4. PROCESSING

Fresh roots are usually transported to cassava chip or starch factories on the same day of harvest. Storing period of fresh roots at the factory depends on the capacity of the factory and the amount of roots received. Roots are usually processed within 2-5 days. Chipping and drying of the roots or the processing into starch should be done not later than 4 days after harvest. The starch content was found to decrease from 24% at harvest to 20% at 4 days and to 11% at 6 days after harvest. The starch quality is also affected by delays in processing.

4.1 Chips

Cassava chipping and drying yards are small-scale enterprises often belonging to farmers; they are located near the cassava growing areas. The equipment consist of a chipping machine and a front-end loader, and chips are dried on a cement floor often covering more than one hectare.

The production of cassava chips involves two steps, i.e. chippings and sun drying. Fresh cassava roots are fed into the hopper of a chipping machine, mounted on wheels to facilitate the distribution of chips on the drying floor. These chipping machines have a rotating circular steel plate about 100 cm in diameter. The blade consists of a 1.0-1.5 mm steel plate which is corrugated at the cutting edge. The chipping machine produces about 3-cm diameter size chips. This can be reduced by narrowing the opening in the cutting plate. The capacity of these chipping machines could be increased if the feed rate and the cutting blade were more uniform (Thanh, 1974). This could be achieved by the use of a conveyor belt, as used in the starch factories for feeding the rasper (Manurung, 1974).

The common practice in Thailand is to chip the roots early in the morning. The fresh chips are distributed by pulling the chipping machine across the drying floor while chipping; the chips may also be spread out manually with the use of a rake. The spread-out chips are turned over every 1-2 hours, using a small vehicle with a special tool attached to the front, to speed up sun drying. The duration of sun drying is dependent on the weather, the chip size, and loading rate on the floor. Usually, without rain, it takes three days to dry the chips to 12-14% moisture content.

4.2 Pellets

The production process for cassava pellets is shown in Figure 5. There are approximately 200 pellelizing factories in Thailand with a total capacity of about 10 million tonnes per year. Because of lack of sufficient markets they operate at only about 50% of capacity (3-4 months per year) (Sriroth and Oates, 2000).

After removal of sand and other impurities, the dry chips are ground in a hammer mill. Cassava particles together with steam are forced through holes in the die. The compressed material emerges hot from the other side of the die; after cooling the strands are cut to length to produce pellets. The pellet diameter ranges from 5 to 6 mm and the length from 15 to 20 mm.

4.3 Starch

In 1996, Thailand had 41 modern cassava starch factories registered with the Thai Tapioca Flour Industries Trade Association. The peak of the starch processing season is from Oct till March, when
most farmers harvest their cassava roots. During the processing season many starch factories have a shortage of working capital to buy cassava roots. Due to a lack of capital the millers have no choice but to sell the cassava starch as soon as possible. This reduces the price. To improve the situation, loans have to be provided by the government.

The production process for cassava starch is shown in Figure 6. Production of one tonne of native starch requires 4-5 tonnes of fresh roots and 30-40 m$^3$ of water.

![Production of one tonne of native starch requires 4-5 tonnes of fresh roots and 30-40 m$^3$ of water.](image)

4.4 Modified starch

There are three methods to make modified starch in Thailand, i.e.:

(1) Degradation or conversion: starch is rendered less sticky in three ways:

( a ) Acid conversion: Hydrochloric and sulfuric acids react with starch liquid to decrease the degree of stickiness, and to reduce the temperature of gelatinization. This starch is called "acid modified starch".
(b) Oxidization: Starch reacts with chloride in alkaline starch liquid. The starch thus derived will become less sticky with the degree of chloride used and the reaction time. This starch is called "oxidized starch" or "hypochlorite modified starch".

(c) Dextrinization or pyroconversion: Starch is roasted in a drum under high temperature, while certain acids are sprayed to react with it. This process will make the starch less sticky. The product is called "dextrin", which consists of three types: white dextrin, popular yellow dextrin, and British gums. The converted starch is suitable for the glue industry.

(2) Pregelatinization: Liquid starch in 40-50% concentration is drum-dried. Starch is cooked and dried to form a thin crispy layer. It is ground and sifted to obtain a fine powder, which immediately becomes a glue when cold water is added to it. The starch at this stage is called "cold water soluble starch" or "alpha starch".

(3) Derivatives: These are processed starches whose molecular structures have been altered through chemical reactions. Examples in this group include esters (acetated starch and phosphoric acid ester), starch ether (carboxymethyl ether and hydroxy-ethyl starch), and cross-linked starch. (Thai Tapioca Flour Ind. Trade Assoc., 1994).

5. MARKETING

The principal market for Thai cassava products is the EU, which in 1997 absorbed about 64% of the total Thai cassava exports (Tables 11 and 12). The EU has set an annual quota for Thai cassava imports of 5.25 million tonnes for the years 1995 and 1996, with a possible reduction in the future. Within this quota the cassava products can enter the EU market at the current preferential tariff of 6%, and beyond the quota it will be subject to a 30% tariff. However, due to competition from other feed grains the price paid for cassava pellets in the EU has decreased, making it less attractive to produce and market cassava pellets. For that reason Thailand has not met its quota for the past five years (1994-1998).
5.1 Fresh cassava roots

Within the cassava plant, starch accumulates mainly in the swollen roots. The moisture content of the root is about 60-65% by weight. The farm gate price for fresh roots has been highly variable, fluctuating from about 800 to 2000 Baht per tonne, with a starch content of 25% (Figure 7); farmers are usually paid a higher or lower price according to the starch content of the roots. The low price of fresh roots in 1996/97 was caused both by overproduction (stimulated by the high
price in 1995/96) and the low price of cassava pellets and starch on the world market, due to an ample supply of relatively cheap corn, wheat and potato starch.

5.2 Dry cassava chips and pellets

In Thailand cassava dry chips are used exclusively for production of animal feed. Each year Thailand exports dry cassava chips and pellets to the EU market (maximum of 5.25 million tonnes under the quota system), while the rest is exported to non-EU markets (Tables 11 and 12).

The price of chips and hard pellets is highly fluctuating (Figure 7), depending on the price of competing commodities on the world market, such as wheat, barley, maize etc. This in turn influences the price paid for fresh roots, which is also highly variable. The latter, however, is also determined by the price of starch, as both the starch and pellet industries compete for the same raw material (Figure 7).

Table 11. Trends in the exports ('000 t) of cassava chips, pellets and starch from Thailand to the EU and outside the EU.

<table>
<thead>
<tr>
<th>Year</th>
<th>Chips</th>
<th>Pellets</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EU</td>
<td>Non-EU</td>
<td>EU</td>
</tr>
<tr>
<td>1981</td>
<td>263.2</td>
<td>71.2</td>
<td>5 193.7</td>
</tr>
<tr>
<td>1986</td>
<td>0</td>
<td>35.7</td>
<td>4 987.1</td>
</tr>
<tr>
<td>1991</td>
<td>18.0</td>
<td>95.1</td>
<td>4 996.0</td>
</tr>
<tr>
<td>1995</td>
<td>0</td>
<td>169.1</td>
<td>3 076.0</td>
</tr>
<tr>
<td>1997</td>
<td>0</td>
<td>138.6</td>
<td>3 380.5</td>
</tr>
</tbody>
</table>

Source: Customs Department and Board of Trade of Thailand.

Table 12. Quantity (tonnes) and destination of cassava products exported from Thailand during 1996 and 1997.

<table>
<thead>
<tr>
<th>Country</th>
<th>Chios</th>
<th>Hard pellets</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Australia</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Belgium</td>
<td>-</td>
<td>-</td>
<td>- 123 976</td>
</tr>
<tr>
<td>Brazil</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>China</td>
<td>- 133 986</td>
<td>-</td>
<td>10 014</td>
</tr>
<tr>
<td>France</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Germany</td>
<td>-</td>
<td>-</td>
<td>- 30 000</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

| Source: | Customs Department and Board of Trade of Thailand. |
|-------------|--------------|--------------|--------------|--------------|--------------|--------------|
| India       | -            | -            | -            | -            | 20           | 718          |
| Indonesia   | -            | -            | -            | -            | 24 771       | 210 814      |
| Ireland     | -            | -            | 8 763        | -            | -            | -            |
| Israel      | -            | -            | 36 000       | 3            | 19           | -            |
| Japan       | -            | -            | 19 400       | 12 664       | 221 625      | 226 936      |
| Laos        | -            | -            | -            | 7 190        | 4 948        | -            |
| Malaysia    | 2 700        | -            | 4 600        | -            | 69 958       | 90 135       |
| Mexico      | -            | -            | -            | -            | 458          | 618          |
| Netherlands | -            | -            | 2 599 215    | 2 726 743    | 32 647       | 18 515       |
| New Zealand | -            | -            | -            | 1 426        | 1 606        | -            |
| Norway      | -            | -            | -            | 452          | 1 394        | -            |
| Pakistan    | -            | 100          | 100          | 100          | -            | -            |
| Panama      | -            | -            | -            | 24           | -            | -            |
| Philippines | -            | 4 500        | -            | 58 080       | 20 868       | 16 324       |
| Poland      | -            | -            | -            | 1 000        | 102          | 3            |
| Portugal    | -            | -            | 169 243      | 197 470      | 70           | 102          |
| Saudi Arabia| -            | -            | -            | 2 821        | 4 896        | -            |
| Singapore   | -            | -            | -            | 34 354       | 46 344       | -            |
| Spain       | -            | -            | 276 580      | 302 315      | 4            | 43           |
| Sri Lanka   | -            | -            | -            | 1 614        | 3 912        | -            |
| South Korea | -            | -            | 465 097      | 404 403      | 7 270        | 6 121        |
| Sweden      | -            | -            | -            | 2 437        | 2 435        | -            |
| Switzerland | -            | -            | 250          | -            | 3 343        | 1 666        |
| Taiwan      | -            | -            | -            | 12 974       | 279 735      | 318 464      |
| Turkey      | -            | -            | 61 263       | 100 370      | 55           | -            |
| UAE         | -            | -            | -            | 458          | 407          | -            |
| UK          | -            | -            | -            | 3 781        | 1 873        | -            |
| USA         | -            | -            | -            | 52 307       | 35 059       | -            |
| Russia      | -            | -            | -            | 2 082        | 44           | -            |
| Other       | -            | -            | -            | 5 556        | 4 871        | -            |
| **Total**   | 2 700        | 138 586      | 3 604 411    | 4 016 106    | 893 365      | 1 140 377    |

**Source:** Board of Trade of Thailand, 1998
Figure 7. Monthly variation in domestic price of fresh cassava roots (Baht/kg) and the FOB Bangkok price (US$/tonne) of cassava starch and hard pellets from Dec 1993 to Dec 1998. Source: Thai Tapi Trade Assoc. (TTTA), Yearbook 1998.
5.3 Starch and its derivatives

Cassava starch is not only produced for domestic use but also for export, which produces annual revenues of about 250-300 million US$ (Table 10). Products with the fastest growing export markets are modified starch and sorbitol. Producing modified starch adds about 60% to the price of native starch and nearly 200% to the price of roots required for its production (Table 13).

Native starch can be consumed directly, but can also be used as a raw material in a variety of industries, e.g. food, sago pearl, transparent vermicelli, instant noodles, seasoning powder (monosodium glutamate), sweetener, paper, plywood, textile and bread (Table 9).

Starch plays a significant role in the daily lives of consumers, either directly or indirectly, in the form of processed products and as an ingredient for the production of many other products. But, its potential uses have not been exhausted. At present, there is a lot of research being conducted with the aim of converting starch into other value-added products.

Table 13. Price links among modified starch, native starch, and roots as well as marketing and processing costs, obtained from a 1991 industry survey.

<table>
<thead>
<tr>
<th>Items</th>
<th>US$/t ¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified starch price c.i.f., Japan</td>
<td>405.0</td>
</tr>
<tr>
<td>Freight and insurance costs, Thailand-Japan</td>
<td>45.0</td>
</tr>
<tr>
<td>Modified starch price f.o.b., Bangkok</td>
<td>360.0</td>
</tr>
<tr>
<td>Exporting costs</td>
<td>20.0</td>
</tr>
<tr>
<td>Modified starch prices at plant in Bangkok</td>
<td>340.0</td>
</tr>
<tr>
<td>Processing costs of modified starch, including 5% weight loss</td>
<td>117.8</td>
</tr>
<tr>
<td>Native starch prices at Bangkok plant</td>
<td>222.2</td>
</tr>
<tr>
<td>Transport costs, Nakhon Ratchasima to Bangkok</td>
<td>9.0</td>
</tr>
<tr>
<td>Native starch prices at plant in Nakhon Ratchasima</td>
<td>213.2</td>
</tr>
<tr>
<td>Processing costs of native starch</td>
<td>52.0</td>
</tr>
<tr>
<td>Value of roots per tonne of starch at plant</td>
<td>161.2</td>
</tr>
<tr>
<td>Value of wastes (10% of the value of roots)</td>
<td>16.1</td>
</tr>
<tr>
<td>Total value of roots per tonne of starch at plant (conversion rate of starch to root= 1:5)</td>
<td>177.3</td>
</tr>
<tr>
<td>Price of roots per tonne (root prices at the plant in Nakhon Ratchasima)</td>
<td>35.5</td>
</tr>
<tr>
<td>Production costs per tonne of roots in 1989/90 (published by MOAC)</td>
<td>17.6</td>
</tr>
</tbody>
</table>


6. RECENT PROGRESS IN CASSAVA RESEARCH

All cassava research undertaken in Thailand aims to improve production and processing efficiency and to broaden markets.

The national average yield of cassava is 14.5 t/ha in Thailand, but experimental yields may be 50 t/ha or more. There are now new clones with much higher yield and root dry matter content than Rayong 1. Hence, there is still much room for yield improvement through breeding and improved cultural practices under Thailand's conditions.
6.1 Germplasm collection, evaluation and improvement

In Thailand, cassava breeding is the responsibility of the Rayong Field Crops Research Center (Rayong-FCRC) of the DOA, as well as of Kasetsart University (KU).

6.1.1 Germplasm collection and evaluation

Before 1960 some twenty cultivars were introduced, mainly from Malaysia, Indonesia and Mauritius. During the 1960s more clones were introduced, from Indonesia in 1963, and from the Virgin Islands in 1965. The first introduction from CIAT was in 1975.

Thailand has presently a collection of 348 cultivars, including three local cultivars, five from Indonesia, 21 from the Virgin Islands, 14 from CIAT and 305 clones from open pollinated and hybridized seeds. Out of these 305 clones, 89 are progenies of hybrid seed from CIAT/Colombia and 216 clones are from the Thai breeding program. Seedlings obtained were selected according to yielding ability, disease and insect resistance, and plant type. Only high performance clones are maintained and further observed.

The germplasm collection is maintained by annual planting in the field at Rayong Field Crops Research Center located in the east, while some accessions of the collection are duplicated at Khon Kaen Field Crops Research Center, located in the northeastern part of the country. The DOA also plans to use tissue cultures for germplasm conservation and exchange. A few cassava clones were introduced from CIAT in the form of tissue culture. This cassava germplasm has been extensively utilized in the breeding program.

Cassava germplasm accessions are being observed and evaluated for root yield, starch content, dry matter content, HCN content, harvest index, disease and pest incidence, germination, vegetative vigor, plant height, branching habit, earliness, daily yield, number of roots/plant, root colour and shape, root perishability, flowering habit, stem colour, leaf colour and shape. Chemical analysis for protein content, HCN content, starch content, and fiber have been done for some accessions in the breeding program.

The introduction of cassava germplasm from CIAT through sexual seed started in 1975. From this first introduction, Rayong 3 was selected. Ten clones were also introduced in the form of meristem culture form CIAT in 1979. Introductions from CIAT of seed populations from better-defined cross parents started in 1982. Many of these introductions have since been utilized in the breeding program.

6.1.2 Germplasm improvement

Cultivar Rayong 1

Cassava breeding research began with the collection of local cultivars throughout the country and their systematic evaluation in 1956 at Rayong-FCRC, Rayong province. There were not many genotypes, and many cultivars from different locations were identified to be the same genotype. This was called "Local Rayong" to be used in comparison with introduced cultivars. It was found that "Local Rayong" had higher yields than all introduced cultivars from Indonesia, the Virgin Islands and CIAT. So, this cultivar was named "Rayong 1" by the Department of Agriculture in 1975.

The breeding program based on open-pollinated seeds from Rayong 1 and introduced cultivars, started in 1971. Not much was gained from the selections of open-pollinated seeds. Controlled hybridization started in 1975 by utilizing a limited number of germplasm...
accessions from Indonesia, the Virgin Islands and from CIAT. Large introductions of cassava germlasm from CIAT, mostly as sexual seed, have contributed to increased genetic variation. Many crosses are being made between Thai and CIAT clones every year, supplemented by a fewer number of crosses among Thai clones. Many hybrid seeds from CIAT have been directly incorporated into the testing program. From CIAT hybrid seeds introduced in 1975, two cultivars were selected: Rayong 3 selected from CM 407, and HP 6 from CM 305 (Sinthuprama and Tiraporn, 1984).

With the return of several researchers trained at CIAT since 1977, the breeding program at Rayong-FCRC began to form into a core of the national program (Sinthuprama and Tiraporn, 1984).

Breeding objectives. The major objectives of cassava breeding are:

1. high yield potential, in terms of dry matter and starch
2. early harvestability
3. diversification of genetic base
4. resistance to pests and diseases

Breeding to produce high yielding cultivars is based on high yield, high harvest index and high root dry matter content. High yielding cultivars will contribute to higher productivity, hence lowering the cost of production per tonne and improving the competitiveness of cassava vis-à-vis other feed grains. Higher root dry matter content will lead to a reduction in the cost of processing.

Breeding for early harvest ability is done by selection for high yield at an early harvest date. Early cultivars will increase the opportunities for more efficient land use by allowing double cropping and crop rotations; these may also improve soil fertility and reduce erosion (Sinthuprama et al., 1993). Breeding for pest and disease resistance includes resistance or tolerance to CBB and red spider mite.

Breeding cultivars suitable for intercropping has been another selection target.

Methodology of the varietal improvement program

The Thai cassava breeding program includes every step of varietal improvement, including germplasm collection, hybridization, F1 seedlings trial, single-row trial, preliminary yield trial, standard yield trials, regional trials and on-farm trials.

15 000 to 20 000 F1 seedlings are evaluated annually and about 10% of these plants are selected for the single-row trial. About a 5% selection rate is practised in the single-row trial, as well as in the following stages of selection, up to the regional trial. All the trials, up to the preliminary yield trial, are conducted at Rayong-FCRC. Standard yield trials are planted in three major research stations, and regional trials are conducted throughout the country in major cassava growing areas. While the majority of the experiment stations are located on rather fertile soils, the soil fertility at Rayong-FCRC is generally low, so that it can well represent the majority of cassava growing areas (Sinthuprama and Tiraporn, 1984).

Promising clones from regional yield trials, usually three to five, are tested in on-farm trials. The trials are conducted by using farmers' land and labour, but the management input is contributed by the researchers. The number of trials depends on the resources available.
The best clone(s) is/are compared with the farmers' crop in farmers' fields using farmers' agronomic practices. Many large plots are required and extension workers participate in the evaluation.

The best selection is named and released as a new variety by the Department of Agriculture.

From 1975 until 1998, Rayong-FCRC of DOA and KU have released six cultivars for industrial use and one cultivar for human consumption. The background and the outstanding characteristics of those cultivars are described in Table 14.

6.2 Agronomic research

The objective of the agronomic research is to develop improved production technology that will lead to high and stable production using the best available cultivars. The major recipients of the technology are small farmers; thus, the technology must be suitable and affordable for the majority of small farmers.

The principal research topics have been land preparation, quality of planting material, planting time, planting methods, plant populations, replanting, weed control, fertilization, stake multiplication, harvesting, as well as the mechanization of harvest.

Cassava fertilization and soil conservation research aimed at increasing or conserving soil fertility and enhancing the sustainability of production. Rotation experiments aimed at controlling water erosion and replenishing or recycling nutrients that were removed by the crop or were leached down the profile.

Research on the long-term effect of various soil management practices on cassava production was conducted by planting continuously for 15 years in the Northeast; it showed that cassava planted in rotation with sequentially planted peanut and pigeon pea could maintain a high relative yield of 87% of that obtained by the same cropping system during the first year of planting. Also, application of some lime and fertilizers could reduce the rate of yield decrease.

Research about the optimum period of weed control for Rayong 60 and Rayong 90, planted either in the early or late rainy seasons in the Northeast, indicate that both cultivars need to be free of weeds at least during the first three months after planting.

Weed control research also aimed to develop weed control practices to reduce labour requirements during periods of high labour demand. The most appropriate weeding method for cassava intercropped with either mungbean or peanut was to control weeds at planting by the application of a pre-emergence herbicide like Metholachlor at a rate of 1.50 kg/ha, followed by that of a post-emergence herbicide like Paraquat at a rate of 0.50 kg/ha by spot treatment whenever necessary.

Table 14. Background and outstanding characteristics of cultivars released in Thailand.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Year released</th>
<th>Parents</th>
<th>Background and outstanding characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rayong 1</td>
<td>1975</td>
<td>Unknown</td>
<td>Selected from local land race. Excellent agronomic traits, relatively high yield. Moderately resistant to major pests and diseases. Adapted well to low</td>
</tr>
</tbody>
</table>
Cropping systems research aimed to develop practices for soil nutrient conservation and soil erosion control. The research emphasized on intercropping cassava with grain legumes. Studies have been conducted to identify the best legumes to be grown in association with cassava, that will cause a minimum reduction of cassava yield, requires minimum additional inputs and have economically attractive returns.

Some specific findings are as follows:

- **Land preparation.** Zero tillage combined with application of a post-emergence herbicide (Paraquat) to kill the existing weed population gave a similar cassava yield as traditional land preparation, which includes one plowing by tractor plus furrowing by animal. Minimum tillage may be introduced for the control of soil erosion and for reducing production costs.

- **Stake storage.** Stems stored up to 30 days in the field had a survival rate of more than 80%. Storage under shade tended to be better than storage under full sunlight.

---

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year</th>
<th>(F) Variety</th>
<th>(M) Variety</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rayong 3</td>
<td>1983</td>
<td>MMex 55</td>
<td>MVen 307</td>
<td>Selected from CIAT Fl hybrid seeds. High dry matter content.</td>
</tr>
<tr>
<td>Rayong 60</td>
<td>1987</td>
<td>MCol 1684</td>
<td>Rayong 1</td>
<td>Selected from DOA Fl hybrid seeds. High fresh yields. Recommended for early harvesting. Excellent agronomic traits.</td>
</tr>
<tr>
<td>Sri Racha</td>
<td>1991</td>
<td>MCol 113x MCol 22</td>
<td>Rayong 1</td>
<td>Selected from KU Fl hybrid seeds. Excellent agronomic traits. High dry matter content.</td>
</tr>
<tr>
<td>Rayong 90</td>
<td>1991</td>
<td>CMC 76</td>
<td>Rayong 90</td>
<td>Selected from DOA Fl hybrid seeds. High dry matter content. Relatively high yield.</td>
</tr>
<tr>
<td>Kasetsart 50</td>
<td>1992</td>
<td>Rayong 1</td>
<td>Rayong 90</td>
<td>Selected from KU Fl hybrid seeds. High yield and high dry matter content.</td>
</tr>
<tr>
<td>Rayong 5</td>
<td>1994</td>
<td>27-77-10</td>
<td>Rayong 3</td>
<td>Selected from DOA Fl hybrid seeds. High fresh yield, easy to harvest, drought tolerant, good germination</td>
</tr>
</tbody>
</table>

Source: Limsila et al., 1996.
Stake size and planting method. Yields were not significantly affected by the length of the stake in the range of 10-30 cm, even though shorter stakes gave a lower survival percentage. Root yields were not different for cassava planted on the ridge, on the flat, or on the flat followed by earthing up 30 days after planting. Horizontal planting gave lower yields than vertical or inclined planting (especially when planted in the dry season); the latter two methods were not statistically different in terms of yield. Depth of planting (5, 10 and 15 cm) had no significant effect when stakes were planted either vertically or inclined (Tongglum et al., 1992).

Planting time. A study on planting time and age of harvest, carried out for three years from 1976 to 1978, indicate that the root yield was highest when cassava was planted in June and decreased if planted later than June. Root yields increased with age of harvest from 8 to 18 months.

Fertilization. Fertilizer trials show that cassava in Thailand responded mostly to application of N, moderately to P and less significantly to K. In one experiment, the root dry matter yield responded positively to 90 kg/ha each of N, P2O5 and K2O, but beyond that level it responded negatively. Broadcasting, banding under the stake, or sidedressing at 20 or 50 cm were found to be equally good fertilizer placement methods.

The long-term effect of fertilization on cassava grown on three soil series has been studied since 1975. The effect of application of municipal compost applied annually at the rate of 12.5 t/ha or incorporation of crop residues (stems and leaves) on root yield was highly significant. It was concluded that high root yields of cassava could be maintained by the annual application of 50 kg/ha each of N, P2O5 and K2O, and a further response could be obtained if compost or crop residues were incorporated before planting. On sandy loam soils in Khon Kaen, K was the most limiting nutrient (Howeler, 1995).

Crop rotation. Long-term rotation experiments in three research stations showed that in the two rotation patterns of cassava/peanut and cassava/mungbean, cassava yields in the fifth and sixth crop year were higher than when cassava was planted continuously without rotation. After six years there was a slight increase in soil organic matter due to crop rotation.

Intercropping. Land use efficiency and restoration of soil fertility through intercropping have been studied since 1970, using peanut, mungbean and soybean. The most promising intercropping system appears to be cassava and grain legumes, which were shown to have a combined economic yield of 170% relative to cassava monoculture. This was also confirmed in large plots on farms.

Weed control. Application of the pre-emergence herbicide Diuron, at the rate of 1.5 kg/ha, caused no crop injury using either vertical or horizontal planting methods of cassava. These practices were as effective as three times of hand weeding.

Erosion control. Since cassava gives a good yield in sandy soil, but has slow initial growth, soil erosion may occur, especially on sloping or slightly sloping land. During the past 15 years the DOA, DOAE and CIAT have worked together closely to develop effective methods to reduce soil erosion in cassava fields. In 1987 an experiment was set up in Pluak Daeng which included 16 treatments to reduce soil erosion in cassava fields. The treatments varied from zero tillage to ridging and intercropped with mungbean, soybean and cowpea etc. It found that preparing the soil with a seven disk-plow and intercropping with mungbean (four rows) gave the best result in terms of preventing soil erosion (Tongglum, 1994).

Since 1994, DOA and DOAE have worked closely with CIAT in the execution of the Nippon Foundation-supported project. This project introduced a rather new approach of
farmer participatory research (FPR), in which researchers help farmers conduct their own experiments on their own farms. This approach is particularly effective in enhancing the adoption of soil conservation practices, as it gives the farmers the opportunity to see with their own eyes the magnitude of soil erosion in their fields, and how certain agronomic practices can markedly reduce these soil losses.

6.3 Processing Research

Experiments are being conducted (Sriroth, 1999) for the use of cassava starch in making biodegradable plastic bags, or some other plastic materials to substitute for conventional plastics. The latter are causing serious environmental problems, since they are difficult to decompose. When buried into the soil, they do not biodegrade; when burned, the incandescent heat damages incinerators and they pollute the air with toxic gases. Recently, the use of aliphatic polyesters is becoming very important for the production of starch-based plastics. The commercial biodegradable plastics composed of gelatinized starch contain a lot of polycaprolactone (PCL). Today, two types of biodegradable plastics are commercially available, i.e. starch-based plastics and aliphatic polyesters. Cornstarch can also be used as raw material. Last year, Japan's National Institute of Bio-science and Human Technology began work with the Thai's TTDI and Mahidol University in a joint Thailand-Japan International Research Project, the goal of which is to develop a useful biodegradable plastic using cassava starch (Tokiwa, 1997).

7. GOVERNMENT POLICIES CONCERNING CASSAVA

Agriculture has maintained its importance in the Thai economy in the past and present, and will undoubtedly be in this position for a long time in the future. A major component of Thailand's exports still consists of primary commodities of agricultural origin. The output of some major crops, such as rice, cassava, rubber, sugar, etc. have been planned to gradually increase. However, the quantities exported depend on the amount of surplus supply over domestic consumption.

Prices of most agricultural products are dependent on world prices. As Thailand has become a member of the WTO, we have to consider the effect of free competition of commodities. To help poor cassava farmers, our government has to stabilize the cassava price by guaranteeing a minimum domestic price. Most of the price uncertainty is usually passed on from those who have strong market power to those who have weak bargaining power, i.e. usually the farmers. To help these farmers, the government has taken a lot of measures to stabilize the price and raise the income of farmers.

7.1 Production policies

More than half of Thai cassava products are exported to the EU, where, since 1993 they have to compete with cheap domestic grain in the production of animal feed. This has led to a marked reduction of exports of cassava pellets, which in turn reduced the price of cassava roots in Thailand. The planted area must therefore decrease to prevent over-production and hardship for farmers. With that objective the cassava growing area in Thailand has been divided into "favourable" and "non-favourable" zones. Only the growers in the "favourable" zone will receive government promotion services.

Growers outside the zone will be encouraged to replace cassava with other crops. Research is under way to find crops to replace cassava in these regions. Thus, the future trend of cassava production will depend strongly on the market, and the market will be dependent on production costs. If no improvement in production-efficiency is attained, there will be little
hope for improving cassava’s competitiveness in the international market. At the present, market demand is largely dependent on EU policies. If, however, a significant reduction in prices of cassava products can be achieved through improved production efficiency, then there will be increased opportunity to create new export markets.

In 1992 the Thai Tapioca Development Institute (TTDI) Foundation was established, using funds collected by the government from cassava exporters. The objective of this institute is to help in stake-multiplication of new cassava cultivars and to distribute these free of charge to farmers. The institute also trains cassava farmers in the use of new cost-saving technologies. Every year about 7,000 cassava farmers receive a two-three-day training at the TTDI Research and Training Center in Huay Bong, Nakhon Ratchasima.

In 1991, The Department of Agricultural Extension (DOAE) and the Department of Agriculture (DOA) also created the "Cassava Stake Distribution Program" to accelerate the dissemination of high-yielding and high-starch varieties throughout the country.

7.2 Marketing policies

In Thailand, cassava is produced mainly for export rather than for domestic use. Most cassava output is exported to the EU. However, the amount of cassava exported to the EU is limited by an annual quota of 5.25 million tonnes. Under this quota the exportation is subject to an especially low import tariff. The high cassava pellet price in the EU has in the past been quite attractive to exporters. In turn, exporters have been able to pay a reasonable price for fresh roots of cassava. This has resulted in the expansion of the cassava growing area. But since 1993 the Common Agricultural Policy (CAP) of the EU has been reformed, resulting in a gradual lowering of the support prices for European domestic grains, thus making these grains more attractive than Thai cassava pellets in the formulation of animal feed. As such, the amount of cassava produced in Thailand is larger than the amount sold in the EU market. The price of cassava products has fluctuated drastically depending on market demand at any particular time. This in turn, affected the price of cassava roots which the farmers received (Figure 7).

Before 1997 the only important market for Thai cassava was the EU, which absorbed more than half of the Thai cassava exports. To stabilize the price, the government allocated a certain export quota to each exporter based on two criteria:

1. The amount of cassava dry chips and pellets in stock by each individual exporter
2. The amount of cassava products the company had exported to non-EU markets

Now the policy has changed, the export quota of cassava products has been lifted. The concerned members of the cassava trade associations (the affiliate members of the Thai Chamber of Commerce) jointly agreed that quota allocations based on stock-checking and previous quotas should not be continued, as it leads to monopolization by those companies that were awarded quotas in the past, and it will not stimulate the buying of cassava roots from farmers.

In 1996/97 cassava fresh root production reached about 18 million tonnes. If nine million tonnes of fresh roots were used to produce starch, there would be a balance of fresh roots to produce chips and pellets of about nine million tonnes, equivalent to about 3.6 million tonnes of pellets, which would not be enough to fulfil the cassava quota in the EU.
8. FULFILLMENT OF OBJECTIVES AND SCIENTIFIC ADVANCES

8.1 Varietal improvement

From 1975 to 1999 six new cultivars have been released for industrial use, i.e. Rayong 3, Rayong 60, Rayong 90, Rayong 5, Sri Racha 1, and Kasetsart 50. All these recommended cultivars are widely adopted by the farmers, but the area planted with improved cultivars was increasing rather slowly due to the low multiplication rate of cassava. For that reason, in 1992 the government approved the allocation of 11 million US$ for the DOA and DOAE to rapidly multiply stakes of those cultivars and distribute them to the farmers. New varieties are now being grown on about 660 000 ha, or 64% of the planted area.

8.2 Improvement of cropping systems with cassava

Normally cassava in Thailand is grown as a sole crop. Intercropping of cassava is practised to a very limited extent. It can be intercropped with either maize or leguminous crops. In turn, cassava can also be intercropped between rows of young oil palm or rubber trees.

Legumes, mostly soybean, peanut and mungbean have been successfully intercropped with cassava in experimental systems. Yields of both legumes and cassava are usually reduced due to crop competition, but total yield or income may be quite high. Peanut is the most suitable crop, followed by mungbean. Soybean is the least suitable because of its poor adaptation to the type of soils in which cassava is grown. It is recommended that two rows of peanut spaced at 10 x 10 cm be planted between cassava rows spaced at 1 m. (Sinthuprama et al., 1993). Cassava farmers are well aware of the problem of soil erosion, and many are now adopting certain measures to control erosion. In one pilot site of the FPR project, in Sra Kaew province, about 30 farmers have already planted contour hedgerows of vetiver grass to prevent soil erosion; they may also intercrop with mungbean or peanut to increase their income.

8.3 Improvement of cassava harvest and post-harvest handling techniques

To encourage farmers to develop a new, suitable machine for digging or harvesting roots of cassava, TTDI, DOAE and DOA organized a contest of cassava harvesting implements attached to an 87 horsepower tractor in 1998. Many farmers and mechanics entered their inventions in the contest, and one to two most suitable harvesting tools were selected for further production and dissemination.

9. LESSONS LEARNED FROM PAST EXPERIENCES AND FUTURE STRATEGIES

9.1 Labour

The labour requirement can be divided into two parts, i.e. labour in the field to produce cassava roots, and labour needed for production of dry chips and pellets or cassava starch. Nowadays, the high cost of labour is a topic of daily discussion. Growing cassava is presently done mainly by hired labour. To improve production costs it is absolutely essential to reduce the labour requirements for production, through the development of more effective weed control practices (both mechanical and chemical), and planting and harvesting tools. Harvesting with a tractor-mounted cassava digger is now practised in some parts of the country.

9.2 Role of women in cassava production
In Thailand, growing cassava is usually carried out by both men and women. Nowadays, the cassava planting has become more and more mechanized. This results in less time spent on preparing the land and in the harvest of the fresh roots. The harvest uses female labour mainly for pulling up plants and cutting-off roots, while male labour is used for pulling up plants and loading of trucks. Since cassava is not a staple food of Thai people, Thai women are not much involved in the processing of starch or the preparation of cassava dishes.

9.3 Cassava research capacity building

Cassava research personnel has gradually increased over the years; a total of 18 researchers are now working on cassava, six in varietal improvement, four in cultural practices, five in soil science, one in entomology, one in postharvest technology and one in stake multiplication. In addition, there are some people working part-time on regional trials at research stations in different parts of the country.

CONCLUSIONS

Major cassava production problems in Thailand are declining soil fertility, soil erosion and limited genetic diversity of the crop. Previous research conducted by the DOA has resulted in breeding and selection of high-yielding and high-starch content cultivars. Latin American germplasm provided by CIAT is now well incorporated into the whole breeding system. Agronomic practices, such as land preparation, stake selection and storage, planting method, planting time, fertilization, crop rotation, intercropping and weed control have been studied. More emphasis is now being given to soil fertility maintenance, erosion control and labour-saving technologies. And also to enhance farmers' awareness of soil erosion by the introduction of a rather new approach of farmer participatory research, in which researchers help farmers conduct their own experiments on their own farm. This approach is effective in enhancing the adoption of soil conservation practices, as it gives the farmers the opportunity to visualize the magnitude of soil erosion in their fields, and to develop agronomic practices that can markedly reduce these soil losses.

REFERENCES


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STATUS OF CASSAVA IN VIET NAM:
IMPLICATIONS FOR FUTURE RESEARCH AND DEVELOPMENT

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The objectives of the study are:

To analyse the past and present situation of cassava in Viet Nam, with a view to describing the lessons learned from past development interventions and their implications for a strategy of future investment in cassava research and development

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EXECUTIVE SUMMARY

Cassava plays an important socio-economic role as a secondary crop in Viet Nam. In the north the crop is an important source of food and feed at the household level; in the south mainly as a source of cash income. In South Viet Nam cassava is predominantly used as a raw material for processing into a wide range of products, both at the household and small-scale processor level, generating employment in the rural sector.

Over the last seventeen years (1980-1997) the total area of secondary food crops has decreased, especially for sweet potato and cassava, while the maize area increased. Cassava has declined in the last seventeen years because of its relatively low profitability (low yield), low (or fluctuating) demand, price fluctuations and marketing problems. Soil fertility problems are also important. Processing is constrained, especially by raw material supply fluctuations and quality. The potential for processing technology is significant.

Cassava yields can potentially increase through the development of improved varieties; appropriate fertilizer use; intercropping or the rotation of cassava and beans; erosion control; weed control by mechanical or chemical means; and by more efficient crop management (especially labour). Cassava product marketing efficiency can be significantly improved by better information (price) and management of marketing systems.

Cassava varietal dissemination in Viet Nam has made rapid and consistent progress. The Viet Nam Root Crops Program, in cooperation with CIAT, has recently (1993-1996) selected and recommended two new cassava varieties: KM 60 and KM 94. In South Viet Nam the new cultivars are now planted on a fairly large acreage, already generating additional economic benefits of about five million US$, which is shared by processors, production organizers and small farmers according to their size of operation. In North Viet Nam, the total economic scale is much smaller; yet, little by little the new cultivars are spreading widely; here the additional cassava yields are converted into additional pig sales per family. It appears to be the most equitable contribution of crop breeding. Cassava, with the immediate possibility of yield increases, will play an increasingly important role as an income generator to upland farmers in Viet Nam.

Principal experiences in linking cassava R&D activities in Viet Nam include:

1. Establishment of the Viet Nam Cassava Research and Extension Network (including advanced cassava farmers, researchers, extensionists, managers of cassava research and development projects, cassava trade and processing companies);

2. The conducting of on-farm research, demonstration trials and farmer participatory research (FPR); and

3. Ten mutual link-up activities (10Ts).

Six essential conditions for a successful cassava R&D program include: Materials, Markets, Management, Methods, Manpower and Money (6 Ms). Viet Nam now has favourable conditions for cassava development. However, other problems should be taken into account: price fluctuations and instability of the market; crop competition; varietal degradation; varietal mixtures and genetic erosion; soil fertility degradation and erosion; high labour requirements; lack of financial resources and facilities from the government to support the cassava technology transfer work (while cassava farmers are very poor, especially those
living in the midlands and mountainous regions where root and tuber crops are important food crops).

During the coming years the cassava planting area in Viet Nam will not be increased, but will remain within the range of 200,000 to 300,000 ha. However, cassava yields will increase by the adoption of new cassava varieties and more intensive cultural practices. On-farm research and transfer of technology for cassava production are key factors for cassava development. They are an important bridge linking science with production. Another top priority is to link small cassava farmers and processors to regional and international growth markets of cassava starch-based products by expanding existing cassava market, process and products analyses in Southeast Asia. This will serve as a basis for developing an action plan for integrated R&D of cassava production, processing and marketing.

**1. INTRODUCTION**

Cassava sustains the lives of an estimated 500 million people in Africa, Latin America and Asia. The crop has a great potential for food security, not only at the family but also at the community as well as at national levels in many countries. Cassava has many advantages compared to cereal crops, in terms of drought tolerance, pest and disease resistance, adaptation to poor soils and an indeterminate harvest period. This is an ideal crop for emergency situations, such as during war or natural disasters (FAO, 1996).

Cassava processing at the household level is an important income generator in poor rural areas, particularly for women, not only in Africa but also in Latin America and Asia. Cassava contributes to economic diversity and creates opportunities for development of other processing industries: for example, the cassava industries in Thailand and Brazil as well as in several African countries on a smaller scale (FAO, 1997).

Viet Nam ranks thirteenth in cassava production in the world. The average annual cassava production during 1993-1995 was 2.37 million tonnes and in 1996 it was about 2.50 million tonnes. However, Viet Nam is the fourth in export of cassava products in the world, after Thailand, Indonesia and China. The annual cassava export volumes averaged 30 thousand tonnes during 1992-1994 and increased up to 150 thousand tonnes in 1997. The Viet Nam cassava industry is still largely underdeveloped and the export volumes are small; however, it has potential, and the sector has been attracting foreign investments to the country for starch and MSG processing, particularly in South Viet Nam, since the early 1990s.

The International Fund for Agricultural Development (IFAD) is an agency that has funded research, field experiments, multiplication and dissemination of cassava varieties in Africa and Latin America. IFAD is developing a global research strategy for cassava in order to enhance global cassava research and development and exploit the potential of this crop for food security, income generation and development of cassava-based industries, including feed, food, paper, textile, alcohol and medicines. This process requires the close collaboration among governments of cassava growing countries, IFAD, cassava research institutions, donor organizations, non-government and private organizations.

The report: "**Status of cassava in Viet Nam: Implications for research and development in the future**" is a case study of Viet Nam to help formulate a global cassava research and development strategy by IFAD. The objective of this study is to analyse the past and present situation of cassava in Viet Nam, with a view to describing the lessons learned from past development interventions and their implications for a strategy of future investment in cassava research and development.
The report includes chapters on:

(1) Cassava production in Viet Nam
(2) Cassava processing and marketing
(3) Main problems in cassava production and consumption
(4) Recent progress in cassava research and extension activities
(5) Lessons learned from cassava development
(6) Implications for future cassava research and development in Viet Nam