Community-based breeding of superior, mosaic disease-resistant cassava in Ghana

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SUMMARY

Participatory cassava breeding is being done with two communities in Ghana; at Nkaakom in the forest zone and at Aworowa in the forest transition zone. The collaboration required a team of scientists and was initiated with village surveys on cassava production, consumption and marketing, followed by interviews of other cassava stakeholders from University researchers to private-sector processors. Cassava seeds obtained from superior, cassava mosaic disease-resistant landraces and varieties were direct-planted in communal plots. Scientists monitored growth and any pest and disease attacks monthly until harvest one year later. Farmers monitored crop growth informally and during field days. At harvest, many of the seedlings yielded several times the national average yield and many remained free of cassava mosaic disease (Fig. 1). Both farmers and scientists selected plants to provide cuttings for further trials: about 60% of the selections of the plant breeder and the farmers were in common.

Figure 1. **Farmers in Aworowa displaying the tuberous root yield of a selected cassava plant.**

INTRODUCTION

Cassava is grown throughout sub-Saharan Africa and increasingly is the main starch staple, particularly in West and Central Africa. An estimated $94x10^6$ t of the tuberous roots were produced in Africa in 2001 with $8x10^6$ MT in Ghana alone Cassava is also a raw material for food industries, livestock feed and a source of starch for chemical industries. However, pests and diseases, particularly cassava mosaic disease, are a major constraint. High-yielding, station-bred, cassava varieties have had limited uptake in much of Africa, including Ghana.

The project therefore has two main aims:

1. To develop an effective means of breeding new cassava varieties which are high yielding, pest (particularly cassava mosaic disease) resistant and acceptable to Ghanaian farmers, through involving farmers from the earliest stages of selection.
2. To understand how cassava landraces developed. This is being done by investigating farmer attitudes and practices regarding seedlings and should facilitate farmer involvement in cassava breeding.

The project is a collaboration between NRI, CRI and IITA[1], and required a multidisciplinary approach. Consequently, a team was put together consisting of NRI and CRI scientists covering agronomy, plant pathology (particularly virology), plant breeding and socioeconomics. The team identified two communities with which the project would work. These were Nkaakom, located in the forest zone, and Aworowa, in the forest/savannah transition zone (Fig. 2). Cassava is an important crop for both communities, and both have good access to markets, perhaps making them more able to utilise new ideas and cultivars.

Situation analyses and stakeholder survey

We began by analysing the current situations in Nkaakom and Aworowa, notably:

- The development of each community, particularly the introduction of cassava and new cassava cultivars;
- The farming system, particularly the production of cassava;
- The social structures within each village, particularly any with which we might work.

Several constraints to cassava production mentioned in both Nkaakom and Aworowa were associated with land shortage – notably short or no fallow, having to rent or sharecrop land, and low-yielding varieties. Counter to this, another main constraint was insufficient demand for even the current production of cassava. This fed via low prices into a lack of money to purchase labour (weeding and land preparation especially) and other inputs (herbicides, etc). Clearly, higher yielding varieties could indirectly combat land shortages, allow longer fallow periods, provide a higher return from labour, and provide opportunities to grow other crops. This also led us to consult other stakeholders – both public and private organizations – about alternative markets. This also raised

[1] The project is funded jointly by the Crop Protection Programme and the Plant Sciences Research Programme. It is also part of the international CGIAR Systemwide Program on Integrated Pest Management (www.cgiar.org/spipm/index.htm(anchor1934631) on *Sustainable integrated management of whiteflies as pests and vectors of plant viruses in the tropics: Phase 2 (R8041).*

awareness of the project with key people such as the chair of the National Variety Release Committee. Stakeholders interviewed included the Ghanaian Ministry of Food and Agriculture, the CSIR research institutes, universities and small businesses, while international organisations included a CGIAR institute, foreign government agencies and international NGOs. There was much interest amongst these stakeholders on promoting non-traditional uses of cassava to increase demand for the crop.

Figure 2. **Location of Aworowa and Nkaakom, the two communities in Ghana involved in the participatory cassava breeding.**

Village-based plant breeding

Meetings were held to discuss the field activities at both Nkaakom and Aworowa, shortly after completing the situation analyses. In Aworowa, the meeting was open to all cassava farmers; in Nkaakom, the maize/cassava group provided a focus. The farmers expressed an interest to work with us and land was made available in each village. Seed was obtained from crossing blocks at IITA, Ibadan, Nigeria. The female parents were either highly cassava mosaic-resistant landraces from Ghana, Togo and Nigeria (coded TME (= Tropical *Manihot esculenta*), or TMS (Tropical *Manihot* species) clones with mosaic resistance derived from *M. glaziovii* back-crossed to *M. esculenta* to regain tuber yield.

The seeds of the crosses were direct-planted in June 2000 at Nkaakom and Aworowa, and on-station at Kwadaso (part of CRI) and in Kumasi. The CRI team monitored germination and spare seedlings were used to fill any gaps. Subsequently, pests,

diseases and crop growth were monitored monthly. Men were responsible for initial land clearance, but afterwards, both men and women cultivated the cassava. Cassava mosaic virus disease was the main pest, affecting more than 50% of plants in most families. Farmers evaluated the trials in December 2000 and May 2001. While seldom selecting specifically against mosaic-affected plants, many did select for healthy green leaves (Table 1). Farmers also used indirect measures of yield potential such as stem girth and soil cracking around the plants, caused by the expansion of the tubers underground.

Harvest and the selection of genotypes for further planting were done in July 2001, about one year after planting. Nkaakom was harvested first (Fig. 3). Groups of about six farmers were asked to evaluate each plant pre-harvest and to select about 10 plants they would like to keep for another growing season, recording the key characters of each selected plant through a facilitator. The cassava plants were carefully 'pulled up' so as to keep the tubers attached to the stem and lined up in families. Farmer groups then re-evaluated the plants and re-selected/confirmed the plants they would like to keep for another growing season (Table 2). The CRI plant breeder and the CRI plant pathologists made similar separate evaluations and also selected plants to retain. Plant height, height of the first branches and tuber yield were recorded for all selected plants.

Figure 3. **Nkaakom farmers at harvest, evaluating the cassava plants derived from seedlings.**

Doing both pre- and post-harvest evaluations was time-consuming and repetitive, so only post-harvest evaluations were done at Aworowa and Kwadaso. The seedlings exhibited great diversity, particularly in vigour, branching, susceptibility to cassava mosaic disease, leaf and stem colour and, of most excitement to farmers, in yield, number, size, shape and colour of their tuberous roots. Despite the plants having been derived from seeds rather than large cuttings and the crop having been harvested after only one year, the tuberous root yield per area of many of the seedlings was several times that of the average yield of about 12 t ha^{-1} of cassava in Ghana (FAO data for

2001). Indeed, several farmers asked if the point of the trial was to show them the benefits of planting seeds (we are assuming that the next cycle of propagation using cuttings will confirm our denial of this).

Table 1. **Pre-harvest attributes reported by farmers in two villages, ranked according to the number of times each was mentioned during evaluation. (M = men; W = women).**

	Nkaakom			Aworowa			Overall
Criteria	**M**	**W**	**Rank**	**M**	**W**	**Rank**	**rank**
Stem diameter	57	51	1	76	24	1	**1**
Branching	64	37	1	59	18	2	**2**
Canopy formation	72	38	1	42	13	3	**2**
Healthy/green leaves	34	21	4	35	10	4	**4**
Soil cracking	5	3	5	28	11	4	**5**
Suitability for intercropping	2	16	5	7	3	6	**6**
Resistance to lodging	4	1	5	9	1	6	**6**

Table 2. **Harvest-time attributes reported by farmers in three villages in their selection of plants at harvest.**

	Times mentioned (%)			
Criteria	**Nkaakom**	**Aworowa**	**Kwadaso**	**Mean**
Tuber yield	100	100	100	100
Branching	33	42	17	29
Big stem	33	44	13	28
Tuber shape	5	36	5	14
Weed suppression	18	14	1	10
Healthy leaves	7	16	1	7
Suitability for intercropping	14	0	2	5
Marketable size	2	0	8	4
Neck length of tubers	5	4	0	3
Tuber skin colour	3	0	4	2
Resistance to lodging	2	4	1	2
Early maturity	5	0	1	2
Non-rotten tubers	0	0	4	2
Drought tolerance	1	0	0	0
Disease resistance	1	0	0	0

At each site, the farmers selected 10–15% of the total seedling population, a similar proportion of seedlings to the plant breeder with about 60% overlap with his selections. Cuttings have been obtained from all the plants selected by the farmers, plant breeder and plant pathologists. These have been replanted at each site, each genotype now being represented by a single plot of 12 cuttings (3 x 4). Plots have also been planted with cuttings of local cultivars, nationally released varieties and selections of superior Ghanaian landraces. So far, plants are growing well at each site and about half of the plots of seedling genotypes are free of any cassava mosaic symptoms.

CONCLUSIONS

Major conclusions to date are:

- The work has benefited enormously from the very obvious diversity and overall pest resistance and vigour of the seedling families used.
- The multidisciplinary team approach has been invaluable.
- Farmers appear to have coped well with evaluating large numbers of seedlings.
- The initial situation analyses and stakeholder survey greatly facilitated the collaboration of the project team with farmers and other stakeholders.

Future plans include:

- A survey of cassava breeding by farmers in representative villages throughout Ghana.
- At the next harvest, when there is more material, attention will be paid to the post-harvest qualities of the cassava tubers both as perceived by farmers and by food scientists.

At the moment, the project provides cassava seed to the farmers. It would also be exciting in a next phase of the project to involve the farmers in parental as well as seedling selection.