ranked varieties were landraces. Three varieties, Migyera, MM96/1871 and SS4, all improved varieties were ranked among the top 5 by the breeder in all districts. Migyera was ranked among the top 5 by farmers in all districts while Mercury and MM96/8171 were ranked among the top 5 by farmers in Mumias and Busia only. Farmers in Teso district tend to prefer landraces as compared to the other two districts. Migyera and MM96/1871 in Mumias district, MM96/1871 and Mercury in Busia district and Migyera in Teso were ranked among the top 5 varieties by both the breeder and farmers using both ranking methods. Migyera was the only variety ranked among the top 5 by the breeder and farmers from all districts.

DISCUSSION

Farmers evaluate varieties intuitively by considering many factors (Sunwar et al., 2006) as compared to breeders who evaluate varieties using quantitative measurements based on scientific knowledge and expertise. Collaboration between farmers and breeder in variety evaluation has been observed to increase breeding efficiency and effectiveness (Witcombe et al., 2006). However, farmer participation in breeding has been seen to increase breeding costs and can only add value if the quantitative methods they use to evaluate varieties are valid and effective (Witcombe et al., 2006).

In this study, farmers across the three districts prefer cassava varieties that have clean plants (resistant to pests and diseases) and produce high yield of storage roots. However, preferences of traits related to plant type (bushiness, length between nodes and height of plants) and quality of storage roots (taste of boiled storage roots and bitterness of storage roots) differed between districts. The differences in preferences for traits related to plant type between the districts can be attributed to the differences in cropping systems between the districts. Farmers in Mumias and Busia districts predominantly grow cassava under mixed cropping system and therefore would prefer non-bushy varieties as compared to farmers in Teso districts who predominantly grow cassava as a mono-crop (EARRNET, 2004).

Highly branched and short plants prevent sun light penetration which affects the performance of the other crop in the mix. Differences in preferences of storage roots quality can be attributed to the differences in cassava utilization methods between the districts. Low bitterness in storage roots is more preferred by farmers from Busia and Mumias districts, than in Teso district. Farmers in Teso district farmers predominantly use cassava after processing to flour while Busia and Mumias district farmers predominantly eat cassava after boiling (EARRNET, 2004). Cassava processing has been shown to reduce cyanide content (Mkumbira et al., 2003).

Farmers' cassava variety evaluation techniques for all the preferred traits are qualitative and based on observation without making any measurements. Using these techniques, farmers' evaluation just like the breeders' evaluation drew-out genotypic differences between varieties for most of the preferred traits. Farmers' evaluation using these techniques also significantly correlated to the breeder's evaluation for related traits. These imply the farmers' qualitative methods are as effective as the breeder's quantitative methods. However, there were no significant differences between varieties when evaluated for cyanide content by farmers. Number of storage roots per plant and storage roots yield evaluated by the breeder did not correlate significantly with, bitterness of storage roots, stem thickness and size of storage roots taken by farmers, respectively in all districts. Though taste of boiled storage roots was among the farmers' preferred traits, the breeder lacked quantitative method to evaluate it. These results show that though farmers' and breeder's evaluation methods are effective, they are deficient and may not be effective for some traits. There is need for participatory approach where farmers qualitative and breeder's quantitative evaluation methods augment each other.

Farmers' and breeders' variety ranking did not significantly correlate within and between districts while the breeder's analysis revealed; lack of significant correlation in variety ranking between districts, swooping of variety ranks when grown in different districts and significant genotype x environment mean squares. These indicate either differences between farmers from different districts in preferences or the presence of genotype x environment interaction (GEI) effects. Though GEI effect has been reported in cassava on most agronomic traits, further experiments to determine whether these differences are as a result of the differences in preferences between the groups should be carried out. GEI effects can be overcome either by breeding for either specific or broad adaptation (Cach et al., 2006).

Breeding for specific adaptation requires demarcation of the cassava growing area into uniform production and utilization niches (Lin and Binns, 1988). Varieties are then selected and promoted in the specific niche where they perform well.

Conclusions

In this study, each district can be considered as separate niches. The most preferred varieties are; Bumba in Mumias, Mercury and MM96/1871 in Busia and Sudhe and Migyera in Teso district. These varieties are adapted to the specific districts and have traits that satisfy the preferences of farmers from the districts.

Demarcating cassava growing region into specific niches may not be feasible since cassava is grown by small scale farmers under diverse production environments which may vary from farm to farm (El-Sharkawy, 2004). Breeding for broad adaptability requires selection of varieties with above average performance across the growing area (stable varieties) (Finlay and Wilkinson, 1963). It is only Migyera which was ranked among the top five varieties across all the three districts by both the farmers and the breeder. Migyera is therefore a stable variety which is resilient to changes in production niches (Lin and Binns, 1988).

Though farmers' qualitative method of variety evaluation is equally effective as the breeder's quantitative methods, they both were ineffective in evaluating some of the preferred traits. The differences in traits preference, variety ranking between districts by farmers and the breeder and the presence of GEI show that,farmers from difference districts may prefer and adopt different varieties. There is therefore need to re-orient cassava breeding strategy and adopt decentralized participatory breeding. Variety evaluation should be conducted in each production niche where both farmers' qualitative and breeder's quantitative evaluation methods are used and supplement each other.

Conflict of Interests

The authors have not declared any conflict of interests.

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