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I B A D A N

# REPORT ON CASSAVA, SWEET POTATO AND POTATO

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Tuber and root-plants are essentially represented in Malagasy Republic by Cassava, sweet potato and potato. Another ones, as some Araceae are only cultivated on very little areas. Dioscorea and varied Arrow-roots do not exist in this country.

The most important one is Cassava; sweet potato is the second one. Potato is only cultivated at an 3000 - 5000 fest altitude.

Areas cultivated, productions and prices have had the next development since ten years.

| | 1960 | | | 1970 | | |
|---|---|---|---|---|---|---|
| | Total areas (has) | Production (Tons) | Price/kg (FMG) | Total areas (has) | Production (Tons) | Price/kg (FMG) |
| Cassava | 300.000 | 740.000 | 2,5 | 350.000 | 900.000 | 3,25 |
| Sweet Potato | 60.000 | 260.000 | 4,0 | 65.000 | 290.000 | 5,00 |
| Potato | 15.000 | 75.000 | 7,0 | 18.000 | 90.000 | 10,00 |

( 1 US dollar = 280 Malagasy francs F.M.G.)

Productive capacity, in kilos/day/hectare, of underground consumable parts, and planting - harvesting duration in days are the next ones.

| Altitude | Cassava | | Sweet Potato | | Potato | |
|---|---|---|---|---|---|---|
| | Production | duration | Production | duration | Production | duration |
| East Coast ( 0 - 1000 ft.) | 45 - 180 | 300 | 90 - 250 | 180 | - | - |
| 1800 - 2500 ft. | 65 - 140 | 600 | - | - | - | - |
| 2500 - 4500 ft. | 25 - 60 | 600 | 40 - 70 | 240 | 20 - 130 | 130 |
| South ( 0 - 1000 ft.) | 45 - 160 | 300 | 30 - 50 | 180 | - | - |

All these data are very variable. In East Coast and table-lands in the Center of the Island, Sweet potato get the better over cassava, on account of its larger productivity potential with a shorter growing duration. On the other hand, in the South, Cassava seems to be better adapted as an underground reserve inspite of its relatively long growing duration. Finally, potato, on account of its purchase price, is a culture much more interesting, in some privileged areas, than cassava and sweet potato.

In Malagasy Republic, Consumption is not only of underground parts, but also, for cassava and sweet potato, of leaves which, boiled, compound many foods with rice.

# C A S S A V A

Cassava cultivation is essentialy practiced in Malagasy Republic as a Contribution family cultivation. However, some farms raise it on large areas, harvesting being prodessed to obtain starch and Tapioca.

## TRADITIONAL CULTIVATION

Very easy and consist of planting, after a often ~~current~~ soil préparation, very variable in length cuttings at distances variyng from 16 x 16 to 30 x 24 inches. Maintenance during growing period is confined to one clean weeding at the best. Harvesting is carried out by small or quantities at one and the same time, according to family requirements or sale, from 6 to 11 months after plantation in hot coasts, and from 18 to 24 months in colder areas. Varieties are always local ones, not or just a bit bitter and yields are about 2 to 6 pounds per plant.

It is very frequently cultivated with sweet potato, sorghum, corn or leguminous plants; spaces between two cassava plants are at that time from 40 to 80 inches and yields are higher, between 4 to 12 pounds per plant.

## MODERN CULTIVATION

Cassava is very often preceded by a green manure which is ploughed in with farmyard manure (20-40 T/ha) and mineral phosphorus and potassium manure. Flat or ridge of earth plantation with 6 to 8 inches cuttings at 40 x 40 inches distances. From 2 to 4 clean weedings. Mechanical harvesting at 10 - 11 months on the coastal area, at 22-23 months in the central area. Yields are around 40 T/ha.

One hectare cost price of cassava is between 280 and 450 US dollars; One fresh roots ton being 12 dollars, 45 T/ha give an 80 dollars profit. If yield is falling down under 30 T/ha, cassava cultivation is being considered as showing a deficit.

## RESEARCH ACTUAL RESULTS

Cassava presents in Madagascar some characters and also diseases and parasites which are interesting to know.

### a/- Hydrocyanic acid amount

It is variyng from 10 to more than 14 mgs in 100 grs of fresh roots. The highest concentration time is spreading from April to August, cold and dry season. It varies also with soils and climatic conditions : Higher in upland lands and lower in dry countries. It is there an inverse correlation between anthocyanic and hydrocyanic acid amounts.

b/- Starch amount

Vulgarized varieties have a 1141 mean density, which is 27,8 % in total starch, therefore 21,9 % industrial starch for a 47,4 T/ha fresh roots mean yield.

It is there an inverse correlation between temperature and density, but direct one between hydrocyaine acid and density which is increasing during dry season and reducing during rainy season.

Starch grains mean diameters of our best varieties are :

| | | | |
|---|---|---|---|
| 14,24 | microns | for | Aipi mangi |
| 14,47 | " | " | Borbona d'Antsirabe |
| 13,73 | " | " | Criolina |
| 13.10 | " | " | Ankrah |
| 12.95 | " | " | Bogor |

c/- Diseases

The most important one is "Mosaic" which is inducing very important damages on some varieties. The main observed features are

1.- virus transmission by an insect ( Bemisia tabaci)

2.- Higher severity in hot and rainy areas.

3.- Probable presence of at least two different strains.

4.- Sensitivity is variable in a variety with its age, season and planting area.

5.- Sensitivity is variable in a variety with growing period; Symptoms can appear at a given time and vanish after and conversely.

6.- Injuries localization sometimes curious in one branch only, or some leaves, the plant remains being undamaged.

7.- Five periods had been defined according to virulence degree.

Another diseases are essentially root-rots induced by Phaeolus manihotis and Clitocybe tabescens. On cuttings, Diplodia theobromae is inducing black dots which can spread in roots. Disease induced by Gloeosporium manihotis is causing a tip branches drying up. Cercospora cassava is not important. Some bacterial diseases induce moist root-rots.

d/- Physiological diseases

Essentially midst root necrosis, brown round root dots, root foot necrosis and midlle woody root.

e/- Pests

Never very dangerous, the most important and frequent being Luperus sp., a bark-rodent; Tetranychus inducing leaves dots; Cockineals - Aonidonytilus albus, Coccus viridis-covering branches; Heteromychus as bark slasher.

1.- Varietal improvement

The main subjet in this programme is to obtain varieties with adaptation as large as possible, having a reasonable tolerance degree to mosaïc and other diseases, with yields as high as possible and interesting starch amount. Preferentially, these varieties have to serve a double purpose : direct consumption and starch factory.

The carrying out steps had been the following ones :

a/- Prospection in local fields to obtain a very large local varieties stock

b/- Trials with these varieties to choice the best ones

c/- Introductions from another countries, either M. utilissima species, or another species (M. Glaziowii and M. Pringlei).

d/- Inter and intra species hybridizations.

e/- Selection between plants obtained

f/- Comparative trials at the central Research Station (Alaotra Lake)

g/- Variety trials in another areas

h/- Popularization of the best hybrids

Thus, in 1969, about 57.000 hybrids, from more than a million of seeds had been studied according to the next summarized plan :

- Annual obtainment of 25.000 to 35.000 hybrid seeds.
- Seeding and eliminations during growing periods.
- 300 to 2000 plants choiced.
- Trial of these plants, and choice of 30 to 200 varieties
- Second trial with choice of 10 to 40 varieties.
- Third trial with choice of 3 to 10 varieties.
- Variety trials and last choice of 2 to 4 varieties.

If one or two varieties are accepted, the number with 5 figures which was characterizing the variety is replaced by a new name : the letter H followed by a number with 2 figures (Ex : H.59, H.60).

The best results obtained these last years with our hybrids are the following ones :

| Localization | Year | highest yield (T/ha) | local Check (T/ha) | hybrid superiority (in %) |
|---|---|---|---|---|
| Ambanja | 1965 | H.43 = 33.200 | 23.506 | 41 |
| | 1966 | H.53 = 17.297 | 14.050 | 23 |
| | 1967 | H.58 = 59.930 | 1.600 (1) | 3645 |
| | 1968 | H.58 = 49.473 | 17.368 | 185 |
| | 1969 | H.58 = 54.701 | 31.803 | 172 |

| | | | | |
|---|---|---|---|---|
| Manakara | 1964 | H.54 = 30.525 | 14.225 | 115 |
| (East Coast) | 1966 | H.54 = 20.266 | 10.842 | 87 |
| Tamatave | 1964 | H.56 = 32.916 | 18.594 | 77 |
| | 1965 | H.58 = 28.521 | 15.722 | 81 |
| | 1966 | H.58 = 21.527 | 12.638 | 70 |
| | 1967 | H.58 = 45.925 | 30.500 | 51 |
| | 1969 (2) | H.58 = 13.984 | 8.515 | 64 |
| Tuléar | 1965 | H.53 = 31.343 | 11.742 | 167 |
| | 1967 | H.53 = 46.700 | 30.428 | 53 |
| | 1968 | H.53 = 45.856 | 20.856 | 120 |
| Ambovombe | 1966 | H.54 = 22.044 | 13.960 | 58 |
| | 1967 | H.53 = 37.392 | 19.819 | 89 |
| | 1968 | H.53 = 19.234 | 1.456 (3) | 1221 |
| Betafo | 1956 | H.43 = 17.071 | 4.443 | 284 |
| (Antsirabe) | 1958 | H.42 = 25.000 | 5.500 | 356 |

(1) = mosaïc very important

(2) = very dry year

(3) = Termites

The best results obtained in Central Research Station are, in T/ha

| | | | |
|---|---|---|---|
| 1965 | H.56 = 57.006 | H.54 = 38.983 | |
| 1966 | H.57 = 64.700 | H.54 = 53.529 | |
| 1967 | 48830 = 41.209 | H.54 = 25.055 | H.58 = 47.060 |
| 1968 | 55254 = 85.310 | H.54 = 62.864 | 51241 = 72.895 |
| 1969 | 55254 = 78.770 | H.54 = 62.840 | 55187 = 75.625 |

## 2.- Cultural practices

Harvesting of 40 T/ha roots and same quantity of branches and leaves contain :

| | Roots | Branches and leaves | Total |
|---|---|---|---|
| N | 73 | 200 | 273 |
| $P_2O_5$ | 34 | 70 | 104 |
| $K_2O$ | 87 | 180 | 267 |
| CaO | 20 | 150 | 170 |
| MgO | 72 | 130 | 202 |

In one Ton of roots, excepting branches and leaves, at 35 % dry matter, we find :

1.82 kg N
0.85 " $P_2O_5$
2.17 " $K_2O$
0.49 " CaO
1.81 " MgO

Subjet to restitution of branches and leaves, for each roots ton produced and harvested, manuring must be at least, and for example :

8.70 kg of ammonium sulfate
4.26 kg of superphosphate
3.62 kg of potassium chloride

Our trials showed also that a direct correlation exists between external and internal root bark potash content, root yields and starch content. 100 kg/ha of potassium chloride may, in some instances, increase root yield of 16 Tons.

Standard manuring are, for each plantation, composed as follows :

40 T/ha farmyard manure
50 to 100 kg/ha $P_2O_5$
90 to 150 kg/ha K

($P_2O_5$ from Reno Hyperphosphate with 45 % CaO)

However, in laterite poor soils with high acidity, the best fertilizer quantities are as follows :

30 to 40 T/ha farmyard manure
50 to 70 kg/ha N
50 to 150 -"- $P_2O_5$
90 to 200 -"- $K_2O$
0 to 600 -"- Dolomie

## PROSPECTS OF RESEARCH STUDIES

Varietal improvement is modified from this year. Indeed, considering acquired advance in yield field and importance showed, very often as a restricting factor, by mosaic disease, the studies are now followed on resistance to this disease.

The method is the following one : to sow each year 70.000 hybrid seeds harvested on our trials and varietal stock, near Ambanja where mosaïc disease is very serious. Susceptible plants are excluded, trials during at least two years with cuttings from undamaged plants and transference on our best actual hybrids of this symptome absence if it can be thus obtained. On the other hand, new species from genus Manihot introduction (from one species, Melanobasis and saxicola), resistance trials, crossing with our best varieties, followed probably by back-crosses.

First study showed, on 19.945 seeds, 744 undamaged plants (3,73%) 8 months after sowing; This first result is interesting, because no variety had been undamaged to date.

This programme will allow to us to try during 5 years about 350.000 seeds, therefore, with a 30 % germination meanpercentage, close by 100.000 plants. With this number, direct obtaining hypothesis of at least one undamaged plant can be retained. If this way is proving improductive, new interspecifie crosses will be our second objective. It will be also interesting, if only plants with very little damage are obtained, to cross these plants between them, taking care to sow hybrids seeds as numerous as possible, to try to get together resistance factors which are very probably multiple.

Beyond this "mosaïc" programme, a field of activity more limited will be starch amount increase of our best actual varieties by hybridization with very high starch percentage varieties.

Finally two very limited subjects will be approached : on the one hand homozygoty drawing near and on the other hand explanation of little seeds coming out.

## PRODUCTION AREAS AND EXPORTATIONS

It should be observed that dry cassava is produced by little farmers only in the south west of Madagascar.

Exportations in 1969 are the following ones :

| | 1000 Tons | Price/kg |
|---|---|---|
| Dry cassava (1966) | 13.604 | 14.30 (FMG - FOB) |
| Tapioca | 5.620 | 1.12 (F.F.- CAF) |
| Starch | 1.646 | |

# SWEET POTATO

## TRADITIONAL CULTIVATION

Cuttings are planted at distances variyng from 8 x 8 to 16 x 28 inches, according to regions. The soil is generally succintly prepared, sometimes with manuring. Harvesting is carried out as Cassava.

Frequently cultivated with another plants, as cassava, sweet potato is lighted upon everywhere in Madagascar, but essentially on East coast and far south.

No industrial cultivation exists.

Yields are variyng from 0,2 to 2,5 pounds per plant.

## ACTUAL PROGRAMME

At first, diseases and pests are essentially the following ones :

Pests = Aspidomorpha, Aphtona, Colosposoma, Brachmia and Alcides are the most dangerous species on leaves.

Diseases = No special interest, because severity is always very weak.

### a/- Varietal programme

Many local "varieties" are existing, with various leaves shapes and roots colors. These varieties are arranged in collections in Central area, east coast and South. Many introductions had been tried conjointly with the local varieties.

The yields which had been obtained are, according to years and trials :

- On central table-lands : beetween 6238 and 30685 kgs/ha
- On East Coast, beetween 9692 and 45667 kg/ha
- In the South, beetween 7460 and 9848 kg/ha.

The highest yields are

On east coast :

| | | | |
|---|---|---|---|
| Menahatoka | (L) | = 45.667 | T/ha |
| Gold rust | (I) | = 33.667 | " |
| Early port | (I) | = 36.134 | " |
| Centenial | (I) | = 28.160 | " |
| Sinoamena | (L) | = 44.167 | " |
| Sinoafotsy | (L) | = 38.167 | " |

| | | | | |
|---|---|---|---|---|
| On central table-lands | Voriravina | (L) | = 14.264 | T/ha |
| | Lohafinjo | (L) | = 27.700 | " |
| | Vomanga kely | (L) | = 25.500 | " |
| | Galona | (L) | = 13.550 | " |
| | Sihanaka | (L) | = 13.396 | " |
| In the south | Vareza | (L) | = 9.848 | " |
| | Sinoamena | (L) | = 7.460 | " |

Local varieties (L) give very good yields and are sometimes more valids than introduced ones (I).

b/- Manuring programme

Trials have always proved a well choiced formula provide a very sensible yields increase, and, on central table lands, they gave next résults :

| Control (no manuring) T/ha | Complete manuring T/ha |
|---|---|
| 4.825 | 9.475 |
| 3.808 | 6.238 |
| 3.908 | 9.294 |
| 6.310 | 14.264 |
| 19.690 | 27.700 |
| 3.710 | 11.500 |
| 4.506 | 13.396 |
| 6.540 | 13.550 |

Near Tananarive, nitrogen response curves showed one introgen kilo give an 80 kgs sweet potato yield increasing. Response is good until 100 U/N/ha, sometimes until 200 U/N/ha. Recommended manure is the following one :

| | |
|---|---|
| Stable litter | = 10 T/ha |
| $NH_4$ Sulphate | = 150 to 300 kgs/ha |
| Dicalcic phosphate | = 100 to 200 -"- |
| Potassium chloride | = 100 to 200 -"- |

this is, in units :

| | |
|---|---|
| N | = 30 - 60 units/ha |
| $P_2O_5$ | = 40 - 90 -"- |
| $K_2O$ | = 60 -120 -"- |

c/- General recommendations

- Planting spacing are from 16 x 16 to 16 x 28 inches (respectively in table-lands and east-coast).
- Planting time is in December - January in central table-lands and in April - June on east coast.
- treatments against pests will be carried out only when pests are becoming dangerous on leaves.

# P O T A T O

Only cultivated at an altitude over 2400 feet essentially in the Tananarive Province (80 % of total planted area).

The cultivation is only family one. The income is high for a relatively short growing time. Studies had been directed essentially on varieties and their diseases, and also manuring. Results are very encouraging ones.

## TRADITIONAL CULTIVATION

Planting distances is 20 x 20 inches, density being around 40.000 pl/ha. Varieties are very often old ones, introduced in Madagascar many years ago, but also recent ones more interesting in yield and diseases resistance.

Planting dates are from December to February, or April; Duration is about 100 to 110 days.

Potato is coming beck esch year on the same soil and yields are low, 3 to 5 T/ha.

## EXPERIMENTAL RESULTS

### a/- Varietal studies

More than 50 varieties had tried : The more interesting results are, with good manuring

| | | |
|---|---|---|
| Kerpondy A' | 30.976 | T/ha |
| Claudia | 29.743 | " |
| Farfadette | 23.125 | " |
| Ackersegen | 23.071 | " |
| Kerpondy A | 21.040 | " |
| Violette du pays | 19.932 | " |
| Bintje A | 19.560 | " |
| Krassava | 19.232 | " |

The ten years mean give the bests results with

- at Antsirabe = Kerpondy
  Fin de siccle
  Rosa
- at Tananarive = Kerpondy
  Claudia
  Belle de Fontenay

for December planting

and Etoile de Leon
Fin de siecle
Royal Kidney
Claudia

for April planting.

Mean yields are from 15 to 25 T/ha with 40 to 60 % of Commercial product with Kerpondy. These yields are very variable according to years and soils, and percentages of commercial tubers are from 0 to 70, the highest being given by Fin de siecle, Kerpondy and Rosa.

b/- Manuring studies

All the trials proved mixed manuring effectiveness. Controls are variyng from 1500 to 5000 kg/ha, as shown on next table :

| Control ( T/ha) | Orgaine maniure + PK ( T/ha) |
|---|---|
| 3.384 | 13.954 |
| 1.837 | 16.142 |
| 3.102 | 10.665 |
| 3.967 | 7.513 |
| 3.542 | 13.042 |
| 3.467 | 8.087 |
| 2.591 | 11.329 |
| 3.330 | 14.489 |
| 3.500 | 5.460 |
| 69 | 2.454 |

The best manuring is :

| | | |
|---|---|---|
| Orgainc manure | = | 20 T/ha |
| Dicalcic phosphate | = | 200 - 250 kg/ha |
| Potassium chloride | = | 150 - 200 -"- |

Nothertheless, it is sometimes preferable to choice superphosphate (100 kg/ha) and to add 100 to 250 kg of Sulfate of ammonia.

Accordingly, the classic formulae are :

| | | |
|---|---|---|
| N | = | 30 to 60 U/ha |
| $P_2O_5$ | = | 90 to 120 " |
| $K_2O$ | = | 60 to 90 " |

c/- Diseases and pests

The most dangerous insects are essentially Heteronychus sp on stalks, Plusia sp, Acherontia atropos, Coelonia solani, Spodoptera littoralis on leaves and Phtorimea operculella on tubers. Some treatments are now proposed to the farmers.

Nematodes are numerous and sometimes very dangerous. Prevention is difficult, and gramineae are often used in alternation with potato.

Diseases are essentially bacterial ones with Pseudomonas solanacearum, which is often very serious. Prevention is conducted with soil and plant treatments, and also by resistant varieties : seed and tuber introductions (from Kenya and Holland respectively) are now in study : interesting results have been obtained with Prisca, Kennebec, Katahodin, Flisak, Lori, Gelderse and Rode. Another diseases are caused by Alternaria solani, Spongospora subterranea and Fusarium sp essentially.

# C O N C L U S I O N

It is interesting to compare food values of these plants, for 100 grams, to Rice

| | Potato | fresh Cassava | sweet Potato | Rice |
|---|---|---|---|---|
| Calories | 82 | 146 | 117 | 360 |
| Protids (grs) | 2 | 1,2 | 1,3 | 6,7 |
| Lipids (grs) | 0,1 | 0,3 | 0,3 | 0,7 |
| Glucids (grs) | 18,2 | 34,8 | 27 | 81,7 |
| Ca (mgr) | 8 | 33 | 34 | 10 |
| Fe (mgr) | 0,7 | 0,7 | 1 | 0,9 |
| Vitamins A (I.U) | 0 | 0 | 500 | 0 |
| $B_1$ (mgr) | 0,10 | 0,06 | 0,10 | 0,08 |
| $B_2$ (mgr) | 0,03 | 0,03 | 0,05 | 0,03 |
| P.P (mgr) | 1,4 | 0,6 | 0,6 | 1,60 |
| C (mgr) | 10 | 36 | 23 | - |

In the central area of the Island (3000 feet altitude), Comparison between kilos/day/hectare productions is the following one :

| | Potato | fresh Cassava | sweet Potato | Rice |
|---|---|---|---|---|
| | 15 - 110 | 20 - 50 | 35 - 60 | 16 - 26 |
| Corresponding Calories | 12,000 - 90,000 | 30,000 - 75,000 | 42,000 - 72,000 | 58,000 - 95,000 |

It is interesting to compare the first table in this conclusion to another one which is the food value for 1000 calories of each product.

| | Potato | fresh Cassava | Sweet Potato: | Rice |
|---|---|---|---|---|
| Calories | 1000 | 1000 | 1000 | 1000 |
| Protids (grs) | 24 | 8.2 | 11.0 | 18.8 |
| Lipids (grs) | 1.2 | 2.0 | 2.5 | 2.0 |
| Glucids (grs) | 216 | 237 | 230 | 229 |
| Ca (mgr) | 96 | 224 | 289 | 28 |
| Fe (mgr) | 8.4 | 4,8 | 8,5 | 2,5 |
| Vitamins A (U.I) | 0 | 0 | 4250 | 0 |
| $B_1$ (mgr) | 1.2 | 0,4 | 0,85 | 0,22 |
| $B_2$ (mgr) | 0,36 | 0,2 | 0,43 | 0,09 |
| P.P (mgr) | 16,8 | 4,0 | 0,5 | 4,5 |
| C (mgr) | 120 | 245 | 196 | - |

Rice is never the first one in this table, for each component.

For this region, cassava is never to be advised and should be considered only as a substitute of sweet potato, the best being potato.

Finally, and for all these plants, it is sure that Institut de Recherches Agronomiques Tropicales à Madagascar propounded methods are giving a very perceptible yields augmentation, and this way, an increase of the farmer food potential and income.