CASSAVA BREEDING AND VARIETAL RELEASE IN THE PHILIPPINES

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ABSTRACT

The cassava breeding program in the Philippines has achieved modest progress since the time CIAT provided support in terms of human resource development and the introduction of elite cassava germplasm as a source of genetic variability.

Through the years cassava breeding in the Philippines has aimed to satisfy both the needs of farmers who grow cassava in diverse agro-climatic conditions, and those of processors who utilize the storage roots for food, feed and industrial purposes.

Using local and introduced materials, hybrids were evaluated and selected in various phases of selection, such as: Observational Trials (single seed evaluation), Single-row Trials, Preliminary Trials, General Yield Trials, Advanced Yield Trials, and finally, Multi-location testing (Regional Trials). All introduced hybrid populations and locally developed hybrids undergo these phases of evaluation and selection. It takes 7 to 8 years of testing before a variety is released as a registered variety by the National Seed Industry Council of the Philippines (NSIC).

Progress in breeding and selection has resulted in the identification of several elite materials possessing high dry matter and starch contents with low to moderate levels of HCN. From 1999 to 2002 four new cassava varieties were recommended for nationwide cultivation in the Philippines. These are: PSB Cv-17 (CG87-03-01), PSB Cv-18 (CG87-02-13), PSB Cv-19 (SM808-1) and PSB Cv-20 (CG91-13-01). These new varieties have high yield potential, high dry matter and starch contents, and are suitable for production of food, feed and starch. Todate there are already 20 registered cassava varieties in the Philippines to provide growers a wide range of choices. In addition, just recently, two new selections were recommended by the Technical Working Group to the NSIC for release. These varieties are KU 50 (from Thailand) and SM818-1. These two have superior dry matter and starch contents as compared to the previously released varieties.

Utilization of these new cassava varieties is being enhanced by the expansion of the cassava area for production of feed and alcohol. The private sector (San Miguel Corporation) expansion of cassava to about 30,000 ha is gaining ground.

Breeding work will continue to focus on the identification of superior varieties that will address the requirement of the cassava-based industry in the country.

INTRODUCTION

Cassava varietal improvement in the Philippines started in the 1960s at the Institute of Plant Breeding (IPB) in Los Banos, Laguna (Bacusmo and Bader, 1992). The original focus of this improvement program, however, was mainly on varietal trials of a few local and introduced varieties (Mariscal, 1987). It was only when the Philippine Root Crops Research and Training Center (PhilRootcrops) was established in 1977 at Leyte State University (LSU), formerly the Visayas State College of Agriculture (ViSCA), Baybay, Leyte, Philippines, by virtue of Presidential Degree No. 1107, that a more organized and relatively well-supported cassava breeding program started. This resulted in the assemblage of a cassava germplasm collection, subsequent screening, and the identification and release of superior local and introduced varieties. The breeding program was further enhanced when PhilRootcrops established a strong linkage with the Centro Internacional de Agricultura Tropical (CIAT) Cassava Program in 1982 through the leadership of Dr. Kazuo Kawano, CIAT's cassava breeder, who initiated the CIAT Regional Cassava Program in

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Asia in 1983, based in Thailand. CIAT provided the national program with improved cassava populations. This resulted in the release of several cassava varieties with parental origin from CIAT and Thailand. More than that, CIAT has helped the Center in strengthening the capability of its breeders to spearhead the systematic evaluation and selection of the improved materials, and their subsequent utilization in the breeding program.

During the more than 20 years of existence of the Center, a modest increase of the national average yield of cassava from 6.0 t/ha in 1977 to 9.8 t/ha in 2002 was attained. This reported yield, however, is the lowest in Southeast Asia. The modest yield increase is attributed to the gradual adoption of high-yielding cassava varieties and improved cultural management practices (Root Crops National RDE Agenda, 1999).

In the Philippines, cassava is one of the important crops that cater to the food, feed and industrial sectors. Walters (1983), Lynam (1986), and Singh (1986) emphasized that cassava will play a major role in satisfying the domestic needs of the country, and that any future increase in output by the cassava producing countries in Asia should be aimed primarily at their domestic markets, such as for animal feed and starch production (food processing, textiles, paper and board, sweeteners and ethanol). Recently the Philippines has experienced a significant increase in production of cassava in order to meet the demand for animal feed and for production of ethanol to be used as an alternative to molasses for the production of liquor. The existing high demand for cassava, therefore, needs a strong backstopping with respect to new improved cassava varieties from the cassava breeding program.

CASSAVA BREEDING

1. Objectives

Cassava breeding in the Philippines aims to satisfy the needs of farmers who grow cassava in diverse agro-climatic conditions, as well as those processors who utilize the storage roots in a variety of ways. The breeding objectives are as follows:

1. High yield
2. High dry matter and starch content
3. Resistance to pests and diseases
4. Tolerance to environmental stresses
5. Good plant type

The level of hydrogen cyanide (HCN) in cassava, although not correlated with yield, is also considered during selection. Low HCN varieties are identified and selected for farmers who use cassava as staple food. High HCN varieties, on the other hand, are used by starch factories because they tend to produce high yields and have a higher starch content, while discouraging thefts. Those varieties having both low HCN and high dry matter and starch contents are considered dual-purpose varieties (for table use and processing type).

2. Breeding and Selection Methodology

The breeding and selection scheme of the Center is patterned after the CIAT cassava germplasm improvement scheme **(Figure 1)** (Mariscal, 1987). From the improved cassava populations introduced from CIAT/Colombia or the Thai-CIAT program, as well as those locally developed from the Center pass through the following scheme:

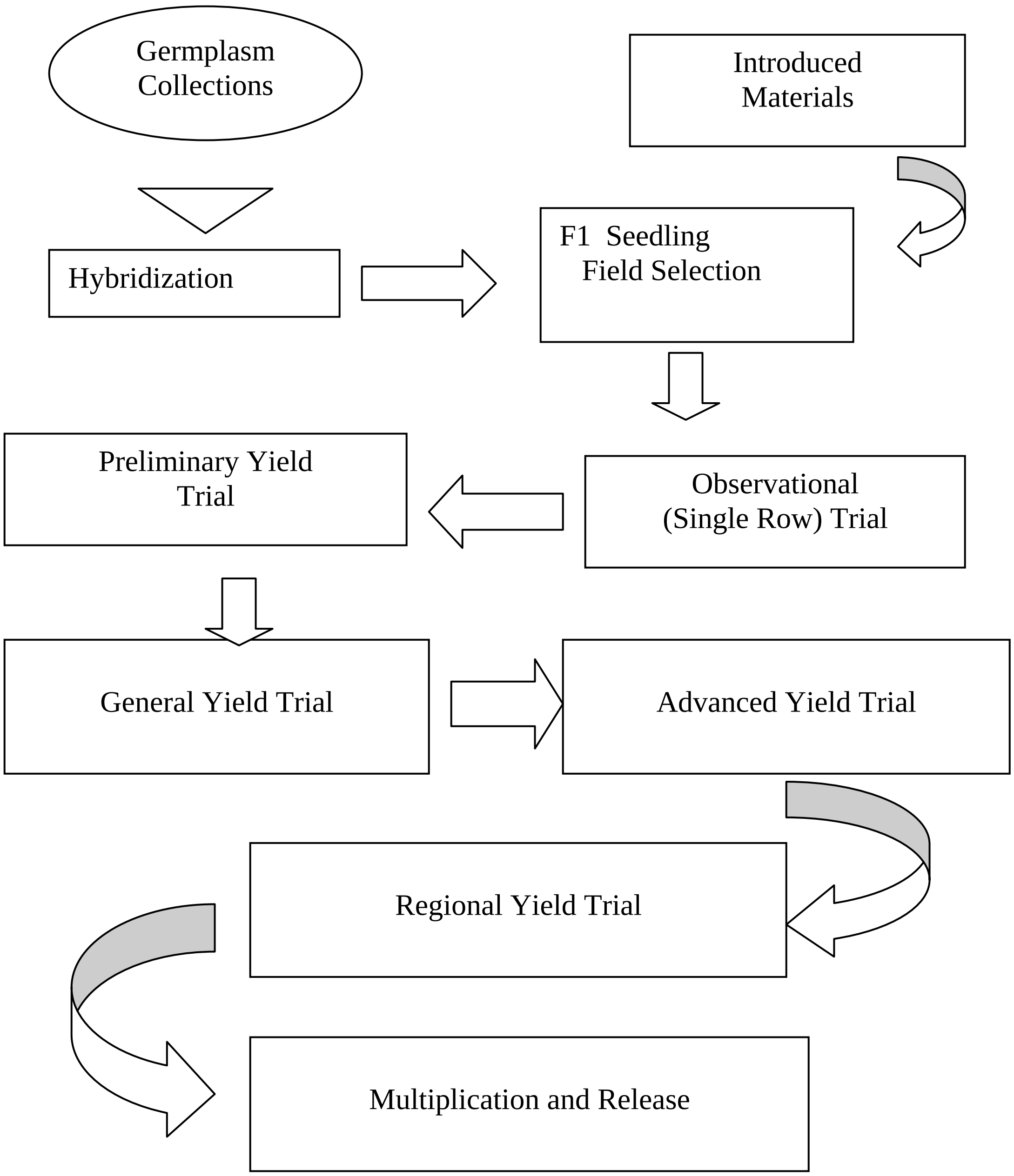

Figure 1. PhilRootcrops breeding and selection methodology.

F_1 Field Selection. Seedlings produced from sexual seed, including those introduced from CIAT/Colombia and the Thai-CIAT program, are subjected to individual plant selection in the F_1 stage. Entries are planted at 2 meters between rows and 1 meter between hills. The harvest is at 10 months after planting and selection criteria are limited to harvest index, plant type, and general appearance of the crop.

Observational Trial. Selections from the F_1 field screening are further tested in the Observational Trial, also known as Single-Row Trial. Normally, five to seven stakes are prepared for each selected clone and planted in a 1 x 1 m planting pattern without replication. A check variety is planted every 10^{th} row. Selection criteria include yield per plant, harvest index, dry matter content, and reaction to pests.

Preliminary Yield Trial. Entries selected from the Observational Trial, as well as local and exotic accessions, enter this phase of screening. Test entries are planted in four to five rows per plot without replication, following the same planting pattern as in the Observational Trial. Selection is based on yield per plot, dry matter, harvest index, hydrogen cyanide (HCN) content, and general appearance of the crop.

General Yield Trial. Selections from the Preliminary Yield Trial are entered in this trial. Test clones are planted in four to five rows per plot replicated three to four times. Distance of planting is 1.0 x 0.75 m. Harvesting is done at 10 months after planting. Important economic characters are closely monitored at this stage and yield per hectare is computed.

Advanced Yield Trial. This is the last stage of selection before clones are included in the Regional Yield Trial of the National Cooperative Testing for Root Crops. A plot measuring 5 x 6 meters is used for each entry and replicated three to four times. A minimum of three different testing sites is required for each selected clone before it is included in the next cycle of evaluation. Harvesting is done 10 months after planting and parameters considered are yield per hectare, dry matter content, HCN content, plant architecture, and general reaction to pests.

Regional Yield Trial. The number of entries at this stage of evaluation is determined by the Root Crop Technical Working Group of the National Seed Industry Council. Agencies involved in variety development submit lists of entries to the group for inclusion in this trial. Potential entries should have passed the Advanced Yield Trial stage of evaluation. Entries determined by the working group are tested in at least ten locations throughout the country following the standard format set by the Technical Working Group. Harvesting is done at 10 months after planting. Parameters gathered in this stage of evaluation include yield, dry matter and starch content, harvest index, HCN content, root shape, ease of harvest and reaction to pest and diseases. Two croppings are required per set of entries before a variety is recommended for registration and release.

Varietal release and recommendation. Results of the two croppings of the Regional trial in all testing sites are summarized and reported during the annual meeting of the Root Crop Technical Working Group. The candidate variety should possess some unique traits and qualities in comparison to the standard check. Entries that qualify for nomination for recommendation are then submitted to the National Seed Industry Council (NSIC) for final approval and release to the farmers for utilization and adaptation.

3. Genetic Gain in Selection

Gains in selection in cassava varietal improvement are enhanced by the wide genetic base of our germplasm collection. PhilRootcrops has maintained and upgraded the genetic stocks of cassava. To date, 322 cassava accessions are maintained in the field genebank. These include both local and foreign collections, as well as elite materials from Advanced Yield Trials **(Table 1).**

Table 1. Germplasm collections of cassava maintained at PhilRootcrops in 2002.

Source	Number of accessions
Local	68
Foreign	92
Tissue culture	25
Elite clones	117
Released varieties	20
Total	**322**

From 1999 to 2002, 5,044 hybrid seedlings have been evaluated **(Table 2).** The sexual seed came from the Thai-CIAT program as well as from crosses made by PhilRootcrops. Summaries of the number of genotypes at different stages of selection are shown in **Table 3.**

Table 2. Total number of cassava hybrid seeds evaluated at PhilRootcrops from 1999 to 2001.

Source	Year	Number of seeds	No. of crosses
Thai-CIAT Program	1999/00	2,400	38
PhilRootcrops	2000/01	2,644	17
Total		**5,044**	**55**

Performance of selected breeding lines from the Thai-CIAT program in the Preliminary Yield Trial generally show exceptional improvement over that of the standard check variety Lakan **(Table 4).** The highest yield of 45 t/ha was obtained from entry OMR40-09-31 which had a dry matter content of 32.2% compared to the check with only 22.4 t/ha and 30.2% dry matter Generally, all the selections outperformed the check variety. This goes to show that these hybrid populations contain superior characteristics.

Table 3. Number of cassava hybrids evaluated at different stages of selection at PhilRootcrops from 1999 to 2002.

Selection stages	1999/00	2000/01	2001/02	Total
Single Plant Trial	1,216	610	-	1,826
Observational Trial	-	180	59	239
Preliminary Yield Trial	30	-	56	86
General Yield Trial	21	21	29	71
Advanced Yield Trial	18	15	11	44
Regional Yield Trial	10	10	12	32
Varietal release	1	2	1	4

Table 4. Performance of selected Thai-CIAT cassava hybrids evaluated in the Preliminary Yield Trial 2001/02.

Entry	Fresh root yield (t/ha)	Dry matter content (%)	Harvest index	HCN content[1)]
1. OMR39-35-22	41.1	32.8	0.61	5
2. OMR39-43-04	42.2	33.6	0.68	3
3. OMR39-48-02	34.2	34.6	0.56	6
4. OMR40-09-34	45.0	32.2	0.55	3
5. CMR39-07-02	38.1	33.2	0.64	4
6. CMR39-07-03	40.8	30.8	0.63	5
7. CMR39-07-04	42.2	31.3	0.56	2
8. CMR39-50-23	40.6	32.4	0.75	3
9. Lakan 1 (Check)	22.4	30.2	0.41	5
10. Lakan 2 (Check)	29.5	32.2	0.50	3

[1)] Sodium picrate method: 6 = high, 1 = low

In the General Yield Trial phase of evaluation, cassava breeding lines selected from seed sent from CIAT/Colombia also showed good performance compared to the check cultivars. Yield of these selections are presented in **Table 5.** An outstanding selection is CM9222-3 which produced an average yield of 37.0 t/ha with a dry matter content of 32.7% and a low level of HCN, making it suitable as a table type variety. Other selections have also shown promising results.

From the series of Advanced Yield Trials conducted during the period covered by this report, some promising genotypes were identified for possible inclusion in the Regional Yield Trials conducted throughout the country. These materials came from CIAT/ Colombia. The results presented in **Tables 6, 7 and 8** show that there are marked improvements in terms of yield, dry matter content and even reaction to scale insects and mites, as compared to the check varieties. It is interesting to note that in **Table 7,** entries SM235-39 and SM2359-7 have shown a high resistance to both scale insects and mites, aside from having high yields and dry matter contents. These two insect pests are the most destructive pests of cassava in the country.

It seems that at this point in time of breeding and selection of new cassava varieties, remarkable improvements have been attained. Progress in selection in all phases of the selection process has been very positive, thanks to the superior germplasm materials contributed by CIAT headquarters and the Thai-CIAT breeding program.

Table 5. Performance of selected cassava hybrids from CIAT/Colombia evaluated in the General Yield Trial of 2000/01.

Entry	Fresh root yield (t/ha)	Dry matter content %	Harvest index	HCN content[1)]
1. SM2454-23	22.1	33.6	0.46	5
2. CM9222-3	37.0	32.7	0.65	4
3. CM9165-9	22.6	34.2	0.52	6
4. CM9165-17	33.3	31.7	0.55	3
5. CM9165-20	24.5	34.5	0.47	5
6. CM9165-25	26.2	35.1	0.51	5
7. Lakan 1 (Check)	32.4	32.6	0.59	3
8. VC-5 (Check)	26.3	31.0	0.52	6

[1)] Sodium picrate method: 6 = high, 1 = low

Table 6. Performance of selected cassava hybrids from CIAT/Colombia evaluated in the Advanced Yield Trial of 2000/01.

Entry	Fresh root yield (t/ha)	Dry matter content (%)	Starch content (%)	Harvest index	HCN content[1)]
1. SM1971-7	22.5	31.3	17.9	0.48	3
2. SM2065-1	25.1	33.3	20.6	0.44	5
3. SM2117-8	30.8	31.4	18.1	0.57	4
4. SM2196-4	27.7	32.1	19.0	0.58	5
5. SM2200-27	21.1	30.4	16.7	0.49	5
6. SM2225-36	41.9	30.2	16.4	0.62	4
7. Lakan 1 (Check)	29.6	30.8	17.3	0.51	5
8. VC-5 (Check)	26.0	28.3	13.7	0.54	7

[1)]Sodium picrate method: 7 = high, 1 = low

Table 7. Performance of selected cassava hybrids from CIAT/Colombia evaluated in the Advanced Yield Trial of 2000/01.

Entry	Fresh root yield (t/ha)	Dry matter content (%)	Starch content (%)	Harvest index	HCN content[1)]	Scale insects rating[2)]	Mites rating[2)]
1. SM2353-17	26.2	34.9	22.9	0.61	5	6.0	1.0
2. SM2353-25	20.4	31.0	17.5	0.64	3	1.0	3.0
3. SM2353-39	21.1	34.0	21.7	0.56	2	1.0	4.0
4. SM2359-4	22.1	34.0	21.7	0.49	4	3.0	2.0
5. SM2359-7	22.2	32.9	20.1	0.56	2	1.0	1.0
6. Lakan 1 (Check)	24.0	33.9	21.5	0.59	4	5.0	1.0
7. VC-5 (Check)	18.7	30.9	17.4	0.61	6	3.0	7.0
8. Lakan 2 (Check)	16.9	34.3	22.1	0.58	3	2.0	3.0

[1)] sodium picrate method: 6 = high, 1 = low
[2)] rating based on 1 to 9 scale with increasing order of pest severity

Table 8. Performance of selected cassava hybrids from CIAT/Colombia evaluated in the Advanced Yield Trial of 2001/02.

Entry	Fresh root yield (t/ha)	Dry matter content (%)	Harvest index	HCN content[1)]	Scale insects rating[2)]	Mites rating[2)]
1. CM9175-25	23.9	48.6	0.60	6	2.0	2.0
2. CM9165-20	22.4	37.0	0.60	7	2.0	3.0
3. CM9165-9	21.6	37.1	0.50	5	2.0	3.0
4. SM2440-6	23.0	32.9	0.70	5	2.0	6.0
5. CM9165-17	31.0	35.6	0.60	6	4.0	3.0
6. CM9222-3	24.9	37.4	0.60	4	4.0	4.0
7. Lakan 1 (Check)	23.7	35.1	0.60	4	3.0	4.0
8. VC-5 (Check)	16.4	31.5	0.60	7	2.0	4.0

[1)]sodium picrate test: 7= high, 1 = low
[2)]rating based on scale of 1 to 9 with increasing order of pest severity

4. Varietal Release and Dissemination

Close collaboration with CIAT in the introduction of improved hybrid populations has resulted in the release of eight cassava varieties of CIAT origin (Mariscal *et al.*, 2001). These varieties produce yields in the range of 24 to 40 t/ha and with dry matter contents in the range of 32 to 34%. The major use of these varieties is for starch processing and animal feed. Recently, four new cassava varieties were released by the National Seed Industry Council for general utilization among farmers. Among these four varieties, one came from CIAT/Colombia and the other three came from the local breeding program of the Institute of Plant Breeding of the University of Los Banos, College, Laguna, Philippines **(Table 9).** Variety PSB Cv-19 (SM808-1) is a selection from an improved population introduced as sexual seed from CIAT/Colombia in 1994. It has an average yield of 32.3 t/ha with 35% dry matter and 22% starch. It has a medium HCN content and was found to be resistant to scale insects and spider mites. This variety is recommended for starch and animal feed production. The other three varieties are recommended for starch, flour and animal feed. From the remaining genotypes selected for testing in Regional Trials, some superior varieties are expected to be released soon. These prospective varieties produced yields of more than 30 t/ha, with a dry matter content of 38 to 40%.

Table 9. New cassava varieties released in the Philippines between 1999 and 2001.

Varietal characteristics	PSB Cv-17 (CG87-3-1)	PSB Cv-18 (CG87-2-13)	PSB Cv-19 (SM808-1)	PSB Cv-20 (CG91-13-1)
Fresh root yield (t/ha)	39.2	39.0	32.3	35.8
Dry matter content (%)	32.0	32.5	35.0	35.3
Starch content (%)	18.9	19.6	22.9	23.4
HCN level	Medium	Medium	Medium	Medium
Root flesh color	White	White	White	White
Reaction to pests				
-Scale insects	R	R	R	R
-Spider mites	MR	R	R	R
Intended use	Starch, feed	Flour, starch	Starch, feed	Starch, feed
Year released	1999	2000	2000	2001

To date, there are already several varieties of cassava for use in the food, feed and starch industry; however, there is a need to have a strong extension program to disseminate and make these new improved varieties available to farmers.

The Philippine Root Crops Research and Training Center (PhilRootcrops) has initiated the following strategy of varietal dissemination among farmers and entrepreneurs:

1. An information drive among farmers through training, field days and the mass media

Short training courses for farmers through NGOs and farmer cooperatives are conducted at the Center or at the sites where farmers intend to plant cassava. Each year during the Center's Anniversary Celebration a farmers' field day is held to show-case the information about the new cassava varieties. This is done through an exhibit and actual plant demonstrations during the field day. Dissemination through radio is also done in order to reach those in far away places who cannot physically be present during the field day.

2. Private entrepreneur contact

The Center also provides information directly to private corporations and individual entrepreneurs who intend to grow cassava at a large-scale.

3. Adaptability trials in specific areas of cultivation

Adaptation trials of recommended cassava varieties is an activity to evaluate cassava varieties for their adaptation to specific growing environments. This serves as a venue for farmers to select the best varieties that can be grown in their locality. Results so far indicate that those varieties that perform best in the adaptability trial are those selected by farmers for planting.

4. Establishment of a system to produce planting material

Using the testing sites of the Regional Trials, each location establishes a seed nursery to multiply the outstanding recommended varieties for distribution in the area. At least a one ha nursery per site is devoted to the production of planting material. Stems produced will be sold at cost to the clientele.

These strategies are designed to meet the increasing demand for cassava in the animal feed and the industrial sector. The San Miguel Corporation, the giant company that produce beverages and drinks has launched a massive campaign for cassava production to support their liquor industry. The company needs at least 30,000 ha of cassava to supply the feed and alcohol industry.

FUTURE DIRECTION

The demand for food to feed our increasing population calls for a vigorous effort to increase food production per unit time per unit area. The national government has focused their policies on food security, poverty alleviation, productivity improvement, global competitiveness, environmental protection and sustainability.

In the Philippines, root crops have been identified as one of the important energy crops that will play a vital role in feeding millions of people; as such, the research and development agenda will focus on the following:

1. Strengthening cassava hybridization work using elite clones and local varieties by way of conventional and unconventional methods of improvement.
2. Aggressively promoting adoption of new recommended cassava varieties.
3. Monitoring the performance of released varieties planted in large-scale production.
4. Continuing the selection of superior varieties that will suit the needs for the food, feed and starch industries.
5. Initiate linkages with the private sector, local government units and non-government organizations in the promotion of cassava for food, feed and industrial uses.

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