A Research Article in AJRTC (2010) Vol. 8 No. 2: Pages 23–33

Developing cassava cultivars based on farmers' needs and on the agro-ecological conditions of north-western Cameroon

Zundel Christine[1,3,4], Chibikom Richard[2], Scheidegger Urs[1], Nagel Peter[3] And Hanna Rachid[4*]

[1]Swiss College of Agriculture, Länggasse 85, CH-3052 Zollikofen, Switzerland
[2]Presbyterian Rural Training Centre Fonta, PO Box, Bamenda, NWP, Cameroon
[3]Institut für Natur-, Landschafts- und Umweltschutz – Biogeographie der Universität Basel, St. Johanns-Vorstadt 10, CH-4056 Basel, Switzerland
[4]International Institute of Tropical Agriculture, BP 2008 (Messa), Yaoundé, Cameroon

Corresponding Author: Rachid Hanna
Email: r.hanna@cgiar.org.

Manuscript received: 08/11/2010; accepted: 10/12/2010

Abstract

Cassava is one of the most important staple food crops in Africa and has recently been gaining importance as a cash crop for smallholder farmers. The dynamics of the system requires new cultivars. The broad objectives of the present study were (a) to specify the need for new cassava varieties; (b) determine the level of G × E interaction in the area; (c) to suggest an effective way to select cultivars in the agro-ecologically diverse environment of the mid-altitudes of Central Africa. We proceeded by a farmers' evaluation of varieties grown on-station, by a formal on-farm variety trial, and by semi-structured interviews. We found that only a few cassava cultivars were available, given the agro-ecologically diverse nature of the area. Farmers preferred new cultivars with a high yield, to best exploit the opportunities related to the high, mainly urban, demand for cassava processed into *gari*. In addition, they preferred cultivars which do not require processing other than boiling, to break the labor peaks implicated in gari production. In the on-farm variety trial, G × E interaction is observed to be lower in the high-potential fields (storage root yields >8.9 Mg ha^{-1}) than in the low-potential fields (storage root yields <8.9 Mg ha^{-1}). The present distribution pattern of local cassava cultivars was found to be based on G × E interaction. We propose a decentralized participatory variety selection scheme to overcome the challenges of G × E interaction in variety selection. The commonly practiced exchange of planting material among farmers will encourage the fast and effective dissemination of new genetic material.

Key words*:* Decentralized participatory variety selection; cassava cropping system; farmers' variety management; genotype × environment interaction; Cameroon

Introduction

Cassava is, together with maize, common beans, cocoyam, yam, plantain and rice, among the most important staple food crops of the North-West Province (NWP) of Cameroon. Mainly produced for home consumption after its introduction to the NWP around 1920 (Ohadike 1981; Warnier 1984), cassava became one of the very important in the area in the mid-20th century. Today, cassava is also a cash earner. Its processed products are very popular with the urban population, because they are easier to prepare and can be kept longer than the other staple crops, *gari* is made from cassava storage roots, grated, fermented, and roasted in palm oil. The dry yellowish granules are ready for consumption after mixing with water. *Waterfufu* is made from cassava roots that are fermented, pounded and sieved. The white paste can be kept for up to 4 weeks. The trend to produce more cassava is furthermore promoted by the fact that this crop can be grown under a wide range of biophysical conditions. Cassava also grows on soils which are too depleted for the successful production of other staple crops, such as maize (Prudencio and Al Hassan 1994; Bakia et al 1999). In view of the changing role of cassava and the changing environment, new cassava varieties are required. This article wants to provide breeders with information on how farmers in an agro-ecologically diverse environment of the mid-altitudes use old and new varieties, and which varieties will be required in the future. It also determines the level of G × E interaction in the area; and suggests a decentralized participatory variety selection scheme (PVS) in the case of cassava in the NWP, aiming at making variety selection and dissemination as efficient as possible.

Cassava cropping system in the NWP. In the North-West Province, as everywhere in Cameroon, cassava is produced by small-scale farmers (Simeu Kamdem 1996). Our preliminary studies showed that cassava farming is limited by the availability of labour rather than land availability, since cassava can be grown on marginal soils. The area grown to cassava, planting time, care (weeding) given to the crop, and quantity processed into *gari* largely depend on labor availability, which is determined by the family structure, the health of the farmer, and the possibility of hiring labor. In the humid savannas of Cameroon (to which the NWP belongs), 80% of the farmers growing cassava for home consumption also plant it as a commercial crop (own observations). Unlike many other crops, it receives little or no external input in terms of fertilizer or plant protection chemicals. Cassava in the NWP is planted at 20,800 plants /ha, which is twice the recommended planting density (Okeleye et al 2001). Harvesting is done continuously, and in small quantities. Farmers harvest as much as they can process within a few days, and large quantities are harvested only when larger sums of cash are needed. Processing is done at home or in community infrastructures. *Gari* is a predominant income earner for farmers, but it also plays an important role in home consumption.

Demand for new cassava cultivars. Considering the growing demand for processed cassava products (especially *gari*) in the NWP, high yielding cultivars with high dry matter content are required. This need can be met either with a few cultivars with a stable performance across farmers' highly variable agro-ecological conditions, or by many different cultivars, each of them adapted to a specific agro-ecological pocket, (Prain et al 1991; Witcombe et al 1996; Ceccarelli et al 2000). Since farmers preferences for qualitative traits are quite uniform in our case (own observations), it would indeed be possible to opt for a few stable cultivars. However, to exploit as much as possible the potential of a batch of newly developed cultivars, a selection scheme should allow for the dissemination of many different cultivars. In addition to physio-ecological adaptation, cultivars to be grown in the NWP require to be resistant or tolerant to the *African cassava mosaic virus* (ACMV) and the cassava green mite (CGM; *Mononychellus tanajoa* (Bondar); Acari: Tetranychidae). Ideally, new cultivars should support the neotropical predatory mite *Typhlodromalus aripo* DeLeon, 1967 (Acari: Phytoseiidae), which today controls CGM in about 20 countries of sub-Saharan Africa. Establishment of *T. aripo* is facilitated by plants with hairy and year-round turgid apices (Hanna et al 2000; Hanna and Toko 2002; Zundel et al 2009). However, only about 3% of the cassava plants in farmers' fields in the mid-altitudes of the NWP presently have hairy apices, and repeated efforts to establish *T. aripo* in this area have failed so far (Zundel et al unpublished.); although *T. aripo* is established in the lower altitudes of the NWP (Zundel et al unpublished.).

Cassava variety development at present. Cassava breeding largely relies on selection of F_1 clones over several clonal generations. In Africa, material performing well in advanced multilocational yield trials of the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, is passed to national cassava programs in other countries and to other IITA research sites. In 2000, about 200 new cassava clones were introduced by IITA for field evaluation in three locations in Cameroon – Bibi Ngoum, Center Province; Nkoemvon, South Province; and Bertoua, East Province. All cassava clones developed by IITA and used in the trials reported in our study had been selected from the introduction in 2000 or earlier.

The Rural Training Centre Fonta (RTC Fonta), which is located about 20 km east of Bamenda, the Provincial capital of the NWP, has been involved in cassava improvement since 1994 (Bakia et al 1999). It had received new cultivars over several years through the IITA-coordinated Ecologically Sustainable Cassava Plant Protection (ESCaPP) Project. At the beginning, a series of several hundred local cultivars collected in Cameroon (hereafter referred to as ESCaPP cultivars) was obtained. A second batch of 10 clones from IITA – selected on the basis of their performance in Nigeria and their resistance to ACMV was obtained in 1999 and widely used in the context of the present study. RTC has since obtained over 100 additional clones after evaluation by IITA at the Mbalmayo station in Center Province.

Need and challenges for a new cassava variety selection scheme. The cultivars provided to RTC Fonta had been developed at altitudes below 1000 m asl. Owing to the fact that large parts of the cassava growing area of the NWP are located above 1000 m asl, the need is obvious for a further selection and dissemination step. It has been demonstrated repeatedly (Iglesias et al 1994; Tan and Mak 1995; Dixon and Nukenine 1997; 2000) that G × E interactions can be significant in cassava farming. Indeed, farmers of the NWP insist that they cannot select new cultivars on the basis of performance in on-station trials; they need to grow them in their own fields to assess them. This statement suggests G × E interactions in cultivar performance. If the assumption proves true, cultivar testing and selection should be organized in a decentralized way. This can be realized only if farmers are willing to bear the main part of experimentation.

Cassava has a low multiplication rate (about 10 plants out of one plant / year), which presents a specific challenge to cultivar selection and dissemination programs. Successful selection schemes require that selection, targeted promotion, multiplication, and distribution are well tuned.

Materials and methods

Farmers involved in the study. The study was conducted within the outreach of RTC Fonta. The farmers involved in the work presented here came from six villages in the Mezam Division, NWP. They were smallholder farmers of the Bafut ethnic group, who had grown cassava for at least three cropping cycles as a cash crop for the rural and urban markets. Twenty-nine out of the 32 participating farmers were women.

Farmers' evaluation of an on-station variety trial. On the station of RTC Fonta, a variety trial with 10 cultivars was planted in June 2002. The purpose was to assess yield performance and parameters relevant to the biological control of CEM in a mid-altitude environment (Table 1). Each cultivar was replicated four times and each replicate consisted of 12 ×12 plants with spacing of 1 m ×1 m. Planting was done on ridges, as practised by farmers in the region (C. Zundel, pers. obs.). The trial area (100 m × 70 m) was bordered by two ridges planted with the cultivar ESCaPP 23 (name given by RTC Fonta). This cultivar is known to be very susceptible to ACMV and was considered a good source of virus inoculum to assess the susceptibility of the tested cultivars to ACMV infection. As practised by local farmers, no external inputs were applied in the experiment. Three hand weedings were done during the trial period.

Farmers were invited on two occasions to evaluate the cultivars: when the crop was 12 months old (aboveground evaluation) and 24 months after planting, i.e, at the time of harvest (above-and belowground evaluation). For the first evaluation, farmers were invited in small groups of two to four. In total, 12 farmers participated in the evaluation on five consecutive days. All farmers and their cassava fields had been visited by the research team at least once before the evaluation (see below). After an introduction to the purpose and the history of the trial, the farmers were given time to stroll through the field. The subsequent semi-structured discussions covered the following topics: observations concerning the aboveground appearance of the 10 cultivars and respective implications for field management and yield expectations; and preferences for specific cultivars at the present growth stage. A ranking of the importance of the preference criteria was done. The cultivars appearing in the top-three preference ranks of at least one farmer were selected for the on-farm variety trial (see below *On-farm variety trial*). In the second evaluation at the time of harvest, a similar procedure was applied. In addition, four plants / cultivar were harvested and their storage roots were boiled and served to the participating farmers for a palatability assessment. At the end of the day, farmers were allowed to select planting material from the varieties discussed, and the various choices were registered.

On-farm variety trial. To determine the level of G × E interaction, we planted an on-farm variety trial covering a total of 11 fields in five villages. The villages were located within a radius of 10 km, and each of the fields was considered as one replicate. At each site, the same five cultivars were planted that had been selected by farmers at the occasion of an on-station variety evaluation at RTC Fonta (see above *Farmers' evaluation of an on-station variety trial*). These were TMS 92/0057, TMS 92/0427, TME 1, and two farmers' cultivars from Cameroon labelled ESCaPP 30 and ESCaPP 32. Farmers were asked to add one of their local cultivars as a check. The trials were planted in August 2003 on ridges across slopes, and the cultivars were arranged side-by-side, stretching vertically across the ridges. Each trial field was bordered by at least four rows of a local cultivar. The fields were visited together with the farmers at 3-month intervals. At this occasion, semi-structured interviews were conducted on the farmers' observations concerning crop development, yield expectations, and perspectives regarding an eventual integration of the new cultivars into their portfolio. The fields were harvested in April 2005, i.e, 20 months after planting.

First, yield data were analyzed using all fields. To test the hypothesis that the potential yield of cultivars was affected by planting in high-potential or low-potential fields, we stratified the fields into six were high-potential and five were low-potential. The background of this hypothesis is the observation that favorable environments are often homogeneous, while marginal environments are more heterogeneous. We used mean yield over all fields and all cultivars (8.9 Mg ha^{-1}) as a criterion for separation. The Farmers' cultivar was excluded from the analyses, since this cultivar was different at each field. Data on yield / area and on the proportion of surviving plants at harvest were analyzed with a mixed model ANOVA (NCSS, 2000), with cultivar as a fixed factor and field as a random factor. Differences between factor levels were tested with a post-hoc test (Bonferroni).

In another approach to assess G × E interaction, we examined the distribution of the five most common local cassava cultivars in six villages of the NWP (Bambui, Fonta, Akossia, Asanje, Nibe, and Mfoya), which are situated within a circumference of 10 km. The inhabitants interact through family relations, farming groups, processing mills, market days, church activities, etc, (Zundel, pers. obs.). It is thus assumed that the existence of any specific cultivar is known in all the villages and that the present cultivar distribution pattern is a response to specific adaptation. We applied Fisher's exact test to see if distribution of these cultivars is random or if it is village-specific.

Visits to farmers' fields with semi-structured interviews. All farmers participating in the study were visited at least once. On the occasion of this call, fields were visited together and semi structured interviews were conducted on the role and importance of cassava, on various cropping practices, variety preference and variety management, field allocation, and cropping constraints.

Results

Existing cultivar portfolio, farmers' way to deal with new cultivars, and potential dissemination channels. Variety preference criteria. The visits to farmers' fields with semi structured interviews, and the on-station variety evaluation confirmed that the farmers' most important criterion for cultivar selection was yield in particular farmers who planted cassava as cash crop. Other positive (but optional) traits were (in order of descending importance): option to consume the storage roots after boiling (this implies soft tissue, nice taste, and lack of bitterness); early maturity; and flexibility in the harvesting period. We found that a mediocre yield was a killer criterion for the selection of a cultivar, regardless of how preferable the other characteristics were (see examples of TMS 92/0326, TMS 92/0239, and TMS 92/0427 in Table 1). Bitterness was always a negative trait in farmers' evaluation of a cultivar, but curiously, bitterness could be accepted if the cultivar produced a high yield (e.g, ESCaPP 30 in Table 1). Moreover, although farmers did not like "curled leaves" (ACMV symptoms), they would still accept the cultivar if other features (e.g, stem thickness) indicated a high yield (e.g, ESCaPP 23 in Table 1), as perceived by farmers.

When evaluating plants of new cultivars before harvesting, the more experienced cassava farmers tended to prefer cultivars which resembled those they grew themselves. In contrast, the less experienced farmers were keen on trying cultivars which looked completely new. For example, they preferred short cultivars over tall ones, while experienced farmers favored tall cultivars.

Variety portfolio management. In the six villages of our study, we identified 16 cassava cultivars, five of which were widespread. We learned of four more cultivars which farmers had once tried to grow but abandoned for various (unknown) reasons. Eleven of the 16 cultivars were "sweet" and could be consumed boiled. The remaining five cultivars were either "bitter" (which correlates with a high cyanogenic potential) or did not soften (within a reasonable amount of time) if boiled, and therefore had to be processed into *gari* or *waterfufu*. Farmers typically grew three cultivars, with an area-wide range of one to six cultivars. In addition, 25% of the interviewed farmers grew one or two cultivars on a very small scale (a few plants only). This was the case with cultivars which were not among the most favored, but where the farmers had decided to maintain them "for other times". Sharing planting material with other farmers was mentioned as another strategy to maintain cultivars.

Despite thein strong preference for high yielding cultivars, all farmers indicated that, at all times, they wanted a cultivar for home consumption, i.e, a cultivar that could be easily boiled and consumed (see also Ngeve et al. in press). Farmers with four and five cultivars indicated that they would replace a low yielder with a new cultivar if the latter was perceived to be of high quality. Farmers with two cultivars wanted to add one or two of the new cultivars to their portfolio. Based on these observations, four to five cassava cultivars appeared to be the optimum size of a cultivar portfolio of a farmer growing sole cassava. This is in accordance with the opinion of an experienced farmer who indicated that three or four cultivars were enough, if they produced well. However, a minority said that having many cultivars was an advantage as a farmer prepared for risks. They found 7 to 20 cultivars to be ideal.

Pure stands vs cultivar mixtures. We found that cassava cultivars were planted either in pure stands or in mixtures. We wanted to know if planting in mixtures was a deliberate choice and why. We found that farmers with large areas (>2500 m^2) under cassava usually planted in pure stands. If cultivars were deliberately planted in mixtures, it was either to avoid the risk of a complete crop failure – especially on marginal soils or on sites with unknown characteristics – or to achieve a specific blend of roots for *gari* production. Farmers indicated, however, that they were often challenged in finding cultivars that complement one another well in mixtures and do not compete with each other in a negative way. Unintended mixtures occurred if farmers did not have enough planting material of one cultivar to plant the whole field, or if the planting material was removed so long ago such that the cultivar name was no longer available. If cultivars were grown in mixtures, farmers usually recognized them in their fields and harvested them plant-wise, depending on their respective maturity and intended use. However, appropriate management and timely harvesting of plants and fields with unintended mixtures were said to be very difficult.

Management of planting material. Scarcity of planting material at the time of planting was said to be a major constraint in cassava farming. Although planting material is available in large quantities at the time of harvest, it may be lacking at the time when farmers want to plant a new cassava field. Constraints for planting a cassava field immediately after the harvest of another field were said to be: 1) land availability, 2) coincidence with peak labor needs for other crops, 3) health or other personal problems rendering the farmer unavailable for planting, or 4) the beginning of the dry season. The usual practice was that farmers collected stems as planting material from the harvested field and kept them in a cool and shady place. Alternatively, they left the stems in the field and selected the planting material from there when the time for planting had come. Once the roots are harvested, the stems gradually loose their vigor as planting material and it is not advisable to keep planting material for longer than 1 - 2 months, depending on variety and condition. Farmers were aware of that and attempted to plant the material as fresh when it was possible. Consequently, if farmers wanted to plant a new cassava field, they asked neighbors, relatives, or farming group members if they could provide planting material, particularly if mature plants of the other person's field looked vigorous. Large distances between fields were another reason why planting materials were traded: if farmers had harvested fields on one hilltop and had land for a new cassava crop available on another hilltop, they preferred to ask the neighbors of the new fields if they could provide cuttings than to carry their own stems from one hill to the next. In return, they gave away their own planting material to other farmers. Smaller quantities of planting material were selected before harvest by removing single stems from plants with two or more stems. This method had the advantage that the stems and leaves were fresh and farmers could do a selection for plants free from ACMV. If planting material is selected when mature cassava is harvested, the leaves are too senescent for ACMV symptoms to be reliably detected and identified. However, when selecting planting material, farmers actually gave more attention to strong and vigorous stems from plants with a high yield than to healthy leaves.

How farmers deal with new cultivars. The two main triggers for farmers to try new cultivars were either the lack of known planting material, which forced them into using planting material from a different source, or the high yield reputation of a cultivar. Planting material of new cultivars usually came from friends from nearby villages, from relatives, or from contractors with whom the farmers worked. Generally, farmers did not have much information about new cultivars when they decided to try them; the reputation of a cultivar to yield well was often sufficient as a basis for a decision. Some farmers considered the agro-ecological conditions of the origin of the new cultivar and compared them with their own environment before taking the decision to try. In most cases, farmers grew as much planting material of the new cultivar as they could get, ranging from a few plants to a whole field.

Potential dissemination channels for new cultivars. As described above, farmers often had to rely on planting material from other people, because they lacked their own material at the time or in the place they wanted to plant. Exchanging cuttings as gifts or requesting cuttings from somebody who had a "nice cassava" crop was also common. This free exchange of planting material among farmers could be an important basis for a low-cost and efficient dissemination of new cultivars.

Genotype × environment interaction. The on-farm variety trial in three villages on 11 fields, with five new cultivars plus one cultivar added by the farmers, showed no significant cultivar effect on yield (mean: 8.9 Mg ha^{-1}; $F_{4, 54}$=1.75, *P*=0.159) (Fig. 1). When grouped into high-potential fields (mean: 12.3 Mg ha^{-1}; n=6) and low-potential fields (mean: 4.9 Mg ha^{-1}; n=5), we found a cultivar effect in the high-potential fields ($F_{4, 29}$=2.92, *P*=0.047), but the difference could not be attributed to a specific cultivar with the post-hoc test. No significant cultivar effect was found on the low-potential fields ($F_{4, 24}$=1.48, *P*=0.256).

The percentage of plants surviving until harvest over all fields was 86%, but there were significant differences between cultivars ($F_{4, 54}$=6.49, *P*<0.001): ESCaPP 30, ESCaPP 32, and TMS 92/0427 had a higher plant survival rate than TME 1. While the cultivar effect on plant survival was not evident in the high-potential fields (mean: 87%; $F_{4, 29}$=2.65, *P*=0.063), cultivars did have an effect on plant survival in the low potential fields (mean: 84 %; $F_{4, 24}$=3.73, *P*=0.025), with ESCaPP 30 had a higher plant survival rate than TME 1.

Cassava yield varied considerably among fields (high-potential sites: $F_{5, 29}$=6.62, *P*<0.001; low-potential sites: $F_{4, 24}$=7.05, *P*=0.002) at high-potential as well as low-potential sites; however, plant survival was statistically similar across fields (high-potential sites: $F_{5, 29}$=1.03, *P*=0.426; low-potential sites: $F_{4, 24}$=1.22, *P*=0.340).

The second study to quantify the site effect on cultivar performance was based on the geographical pattern of local cultivar use. Table 2 presents the distribution of the five most common cultivars in six villages. Only one cultivar (Local Pawpaw Leaf) was grown in all six villages. One cultivar (Fonta Cassava) was grown in five villages, one (Nkong) in four villages, one (Mambo) in three villages, and one (Nsongwa) in two villages. Fishers' exact test (*P*<0.001) showed that there was an association between villages and cultivars.

Discussion

Need for new cultivars: what is required? The need for new cultivars was assessed directly in interviews and indirectly during field visits. Considering the diversity of topography, vegetation, and crop uses in the area, We found that the number of cultivars presently grown in the area was small. Indeed, almost all farmers wished to have more cultivars or wanted to replace some of their own cultivars with higher yielding cultivars if these were available for them. This points to an insufficient availability of adapted cultivars in the study area. Hillocks (2002) reports similar findings for other countries in the cassava belt of Africa. Despite increasing demand for *gari*, farmers desired to have high yielding cultivars that could also be boiled and eaten without any further processing to satisfy their household need. Another reason may be that the labor for *gari* production within the family is sometimes scarce or difficult to plan. Growing high yielding cassava that can be sold also for fresh consumption gives farmers more flexibility in organizing their manpower. Because of the cultivar effect on plant survival found in the on-farm variety trial, emphasis should be given to cultivars that provide sufficient hardy planting material, and those that have a vigorous young stage, under both dry and wet conditions.

The study underscores the presence of strong demand for multipurpose cultivars with a high yield potential under the given agro-ecological conditions of the NWP. Since these conditions are diverse, farmers don't strive for one excelling cassava cultivar, but instead try to grow as many cultivars as possible, and seek the best growing conditions for each (Ch. Zundel, manuscript in preparation). Labor peaks and the availability of planting material are two major limitations of the present cassava cropping system in the area. Thus, new high yielding cultivars have to have a flexible harvesting time, to break the labor peak during harvesting and processing, and they must provide sufficient and long-lasting planting material. Similar constraints are reported by Hillocks (2002), Ceballos et al (2004) and Manu-Aduening et al (2006).

G × E interaction – Need for a decentralised variety selection scheme. The idea that a cassava variety selection scheme in the NWP will have to cope with considerable G × E interaction led us to test this hypothesis in an on-farm variety trial and in a study on the present spatial distribution of cultivars. Our assumption is supported by the fact that cultivar effects on yield were more visible on high-potential fields than on low-potential fields, where variation overrode any difference between cultivars. This is an indication that the divergence between marginal environments is larger than that between favorable environments. Thus, the lower the yield potential of an area, the more difficult it becomes to propose the "right" cultivar. The suspected G ×E interaction is further supported by the present distribution of local cultivars in the area: the planting of many local cultivars was restricted to a few villages, although the exchange of planting material was common among farmers, within and across villages. The interviews showed that farmers have a clear idea of G × E interactions. Farmers were able to tell on which soil and in which village a specific local cultivar performs well and where it did not. If farmers considered trying a new cultivar, they took into account the environment where the cultivar was presently grown and compared it with their own environmental conditions.

It becomes evident that conclusions on cultivar performance are valid only for the agro-ecological pocket where they were tested. Extrapolations to other agro-ecological pockets are not possible. Thus, every village, if not every farmer, must have the oppotunity to test the new genetic material. Strong G ×E interactions on a small spatial scale, and thus the need for decentralized selection schemes, were also observed in other cases. Kornegay et al. (1996) found that in Colombian bean growing, the differences between farmers' fields are as large as differences between researchers' and farmers' fields. Decentralized selection is also advocated by Sperling et al (1993) for bean selection in Rwanda, by Joshi and Witcombe 1996 and Sthapit et al 1996 for rice breeding in Nepal, and by Ceccarelli et al 2000 for barley selection in Syria.

Useful decentralized selection for cassava in the NWP of Cameroon means 1–3 trial sites / village. If there are cultivars that perform well in many sites, they may be directly promoted in new areas, since they seem to be stable over a wide range of conditions. But there is no harm if no such stable cultivars exist, and if each village has another set of best cultivars, since there is no need or pressure to narrow promotion to a few of the tested cultivars. The only pressure would be existing seed laws which make the release of many varieties expensive.

By concept, decentralized selection does not automatically mean participatory selection. In practice, however, farmers' participation is needed to make a decentralized selection affordable (Ceccarelli et al 2000). It has to be kept in mind that handing over selection from an institution to farmers does not mean an elimination of costs but a different distribution of costs among the stakeholders (Morris and Bellon 2004, Hoffmann et al. 2007). Zundel et al (manuscript in preparation) found farmers to be the best to plan, manage, and evaluate decentralized variety trials.

Outline for a participatory variety selection scheme in the NWP of Cameroon. A decentralized participatory selection scheme needs to rely on institutions (NGOs) operating at the local level and playing the role of an effective interface between breeders and farmers. The responsibilities of such variety hubs in the NWP of Cameroon are outlined in the following.

As a basis for farmers to select the cultivars they want to test in their village, the cultivars should be grown by the variety hub on suitable land ("on-station"). If done in a replicated trial, the multiplication of planting material and feedback to the breeders on the performance of these cultivars can go hand-in-hand. Planting material of new cultivars should be provided to interested village groups continuously over a certain time period.

The schedule for farmers' evaluation on the hub's station can be derived from the periods when farmers usually observe their cassava crop very closely, i.e., 3 months after planting (emergence and young development); 12 months after planting (after the dry season; canopy fully developed; probable diseases clearly expressed); 18 months after planting (*ex-ante* yield assessment and estimation of harvesting time); and at harvest (yield potential, processing qualities). To keep the system running smoothly, the variety hub needs to allocate resources that can provide about 50 cuttings / cultivar and / experimental on-farm site.

The breeder and the variety hubs need to collaborate in a way which allows the supply of new cassava cultivars to the target area at regular intervals. Cassava clones should be shipped to the variety hubs in the NWP as soon as they pass the advanced yield trials and are introduced to Cameroon. Since selection is usually done at Mbalmayo (Central Province) in the low-altitudes, many cultivars which could have been highly performing in the mid-altitudes might otherwise be dropped. Sperling et al 1993 emphasized an early involvement of farmers to prevent a loss of genetic material which could potentially be of interest to the end user areas. In this case, many more varieties got adopted because farmers were involved earlier in the selection process. A pre-requisite for the functioning of the proposed scheme is the regular arrival of

Table 1. Cultivars included in the on-station variety trial at RTC Fonta.

Cultivar	Origin	Name given by farmers	Yield (Mg ha-1)	Cooking/processing quality (assessed by farmers)	Appearance (assessed by farmers)	ACMV resistance	CGM resistance	No. of farmers selecting the cultivar for their own trial*
ESCaPP 30	Cameroonian cultivar	Bitter Purple	17.4 ± 0.29	Very bitter; very white; for *gari*	Tall; attractive leaf color	Slightly susceptible	Moderate	12
TMS 92/0057	Improved	Small Long Leaves	16.8 ± 0.18	Nice taste; cooks well	Tal	Resistant	Susceptible	14
ESCaPP 32	Cameroonian cultivar	Agric Pawpaw Leaf	13.9 ± 0.11	Slightly bitter; for *gari* or waterfufu	Tall	Susceptible	Resistant	15
TMS 92/0427	Improved	Short Short Stem	13.5 ± 0.49	Nice taste; cooks well	Short	Resistant	Moderate	5
Fonta Cassava	Local	Fonta Cassava	9.8 ± 0.06	Doesn't cook; for *gari* or waterfufu	Tall	Susceptible	Susceptible	2
TMS 92/0326	Improved	Njamahnjamah Leaf	9.3 ± 0.03	Nice taste; cooks well	Short, branching	Slightly susceptible	Susceptible	0
TME 1	Nigerian cultivar	Plum Leaf	8.7 ± 0.25	Nice taste; cooks well	Tall	Slightly susceptible		Tolerant13
TMS 91/0239	Improved	Small no be Sick	8.0 ± 0.14	Nice taste; cooks well	Short	Resistant	Resistant	4
TMS 92/0235	Improved	Trouble Maker	7.8 ± 0.09	Nice taste; fibrous; for *gari* or waterfufu	Cross-branching	Resistant	Tolerant	0
TMS 30572	Improved	Folded Leaves	6.6 ± 0.16	Poor taste; for *gari*	Short	Resistant	Moderate	0

ESCaPP=Ecologically Sustainable Cassava Plant Protection Project; ACMV=African Cassava Mosaic Virus; CGM=Cassava Green Mite; * maximum of 18 farmers.

new genetic material. Good contacts and smooth collaboration between the breeder and the variety hubs are therefore crucial. More important than a high number of new cultivars is the regular provision of about the same number of new cultivars to the hubs, not to challenge the capacities of the station and the farmers, but to allow for the constant use of the capacities built up. This implies a more systematic way to work with farmers. A 2 -stage approach for cultivar exposure to farmers (similar to Sperling et al. 1993) could help: one or two lead farmers / village farming group are invited to evaluate the material at the variety hub and to take interesting material home for testing. This allows a hub to cover a wide area with planting material. Fifty cuttings / cultivar and / village field are sufficient. Moreover, the village test fields are closer to the farmers, in terms both of agro-ecological conditions and of distance. Farmers then select cultivars from the test fields in their own village and try them on their own land. In our case, Rural Training Center trainees with some experience in cassava farming are ideal to bring home cultivars from “their hub” at the end of their course, and to establish a test field in their village.

Based on the results of our field visits and interviews, the hubs should focus on providing nuclei of material to many villages, rather than multiplying and disseminating the new cultivars to all farmers. Once these nuclei are established in the villages, the new cultivars will naturally be disseminated through neighborhoods, farmers’ groups, and relatives.

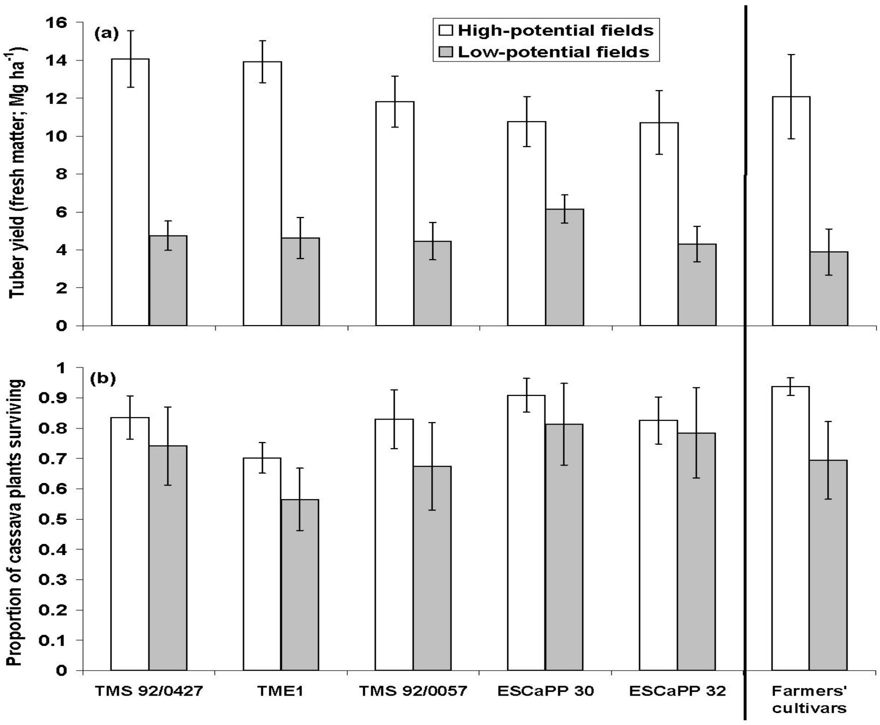

Figure 1. Yield (a) and proportions (b) of surviving plants of five different cultivars and the farmers’ own cultivars on high-potential fields (n=6) and on low-potential fields (n=5). Data points are means. Vertical bars are standard errors of the means.

Table 2. Number of visited farmers / village and number of farmers who grow a specific cultivar.

Village	Mfoya	Nibe	Asanje	Akossia	Bambui	Ndoka
Number of visited farmers	11	2	2	3	3	7
Cultivar Fonta Cassava	10	2	2	0	1	1
Cultivar Local Pawpaw Leaf	10	2	2	3	2	3
Cultivar Nkong	10	2	2	3	0	0
Cultivar Nsongwa	0	0	0	0	3	7
Cultivar Mambo	0	0	2	0	1	6

Acknowledgements

This research was supported by a PhD fellowship grant to C. Zundel from the Swiss Development Cooperation (SDC). R. Hanna was supported through a grant to IITA by the International Fund for Agricultural Development. Thanks to the Rural Training Centre (RTC) Fonta for allowing us to use their land and to the IITA for their new cassava cultivars. Many thanks go to C. Ngwa, C. Mifere, L. Dooquah, and D. Mankaa for their technical assistance.

References

Bakia B., Ambe J.T. and James B. 1999. Technology transfer strategies: the case of sustainable cassava plant protection in Cameroon. African Journal of Root and Tuber Crops 3:23−27.

Ceballos H., Iglesias C.A., Pérez J.C. and Dixon A.G.O. 2004. Cassava breeding: opportunities and challenges. Plant Molecular Biology 56:503−516.

Ceccarelli S., Grando S., Tutwiler R., Baha J., Martini A.M., Salahieh H., Goodchild A. and Michael M. 2000. A methodological study on participatory barley breeding I. Selection phase. Euphytica 111:91−104.

Dixon A.G.O. and Nukenine E.N., 1997. Statistical analysis of cassava yield trials with the Additive Main Effects and Multiplicative Interaction (AMMI) model. African Journal of Root and Tuber Crops 3:46−50.

Dixon A.G.O. and Nukenine E.N. 2000. Genoptype × Environment interaction and optimum resource allocation for yield and yield components of cassava. African Crop Science Journal 8:1−10.

Hanna R. and Toko M. 2002. Africa-wide classical biological control of cassava green mite – overview, accomplishments, and future actions and priorities. Pages 4−12 *In*: Proceedings of the 3rd Inter-regional Meeting of the Africa-wide Cassava Green Mite Biocontrol Project. Edited by Hanna R. and M. Toko, IITA, Biological Control Center for Africa, Cotonou, Republic of Benin.

Hanna R., Ojo D., Yaninek S., Toko M., Onzo A., Paraiso G. , Gnanvossou D. 2000. Abundance of exotic phytoseiids on cassava in Africa: effect of shoot apex characteristics. XXI International Congress of Entomology, Iguassu Falls, Brazil, pp 10.

Hillocks R.J. 2002. Cassava in Africa. Pages 41−54 *In*: Cassava: biology, production and utilisation. edited by R.J. Hillocks, J.M. Thresh, A.C. Bellotti. CABI Publishing, Wallingford, UK.

Hoffmann V., Probst K., and Christinck A. 2007. Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? Agricultrue and Human Values 24:355 −368.

Iglesias C.A., Calle F., Hershey C., Jaramillo G. and Mesa E. 1994. Sensitivity of cassava (*Manihot esculenta* Crantz) clones to environmental changes. Field Crop. Res. 36:213−220.

Joshi A. and Witcombe J.R. 1996. Farmer participatory crop improvement II. Participatory varietal selection, a case study in India Experimental Agriculture 32:461−477.

Kornegay J., Beltran J.A., Ashby J. 1996. Farmer selections within segregating populations of common bean in Colombia: Crop improvement in difficult environments. Page 151−159 *In*: Participatory plant breeding, Proceedings of a workshop on participatory plant breeding, 26-29 July 1995 Eyzaguirre, P. and M. Iwanaga, Wageningen, The Netherlands. International Plant Genetic Resources Institute, Rome, Italy.

Manu-Aduening J.A., Lamboll R.I., Ampong Mensah G., Lamptey J.N., Moses E., Dankyi A.A., and Gibson R.W. 2006. Development of superior cassava cultivars in Ghana by farmers and scientists: The process adopted outcomes and contributions and changed roles of different stakeholders. Euphytica 150:47−61.

Morris M.L and Bellon M.R. 2004. Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. Euphytica 136:21−35.

Number Cruncher Statistical System 2000, www.ncss.com/pdf/manuals/NCSSUG3.pdf

Ngeve J.M., Dixon A.G.O., Whyte J.B.A., Akoroda M.O., Tenku S.N., and Hanna R. in press. Boilable cassava varieties: What is their role within the context of the global agricultural economy? African Journal of Root and Tuber Crops.

Ohadike D.C. 1981. The influenza pandemic of 1918−1919 and the spread of cassava cultivation on the lower Niger: a study in historical linkages. Journal of African History. 22:379−391.

Okeleye K.A., Ikeorgu J.E.G., Melifonwu A., Aihou K., Maroya N.G., Dosoo E., Awah E.T., Tumanteh A., Salau R.A. 2001. Cassava-based cropping systems and use of inputs in different ecological zones of West and Central Africa. African Journal of Root and Tuber Crops 4:13−17.

Prain G., Uribe F., and Scheidegger U. 1991. Small farmers in agricultural research: farmer participation in potato germplasm evaluation. Pages 235–250 *In:* Joining farmers' experiments. Experiences in participatory technology development. ILEIA readings in sustainable agriculture edited by B. Haverkort, J. Vander Kamp, and A. Waters-Bayer. Intermediate Technology Publications, London,UK

Prudencio Y.C. and Al Hassan R. 1994. The food security stabilisation roles of cassava in Africa. Food Policy 19:57−64.

Simeu Kamdem M. 1996. Le manioc au Cameroun, une filière vivrière autorégulée. Cahiers Agriculture. 5:257−264.

Sperling L., Loevinsohn M.E. and Ntabomvura B. 1993. Rethinking the farmer's role in plant breeding: local experts and on-station selection in Rwanda. Experimental Agriculture. 29:509−519.

Sthapit B.R., Joshi K.D. and Witcombe J.R. 1996. Farmer participatory crop improvement III. Participatory plant breeding, a case study for rice in Nepal. Experimental Agriculture 32:479−496.

Tan S.L. and Mak C. 1995. Genotype × environment influence on cassava performance. Fields Crop Research. 42:111−123.

Warnier J.-P. 1984. Histoire du peuplement et génese des paysages dans l'ouest camerounais. Journal of African History. 25:395−410.

Witcombe J.R., Joshi A., Joshi K.D. and Sthapit B.R. 1996. Farmer participatory crop improvement I. Varietal selection and breeding methods and their impact on biodiversity. Experimental Agriculture. 32:445−460.

Zundel C., Nagel P., HannaR., Korner F., Scheidegger U. 2009. Environment and host-plant genotype effects on the seasonal dynamics of a predatory mite on cassava in sub-humid tropical Africa. Agricultural and Forest entomology. 11:321−333.