PLANT SCIENCES RESEARCH AND CROP PROTECTION PROGRAMMES

Participatory breeding of superior, mosaic disease-resistant cassava

R7565 (ZA0370)

FINAL TECHNICAL REPORT

1st March 2000 – 31st March 2003

RW Gibson

Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK

11th April, 2003

This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID. R75675; Plant Sciences Research and Crop Protection Programmes

EXECUTIVE SUMMARY

Situation analyses of two farming communities in the Forest and Forest Savannah Transition Zones (Nkaakom and Aworowa respectively) identified the main customs and practices of cassava production. Cassava has changed over the last several decades from being not grown or a minor crop to becoming the main food crop and a major cash crop. Much of this increase was associated with lack of new land to open and impoverished soils on previously cropped land. The activities of non-farmer stakeholders in cassava breeding and how they might interact with the project have also been explored. The IFAD-funded RTIP project has funded increase research and development activities in the university and public research sector and large-scale distribution of released varieties. GTZ has also supported the agricultural sector generally; relatively few NGOs seem to support cassava-linked activities. There is increasing industrial interest in cassava as a source of food for humans and livestock and starch as a chemical feedstock. In ten diverse farming communities, no farmer interviewed understood the role of pollen; most were aware of cassava seeds and seedlings. Cassava seedlings seem generally to be avoided by farmers as a source of planting material and food, often being weeded out. However, a few farmers in most communities had tested a few seedlings and many farmers used them when other planting material was scarce. Farming communities seldom exchanged landraces, though occasionally did so purposefully. Migrant workers and settlers bringing new varieties from their place of work or previous home seem an important means by which communities obtain new landraces.

Seed stocks derived from diverse genetic backgrounds but including resistance to pests and diseases, particularly CMD, and high storage root yields were selected by IITA. These were provided to the Nkaakom and Aworowa farming communities for evaluation and selection of superior genotypes and were sown in communal plots. They were also sown at the CRI research farm. Seedlings were monitored monthly by the multidisciplinary project team for agronomic and pathological characters. They were also evaluated with farmers, firstly for aboveground characters, secondly for pests and diseases and finally at harvest for both above- and below-ground characters. Farmer recorded a wide range of mostly positive criteria. Using their own criteria, both farmers, the CRI cassava breeder and CRI pathologists selected seedlings to retain as clones in a further trial at each location. A further similar annual cycle of monitoring, evaluation and reselection of clones was conducted at each location, reducing their number tenfold over the two generations. Clones have now been distributed to individual farmers. The resultant clones are mostly preferred by farmers over their own landraces, being both higher yielding and less affected by CMD. Farmers were consistent in their selection and overlapped that of the CRI breeder by about 60%. Farmers generally rated the project as beneficial and participants at an end-of-project workshop also validated the approach. The project provided both experiential training and formal training in participatory research and plant breeding to CRI staff.

CONTENTS

BACKGROUND

Cassava is increasingly the main starch staple eaten in sub-Saharan Africa, particularly in West Africa. Cassava is subject to the ravages of a wide range of pests and diseases; one of the main constraints to production throughout Africa is cassava mosaic disease (CMD) caused by various cassava mosaic geminivirus species. Although modern varieties bred on-station are increasingly available, cassava production in most African countries is still reliant on landraces developed by generations of farmers using traditional breeding approaches. Relevant exceptions to this include Nigeria, where the International Institute of Tropical Agriculture (IITA) is centred, and Uganda where an epidemic of CMD has devastated production based on susceptible landraces. Indeed, a very evident success of modern cassava breeding in Africa has been the release of varieties resistant to these viruses. Genes for resistance derive only either from a very few very resistant African landraces or have been introgressed from the non-tuber-forming *Manihot glaziovii*. However, most landraces grown in Africa are relatively susceptible to CMD; hence the persistence of this problem.

In Ghana, *fufu* and other traditional foods prepared from cassava provide the staple carbohydrate and, with a *per capita* production of 450kg of cassava/*annum*, Ghana's total production of cassava is exceeded in Africa only by the far larger and more populous Nigeria and Democratic Republic of Congo. As well as being a source of cheap food, cassava is a crop of opportunities: CPHP-funded work alone has identified markets in Ghana for industrial starch of 5,000MT *per annum*. CMD is widespread in Ghana and, apart perhaps from weeds, is the main biotic constraint. None of only four varieties released in the past few decades have been widely adopted (Collaborative Study of Cassava in Africa (COSCA): Working Paper No.21; 1999), despite the importance of cassava to Ghana's economy and despite three of the released varieties being high yielding clones resistant to CMD. These three varieties had been bred in Nigeria by IITA and the fourth was the result of mutation breeding using irradiation.

The limited success of formal crop improvement/breeding for cassava and the reasons for the continuing success of landraces had not been well documented anywhere in Africa. In Ghana, such breeding has focused mainly on increasing yield, selecting primarily on research station farms. The main stages of the cassava breeding process at the Crops Research Institute (CRI) of Ghana comprise: screening and selection of superior genotypes amongst seedlings derived from seed obtained from IITA in Nigeria, clonal evaluation and selection on-station leading to preliminary yield trials (PYT), advanced yield trials (AYT), uniform yield trials (UYT) and final multi-locational yield trials (MYT), testing yield stability of a few clones across different ecological zones. Only after these stages are completed, a process lasting perhaps a decade, have farmers been involved - with on-farm trials to validate and promote new clones. Thus, farmers and other stakeholders have a largely passive role, with little direct input even to selection criteria, being involved close to the end largely to endorse the selected genotypes prior to their release by the national variety release committee.

Over at least the past decade, research in developing countries has indicated, for a range of seed-propagated crops, benefits of selecting new varieties from the very beginning with farmers under on-farm conditions. This process whereby farmers have an active role early in the breeding cycle has been given the broad name of participatory plant breeding (PPB). CIAT, working with cassava in South America, reported considerable improvements in adoption by utilising participatory varietal selection (PVS). As a result of the low rates of adoption of cassava varieties in Africa, it was decided to assess PPB options for cassava. Novel aspects for Africa of the concept were that it involved a predominantly vegetatively-propagated crop and a main target was a virus disease, CMD. This therefore required a participatory plant breeding team including plant breeding, plant pathology and social science. Given the success of landraces, a need to understand better how they evolved and to adopt any appropriate components, were also seen as potentially important.

The project included both CRI in Ghana and IITA as partners. Ghana was identified as an appropriate country to locate the project given its very high *per capita* production and consumption of cassava and because of its low adoption of modern varieties (MVs). Its pest problems also seemed fairly representative of many African countries. In addition, it is a target country for both CPP and PSRP and CPHP outputs had identified opportunities for utilising increased outputs of cassava. Furthermore, a multi-million dollar Ministry of Agriculture and Food (MOFA) IFAD-funded Root and Tuber Improvement Project (RTIP) had just started in Ghana, ensuring a high level and broad range of cassava activities. The CRI has a mandate for research on cassava in Ghana and the main breeding programme. IITA has the regional mandate for research on cassava throughout Africa and has been the predominant actor in cassava improvement there over the last few decades.

PROJECT PURPOSE

The project aims to increase the production of cassava by developing superior cassava genotypes resistant to local pests and diseases through an improved collaboration between farmers and trained plant breeders. Particular aims of the project are to:-

- develop cost-effective participatory plant breeding (PPB) for cassava, emphasising farmer inputs, and using cassava as both a target and a model vegetatively propagated crop;
- leading to the development of superior, CMD-resistant varieties through the use of seed derived from agronomically superior and CMD-resistant parents and by training farmers in selection;
- obtain knowledge of how cassava landraces evolve and spread, particularly CMD-resistant ones, so that PPB can incorporate farmer methods.

Cassava is the main starch staple food for many subsistence farmers and their families in sub-Saharan Africa, but most production utilises relatively low-yielding and CMD-susceptible landraces. Initial surveys have shown that farmers make only limited use of natural seedling populations and these are not derived from purposeful crosses

involving mosaic-resistant and agronomically superior parents. Consequently, new superior mosaic-resistant landraces seldom arise. Farmers want superior varieties (COSCA: Working Paper No. 10). However, conventionally bred cultivars have had little success in Africa despite the initiation of breeding programmes in the colonial era, whereas landraces have been very successful and remain the main means of growing cassava throughout Africa. In Ghana, no conventionally bred variety has been widely adopted. Evidence from other crops (*e.g.* rice) indicate that participatory breeding is effective at producing the diversity and range of genotypes required by largely subsistence farming families living in relatively marginal rain-fed areas in which cassava is often grown.

Farmers seem largely unaware of seedlings, their importance for the generation of new varieties or the need or opportunity to access seedlings from genetically superior parents. The project aims to overcome limitations in traditional farmer breeding systems and thereby satisfy the farmers' demands for superior varieties, enabling them to access to more diverse, more disease resistant and agronomically superior seedling stocks. Working through the informal system will ensure the outputs are tailored to the requirements of resource-poor farmers and so directly assist in the alleviation of poverty. National programmes in most African countries are chronically under-funded and involving farmers through incorporating their traditional breeding systems should achieve national objectives of providing farmers with superior varieties without overburdening national programmes financially. An underlying theme of the project is to understand the institutional circumstances so that the breeding approach developed requires largely local, low-cost resources sustainable by farmers, national programmes and other stakeholders. National (Ghana) and international (IITA) scientists including conventional cassava breeders are giving strong support to the proposed work and will make direct contributions.

RESEARCH ACTIVITIES

Overview

The project is a collaboration between the Natural Resources Institute (NRI), the Crops Research Institute (CRI) in Kumasi, Ghana, and The International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria. IITA provided seed of crosses amongst mostly highly cassava mosaic resistant Ghanaian, Togolese and Nigerian landraces (coded by IITA as the TME (Tropical *Manihot esculenta*) series) and amongst TMS (Tropical *Manihot* species) series clones with mosaic resistance derived from *Manihot glaziovii* back-crossed to *Manihot esculenta* to regain tuber yield. The resulting seed was planted at two community-based field trial sites in Ghana, at Nkaakom village (near to Kumasi and in the Forest Zone) and at Aworowa (near to Techiman town and in the Forest/ Savannah Transition Zone). The seed was also planted at Kwadaso, the CRI research station farm near Kumasi. CRI researchers and farmers evaluated and selected seedlings and subsequent clones at all three sites. These activities enabled the following combinations to be tested:

- researcher-led on-station (conventional);
- farmers' selection criteria but on-station;
- researcher-led on-farm;
- farmer-led on-farm.

Plate 1. The locations of Aworowa and Nkaakom. *Kwadaso is located in the suburbs of Kumasi. Numbers relate to villages sampled - see Table 1 for key.*

A detailed Situation Analysis in both Nkaakom and Aworowa provided both an entry point and an improved understanding of the role of cassava in both communities. Further knowledge of the roles and diversity of cassava in Ghana and how it was derived was obtained in surveys conducted in further eight communities selected to represent the range of cassava production systems in Ghana. Interests and activities of non-farmer cassava stakeholders was obtained through a separate Consultation with Stakeholders. A Workshop was held towards the end of the project in order both to disseminate project achievements and to identify how best to do so and also to identify further required activities.

Activity 1. Situation analysis in participating villages to understand farmers' and other stakeholders' current knowledge, perceptions and practices with respect to cassava.

The project aims to be a pilot study, identifying a cost-effective way in which farmers can be involved in the identification of superior cassava genotypes. Two villages located in two major agro-ecologies in Ghana were therefore targeted so they could be studied intensively. An *a priori* situation analysis was done for each village, partly as an entry point to collaborating with the farmers and partly to help us to define important characteristics of such communities. The study was carried out by a multidisciplinary core team consisting of Dr AA Dankyi, Mr RI Lamboll (socio-economists), Mr JA Manu-Aduening (agronomist), Dr RW Gibson, Dr E Moses, Dr JN Lamptey (plant protectionists) and GA Mensah (a breeder) aided by Ministry of Food and Agriculture (MOFA) staff and CRI technicians,some of who were local to each village. We had previously visited and identified two villages, Nkaakom in the Forest Zone and Aworowa in the Forest/Savannah Transition Zone as target villages for our participatory breeding work. Only limited amounts of data were available on crop production in the two villages despite them being chosen partly because scientists at CRI and/or MOFA extensionists had previous experience in the villages. The team held a brainstorming session to identify what was needed to know about the two villages in order to facilitate our work there and to confirm that the villages were appropriate sites. The resulting checklist developed by the team included: -

- The history of each village particularly changes in cassava production.
- Constraints limiting crop production by individual farmers.
- The farming system in each village and how cassava fitted in.
- Farmer knowledge of cassava biology, particularly of seedlings.
- Cassava varieties currently grown; their different uses and contribution to livelihoods.
- The village infrastructure and institutions, particularly those that involve cassava and dissemination of information.
- Farmers' perceived constraints to cassava production.

Using these items as a checklist, rapid rural appraisal (RRA) techniques such as drawing a historic profile of the village, seasonal cropping calendars, drawings (of seedlings), 'matrix ranking', preference or pair wise ranking and Venn diagrams were

used where possible. For many of these techniques, the diagram, drawing or chart prepared by the farmers provided the focus with the team recording farmers' detailed responses during the discussion. The diagram, drawing or chart prepared by the farmers also then provided the record. Otherwise, the team recorded farmers' responses to the questions. A Focus Group Discussion (FGD) approach was adopted. The groups were elders (men and women) and separate groups of women and men cassava farmers. These groupings were made with a view to getting an indication of the range of views and knowledge of the farmers in a short time. The elders group targeted the history of their settlement and the changes in the farming systems, whilst the women's and men's groups discussed the general farming systems, each giving their different perspective.

Activity 2. Survey natural occurrence of cassava seedlings in farmers' fields and investigate farmers' perceptions and practices of cassava propagation.

The study was carried out in ten villages including Aworowa and Nkaakom. The villages were selected to reflect high levels of cassava production yet diverse agroecological conditions and market accessibility (Table 1) using the COSCA report No.21 (1999) as a guide. The selected villages were Nyamebekyere and Agona Nkwanta (Western Region), Wuti and Koluedor (Volta Region), Kwaa Darko and Akyem Amanase (Eastern Region), Yapeilgu and Jonikponta (Northern Region), Aworowa (Brong Ahafo Region) and Nkaakom (Ashanti Region)(Plate 1).

The Coastal Savannah lies along the coast, stretching from the eastern border with Togo to parts of Central Region. This zone has the lowest rainfall, averaging between 600 and 800mm/*annum*. The soils are mostly sandy and low in organic matter. The Forest Zone lies immediately inland from the Coastal Savannah Zone. It covers most of the Western, Ashanti, Eastern and Brong Ahafo regions. The soils in this zone are generally more fertile than the other ecological zones and consists of well-drained forest ochrosols or forest oxysols, although they may be leached by high rainfall which averages 1500mm, bimodally distributed. There is no clear boundary between the forest and inland savannah, a so-called Forest-Savannah Transition Zone stretches from east to west, immediately north of the forest zone. The soils are deep and friable but well drained, and there is less dense forest cover. Rainfall is still bimodal and averages about 1,300mm/*annum*. Because of favourable climate and less dense vegetation, the transition zone is extensively cultivated and an area of commercial farming. The Guinea Savannah covers the remaining third or more of the country. It has the savannah ochrosols and groundwater laterites (poorly drained loams). Rainfall is unimodal, averaging about 1,100mm/*annum*.

In each village, RRA techniques were again used where possible. As in the Situation Analyses of Nkaakom and Aworowa, farmers were initially divided into groups: older men and women; active men farmers; and active women farmers. Historical charts were used to understand exchanges in cassava cultivars during the development of each village. Group discussions and individual interviews were used to explore farmer

knowledge of cassava propagation and identify significant varietal criteria. Transect walks were used to confirm results and to understand the local agroecology.

Table 1. Characteristics of the survey villages

Villages	Access to market	Rainfall regime	Ecological zone
1. Nyamebekyere	good	High	Forest
2. Agona Nkwanta	good	High	Forest
3. Akyem Amanase	good	High	Forest
4. Kwaa Darko	medium	High	Forest
5. Nkaakom	good	Medium	Forest
6. Aworowa	good	Medium	Forest-Savannah transition
7. Wuti	medium	Low	Coastal Savannah
8. Koluedor	medium	Low	Coastal Savannah
9. Yapeilgu	poor	Low	Guinea Savannah
10. Jonikponta	poor	Low	Guinea Savannah

Activity 3. Facilitate farmer and other stakeholder understanding of current cassava breeding opportunities.

Activity 2 identified that farmers initially had only limited knowledge of the sexual propagation of cassava. Consequently, only limited direct training was done and most learning was achieved as a result of observation by farmers, using the communal seedling trials in Aworowa and Nkaakom as an experiential learning system. A survey of non-farmer stakeholders was done to collect baseline data on, and initiate links with other individuals or organisations that may influence cassava selection by farmers or may be uptake pathways for project outputs. This facilitation of other stakeholder understanding of current cassava breeding opportunities is described under Activity 7.

Activity 4. Jointly plan with all stakeholders different seedling selection procedures.

Men and women farmers in Aworowa and Nkaakom were selected for inclusion in PPB activities according to one main selection criterion, that they grew cassava, but the Situation Analysis was used to guide the process. Farmers were invited to participate by CRI and MOFA staff operating in the villages. At Nkaakom, the study focused on a group (maize-cassava growers association) but other farmers were also encouraged to join. In Aworowa, no similar group had been identified so the invitation was to all farmers. Farmers' initial lack of knowledge of cassava breeding restricted their contributions to planning different seedling selection procedures. Seed stocks were therefore selected by the IITA cassava breeder (Dr A Dixon) and detailed arrangement of seedling trials were planned by the CRI/NRI team. Farmers' main initial contribution

was to ensure the strategic location of a site in each village where it was both safe and readily accessible to the whole community. Midway during the project, a questionnaire-based survey was conducted to examine, amongst other matters, how the communities of Nkaakom and Aworowa viewed the project activities.

Activity 5. Implement farmer- and station-based trials of at least four different approaches to breeding cassava.

Following discussions with farmers and other stakeholders and review meetings of the project team, cassava breeding was implemented at three sites. Two sites, Nkaakom and Aworowa, were community-based and one was at the CRI research farm at Kwadaso. The two communities were selected to represent two distinct agro-ecologies, the Forest and the Forest-Savannah Transition Zones (the most important zones for cassava production) respectively. The two villages also differed in terms of size, population and social amenities such as school and churches. Cassava was an important crop in both communities but there were clear differences in its production systems, landraces grown, uses and contribution to livelihood of the communities, other crops grown, closeness to market centers and the previous agricultural extension activities in the communities. The Crops Research Institute farm at Kwadaso is located in the suburbs of Kumasi, in the Forest Zone. The four types of breeding approach to be compared were:

1. researcher-led on-station (conventional);
2. farmers' selection criteria but on-station;.
3. researcher-led on-farm;
4. farmer-led on-farm.

Approaches 1 and 2 were done at Kwadaso, involving local farmers for approach 2, and approaches 3 and 4 were done at both Aworowa and Nkaakom.

Seeds of 18 half-sib families (Table 2) were provided by IITA from crossing blocks at the Ibadan (Nigeria) Institute farm. The families were chosen on the basis of the mother plants having one or more of the following attributes:

- CMD-resistant landrace (Tropical *Manihot esculenta* [TME] series);
- CMD resistance derived from *Manihot glaziovii* (Tropical *Manihot* species [TMS] series);
- High storage root (tuber) yield;
- Ghanaian or West African origin.

Another underlying theme was to obtain seeds with a much greater diversity than farmers currently had access to.

At Nkaakom, it was decided to work primarily through a maize/cassava farmers association, though an open invitation was given to all cassava farmers in the community. At Aworowa, an open invitation was given to all interested farmers; one who had planted cassava from seeds was given a special invitation. In both villages, a

minimum of thirty farmers was targeted, but the number actually exceeded forty. There was a core of participating farmers in each community.

Plots measuring 5m by 10m were hand-sown at each of the three sites with seeds of each family and labelled. Seeds of each family were planted in a block of four rows with an inter-row and intra-row spacing of 1m and 0.5m respectively and a target population of 40 plants per family. The two on-farm trials had 15 and 16 families while the station trial had all18 families (Table 2). The percentage seedling establishment for each plot/treatment was recorded by researchers between 28 and 40 days after sowing. Plant height, stem girth, height of first branching, any lodging, general plant vigour and diseases and pests scores (range of 1-5) were also recorded at 3, 6, and 9 months after sowing for all plants in each family. The seedlings were also assessed for CMD and other major diseases and pests such as cassava anthracnose disease (CAD), cassava bacterial blight (CBB), cassava green mite, cassava mealybug and *Bemisia* whitefly. Incidence and severity of diseases at all locations were assessed at 3, 6, 9 and 12 months

Table 2. The female parent of the 18 half-sib families used in the experiments planted at Nkaakom, Aworowa and on-station at Kwadaso.

Accession number	Source	**Nkaakom**	**Aworowa**	**Kwadaso**
TME 1	Nigerian landraces	+	+	+
TME 3		+	+	+
TME 4		+	+	+
TME 9		+	+	+
TME 47		+	+	+
TME 117		+	+	+
TME 279		+	-	+
TME 497		+	+	+
TME 246		+	+	+
TME 396	Togolese Landraces	-	+	+
TME 398		+	-	+
TME 411		-	+	+
TME 270	Ghanaian Landraces	+	+	+
TME 633		+	+	+
TME 644		+	-	+
TMS 30572	IITA-bred clones	+	+	+
TMS 4(2)1425		+	+	+
TMS 92/0326		+	+	+

+/- = included/not included in trial at that site

Table 3. Chronology of activities during the seedling cycle of on-farm cassava evaluations.

Activity	**Nkaakon**	**Aworowa**
Feasibility/introductory visit	March 2000	March 2000
Land preparation	April 2000	April 2000
Situation analysis	May 2000	May 2000
Field layout and planting	13th June 2000	7th June 2000
Watering of planted seeds	18th – 31st July 2000	30th June –14th July 2000
Emergence count	18th July 2000	25th August 2000
Evaluation by agronomist and pathologists	27th August 2000	2nd September 2000
First farmer evaluation	December 2000	December 2000
Evaluation by agronomist and pathologists	February 2001	February 2001
Second farmer evaluation	March 2001	March 2001
Final assessment and harvesting	26th & 27th June 2001	29th June 2001

after sowing. Disease severity was assessed on each plant within the family. Severity ratings were based on a 1-5 scale, 1 representing apparently unaffected plants and 5, very severely affected plants. Pest assessments were carried out during the dry season (November to February) using the same scale (1-5). Finally, at harvest in June 2001, the CRI plant breeder selected seedlings that he would wish to retain for further evaluation using his usual criteria. Farmers evaluated on three separate field days during the annual growing cycle (Table 3). The first was at the 6th month after sowing when the plants were actively growing. The purpose was to know which aboveground characters farmers select for. Each farmer was given an assessment form on which the farmers could identify and record 10 good plants which they would like to grow in their farms and explain why. They were also required to identify and record the 5 best and 5 worst families of seedlings, stating why. This exercise was facilitated by scientists and extensionists. During the second farmer assessment, 9 months after sowing, farmers in small groups were asked to observe and take note of any symptoms of a disease or pest in the trial. The third assessment was carried out at harvest in June, 2001, approximately one year after planting. Its purpose was to assess both below and aboveground plant parts and select good seedlings for further evaluation as clones, recording reasons (Table 4).

Stems of seedlings that were identified by either farmers or researchers (plant breeder and plant pathologists separately) were cut into 12 pieces and used as cuttings for a single replicate clonal field trial in each of the three trial sites. Evaluations were carried out as for the seedling trials.

Table 4. List of families and the number of seedling accessions selected at each of the three sites for second cycle of testing

Families	Nkaakom	Aworowa	Kwadaso
TME 1	6	4	5
TME 3	8	7	5
TME 4	17	6	6
TME 9	15	10	7
TME 47	9	5	2
TME 117	9	3	7
TME 246	5	0	4
TME 270	3	7	2
TME 279	5	13	4
TME 396	0	5	5
TME 398	0	0	6
TME 411	0	7	6
TME 498	15	17	11
TME 633	3	7	5
TME 644	13	0	10
TMS 4(2)1425	17	12	6
TMS 30572	20	10	11
TMS 92/0326	15	18	7
Total	**160**	**131**	**109**

Table 5. Chronology of activities carried out during the first clonal cycle of on-farm cassava evaluation.

Activity	Nkaakom	Aworowa
Land preparation	July 2001	July 2001
Planting	August 2001	August 2001
Watering	August/Sept 2001	August/Sept 2001
Sprouting count	September 2001	Sept 2001
Evaluation by agronomist and pathologists	Sept/Oct. 2001/2	Sept/Oct. 2001/2
Evaluation by agronomist and pathologists	Dec/Jan. 2001/2	Dec/Jan 2001/2
Evaluation by agronomist and pathologists	April 2002	April 2002
Farmer evaluation	May 2002	May 2002
Evaluation by agronomist and pathologists	June 2002	June 2002
Final assessment and harvesting	July 2002	July 2002

Following harvest in July 2002, selected clones were replanted in a further single replicate trial as before (Table 5). However, since now there were more cuttings available, it was also arranged for farmers to take cuttings of five preferred clones and to evaluate them in their own farms against their landraces. Farmers have been asked to

evaluate them using their own criteria. These trials are planned to be harvested in July/August 2003.

Activity 6. Monitor farmer to farmer interactions, including exchange of new genotypes.

Midway during the project, a questionnaire-based survey was conducted to examine, amongst other matters, how much farmers in Nkaakom and Aworowa who were not involved in project activities knew of the project. This is described in detail in Appendix 3 of the Working Paper "Participatory breeding for superior mosaic resistant cassava in Ghana: two years of seedling/clonal evaluation by farmers and scientists." The situation analyses for each village included the development of historical charts by village elders. These were used to investigate changes in the cultivars of cassava grown in each village with time, including the reasons for such changes and the origin of new cultivars

Activity 7. Stakeholder evaluation of participatory breeding approach to cassava.

The previously-described situation analyses in the ten villages but particularly in Aworowa and Nkaakom provided information on the farmers' knowledge and interest in cassava participatory breeding. A questionnaire-based evaluation by farmers of PPB for cassava was done in Nkaakom and Aworowa in September 2001, following one completed cycle of PPB in each village. This is described in detail in Appendix 3 of the Working Paper "Participatory breeding for superior mosaic resistant cassava in Ghana: two years of seedling/clonal evaluation by farmers and scientists."

A consultation exercise was also done, mostly during March 2001, as a means of both learning more about the interest of other stakeholders in Ghana in project activities and developing contacts with other individuals and organisations that may influence cassava selection by farmers or may be uptake pathways for project outputs. A preliminary determination was made that the range of stakeholders to be consulted should include donors to cassava activities, cassava researchers, extension service providers to cassava farmers and end-users of cassava. A joint NRI/ CRI team drew up an initial checklist of questions to guide discussions:-

1. Name/Address/Source of funds/Mission.
2. Their perception of their roles in plant breeding/cassava breeding/cassava propagation.
3. What are they doing in plant breeding/cassava breeding/cassava propagation?
4. Their perception of the roles of others in plant breeding/cassava breeding/cassava propagation.
5. What do they think of our project (strengths/weaknesses/suggested improvements)?
6. (How) would they wish to contribute/be involved?

After drafting the outcome of individual consultation, the resulting resumé of each interview was sent to the individual involved in order to allow them to correct any

errors or misinterpretations. Copies of the report have been distributed, including to all interviewees and also to all participants in the Workshop (see Activity 8). A further opportunity for stakeholders to evaluate project activities towards the end of the project was provided by a Workshop on Participatory Cassava Breeding held in October 2002 (see Activity 8).

Activity 8. Prepare and run a workshop in Ghana to validate current project outputs, identify uptake pathways and examine demand by stakeholders for further initiatives.

A workshop was held at the Coconut Grove Hotel, Elmina, Ghana on 2nd to 4th October 12, 2002:

1. To review project activities and findings with stakeholders;
2. To set project activities in the context of other on-going activities in cassava germplasm research, development and dissemination in order to:
    - Identify uptake pathways;
    - Identify new opportunities for cassava participatory breeding and related activities and build on current achievements.

Participants were identified largely through information obtained during the Stakeholder Consultation exercise and largely comprised pre- and post-harvest cassava researchers at CSIR institutes and various universities, extensionists and officials of the Ministry of Food and Agriculture (MOFA) and farmers. Many of the participants were active in the IFAD-funded Root and Tuber Improvement Project (RTIP). The importance of cassava to Ghana was outlined, setting cassava research and development in context and identifying the main stakeholders involved in the crop. CSIR institutes and universities are particularly important in cassava research including selection of new varieties, MOFA predominates in extension and RTIP is currently funding most cassava research, development and extension activities. The work of the project on participatory selection of cassava genotypes by farmers and scientists, the implications of pests and diseases for this process and the perceptions participating and non-participating farmers of the project were presented to the Workshop by members of the project team. Workshop participants divided into groups to discuss:

1) Pests and diseases as criteria for cassava breeding and variety release;
2) End-user v farmer focused approach to cassava breeding and related activities;
3) Promotion of the product (cassava variety) versus promoting process (participatory plant breeding).

And were then divided into special interest groups to consider the significance for cassava PPB of:

- End-user (rather than specifically farmer) driven breeding;
- Variety release implications;
- Stakeholder capacity (adequacy of etc);
- Social science issues;
- Promotion of cassava PPB project outcomes.

Results were contributed through brief, written comments by individuals and by records of group discussions.

OUTPUTS

The achievements of activities 1 – 8 have largely been described in the following working papers already submitted to CCP and PSRP, to which reference should be made for further details of the methods used, results and conclusions.

- **Situation analysis of villages collaborating in cassava participatory breeding**
- **Participatory cassava breeding in Ghana: consultations with stakeholders + Annex**
- **Participatory breeding for superior mosaic resistant cassava in Ghana: two years of seedling/clonal evaluation by farmers and scientists**
- **Workshop on participatory cassava breeding: update and opportunities**

At least one further working paper describing the outcomes of a survey on informal exchange of cassava genotypes and farmer knowledge and use of sexual propagation of cassava will be produced. Several of these working papers will also contribute to Mr JA Manu-Aduening's PhD thesis and it is intended that, where appropriate, the contents will be published in peer-reviewed journals.

Output 1. A cost-effective system for farmers and researchers producing improved pest-resistant cassava varieties developed.

Output 2. A diversity of superior, disease-resistant cassava clones made available to farmers by researchers.

Outputs 1 and 2 were both addressed by activities 1, 3, 4, 5, 6 and 7 and the latter describe how seedlings from 18 open-pollinated cassava families were provided to farmers. The female parent of these families had a diverse origin, either from Ghana, Nigeria or Togo (TME families) or derived from crosses with wild *M. glaziovii* and possessed such superior characteristics as high storage root yield and resistance, particularly to CMD. These seedling populations were distributed to farming communities and used to compare four breeding approaches:

1. researcher-led on-station (conventional);
2. farmers' selection criteria but on-station;
3. researcher-led on-farm;
4. farmer-led on-farm.

In order to achieve this, the project adopted what was effectively a 2 x 2 factorial experiment comprising "On-station" versus "On-farm" as one set of treatments and "Researcher selection" versus "Farmer selection". Approaches 1 and 2 were done at

CRI research station farm at Kwadaso, involving local farmers for approach 2, and approaches 3 and 4 were done at both Aworowa and Nkaakom.

"On-farm" as a treatment initially comprised identifying two suitable communities and introducing ourselves and the project in order for us to be invited to conduct project activities in each community. It was also an opportunity for each side to make/gain commitments: the researchers offering a diversity of cassava seedlings plus technical knowledge, and the communities offering land, time and technical knowledge. Afterwards, a situation analysis in each community provided background to enable the researchers to interact more effectively with the communities.

Situation Analysis - Findings

Nkaakom Village

Brief background to Nkaakom Village (Table 6)
Nkaakom is located in Atwima district about 5km from the district centre (Nkawie) in Ashanti Region in the Forest Zone. It is 18 km from the city of Kumasi on a main road leading to Nkawie, so Kumasi and Nkawie are significant for both marketing and employment. The population of the village is about 450 and over 65% are farmers aged between 20 and 60 years (MIS data – MOFA 1998). This district has a bimodal annual rainfall ranging between 1200 and 1600mm per annum. The soils are shallow, relatively fertile (can support most arable crops) and the land is mostly flat.

Nkaakom village was established in the late 1700s or in the early 1800s. The village was prosperous during the period of the First World War (1914) when great wealth was derived from the sale of cocoa. The great fire outbreaks of 1983 destroyed cocoa and food crop farms on a large scale in the village resulting in food shortages and hunger. However, by 1987, farming activities had been revived somewhat with the re-establishment of cocoa farms. Farmers in this village have been exposed to agricultural research and extension and other developmental activities over the last fifteen years.

Main Food Crops
Plantain, cocoyam, several species of yam, tomatoes, eggplants and pepper were the main food crops reported to have been cultivated by the early settlers of Nkaakom. Maize and cassava were introduced to Nkaakom in 1945, increasing available food. By 1983, cassava and maize had become, and still remain, the most important food crops in Nkaakom followed by plantain then yam.

Cash Crops
Cocoa was the first cash crop cultivated by the early settlers in the village and has remained so. Virgin lands were easily accessible to settlers between 1800 and 1965 and this contributed to high production of cocoa, making Nkaakom a prosperous village. Cocoa production peaked between 1950 and 1965. Cassava and maize were cultivated as

cash crops after the independence of Ghana in 1957. Cocoa, cassava and maize are the main cash crops of the village.

Livestock

Early settlers of the village kept poultry on a limited scale but depended mostly on bush meat, which the available virgin forests supplied. Very little has changed over the years as goats, sheep and cattle were never favoured in the village as these animals were considered potential destroyers of farm crops. The poor development of livestock was also due to disease outbreaks during the rainy season that killed most of the introduced animals.

Cassava

Early settlers of Nkaakom did not cultivate cassava. The first variety to be cultivated in the village, "*Edabo*", was introduced from Volta region into Nkaakom in 1945 possibly through a migrant farmer and is still being cultivated. A migrant farmer also introduced a second variety, "*Kwabena Amo*", to Nkaakom from Volta region in 1957, also still being cultivated. "*Bankye green*" was introduced to the village from Koforidua in 1970 by a local woman. In 1983 a variety called "*Owereko*"was introduced into the village from Ejisu by an Nkaakom farmer but this variety was abandoned as its tubers rot in the wet season. "*Bankye broni*", introduced into the village in 1983, has been abandoned for the same reason. Most cassava is intercropped, usually with maize although cocoyam, plantain and other crops may be added at the later stages of growth (Figs. 1 & 2). Sole cassava cropping occurs when farmers choose to replant cassava following harvesting a previous cassava crop as the land may then not be able to support any other crop.

Figure 1. Cassava cropping calendar of Nkaakom as given by the women

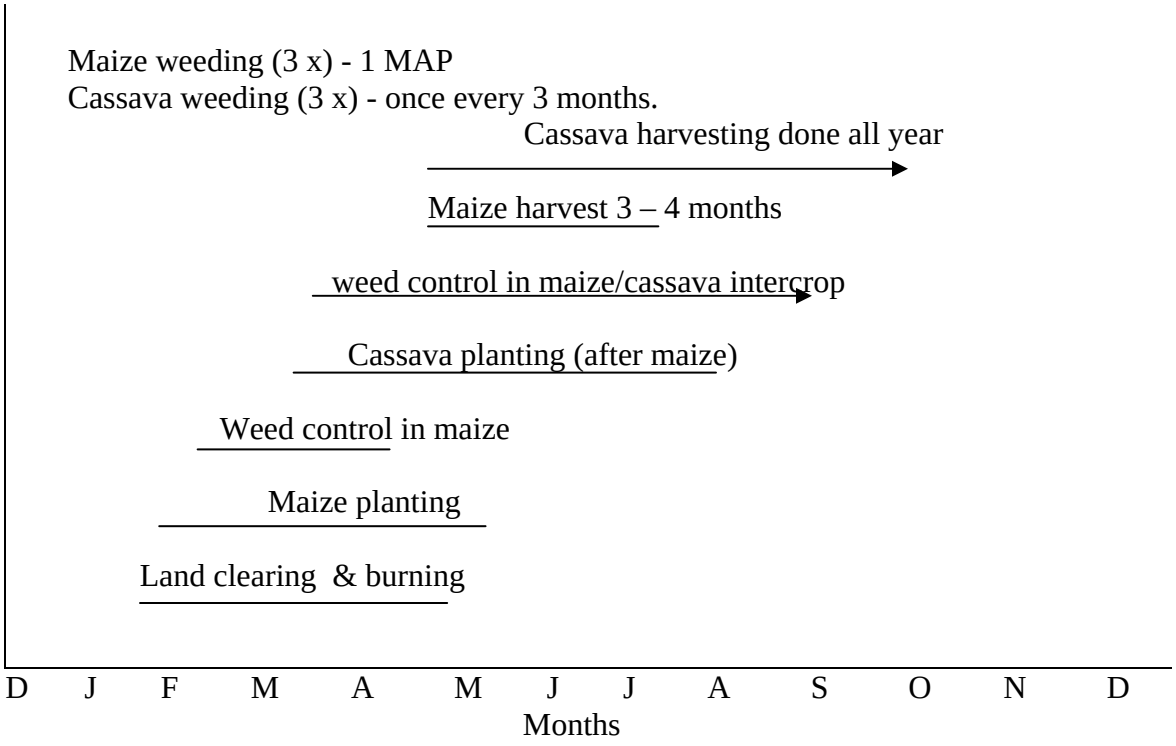


Figure 2. Cassava cropping calendar of Nkaakom as given by the men

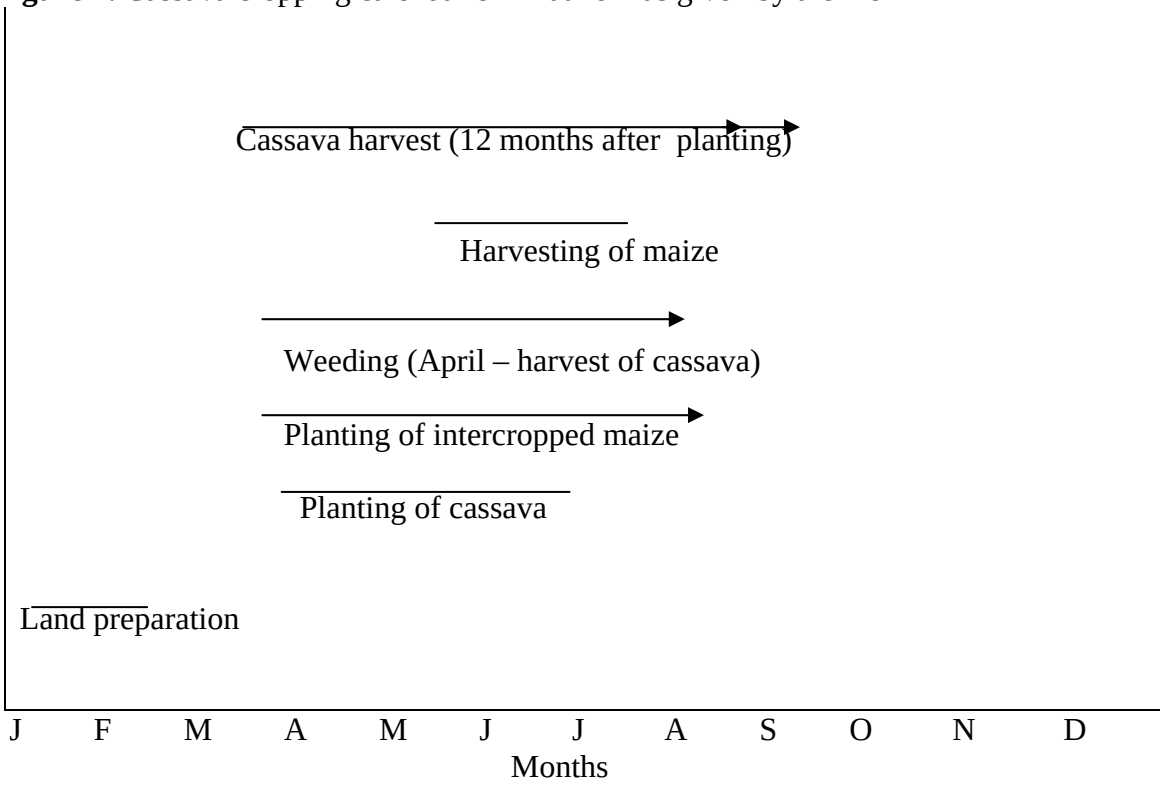


Table 6. Situation analysis at Nkaakom village, Forest Zone 20 May, 2000

Checklist	Women	Men	Elders
Land	Rent is No. 2 constraint, but yield not a high priority.	Land owned by individuals. Some also rent when need to expand-rent from those in village with spare land. Land is normally cropped continuously for 6 years and then fallow for 4 years. Land near main road is being sold for housing etc. A cassava farmer has about 1 acre of cassava	1800-lots of land available. In 1940s, land started to be rented or share cropped. Now land is scarce and not easily available. No true fallow. Lots of land occupied by cocoa trees. Cassava & maize increased post - independence due to land shortages.
Farming system		More than 10 years ago, rainfall started in Feb and stabilized by end of March. Now starts in March and stabilizes by May. Land is generally fertile and can support a crop for 3 years.	1800 - land very fertile Post -independence logging - land less fertile Bush meat (eg grasscutters and bush rats) still available. No virgin forest.
Crops	Cassava and maize most important food and cash crops. Cocoa not important. 90% of cassava intercropped with maize. 10% sole cassava (following previous cassava crop). Cassava+maize +cocoyam+plantain intercrop. Fields cleared -Feb - March Planting - April-Nov Weeding-every 3 months Harvest -after 15-16 months onwards. Plant by plant as needed for daily use. *Source of planting material* Cassava planted after maize emerges. Maize is weeded as for cassava and harvest after 3-4 months *Who did what?* No pests, especially after first weeding (just rotting of roots)	Cassava and maize highest priority, but cocoa also significant. Maize is main cassava intercrop. Cocoa yam appears as volunteers Fields cleared Jan-Feb Planting cassava Apr-Aug Weed as required Rogue diseased plants (Farmer Field School farmers) Harvest 12 months + depending on variety. Harvest whole field. Planting material from own field. If not buy from own village or outside village. Plant maize Apr-July. Maize after cassava. Weeding as for cassava. Harvest 3-4 months later. Everybody (men, women and children) participate in all activities except clearing (men only). Men plant cassava with cutlasses/ women with hoes. Pests on cassava: *mmembe* (grasshoppers); *sonsono* (worm-like pest which chews leaves). Mealybugs?	Cassava and maize for food Cocoa for cash

Cassava knowledge	Seedlings produce only 1 tuber which is round. Cuttings produce many tubers. On request, 1 woman brought a seedling sample. Most women didn't recognise cotyledons as different (1 did).	Men drew fruit (round + 1 seed). Picture showed many tubers from seedling, but actually knew it had only 1 tuber. Never planted seeds. Always removed seedlings because had only 1 root.	
Cassava types	5 types known, but only 2 commonly used. *Need to clarify names as some seem different* 4 attributes + 1 (poundability in dry season) Poundability - No. 1 Yield-No. 4	4 types, but only used 2. Scientists criteria are very good (as reflected in varieties brought to village) BUT no market for these varieties 9 attributes Cash =1 Yield=2 *Fufu*= 4 No-one working with seedlings	Currently 3, but 5 over entire time
Utilization	*Fufu*/gari/kokonte/ cassava dough	*Fufu*/ gari Money; Food security; School fees; security for loan (cassava field). One farmer has bought a vehicle (bankye burger) using profits from cassava.	Cassava not preferred food
Institutions	Inside-School/ Church/ farmers group Outside-Agric (MOFA)/Self-help group/market/Vocational training (sewing, hair dressing). Good contact with agric.	Inside-school/ church/ cassava-maize association Outside-Agric/FFS(IFAD)/ Research Given power tiller by IFAD for transport also helped to construct tracks to fields. Get visitors due to cassava-maize assoc. Good contact with Agric, but not NGOs. Main source of info- other farmers e.g. a new cassava variety this way.	
Constraints	Labour	Labour Weeding affects health	
Opportunities	New varieties-high yielding + poundable Cassava processing plant Cocoa is coming up	In response to prompted question: Varieties with high yield, high branching to suppress weeds, in-ground storability, disease and pest tolerance, good taste.	

Aworowa Village

Brief background to Aworowa (Table 9)
Aworowa is located in Techiman District in Brong-Ahafo Region on the main road from Techiman to Wenchi and is in the Forest Savannah Transition Zone. This zone has an erratic bimodal annual rainfall ranging between 900 and 1500mm *per annum*. The land is hilly and the soils are gravelly on gentle slopes and easily eroded. Aworowa's population is about 6000 of which 67% are farmers (National census data, 2000). The present Aworowa settlement was established in 1900 by movement of the people of Amanfoso (about a kilometre away from the present township) to a location close to the main road linking Techiman and Wenchi. Outbreaks of fire in 1983 also brought hardships here, farms being burnt and food crops lost, leading to famine. There was also lack of income as cocoa farms also got burnt. Research and extension activities on food crops especially maize, cassava and cowpea under the Ghana/CIDA Grains Development Project (GGDP) and other projects led by MOFA and CRI has been active in the village since 1979. It also has a communal gari factory.

Main food crops
Around 1900, yam, cocoyam and plantain were the main food crops cultivated in Aworowa. Cassava was a minor food crop, as the indigenous people of the area use little or no cassava in their meal preparations. The composition of the main food crops in Aworowa changed as cassava gained prominence and maize was introduced into the farming systems. Arranged in an order of importance the main food crops of Aworowa in the 1950s to 1973 were cassava, yam, plantain, maize and cocoyam. Cassava still predominates, followed by yam and maize.

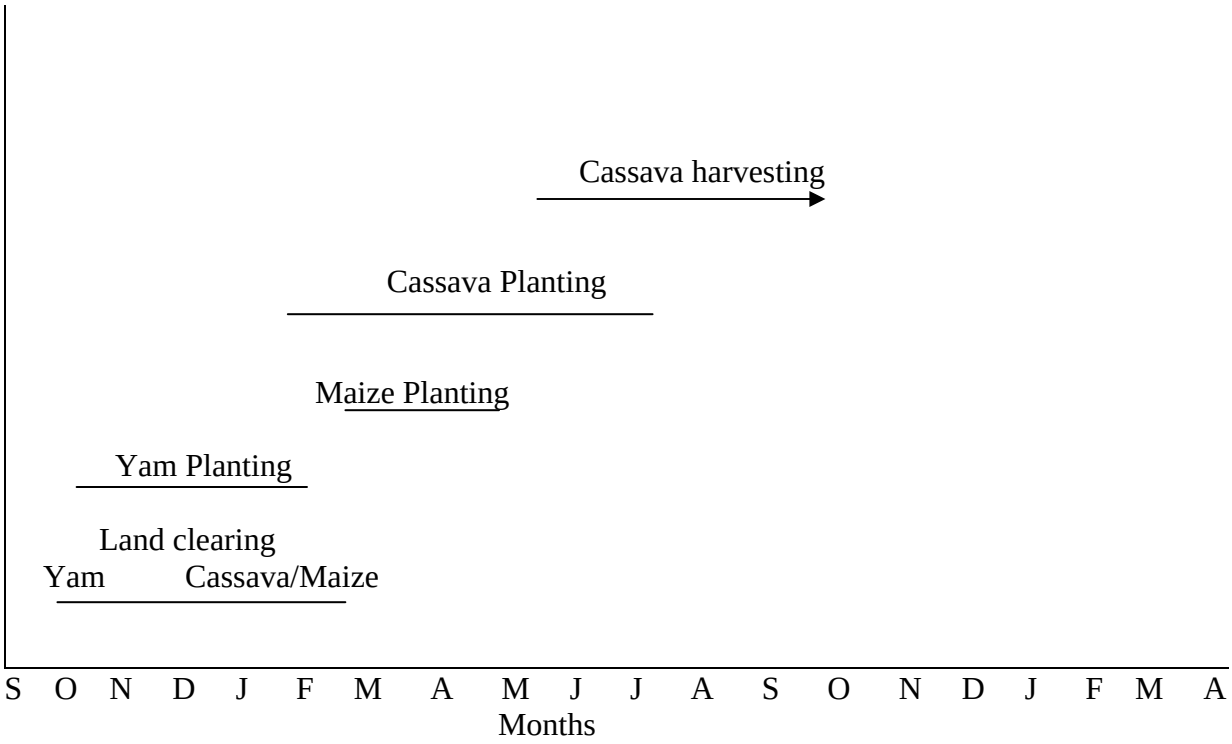
Cash crops
Cocoa and cola nut were the main cash crops of Aworowa from the early settlement era until 1951 when maize was grown on commercial scale. In 1983, however, fire destroyed most of the cash crops of Aworowa and cassava, maize, cashew and cocoa, in that order of importance, are now the main cash crops.

Livestock
Sheep, pigs, poultry and ducks were the livestock kept by the people around 1900 and the composition of livestock did not change until 1970 when goats were introduced. The fires of 1983 destroyed some of the livestock of the town. Cattle were introduced into Aworowa in 1997 and the current livestock includes sheep, pigs, poultry, ducks, goats and cattle.

Cassava
Two varieties of cassava cultivated early in the history of Aworowa, "*Bankye kokoo*" and "*Azuma*", could be traced as part of the early food crops grown around 1900. "*Bankye kokoo*" was phased out in 1970. A little "*Azuma*", however, is still produced. A local farmer introduced the variety "*Akosombo*" into Aworowa in 1967 and is still grown. "*Wenchi bankye*" and "*Bankye Bodee*" were introduced in 1970, *Wenchi bankye* displacing

"*Bankye kokoo*". An Aworowa farmer introduced "*Wenchi bankye*" from nearby Wenchi. "*Sefwi bankye*" has been cultivated since 1985 and is still grown. Two other varieties, "*Nkomti*" and "*Agric bankye*", were introduced in 1995 and 1996 respectively. An Aworowa farmer introduced "*Nkomti*" from Nkwaeso.

Figure 3. Cropping calendar of Aworowa as given by women group



Cassava is both monocropped and intercropped, with maize as the most common intercrop (Figs. 3 & 4). Cassava is utilized in the following forms in the order of importance: *Fufu*, kokonte and gari. It is also used in preparation of soup (leaves), selling of the stems (as planting materials), and as animal feed, for soil fertility maintenance and as a source of income to support livelihood (cash, vehicle, housing, marriage ceremonies, and marriage proof of security). The cassava attributes desired by the farmers were good yield, early maturity, large tubers poundable into *fufu*, good for gari, and marketable (Tables 7 & 8).

Table 7. Matrix ranking of the cassava types and the attributes desired by the women farmers in Aworowa.

Attributes	**Types**						
	Wenchi bankye	*Nkomte*	*Akosombo*	*Bankye fufuo*	*Asrene*	*Sefwi bankye*	*Bankye kokoo*
Yield	1	2	3	4	5	6	7
Maturity	3	1	4	2	4	4	4
Tuber size	1	6	2	3	4	5	7
Fufu	2	1	4	6	7	5	3
Gari	6	5	3	2	1	4	7
Marketability	1	2	4	6	7	5	3
Total	**14**	**17**	**20**	**23**	**28**	**29**	**31**
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Figure 4. Cropping calendar for Aworowa as given by men

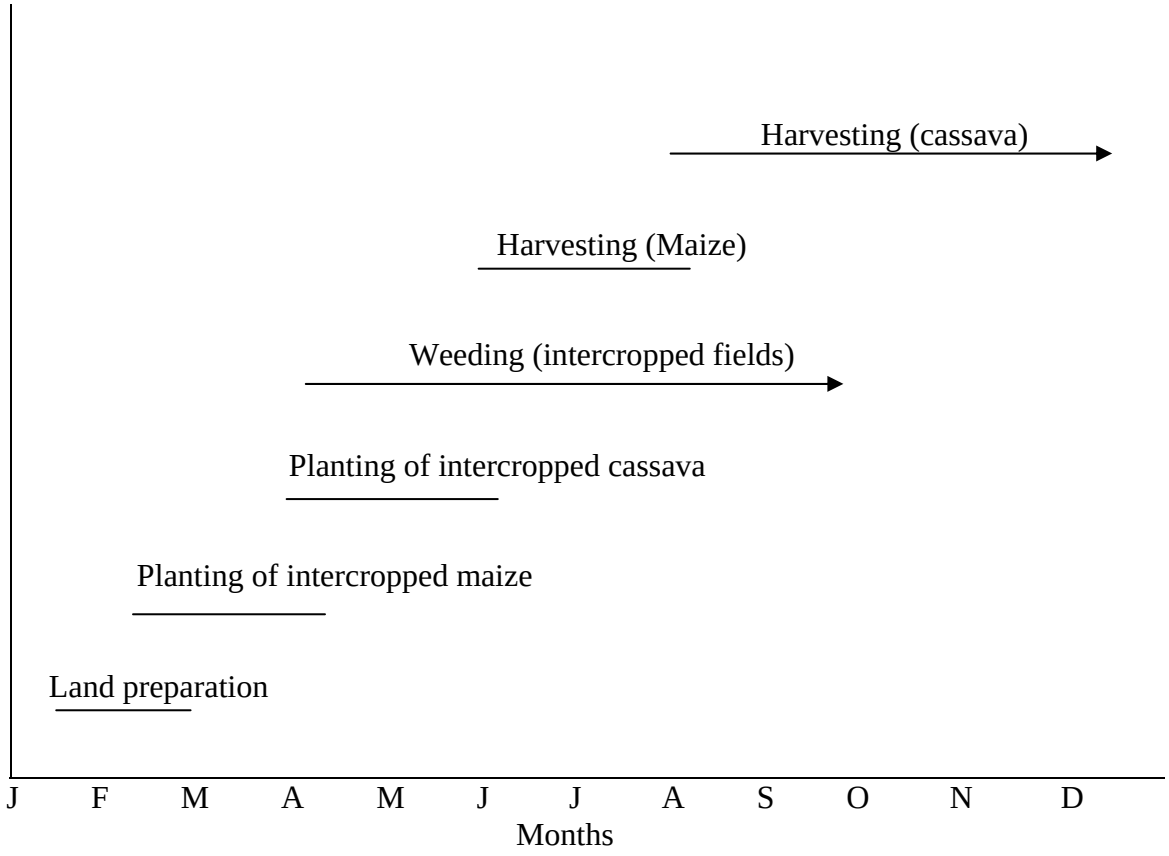


Table 8. Matrix ranking of cassava types and attributes mentioned by male farmers at Aworowa.

Types	**Attributes**											
	Fufu	Yield	Cash	Gari	Konkonte	Earliness	Animal feed	In-ground storage	Taste	Fertility management	All year poundability	Total
Wenchi	1	1	1	2	2	2	same	1	8	1	8	27
Akosombo	5	2	2	1	1	5	"	2	8	8	8	41
Nkomte	3	3	3	3	8	1	"	8	3	8	8	48
Bankye kokoo	2	5	5	5	8	8	"	3	2	8	1	47
Sefwi bankye	4	4	4	4	8	4	"	8	1	8	2	47
Besere-bemma	8	8	8	8	8	3	"	8	8	8	8	75
Taboo	8	8	8	8	8	8	"	8	8	8	8	80
Akrosoma	8	8	8	8	8	8	"	8	8	8	8	80

Table 9. Situation analysis at Aworowa, Transition Zone: 23 May, 2000

Checklist	Women	Men	Elders (all men)
Land	Family land -those without (e.g. settlers) have to rent. Sharecropping - for maize/cassava intercrop: maize=Abusa (2:1) cassava =Abunu (1:1) Land is available to rent. Farm size = 1 acre. Both men and women can inherit. Head of family (man or woman) rents	Difficult to get land. Increased population. Land available to rent: Abunu; Abusa; Cash rent. Farm size = 3 acres.	Land is available. Population pressure causing renting.
Farming system	Declining soil fertility. More weeds and increase in spear grass. Cassava No, 1 food & No. 2 cash Maize No. 1 for cash	Rainfall changed over 10 years. Duration reduced (previous started in Feb; now March/ April or May). Soil-was forest, now grassland. Less fertile and evidence is more weeds. No.1 crop maize; No 2 cassava Bush meat - declining through bush fires. Sheep; Poultry; goats; duck; cattle; rabbit; pigs and snails	4 soil types:Asaase tuntum (black), Asaase *fufu*o (white) Asase kokoo(red) Ewora (valley bottom soil) No area set aside permanently e.g. forest Cash-cassava; maize; cashew; cocoa Food-cassava; yam; maize plantain; cocoyam; beans Livestock: sheep; pigs; poultry; goats; cattle; ducks
Cassava Cropping systems	Maize/cassava (M/C) M/C+ yams Cassava <u>M/C:</u> Land preparation-Feb-Mar Plant-March-Oct Weed-1 MAP + at least twice more Harvesting- 7 - 18 MAP depending on variety Women mostly cultivate cassava (men – tomato) Planting material from own fields; neighbours; neighbouring villages.		
Cassava knowledge	Seedlings have one round tuber which is not eatable. Stem cutting produces many tubers One woman said if you take cutting for seedling stem, it produced normal tubers, but other women tried to suppress this suggestion. Don't plant seeds. Usually uproot seedlings.	Describe seeds, cotyledons, long taproot of seedlings, but said it had no tuber.	
Cassava types	Types = 7 Attributes = 6 All attributes are essential, but may not be found in all. Poundability mentioned a lot. None of women using seedlings	Types = 9 Attributes = 11 Ranked attributes; Poundability, Yield, Cash Research criteria not known, because not involved. Only one farmer using seedlings - thought seedlings very vigorous	Types = 8 Mentioned yield
Utilization	*Fufu*/ Kokonte/gari/Cash/ Leaves (+cocoyam leaves) (all varieties) Human food and livestock feed Cassava keeps land 'warm' Sell stems	*Fufu*/Gari/Kokonte/Akple/Akyeke/ Animal feed Fertility maintenance Livelihoods: cash, food, vehicles, housing, marriage ceremony; marriage proof of security(cassava field)	
Institutions	Inside- Clinic, School, Market, Post office, gari factory, Yam farmers group. For cassava: Market, Gari factory. Outside: Techiman market; No agric	Inside-church, school, Agric, Police, Clinic, Processing plant/ Gari factory?	
Constraints	Weeds, Soil fertility, Grasscutter Poor soils promote weeds. Weeds encourage grasscutter. Doing nothing to address Need cash for : Clearing, mounding, 1st weeding No idea how research can help	Cash to expand farm; lack of buyers; in ground storage; processing; low yields; lack of transport from fields to village.	
Opportunities	Good opportunity- can be stored as gari. Prompted - new varieties from research		

Issues emerging from the approach/method adopted.
The approaches used in the situation analysis allowed quick understanding of the study area. It was qualitative, took a short time (compared to formal surveys) to undertake and provided some information for the project from its start. However, there was a need to go back for supplementary information.

The historical chart effectively and efficiently addressed the history of the participating villages *vis-a-vis* the introduction and growth of cassava production in the study area. In both villages, cassava has become important in the last decades and it is associated with population increase and a decline in access to land. The villages have an oral history which includes cassava and goes back to the time when they were founded. The collective memory was convincing in that the parts that could be checked were accurate.

Land issues were not properly addressed, and village maps were drawn separately. An increasing shortage of land and unequal distribution of land has led to increased renting and sharecropping. In both villages, individual families own the lands and these are entrusted to each family head. There has been a decline in soil fertility due to deforestation and continuous cropping reported in both villages.

The crop calendar gave ample information on the cultivation of cassava and associated crops. There is labour shortage during land preparation, planting and harvesting. Land clearing and weeding involves much labour. Aworowa had started using tractors and Nkaakom is using some herbicides. The long distance to walk is not a key problem of the land shortage: however, it increases labour charges for carting the heavy cassava home and to market.

Preference ranking was effective in investigating the cassava types and their desired attributes as perceived by the farmers. Reasons ascribed to the choice of a particular type of cassava could contribute to the project and challenged current on-station plant breeding procedures and selection criteria. In particular, our information highlights that: -

- Most cassava in both villages is planted as an intercrop alongside maize.
- Poundability (required for making *fufu*) is the top priority of the farmers.
- Not much knowledge on pest and disease was expressed even though cassava mosaic was common in their crops.

The Venn diagram used to investigate the association of various institutions existing/operating in the village could not be well understood by the women farmers. However, there seemed to be relatively few, perhaps no, organisations with which our work sits well, particularly in Aworowa. Current institutions may be useful more as secondary means of information flow – for example, use as notice boards – rather than as organisations we work directly with. The current organisations may also be too exclusive: -

- The maize-cassava group in Nkaakom may exclude women and may exclude non-maize growers.
- None of the institutions we were told of in Aworowa included any Muslim ones.

A constraints table constructed from idea cards led to considerable discussion, revealing many farmer-perceived constraints to cassava. The major constraint mentioned were, labour shortage at peak periods, low soil fertility, weeds, poor market avenues, poor in-ground storage of cassava root, and lack of cash to buy inputs. Cassava production seemed very much associated with (but no evidence that it caused) increasing pauperisation as land resources become exhausted and divided amongst an increasing population. Cassava was introduced to both villages at times of economic hardship and with the aim of increasing an inadequate food supply. Increasing cassava production is similarly associated with decreasing soil fertility, associated with increasing population, lack of spare land and consequent inability to allow land to lie fallow, and over-logging. Cassava is planted throughout the rainy season, but probably mainly at the beginning of the rains. Land preparation is a major constraint in both villages.

Table 10. Changes in area planted with cassava over 10yrs by market access and rainfall regimes as determined by number of responses of farmers in ten villages.

Production	**Market access**			**Rainfall regimes**		
	Good	***Medium***	***Poor***	***High***	***Medium***	***Low***
Increase	99*	69*	33	78*	38*	85*
Decrease	27	13	20	25	10	25
Same	15	6	4	8	11	6
Can't tell	3	1	1	4	0	1

* Chi-squared test: significantly (P>0.05) more farmers responding that cassava production will increase rather than decrease.

They have several varieties, which vary in time of maturity of tubers, their in-ground storage and time when they are poundable. Aworowa has more varieties than Nkaakom. All cassava varieties seemed to have come from elsewhere than our villages. Harvesting is generally from 12 months and can be piecemeal for family use. In Nkaakom, tubers are used mainly to prepare *fufu*, either to be eaten by the family or by a purchaser. In Aworowa, there is a local *gari* factory too. Cassava is an important crop for young farmers just starting off; at least in Nkaakom, lack of job opportunities in nearby Kumasi was forcing youngsters to stay in the village. At present, most cassava is intercropped with other, more demanding crops such as maize, but increased pressure on land may lead to monocropped cassava. However, intercropping is also a way by which farmers try to get more out of the same piece of land, so this outcome is not certain. For many reasons, however, **it seemed certain that cassava production will continue to increase.** This conclusion was later confirmed by a survey in a further eight villages (Table 10).

Achievements of cassava breeding at the three sites

Seedling generation (2000 – 2001)

Farmers' first assessment: aboveground characters
In all, 76 farmers took part in the first assessment, 51 farmers at Nkaakom and 25 farmers in Aworowa. Tables 11 - 13 summarise different aboveground characters used in the assessment by farmers in the two villages. In both villages, farmers listed characters such as high canopy formation and branching. These characters are associated with plant vigour, cassava multiplication ratio (i.e. amount of stem materials/plant for making new cuttings), weed control and intercropping. Others such as stem size and cracking of soil (assumed to be by tubers expanding underground) were farmers' indicators for likely yield.

Farmers frequently mentioned healthy or green leaves but they seemed to attach less importance to the converse (the presence of pests and diseases), as most of the plants they recorded showed some symptoms of diseases and pests. It is noteworthy that most of the characters used by farmers are not used in conventional cassava breeding in Ghana.

Table 11. Farmers' main aboveground selection criteria (times* chosen) by gender and villages during the first assessment.

a) Nkaakom

Farmers		Characters						
Gender	No. of farmers	Shade/ Canopy formation	Stem Diameter	Branching Height	Healthy/ green leaves	Suitable for intercropping	Cracked soil	Resist lodging
Men	30	72	57	64	43	2	5	4
Women	21	38	51	37	18	16	3	1
Total	51	110	108	101	61	18	8	5

b) Aworowa

Farmers		Characters						
Gender	No. of farmers	Stem Diameter	Branching Height	Shade/ Canopy formation	Healthy/ green leaves	Cracked soil	Suitable for intercropping	Resist lodging
Men	19	76	59	42	35	28	7	9
Women	6	24	18	13	10	11	3	1
Total	26	100	77	55	45	39	10	10

*Farmers each gave reasons for up to 10 plants; the number of reasons was open-ended.

Table 12. The five best cassava families selected by farmer of the two villages based on aboveground characters

Nkaakom/ rank	Families	Farmers' reaction	Aworowa/ rank	Families	Farmers' reaction
1	92/0326		1	92/0326	
2	30572		2	TME 498	
3	TME 9		3	TME 9	
4	TME 4	Increasing	4	4(2)1425	Increasing
5	4(2)1425	Preference	5	TME 279	Preference

In both villages, the 5 best families selected by farmers (on the basis of their aboveground attributes) were either the progenies of released varieties or Nigerian half-sibs (Table 7). All the half-sib families from Togo (Table 8) performed poorly.

Table 13. The five worst families selected by farmer of the two villages based on aboveground characters

Nkaakom/ Rank	Families	Farmers' reaction	Aworowa/ rank	Families	Farmers' reaction
12	TME 117		11	30572	
13	TME 246		12	TME 396	
14	TME 270		13	TME 117	
15	TME 633	Decreasing	14	TME 411	Decreasing
16	TME 398	Preference	15	TME 47	Preference

Disease and pest assessments by farmers

The pests and diseases recognised by farmers in each of the villages were similar though some of their descriptive names for them were different (Tables 14 & 15). For example, cassava mosaic disease (CMD) is described in one community as *Bankye Kwata* (cassava leprosy) whilst in the other as *Bankye adadewa* (stunted growth). In both villages, farmers appeared to have more knowledge of the pests than of the diseases of cassava, perhaps because the former are more apparent. Consistent with this, some of the plants and families selected for evaluation in the next growing season showed signs of severe disease. Similarly, bees, though causing no damage, were considered as a pest and spiders, though actually beneficial predators, were considered to be pests. The farmers also mentioned a belief that the most disease and pest susceptible cultivars yield adequately in their villages, taste better and are most suited for the preparation of local dishes.

Table 14. Summary of cassava pests and diseases identified and described by farmers at Nkaakom

Pests/diseases Farmers name	**Pests/diseases English name**	**Description of symptoms**	**Mode of infection**	**Importance**	**Control measures**	**Uses**	**Time of infection/ infestation**
Nkanka	Termites	-thin leaves	-insects -soil borne	-dehydrates the tuber -low yield -lodging	-treat soil with chemicals	None	-any time -dry season
Bankye Nkokodwie	Mealybug	-rolled leaves	-contact (from leaf to leaf)	-causes dehydration -yellowish leaves	-rogue out	None	-any time -dry season
Bankye Adadewa *Bankye sasabro*	Cassava Mosaic disease	-stunting -shortening of internodes -chlorotic	-infectious	-low yield -affect tuber quality	None	None	-rainy season
Bankye kuro	Anthracnose	-	-infectious	-low yield -prone to lodging	None	-cannot use infected cuttings for planting	-any time
Bankye dwie	Cassava lice	-leaf distortion -produces white substance	-termites	-does not cook	Chemical spraying	None	Dry season
-	White galls or swollen stem	-white galls	Unknown	Not important	-	-	Dry season
Mmebe	Grasshoppers	- hopping insect	Unknown	-roguing	-	-	Dry season

Table 15. Summary of cassava pests and diseases identified and described by farmers at Aworowa

Farmers name	English name	Description of Symptoms	Mode of infection	Importance	Control measure	Uses	Time of infection/ Infestation
Bankye kwata	Mosaic virus	-rolled leaves -distortion of leaves -stunted growth	-cuttings -ants (insects)	low yield poor growth	-clean & healthy cuttings -plant on fertile soil -chemical treatment	None	-rainy season -onset of dry season
Apaapaye	Anthracnose	-produces cracks on the stem	-grass-hoppers	Necrosis death of tissues with cracks poor germination	-spray against grass hoppers	None	-usually 10 months after planting
-	Die-back	-stunting	-grass hoppers	low yield	None	None	not known
-	Grasshoppers	-chew leaves	-grass hoppers	low yield	-no control -chemical		Dry season
Akate	Mealybug	-short inter nodes -produces white substances on leaves	- ants	poor growth poor yield poor establishment of diseased cuttings	-chemical spraying	None	Dry season (Jan- Mar)
Nkanka	Termites	-pre-mature death -poor yield	-Soil borne -insects	poor yield poor growth	-chemical treatment	None	Dry season (Jan-Mar)
Ananse	Spider	-produces black colouration	-insects	stunting low yield	None	None	Wet season
Kankabi	Millipede	-produces black/brown colouration	-insects	chew leaves	None	None	Wet season
Wowa	Bees	-brown colour	-insects	sucks juice from flowers	None	None	Wet season

Farmers' assessment at harvest

Table 16. Farmers' selection criteria at harvest.

Criteria	**No. of times mentioned**			
	Kwadaso	**Aworowa**	**Nkaakom**	**Total**
Tuber yield	307	227	258	792
Branching	51	96	85	232
Big stem	39	99	86	224
Suitable for *fufu*/*ampesi*	75	50	69	194
Tuber shape	16	81	14	111
Weed suppression	2	31	46	79
Healthy(green) leaves	3	37	18	58
Suitable for intercropping	6	0	35	42
Processing	1	26	14	41
Marketable size	25	0	5	30
Neck length	0	10	12	22
Starch content	8	0	0	8
Tuber skin colour	11	1	7	19
Resistant to lodging	2	9	5	16
Poundable all year	4	0	10	14
Maturity (early)	2	0	12	14
Non-rotten tubers	12	0	1	13
Non-fibrous tubers	8	0	3	11
Drought tolerant	1	0	2	3
Disease resistant	0	0	2	2

Yield was the most important attribute (scoring 54% at Kwadaso, 34% at Aworowa and 37% at Nkaakom) for the individual farmers (Table 16). This supports what most farmers said during the first two evaluations; that most attributes they mentioned such as good canopy, thick stem, soil cracking and branching were being used as indirect indicators of high root yields.

High branching and high canopy formation make the plants more competitive with weeds resulting in greater radiation interception and a high rate of photosynthesis. Farmers also frequently mentioned suitability for *fufu/ampesi*, though, this could not be determined by visual observation of the foliage. Disease resistance was rarely mentioned; pest resistance was not mentioned. However, since pest and disease resistance support high yields, farmers may have been incorporating these characters indirectly.

Researchers' assessments of pests and diseases status in the study area

Generally, three cultivars (*Wenchi bankye, Bensre benma* and *Akosombo*) were the predominant landraces found on farmers' fields (around the project site) at Aworowa. At Nkaakom, the common cultivars were the landraces; *Ebado, Bankye green, Bankye fufuo, Bankye broni* and the released varieties*; Afisiafi* and *Abasafitaa*. At the time of the survey,

most of the fields observed were 6 months and older. At Aworowa, all the cultivars were badly affected by CMD with a score ranging from 3 to 4.5 and yield seemed likely to be seriously affected. Anthracnose was low (av. 2.5); CBB and bud necrosis was absent. Pests such as cassava green mites were absent but a few *Bemisia whiteflies* were found early in the mornings. The common weed found was spear grass (*Imperata cylindrica*). Most farmers intercropped cassava with maize, plantain, cocoyam, cowpea and citrus or oil palm. Most of the soils are a well-drained sandy loam. At Nkaakom, the severity of ACMV was mild (av.3). CBB was absent but there were a few incidences of anthracnose.

Pests and diseases found in the seedling trials.
Families TME 9, TME 1, TME 279 and TME 498 had a lesser proportion (<50) of individuals affected by CMD (Table 17). Overall, TME 498 had about 70% of unaffected seedlings, rather more than for the progenies of the released varieties, 92/0326, 4(2)1425 and 30572. The mean severity of CMD for affected seedlings at the three locations ranged between 2.4 and 4.5. Data on cassava bacterial blight indicated that several of individuals were susceptible to CBB. The percentage of infected plants ranged up to 78%, though damage was generally not severe. CAD infection levels were low: the highest was 15% (TME 1).

Table 17. Shows the percentage number of plants for each family that were infected with the three diseases (ACMV, CAD and CBB) at six months after planting. Mean severity in parenthesis

Families	Nkaakom			Aworowa			Kwadaso		
	ACMV	CBB	CAD	ACMV	CBB	CAD	ACMV	CBB	CAD
TME 9	39.6 (3.4)	5.1 (2.0)	0.0 (1)	41.7 (4.1)	47.2 (2.1)	0.0 (1)	44.4 (3.3)	8.3 (3.3)	0.0 (1.0)
TME 1	41.7 (2.9)	38.9 (2.0)	0.0 (1)	62.2 (3.6)	35.5 (2)	0.0 (1)	60.0 (2.9)	0.0 (1.0)	15.0 (2.3)
TME 279	47.5 (2.7)	69.6 (2.1)	0.0 (1)	37.2 (3.9)	25.6 (2.0)	0.0 (1)	51.2 (3.4)	0.0 (1.0)	4.8 (2.5)
TME 246	71.4 (3.5)	78.6 (2.0)	0.0 (1)	-	-	-	71.8 (3.1)	10.2 (2.7)	5.1 (2.0)
TME 270	77.8 (4.5)	50.0 (2.0)	0.0 (1)	87.8 (3.6)	30.3 (2.0)	0.0 (1)	62.9 (3.1)	0.0 (3.1)	0.0 (1.0)
TME 117	65.3 (3.8)	32.6 (2.1)	2.0 (2)	76.7 (3.2)	37.2 (2.0)	4.6 (3.5)	86.1 (3.0)	0.0 (1.0)	8.3 (2.3)
TME 633	78.4 (4.1)	21.6 (2.1)	0.0 (1)	94.6 (3.6)	77.3 (2.0)	0.0 (1)	91.1 (3.3)	8.9 (3.0)	1.3 (3.7)
30572	32.7(2.8)	55.2 (2.0)	2.0 (1)	44.8 (2.8)	67.2 (2.1)	0.1 (1)	60.5 (3.5)	0.0 (1.0)	11.6 (2.6)
TME 4	47.7 (3.4)	56.8 (2.0)	0.0 (1)	41.9 (2.9)	35.5 (2.1)	0.1 (1)	28.9 (3.6)	0.0 (1.0)	7.8 (2.0)
TME 644	57.9 (3.7)	47.6 (2.0)	3.5 (2)	-	-	-	67.4 (2.8)	27.9 (3.2)	2.3 (3.0)
TME 47	68.5 (4.1)	29.6 (2.3)	0.0 (1)	98.2 (3.6)	64.8 (2.1)	0.0 (1)	76.4 (4.5)	31.2 (3.1)	5.8 (2.0)
92/0326	38.3 (3.6)	63.3 (2.0)	1.0 (3)	33.3 (2.5)	29.6 (2.0)	0.0 (1)	70.7 (2.8)	0.0 (1.0)	9.7 (2.5)
TME 498	39.5 (3.4)	60.5 (2.1)	2.3 (3)	26.1 (3.5)	26.1 (2.0)	0.0 (1)	29.2 (3)	0.0 (1)	0.0 (1.0)
4(2)1425	23.1 (3.0)	62.9 (2.1)	0.0 (1)	51.9 (3)	63.4 (2.1)	0.0 (1)	63.8 (3.3)	0.0 (1)	2.3 (2)
TME 3	45.0 (3.4)	65.0 (2.2)	0.0 (1)	30.7 (3.8)	42.3 (2.7)	0.0 1)	29.1 (2.4)	4.2 (3.0)	0.0 (1)
TME 398	50.0 (4.3)	37.5 (2.3)	0.0 (1)	-	-	-	71.8 (3.3)	0.0 (1.0)	10.3 (2.7)
TME 396	-	-	-	93.0 (4.3)	30.2 (2.0)	0.0 (1)	87.8 (3.4)	7.3 (3.0)	2.2 (3.0)
TME 411	-	-	-	89.2 (3.0)	53.5 (2.8)	3.5 (3)	87.5 (3.0)	6.3 (3.0)	3.1 (3.0)

Table 18. Mean yield (MT/ha) of cassava seedling (by families) selected by farmers and scientists.

Family	Aworowa	Nkaakom
TME 1	11.05	13.8
TME 3	17.4	30.3
TME 4	22.9	23.3
TME 9	32.8	17.9
TME 47	16.5	23.8
TME 117	9.5	13.9
TME 246	-	11.9
TME 270	18.3	8.7
TME 279	14.8	17.3
TME 396	13.8	-
TME 398	-	32.1
TME 411	19.7	-
TME 498	18.8	20.7
TME 633	18.2	14.6
TME 644	-	20.4
30572	15.3	26.3
4(2)1425	21.2	28.0
92/0326	20.4	31.9
Mean	**18.0**	**21.4**

Yields

A mean yield of up to 32t/ha for selected seedling in the different families was recorded in both villages (Table 18), with yields of individual seedlings considerably higher. This was very encouraging as it was higher than the yields apparently expected by most farmers from plants of their own landraces normally grown using cuttings and was especially surprising to them as it came from seedlings. However, this was also suspected to be somewhat misleading. The extreme diversity of vigour of different seedlings and the susceptibility of some to CMD resulted in some plants having little competition from the neighbours. The mean yields of selected seedlings of most of the families were several times higher than the average yield of 12.1 t/ha for cassava in Ghana (FAO, 2001).

Table 19. The ten best families selected at harvest by farmers in the two villages.

Nkaakom		Aworowa	
Families	**Frequency**	**Families**	**Frequency**
TME 644	62	TME 498	51
TMS 30572	58	TMS 92/0326	49
TME 9	49	TME 1	49
TME 4	49	TME 633	46
TME 633	37	TME 4	44
TME 279	35	TMS 4(2) 1425	32
TME 117	31	TME 279	27
TME 27	26	TME 9	25
TMS 4(2)1425	25	TME 270	18
TME 1	22	TME 411	12

Table 20. Seedling selections by farmers, cassava breeder and pathologists

Location	***Seedling***	**Farmers**	**Breeder**	**Pathologists**	**Total selected**
Aworowa	702	104	100	74	131
Nkaakom	653	127	85	62	160
Kwadaso	687	91	59	69	109
Total	**2,042**	**322**	**244**	**205**	**400**
Correspondence with farmer's selection			86%	64%	

Corresponding selections: Farmers/breeder = 209
Farmers/pathologists = 131
Breeder/pathologists = 119

There appeared to be some correspondence between the families selected as best in both villages, TME 9, TME 4, TME 633, TME 279, TME 1 and 4(2) 1425 all being highly ranked in both villages (Table 20). Selections of individual seedlings by farmers and breeders corresponded closely. This is reassuring in that it confirms that farmer and professional plant breeder selection has a sufficiently similar outcome for them to be able to collaborate effectively. Selection by farmers and pathologists and by the breeder and the pathologists was less close. Pathologists' selection was based mainly on absence of disease and pest damage and, at least directly, did not include such characters as yield, plant vigour and other phenotypic characters so it is perhaps surprising that their selections overlapped as much as they did.

Evaluation of project activities.
A survey was carried out in September 2001 by a CRI social scientist to ascertain farmers' perception and evaluation of the participatory cassava breeding project in its

first year of operation. See Appendix 3 of Working Paper – Participatory breeding for superior mosaic resistant cassava in Ghana: two years of seedling/clonal evaluation by farmers and scientists. This revealed that farmers valued the project activities, in particular, the knowledge they were gaining on seedlings and also the new genetic resources they were accessing. However, they also emphasised the cost of their involvement to themselves and indicated a desire for recompense other than knowledge and cassava diversity.

First clonal generation (2001 – 2002)

Farmers' assessment on the aboveground attributes (9 months)
Farmer selection criteria at 9 months on the aboveground attributes of the first clonal generation of the selected accessions followed a similar pattern in both villages and as for the previous selections amongst seedlings (Table 21). The emphasis was again on characters such as tall stems, suitability for intercropping, "nice-looking" leaves (though not necessary disease-free), good branching (provides more planting materials), thick stems (implying large tubers) and good weed suppression.

Table 21. Farmer selection criteria at 9 months based on the aboveground attributes

a) Nkaakom

Farmers		Characters					
Gender	No. of farmers	Stem length	Stem size	Branching	Nice leaves	Intercropping	Weed control
Men	31	28	31	14	25	20	42
Women	15	26	10	21	32	36	31
Total	46	64	41	36	57	56	73

b) Aworowa

Farmers		Characters					
Gender	No. of farmers	Planting materials	Stem size	Branching	Healthy leaves	Intercropping	Weed control
Men	31	13	6	12	24	14	29
Women	5	39	15	5	10	22	13
Total	36	52	21	17	34	36	42

Farmers' assessment at harvest (12 months)
At harvest, in both villages almost all the farmers when stating the reasons for their individual selections of 10 clones mentioned yield, poundability, and early maturity in their individual written explanations (Table 22). Other characters such as non-rotting tubers, marketable tuber size, disease-free and suitability for intercropping were also

mentioned. However, when farmers at Nkaakom were asked as a group to rank the characters mentioned in their selection, the top three characters were non-rotting (1st), poundable all year round tubers (2nd) with tuber yield only coming third. It is not easy to explain the difference. Farmers were clearly subjected to "peer pressure" when responding in a group, but it neither explains why the result should differ nor identifies which is the more meaningful. This should be clarified as farmers make closer evaluations of the clones in their own fields.

Table 22. Ranking of characters by Nkaakom farmers as a group or as individuals in their selection at harvest.

Rank	Group ranking	Individual ranking
1	Non-rotting tubers	Tuber yield
2	Poundable all year round	Healthy leaves
3	Tuber yield	Big stem
4	Marketable tuber size	Branching
5	Suitable for intercropping	Marketable tuber size
6	Early maturing	Disease free
7	Resistance to lodging	*Fufu* and *Ampesi*
8	*Fufu* and *Ampesi*	Weed control
9	Disease free	Tuber skin colour
10	Branching	Suitable for intercropping
11	Non-fibrous tubers	Early maturing
12	Round tuber shape	Resistance to lodging
13	Planting materials	Tuber shape
14	Big stem	Non-rotting tubers
15	Red tuber colour	Poundable all year round
16	Neck length	Drought resistant
17	Healthy leaves	Non-fibrous tubers

Result of farmers' mealiness test (texture and taste) indicated that 73 out of the 168 accessions at Nkaakom were good for either *fufu* or *ampesi* with only three of them being bitter (Table 23). At Aworowa 51 accessions were also selected and at Kwadaso, 68 were selected. These figures look promising but the test must be carried at different times of the year in order to meet the number two requirement (poundable all year round) of the farmers.

Table 23. Farmers' assessment of texture and taste of boiled tubers at harvest

Location	No. of accessions	Texture -good	Texture -soggy	Taste - good	Texture -bitter	No. selected
Nkaakom	168	70	6	52	3	73
Aworowa	141	51	15	71	12	51
Kwadaso	116	68	8	65	5	68

Selection

As with the seedling selections, selection of clones by farmers and breeders was close, 60% of seedlings selected by farmers overlapping with the selection by breeders (Table 24). Also again, correspondence between selections by the farmers and the pathologists, and by the breeder and the pathologists was less close.

Table 24. Numbers of clones selected by farmers, cassava breeder and pathologists

Locations	No. of clones evaluated	Checks added	Farmers' selections	Breeder's selections	Pathologists' selections	Checks selected	Total selected
Aworowa	131	10	63	55	93	4	67
Nkaakom	160	8	61	36	31	3	64
Kwadaso	109	7	58	48	37	5	60
Total	**400**	**25**	**182**	**139**	**161**	**12**	**191**

Corresponding selections: Farmers/breeder = 82
Farmers/pathologists = 74
Breeder/pathologists = 69

Table 25. Correspondence of farmers' selection from year 1 to year 2

Locations	No. of accessions selected	Checks added*	Selected by farmers in yr. 1 (A)	No.of (A) selected in yr.2	Other seedling clones selected from yr. 1.	Checks selected in yr.2*	Total selected by farmers in yr.2
Aworowa	131	10	104	46	13	4	63
Nkaakom	160	10	127	50	9	2	61
Kwadaso	109	10	91	47	6	5	58
Total	**400**	**30**	**322**	**143**	**28**	**11**	**182**

* Checks comprised 2 released varieties, 3 local landraces and 5 landraces selected from amongst germplasm collect in Brong Ahafo

*Checks selected by farmers:

local landraces = 1
Introduced landraces = 6
Released varieties = 4 (NB; Afisiafi, IITA clone TMS 30572 was mainly selected)

Farmers appear to have had a degree of consistency in their selection, selecting 44 % of the seedlings they had selected as seedlings and only 36% of the seedlings selected previously by either the pathologists or the plant breeder, though this was not statistically significant (Table 25). Surprisingly, only one in nine of their local landraces were considered worth retaining by the farmers. However, farmers selected the introduced landraces in six of 15 opportunities and the released varieties in four of six opportunities. The selection of the introduced landraces was not surprising given their high yields. The

main released variety selected was cv Afisiafi, IITA clone TMS 30572. In fact, this variety has not been readily adopted by farmers but this is apparently largely due to its poor poundability, and the clonal selections have not yet included this attribute even though it was subsequently tested.

The frequency of selection by the farmers showed that 36 of 38 farmers at Nkaakom all selected one plant (ie. agreed on same plant) out of the 170 accessions present ($P<0.05$) and 13 were selected by 8 or more farmers (Fig. 5). Similarly, 42 of 54 farmers at Aworowa all selected one plant (ie. agreed on same plant) out of the 141 accessions present ($P<0.05$) and 22 plants were selected by 7 or more farmers (Fig. 6). Both these results indicate a high degree of correspondence between selections by farmers.

Figure 5. Correspondence of selection of accessions by farmers at Nkaakom

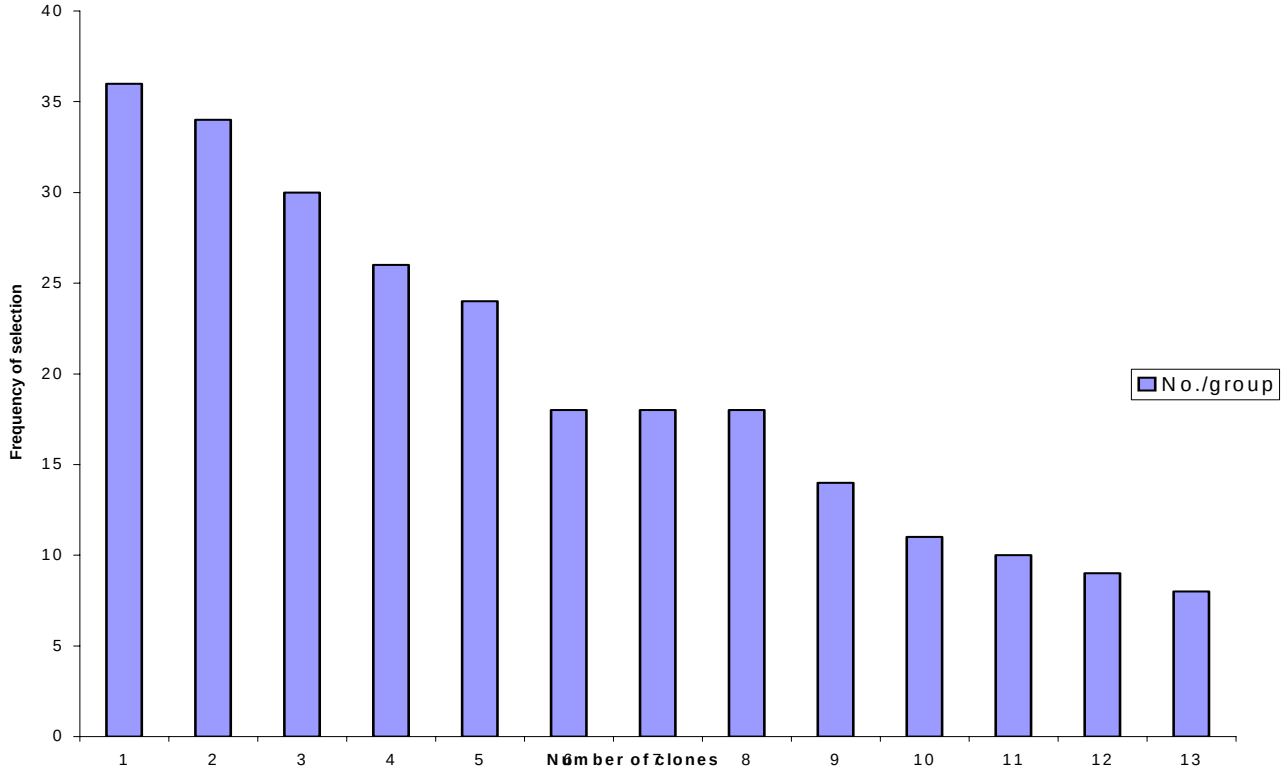
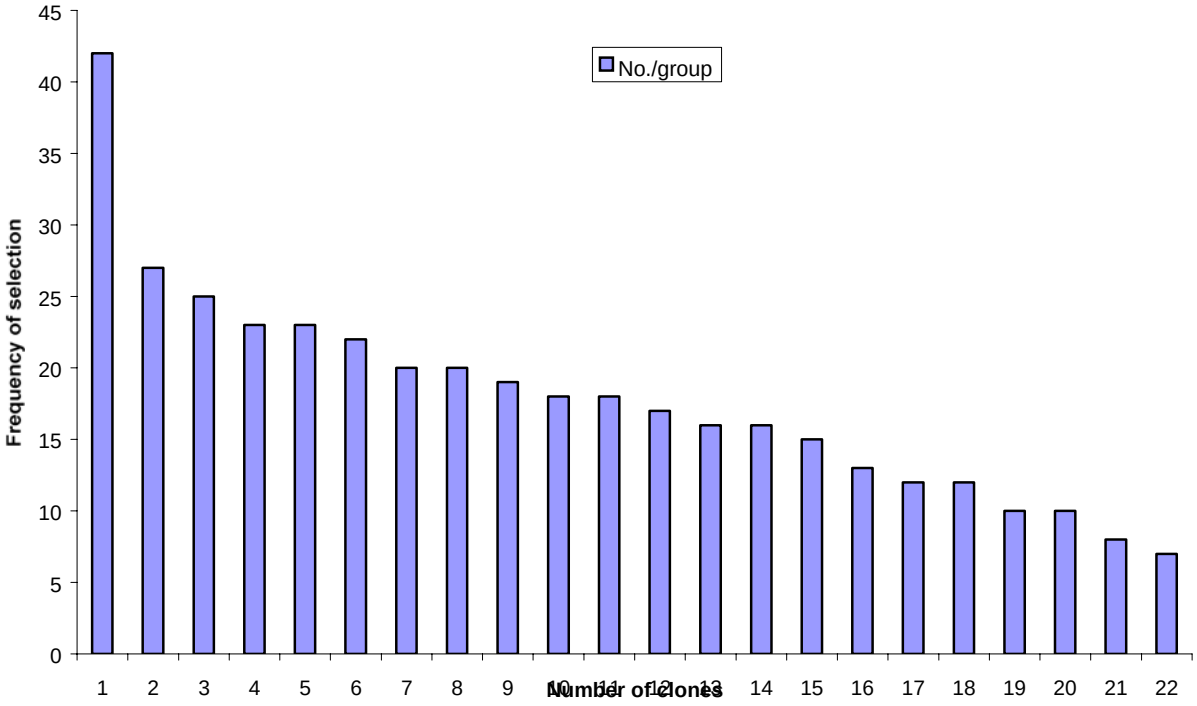


Figure 6. Correspondence of selection frequency by farmers at Aworowa



Overview and Conclusions of cassava breeding activities

Achievements of participatory breeding activities
From a total of 2042 seedling established in year one at the three locations, 400 (20%) were selected at the end of year one and 179 (9%) by year 2 (Table 26). This selection was the combined result of selection by two key stakeholders (farmers and researchers [plant breeder + pathologists]), so ensuring genotypes perceived as useful by either group were not discarded.

Farmer selection criteria were identified. Generally, farmers in both villages listed 9 major characters they use as their guide for the selection of cassava. These are: yield, non-rotting tubers, healthy/green leaves (disease-free plants), thick stems, early branching and high canopy formation (weed control), poundability, suitability for intercropping and resistance to lodging. Other characters such as stem colour were mentioned but do not seem to be very important.

Table 26. Summary of progression of cassava population selected from seedling to clonal stage 1.

Locations	*Seedling*	**Clonal - 1**	**Total selected**
Aworowa	702	131	63
Nkaakom	653	160	61
Kwadaso	687	109	55
Total	**2,042**	**400**	**179**

IITA seedlings represented a huge increase in diversity available to farmers. Farmers were happy to see and learn about the wide diversity of cassava in the garden. They were fascinated by the wide diversity and the high yields which resulted from the use of seeds; most of them enquired to the scientists about the use of seeds in their own fields. IITA seedlings included many genotypes that were very resistant to CMD.

General observations

Farmers **selected** accessions based on a **wide range** of **positive** characters whilst plant breeders and researchers tend to **reject** accessions based on a **few negative** characters.

Farmers' knowledge of the identities of pests seemed better than that for diseases: they seemed to know little about the mode of infestation/infection, control, and their effects on yield and quality.

CMD seemed to be the main disease of cassava in the villages, almost all plants of the local landraces being affected. However, there seems to be no quantitative data available for Ghana on the likely effects of this on yield, or conversely on the benefits to be expected from incorporating CMD resistance.

Whilst a criticism of formal breeding has been that it focuses on yield (see Introduction), farmers also seemed to do the same, at least in the evaluations so far. It will be interesting to examine whether this changes in their more detailed evaluations on their home-farm.

Emerging issues

- There is a need to develop wider links with more institutions so as to **promote** the outcomes (both process and product) of the project.

- The issue of variety release has not been fully addressed. Whilst unreleased genotypes can be utilised by farmers (e.g., landraces), they cannot be disseminated officially so release is important in ensuring rapid widespread access by farmers.

- The increase in diversity of cassava now available to farmers may provide the potential for cassava to address **new markets** (end-users). A "classic" example is that several of the accessions had bright orange flesh, indicating the presence of β-

carotene. This may give such genotypes an "edge" as chicken feed, providing the natural colorant for yellow yolked eggs.

- Diseases (especially ACMD) continue to be a major constraint in cassava production. Though successes have been made through the use of CMD-resistant seedstocks, there is the need for increased **training** for farmers on disease and pest management.

- MOFA and other institutions as well as farmers must be encouraged to consider the trials as their own, so that they begin to take their own initiatives whilst continuing to collaborate with researchers.

- Researchers should be more open to the opportunities made available from the availability of local/indigenous knowledge as a guide in the breeding/selection process.

Conclusions

An overview of the activities and processes used during the two-year participatory breeding for superior mosaic resistant cassava is presented in Table 27. These activities were mostly collaborations and have created new learning environment for researchers, extensionists and farmers. It has also improved linkages within and between national institutions.

Although Table 27 has several "layers" and therefore seems likely to involve much time, in reality this was not so. Many of the "layers" involved brief communications or meetings with relatively few individuals. The Situation Analysis used PRA techniques designed to obtain the essential information quickly. It involved six researchers/ extensionists plus farmers one day collecting data and the research team two days in analysis. The latter at least could be reduced as the key decisions for which information was required for the PPB were "Shall we work with this village (yes/no) and, if so, how and who shall we work with?". There were two farmers' days during the annual growing cycle. These had no role in the actual selection process but did have a role in informing farmers and maintaining interest. They could be linked to other learning activities. A major output of the Project was to have developed a system whereby, apart from the pathologists' selection, selection by both the CRI cassava breeder and the farmers became focused into a single intensive day when the crop was harvested. The process therefore involved little additional researcher time compared to conventional breeding. It also involved little time of individual farmers (though it involved a lot of farmers) and farmers found it useful.

Table 27. Summary of Participatory Cassava Breeding activities and processes used

Processes	**Responsible groups**
1. **Planning**	
a. Planning meetings at CRI	NRI/CRI/MOFA
b. Research team formation	
c. Identification, definition and prioritising of problems and opportunities – situation analysis	
d. Feasibility/introductory visit	
2. Trial (On-farm and on-station)	
a. Choice of trial and design	NRI/CRI/MOFA
- Researcher-led on-station/on-farm	
- Farmer –led (selection criteria) on-farm/on-station	
b. Source of planting materials	
- Origin (landraces from Ghana, Nigeria & Togo)	IITA
- Crossess (IITA, Ibadan, Nigeria)	
- Released varieties & locally selected landraces	
- Data to be collected (farmers, scientists & other stake holders)	NRI/CRI
3. Conduct of trials	
a. Farmer and site selection	FARMERS /CRI/MOFA
b. Management of trials	
c. Data collection	
d. Farmer and researcher evaluation/selection of genotypes	
e. Data analysis	
f. Review of trial results and research activities	
- Team review	
- Review workshop	

The PPB also required no costly maintenance and staffing of a research farm and it is noteworthy that the only calamity to affect a trial was the waterlogging and consequent tuber rotting at Kwadaso farm. Time and effort were expended by the research team making monthly visits to each trial to collect various agronomical and pathological data. These were partly collected to support a PhD thesis of a team member. Some of the data may also be required to support future applications to the Variety Release Committee. It is at present, however, unclear what these requirements will be in Ghana for a genotype identified by PPB. Although the PPB has inevitably (given the annual nature of the crop) achieved only two selection cycles, the CRI plant breeder is already convinced that useful genotypes will be identified within another two annual cycles, far faster than the minimum of about a decade for conventional breeding. He and the research team also recognises that time will have been gained because material will already have been tested on-farm and time will not be wasted because genotypes selected over several years on-station are ultimately rejected by farmers.

The project team recognises that the model PPB developed so far is not the final model. With the current model, all seed originated from Nigeria. A single continent-wide centre at which diverse genotypes can be maintained for all has some logistical advantages but there would also be advantages in assessing parental material for future Ghanaian varieties in Ghana. The role of CRI and CRI scientists in identifying and accessing appropriate germplasm for future crosses and seed needs consideration. The current model fails to take into account the requirements of end-users poorly known to farmers. Perhaps this needs to be included or perhaps such requirements can best be satisfied by on-station breeding. The needs of the Variety Release Committee have also not been addressed.

Output 3. Knowledge of farmer perceptions and practices in relation to cassava propagation (including seedlings), selection (including mosaic resistance) and exchange.

Importance of cassava flowers, seeds and seedlings in the farming system

Generally, farmers knew and have observed cassava flowers, seeds and seedlings on their landraces grown on their farms (Table 28 - 32), several appreciating that not all cultivars flower and some realising that flowering did not occur in non-branching cultivars (the flower derives from the terminal bud of a shoot and new shoots come from axillary buds). Farmers had a wide range of incorrect concepts of the role of pollen, none realising its necessity for setting seed, consistent with one previously reported comment that bees may be a pest (Table 15). Given that seeds are unimportant in the usual propagation of cassava - by cuttings - this is of little consequence in normal cassava cultivation, but are farmers aware of the role of pollen in their crops for which it is important, for example, maize?

The Coastal Savannah was unusual in that most farmers interviewed there had not seen seedlings (Chi-squared: $P<0.05$). Indeed, farmers in one village reported that they had no seedlings, and this was confirmed by the transect walk. Farmers were divided roughly equally into whether they left them in their fields or weeded them out and a few had used them, for example, eating the tubers. It seemed important that the main reason why farmers had used planting material derived from seedlings was because there was a shortage of other planting material. In most villages, at least one farmer was experimenting with seedlings.

Table 28. Farmers' (300) observations and use of cassava flowers, seeds and seedlings across all villages

Activity	Observation/question	Response	% observed*
Cassava flowers	Ever seen flowers	Yes No	91.3 4
	Months seen	Some have seen them in all months but 60% identified June - October	
	Seen on all varieties	Yes No	65.8 27.1
	Non-flowering types	Non-branching types	12
Pollen	What does pollen do	Brings diseases Sheds cassava leaves Plants matured Honey Don't know	4.8 2.7 11.6 2.4 60.9
Cassava seeds	Ever seen seeds?	Yes No	80.8 11.1
	Ever done anything with them?	Yes No	4.6 59.5
Cassava seedlings	How do you recognize them	Stands straight Bigger stem First to be seen Only one tuber Grows faster Poor tubers	26 5.7 7.1 10.1 4.1 2.4
	Ever done anything with them?	Allow to grow Destroy them	28 26.2
Tubers (seedlings)	Ever eaten tubers from seedlings?	Yes No	25 44
	How often seen	Yearly Not every year	38.7 13.4
	Months seen	March – June & September	

* Values in this column refer to the percentage of responses by 300 farmers. Not all farmers responded to all questions so totals do not always equal 100.

Table 29. Observation of cassava flowers by 300 farmers in different cropping systems.

Cropping system	**Observed flowers?**			
	Ever seen cassava flowers? (%)		***Do all your varieties flower? (%)***	
	Yes	**No**	**Yes**	**No**
Monocropping	38	2	27	14
Intercropping	222	10	156	64
Total	*260*	*12*	*183*	*78*

Table 30. Observation of cassava seedlings across the different agroecological zones by 300 farmers.

Ecological zones	Ever seen cassava seedling	
	Yes	***No***
Forest	103	16
Coastal Savannah	12	39
Forest-Savannah Transition	20	5
Guinea Savannah	35	6
All zones	*170*	*66*

Table 31. Farmers' (300) observation of where cassava seedlings are mostly found

Location	**Observed seedlings (%)**	
	Yes	***No***
Abandoned fields	30	34.8
Abandoned cassava fields	41.9	19.9
Margins of foot paths, pathways and fields	9.2	39.9
Abandoned but recently cropped fields	45.9	16.2
Cassava tops have been abandoned	29.5	25.8
Elsewhere	6.1	37.6

Table 32. Farmers' (300) experience on cuttings from cassava seedlings

Activity	Response	%
Ever used cuttings from seedling?	Yes	24.4
	No	43.4
If yes, when?	Last 10yrs.	<20
Why?	Scarcity of cuttings	11.5
	Good yield	3
	Nice looking	7.1
	Early maturing	0.3
	To experiment	1.7
From where?	Old cassava field	21.6

Cassava varieties

Despite the common presence of seedlings, farmers in all ten communities reported in interviews that their cultivars all originated outside their village. There was very little recent importation of new varieties reported, except in the north where poor migrant workers returned from the more prosperous south with planting materials of new varieties. In most of the villagers, cassava was neither the initial nor the preferred food. It was generally introduced to the villages after the First World War and its introduction was associated with depletion of the forest and declining soil fertility. Cassava appeared to have arrived earliest in the communities in the Coastal Savannah, consistent with historical records of its introduction through coastal trading ports.

In most of the villages, 3 - 6 varieties were reported (Tables 33 & 34). Consistent with a previous COSCA report, most villages had no knowledge of officially released varieties. In two or three villages where farmers planted between 5 and 9 different varieties, most of the farmers were settlers or occasional emigrants from south and whether this diversity would be temporary is unclear. A few of the varieties were planted in more than one village and more than one ecological zone. Almost all cassava plants were affected by CMD: anthracnose and leaf blight were also observed on transect walks.

Table 33. The number of farmers in each village mentioning a particular cassava variety

Varieties	Villages										**All**
Zone	Forest					FS T	Coastal Savannah		Guinea Savannah		
	Agona Nkwanta	***Nyamebekye re***	***Nkaakom***	***Kwaa Darko***	***Akey Amanase***	***Aworowa***	***Wuti***	***Koluedor***	***Jonikponta***	***Yapeilgu***	**Total**
Bensre benma	5	4				18					27
Wenchi						10					10
Bankye kokoo			1			1					2
Ampenkyene	1										1
Agege				3							3
Bosome nsia				4			4		1	5	14
Duafra				10	5						15
Madumaku				1	1						2
Kwaku				1							1
Nkuguo				3							3
Tuaka				1	18						19
Afisiafi				4							4
Asrodo				1							1
Ankra					4						4
Tiwusi					1						1
Beambase									26	1	27
Achilo	16										16
Buyado										18	18
Abunadow										2	2
Banadwe										1	1
Dadzie										3	3
Debo			28								28
Bankye green			1								1
Salaga							6				6
Fetogbedgi							5				5
Agric							7				7
Volovi							3				3
Katayide							5				5
Adwo	2	21									23
Lagos								9			9
Adesu								3			3
Katawere								5			5
Akpanya								6			6
Olabalaba								7			7
Steer	4	2									7
Congo	1										1
Kantatu	3										3
Total Varieties/village	***7***	***3***	***3***	***9***	***5***	***3***	***6***	***5***	***2***	***6***	

Table 34. The number of different cassava varieties mentioned by farmers for the different access to market in the different ecological zones

Different markets	**Ecological zones**			
	Forest	***Coastal savannah***	***Forest-savannah transition***	***Guinea savannah***
Good	18		3	
Medium	9	4		
Poor				7
Total no./zone	***27***	***4***	***3***	***7***

Source of cassava varieties and reasons for keeping them

Most of the farmers considered they had received the original planting material for the varieties they were growing from other farmers (Table 35). Others considered they had always maintained their own planting material, presumably retaining it within the family between generations.

Table 35. Farmers' original sources of cassava varieties and reasons for keeping them

Varieties	**Source of variety**	**Reasons for keeping variety**
All vars listed in table 7	Own: 119 (41%)	Marketability : 97.6%
	Other farmers:161 (55.7%)	Good post harvest: 94.6%
	Research: 4 (1.4%)	In-soil storage: 89.6%
	MoFA: 2 (0.7%)	Good for gari: 88.5%
	Others: 3 (1%)	More branching: 86.5%
		Disease tolerance: 82.9%
		Insect tolerance: 82.9%
		Early maturing: 82.9%
		Late maturing: 72.5%
		Poundability: 70.8%
		Good tuber size: 58%

Table 36. Farmers' main reasons for planting cassava and their uses

Activity	Response	Proportion
Why plant cassava	Cash Food Both	5.4% 5.1% 88.5%
Proportion sold last year	<25% 25-50% 50-75% 100%	8.5% 17.1% 28.1% 39.2%
Month sold	Mainly March-April	13-15%
Any market in mind	Yes No	86.5% 8.1%
Uses	*Fufu* Gari Agbelima Etc.	

Table 37. Relative importance of some attributes of cassava to farmers interviewed across all villages.

Attributes	Ratings (%)			
	Very important	***Some what important***	***Not important***	***Can' t tell***
Yield	97	2	0.3	0.7
Tuber size	93.9	3.7	0.7	1.7
Marketing	93.7	1	5	0.7
Maturity(early)	92.9	4.4	0.7	1.7
In-house storage	92.5	2.7	1.4	2.7
Tuber number	89.9	6.1	1	2
Is-soil storage	88.5	6.1	2.4	2.7
Taste	87.5	8.8	1.7	1.7
Lodging tolerance	85.1	11.8	1	1
Food processing	82.4	6.1	8.8	2.4
Disease tolerance	74.2	17.6	5.4	2.4
Pest tolerance	73.2	17.3	6.4	2.7
Industrial processing	66.6	17.6	12.8	2.7
Branching	52.7	27.7	17.2	2
Plant height	31.4	27.7	38.2	2

Output 4. Scientists and farmers experienced in PPB.

At the beginning of project activities, Mr JA Manu-Aduening, the main Ghanaian actor in the project, attended a course on Participatory Natural Resources Management at the Natural Resources Institute in October 2000 and the MSc plant breeding unit course at Birmingham University in January 2001. He has also led the project cassava breeding activities in Ghana throughout and he is currently a thesis to be submitted as part of a PhD programme to the University of Greenwich. However, most project activities have involved a team comprised of researchers from the Crops Research Institute in Ghana (JA Manu-Aduening, E Moses, AA Dankyi, JN Lamptey, GA Mensah) and the Natural Resources Institute in UK (RW Gibson, RI Lamboll and L Kenyon) working closely together. All these researchers gained considerably in knowledge of PPB, though perhaps especially the CRI cassava breeder, Mr GA Mensah, learning firsthand the criteria of farmers and other stakeholders for a "good" cassava cultivar. The project also made agriculturalists in Ghana generally more aware of PPB, for example through the stakeholder consultations and through the workshop.

Output 5. Workshop on cassava participatory breeding

Which will achieve the following:

- Project activities and findings reviewed with stakeholders;
- Project activities set in the context of other on-going activities in cassava germplasm research, development and dissemination and
- uptake pathways identified;
- Opportunities for cassava participatory breeding and related activities identified.

The workshop attended by about 38 participants was held at the Coconut Grove Hotel, Elmina, Ghana on 2nd to 4th October 12, 2002. A detailed account of the workshop activities, processes and achievements are given in a working paper entitled: 'Workshop on participatory cassava breeding: update and opportunities.'. Participants largely comprised pre- and post-harvest cassava researchers at CSIR institutes and various universities, extensionists and officials of the Ministry of Food and Agriculture (MOFA) and farmers, representative of much cassava-based activities in Ghana. Presentations were made to the meeting describing the importance of cassava to Ghana, setting in context cassava research and development and identifying the main stakeholders involved in the crop. Presentations were given on participatory selection of cassava genotypes by farmers and scientists working within the project, the implications of pests and diseases for this process and the perceptions by participating and non-participating farmers of the project.

- Cassava Research and Development — Mr S.K. Nyamekye
- Participatory selection of cassava — Mr J.A. Manu
- Implications of pests and diseases for participatory cassava breeding — Dr E Moses

- Farmers' assessment of our communal cassava breeding trials Dr A Dankyi

- Participatory breeding in Ghana: consultations with stakeholders Mr R Lamboll

These presentations were then discussed, other Workshop participants contributing their experience to validate or question project achievements.

Subsequent sessions based on both group discussions and plenary sessions were used to identify uptake pathways and new opportunities for cassava participatory breeding and to examine how best to build on current achievements. The following broad conclusions were drawn.

A) **For the Product.** MOFA/RTIP was identified as the main organisation in Ghana funding the multiplication and distribution nationally to farmers of planting material of released cassava varieties. Other donors such as GTZ were providing funding, but on a smaller scale and in more limited areas, for example, in Sunyani District. The actual multiplication and distribution of the cassava planting material was being done through MOFA. GTZ had assisted four MOFA staff to attend the Workshop: it seemed likely that both RTIP and GTZ would assist in the multiplication and distribution of any cassava varieties released as a result of Project activities.

B) For the Process. No other organisation currently involved in participatory cassava breeding was identified. However, the Workshop participants expressed strong support for decentralised cassava breeding subject to the procedure being proven. There is already considerable interest in the process of participatory breeding for other crops under CSIR's mandate.

Further sessions and group discussions identified the following key issues for cassava breeding and their implications.

Table 38. Issues and opportunities for participatory plant breeding identified during the project workshop

Issues	Implications/Opportunities
End-user/farmer driven breeding End-users:	*End-users require more emphasis but they and their needs need to be better identified.*
Farmer focus:	*Current emphasis by breeders on farmer criteria should be continued to ensure high rates of adoption.*
Researcher focus:	*Use of CMD-resistant seedstocks has been very successful but:* - *more emphasis needs to be put on sporadic but devastating diseases (Cassava bacterial blight kept coming up as the key example);* - *and resistance to pests and diseases needs to be balanced against need for other attributes.*
Variety release The "Breeding" group recommended the maintenance of the current strict regime	*There was concern amongst Workshop members generally that this would further delay the release of varieties.*
Stakeholder capacity Farmer capacity	*Whether farmers had sufficient time, knowledge (especially of diseases) and appreciation of the long-term importance of breeding were recurring concerns; a need for increased farmer training and incentives were recurring themes.*
Non-farmer stakeholder capacity	*There was concern that non-farmer stakeholders had a very weak or non-existent capacity to interact with breeding: there was a strong demand for a starch analysis laboratory.*
Social science issues	*Ghanaian national breeding effort has been targeting farmers and food consumers. If emphasis shifts towards other potential industrial users, what impact will it have on national food security and on the livelihoods of farmers?*
Promotion of cassava PPB project outcomes Cassava varieties are currently multiplied and distributed largely through MOFA.	*There was a consensus that the breeding process should now also be promoted to the farmers (as in participatory plant breeding) as well as varieties (product of breeding process).*

CONTRIBUTIONS OF OUTPUTS

Contribution towards DFID's development goals

Cassava was the main source of food for the farming communities investigated and was also a major source of cash. Both farmers and stakeholders involved in other ways with cassava indicated that cassava has increased in importance steadily over the last several decades, and this process seems likely to continue. This process is partly driven by land shortages and soil impoverishment requiring farmers, particularly young ones, to grow a crop with high productivity even in less fertile soils. However, it is also driven by increasing opportunities for utilisation of the crop in new urban markets: as a cheap source of the most popular food in most of Ghana, *fufu*, as a cheap convenience food, for example, pre-cooked as gari, as a livestock feed, particularly for broiler and egg production and for various industrial uses including in export markets. Cassava production, processing and consumption plays an important role in the livelihood strategies of poorer people. The project is widening opportunities which contribute directly to DFID's goal of alleviating poverty.

The project has utilised a broad livelihoods approach, addressing as far as possible all aspects of cassava production both within farming communities and externally, including markets. Farmers have been involved closely in all relevant project activities, having a leading role where possible. The project has also paid considerable attention to minimising their time inputs. Both farmers and researchers have received considerable experiential learning and a researcher has received formal training in participatory research and plant breeding. The farmers considered that the project was generally beneficial to them and Ghanaian participants drawn from a range of interest groups at an end-of-project workshop also validated the approach. Planting material of all selected accessions has been transferred to individual farmers. This material has also been planted in a communal plot in each village where it is accessible to both farmers and researchers. It is therefore considered likely that the approach and superior accessions generated by the project will be sustained.

Promotion pathways

A survey was made of other individuals and organisations involved in activities overlapping or otherwise interacting with project activities within the first year of the project in order to identify possible partners for sharing activities and promoting outputs. The timing of the project coincided with the start of a multi-million dollar IFAD-funded project to MOFA, the Root and Tuber Improvement Project (RTIP). This project has massively increased cassava-related activities in MOFA and other public institutions, including CRI. MOFA, with which the project was already collaborating closely, was identified as the key institution involved in the dissemination of planting material of released varieties to farmers, has an extensive multiplication programme and would be

keen to assist in the multiplication and distribution of any varieties released by the project. GTZ was also funding various activities of MOFA involving cassava, particularly through its sedentary farmers project in Sunyani. The latter is close to Aworowa, one of our project sites. Discussions with both expatriate and local MOFA staff have confirmed their interest in further testing of project-selected accessions with their local communities, testing both the process (participatory selection) and the materials (accessions).

At the time of our initial survey, few NGOs were identified that were keen to participate in project activities. However, World Vision has recently increased its rural sector support and is now also keen to test project-selected accessions with their local communities.

CRI, the main publicly funded research institute with the mandate for crop breeding has shifted its previous on-station breeding and selection to farmer participatory process not only in cassava but also in other crops such as cowpeas and sweet potato.

Follow-up actions required

1. The project is now entering one of its most exciting phases, farmers having taken planting material of promising genotypes back to their home farms. 39 farmers at Nkaakom and 36 at Aworowa have received 124 seedling clones (61 at Nkaakom and 63 at Aworowa) for testing on their farms. These accessions have also been planted at the communal farms and at the research station. How these genotypes perform under these conditions and how the farmers judge them **needs to be monitored up to and after harvest**.

2. Links already established with such institutions as GTZ Sedentary Farming Project in Sunyani, World Vision in Kumasi and MOFA generally provide the opportunity to scale out the process of PPB with cassava. They also offer opportunity to further test selected accessions both in similar and dissimilar environments, considerably adding to the scientific and developmental imapct of the project. We are already working with **MOFA** at Nkaakom and Aworowa, **GTZ** funded 4 MOFA staff associated with its project in Sunyani to attend our Workshop and **World Vision** is one of the few NGOs in Kumasi working actively with farmers.

3. The apparent success of some of the landraces selected from amongst germplasm obtained within Brong Ahafo Region is consistent with the slow exchange of landraces by traditional means between Ghanaian rural communities identified by project surveys. These results suggests that there may be many superior landraces within Ghana that are unknown to the majority of Ghanaian farmers. This therefore suggests that it might be possible to increase the production of cassava in Ghana by the simple means of enabling farmers to access a wider diversity of landraces through their planned **supply from the otherwise relatively unutilised collections of Ghanaian germplasm** to rural

communities. Selection of superior clones could be achieved in much the same way as seedlings and clones derived from them were selected by PPB.

4. Farmers exhibited a lack of a clear understanding of cassava pests and diseases, despite training. There seems to be the opportunity and need for MOFA extensionists to acquire a more effective training system and a **participatory learning approach** might achieve both this and some quantitative data on the impact of diseases such as CMD.

5. Formal release of varieties by the Variety Release Committee provides key advantages to a cassava clone, namely that it can be officially maintained, multiplied and disseminated to farmers by MOFA using public or other funds. At present, it is unclear what data are required for a clone selected using PPB to be released as a variety in Ghana. Several members of the Committee have been contacted and have promised support in clarifying the situation **so that PPB provides the data required by the Variety Release Committee**.

6. The project team realised during project activities, particularly the consultations with non-farmer stakeholders, that PPB could not easily address the development of cassava varieties targeting markets which farmers are unfamiliar with, notably the urban industrial and semi-industrial markets. This "problem" was further highlighted by participants at the end-of-project Workshop at Elmina and needs addressing. It is unclear at present whether the best approach is **for on-station conventional breeding to target production of such cultivars or whether a variant of PPB needs to be developed**. It may depend on whether rich farmers mostly grow the resultant crops on well-resourced farms similar to research station farms or whether small-scale resource-poor farmers continue to be the main producers of cassava.

Project disseminations

In order to achieve rapid dissemination of project outputs to key individuals and organisations, a series of Working Papers were prepared during the course of the project.

1. **Situation analysis of villages collaborating in cassava participatory breeding**

2. **Participatory cassava breeding in Ghana: consultations with stakeholders + Annex**

3. **Participatory breeding for superior mosaic resistant cassava in Ghana: two years of seedling/clonal evaluation by farmers and scientists**

4. **Workshop on participatory cassava breeding: update and opportunities**

At least one further working paper describing the outcomes of a survey on informal exchange of cassava genotypes and farmer knowledge and use of sexual propagation of

cassava will be produced. Several of these working papers will also contribute to Mr JA Manu-Aduening's PhD thesis and it is intended that, where appropriate, the contents will be published in peer-reviewed journals.

Two presentations on project activities were given at the 8th Triennial Symposium of the International Society for Tropical Root Crops – Africa Branch at IITA, Ibadan, Nigeria (12th-16th November). The presentation on "The Importance of Diseases in Participatory Cassava Breeding" given by E Moses & JNL Lamptey received 2nd prize for quality of the presentation.

Manuscripts of the above presentations have been submitted but Proceedings are not published until the next meeting (in 2004).

RW Gibson and J Manu-Aduening attended the International Symposium (May 7 - 10th, 2001) on: "Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement - an Africa-wide Exchange of Experiences" at the West African Rice Development Association (WARDA), Côte D'Ivoire and jointly read a paper on "Improving cassava through a combination of Ghanaian farmers' and scientists knowledge of cassava breeding".