CASSAVA BREEDING AND VARIETAL DISSEMINATION IN INDONESIA DURING 1975-2000

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ABSTRACT

High-yielding varieties, adapted to local conditions and satisfying local preferences, is one of the most important components of improved technologies. Since cassava is propagated vegetatively using farmers' own planting material, the use of high-yielding varieties will give substantial economic gains without much additional costs. However, the suitability of certain high-yielding varieties could be limited and farmers will continuously require higher yields in order to remain competitive. Thus, breeding and varietal improvement will continue to be necessary.

Progress in cassava breeding in Indonesia has been relatively slow, since it depends to some extent on the conscientiousness of the scientists as well as on the priorities of the government. Because of a very limited number of people involved in cassava breeding and recent changes in institutional responsibilities, only six cassava varieties have been officially released since 1978. One of these no longer exists, while some other released varieties were the result of natural hybridization. Two of the six varieties officially released were selected from hybrid seed introduced from CIAT/Colombia. Possibly, two new varieties introduced from the Thai-CIAT program will be released in 2000.

In 1995, the national mandate for cassava research was assigned to RILET. The institute's cassava breeding program was established according to CIAT's conventional methodology, which consists of hybridization, single plant selection, single row selection, preliminary yield trial, advanced yield trials, multilocational trials and proposal for varietal release. Collaboration with other institutes, universities and private companies were enhanced to try to achieve the release of one new variety each year.

Varietal multiplication and dissemination by the government are still very limited. However, since 1999 there has been an aggressive multiplication program as a means to support varietal dissemination. When this program is correctly implemented there will be an exponential increase in the area planted to high-yielding varieties. Since 1995 the government of Indonesia has established provincial-level institutes, called Assessment Institute for Agricultural Technology, with the responsibility to adapt new technologies to local conditions and enhance their dissemination and adoption. Collaboration with international as well as other national research centers dealing with cassava will strengthen the research capability and further enrich genetic variability.

INTRODUCTION

Cassava is grown throughout Indonesia, but is highly concentrated in Java and the Southern part of Sumatra. The variability of the physical environments, either soils or climates, are very wide. Howeler (1992), estimated that cassava in Indonesia is grown on the following soil orders: 24% on Alfisols, 22% on Ultisols, 20% on Entisols, 18% on Inceptisols, 8% on Vertisols, 6% on Mollisols, 2% on Histosols and 1% on Oxisols. The proportion of soil orders on Java island is much larger than on the other islands except for Oxisols and Histosols, which are not found on Java.

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Climatic conditions which are characterized mainly by the intensity and distribution of rainfall, also vary. In general, there are wetter areas which extend from West Java to the western parts, and drier areas which extend from Central Java to the eastern parts of Indonesia. As a rule of thumb, the northern areas are also relatively wetter compared to the southern areas.

Most of the soil orders planted with cassava, especially the Ultisols, have a low organic matter content and have very low levels of P, K, Ca, and Mg. If the topography is undulating or hilly and there is high rainfall intensity, erosion can be serious. Continuous cassava planting without appropriate soil management will lead to declining yields. Farmers usually apply only small amounts of chemical fertilizers to cassava, while the crop is very efficient in exploiding scarce nutrients in the soil.

Cassava is grown mainly by small farmers with labor-intensive methods, making little use of purchased inputs because they have limited financial resources. The technology most necessary under these socio-economic conditions is a high-yielding variety. Indeed, an improved variety is the most useful and cheapest technology component for farmers. Puspitorini *et al*. (1998), and Kawano (1998), provided evidence that the socio-economic contribution of high yielding cassava varieties in increasing farmers' income was substantial.

Considering the diverse ecological conditions as well as the various ways of cassava utilization, a wide range of different varieties is required. The existence of hundreds of local cassava varieties, which have been selected by farmers and are still mostly used, is a useful guide for future germplasm improvement. A great and ambitious task to serve the people's needs by providing improved cassava varieties was launched in 1995. Unfortunately, even though many activities continued, others were interrupted due to various circumstances.

HISTORICAL REVIEW OF CASSAVA BREEDING IN INDONESIA

Regardless of the activities performed, the mandate for developing high yielding varieties is the task of governmental institutes, because high yielding varieties should be the property of the general public, especially the poor. Of course, this does not mean that the private sector can not breed new varieties for their own use.

Cassava breeding and the release of new varieties already began during Dutch colonial times; Dutch varietal names such as Faroka and Vandrum are an indication of this. Since 1984, Brawijaya University in Malang has undertaken collaborative research with the Research Institutes for Food Crops located in Bogor and Malang, as well as with a private enterprise which had previously developed a cassava plantation in Lampung called Umas Jaya Farm (UJF); all three entities worked in collaboration with the CIAT Cassava Program in Asia (Poespodarsono, 1998).

Such collaboration has many advantages, and has resulted in the release of several new varieties. Professional capabilities were strengthened through training and personal communication, while the participation in workshops in other countries broadened the scientists' vision. Unfortunately, many of the senior scientists thus trained were assigned to other tasks not directly related to cassava breeding.

A new phase of action began in April, 1995. At that time, several new Research Institutes were established, even though they are basically new only in name and in their specific mandates. The Research Institute for Legumes and Tuber Crops (RILET), which

was previously called the Malang Research Institute for Food Crops (MARIF) is one of these new institutes. RILET was assigned the national mandate to generate technologies for legumes and tuber crops, including the generation of new varieties. Because of limitations in personnel and financial resources, research on tuber crops has concentrated mainly on cassava and sweetpotato.

CASSAVA BREEDING ACTIVITIES

Using germplasm locally available, a rudimentary cassava varietal improvement program was started in 1985. Fortunately, a breeding methodology had already been developed by CIAT, which we slightly adapted and adopted. The methodology started with parent selection, followed by hybridization. Fortunately, we have an opportunity to make crosses, since there is a research station nearby RILET's headquarters, located at about 800 masl, where cassava will flower. The selection process starts with selection of seedlings resulting from those hybrid seeds, followed by selection in single rows, single plots, preliminary yield trials, advanced yield trials, and multi-locational yield trials; eventually this may culminate in a varietal release.

From 1995 until 1998, hybridizations made in 1994, either through controlled or open pollination, have produced more than 10,000 seeds. This means that the number of seeds locally produced was equal to, or slightly more than, the number of seeds received by Umas Jaya Farm (9,272) from CIAT during the same period. However, our crosses involved a much smaller number of parents. New collaboration, which is expected to be more viable, between RILET and UJF is about to start. RILET uses the code OMM for open pollinated crosses and CMM for controlled pollination, while UJF keeps their own code, which is UJ.

The objective of the cassava breeding program is to satisfy the need for two distinct groups of varieties i.e. non-bitter and bitter varieties. The two groups have common characteristics which are:

1. High fresh root yield
2. High dry mattter and starch content
3. Tolerance to red mites
4. Tolerance to *Cercospora* blight
5. Adaptation to marginal soils
6. Good root shape
7. Non-branching

Specific characteristics for non-bitter varieties only are:

1. Low cyanogenic potential, i.e. less than 40 ppm HCN as determined by the quick picrate acid method
2. Good flesh texture after being boiled or fried
3. Yellowish flesh
4. Varied harvestability

In addition, there are some special requirements for special utilization purposes. Specific requirements with respect to roots are: they should have a uniform size from the top to the bottom, six centimeters in diameter, 20 centimeters in length, easy to peel, non-bitter and with good flesh texture. Specific requirements for leaves are: non-bitter, high-

leaf productivity, preferably multi-branched. There is great demand for cassava leaves and the price is high, especially in urban areas.

The schemes for breeding non-bitter and bitter varieties are slightly different. For non-bitter varieties, a taste test is conducted at the single plant selection step as this character is of high priority. Whatever other good characters other than taste it may have, the line will be rejected if the taste is bitter; in that case the material will be moved to the scheme used for breeding bitter varieties. If the taste is acceptable, the next character to be determined is flesh texture. If the texture is not acceptable, the material will also be allocated to the scheme for bitter varieties. If these two main requirements are satisfied, the next steps are the same as those recommended by CIAT. The selection scheme for bitter varieties is completely the same as the CIAT procedure, as described by Hersey (1988).

Inter-institutional or multi-disciplinary collaboration is also encouraged. Scientists of other disciplines, especially entomologists and plant pathologists, become involved in the breeding scheme to evaluate for tolerance to pests and diseases. This collaboration is essential for the selection of cross parents, while pest and disease tolerances are also evaluated prior to conducting the preliminary yield trial. Soil scientists also may become involved in the breeding scheme for evaluating the adaptation to marginal soils, while food technologists are involved either in quality evaluation or in product development.

Problems and their Solutions

1. The factor most constraining the growth of the program is lack of personnel. This problem is not easy to solve.
2. Research capabilities. We must admit that many cassava breeders are not trained as such but have become breeders through practice. This constraint, of course, should be considered as a challenge. Self-study and personal communication, as well as guidance by more authoritative professionals, are very important.
3. The available genetic diversity is limited. Since the diversity of the genetic stock will determine the prospect of breeders' success, the limitation of genetic diversity is likely to slow down the process. However, there is also an advantage. The funds required for managing the germplasm collection is also limited. In an attempt to reduce this limitation, we always use *in situ* genetic stocks, which are the farmers' local varieties. Since most of the characters needed by farmers are already present in these varieties the chance of success is expected to be high.
4. International concern for cassava breeding will not last forever. Strengthening professionalism and increasing collaboration are urgently needed, but CIAT's role in this is diminishing, while the battle against poverty has not yet been won. What can be done about this?

BREEDING ACHIEVEMENTS

Six high yielding cassava varieties, having different characteristics, have officially been released in Indonesia between 1978 and 1998 (**Table 1**). However, one of these, Adira 2, no longer exists. Two of the six, i.e. Malang 1 and Malang 2, were selected from hybrid seed introduced from CIAT/Colombia; their original codes were CM4049-2 and CM4031-10, respectively. Adira 1, the first high yielding variety released was generated through open pollination. Its female parent is named Mentega, because the flesh color is yellow. Mentega means "butter" in Indonesian. This variety has spread mainly in the area

around Bogor in West Java, as well as in Pati district in Central Java. It is grown in thousands of hectares, mainly near household- and small-scale starch processing centers. The yellowish flesh does not have an effect on starch color and quality. It seems that Adira 1 is best adapted to higher rainfall areas.

Table 1. High yielding cassava varieties officially released in Indonesia.

Variety name	Type of crosses	Year of release	Taste	Outer skin color	Flesh color
1. Adira 1	Open	1978	Non-bitter	Reddish brown	Yellow
2. Adira 2	Open	1978	Bitter	Dark brown	White
3. Adira 4	Open	1986	Bitter	Dark brown	White
4. Malang 1	Controlled	1992	Slightly bitter	Creamy white	Yellowish white
5. Malang 2	Controlled	1992	Non-bitter	Brown	Pale yellow
6. Darul Hidayah	Selfed	1998	Non-bitter	Creamy white	White

Adira 4, released in 1986, is very popular. But because of its bitter taste, its acceptability is limited to industrial and dried form utilization only. Adira 4 is especially well accepted in areas where wild pigs and theft of cassava roots are serious problems. Adira 4 appears to be more widely adapted as compared to Adira 1. The characteristics of Malang 1 and Malang 2 have been described by Kawano (1998).

The last variety listed in **Table 1**, Darul Hidayah, was generated by "chance breeding" in Lampung. This variety originated from the seed of grafted cassava. A cassava plant discovered in the forest was grafted onto root stock of *Manihot glaziovii*. Surprisingly, the grafted cassava produced flowers and seed, even though it was planted at a lower elevation (less than 100 masl). When one of the seeds was planted and then propagated vegetatively by the grafter (Haji Jamil), the root yield was enormous (about 70 kg per plant). Even though this variety has high yielding potential, it is very susceptible to mites and has a narrow adaptability.

Possibly, two other varieties will be released in the year 2000, both introduced from Thailand. The original names of these varieties are Rayong 90 and Kasetsart 50 which were released in Thailand in 1989 and 1992, respectively. In several yield evaluation trials Kasetsart 50 was found to be very drought tolerant.

Table 2 shows the most recent breeding achievements. Twelf promising cassava lines are being tested in multi-locational trials which will be harvested in October 2000. In previous Advanced Yield Trials the fresh root yield was about 50 t/ha. The root dry matter content was 30-37%. Some clones (PT 4 and BIC 108) are non-bitter and have good taste.

Table 2. Promising cassava clones tested in multi-locational trials in 1999/2000.

Clone	Fresh root yield (t/ha)	Dry matter content (%)	Harvest index	Taste	Parents
CMM95075-6	58	32.43	0.55	slightly bitter	MLG 10075/10006
CMM95032-12	58	30.56	0.56	slightly bitter	MLG 10020/10152
CMM95032-8	58	30.95	0.56	slightly bitter	MLG 10020/10152
CMM90-6-72	56	31.93	0.60	bitter	Adira 4
CMM95066-1	55	32.65	0.64	bitter	MLG 10071/10032
CMM95089-11	55	30.27	0.54	slightly bitter	MLG 10152/10033
CMM95023-5	55	35.69	0.60	slightly bitter	MLG 10018/10075
CMM95014-19	55	37.89	0.55	slightly bitter	MLG 10012/10075
CMM95014-3	53	36.80	0.45	bitter	MLG 10012/10075
PT-4	53	n.a.	n.a.	non bitter	Local Malang
BIC-108	52	n.a.	n.a.	non bitter	n.a.
PT-6	50	n.a.	n.a.	slightly bitter	Local Malang

Notes: n.a. = not available

VARIETAL DISSEMINATION

There has not been an aggressive program to disseminate new cassava varieties in Indonesia. The slow varietal dissemination was caused by institutional problems. Dimyati (1995) ascribed the problems of dissemination of cassava varieties mostly to strict governmental control on varietal releases.

It is expected that the newly founded Provincial Research Institute, called the Assessment Institute for Agricultural Technology, will help to speed up varietal dissemination.

CONCLUSIONS

1. Cassava breeding activities in Indonesia are still rather limited in scope. Even though cassava breeding is very important, there is a serious limitation of resources, such as scientists, laboratories and breeding materials.
2. However, several high-yielding varieties have already been released. Other promising clones will be released in the near future.
3. Collaboration between researchers, both domestically and internationally, are urgently needed.

REFERENCES

Dimyati, A. 1995. Cassava technology transfer in Indonesia. *In*: R.H. Howeler (Ed.) Cassava Breeding, Agronomy Research and Technology Transfer in Asia. Proc. 4th Regional Workshop, held in Trivandrum, Kerala, India. Nov 2-6, 1993. pp. 183-194.

Hersey, C. 1988. Cassava Breeding-CIAT Headquarters. *In*: R.H. Howeler and K. Kawano (Eds.). Cassava Breeding and Agronomy Research in Asia. Proc. 2nd Regional Workshop, held in Rayong, Thailand. Oct 26-28, 1987. pp. 99-116.

Howeler, R.H. 1992. Agronomy Research in the Asian Cassava Network-An overview 1987-1990.

In: R.H. Howeler (Ed.) Cassava Breeding, Agronomy and Utilization Research in Asia. Proc. 3rd Regional Workshop, held in Malang, Indonesia. Oct 22-27, 1990. pp. 260-285.

Kawano, K. 1998. Socio-economic contribution of cassava varietal improvement to the small farmer communities in Asia. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 170-190.

Poespodarsono, S. 1998. Recent progress in cassava varietal improvement in Indonesia. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou Hainan, China. Nov 3-8, 1996. pp. 145-155.

Puspitorini, P., U. Kartawijaya and K. Kawano. 1998. Cassava varietal improvement program at Umas Jaya farm and its contribution to small farmer communities in Sumatra, Indonesia. *In*: R.H. Howeler (Ed.). Cassava Breeding, Agronomy and Farmer Participatory Research in Asia. Proc. 5th Regional Workshop, held in Danzhou, Hainan, China. Nov 3-8, 1996. pp. 156-169.