Farmer participatory evaluation of eight elite clones of cocoyam (*Xanthosoma sagittifolium* L. Schott)

E. L. OMENYO*, E. MOSES, H. ASUMADU & A. A. ANKOMA
CSIR – Crops Research Institute, P.O.Box 3785, Kumasi, Ghana
**Corresponding author's email, leoline2gh@yahoo.com*

ABSTRACT

Twenty cocoyam farmers from the Ejisu-Juabeng municipality were involved in a farmer participatory on-station evaluation of cocoyam at Fumesua (a rainforest agro ecological zone of the Ashanti Region of Ghana) for 2 years (2009-2010) major growing seasons). Eight elite clones of cocoyam were evaluated for high yield, tolerance to major diseases and pests and culinary properties. Phenotypic attributes evaluated at peak vegetative phase 24 weeks after planting (24 WAP) were plant height, number of leaves and leaf area. At harvest, 12 months after planting (12 MAP), variables evaluated included number of cormels, weight of cormels, and yield per plant. Season × clone interaction for all variables evaluated were significant. The clones also differed significantly in all the parameters evaluated. Leaf area, number of cormels and weight of cormels were all positively correlated with yield. Based on farmers' recommendation and performance of the clones, four clones (3 purple and 1 white) yielding between 5.3 – 6.2 t ha^{-1} (higher than the locally cultivated 4 .2 t ha^{-1}) and tolerant to major diseases and pest, and having acceptable culinary properties have been proposed for release to farmers in the Ejisu-Juabeng Municipality.

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Introduction

Cocoyam is an important starchy staple in the diets of many inhabitants in the tropics and sub- tropical regions of the world. It is a food security crop utilised mostly in the event of failure or shortage of other crops. The Akans in Ghana have nicknamed it "Okumkɔm" literally meaning the killer of hunger. This is indicative of the importance of the crop in the food security system in the country. The cormels are used in the preparation of variety of favourite dishes notably "Fufu", "Ampesi", "Ɛtɔ" etc. According to Janseens (2001) cocoyam leaves contain 20 per cent proteins (on dry matter basis), and they are eaten as leafy vegetables in soup and stew. The leaves can also be fed to poultry.

In Ghana, the average on-farm yield is between 4.0 and 4.7 t ha^{-1} whilst the potential yield is estimated at 7.6 – 10 t ha^{-1}. The per capita consumption is estimated to be about 54 kg/head/year (PPMED,1991), which is second to cassava. Regardless of this, however, production is yet to meet demand in most areas. Average productivity decline over the last 6 years was 1.73 t ha^{-1}, whilst average cropped land for the same period increased by 8.4 per cent (MoFA, 2006). Decline in productivity could be attributed

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to lack of improved varieties resulting from narrow genetic base in the farming system (Dankyi & Sagoe, 1994), and this problem still persist. Diseases (especially the root rot and cocoyam dasheen mosaic virus can reduce cormel yield to about 90% and 50% respectively), pest prevalence, drought and declining soil fertility status are other factors accounting for the low yields.

From the perspective of breeding, the challenge is to increase productivity through the introduction of improved cultivars which are high yielding, tolerant/resistant to major diseases and pests.

Materials and methods

A total of 109 landraces of cocoyam were collected countrywide and screened for two major growing seasons (2002/2003-2004/2005) at cocoyam disease endemic areas of Nkakom (near Nkawie) in the Ashanti Region, Nsoatre and Aworowa in the Brong Ahafo Region for yield and disease characteristics. Eight clones (5 purple and 3 white) were identified as having relatively higher yields between 5-10 t ha^{-1}. and also tolerant to major diseases especially the root rot and dasheen mosaic virus. The eight elite clones were grown with farmers in a randomized complete block design with four replications at Fumesua during the 2009/2010-2010/2011 major growing seasons. Plots were 3 m wide by 8 m long. Planting was done at 1 m between rows and 1 m between plants within rows (10,000 plants/10,000 m^2) giving 24 clones per plot.

Field days were organized with 20 farmers (13 females and 7 males) at both peak vegetative (24 WAP) and harvesting (12 MAP) stages to assess the clones. Phenotypic traits measured at peak vegetative stage were plant height, number of leaves and leaf area. Yield components measured include number of cormels/plant, weight of cormel (g), yield per plant (g), and yield t ha^{-1}. The clones were screened for foliar diseases as well as corm and cormel rots. Disease severity was scored on a modified 1-5 scale, where 1 = no visible symptom of disease observed and 5 = tertiary symptoms with irreparable damage to tissue and organs observed (IITA, 1994).

All measurements were taken from the two middle rows of each plot. Plant height was measured from the soil level to the tip of the fully expanded youngest leaf. The number of fully expanded leaves was counted for each of four tagged plants, and the average recorded as the number of leaves per plant. Leaf area was determined by using the mathematical relationship between linear measurement of leaves which relate leaf area (Y) to the product of length (L) and breath (B), i.e. Y = K (LB) where K = 0.923+0.004 (Agueguia, 1993). The length was measured from the point of petiole attachment to the sinus region of the main vein and the breath along the point of petiole attachment.

The soil and climate data of the experimental site under which the experiments were conducted were recorded as shown in Tables 1 and 2.

Results and discussion

The clones did not differ significantly ($P < 0.05$) in plant height, number of leaves and leaf area (Table 3). The tallest clone (SW 011) and shortest clones measured 135.0 cm and 115.3 cm, respectively. The highest numbers of leaves (6.8) were recorded by the local, ABN 01/004 and BD 96/183

TABLE 1

Edaphic Data of the Experimental Site

Soil *P*H	5.6
Organic matter	2.34
% Nitrogen	0.14
Available ppmp	72.52
Ex. Cat. Me. 100 Ca	8.81
Mg	2.14
K	0.78
AL+H	0.04
Texture	Sandy loam

TABLE 2

Rainfall Data for the Two Major Growing Seasons

Variable	2009/10	2010/11
Annual precipitation (mm)	1,037.0	1,249.0
Rainy days	90	115

was a significant difference between the clones ($P = < 0.05$) in all the yield components observed (Table 3). All the introduced clones performed better against the local. Amongst the introduced clones, the white ABN 01/004 performed better in all the yield components recorded. The 2010/11 growing season had a higher and more longer rainy days than 2009/10 (Table 2). This reflected in a resultant significant difference ($P < 0.05$) in all traits observed between the seasons (Table 4). One of the features of cocoyam is its high water requirement. Any water stress during the growing period can retard the general growth and development and, consequently, reduce the yield. (Caesar, 1980; Onwueme, 1978; Torres *et al*., 1994, 2000). In the study, all traits observed were higher in 2010/11 than 2009/10 growing season.

TABLE 3

Mean Values for Phenotypic and Yield Components at 24 WAP and 12 MAP During the Two Major Growing Seasons.

Clone	*Plant height (cm)*	*Number of leaves*	*Leaf area (cm^2)*	*Number of cormels*	*Weight of cormels (g)*	*Yield/plant (g)*	*Yield t ha^{-1}.*
SCJ 98/05	117.6	6.5	1178.8	7.3 a	75.0 b	532.3 b	5.3 bdc
ABN 01/004	119.5	6.8	1297.3	7.1 ba	95.8 a	638.0 a	6.3 a
ADE 011	124.1	6.1	1216.5	6.8 ba	96.6 a	620.1 ba	6.2 ba
AGA 97/162	115.3	6.1	1460.8	6.8 ba	87.5 ba	598.8 ba	5.9 ba
RAX 93/008	126.5	6.6	1380.7	6.5ba	86.0 ba	544.1 bac	5.4 bac
SW 011	135.0	6.3	1523.7	6.1 bac	76.0 b	455.0 dc	4.5 dc
B D 96/183	117.3	6.8	1556.8	6.0 bc	93.1 a	576.5 ba	5.7 ba
SCJ 98/09	121.1	6.5	1369.0	6.0 bc	87.1 ba	519.6 bdc	5.2 bdc
LOCAL	127.5	6.8	1515.7	5.1 c	83.5 ba	429.0 d	4.3 d
Mean	122.6	6.5	1388.8	6.4	86.7	545.9	5.4
Lsd	19.76	0.87	481.75	1.2	15.32	102.54	1.029
Cv	13.7	11.4	29.5	15.9	15.0	16.0	16.0
P < 0.05	ns	ns	ns	S	S	S	S

Means with the same letters are not significant at $P < 0.05$.

whilst ADE 011 and AGA 97/162 had the lowest number of leaves of 6.1. Leaf area was highest (1556.8 cm^2) in BD 96/183 and lowest (1178.8 cm^2) in SCJ 98/05. There

Traits that were positively correlated with yield were weight of cormels, leaf area and number of cormels . Plant height and number of leaves were all negatively correlated with yield. Leaf area, number of leaves, and number of cormels were all positively correlated with weight of cormels, whilst plant height was negatively correlated with weight of cormels (Table 5). Many of the characters considered in the study were correlated perhaps because of the positive mutual associations among them. The positive correlation of weight of cormels with some yield components such as leaf area and number of cormels in the study were the result of their respective direct influence on yield. A similar observation was made by Agueguia (1993).

The clones proposed for release (asterisked) showed no visible symptoms, mild symptoms to moderate symptoms of root rot, dasheen mosaic virus and leaf blight diseases, respectively (Table 6). Dasheen mosaic disease is an important viral disease of cocoyam that reduces yield significantly in susceptible cultivars. Disease severity score of 2.0 recorded by the four clones intended for release is an indication of good diseases

TABLE 4

Effect of the Two Major Growing Seasons on Phenotypic and Yield Components of the Clones

	Parameters						
Growing seasons	*Plant height (cm)*	*Number of leaves*	*Leaf area (cm^2)*	*Number of cormels*	*Cormel Weight (g)*	*Yield / plant (g)*	*Yield t ha^2*
2009/2010	105.22 a	6.11 a	1109.7 a	6.92 a	73.66 a	509.72 a	5.09 a
2010/2011	140.14 b	6.96 b	1688.0 b	5.96 b	99.85 b	595.10 b	5.95 b
Lsd	9.31	0.41	227.1	0.57	7.23	48.34	0.485

TABLE 5

Correlation of Metric Traits over the Two Growing Seasons

Trait	*Yield*	*Plant height*	*Leaf area*	*Number of leaves*	*Number of cormels*	*Weight of cormels*
Yield.	1	-.583	100	-.082	.642	.792*
		.099	.798	.833	.062	.011
Plant height		1	.238	-.053	-.540	-.376
			.537	.892	.224	.318
Leaf area			1	.187	.006	.040
				.629	.988	.919
Number of leaves				1	-.358	.129
					.343	.741
Number of cormels					1	.102
						.795
Weight of cormels						1

* significant

TABLE 6

Incidence of Root Rot, Dasheen Mosaic Virus and Leaf Blight at Fumesua During the Two Growing Seasons

	2009/2010 major growing season			2010/2011 major growing season		
Clone	*Root rot*	*Dasheen mosaic virus*	*Leaf blight*	*Root rot*	*Dasheen mosaic virus*	*Leaf blight*
ABN 01/004	2.0	2.5	3.0	2.0	2.0	2.5
*ADE 011	1.0	2.0	3.0	1.0	1.0	1.0
SW 011	1.5	2.0	3.5	1.0	1.5	1.5
*RAX 93/008	1.5	2.0	2.0	1.0	1.0	1.5
LOCAL	2.0	3.0	4.0	1.5	2.5	2.0
BD 96/183	1.0	2.0	4.0	2.0	3.0	2.0
*AGA 97/162	1.0	2.0	2.0	1.0	1.5	1.0
SCJ 98/05	1.0	2.0	2.0	1.0	1.0	1.0
*SCJ 98/09	1.0	2.0	2.5	1.0	1.0	1.0
Mean	1.33	2.16	2.88	1.27	1.53	1.5
S.e.	0.14	0.11	0.27	0.14	0.24	0.18

tolerance. Root rot disease contributes to low yields in cocoyam production in susceptible cultivars. The four clones identified for release were not affected by root rot. This quality of the four clones is a very good attribute that will contribute to sustainable good yields when other production constraints are controlled. The four clones exhibited moderate tolerance to leaf blight disease.

Colour, leaf size, number of leaves, disease and pest, plant height, length of petiole and thickness of petiole were the main determinants of good cocoyam clones in decreasing order of importance to the farmer (Table 7). Colour was a dominant character in ranking cocoyam clones, hence, ranked highest. Farmers preferred the purple clones to the white because of its high market value, many food uses , better taste and stickiness which makes it poudable into 'fufu'(a favourite Ghanaian dish). Because cocoyam leaves have equally high economic value and can be used in the preparation of soup and stew, larger sizes and higher number of leaves meant more economic returns to the farmer. Farmers were of the view that the bigger size and higher number of leaves are also determinants of higher yield. Farmers', however, had a low perception of the importance of foliar diseases and the economic loss they can cause to cocoyam. Some farmers, however, argued out that the mottled and discolored leaves of cocoyam

Table 7

Farmers' Perception and Ranking of a Good Cocoyam Plant During the Peak Vegetative Stage

Parameter	*Percentage score*	*Rank*
Pest and diseases free	60	4
Leaf size	100	2
Number of leaves	100	3
Plant height	30	5
Colour	100	1
Length of petiole	10	6
Thickness of petiole	10	7

depreciate the market value and results in poor yields. Generally, the farmers were of the consensus that robustness of a cocoyam plant does not always translate into higher cormel yield.

Farmers' criteria of importance in the selection of good cocoyam cormels and ranking of the clones are shown in Table 8. The key determinant was the colour of skin/ flesh, followed by taste, size of cormels, number of cormels, disease and pests, texture, sprouting at harvest, smoothness of the skin and shape of cormel in order of importance. Farmers again ranked colour (colour of skin and flesh) highest because of the reasons earlier mentioned. According to the farmers' taste is a dominant feature of a good cocoyam against yield (size and number of cormels). Although the white clones ABN 01/004 and BD 96/183 had comparatively higher yields than some of the purple clones, they were rejected by the farmers because of their bland taste, early sprouting and sogginess. This agrees with Witcombe (1996) that farmers evaluate varieties for multiple traits, and do not place an overriding emphasis on yield. Hence, the most preferred varieties are often not amongst those selected by breeders for yield alone. Early sprouting, however, according to some of the farmers is an indication of early maturity. Such clones, they admitted, when harvested at the right time could be used to break the hunger gap.

Table 8

Determinants of Good Cocoyam Cormels as Perceived by Farmers After Harvest and Sensory Evaluation

Parameter	*Percentage score*	*Rank*
Disease and pest free	80	5
Colour of skin and flesh	100	1
Size of cormels	100	3
Number of cormels	100	4
Taste	100	2
Texture	80	6
Sprouting	0	9
Smoothness of skin	50	8
Shape of cormel	30	7

After ranking at the vegetative, harvesting and sensory evaluation stages, farmers finally determined the choice of clones they wanted to plant on their farms assigning reasons (Table 9). Farmers' choice of a clone depended on the colour of the flesh/skin of cormel, taste, yield and the kind of dish that could be prepared from it. The purple clones were highly ranked than the white because of their wider use, good taste and higher market value.

Conclusion

The study suggest that leaf area, number of cormels and weight of cormels are ma-

Table 9

Farmers' Choice of Clones to Plant with Reasons

Clone	*Remarks*	*Rank*
ADE 011	Purple flesh, good taste, high yield, good for "fufu", "Ampesi"	1
SCJ 98/009	Purple flesh, good taste, good yield, good for ''fufu'', ''Ampesi'',"Ɛtɔ',	2
RAX 93/008	Purple flesh, good taste, good for "fufu", "Ampesi", "Ɛtɔ"	3
AGA 97/162	White flesh, good for "mpɔtɔmpɔtɔ", "good" for "Ampesi", good yield.	4

jor components of yield to consider when breeding/selecting cocoyam for higher yields. From the farmers' perspective, colour and taste rather than yield are the overriding traits of a good cocoyam.

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REFERENCES

Agueguia, A. (1993) Non destructive estimation of leaf area of cocoyam (*Xanthosoma sagittifolium* L. Schott). *Journal of Agronomy and Crop Science* **171**, 138 – 141.

Aguieguia, A. (1993) Association of metric traits and path analysis in cocoyam (*Xanthosoma sagittifolium* L. Schott.). *Indian J. Genet.* **53**(3), 287 – 291.

Caesar, A. (1980) Growth and development of *Xanthosoma* and *Colocasia* under different light and water supply conditions. *Field Crops Res.* **3**, 235 – 244.

Dankyi, A.A. & **Sagoe, R.** (1994) *Cultivation of cocoyam in the Tano District of the Brong Ahafo Region of Ghana* (Unpublished paper).

IITA (1994) Plant protection survey protocols. Diagnostic survey annex: *Protection Summaries ESCaPP Project (Draft Pub)*

Janseens, M. (2001) Crop production in tropical Africa. Bonn, Germany: Institut fur obstund germusebau, abt. Tropicscher pflanvenbau, rheinische friedrich – wilhelms Universitat Bonn, auf dem hugel 6, D-53121 Bonn, Germany. *Directorate General for International Co-operation, Karmelietenstraat 15, B-1000* pp. 221 – 228. Brussels, Belguim.

MoFA (2006) *Annual Report 2006.* Ministry of Food and Agriculture, Accra, Ghana.

Onwueme, I. C. (1978) *Tropical tuber crops: Yams, cassava, sweet potato and cocoyam.* John Wiley and Sons, New York. 234 pp.

Onwueme, I. C. & **Charles, W. B.** (1994) Tropical root and tuber crops. Production, perspective and future prospects. *FAO Plant Production and Protection Paper 126*, pp. 139 – 161.

PPMED (1991) *Agriculture in Ghana, Facts and Figures*. Ministry of Food and Agriculture, Accra, Ghana.

Torres, S. L., Gomez, O., Arias, O. & **Thorpe, O.** (1994) Micropropagation and field performance of virus – free white cocoyam (*Xanthosoma* spp.) in Costa Rica. In *Carribean Food Crop Society. 30th Annual Meeting. St Thomas, U.S.A.* pp. 137 – 145.

Torres, S. L., Gomez, F., Saborio, R. & **Valverde, R.** (2000) Comportamiento en el campo de seite genotipos de tiqusque (*Xanthosoma* spp.) propados *in vitro*. *Agronomia costarricense* **24**(1), 7 – 17.

Witcombe, J. R. (1996) *Participatory approaches to plant breeding and selection biotechnology and development Monitor, No. 29,* p. 26.