# A FEASIBILITY STUDY ON MANIOC PRODUCTION IN N.E. BRAZIL

AID Contract No. AID/LA - 681 (Brazil)

by

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# P R E F A C E

A team of five scientists from the University of Georgia were contracted by the N.E. Brazil office of AID to conduct a feasibility study on manioc production in N.E. Brazil. The study was conducted during the period of June 15 to August 15, 1971. The areas of specialities encompassed by the team were Agronomy, Food Technology, Marketing Economics, Production Economics and Animal Science and Administration. The team was assisted by a Brazilian Agronomist, Mr. Tarcisio Pereira.

The objectives of the study were to determine if it was agronomically and economically feasible to produce manioc in N.E. Brazil and, if so, what research and training programs would be needed to enhance production.

Midway during the study the team presented an oral report of their findings to AID Associate Director, Mr. C. D. Green, and other interested AID personnel. Also, the team was invited to present a seminar to the faculty and invited guests of the Universidade Federal Rural de Pernambuco. The seminar was presented on July 28 and attended by approximately 50 people representing various phases of the N.E. agricultural industry.

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# SECTION I

## CURRENT STATUS OF MANIOC PRODUCTION, UTILIZATION, MARKETING AND PROCESSING IN N.E. BRAZIL

### A. PRODUCTION ASPECTS

World Production - Except for manioc grown on the mainland of China for which no figures are reported, total world production for the crop was 82,739 thousand metric tons in 1967 (15). This crop occupied 9,378,000 hectares of land and produced an average of 8.8 metric tons/ha. Each of eight South American countries and three West Indies nations (Cuba, Dominican Republic and Haiti) produced more than 100,000 metric tons. Brazil produced five times as much as all other countries combined, i.e., 27,268 of the 32,783 thousand metric tons produced in Latin America. Yields per hectare of land planted to manioc in Bolivia (17 metric tons/ha) and Paraguay (15 M tons/ha) exceeded those for Brazil (14.3 M tons/ha). Brazilian yields/ha are slightly higher than those in Thailand (13.9) and India (13.3), about twice those of Indonesia (74) and Colombia (72) and 2-3 times that of most African nations (av. 6.7). If one assumes that 83 million metric tons represents the total amount of manioc grown, then Brazil's share of production would be one-third, approximately the same as that of the next four ranking countries (Indonesia, Congo, Nigeria and India) and more than all the rest of the world combined (Table 1).

N.E. Brazil Production - Northeast Brazil has nearly one-half of all the manioc area (49.4%) planted in Brazil (Table 3). Very little change in the relative position of the N.E. occurred in the 1960-1969 period (Table 2). Total hectares planted increased nearly 50 percent

TABLE 1. World Production of Manioc in 1967.

| | AREA IN HA (X 1,000) | METRIC TONS (X 1,000) | YIELD KG/HA |
|---|---|---|---|
| N.C. America (15 nations) | 111 | 604 | 5,400 |
| Cuba | 30 | 200 | 6,700 |
| Dominic Rep. | 25 | 160 | 6,400 |
| Haiti | 30 | 120 | 4,000 |
| South America (11 nations) | 2,400 | 32,179 | 13,400 |
| Argentina | 25 | 303 | 11,900 |
| Bolivia | 10 | 170 | 17,000 |
| Brazil | 1,914 | 27,268 | 14,300 |
| Colômbia | 250 | 1,800 | 7,200 |
| Ecuador | 34 | 327 | 9,700 |
| Paraguay | 97 | 1,460 | 15,000 |
| Peru | 42 | 507 | 12,200 |
| Venezuela | 26 | 328 | 12,700 |
| Asia (16 nations) | 2,265 | 19,323 | 8,500 |
| Ceylon | 69 | 346 | 5,000 |
| China (Taiwan) | 19 | 299 | 15,700 |
| India | 279 | 3,715 | 13,300 |
| Indonesia | 1,519 | 11,291 | 7,400 |
| Malaysia, W. | 20 | 310 | 15,500 |
| Philippines | 83 | 514 | 6,200 |
| Thailand | 130 | 1,800 | 13,900 |
| N. Viet Nam | 100 | 720 | 7,200 |
| R. Viet Nam | 37 | 262 | 7,200 |
| Africa (41 nations) | 4,591 | 30,518 | 6,700 |
| Angola | 115 | 1,525 | 13,300 |
| Burundi | 73 | 850 | 11,700 |
| Cameroon, E. | 80 | 500 | 6,300 |
| Cameroon, W. | 30 | 250 | 8,300 |
| Central Africa | 200 | 1,000 | 5,000 |
| Congo, Brazz | 100 | 400 | 4,000 |
| Congo, Rep. | 740 | 8,000 | 10,800 |
| Dahomey | 180 | 1,120 | 6,200 |
| Gabon | 50 | 125 | 2,500 |
| Ghana | 138 | 1,174 | 8,500 |
| Guinea | 30 | 446 | 14,900 |
| Ivory Coast | 200 | 1,100 | 5,500 |
| Kenya | 90 | 600 | 6,700 |
| Liberia | 64 | 430 | 6,700 |
| Madagascar | 230 | 900 | 3,900 |
| Malawi | 6 | 140 | 23,300 |
| Mali | 10 | 150 | 15,000 |
| Niger | 24 | 169 | 7,200 |
| Nigeria | 1,100 | 6,500 | 5,900 |
| Rwanda | 15 | 190 | 12,700 |
| Senegal | 42 | 219 | 5,200 |
| Sudan | 17 | 130 | 7,700 |
| Tanzania | 260 | 1,120 | 4,300 |
| Togo | 148 | 1,118 | 7,600 |
| Uganda | 500 | 1,800 | 3,600 |
| Zambia | 40 | 160 | 4,000 |
| Oceania (5 nations) | 11 | 115 | 10,500 |
| World (88 nations) | 9,378 | 82,739 | 8,800 |

Source: FAO Production Yearbook, 1968.

TABLE 2. N.E. States and Brazil Manioc Roots Production, Area and Value of these Crops during 9 Years (1960-1969).

| MANIOC | CULTIVATED AREA, QUANTITY PRODUCED AND VALUE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (Ha.) | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| | | | | | (IN HECTARES) | | | | | |
| Ma. | 79,132 | 101,571 | 98,223 | 107,581 | 114,881 | 128,836 | 160,202 | 197,621 | 192,647 | 224,596 |
| Pi. | 33,301 | 42,056 | 49,903 | 56,029 | 57,249 | 61,047 | 62,153 | 63,678 | 67,775 | 68,914 |
| Ce. | 51,066 | 53,762 | 60,370 | 65,161 | 71,448 | 69,090 | 72,426 | 84,993 | 122,693 | 137,612 |
| RN. | 34,958 | 38,366 | 39,872 | 38,406 | 38,923 | 47,857 | 60,037 | 88,963 | 86,755 | 59,123 |
| Pb. | 50,803 | 51,205 | 56,557 | 58,691 | 61,273 | 55,799 | 63,122 | 64,532 | 62,137 | 53,404 |
| Pe. | 147,505 | 132,288 | 145,393 | 152,757 | 150,460 | 143,016 | 119,667 | 139,707 | 141,044 | 141,328 |
| Al. | 40,771 | 43,498 | 47,298 | 51,231 | 51,062 | 46,713 | 46,713 | 41,503 | 45,209 | 44,626 |
| Se. | 41,863 | 42,356 | 41,259 | 49,741 | 48,663 | 47,854 | 46,395 | 49,896 | 49,575 | 46,305 |
| Ba. | 177,548 | 174,793 | 157,019 | 173,391 | 174,912 | 180,077 | 186,753 | 198,480 | 225,792 | 228,353 |
| N.E. TOTAL AREA: | 656,947 | 679,895 | 695,894 | 752,988 | 768,871 | 780,289 | 817,468 | 299,373 | 993,627 | 1,004,261 |
| | | | | | (YIELD IN METRIC TONS) | | | | | |
| Ma. | 781,284 | 887,597 | 1,084,297 | 1,200,721 | 1,224,240 | 1,308,604 | 1,588,506 | 1,776,046 | 1,743,798 | 2,112,673 |
| Pi. | 360,338 | 439,498 | 510,455 | 701,637 | 664,220 | 673,754 | 591,069 | 714,890 | 737,568 | 720,227 |
| Ce. | 678,106 | 917,876 | 939,647 | 1,059,401 | 1,074,764 | 1,076,583 | 1,120,182 | 1,368,799 | 1,907,722 | 2,163,508 |
| RN. | 198,188 | 217,207 | 235,240 | 215,574 | 198,066 | 236,847 | 326,080 | 555,557 | 556,375 | 399,345 |
| Pb. | 581,882 | 562,388 | 632,962 | 625,166 | 616,808 | 597,058 | 577,985 | 695,474 | 623,471 | 535,449 |
| Pe. | 1,350,527 | 1,242,023 | 1,601,955 | 1,623,245 | 1,607,388 | 1,445,491 | 1,195,981 | 1,529,750 | 1,507,743 | 1,756,198 |
| Al. | 397,180 | 463,467 | 490,837 | 523,379 | 484,936 | 456,510 | 466,838 | 474,662 | 505,755 | 502,191 |
| Se. | 648,846 | 676,067 | 693,036 | 854,663 | 781,243 | 872,459 | 784,803 | 813,026 | 819,595 | 762,802 |
| Ba. | 2,635,143 | 2,440,211 | 2,082,145 | 2,318,597 | 2,668,324 | 2,819,758 | 2,961,691 | 3,374,166 | 3,898,567 | 4,056,688 |
| N.E. TOTAL YIELD | 7,631,494 | 7,846,334 | 8,270,574 | 9,122,383 | 9,319,989 | 9,487,064 | 9,613,135 | 11,302,370 | 12,300,595 | 13,009,081 |

Source: SUDENE, July 1971, Statistical Department.

TABLE 3. N.E. States and Brazil Production, Area and Value of Manioc Crops during 9 Years (1960-1969).

| MANIOC | CULTIVATED AREA, QUANTITY PRODUCED AND VALUE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Value 1,000 Cr$ | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
| Ma. | 579,085 | 1,058,388 | 1,647,848 | 3,106,578 | 5,717,854 | 10,509,816 | 20,491,361 | 29,834,109 | 38,585,450 | 50,086,081 |
| Pi. | 297,851 | 508,326 | 1,030,169 | 1,842,864 | 2,619,290 | 4,225,840 | 9,117,085 | 15,137,137 | 21,422,075 | 21,364,819 |
| Ce. | 743,456 | 1,130,921 | 3,524,984 | 4,744,977 | 8,060,006 | 11,030,331 | 15,603,402 | 24,000,766 | 48,882,106 | 66,219,551 |
| RN. | 341,714 | 568,242 | 1,424,008 | 1,686,749 | 2,903,376 | 5,378,264 | 12,884,548 | 28,085,690 | 25,330,610 | 16,637,984 |
| Pb. | 989,798 | 1,836,519 | 3,635,831 | 5,573,874 | 10,992,382 | 15,473,582 | 21,386,580 | 28,901,670 | 24,862,478 | 28,130,257 |
| Pe. | 2,361,830 | 4,692,740 | 11,274,029 | 10,575,058 | 13,793,545 | 26,513,472 | 34,545,823 | 55,168,318 | 62,215,676 | 84,139,177 |
| Al. | 696,041 | 1,447,403 | 2,814,489 | 3,532,540 | 5,219,328 | 7,838,348 | 10,885,938 | 14,702,539 | 19,260,923 | 25,255,472 |
| Se. | 763,150 | 1,433,650 | 5,873,071 | 7,386,081 | 7,216,217 | 15,975,508 | 18,439,056 | 29,763,630 | 37,855,772 | 36,231,246 |
| Ba. | 2,799,479 | 4,858,755 | 7,428,222 | 10,358,794 | 16,657,163 | 27,030,203 | 52,919,829 | 75,048,706 | 101,628,443 | 126,985,550 |
| N.E. Total Value | 9,572,404 | 17,534,944 | 38,652,651 | 48,807,515 | 73,109,161 | 123,975,364 | 196,273,622 | 300,642,565 | 380,043,533 | 455,050,137 |
| AREA | | | | | | | | | | |
| N.E. | 656,947 | 679,895 | 695,894 | 752,988 | 768,871 | 780,289 | 817,468 | 929,373 | 993,627 | 1,004,261 |
| Br. | 1,342,403 | 1,414,081 | 1,476,774 | 1,617,810 | 1,715,857 | 1,749,960 | 1,779,806 | 1,914,439 | 1,998,197 | 2,029,373 |
| PROD. | | | | | | | | | | |
| N.E. | 7,631,494 | 7,846,334 | 8,270,574 | 9,122,383 | 9,319,989 | 9,487,064 | 9,613,135 | 11,302,370 | 12,300,595 | 13,009,081 |
| Br. | 17,613,213 | 18,407,218 | 19,843,422 | 22,248,644 | 24,355,602 | 24,992,579 | 24,710,041 | 27,268,193 | 29,203,229 | 30,073,943 |
| VALUE | | | | | | | | | | |
| N.E. | 9,572,404 | 17,534,944 | 38,652,651 | 48,807,515 | 73,109,161 | 123,975,364 | 196,273,622 | 300,642,565 | 380,043,533 | 455,050,137 |
| Br. | 23,699,681 | 38,585,606 | 82,857,609 | 117,178,318 | 194,783,983 | 309,228,840 | 473,033,271 | 706,339,539 | 936,756,762 | 1,136,209,637 |

Source: SUDENE, July 1971, Statistical Department.

in the base period, both in the Northeast and in Brazil as a whole. The value of manioc produced in the N.E. was Cr$ 455 million or 40% of the total for Brazil in 1969 (Table 3). Growth rates for area and production in the N.E. between 1960-61 and 1968-69 were 5.4% and 6.3% respectively. For Brazil these same rates were 4.9% and 6.2%.

Yields per hectare have usually stayed within the range of 11.5-12.4 metric tons/ha (Table 4) and have fluctuated by less than a ton per hectare during the period 1960-1969. No fertilizer of any kind is used on the crop. Lime is not applied to improve the pH of the soil. In rotation programs, the crop usually follows beans and corn after yields of these two crops decline to unprofitable levels as the soil's fertility declines. The only factor that mitigates against the decline of hectare yields is the continued increase of new lands opened for manioc production after it is used initially for beans and corn.

There are indications from other parts of Latin America (So. Brazil, Bolivia, Venezuela) that yield and possibly protein content (Colombia) can be increased significantly over present low levels by the selection of better varieties and the improvement of cultural practices (Colombia, Nicaragua). It is known that with good land, properly irrigated and fertilized and where pests are adequately controlled, that yields of 70-90 tons per hectare are possible; yet the world average is only one-tenth this value. In Africa, where 4.5 million hectares are planted to manioc, the average yield is only 6.7 metric tons/ha.

TABLE 4. Average Yield of Manioc Per Hectare in Northeast Brazil for the Years 1960 to 1969.

| YEAR | YIELD PER HECTARE (in metric tons) |
|---|---|
| 1960 | 11.6 |
| 1961 | 11.5 |
| 1962 | 11.9 |
| 1963 | 12.1 |
| 1964 | 12.1 |
| 1965 | 12.2 |
| 1966 | 11.8 |
| 1967 | 12.2 |
| 1968 | 12.4 |
| 1969 | 12.3 |

Source: Instituto Brasileiro de Estatistica. Anuário Estatistico do Brasil, 1970.

Production of manioc per hectare varies greatly in N.E. Brazil. For the year 1969, average production by state varied from a low of 6.8 tons per hectare in Rio Grande do Norte to a high of 17.8 tons in Bahia (Table 5). Since the major cost of producing manioc is labor, and labor input is relatively fixed per hectare, the higher the production level the lower the cost of production. These relationships are presented elsewhere in this paper.

Existing Areas of Production in the N.E. - Manioc is produced in almost every municipality within each state in N.E. Brazil and is usually listed as one of the major food crops in each regardless of whether it is located in the wet humid area (Zona da Mata), the transition zone (Agreste), or the dry lands (Sertao). In the form of meal or flour it is the traditional source of food for most Brazilians. In N.E. Brazil, per capita consumption is estimated to be 73.8 kilos/year in the rural areas and 32.0 kilos/year in urban areas.

TABLE 5. Average Yield of Manioc in Each of the Nine N.E. Brazilian States during 1967, 1968 and 1969.

| | YIELD PER HECTARE (in metric tons) | | |
|---|---|---|---|
| | 1967 | 1968 | 1969 |
| Maranhão | 9.0 | 9.1 | 9.4 |
| Piaui | 11.2 | 10.0 | 10.5 |
| Ceará | 16.1 | 15.5 | 15.7 |
| R.G.do Norte | 6.2 | 6.4 | 6.8 |
| Paraiba | 10.8 | 10.0 | 10.0 |
| Pernambuco | 10.9 | 10.7 | 12.4 |
| Alagoas | 11.4 | 11.2 | 11.3 |
| Sergipe | 16.3 | 16.5 | 16.5 |
| Bahia | 17.0 | 17.3 | 17.8 |
| Averages N.E. | 12.2 | 12.4 | 12.3 |
| Averages all BR. | 14.3 | 14.6 | 14.8 |

Source: Instituto Brasileiro de Estatistica. Anuário Estatistico do Brasil, 1970.

Production methods are quite primitive and it appears that considerable increases in productivity could be obtained with minimal inputs of modern technology. Its widespread distribution is accounted for by the fact that it is adapted to an exceedingly wide range of soil and environmental conditions. It is drought resistant and yet it can be produced under rather high rainfall conditions with proper soil drainage. It is produced on a wide range of soil types and soil fertility levels and the various cultivars seem to have been naturally selected for production on poor soil. In fact, a general practice on new land in N.E. Brazil in areas where other crops such as corn and beans can be produced is to plant these crops first and then after the natural soil fertility has been depleted, plant a crop of manioc. This denotes that all farmers recognize that manioc can and does produce on poor soil. Likewise, where most crops perform best at a soil pH of 6.0 - 6.5, manioc performs equally as well on soils ranging in pH from 5 to 9. These aspects of the natural genetic composition of manioc make it a very unique crop and undoubtedly accounts for its widespread production in Brazil as well as other parts of the tropical world.

New Areas of Production in the N.E. - In N.E. Brazil thousands of hectares of land exist that could be adapted to manioc production with proper soil and water management (19), improved varieties, better transportation and markets even without the use of fertilizers. Fertilization may not be profitable to producers under the present cost of purchasing and transporting fertilizers and with the present farm prices of the crop. However, manioc is being produced in the Sertão area of N.E. Brazil without additional water and fertilizer. This climatic zone encompasses the largest land area in the N.E. and agricultural expansion is limited only by technology, transportation and markets. In spite of the fact that rainfall is low (200-700 mm/yr) and concentrated within a rather short period of time (January-May), a well organized and executed research program in dry land farming methods could reap great dividends in this area. In the Agreste zone, where heavier and more equal distribution of rainfall occurs, there are also many hectares available for expansion as well as the possibility of increasing production on existing acreages. With the use of new varieties, fertilizers, lime and insect and disease control, there is every reason to believe that substantial gains in yield/ha could be realized.

Soil and Water Relationships - The soils of N.E. Brazil are extremely variable and a complete discussion of them will not be attempted in this report. However, they can be generally classified under the U.S. Comprehensive System into three large groups: Alfisols (non-calcic brown, calcic brown, red and brown mediterranean and terra roxa), Ultisols (red-yellow podzolic) and Oxisols (red-yellow latosols). Most of the manioc is grown on Oxisols and Ultisols. The Alfisols, with mineral fertility and structure being generally good, may be important for manioc, especially the terra roxa. While terra roxa soils are predominant in Southern Brazil, very little of this type of soil exists in N.E. Brazil (5).

In regard to pH, which usually affects base saturation of the soils, the Oxisols are usually moderately acid (5.6), the Ultisols very acid (4.3) and Alfisols are neutral to slightly alkaline (6.9 - 8.0). This corresponds to conditions of moderately low, very low and high percentage base saturation, respectively.

Broad differences in soil texture exist in the soils of N.E. Brazil and texture is important for successful root development of manioc. Oxisols and Alfisols are characterized by a finer texture than Ultisols and would therefore be less desirable for manioc. Oxisols generally exhibit a lighter textural characteristic or coarser feeling despite the high clay content (70%). This is due to a stable aggregation, creating a friable condition in the soil. Ultisols are considered to be very poor in physical condition because of their acidic condition and very low base saturation. Comparisons of yield results on these soils should give some indication of the influence of soil physical properties on manioc production.

The Ultisols are the primary type soil in the Zona da Mata (12) and can be generally described as shallow, sandy, well drained moderately acid, and well aerated soils with a low capacity for water retention, low quantities of K and Na and moderate quantity of Ca and Mg. The quantity of N, P and S present depends on the type of natural vegetation, which depends on the climatic and topographic conditions existing (25). The major crop in this area is sugarcane but manioc is produced and averages 12 T/ha.

The Alfisols are generally characterized as shallow, clayish soils, with moderate drainage and aeration and a high capacity for water retention. They are usually neutral in pH with moderate quantities of K and Na and high in Ca and Mg (25). These soils exist in all areas of N.E. Brazil. Yields on these soils are not known specifically but are generally around 10-12 T/ha.

The soils of the Sertão are primarily Oxisols which are characterized as deep, clayish with good drainage and aeration, a high capacity for water retention, slightly acid, moderate high in K and Ca and low in Na and Mg (25). The production of manioc in this area generally averages 8-10 T/ha except in extreme drought years.

Results from analysis of 15,000 soil samples taken over the entire N.E. Brazil area showed a high percentage of the sample deficient in P, but most samples had a good supply of K, and most soils, especially those in the Zona da Mata, required lime at rate of at least one T/ha (18).

The high, low and average rainfall per year for eight of the N.E. states is shown in Table 6.

TABLE 6. Average Annual Rainfall for Eight N.E. States in Year 1965 and 1966.

| STATE | NO. MUNICIPALITIES CHECKED | AVE. RAINFALL (in mm) | RANGE (in mm) |
|---|---|---|---|
| Piaui | 10 | 1155.4 | 665 - 1704 |
| Ceará | 10 | 921.3 | 499 - 1962 |
| R.G.Norte | 10 | 922.4 | 622 - 1184 |
| Paraiba | 8 | 1126.6 | 783 - 1315 |
| Pernambuco | 10 | 946.9 | 472 - 1666 |
| Alagoas | 10 | 1102.0 | 964 - 1596 |
| Sergipe | 9 | 1001.3 | 905 - 1425 |
| Bahia | 7 | 772.8 | 491 - 1153 |

Source: Monthly Rainfall Measurements Data - Department of Natural Resources, SUDENE.

It can be noted that the total and average range of rainfall would be considered sufficient for manioc production in all areas; however Figure 1 shows a plot of the annual rainfall at the Experiment Station at Araripina from 1961 to 1970. From this figure it can be noted that this area, typical of the Sertão or drought polygon, is susceptible to droughts. This fact is well documented in the literature and needs no elaboration in this report. In addition to periodic droughts, a problem exists in annual distribution of rainfall. In the Araripina area, light rain occurs in December and January with the heaviest amounts occurring in February and March and again becoming light in April. This gives at most a 5 months growing season with 7 months of dry weather. Proper soil and water management using methods adapted for dry land farming would greatly enhance production.

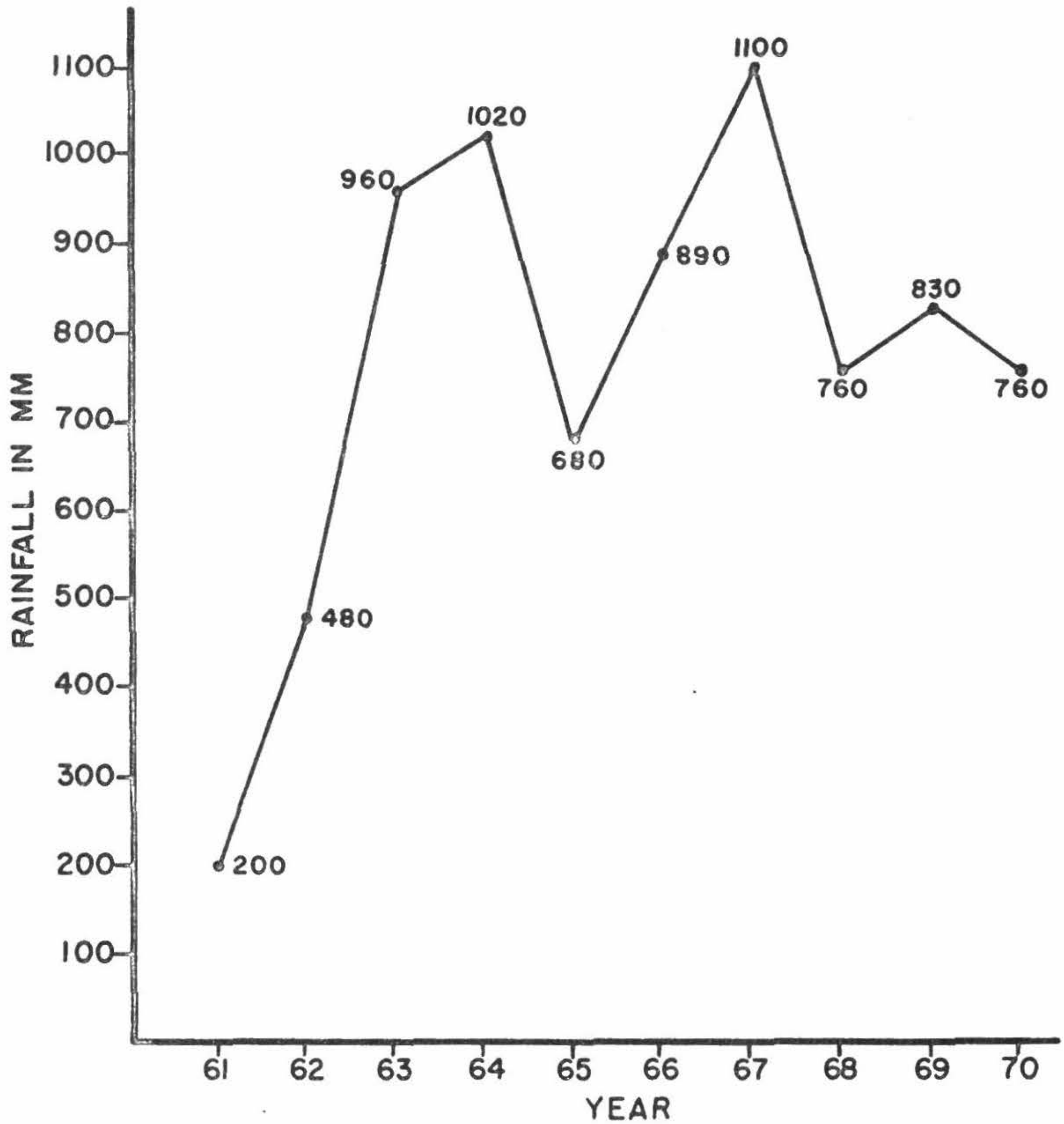



FIG. 1. Annual rainfall at the Experiment Station in Araripina 1961-70.

Source: Unpublished data from Director of the Experiment Station, Araripina, Pernambuco, Brazil, July, 1971.

Production Practices - The production of manioc in the N.E. is entirely manual and crops such as corn and beans and sometimes rice are frequently interplanted with this crop. This makes cost of production data extremely difficult to obtain or develop. Likewise, it is sometimes planted after crops of corn and beans are harvested and the land considered nonproductive for these crops.

The land is usually prepared by hand. The weeds, etc., are cleared with a machete and hoe, and the soil mounded or a furrow opened by hoe for planting the manioc sticks.

The vegetative cuttings are usually 10-15 cm long, taken from the lower portions of the old plant stalks which have been stored in a cool, shady place for 2-3 months or more.

In areas where rainfall is periodic, planting is usually done when the rainy season begins. However, it is frequently quite difficult in some areas for the farmer to distinguish between the occurrence of local showers and the beginning of the true rainy season (20).

Insect and diseases are only occasionally a problem and since insecticides and fungicides are expensive they are not generally utilized on this crop.

Harvesting is done manually after a growing season of 12 to 24 months depending upon the area where grown.

The varieties utilized are old line varieties prevalent in the area and handed down from one year to the next. It is not known whether they are virus infected or not but it appears they are. This team observed considerable variation among plants in growth habit, leaf color, etc., in most fields visited. This is probably associated with the fact that even though manioc is propagated vegetatively it has a tendency to mutate and these mutations have been passed on due to improper selection of plant material.

B. UTILIZATION

Human Food - Manioc is looked upon as a subsistence crop having poor nutritional value but supplying more calories per hectare of land than any other crop planted in the tropics. Except for relatively minor amounts of manioc grown in the Southern U.S. and in the Union of South Africa, almost the entire world's production is produced and consumed in the developing countries. At least two hundred million people in the tropics depend largely on manioc as a staple food.

Unfortunately, the development of programs to enhance the value of root crops has not kept pace with the worldwide attention that has been given to the cereal grains. As a consequence, the selection of plants providing greater yields, higher protein content, improved digestibility, and/or a better complement of vitamins and minerals has not been explored to the extent that seems warranted by the plant's importance.

Coursey and Haynes (11) estimated that in Latin America, root crops contribute 15% of the total calories required per person/day. However, a much higher percentage would probably prevail in N.E. Brazil since in 1969, only 30% of the total population of Brazil consumed over 43% of the 30 million metric tons of manioc produced. Obioha (34) indicated that Nigeria's entire population could rely on manioc alone to meet 80% of its caloric needs.

In Northeast Brazil the diet of the manual laborer and his family is limited both as to content and variety. As a consequence of poor economic status, he has come to depend heavily upon coffee with sugar, manioc, beans, rice, salted dried meat and corn in that order. Only when these wants have been satisfied does he purchase fresh meat, poultry, eggs, milk, cheese and other commodities. While he varies his diet to a certain extent by obtaining fruits and vegetables when they are in season, the staples (except for beans) in his diet are notoriously poor in protein content and high in carbohydrates. During extremely rigorous times, coffee, sugar and manioc represent his mainstays and the last-named provides his only insurance against starvation. Since manioc is comprised primarily of carbohydrate and has only an insignificant amount of protein, the insurance is at best temporary. It is against this backdrop that efforts must be directed to improve the situation. With proper guidance and training and with little additional expenditure of capital, some changes can be brought about quickly. Others will require time to evolve and will need federal or other agency support.

At a meeting held in Rio de Janeiro, July 19, 1971, and attended by prominent Brazilian scientists, businessmen, USAID officials and two AID manioc team members, there seemed to be general agreement that a field study to assess the value of manioc fortification was needed. The group considered it important to ascertain if the consumer would pay a few additional centavos for fortification.

A survey was made by the Instituto de Tecnologia Alimentar (ITA) in Campos, Rio de Janeiro, and the following facts were determined: about 53% of manioc production is derived from a family type industry and very little is sold to the "outside." This family type processor does not enlarge or prosper because he has only a small supply of roots and little capital for purchasing additional raw material (roots). Most have only temporary employees who earn less than Cr$ 10/week and receive no other service benefits; 25% have drying ovens. Most of the buyers who do not operate within this framework do not know where their supply originates. They say they "get it from a truck."

Technological improvement is much needed. Since most consumers get their "farinha de mandioca" in a supermarket, the reprocessor could be a likely intervention point. However, supermarket purchasers are those with better than average incomes and can afford a quality product while those in lower economic strata would not be reached through such a mechanism. Yet the reprocessor would be ideal from the standpoint of fortifying and making a product to sell in small packages that are convenient for the family purchaser to carry home.

The Planning, Evaluation, Research and Special Programs Unit of the Ministry of Health (PAPPE) indicated a willingness to underwrite a central distribution system for preparing a fortified manioc product but wanted some assurance that manioc producers would cooperate. Dr. Álvaro de Mello is of the opinion that the problem of organizing the producer would be difficult unless he could be assured of a guaranteed basic price.

Animal Feed - Manioc is being used in livestock feed as a good source of calories. However, world production reports do not indicate the quantity used for animal consumption. Brazil ranks very high in manioc production but uses relatively small quantities for animal feed. Imports into the U.S. for animal feeding are nil, whereas large imports occur into certain countries in Western Europe (1). The Federal Republic of Germany, Belgium, France and the Netherlands imported 883,514 metric tons with a value of US$ 57,500,000 in 1966.

Germany alone imported 701,709 tons or 79.4% of the total imported into Western Europe. Seventy-five percent of the imported manioc into Germany was in the form of dried roots and the remaining 25% was in the form of meal or flour. It was estimated that approximately 462,000 metric tons of manioc were used in the formulation of feedstuffs for animals, which represented 10% of the feedstuffs used in Germany in 1966. Manioc was utilized as about 3% of the feedstuffs in the Netherlands.

There is a variety of manioc products used as feedstuffs in the feed manufacturing industry. The most common forms used are chips, broken roots, pellets, slices and processing residue.

Limited use has been made of manioc leaf meal which is composed of the leaves and small tender stems. It is similar to alfalfa meal in its physical appearance, composition and feeding value (36). Manioc leaf has a good potential as a protein and vitamin supplement, since varieties with high foliage yields are available in N.E. Brazil. This team observed a variety at the University of Bahia, which the Vice-Director, Mr. Santana, stated yielded up to 58 metric tons/ha/year (fresh weight) with three cuttings. The removal of the tops decreased root yields from 50 to 20 T/ha (unpublished data).

The principal value of manioc is, however, calories. It is very high in starch content, but very low in fat, protein, minerals and vitamins. On a dry matter basis, the caloric content of manioc is about equivalent to corn, but its levels of lipids, protein, minerals and vitamins are much lower than corn except for the Colombian variety "Llanera" (26).

The value of manioc in swine diets has been recognized for many years and several reports have appeared in the literature since 1900 (3, 4, 9, 10, 17, 21, 23, 26, 27, 28, 30, 31, 35, 43, 45). The predominant portion of the research involves comparison of diets with manioc and diets containing other roots, tubers or cereal grains.

Generally it has been observed that the carcasses of swine fed on diets high in manioc were very white in color, of fine flavor, and, though perhaps not quite so firm as that from corn-fed hogs, they were firmer and shrunk less in cooking than those from animals fed cowpeas or peanuts (43).

The most recent and extensive swine research with manioc has been conducted in Colombia, S. A., by Maner and co-workers (26, 27). The practice of feeding raw manioc and a protein supplement free-choice was compared with a basal corn completely mixed diet. Those fed raw manioc free-choice and a controlled quantity of protein supplement gained slightly slower. Feed efficiency was improved with the manioc and free-choice feeding.

In another experiment, silage was made with fresh roots or a combination of the whole plant (roots, stalks and leaves). Manioc and a standard protein supplement were fed free-choice to three different treatment groups. Pigs receiving the root silage gained slightly faster on less feed than those given fresh manioc and supplement; therefore, silage appears to be a good alternative way of feeding manioc.

The stalk and leaves reduced consumption of the total plant-silage and gains were slower and feed per unit of gain increased. The stalks were not suitable in the pig feed.

Castillo et al. (9) also studied manioc silage as a feed for growing swine. A chemical analysis of the material was made before ensiling and periodically after ensiling. There was some loss of nutrients in the runoff solution. In feeding trials, the use of manioc silage was satisfactory in the diets.

Research reports pertaining to the use of manioc leaf meal in swine diets are very limited. Velloso et al. (45) found manioc leaf meal could satisfactorily replace alfalfa meal when used as 5% of a diet for finishing pigs.

Properly fortified manioc residue meal should be an acceptable feed ingredient in poultry rations, yet there are only a few research articles available. Some of the earliest research with chicks was conducted in the Philippines (41). The results showed that manioc refuse was approximately 77% the value of rice bran, but a combination of the two was 92% the value of rice bran alone. However, Temperton and Dudley (42) reported laying hens had tolerated substitution with manioc meal up to 40% of corn meal, wheat middlings and oats.

In 1951, seven experiments were reported from a study in Guatemala (40). The processing residue meal (by-product of starch manufacturing) was used in several different types of diets. They concluded that growth rate of chicks fed manioc residue meal and the efficiencies of feed utilization were satisfactory and the meal could be used to replace corn in baby chick diets. The highest percent of manioc residue meal in any diet tested was 47.5%.

Klein (22) found that manioc meal could be used up to 10% of chicks' diets with satisfactory results. Vogt's (46) findings also indicated a level of 10% manioc meal was satisfactory in chick diets, but levels of 20% or more depressed gains. A level of 20% manioc meal was satisfactory in layer diets.

Soares, et al. (39) studied dried manioc meal and wheat middlings as carbohydrate substitutes for part of the ground corn in chicks' diets. Chicks fed diets with 10% of the corn replaced by manioc meal had the most rapid daily gain.

In N.E. Brazil, Carvalho, et al. (8) reported satisfactory growth of chicks on rations in which wheat bran was substituted with a mixture of cowpea meal, manioc scraping meal and corn. They stated, however, that although the growth rate was adequate the incidence of perosis was higher with this ration due to the low choline content. Thus, the addition of choline was recommended.

In a study on milk production (7) manioc residue meal was used to replace the cereal grain up to 41.5% of the ration. There was a linear decrease in milk production with each higher level of manioc meal used in the diet (7.78 kg down to 7.34 kg of milk per day). However, net income was highest with the highest level of manioc in the diet and lowest where no manioc meal was used.

A trial was conducted with dairy cattle in Costa Rica (32) to evaluate the value of manioc leaf meal in replacement of alfalfa meal. The results were that milk production increased when alfalfa was fed and production decreased consistently when they were given manioc leaf meal. While the difference was not statistically significant, the authors state the production was 90 to 96% of the production with alfalfa. Therefore, it was concluded that the leaf meal was a valuable feeding product and an economical replacement for alfalfa leaf meal.

There are only a few research reports available pertaining to the use of manioc in cattle finishing trials, and the number of animals per test have been limited also. However, the results are good and there appears to be real potential for the increased use of manioc in cattle rations in tropical areas. In one experiment conducted in N.E. Brazil, cattle fed on a diet with manioc as 75% of the diet gained as fast or faster than four other treatments (33). Good gains have been achieved with manioc and cottonseed meal in a study conducted in Minas Gerais, Brazil (2).

Magalhães (24) working at the Federal University of Vicosa reported that young calves 10-14 months old (ave. wt. 183 kg.) gained faster and were more efficient in feed consumption when fed ground manioc (roots, stem, leaves) plus cottonseed meal than on molasses plus cottonseed meal. The daily gain in weight was 858g and 758g respectively as compared to 62g/day on pasture only.

In 1966, Holstein and Zebu cattle were fed for 112 days at the Cedro Experiment Station in Vitória de Santo Antão, Pernambuco, Brazil, fresh manioc roots at the rate of 0.5 kg per 100 kg of body weight along with free-choice of fresh and ensiled cane tops. The conclusion was that there was no stimulatory effect of feeding the manioc roots (14).

Only one feeding trial has been conducted in N.E. Brazil on the economic possibility of feeding fresh manioc roots to beefcattle (14). No test work has been conducted with fresh stems and leaves nor ensiled forms to beefcattle. The team did not observe any research work underway in N.E. Brazil on feeding processed or raw manioc products to swine, chickens, or dairy cattle.

In all of N.E. Brazil in 1971 only limited feeding of manioc to livestock by commercial operators was taking place. Near Recife, this team observed one Holstein herd, numbering 110 animals of all ages, being fed manioc. The only market product of this herd was purebred, registered cows and bulls. No market milk was sold, hence the management was not interested in maximizing milk yields at economic rates. Fresh manioc roots were fed at an estimated rate of 1.5 - 2.0 kg per milking cow per day. In addition an estimated rate of 5.0 kg of manioc silage was fed per milk cow per day. Composition of the silage was approximately 30 percent chopped roots, 69 percent stems and leaves and 1 percent salt. The stems and leaves of the manioc plants were harvested six months after planting, then cut again four months later and four months later the entire plant was harvested. Estimated yield of roots only at the end of the 14-month period was 20 tons per hectare. Pasture was also provided along with the manioc.

No attempt has been made to determine if the addition of fresh manioc roots and manioc silage increased milk flow over pasture grass alone. It was not known if a decrease in yield of roots resulted from two cuttings of the stems and leaves.

The manager stated that, "Prior to feeding manioc several years ago, 5.0 kg of protein concentrate feed was fed per cow per day, and average milk produced per animal was 11 liters." In 1971, with grass and manioc the estimated average production was 6 liters. If these results are factual, shifting of the herd from concentrate feeds to manioc resulted in a loss of Cr$ 3.00 of milk for each Cr$ 1.00 saved in feed cost, without considering the additional labor cost and loss of manioc production and preparation or loss of roots from harvesting stems and leaves.

On a number of feed lots in the Fortaleza area several are reportedly using manioc roots as a supplement to pasture grasses. No attempt has been made to assess differencies in weight gains of feeding manioc in addition to grass. Hence, no economic analysis of cost-benefits can be made.

One restaurant owner in Recife is feeding raw manioc roots in his hog operation. The pigs between 60 and 120 days of age are fed protein concentrate plus manioc. From 120-210 days they are fed table scraps from the restaurant plus up to 50 percent manioc roots. Since there is no controlled feeding the benefit of manioc cannot be assessed but the owner stated that "the entire operation was profitable". The hogs weighed 95-105 kg at the end of 210 days.

C. MANIOC PROCESSING

In the Northeast there are thousands of family-size flour mills. Often these are wholly or partially enclosed units containing a few crude pieces of machinery and other equipment such as a cylindrical or U-shaped washer, a motor driven rasper, a hand-operated screw press and a wood-fired oven with a flat-metal plate over which the heated drying meal is raked. It is estimated that, of manioc growers processing less than three hectares of manioc, about 30% own such plants and that most of their neighbors either use the equipment without charge or provide the owner with a certain amount of final product (up to 25%). When the grower has more than 3 hectares planted in manioc, it is generally not profitable for him to operate under barter conditions. Instead, he may own a larger flour mill and hire personnel from nearby to help with peeling, washing, macerating, pressing, gelatinizing, drying and bagging the meal or sell it to an operator who will handle the product.

In even the largest flour mills in the N.E., a great proportion of the work is performed manually. The machinery in these processing plants is often hand operated (as the filter press shown in Fig. 2) or driven by a small power motor (as the rasper shown in Fig. 3). These two units are capable of handling 300 kg (filter press) and 800 kg per hour (rasper) respectively.

The most intricate apparatus observed in actual use in a farinha factory was a power driven rasper capable of macerating 1500 kg of roots per hour. This machine (Fig. 4) sold for Cr$ 1200 and, when equipped with a vibrating screening table, for Cr$ 1600. A small power driven uniformizing (grinding) machine (Fig. 5) capable of handling 300 kg of product per hour sold for Cr$ 500.

The Banco do Nordeste do Brasil S/A (Mandioca, Aspectos da Cultura e da Indústria) made a detailed study of manioc processing (see Flow Diagram I). The Bank concluded that many of the smaller plants with primitive machinery were just as successful, if not more so, than some of the larger installations with more modern equipment. Further, they found that failure of plants resulted when (1) the flour plant was improperly located, (2) the water supply was inadequate, (3) a continuous and dependable supply of roots was lacking, (4) the machinery was

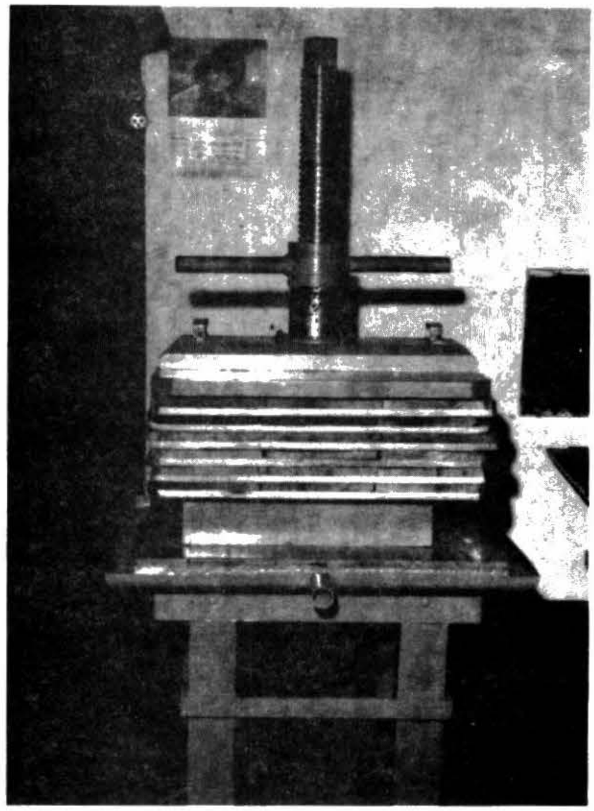


FIG. 2. Hand operator filter for pressing fruit water from macerated roots. This filter is capable of pressing 300 kg per hour and is built to sell at Cr$ 500.

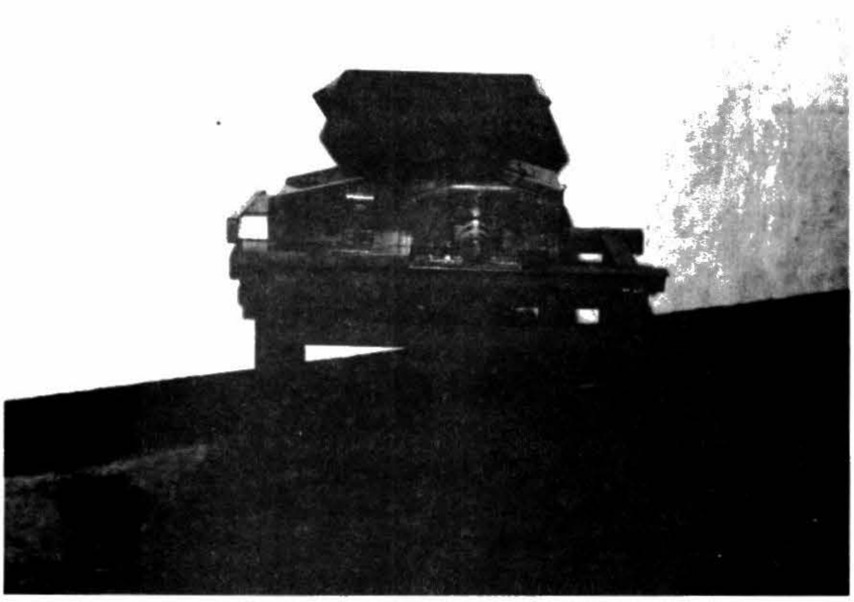


FIG. 3. Power driven rasper with hand operated "feeding block". This machine has a capacity of 800 kg per hour and sells for Cr$ 300.

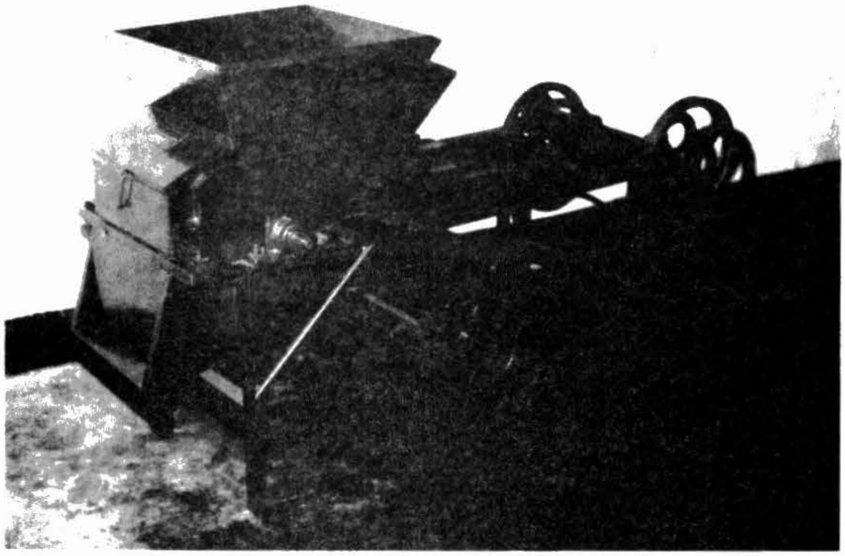


FIG. 4. Large motorized rasper and two power driven feeding blocks. This machine macerates 1500 kg of roots per hour and sells for Cr$ 1200. When a vibrating table is added to catch the rasped roots from the trough (lower left), the complete device costs Cr$ 1600.

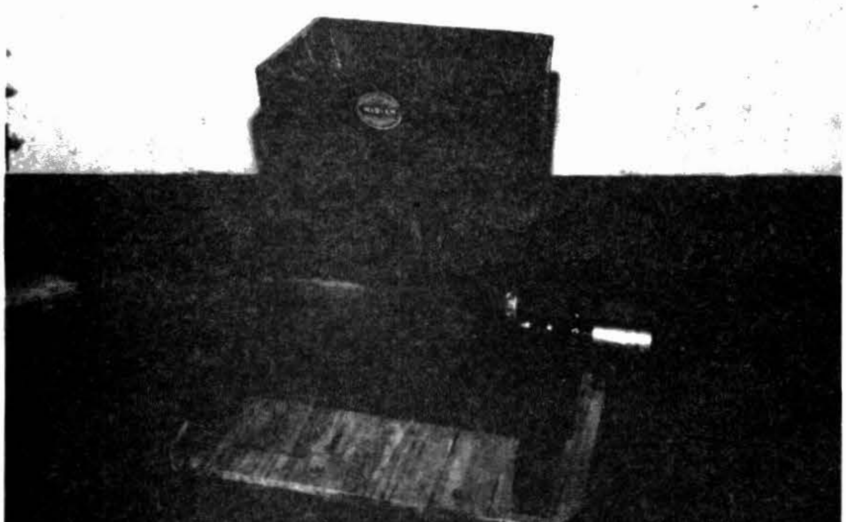
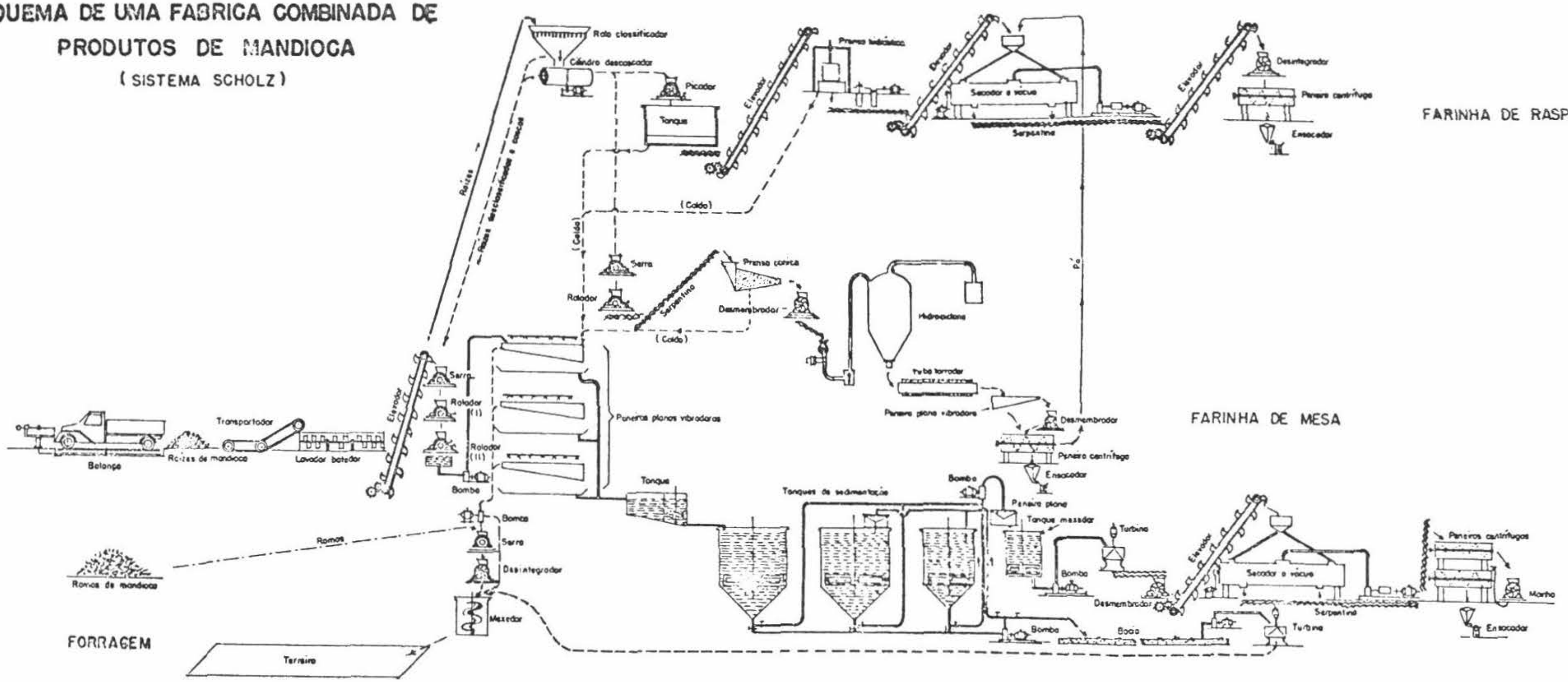


FIG. 5. Motor driven Uniformizer (grinder). This machine handles 300 kg per hour and sells for Cr$ 500.

FLUXOGRAMA 1

# ESQUEMA DE UMA FABRICA COMBINADA DE PRODUTOS DE MANDIOCA

(SISTEMA SCHOLZ)



inefficient, (5) labor was uneconomical, and (6) technical supervision was poor.

On the other hand, the Bank was willing to entertain loans for the installation of a big plant if it met the following conditions:

(1) Ability to produce flour of good and reproducible quality.

(2) Capacity of at least 10 tons/day.

(3) Ownership of at least 200 hectares of mandioca.

(4) Worked continuously (day and night).

(5) Leaves were utilized as forage.

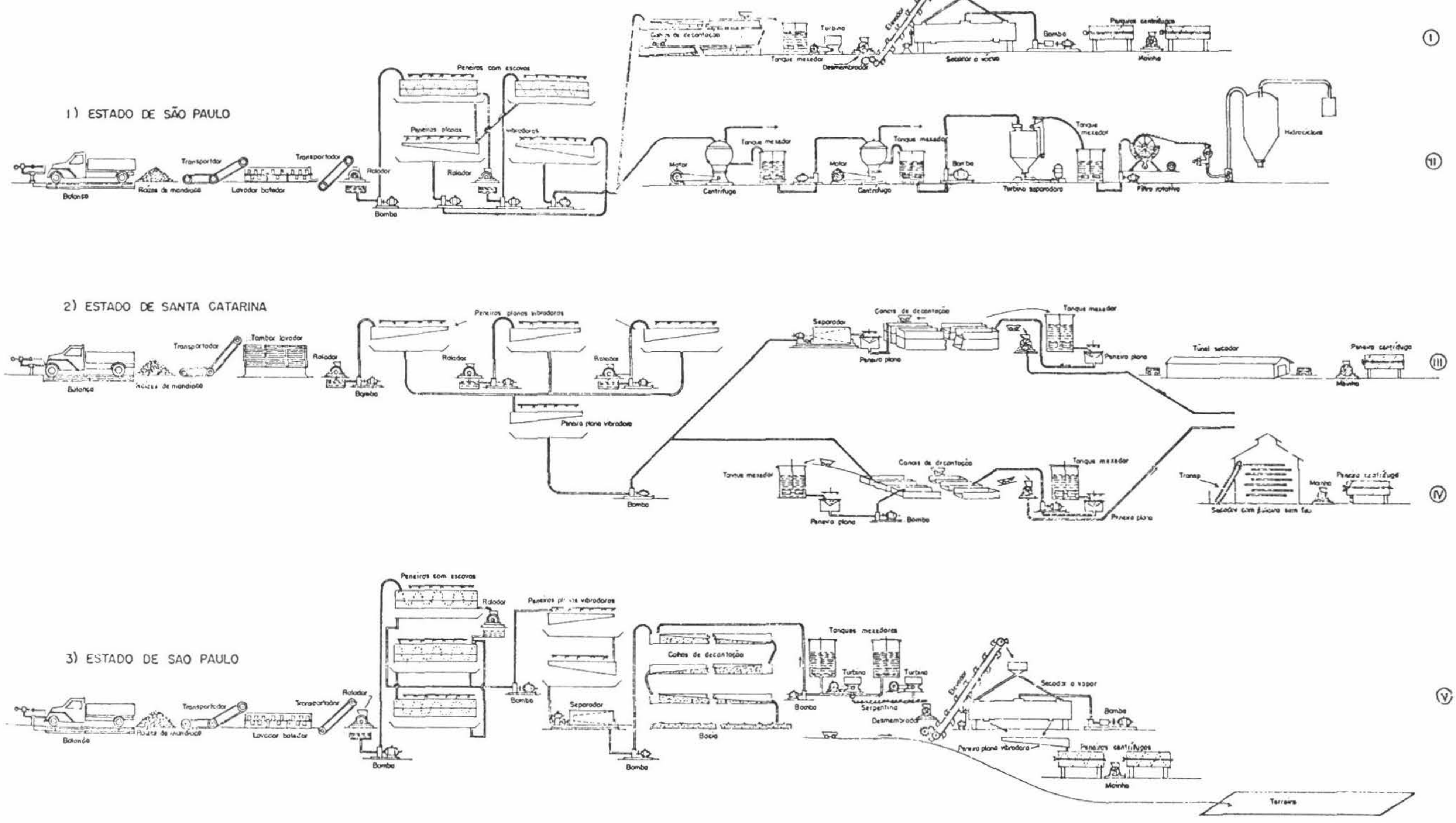
No plant visited by the Bank met these criteria.

In N.E. Brazil very little starch is produced and no large processing plants are actively producing tapioca at the present time. Within the past decade, plants were constructed and equipped at Glória do Goitá, Crato, Fortaleza, and Sapé - the last named at a cost of Cr$ 3,000,000. None of these plants was able to produce starch commercially. All lacked the technical skill necessary to satisfactorily extract starch from roots and/or chips. In several, either the planning of the plant or the equipment (or both) was inadequate. An adequate and continuous supply of roots (or chips) and of good water was unavailable for two of the plants. Economic considerations were such that one of the plants did not even open.

As was done for flour, the Banco do Nordeste do Brasil S/A analyzed the operations of starch factories in the South, the Central South and the Northeast (see Flow Diagram II). As a result of these studies, they observed a number of errors in operations and/or machinery and recommended solutions to circumvent these mistakes when planning future

FLUXOGRAMA II

# ESQUEMAS DE FÁBRICAS DE AMIDO EXISTENTES NO BRASIL



installations (see Table 7).

Despite the comprehensive list of uses of manioc shown in Table 8 the industrial position of Brazilian starch (tapioca) began to deteriorate following World War II. Several factors were responsible. Among these the following should be cited:

(1) Most of the tapioca starch imports were cut off during the war and the potato starch industry was able to partially replace unavailable root and tuber starches;

(2) Importation of tapioca starch of good quality from Indonesia and Thailand resumed following World War II;

(3) Properties of dextrins, derived waxy starches, oxidized starches, cross-linked starches, starch phosphates, pregelatinized starches, and acid-modified starches produced from corn, cereals and potatoes were able to satisfactorily substitute for tapioca and;

(4) Brazilian technology did not keep pace with world starch technology.

The current popularity in Europe of manioc chips as an animal feed has led to a slight "turn-around" in demand in recent years. In 1969 the export of chips and flour amounted to approximately 55,000 metric tons. Yet, if one compares export tonnage with total production (i.e., 30,073,000 metric tons), he finds that this represents less than 0.6% of production (on a dry weight basis).

TABLE 7. Errors in Operations and/or Machinery and Recommended Solutions.

| ERRORS | RECOMMENDED SOLUTIONS |
|---|---|
| **MACHINERY OR OPERATIONS** | |
| Washer - drum or wooden basin type | Washer should have non-rusting metallic axles and beaters and the bottom should be of perforated metal. Should make efficient use of water. |
| Rasper - of small diameter and light weight. Block badly positioned or adjusted for roots. Saws thick and easily rusted. | Large diameter cylinder with heavy grating and reinforced blocks. Blocks adjustable to fit perimeter of rasper. Nonrusting circular saws placed ahead of graters. |
| Pulp screens - brush screens cause deterioration, loss of starch and are difficult to clean. | Screens should be flat and cleanable with water jets. There should be a second series of finer screens. |
| Mechanical sedimentation - turbines and separators are expensive to operate and lose starch. | Chemical treatment of starch milk. A series of special sedimentation tanks allows good separation. Water should be renewed twice. |
| Settling chambers - require much labor and higher maintenance costs. | Automatic decanting with minimal labor gives product with better reproducibility, desired color and viscosity. |
| Final turbines - (centrifuges) common type is obsolete and requires too much labor | Automatic discharge types permit self-cleaning and freeing of product impurities. |
| Drying - temperatures above 50$^{o}$ C cause dextrinization of starch. | Control temperature and ventilation and any type of dryer can be used. |
| **RESIDUE PREPARATION** | |
| A. Washed mass and meal - technique of preparation is expensive. | Mix washed mass with dried, ground manioc stems to facilitate pressing and drying. |

TABLE 7. (continued)

| RESIDUE PREPARATION | |
|---|---|
| B. Decanting station water - wasted in all Brazilian factories; yet contains the proteins and up to 2% of root starch. | Catch in tanks outside the factory. When added to meals (A), can be used as forage. Flocculate protein by chemical treatments. |

Recommendations above are sufficient to provide ideas of improved techniques. There are other errors caused by oxidations or undesired fermentation that should be eliminated.

Source: Banco do Nordeste do Brasil S/A. Aspectos da Cultura e da Industria da Mandioca, Fortaleza, Ceará. May 1967.

TABLE 8. Uses of Manioc.

Root

Raw (peeled young root or aipim)
Cooked, boiled, or baked for table use (95% of production)
Shredded and mixed with coconut, oil, peanuts, greens, spices
Dried (called kokonte, gaplek, etc., in Africa)
Grated and fermented, added palm oil, fried (called gari in Africa)
Fried slices (French frying, etc.)
Residue (fiber or bagasse) from starch extractives
Chipped or sliced for livestock (dairy and beef cattle, goats, pigs, chickens)
Root peel livestock feed
Broken roots
Pellets (landang)
Juice (tucupay or cassaripo)

Leaf

Used as a vegetable
Cooked
Soup ingredient
Fortified food supplement
Livestock feed
Ensilage
Dried - Used in animal feed fortification
Leaf meal. Feed concentrates

Stalk (stems)

Cuttings for plant propagation
Grafting material for increased yields
Mixes with leaves as ruminant feed
Dried. Used in animal feed concentrate

Chips (raspa or gaplek)

Ground into meal or flour
Extracted for starch
Fermented (fufu) - meat, oil, vegetables, spices and water added
Animal feeds
Pellets

TABLE 8. (continued)

Meal or flour (farinha da raspa)

Bakeries, pastries, alimentary pastes (macaroni)
Boiled in soups, sauces, gravies, etc.
Bread extender
Porridge (gruel)
Fortified flour (with wheat, soya, peanut, vitamins, etc.)
Improved bread flour (with added calcium stearyl lactate as a conditioner)
Protein enriched flour (fish protein concentrate, soybean isolate, caseim, etc.)
Selected amino acid enriched flour (lysine, tryptophane, methionine, etc.)
Fermented (Eba)
Glues
Adhesives

Starch

Baked goods
Desserts - puddings, pie fillings (sagu)
Infant foods
Confections (molding of cast candies)
Thickening agents (synthetic jellies)
Bodying agents (caramels)
Dusting agents (chewing gum)
Fermented beverages (beer)
Textile sizing and strengthening
Laundry starch
Paper sizing and bonding
Gums (envelopes, postage stamps, gummed tapes)
Dextrins (bonding pigment to paper; preventing glass checking)
Adhesives (cardboard, plywood, and veneer)
Glues and pastes
Blended with peanut flour, nonfat milk solids, vitamins
Enriched with FPC, soy, corn, rice (pasta)
Alcohol
Acetone
Glucose
Oil well drilling

Modified starches

Precooked soluble starches - "instant" puddings
Thin - boiling starches (candy manufacture)
Oxidized starches
Improved starches (ex: added glyceryl monostearate as a binding agent)

D. PRODUCTION COSTS/RETURNS IN N.E. BRAZIL

Agriculture in the Northeast can be characterized as poor. The traditional crops grown by farmers, manioc, beans and corns, exhibit low yields relative to Southern Brazil. These crops are well known to farmers and it appears that land and labor resources are being allocated efficiently as demonstrated in this report. For example, even though these three crops are grown to some extent in all municipios of the Northeast extensive production of any one of them appears to be concentrated in particular municipios where soil and moisture conditions are appropriate for a given crop. Excessive rainfall excludes corn as a major crop from the Mata region, since it cannot be properly dried there, while lack of rainfall in some areas makes the land suitable for manioc only. In areas of intermediate rainfall the better soils are usually reserved for corn and beans though changes in relative prices for these crops can alter this pattern of land use. The estimates of long-run comparative returns presented below support these observations.

From the above it follows that increases in production cannot be expected from a simple re-allocation of land and labor resources but rather from the adoption of new techniques that increase output per unit of land and labor. Section III (pages 93- 99) elaborates on possible programs to effect these increases in supply.

The characteristic of poor but economically efficient is apparent in the processing of the manioc root into flour. This process takes place in numerous small plants that can, again considering the state of the arts, produce flour cheaper than large industrial processing plants. Large scale processing has been attempted in the Northeast but as far as could be ascertained all efforts have met with failure and at present all large plants are closed. This situation is to be contrasted to the one in the South where large mechanized plants are in operation. The capital/labor price ratio is such in the Northeast that even though absolute wages are lower than in the South, the Northeast is in a comparative disadvantage to the South in large scale processing. The capital price concept being used includes the cost of the know-how to operate the mechanized plants.

Fertilizer Response - The use of fertilizers in Northeast Brazil agriculture is not widespread. The heaviest use of fertilizers is made in sugarcane fields and it is doubtful that any fertilizer would be used even there in the absence of the subsidy to Northeastern sugar production. The question whether little or no fertilizer is used in manioc production because of unfavorable product/factor price ratios or because of unresponsiveness of manioc yields to fertilizer applications needs to be investigated.

Several studies of fertilizer response have been conducted in the Northeast and some results are presented in Tables 9 to 11. The interpretation of the results is not easy since statistical tests are usually not reported and in some cases the amount of fertilizer applied is not reported.

The results for the States of Paraiba (Table 9) and Pernambuco (Table 10), taken at face value, imply a positive response of manioc yields to the application of the three major elements, the response being largest for phosphate. A comparison of the incremental yield valued at Cr$ 100 per ton of roots (which is below the current high

TABLE 9. Fertilizer Response of Manioc in the Coastal Table Lands, Santa Rita, Estado da Paraiba, 1968-1969.

| NUTRIENT AND DOSES | YIELD (TON/HA) | INCREMENTAL YIELD | VALUE CR$ | COST OF FERTILIZER CR$ |
|---|---|---|---|---|
| N | | | | |
| 0 | 12.0 | - | | |
| 80 | 14.1 | 2.1 | 210 | 89 |
| 160 | 15.9 | 1.8 | 180 | 89 |
| $P_2O_5$ | | | | |
| 0 | 4.9 | - | | |
| 60 | 17.8 | 12.9 | 1290 | 67.50 |
| 120 | 19.3 | 1.5 | 150 | 67.50 |
| $K_2O$ | | | | |
| 0 | 13.7 | - | | |
| 60 | 14.0 | .3 | 30 | 35.50 |
| 120 | 14.3 | .3 | 30 | 35.50 |

NOTES: Nutrient doses are in kilograms per hectare. The incremental yield was valued at a price of Cr$ 100.00 per ton which is below the current market price for roots at the farm. Fertilizer costs are based on current (July 1971) fertilizer prices in the Recife market. No statistical significance tests reported.

Source: Luiza Gomes da Silva, "Adubacão NPK na Cultura da Mandioca em Tabuleiro Costeiro no Estado da Paraiba," Pesquisas Agropecuárias no Nordeste, SUDENE, Recife (Janeiro-Junho 1970), pp. 73-74.

TABLE 10. Fertilizer Response of Manioc in Araripe, Western Pernambuco, 1964.

| NUTRIENT AND DOSES | YIELD (TONS/HA) | INCREMENTAL YIELD | VALUE OF INCREMENT CR$ | COST OF FERTILIZER CR$ |
|---|---|---|---|---|
| N | | | | |
| 0 | 18.6 | - | | |
| 30 | 19.5 | .9 | 90 | 33.4 |
| 60 | 17.2 | -2.3 | -230 | 33.4 |
| $P_2O_5$ | | | | |
| 0 | 14.6 | - | | |
| 60 | 21.1 | 6.5 | 650 | 67.50 |
| 120 | 19.6 | -1.5 | -150 | 67.50 |
| $K_2O$ | | | | |
| 0 | 15.2 | | | |
| 60 | 20.0 | 4.8 | 480 | 35.5 |
| 120 | 20.2 | .2 | 20 | 35.5 |

NOTE: See notes Table 7.

Source: Instituto de Pesquisas Agronômicas, Relatório Anual 1965, Secretaria da Agricultura, Indústria e Comércio, Estado de Pernambuco, Recife, p. 54.

market price of Cr$ 140 to Cr$ 180) with the cost of fertilizer at current Recife market prices (Table 12) shows in addition that fertilizer applications would in most cases be profitable (an exception being potassium in Paraiba and higher doses of all three elements in Pernambuco). The results for Ceará, however, (Table 11) report no significant difference in yields with or without fertilization.

More recent results at the Araripina Experiment Station in Western Pernambuco show also a positive response to fertilizer which resulted in an average increase of 5.2 tons of roots per hectare, over unfertilized, unlimed plots. The addition of 3 tons of Calcium per hectare increased yields additionally by 2.5 tons, for a total increase of 7.7 tons. The significance tests which were reported in this experiment show, however, that the increase in yields would have to be 8.9 tons to reach the 5% significance level. Were this increase in yields of 7.7 tons a certain result, it still does not follow that it would be profitable to use fertilizer at available prices for manioc roots. Table 13 shows the value of the incremental output, and compares it with the cost of fertilizer required to obtain it, at manioc root prices ranging from 5 to 20 centavos per kilo. It is apparent that root prices have to be 6 or more centavos to pay for the cost of fertilizer.

The uncertainty surrounding the results with fertilizer lends support to the position taken by some members of IPA to the effect that fertilizer recommendations to manioc farmers should not be made without additional data. If anything, these results point to the need for more fertilizer response tests conducted under conditions that will enable one to draw firmer conclusions as to the impact of fertilization on manioc production.

TABLE 11. Fertilizer Response of Manioc in Pentecoste, Ceara, 1968.

| TREATMENT | YIELD (TONS/HA) |
|---|---|
| NPK | 11.8 |
| NP | 11.8 |
| NK | 11.8 |
| N | 10.3 |
| PK | 10.1 |
| P | 9.0 |
| K | 10.1 |

NOTE: Fertilizer doses not specified. The F statistic for variance between treatments was .739 and not significant at the 5% level.

Source: Escola de Agronomia, Universidade Federal do Ceará, Relatório Técnico 1968, Fortaleza, Ceará, pp. 36-37.

TABLE 12. Fertilizer Cost, Recife, Brazil, 1971.

| BASIC INGREDIENTS | CR$/TON | | CR$/KG |
|---|---|---|---|
| Ammonium Sulphate (20% N) | 223.20 | | 1.12 |
| Urea (45% N) | 427.80 | | 0.95 |
| Superphosphate (20% $P_2O_5$) | 224.80 | | 1.11 |
| Triple superphosphate (45% $P_2O_5$) | 502.10 | | 1.12 |
| Diamononium Phosphate (18:46:0) | 612.30 | $P_2O_5$<br>N | 1.12<br>0.61 |
| Muriate of Potash (60% $K_2O$) | 354.90 | | 0.59 |
| Potassium Sulphate (50% $K_2O$) | 461.60 | | 0.92 |
| <u>Mixed Fertilizers</u> | | | |
| 5:39;9 | 589.54 | | |
| 10-30-20 | 646.10 | | |

Source: Profertil - Emprêsa de Produtos Quimicos e Fertilizantes S.A. - Recife, Brazil - July, 1971.

TABLE 13. Increases in Net Income from Fertilizer and Lime Applications at Different Prices for Manioc Roots, N.E. Brazil, 1971.

| SALES PRICE PER KILOGRAM IN CENTAVOS | GAIN IN YIELDS | TOTAL VALUE ADDED | LESS FERTILIZER COST AND LIME[1] Cr$ | Cr$ GAIN PER TON |
|---|---|---|---|---|
| | (ton) | | | |
| 5 | 7.7 | 385 | 446 | -61 |
| 6 | 7.7 | 462 | 446 | 16 |
| 7 | 7.7 | 539 | 446 | 93 |
| 8 | 7.7 | 616 | 446 | 170 |
| 9 | 7.7 | 693 | 446 | 247 |
| 10 | 7.7 | 770 | 446 | 324 |
| 11 | 7.7 | 847 | 446 | 401 |
| 12 | 7.7 | 924 | 446 | 478 |
| 13 | 7.7 | 1001 | 446 | 555 |
| 14 | 7.7 | 1078 | 446 | 632 |
| 15 | 7.7 | 1155 | 446 | 709 |
| 16 | 7.7 | 1232 | 446 | 786 |
| 17 | 7.7 | 1309 | 446 | 863 |
| 18 | 7.7 | 1386 | 446 | 940 |
| 19 | 7.7 | 1463 | 446 | 1017 |
| 20 | 7.7 | 1540 | 446 | 1094 |

[1]Includes transportation cost for average distance of 200 kilometers

Manioc Production Cost - Since no fertilizers are used in the production of manioc in the N.E., production costs are essentially labor expense and land rent. Four different studies are available on labor inputs. One study considered labor costs in all three rainfall zones located in the Northeast (Table 14). These data indicate that yields are nearly the same regardless of rainfall. However, personal interviews indicated that yields declined as rainfall declined below a certain minimum. One possible explanation for this apparent discrepancy is that in areas with more rainfall the better land is used for crops other than manioc while in dryer areas where, for example, corn and beans cannot grow, manioc is the only crop and, hence, is not relegated to poorer soils. All things being equal, of course, manioc yields would be expected to decrease with decreasing rainfall.

Existing wage rates for agriculture workers in July 1971 were found to vary considerably in the Northeast. Wages were higher near the more urban cities along the coast and declined as one went into the interior. The range in payment was from 2.0 to 5.0 Cr$ per man day plus meals in some cases. The most frequently mentioned wage rate was 3-4 Cr$ plus meals. Hence, a wage of 3.5 Cr$ per man day is used in the following cost analysis.

Average man days shown in Table 15 was used. To each item of production the 3.5 Cr$ cost was applied. The result, as shown in Table 16, was a total cost of 488.7 Cr$ per hectare or 42.5 Cr$ per ton. In addition to labor cost a land rent or return to land was computed on the basis of one hectare worth Cr$ 300. An interest change was calculated on cost items except for harvest. Harvest is performed immediately prior to the sale of the crop so no investment time is required.

TABLE 14. Labor Input in Manioc Production in Northeastern Brazil by Zones (Man Days Per Hectare).

| | ZONE 1 (More than 750mm Rainfall) | | ZONE 2 (500-750mm Rainfall) | | ZONE 3 (Less than 500mm Rainfall) | |
|---|---|---|---|---|---|---|
| | Mean | (Range) | Mean | (Range) | Mean | (Range) |
| Land Preparation | 17 | ( 9-25) | 20 | (12-28) | 13 | (7-19) |
| Planting | 33 | (20-47) | 31 | (17-45) | 13 | (7-20) |
| Cultivation | 27 | (17-37) | 18 | (11-25) | 10 | (5-15) |
| Harvest | 16 | (10-22) | 21 | (10-32) | 14 | (9-19) |
| TOTAL: | 93 | | 90 | | 50 | |
| Yield per hectare in tons | 9.6 | (5.1-14.1) | 10.8 | (7.6-14.1) | 10.2 | (7.3-13.2) |

Source: Banco do Nordeste do Brasil, S.A., Departamento Rural, Informacões Básicas para Elaboracao de Orcamentos Agrícolas no Nordeste, Fortaleza, Ceará (Junho, 1969), pp 117-118, 130-131, 139-140.

TABLE 15. Labor Input in Manioc Production in Three N.E. States in Man Days Per Hectare.

| | ALAGOAS (10.7 tons) | MARANHAO (10 tons) | SERGIPE (13.9 tons) | AVERAGE (11.5 tons) |
|---|---|---|---|---|
| Land Preparation | 39 | 22 | 25.6 | 28.9 |
| Planting | 10 | 15 | 24.3 | 16.3 |
| Cultivation | 34 | 20 | 100.0 | 51.3 |
| Harvest | 13 | 12 | 15.5 | 13.5 |
| TOTAL: | 96 | 69 | 165.4 | 110.0 |

Source: Convênio SUDENE/Estado de Alagoas, Secretaria da Agricultura, Indústria e Comércio, 1968/69.

Department of Secretary of Agricultural Economics, Agricultural Department of Mananhão, 1967.

Convênio SUDENE/Estado de Sergipe, CONDESE, 1969.

TABLE 16. Production Costs Per Hectare of Manioc Roots, N.E. Brazil, 1971.

| ITEM | MAN DAYS | COST - Cr$ |
|---|---|---|
| Land Preparation | 28.9 | 101.1 |
| Planting | 16.3 | 57.1 |
| Cultivation | 51.3 | 179.6 |
| Harvest | 13.5 | 47.3 |
| Land Rent or equivalent/hectare | - | 45.0 |
| Interest Charge[a] | | 58.6 |
| TOTAL CHARGES | - | 488.7 |
| Cost per Ton (11.5 tons/ha) (Cr$) | | 42.5 |
| Cost per Kilogram (centavos) | | 4.25 |

[a]Land preparation and planting charged for 18 months at 13%, cultivation cost computed for 12 months, land rent computed for an average of 9 months.

The cost of production was calculated for an average yield of 11.5 tons per hectare and is shown to be slightly above 4 centavos per kg. (Table 16). Short of estimating a production function for manioc (and then obtaining its corresponding dual cost function) little can be said about variations in average costs when yields per hectare vary. However, if we assume that only labor inputs for harvest change, when yields per hectare change (exogenously), we can perform the exercise of calculating costs per kilo under alternative yields per hectare. The results of this exercise are reported in Table 17 and show that average costs per kilo drop by 70% when yields increase from 6 to 24 tons.

Costs of Production for Alternative Crops: Corn and Beans - Corn and beans are two traditional crops in the Northeast that compete with manioc for land and labor. Some information is available on physical inputs into the production of these crops and is reported in Tables 18 to 20. Table 18 shows the inputs and costs (at July 1971 prevailing wages) for the joint production of corn and beans, normally grown in association. The other two tables report only the inputs for corn (Table 19) and beans (Table 20) separately but it should be kept in mind that some of the operations are done concurrently (e.g., cultivation). The major input is clearly labor, averaging 110 man days when the separate corn and bean labor inputs are added or 107 according to the joint production figures (Tables 18, 19, and 20, respectively). Either one of these approaches places the total costs per hectare around Cr$ 450 (July 1971 wage rates) for the joint production of 1 ton of corn and either 0.375 or 0.7 tons of beans depending on which figures one uses.

TABLE 17. Manioc Production per Hectare and Projected Total Cost and Average Cost Per Kilogram, N.E. Brazil, 1971.

| TONS | TOTAL COST[1] | COST PER UNIT | |
|---|---|---|---|
| | | TON | KILOGRAM |
| 6 | 466.0 | 77.7 | 7.77 |
| 8 | 474.2 | 59.3 | 5.93 |
| 10 | 482.4 | 48.2 | 4.82 |
| 12 | 490.6 | 40.9 | 4.09 |
| 14 | 498.8 | 35.6 | 3.56 |
| 16 | 507.0 | 31.7 | 3.17 |
| 18 | 515.2 | 28.6 | 2.86 |
| 20 | 523.4 | 26.2 | 2.62 |
| 22 | 531.6 | 24.2 | 2.42 |
| 24 | 539.8 | 22.5 | 2.25 |

[1]Includes labor for land preparation, planting, cultivation, harvest at Cr$ 3.50 per man/day, land rent or equivalent and interest costs on labor costs and rent.

TABLE 18. Inputs and Estimated Costs of Jointly Producing 1000 kg of Corn and 375 kg of Beans Per Hectare, N.E. Brazil, 1966.

| ITEM | AVE. MAN DAYS | ANIMAL DAYS | IMPLEMENT DAYS | COST-Cr$ |
|---|---|---|---|---|
| Land Preparation | 38 | 6 | 6[c] | 145.0[e] |
| Planting | 8 | - | - | 23.0 |
| Cultivation | 40 | - | - | 140.0 |
| Harvest | 21 | 2 | 2[d] | 77.5 |
| Land Rent or equivalent/ha[a] | - | - | - | 45.0 |
| Interest Charge[b] | - | - | - | 13.5 |
| TOTAL | 107 | 8 | 8 | 444.0 |

[a] Land rent computed for an average of 6 months.

[b] Land preparation, planting and cultivation charged for 4 months at 13 percent.

[c] Cultivator

[d] Ox Cart

[e] Man days computed at 3.5 Cr$ per day, animal and implements computed at 2.0 Cr$ per day (July 1971 prices).

Source: Man, Animal, Implement Needs and Yields Obtained

from: Insumos Físicos para Culturas Selecionadas na Região Nordeste do Brasil, 1965, 1966, Ministério da Agricultura, Departamento Econômico, Rio de Janeiro, Janeiro, 1967, p. 26.

TABLE 19. Labor Inputs in Corn Production in Northeastern Brazil, by Zones. (Man Days Per Hectare)

| | ZONE I (More than 750 mm Rainfall) | | ZONE II (500 - 750 mm Rainfall) | | ZONE III (Less than 500 mm Rainfall) | |
|---|---|---|---|---|---|---|
| | Mean | (Range) | Mean | (Range) | Mean | (Range) |
| Land Preparation | 14 | (10-18) | 12 | ( 7-17) | 12 | ( 8-16) |
| Planting | 7 | ( 5-11) | 5 | ( 3- 8) | 5 | ( 3- 8) |
| Cultivation | 11 | ( 7-15) | 13 | ( 6-20) | 12 | ( 8-16) |
| Harvest | 6 | ( 4- 9) | 7 | ( 3-11) | 5 | ( 3- 7) |
| Handling | 13 | ( 9-18) | 18 | (10-26) | 12 | ( 6-18) |
| TOTAL | 51 | | 55 | | 46 | |
| Yield per hectare in kg | 11 96 | (10-54-1338) | 817 | (554-1188) | 1000 | (582-1418) |

Source: Banco do Nordeste do Brasil, S.A. Departamento Rural, Informacões Básicas para Elaboracão de Orcamentos Agrícolas no Nordeste, Fortaleza, Ceará (Junho, 1969), pp. 119 - 132 - 140.

TABLE 20. Labor Inputs in Bean Production in Northeastern Brazil, by Zones (Man Days Per Hectare)

| | ZONE I (More than 750 mm Rainfall) | | ZONE II (500 - 750 mm Rainfall) | | ZONE III (Less than 500 mm Rainfall) | |
|---|---|---|---|---|---|---|
| | Mean | (Range) | Mean | (Range) | Mean | (Range) |
| Land Preparation | 15 | ( 8-21) | 16 | ( 8-24) | 22 | (18-26) |
| Planting | 11 | ( 6-18) | 7 | ( 5-10) | 5 | ( 3- 9) |
| Cultivation | 15 | ( 7-23) | 13 | ( 6-20) | 21 | (14-28) |
| Harvest | 9 | ( 4-14) | 6 | ( 4- 9) | 14 | ( 8-20) |
| Handling | 8 | ( 4-12) | 8 | ( 4-14) | 7 | ( 4-11) |
| TOTAL | 58 | | 50 | | 69 | |
| Yield per Hectare in kilos | 860 | (466-1254) | 627 | (415-929) | 605 | (502-706) |

Note: Feijão Mulatinho in Zones I and II and Feijão Macassar in Zone III.

Source: Banco do Nordeste do Brasil, S.A., Departamento Rural, Informacões Básicas para Elaboracão de Orcamentos Agrícolas no Nordeste, Fortaleza, Ceará (Junho, 1969), pp. 114 - 128 - 138.

This total cost figure is very close to that found for manioc which is about Cr$ 500 per hectare. What the net returns are will then depend on yields and prices for manioc and its competitors, corn and beans. Using an average yield of 11 tons of manioc roots per hectare and a farm price of only Cr$ 100 per ton, the net returns per hectare would be around Cr$ 600. Corn and bean prices at the farm level are not available for July 1971. Working back from the Recife wholesale prices in July 1971, of Cr$ 1.00 per kilo of beans and 0.50 per kilo of corn, one can arrive at a farm price by deducting 10% for assembly cost and allowing transportation for an average distance of 200 kilometers at Cr$ 35 per ton (Fig. 6). The estimated farm level prices would then be Cr$ 0.86 and 0.41 per kilo of beans and corn respectively.

At the above farm prices, the gross returns for corn would be Cr$ 410 and for beans either Cr$ 602 or 322 depending on the yield used. Gross returns would vary then from a low of Cr$ 732 to Cr$ 1,012 implying a net return (after deducting costs of Cr$ 450 per hectare) of Cr$ 282 or Cr$ 562. Even using the higher yield for beans of 0.7 tons per hectare (average yield in Pernambuco for the 1960-1969 period was only 0.5 tons) net returns per hectare appear, at the current prices, to be higher in manioc than in corn and beans. If the higher actual root price of 14 or 15 centavos per kilo prevailing in July 1971 had been used, the net returns in manioc would have been even higher. Manioc, at the current prices appears to have a much higher return per hectare than corn and beans. This finding would explain (in part at least) the large increase in planting of manioc that has occurred over the last few months.

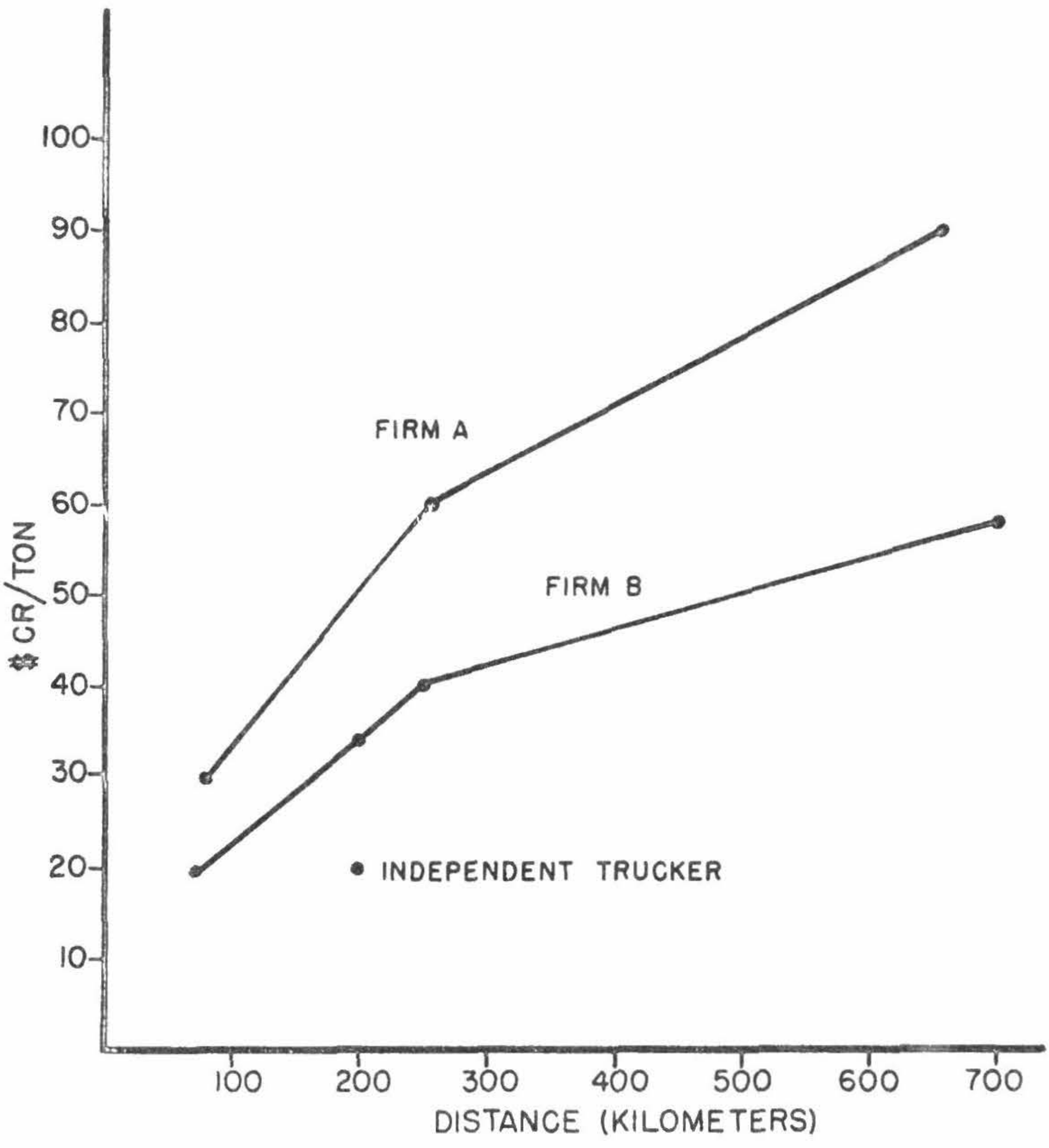



FIG. 6. Relationship of per ton trucking rates with distance, Northeast Brazil, 1971.

Source: Commercial trucking firms, Recife, July, 1971.

The comparative returns over a longer time period are examined in the next section.

Comparative Returns Over a Longer Time Period - The net returns estimated above for manioc and corn-beans using current market prices showed manioc to be more profitable than corn and beans. At one point in time, however, factor-product prices need not reflect their long run equilibrium.

To gain some insight as to the comparative returns over time, data from the State of Pernambuco will be used covering the period 1960-1969. Farm level data are not available so an implicit price was calculated by dividing value of production by quantity produced. These implicit farm prices both in nominal and real terms appear in Tables 21 and 22. The ten-year mean prices per ton for manioc, corn and beans are, respectively, 61, 240 and 712 Cr$ (1970 Cruzeiros).

The ten-year average yields are 10.3 tons for manioc, 0.8 tons for corn and 0.5 tons for beans (13).

The average gross value of production per hectare will then be (again in 1970 Cr$) 629 Cr$ for manioc and 547 Cr$ for corn and beans. Cost of production (in 1970 Cr$) are 415 for manioc and 370 for corn and beans. Net returns then will be 214 and 177 Cr$ per hectare for manioc and corn and beans. These figures are not directly comparable since manioc production takes 1 1/2 or more years and during that period two corn-bean crops can be grown. On a yearly basis, net returns per hectare in manioc will be approximately Cr$ 140, which can be compared directly with the net returns of Cr$ 177 per year for corn-beans.

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TABLE 21. Implicit Farm Prices for Selected Commodities in Pernambuco in Nominal Terms.

| | MANIOC (per ton roots) | CORN (per 60 kg/bag) | BEANS (per 60 kg/bag) |
|---|---|---|---|
| 1960 | 1.29 | .35 | 1.21 |
| 1961 | 2.73 | .61 | 1.73 |
| 1962 | 5.21 | 1.40 | 3.97 |
| 1963 | 5.96 | 1.63 | 4.21 |
| 1964 | 8.92 | 3.07 | 7.18 |
| 1965 | 17.2 | 4.33 | 14.4 |
| 1966 | 29.9 | 6.38 | 18.6 |
| 1967 | 36.0 | 5.99 | 15.4 |
| 1968 | 38.9 | 7.12 | 19.6 |
| 1969 | 47.9 | 11.06 | 40.8 |

Source: Banco do Nordeste do Brasil, S.A. Departamento Rural, Informacões Básicas para Elaboracão de Orcamentos Agrícolas no Nordeste, Fortaleza, Ceará (Junho, 1969).

TABLE 22. Implicit Real Farm Prices for Selected Commodities (1970 Cr$).

| | MANIOC (per ton roots) | CORN (per 60 kg/bag) | BEANS (per 60 kg/bag) |
|---|---|---|---|
| 1960 | 46.1 | 12.5 | 43.2 |
| 1961 | 70.0 | 15.6 | 44.3 |
| 1962 | 88.3 | 23.7 | 67.3 |
| 1963 | 57.3 | 15.7 | 40.5 |
| 1964 | 44.8 | 15.4 | 36.1 |
| 1965 | 55.1 | 13.9 | 46.1 |
| 1966 | 69.7 | 14.9 | 43.4 |
| 1967 | 65.2 | 10.8 | 27.9 |
| 1968 | 56.8 | 10.4 | 28.6 |
| 1969 | 57.8 | 13.4 | 49.3 |
| Average | 61.1 | 14.4 | 42.7 |

Source: Banco do Nordeste do Brasil, S.A. Departamento Rural, Informacões Básicas para Elaboracão de Orcamentos Agricolas no Nordeste, Fortaleza, Ceará (Junho, 1969).

This differential of close to 27% in favor of corn and beans reflects the average situation over a ten-year period and is consistent with the observation that, other things being equal, manioc tends to be relegated to the less fertile land.

E. MARKETING

Domestic - The rural manioc market is basically barter exchange. The farmer harvests his crop at periodic intervals throughout the year, eats some of it and sells some of it to a neighborhood miller or processes it in his own mill. Payment for the use of the mill is usually made in kind. His surplus is usually sold to a neighborhood store (or in open street markets). The neighborhood store owner may in turn sell it to a local trucker, or transports it in his own vehicle or pays a trucker to haul it to an urban market. Here, it may be sold again to a local wholesaler or directly to retailers from open market places. Frequently, when a farmer sells to a local store, it amounts to a type of bartering in which the farmer receives merchandise (food and/or clothing) needed for his family. There are apparently a number of various type assemblers including millers paid in kind (0.5 - 3.0 T/yr.[1]), miller-buyers (1-120 T/yr.), small assemblers (3-75 T/yr.), public market buyers (50-600 T/yr.), trucker-buyers (20-150 T/yr.) and large itinerant assemblers (100-1,200 T/yr.). However, no one single channel from farmer to consumer is dominant. The estimate of the total number of the various types of assemblers in the Recife area

[1]Figures in parentheses refer to the quantity of product (in metric tons) handled by each class of assembler annually.

alone is 435, the majority of which are small operators. Generally, the smaller ones sell to large itinerant assemblers or trucker-buyers both of which supply the wholesalers and many of the retailers on a constant supply basis (29).

Generally, the price obtained by the farmer from one of these assemblers is rather constant among buyers in a general area for a given day since several buyers are present at the local store or convergence center market. What is lacking is any source of market news for the farmer and thus prices between these centers can vary greatly on any given day by more or less than transportation costs.

Transportation and information costs are usually too great for the local farmer who usually has no money and must sell directly to the trucker-buyer or the local owner. He cannot afford to enter into any type of agreement and pay in kind for shipment since he has no outlet in urban areas and no one to look after his own welfare. Market news outlets and extension programs aimed at keeping the farmer informed should greatly alleviate this problem. Marketing cooperatives could render a valuable service to small producers.

Neither radio nor newspapers serve as a significant source of market information for farmers and assemblers. Virtually all market information in the manioc assembly system is by word of mouth. Farmers have to rely on buyers for price information. The large number of buyers provides some influence on competition, however.

There is considerable variation in the quality of manioc flour. As a result, retail prices may vary by 300 percent and farmer flour prices vary accordingly.

Under present storage technology and conditions little flour is stored. Retailers and wholesalers buy fresh flour at weekly or semi-monthly intervals. Storage is performed by leaving the roots in the ground.

The major form of transportation by assemblers is by animal back since less than 10 percent of the roads are paved.

Though official grades and standards exist they are not being utilized. The team, in visiting several local markets in the N.E., observed a large range in quality of product (manioc flour) and, accordingly, prices. In the same market area prices ranged from 0.50 to 2.00 Cr$/kilo for flour ranging from very poor to excellent quality.

The CARE[1] project at Recife was visited by the team and this appears to be an excellent means of increasing competition and provides a more direct route from farmer to consumer. More establishments of this nature should be encouraged and financed by federal and state governments.

Exports - The volume and values of manioc flour, chips, starch, tapioca and aipim exported from Brazil during the 1955 to 1969 period are shown in Tables 23 and 24. The various volumes have fluctuated considerably during the time period, due to changes in supply, and demand. Table 25 shows exports of manioc products by country of destination for some recent years.

From the three products exported in volume in 1969 (flour, chips and starch), chips were selected for further analysis. For the

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[1] An urban marketing center designed to bring together the producer and the retailer and/or wholesaler; thus, eliminating many intermediate handlers (29).

TABLE 23. Brazilian Exports of Manioc Products 1955 - 1969.

QUANTITY (Tons)

| YEAR | FLOUR | CHIPS | STARCH | TAPIOCA | AIPIM |
|---|---|---|---|---|---|
| 1955 | 30803 | - | - | - | - |
| 1956 | 22673 | - | - | - | - |
| 1957 | 7155 | - | - | - | - |
| 1958 | 404 | - | 13031 | - | - |
| 1959 | 2824 | - | 23041 | - | - |
| 1960 | 28333 | 2508 | 35258 | 846 | - |
| 1961 | 11429 | 5381 | 16555 | 1217 | - |
| 1962 | 527 | 1692 | 8507 | 1197 | - |
| 1963 | 524 | 6825 | 2814 | 914 | - |
| 1964 | 36030 | 9487 | 17522 | 1200 | 3203 |
| 1965 | 23514 | 21561 | 31911 | 1083 | 41801 |
| 1966 | 24270 | 19583 | 16088 | - | 27052 |
| 1967 | 81 | 13932 | 5558 | - | - |
| 1968 | 754 | 7887 | 7172 | - | - |
| 1969 | 46598 | 9611 | 10354 | - | - |

Source: Instituto Brasileiro de Geografia e Estatistica, Anuário Estatístico do Brasil (various issues).

TABLE 24. Value of Brazilian Exports of Manioc Products, 1955-1969, in Thousands of US Dollars.

| YEAR | FLOUR | CHIPS | STARCH | TAPIOCA | AIPIM | TOTAL |
|---|---|---|---|---|---|---|
| 1955 | 3135 | - | - | - | - | 3135 |
| 1956 | 2301 | - | - | - | - | 2301 |
| 1957 | 1072 | - | - | - | - | 1072 |
| 1958 | 42 | - | 1275 | - | - | 1317 |
| 1959 | 128 | - | 1866 | - | - | 1994 |
| 1960 | 1184 | 140 | 2675 | 129 | - | 4128 |
| 1961 | 504 | 299 | 1338 | 199 | - | 2340 |
| 1962 | 66 | 94 | 781 | 196 | - | 1137 |
| 1963 | 58 | 256 | 295 | 171 | - | 780 |
| 1964 | 1387 | 380 | 1149 | 204 | 125 | 3243 |
| 1965 | 982 | 974 | 2122 | 189 | 1877 | 6144 |
| 1966 | 1159 | 1029 | 1393 | - | 1318 | 4899 |
| 1967 | 9 | 839 | 558 | - | - | 1406 |
| 1968 | 79 | 510 | 648 | - | - | 1237 |
| 1969 | 2015 | 476 | 863 | - | - | 3354 |

Source: Instituto Brasileiro de Geografia e Estatistica, Anuario Estatistico do Brasil (various issues).

TABLE 25. Brazilian Exports of Manioc Products by Country of Destination, Selected Years.

| PRODUCT | COUNTRY | TONS | US$ 1000 |
|---|---|---|---|
| | 1 9 6 4 | | |
| Manioc Roots | Germany | 3203 | 125 |
| Flour | Germany | 35036 | 1305 |
| | U.S.A. | 18 | 2 |
| | Portugal | 74 | 6 |
| | Uruguay | 902 | 74 |
| | | 36030 | 1387 |
| Chips | Germany | 7605 | 298 |
| | Belgium-Luxemburg | 150 | 6 |
| | Canada | 54 | 1 |
| | U.S.A. | 1678 | 74 |
| Starch | Germany | 700 | 48 |
| | Canada | 496 | 32 |
| | U.S.A. | 15971 | 1043 |
| | France | 40 | 3 |
| | Guatemala | 20 | 1 |
| | Italy | 6 | 1 |
| | Netherlands | 179 | 12 |
| | U.K. | 110 | 8 |
| Tapioca | Belgium-Luxemburg | 15 | 2 |
| | Canada | 102 | 19 |
| | Spain | 135 | 23 |
| | U.S.A. | 918 | 153 |
| | Portugal | 5 | 1 |
| | Switzerland | 20 | 4 |
| | Uruguay | 6 | 1 |
| | 1 9 6 5 | | |
| Manioc | Germany | 36670 | 1646 |
| | Hungary | 944 | 46 |
| | Netherlands | 2036 | 84 |
| | Switzerland | 2150 | 101 |
| Flour | Germany | 23088 | 953 |
| | U.S.A. | 40 | 4 |
| | Italy | 1 | - |
| | Portugal | 25 | 2 |
| | Uruguay | 359 | 23 |

TABLE 25. (continued)

| PRODUCT | COUNTRY | TONS | US$ 1000 |
|---|---|---|---|
| Chips | Germany | 1954 | 86 |
| | Canada | 1941 | 89 |
| | U.S.A. | 15667 | 705 |
| | Switzerland | 2000 | 94 |
| Starch | Germany | 8300 | 332 |
| | Canada | 432 | 30 |
| | Denmark | 250 | 14 |
| | U.S.A. | 22287 | 1706 |
| | Netherlands | 142 | 11 |
| | Peru | 500 | 29 |
| Tapioca | Belgium-Luxemburg | 36 | 6 |
| | Canada | 65 | 12 |
| | Spain | 129 | 22 |
| | U.S.A. | 805 | 139 |
| | Mexico | 22 | 4 |
| | Portugal | 7 | 1 |
| | Switzerland | 20 | 4 |
| | 1 9 6 7 | | |
| Manioc | Germany | 267 | 15 |
| | U.S.A. | 167 | 10 |
| | Netherlands | 287 | 16 |
| Flour | Germany | - | - |
| | Bolivia | - | - |
| | U.S.A. | 22 | 3 |
| | Portugal | 29 | 3 |
| | Uruguay | 28 | 3 |
| Chips | Belgium-Luxemburg | 100 | 6 |
| | Canada | 1090 | 66 |
| | U.S.A. | 12531 | 753 |
| | France | 5 | - |
| | Netherlands | 200 | 12 |
| | U.K. | 5 | - |
| Starch | Germany | 200 | 20 |
| | Canada | 160 | 16 |
| | U.S.A. | 5108 | 513 |
| | Netherlands | 90 | 9 |

TABLE 25. (continued)

| PRODUCT | COUNTRY | TONS | US$ 1000 |
|---|---|---|---|
| Tapioca | Canada | 107 | 22 |
| | Spain | 74 | 13 |
| | U.S.A. | 823 | 172 |
| | Mexico | 11 | 3 |
| | Switzerland | 10 | 8 |
| | 1968 | | |
| Flour | Germany | - | - |
| | U.S.A. | 43 | 5 |
| | Portugal | 48 | 3 |
| | Uruguay | 668 | 70 |
| Chips | Canada | 2612 | 165 |
| | U.S.A. | 5275 | 344 |
| Starch | Germany | 200 | 19 |
| | Canada | 800 | 68 |
| | U.S.A. | 5818 | 523 |
| | Netherlands | 131 | 12 |
| | Portugal | 10 | 1 |
| | U.K. | 213 | 24 |
| Sagu | Canada | 23 | 3 |
| | U.S.A. | 18 | 3 |
| | Portugal | 1 | - |
| Tapioca | Canada | 155 | 31 |
| | Spain | 5 | 1 |
| | U.S.A. | 841 | 175 |
| | Portugal | 7 | 2 |
| | Switzerland | 5 | 1 |
| | 1969 | | |
| Manioc | Germany | 33213 | 1417 |
| | Belgium-Luxemburg | 100 | 4 |
| | U.S.A. | 1000 | 46 |
| | France | 100 | 3 |
| | Netherlands | 3612 | 154 |
| | Paraguay | 100 | 4 |

TABLE 25. (continued)

| PRODUCT | COUNTRY | TONS | US$ 1000 |
|---|---|---|---|
| Flour | Germany | 9530 | 397 |
| | Belgium-Luxemburg | 36518 | 1570 |
| | U.S.A. | 46 | 5 |
| | Portugal | 29 | 3 |
| | Uruguay | 474 | 40 |
| Chips | Germany | 549 | 23 |
| | Belgium-Luxemburg | 1000 | 50 |
| | Canada | 1919 | 94 |
| | U.S.A. | 6043 | 304 |
| | Netherlands | 100 | 4 |
| Starch | Argentina | 625 | 47 |
| | Canada | 2809 | 243 |
| | U.S.A. | 6792 | 562 |
| | Netherlands | 128 | 10 |
| Sagu | Canada | 60 | 9 |
| | U.S.A. | 32 | 4 |
| | Mexico | 11 | 2 |
| Tapioca | Canada | 134 | 27 |
| | U.S.A. | 685 | 144 |
| | Mexico | 13 | 2 |
| | Switzerland | 5 | 1 |

Source: IBGE, Anuário Comércio Exterior (various issues).

Note: The figures reported in this table are rounded to the nearest ton and thousands of dollars and hence should not be used to determine price per ton when the quantities involved are small. For example, 1.4 tons appears as 1 ton and 1.6 thousand dollars appears as 2 thousand dollars.

period 1960-1969, the weighed average FOB price was $50.75 per ton (US dollars). In 1969, the FOB price for manioc chips was $49.50 per ton. This was the FOB price from ports in Southern Brazil for 1969 since there were no exports from the Northeast. From 1969 to 1971 the FOB price remained about the same.

Hence, Northeast Brazil is facing a competitive FOB price for manioc chips of approximately US$ 50 per ton. It is shown in Table 26 that the only way for a Northeast processor to compete in the export market is to be able to buy manioc roots delivered to the chipping mill for 6 centavos or less. Cost of production is in the range of 4-6 centavos. Comparison of returns to farmers for the period 1960-1969 indicate that the price of manioc must be slightly over 6 centavos for manioc to be competitive with beans and corn. Hence, it would appear that farmers would produce for a chip factory at 6 cents and could continue to produce at this price. However, the possibility is marginal and such things as a short crop of manioc, a drought, favorable prices for beans and corns would result in shortages of roots to supply the chipping mill. Hence, the projected cost of US$ 3.00 per ton for chipping may be low if the plant were to operate only intermittently.

Price Fluctuations - It has been repeatedly asserted that manioc root and manioc flour prices present wide fluctuations from year to year. These fluctuations are attributed to shifts in the supply curve of manioc due to changing weather conditions and to changes in quantity supplied due to farmer response to price. Since manioc production takes 1 1/2 years or more it is said adjustments to market disequilibria cannot be effected as quickly as in corn or beans.

TABLE 26. Manioc Chip Production, Processing, Handling and Transportation Costs Used to Compute FOB Price, N.E. Brazil, 1971.

| ITEM | COST US DOLLARS PER TON | |
|---|---|---|
| Manioc Roots delivered to Chipping Plant | 11.43 | |
| (a) 6 centavos/kg | | |
| Cost of Chipping and Drying[1] | 300 | |
| | | $14.43 |
| Manioc Chip Yields 35% of root weight | X 2.86 | |
| Cost of Chips at the Mill | | $41.27 |
| Transportation Cost from Mill to Port (80 km)[2] | 3.70 | |
| Port Costs, including taxes (500 ton lots)[3] | 2.20 | |
| FOB Cost Recife | | $47.17 |

[1]Obtained from Summary Report - Cultivation of Manioc in Brazil, ITA Project, Pernambuco, Barry Critides, July 28, 1966.

[2]Abstracted from Figure 6.

[3]Obtained from Port authority, Recife, Brazil, July 14, 1971.

The empirical evidence shows that, if anything, manioc root prices at the farm level fluctuate less than corn and bean prices, as measured by the respective coefficient of variation. Table 27 (calculated from values in Table 28) also shows, however, that wholesale prices of manioc flour are subject to larger fluctuations than bean prices, but (roughly) comparable to corn prices. The smaller coefficients of variation at the farm level relative to the wholesale level of manioc and corn are puzzling and cast some doubts on the price series used by the State Government of Pernambuco to value farm output.

Fluctuations in manioc flour prices could be reduced by open trade between the Northeast and the rest of the country since it is unlikely that weather conditions will be adverse both in the South and the N.E. simultaneously. With open trade, prices in the N.E. could not differ from those in the South by more than transportation costs. Though manioc flour is brought into the Northeast area during periods of scarcity, substantial price differentials still exist between the two areas (as of July 1971), even when transportation costs are considered.

Minimum guaranteed prices are in effect for manioc flour but are fixed at such a level (8.95 Cr$ for a 50 kg bag compared to a current market price of 50 Cr$ or more) that they are ineffective. In any event were the minimum prices effective, they would only serve to set a floor to prices, forcing the government to stock up in the perishable flour, which could not subsequently be used to lessen a price rise in the event of a scarcity, and entailing a loss to consumers who would not benefit from temporarily lower prices.

TABLE 27. Coefficients of Variation of Real Prices of Manioc Root, Corn and Beans at the Recife Market Wholesale Level and at the Farm Level in Pernambuco.

| | WHOLESALE[2] | FARM[1] |
|---|---|---|
| Manioc | 37.5% | 20 % |
| Corn | 34.4% | 24 % |
| Beans | 24.6% | 24.8% |

[1]Farm level price refers to the implicit price obtained by dividing the estimated value of production by the estimated production as reported in the Anuário Estatístico de Pernambuco. Nominal prices were deflated by the General Wholesale Price Index to obtain real prices.

[2]Calculated from values in Table 28.

TABLE 28. Real Wholesale Prices of Selected Commodities in the Recife Market (1970 - Cruzeiros)

| YEAR | MANIOC FLOUR (50 kg) | CORN (60 kg) | BEANS (60 kg) |
|---|---|---|---|
| 1960 | 12.6 | 12.7 | 68.6 |
| 1961 | 18.1 | 14.4 | 52.3 |
| 1962 | 51.2 | 28.3 | 92.8 |
| 1963 | 45.1 | 18.4 | 59.8 |
| 1964 | 24.4 | 15.4 | 50.5 |
| 1965 | 36.0 | 22.0 | 68.9 |
| 1966 | 42.9 | 16.8 | 79.0 |
| 1967 | 35.1 | 32.2 | 43.6 |
| 1968 | 24.4 | 12.3 | 41.6 |
| 1969 | 26.1 | 14.5 | 70.4 |
| Average | 31.6 | 18.7 | 62.8 |
| Per Kilogram | 63 cents | 31 cents | 1.05 cents |

Source: Departamento Estadual de Estatística, Anuário Estatístico de Pernambuco.

Estado de Pernambuco, Secretaria da Agricultura, Indústria e Comércio, 1965 and 1969.

Note: Nominal prices deflated by the General Wholesale Price Index - 1970 = 100.0

F. RESEARCH ACTIVITIES

Project Activity in N.E. - Currently the research activities on manioc are limited primarily to variety trials. There have been some experiments conducted in the past with the use of manioc in beef and chicken rations but none are active at the present time.

In the area of food technology, some research is being initiated at the Instituto de Nutricão, Federal University of Pernambuco (UFPe.) where an interesting research program on manioc fortification is in progress under the direction of Dr. Álvaro V. de Mello with the assistance of four technicians and four students. In addition, the Institution gives a 6-week course annually for medical doctors specializing in nutrition and public health. This course is now in its ninth year and is attracting students not only from the N.E. but from South Brazil, Peru and other Latin American countries.

This team has not been able to learn of any present or previous economic research on manioc. It appears that research in this particular area is completely lacking.

Manpower - The manpower available for research appears adequate in total number in the plant and animal sciences. However, most of the scientists have only B.S. degrees, a few have M.S. degrees, but none hold the Ph.D. degree. Furthermore, the wide diversity of crops and animals demanding attention tends to dilute the effectiveness of the available personnel.

The Federal University of Pernambuco has several staff members in nutritional science. Their level of training except for Drs. Mello and Chaves is similar to that of other fields, consisting essentially of

B.S. degrees. An advanced degree program has just gotten underway.

There is no one connected with the State or Federal Experiment Stations or Colleges in the area of Agricultural Economics. The Economists encountered in the team's visits were usually associated with the Banco Nacional do Brasil or some other commercial organizations.

# SECTION II

## DIAGNOSIS OF KEY PROBLEMS LIMITING MANIOC PRODUCTION, PROCESSING, UTILIZATION AND MARKETING

### A. AGRONOMIC

The primary agronomic factors limiting an increase in manioc production in N.E. Brazil appear to be: (1) low soil fertility, (2) low retention of nutrients by the soil, (3) low water retention, and (4) unequal distribution of rainfall.

However, in addition to these very basic problems which affect the production of all crops, there are specific problems directly affecting manioc. For example, because of varietal adaptability, a variety that does well in one location may do poorly in another. Also, varietal characteristics must be maintained through rouging and superior propagation material has to be selected on the basis of size, location on the stalk, and freedom from disease. In addition, the method of storage of propagation material is important as is the method of planting (horizontal, inclined, or vertical). Of further importance are plant density, as related to soil fertility and moisture, and planting depths. Other important considerations with manioc culture include disease and insect control, identification of disease resistant varieties, and proper storage of roots.

Manioc culture in N.E. Brazil is adversely affected by soils that are naturally low in fertility, soils that are poor in water and nutrient holding capacities, and other serious production problems that limit yields. Even so, manioc is still produced in large quantities. The obvious explanation for this is that the farmer produces manioc because he is so thoroughly familiar with its culture. Thus, it would appear that the major limiting factors on expansion of production are both agronomic and economic. The agronomic problem is one of increasing yields/ha and is associated with proper soil and water management, variety selection and cultural practices including time of planting, and fertilizer response. The economic problem is one of finding the most efficient way to increase yields. Land availability is not a problem because hundreds of thousands of hectares are available for manioc production in addition to the nearly one million hectares already under cultivation.

Although fertilizer costs in N.E. Brazil are nearly the same as for similar analysis in South Central Brazil, the cost of transportation to the user is much higher. This raises the true cost of fertilizer to the N.E. farmer and makes fertilizer usage less competitive with other areas.

B. UTILIZATION

Human Food - A key problem in expanding the utilization of manioc as a human food is the rather limited selection of consumer products derived from this crop. As pointed out before, manioc is consumed primarily as flour made by grinding the entire root after peeling and this flour is not very palatable. Thus, as individual incomes increase, the tendency is to substitute some other form of starch such as Irish potatoes in the diet, and manioc flour is left to be consumed by the poor.

If new products were developed from manioc, consumption could be increased even though such increases might be small in comparison with present consumption figures. Such products might include canned or dried slices or chunks for inclusion in soups or mashed as are potatoes, or prepared as French fried slices, and fried chips. Other possibilities would be manioc macaroni and manioc paste or powder for use in soup mixtures, etc. The American Irish potato industry succeeded in getting more people to eat more potatoes by introducing new products and new methods of preparation. Why can not this same approach be applied to manioc?

Animal Feed - The key problems limiting the utilization of manioc as an animal feed appear to be associated with a lack of sufficient technical and economic information. Although some research has been conducted in Brazil which indicates that manioc can be utilized by various species of animals (beef, dairy, pigs, chickens), the precise quantity, type of product (chips, leaf meal, flour, etc.), quality of product and comparative cost have not been clearly defined. Yet, as pointed out before, many European countries are utilizing manioc in feeds and the quantity is specified. Why then does not Brazil, the largest producer of manioc in the world, use it as an animal feed? The answer to this question appears to be economic. It costs too much for the feed (roots) and also, there is very little demand for mixed feed in the livestock industry. However, in many areas of N.E. Brazil cattle suffer from a lack of food during the dry season. Could not manioc be processed by the farmer as food for his animals during periods of nutritional stress? We believe he could if sufficient research information were obtained to determine how to prepare it, store it and the quantity required when fed with protein supplement and silage. This team found some farmers who fed manioc to livestock either as fresh roots or as a mixture of roots, stem and leaves that were dried and ground to a fine powder. Research being conducted in Colombia at CIAT has shown that palatability can be a problem with manioc in animal feeds, but insufficient research has been conducted in Brazil to determine if this problem can be overcome.

As for the economic aspects, it appears to be rather expensive at present to feed manioc to livestock if the comparison is made only with grass feeding. However, price differentials have a way of changing as production costs decrease. It seems that too often the research scientist is concerned more with the present cost of a product than with the potential the product has. Considerably more basic information on the merits and limitations of manioc in animal diets must be obtained before the true economics of the situation can be determined.

C. PROCESSING

The production of satisfactory chips, flour and starch depends upon good quality control. The water used for washing the roots, rinsing the wet ground pulp, and extracting and rinsing the starch not only needs to be available but must be in adequate amounts, clear,portable and free of metallic impurities. The machinery and other equipment should be of sanitary design, not subject to rusting and easy to clean. The mechanics of operation should be such that the raw material and product are handled quickly so that there is little opportunity for deterioration or spoilage. The final product should be dried well and uniformly so that it has the desired appearance and color, a low bacterial, mold and yeast content, and be free from any sour or offensive odor. In addition it should have a neutral pH (6.3 - 6.5), low moisture content (11-13%), low ash (0.2%) and high viscosity.

Most plant operators appear to have little knowledge of the causes of spoilage. Often the water used for washing the roots contained metal impurities that caused the meal to be discolored. In some plants, large piles of peels were allowed to remain in the peeling rooms for long periods of time where they attracted insects and rodents and developed foul odors. Fragments of roots often were allowed to remain in the corners of troughs and the housing of rasping drums and, when the equipment was not cleaned regularly, developed putrid odors. Occasionally, press cloths were used again and again without rinsing or replacing. Also, in some plants, the ash from the ovens was permitted to blow into the drying product resulting in discoloration and grittiness of the product. When drying techniques and/or storage conditions were unsatisfactory, the meal picked up moisture and developed musty odors. Good products were obtained only when all steps in processing were handled properly.

The working class Brazilian in the N.E. has developed a fairly inelastic order of food needs as follows:

1. Coffee-sugar (must be considered together as a single need).
2. Manioc
3. Beans
4. Rice
5. Corn
6. Meat (carne de sol or carne de charque).
7. Chicken

To this would be added fruits and vegetables in season. When times in the Sertão are good, fresh meat, milk and cheese are added. In times of drought, these several foods disappear from the diet in reverse order. Chicken, dried meat, corn, and rice are sacrificed. In very severe times, even beans are removed so that no protein at all remains in the diet. Then the family is left on a "long ride downhill". Unless outside support (technical as well as economic) is provided, the family suffers from malnutrition and eventually, from starvation due to protein depletion.

The National Institute for Social Security (INPS) which reaches about 1/3 of the Brazilian population (ca 38 million people) concluded that malnutrition was the primary cause of the need for medical attention by large numbers of the population. INPS had considered distributing a high protein flour mix but AID (see Frazao file letter) pointed out the difficulties in getting people of low economic and educational level to use mixes that were outside their normal food patterns and suggested, instead, the possibility of INPS distributing fortified manioc.

The problem of introducing a fortified manioc so that it can be used in mass feeding is a very difficult one.

Such a fortified product would need to consist of the flour plus adequate amounts of a suitable source of protein such as fish protein concentrate (FPC), soy protein isolate (SPI), torulopsis (food yeast) or casein. In addition, it would be desirable to insure the presence of amino acids such as lysine, methionine and tryptophan, and vitamins such as A, B1, B2, and C.

A project on the enrichment of manioc is now underway and is jointly sponsored by the Ministry of Health and AID. At the meeting at the Ministry of Health in Rio de Janeiro, July 19-20, 1971, preliminary results of feeding trials (rats) were compared but no decision has been made as to the best way to proceed with human feeding trials.

There is no record of the number of flour mills in Brazil but a very conservative estimate would indicate that some 150,000 - 200,000 such establishments exist in the country and that of these, at least 60,000 - 80,000 are in the N.E.[1] It would be a practical impossibility to attempt to fortify manioc at each plant. If there were a central distribution point or if the flour were reprocessed before it reached the consumer it would be possible to intervene at that point and add the fortificant at the time of uniformizing. Most flours are produced, processed, marketed and utilized in toto in the immediate microarea. At the moment, the most practical intervention point is with the reprocessor of those flours that are handled in commercial marketing channels. While this by-passes the people who may most need protein and vitamin fortification, it reaches many in the urban areas and, by example, in time could filter down to the less informed and those in rural areas and in the more remote regions of the country.

In the United States, Extension specialists visit and consult with food plant operators and help them in planning, designing and operating their plants. No such guidance appeared to be available in N.E. Brazil.

One of the key problems limiting the satisfactory processing of manioc in N.E. Brazil is the lack of trained technicians for planning, installing and operating modern plants. The team visited several modern

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[1] According to the Mich. State Univ. Res. Rept. No. 2, p. 9-58 (29), the average processing volume of mills was 551 kg/day. Since Anuario Estatístico do Brasil, 1970, indicated Brazil produced 30,073,943 metric tons, N.E. Brazil's share would be 43.3% of that total.

plants in N.E. Brazil all of which had ceased operation from 2-7 years ago. The reasons given for closing were (1) inadequate design resulting in ashing or smoking of the product, (2) inability to get the various phases (starch, chips, flour) of the operation functioning properly, (3) poor or inadequate water supply and (4) inadequate supply of manioc roots.

The U.S. Food for Peace Program, administered jointly by the AID and the Department of Agriculture, helped Brazil start one of the largest and most successful school lunch programs in the world. Food for Peace commodities in 1968 helped feed nine million children in more than 90,000 schools. Commodities amounting to 105,000 tons worth $7 million were sent by the U.S. but purchases by Brazilian State and federal agencies came to $55 million and, in addition, many commercial firms donated equipment and supplies. Brazilians everywhere have enthusiastically taken part in the program and by 1969 it had broadened to such an extent that it involved not only parents in all the States and territories but also national officials, State governors, mayors, educators, private businessmen and the military (44). As a result of this program local warehouse and transportation facilities have improved and laws and codes have been enacted to improve planning and training, to increase purchases of foods, and to provide serving equipment.

Presently, the foods available to the Food for Development Program (which superceded the Food for Peace Program) include bulgar wheat, rolled oats, rolled wheat, nonfat dry milk, liquid butter, wheat-soy blend and corn-soy-milk. In addition to the school lunch program, this agency has a mother/child program and several voluntary agencies such as the Church World Service/Lutheran World Relief (CWS/LWR) have programs that receive food from AID. From the excellent rapport that has already been established between Brazilian governmental agencies and the Food for Development Program, it seems that a very good fortification program could be introduced within this same general framework.

Valid information on the role of manioc can be determined only under controlled conditions and a comprehensive research program in this area is urgently needed. It was our understanding that the Food for Development Program would entertain a planned program from a nutrition group that provided fortification of manioc according to:

1. A planned write-up.
2. Simultaneously testing an adequate fortified manioc and an unfortified control.
3. Selecting two closed communities of 500-1,000 people or separating two approximately similar areas and using one of the two as a control and the other as a test with fortified manioc (one suggestion was to use employees and families in the Zona da Mata working in two sugar mills of approximately the same size) and maintaining control of other items of dietary.
4. Supply control of fortified diets for a period of 2-3 years and clinical examinations of all persons at 3-6 mo. intervals for the effect of diet on health and well-being.
5. Provide records and summary of findings.

Such a project could cost as much as US$ 100-200,000 and would need to be funded by some U.S. agency.

Probably the Nutritional Institute of the Federal University in Recife is the best prepared institution in the N.E. to undertake such a program. However, AID might wish also to consider the Federal University in Minas Gerais (Vicosa).

The only Brazilian agency in a position to try field tests of fortified foods is the Campanha Nacional de Alimentacão Escolar (National Campaign for School Lunch Program or CNAE). This organization has experiments underway using lysine enriched flour and macaroni. Also, CNAE is trying fish protein concentrate (FPC) in flour. Since FPC is not a commonly known product in Brazil, it may meet with consumer resistance.

D. MARKETING

Domestic - In development planning, marketing is often overlooked as a factor and is relegated to a secondary role. However, the marketing system can contribute to development by releasing resources currently tied up in distributing the product. If marketing channels are less torturous and costly to navigate, more goods will flow through them.

The main factors adversely affecting the marketing of manioc in N.E. Brazil are: (1) expensive transportation, (2) system of market outlets, (3) lack of market news service, (4) lack of effective grades and standards, and (5) fluctuating supply.

Transportation affects the marketing of manioc and consumer prices by increasing marketing costs. Transportation (by truck) is relatively expensive per unit of distance in the Northeast compared to south central Brazil. This cost is from 25-50 percent higher, due to poorer roads, less competition by trucks for freight and fewer two-way hauls into and from the interior.

The prevailing tortuous system of market outlets adds to marketing cost. As was pointed out in Section I, there is no one dominant marketing channel for manioc. For example, manioc roots may be processed by the farmer, the flour may be sold to a small assembler, the small assembler in turn may sell to a large assembler, who may sell to a still larger assembler, who may sell to a trucker-buyer who sells to a wholesaler who sells to numerous small rental-type operations. Each of these operations requires a mark up in price to provide a margin of profit.

There is a total lack of market news service at the farmer or flour mill level.[1] Hence prices at this level may vary widely even within small geographical limits. Present market news is by word of mouth with the possibility that the buyer influences prices downward by reporting false price data to the farmer.

In the retail markets individual grades and standards are in active use. However, the grades are not common and personal inspection is necessary to determine the grade. For example, without visual examination, a retailer making his first purchase of manioc from a wholesaler would not know what "good" or "average" flour meant to that particular wholesaler. Federal standards have been determined but are not in general usage.

The fluctuating supply of manioc in N.E. Brazil is widely recognized. As discussed previously, the reasons for this fluctuation are many and varied. From one year to the next, fluctuating supplies of manioc have

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[1] Limited distribution of wholesale prices are made to wholesalers in Fortaleza, Recife and Salvador, See SIMA/PR Secretaria de Agricultura, Ministério da Agricultura, USAID.

caused wholesale prices to more than double in some instances or decline by 50% or more in others.

Because of these wide price fluctuations the prices received by farmers differ from those anticipated. Consequently, an element of uncertainty is introduced into planning of agricultural production and resource misallocation is often the result.

Export Market - Brazil has traditionally been an exporter of manioc products. However, most, if not all, of these products have originated in the South. In some years, the Northeast imports manioc from the South. A few years have occurred in the Northeast when the supply of manioc was great enough to depress prices sufficiently to permit competition in export markets. However, such years have not been frequent enough to sustain the marketing organization required for export trade. Furthermore, as mentioned in Section I, the production cost for manioc roots in the Northeast is near the breakeven point for possible export. Presently, an acquisition cost of 6 centavos per kilo is the maximum that could be paid for profitable export. In the Northeast, the actual cost of production is very near this maximum price. As long as this situation exists, the Northeast will not be able to compete in the export market.

Before the Northeast can enter and maintain an export market, ways must be found to lower production costs. This could be accomplished, of course, by increasing yields for a given amount of input. It is unlikely that increased yields can be obtained with existing methods and techniques. More efficient production will require either genetical improvement of plants and/or different cultural procedures. Further elaboration of this subject will be given in Section III.

E. RESEARCH AND EXTENSION

The major limitations on research and extension are (1) insufficient numbers of personnel, (2) inadequate training, (3) lack of cohesion between the various units of research, teaching and extension and (4) lack of sufficient funds to support an adequate program.

Although many of the Experiment Stations appear to have large staffs, the number at each station is rather small when one considers their responsibilities. They are working in almost all the various disciplines of agriculture and with the majority of the animals and plants produced in N.E. Brazil. In addition, the production of all plants for human or animal consumption involves a great deal of input on soil and water management. N.E. Brazil has only just begun a comprehensive survey and classification of soil types and this program should be enlarged. However, virtually no research has been conducted on soil and water management in relation to manioc and this is highly important. The primary reason for this appears to be a shortage of soil scientist and agronomists.

Peterson _et al_ (37) pointed out that in Brazil as a whole, the need for agronomists is approximately four times as great as the supply. In the N.E. there are four major higher educational institutes which at present are graduating about 80 agronomists annually. The University of Ceará has as its objective the granting of MS degrees in Agricultural Engineering, Animal Science, Plant Science, Economics and Agricultural Technology (Food Processing) by 1975. It is also their objective to have 100% of their instructors with MS degrees and some with Ph.D. degrees by 1975 (personal communication with director of the school).

The majority of the research and extension staff have limited training. Most have only BS degrees but there appears to be a conscientious effort to upgrade the educational level of the professional staff. It is extremely important that advanced training be increased since generally undergraduate degrees do not provide an individual with the knowledge and expertise required to initiate, conduct and evaluate complicated research programs. In addition, this team has found a rather low number of personnel trained, even at the BS level, in agricultural disciplines such as food technology, soils, economics, engineering, entomology, and plant pathology. It appears that generally an individual after obtaining a BS degree is required to work on any and all phases of agriculture. This is not possible if he is expected to generate new ideas and techniques to further agricultural output.

There exists a lack of cohesion between education, research and extension. Agricultural instructors do not usually conduct research, the research personnel are extremely slow in publication of results and there are few publications and these are poorly distributed.

The extension program is separated completely from the research group. Extension programs appear to be built around interviews with researchers who usually have not analyzed their data and are thus giving only opinions. There are few, if any, contacts between extension personnel and the manioc producer or processor. Much of the research published was poorly designed in the beginning resulting in high coefficients of variability and requiring extremely wide differences for significance. This type of publication is almost worthless to the extension specialist and the farmer. Part of this problem may be associated with the low salaries of the professional staff and lack of advancement which provides no incentive for improving publication rate or quality.

Generally, it would appear that federal and state appropriate funds for research are extremely small. The University of Ceará depends heavily on agencies such as AID, Ford Foundation and SUDENE for grant money for conducting research. At this institution, state and federal research personnel and University personnel have been combined providing for more input of research findings into the teaching program than found at other Universities (personal communications with Director).

It appears that research output is not sufficient to support a strong extension program in the N.E. at the present time.

# SECTION III

## SUMMARY AND RECOMMENDED ACTION PROGRAMS FOR ALLEVIATING THOSE FACTORS LIMITING MANIOC PRODUCTION, UTILIZATION, PROCESSING AND MARKETING

Manioc, as one of N.E. Brazil's primary staple crops, represents an inadequately explored commodity for economic development. It is a relatively low cost source of food energy and its various food forms are well established in the consumption habits of the people. Since it is so well accepted by the general public, there are indications that even under conditions of growth and rising per-capita incomes, increases in demand will accompany population growth. Although it has nutritional deficiencies in terms of human and livestock consumption, these can be remedied through breeding and/or fortification of the processed products with protein, amino acids and vitamins.

The European Economic Community (EEC) has shown large increases in the use of manioc as a livestock feed. West Germany, in particular, has substantially increased imports, and if Brazil can place manioc chips in Europe at competitive prices with barley and corn it should be able to capture part of this market. However, feed manufacturers in Europe take such important factors as feeding value, price, and a dependable supply into consideration. Therefore, imported manioc not only must be priced competitively, but it must be high quality. Since consumption of manioc products by the EEC is expected to increase in the future, it is vitally important that any manufacturer of chips in Brazil pay particular attention to quality control if they expect to export to this market.

The potential for expanding output of manioc in N.E. Brazil is restricted only by total demand and prices relative to production costs. At the present time, the scarcity or prices of such production inputs as land and labor appear to offer no real limitation on production expansion. The possibilities for doubling, or even tripling, total output from existing acreage and manpower with nominal increases in capital inputs are not unrealistic at the present time. Generally, limited agronomic technology and market instability are the major factors restricting manioc expansion at this time. Other factors such as relatively high prices of chemicals, machinery, and other capital items and poor processing technology are further impeding output levels.

Manioc's image as a subsistence crop and not as a potentially great agricultural asset probably accounts for its unfavorable developmental climate. Some people in N.E. Brazil are of the opinion that interest in investing in manioc production or processing is low because national credit policies favor other types of agricultural investments. This policy environment apparently fails to recognize the contribution of an exportable surplus to trade balances or the comparative economic advantage of substituting domestic manioc for imported food and feed products. Therefore, favorable national policies are essential to foster research and generate the public and private investment needed for manioc development. Unfortunately, this team did not have the time and, furthermore, the scientific literature available for N.E. Brazil does not provide the data or analyses to indicate the levels and kinds of investment and alternative pay-offs from them.

Until the comparability of data is improved and further economic research is established, the ultimate effects of manioc's potential on food supply, incomes and employment can only be generalized ... in terms of direction of the effect ... which certainly appears to be positive at the present time.

Manioc is apparently relatively free from insect and disease attacks. However, the literature, on a world-wide basis, and from Brazil reveals that certain insect and diseases are sometimes a problem and should not be overlooked in a program on yield improvement.

Viruses can be and are a problem in some areas of the world. Therefore, it is probable that they are present in the varieties used in N.E. Brazil. However, it is not known how many different viruses are involved. It is quite possible that symptoms of certain viruses are masked under the environmental conditions of N.E. Brazil. Thus, their influence on yield reduction would go unobserved and also be difficult to ascertain.

Another aspect of insect and disease infestations which should not be overlooked in the production program is that under certain crop rotation series a definite increase in root rot caused by Phytophora can occur. There is evidence that this occurred on manioc in rotation with rice and peanuts in central Africa which resulted in a severe decrease in yield of all crops in the rotation series.

Post-harvest losses due to microorganisms and physiological degradation presently appear to be a major obstacle in commercial storage, marketing and exporting of manioc, and should not be overlooked in the research program.

The prospect of improving the yield, nutritional value, and disease and insect resistance of manioc appears to be good. The literature shows that cultivars and species with high crude protein (7.2%) content and disease resistance are available. There appears to be no serious problem in obtaining a gene flow from one species or cultivar to another. The morphological classification of manioc cultivars (38), the systematic computer evaluation of the genetic variability existing in the genus Manihot (16) and the work being conducted at CIAT (Colombia), should be an invaluable aid to plant breeders in designing and conducting a strong breeding and selection program when initiated.

Manioc utilization in livestock feeding and production has a great potential. The leaves, roots and by-products of manufacturing can be utilized in feeds for hogs, cattle, chickens, and other livestock. Although most varieties are not at present equal to cereal grains in nutrient content, many have the unique characteristic of high yields and good growth potentials on poor soils and under adverse climatic conditions where cereal grains cannot grow or produce adequately. Recently, a specific cultivar named "Llanera" was reported in Colombia (CIAT) to yield an average of 40 T/ha. under farm conditions with a potential of 100 T/ha. on deep and fertile soils. The analysis of this variety shows a content of 7.2% crude protein, with a quality, expressed by amino acid profile, similar to the protein of common corn- but inferior to Opaque-2 high lysine corn (26). Probably one of the greatest uses of manioc in the future will be in utilizing it in animal feeds and thus making a significant contribution to the energy and protein needs of the human race.

The enhancement of the protein content of manioc, as with other root crops, has lagged far behind similar programs for cereal grains. Yet genetic improvement and fortification have made a start with the interesting research underway at Centro Internacional de Agricultura Tropical (CIAT) in Calí, Colombia, and at the Instituto de Tecnologia Agrícola e Alimentar (ITAA) in Rio de Janeiro.

There is no question that manioc can be processed and fortified to meet the nutritional needs of both humans and animals. However, the engineering technology needed for developing processing plants does not exist in N.E. Brazil at present nor is there a constant supply of quality roots. The manioc processing industry in N.E. Brazil is plagued with inadequate supply, poor utilization of the by-products and lack of highly trained technicians. Land, labor and production technology are generally available but very little has been accomplished in molding these into a cohesive unit with the main objective of providing a constant supply of raw material.

The manioc starch industry, if and when it is started, will also have its problems. Unlike the processors of cereal starches who depend heavily on by-products and modified products, the manioc industry today has very little work underway to produce modified or derived products from manioc and consequently has developed relatively few by-products. Thus, if it is to compete in the world market, it will have to depend heavily on producing starch alone. At present the starch that is produced cannot replace completely the cereal starches used in baking, brewing, etc., but in Brazil considerable monetary gains could be realized if manioc starch could be substituted for cereal starches in these industries. This appears to be feasible for N.E. Brazil since it is being practiced with considerable success in certain other countries. However, in a manioc starch industry, quality control will be a very important factor. Also, a strong marketing organization must be formed and research will be needed on new uses, products and markets. The advantages of manioc starch should be explored instead of trying to compete with the cereal starches for the same markets and uses.

A. RECOMMENDED RESEARCH

The following recommendations for research are presented for consideration. No attempt has been made to delineate the details of the research but only to outline the broad general areas needing attention.

Agronomic Research - It is suggested that an active agronomic research program on manioc is feasible and should be initiated and funded as soon as possible. The primary objective of the program would be to increase yields/ha. economically.

Considerable emphasis should be placed on soil and water management practices required on dry or droughty soils, particularly in the Sertão area and the coastal tabuleiros. Attention should be given to the relationship between essential elements in the soil solution and yield. An over- or undersupply will result in reduced yields. A continuous supply in dilute solution is essential and therefore slow release fertilizers should be incorporated into the research and management program.

Research emphasis should also be placed on determining the soil moisture requirement, soil pH, nutrient requirements, and stand density on the better cultivars in each of the 3 regions of the N.E. The cost of production in terms of planting, weeding, insect and disease control, and harvesting should be tabulated in cooperation with an Economist and efforts made to reduce production cost to the point where manioc can be produced for processing of starch or chips for export and/or utilized in animal feeds.

Since the soils of N.E. Brazil are extremely variable in origin, texture, fertility, etc., all field research should be coordinated with the soil specialist before initiating.

Both short- and long-term breeding programs should be considered with the objective of developing varieties with higher yields, protein content, quality, resistance to insect and diseases (particularly viruses) and more drought resistance. Furthermore, consideration should be given to selecting for a high foliage producing variety for making silage and leaf meal for livestock feed.

It is further suggested that after the research and manpower facilities become adequate that N.E. Brazil consider establishing a manioc germ plasm bank in each of the three rainfall zones. These banks should preferably be established under the direction of one institution whose overall administration and funding is provided by the organization in N.E. Brazil which is the least susceptible to changes in national policy. This would insure adequate and long term support which is essential.

At each of these centers, all existing varieties obtainable would be collected, classified by morphological characteristics, nutrient content and indexed for viruses and maintained virus free.

These banks would serve as a source of germ plasm for breeders throughout Brazil and South America and provide a uniform method of classification to reduce duplication, even though some duplication is highly advisable to determine performance under different environmental conditions. What is meant here is more than a routine variety collection. The centers should cooperate with CIAT. Plantings should be made in such a plot design as to enable efficient evaluation of germ plasm.

B. LIVESTOCK

A research program should be established to conduct extensive detailed experiments with swine, poultry, cattle and laboratory animals. The emphasis should be on determining the quality and quantity of manioc in animal diets, especially with the new higher protein varieties. Detailed research will be necessary in the broad categories of feed preparation, ration palatability, and protein, lipid, mineral and vitamin nutrition.

C. INSECTS AND DISEASES

Post-harvest losses due to insects, microorganisms and physiological degradation presently appear to be a major obstacle for the commercial storage, marketing and export of manioc. Based on research to date, the practical solution to these problems appears feasible with limited resources, and the odds for success and the dividends to be expected from such research projects should be very high.

D. PROCESSING

Research is needed in facilitating and modernizing manioc processing, fortification of products and new product development for human and animal consumption. Roots having higher vitamin content, such as the yellow fleshed varieties, should be evaluated.

Manioc flour fortified with fish protein concentrate, with soy protein isolate, with torula yeast and with caseinate should be experimentally prepared. The one or two with the highest acceptability value, as determined by taste panels, should be made available for mass feeding to further deleniate consumer acceptability. Similarly, a manioc macaroni enriched by using varying proportions of cowpeas, Opaque-2 and floury-2 corn, ground nut meal, soybean meal, IR-5 or IR-8 rice and Atlas 50 and 66 wheats could be prepared. The ultimate products would add variety and serve as a better nutrient source. These same products could be fortified with lysine, methionine and tryptophan. Flours could be improved by adding calcium-stearyl lactyl lactate as a conditioner. Manioc could be used in higher proportions in breads and other bakeries if methods of incorporation were altered, i.e., by mixing for longer periods of time, use of different temperature-time relationships in baking and changing the type of ingredients added. Binding agents such as glyceryl monostearate could be used to provide satisfactory dough and loaf structure.

Research programs need to be initiated in the major universities and experiment stations throughout the N.E. Personnel in these institutions should include resident and extension home economists and food technologists who can determine satisfactory ways of producing, processing, storing and utilizing manioc so that a product of better and more uniform quality can be assured. In addition, such personnel should be charged with finding new and improved ways of utilizing the fresh root, chips, flour and starch and of getting this information to the people throughout the region.

Research on methods of rapid detoxification of manioc tuber and the use of pure culture and controlled fermentation for the production of gari[1] and/or similar products should be initiated. All processing and new product research should be coordinated with consumer acceptability studies.

E. HUMAN NUTRITION

Research is needed on the biological value and nutritive ratio of menus in which manioc is the predominant or subsidiary item. Menus of this type should be completely evaluated, not only by proximate analysis, but by actual feeding experiments in which metabolism trials, nitrogen balance studies and possibly isotopic tracer studies with experimental animals should be included. There is a definite need for information relating to the utilization of manioc at the cellular level.

Menus and new products in which manioc leaves are utilized should be developed and evaluated by Home Economists, Food Technologists and Nutritionists.

The health-related aspect of feeding manioc has been inadequately explored. Since the fermentation processes do not eliminate all the prussic acid, there is a possibility that residual poison can accumulate in the body through continued consumption of manioc products made from bitter varieties. Manioc consumption has been implicated with the

[1]A product prepared in Africa by grating raw manioc roots to a 10-80 mesh size, reducing the flour to about 50% moisture, then allowing 4 or 5 days for fermentation. After fermentation, it is sieved and fried, sometimes with the addition of red palm oil for flavor (34).

incidence of goitre in Nigeria but the goitrogenous substance has not been identified or confirmed; therefore, research should be initiated using experimental animals to either verify or refute this belief.

F. MARKETING

Since production is organized in small units both at the farm and processing level a cooperative structure for producers and processors is suggested. Such organization would improve the present marketing system by providing information on market prices and transportation costs and simultaneously give access to bank credit to small operators currently outside the formal credit system. Extension of research results would also be facilitated if producers had a formal organization. Widespread use of grades and standards would facilitate trade between distant centers by reducing uncertainty of product quality.

G. ECONOMIC INPUTS

Although the need for economic data is referred to in Section III, A-F above, a more clear cut description is needed. This description is supplied in this section under the following subheads.

Production - Considerable work needs to be conducted on production input-output data. For example, the relative merits of the costs of the traditional (human power) production methods should be compared to production techniques of partial or complete mechanization (including machine and animal power). The goal is to lower the economic costs of manpower requirements in land preparation, planting, fertilizing, cultivation and harvesting. Harvesting techniques, per se, must be critically examined to determine the relative merits of complete versus partial harvesting, harvesting of stems and leaves for livestock feed (which lowers root production) and what part or parts of the plant should be partially harvested.

The economics of fertilizer inputs should be determined. Methods need to be derived to achieve quantity discounts, what analysis of fertilizer is needed (to fit local conditions), and how to lower transportation and distribution costs.

Credit will be necessary if modern inputs are utilized. The best methods of obtaining financing, terms, etc., need to be determined for such items as machinery, animal power and fertilizers.

New Products - While efforts are being made to develop new products such as canned or dried slices, French fried slices and/or fried chips, manioc macaroni, paste and powders, the economics of manufacturing, distribution and marketing methods and measurement of market potentials should be conducted.

Animal Feeds - The economic costs and returns of varying inputs of manioc components (roots, stems, leaves) and protein mixes for all kinds of animals including beef, dairy, pigs and chickens under N.E. Brazil price-value relationships should be determined.

Processing - The market potential for fortified manioc flour needs to be determined. This will involve analysis of costs of fortifying. The place or places of fortifying and best methods of distribution must be specified. Methods of developing consumer acceptance is of prime importance.

An estimated 60,000 - 80,000 flour mills are in N.E. Brazil. In 1966, the average mill processed 551 kilograms of flour daily. Operating 200 days annually the average mill requires the output of 25 hectares annually. A detailed analysis of optimum firm size appears essential. This may require the introduction of some additional machinery (which in turn leads to some industry). Product flows should be developed using work simplification techniques. Technical assistance must be made available in planning, designing and operating flour mills.

Expansion of processing in the Northeast for the export market for starch, chips and flour appears to have limited potential until yields per hectare increase and/or production costs per kilo are decreased. As these things occur, aid in planning, designing, and operating these specialized mills will be required.

Assembly, Transportation and Distribution - A transportation model needs to be developed to determine the value of new paved and unpaved highways on assembly, transportation and distribution costs and the projected supply responses of farmers to these new conditions. This is true for both raw product (roots) and finished product (flour).

Other - New methods must be devised for obtaining and disseminating market news of value to farmers.

Acceptable, workable grades and standards for flour need to be developed. Methods of implementing these grades and standards should be devised.

Forecasting of retail and farm prices should be initiated. This advisory service would aid in removing some of the supply fluctuations.

## H. RESEARCH AND EXTENSION PERSONNEL TRAINING PROGRAMS

All three universities of agriculture in the Northeast were visited. The University of Ceará at Fortaleza has 91 faculty members of whom 25 are presently away studying for advanced degrees. The

Rural University of Pernambuco at Recife has 120 faculty members. The University of Bahia at Cruz das Almas has 50 faculty members. Most of the faculty at the three universities are trained either in agronomy or in the biological sciences. Very few have advanced training and practically none have the Ph.D. degree.

Northeast Brazil is drastically understaffed in food technologists, experimental nutritionists, human nutritionists, agronomists and biological scientists with advanced training, economists, and public health trainees. Scientists in food and nutrition areas, are particularly lacking. At the University of Ceará, there are two home economists both of whom are away at the present time working on advanced degrees in the United States. The Rural University at Pernambuco virtually has no one in research. At the nearby Institute of Nutrition, there is, however, one active scientist with the doctoral degree. He is assisted by four technicians and four staff members.

In the Northeast, there is also a shortage of technical information needed to solve farm problems involving manioc production, marketing and utilization. In addition, a weak base of technical competency exists in the agricultural universities. Consequently, there is insufficient published applied research to provide the information needed by the extension service for the solution of farm problems.

The extension staff is too small in numbers to cope with all the problems needing attention. There appears to be close communication between the research and extension staffs. However, there does seem to be a need for closer cooperation and more involvement of extension personnel in research and teaching activities.

As is to be expected when labor is cheap and plentiful, only moderate interest exists in making agricultural operations more efficient. Actually, some have the attitude that agriculture should remain status quo and thereby provide as many jobs as possible. This is a short ranged outlook perpetuating a situation, which, at best can only provide subsistence-type jobs. In an over-populated country without vast resources or unusual potential, perhaps this is the best that can be done. Brazil, however, is not such a country and cannot develop to her full industrial and technological potential if a large percentage of her population is engaged in the production of food and fiber. In the long run, a more efficient agricultural base will create not only more jobs, but better jobs.

An improvement in the transportation system of the Northeast would undoubtedly benefit both agricultural and industrial development. However, if both new roads and expanding education programs cannot be provided simultaneously, the former should not be provided at the expense of the latter. An educated populace is the key to success for any developing nation. It is impossible to provide the technological know how that a farmer or industrial worker needs if he does not possess at least the rudiments of a basic education. Education also makes people more mobile and results in their migration to locations offering greater opportunities. This would be an important aspect in the development of Brazil.

It is suggested that N.E. Brazil work toward establishing graduate programs in Plant and Soil Science, Food Science, Animal Science and Economics in the three major Universities. This long range program will be required to supply the scientific personnel needed in the future. Initially one University could be selected if funds are limited. The University Federal Rural de Pernambuco is recommended for consideration due to its geographic location with the University of Ceará as a second choice. The State of Pernambuco, being long and narrow, includes all the various rainfall zones, soil types, etc., that are indigenous to the N.E. Likewise, organizations such as ANCAR-Pe., IPA, IPEANE and the Universidade Federal are located in close proximity. It is suggested that joint staff appointments between some of these organizations would be worthwhile. This would permit a more expanded curriculum and expose the students to the most recent information.

With this in mind, it is suggested that immediate attention be given to training additional members of the faculty at all the institutions through the doctoral level and to encourage a number of the present technicians to earn the B.S. or higher degree thus providing a basis on which to build this long range program. In view of the present short supply of scientists in the Northeast, an exchange arrangement between some Universities in the United States would be advantageous. By this procedure, a visiting professor from the U. S. could then compensate for any loss in existing faculty. Graduate students should be an important part of such a program. They should have close contact with the visiting professors. A portion of the training of graduate students should be at universities in Northeast Brazil with continuation and/or extension in the United States. Study in the U. S. should be at one of the leading schools in the area of each student's interest. An exchange student should be encouraged in seeking additional training only if it is quite certain he intends to return to the Northeast and participate in the research and/or teaching programs of his discipline.

Special consideration should be given to including extension faculty members from the U. S. in this exchange program. Many have had broad experience not only in state and county extension activities, but also in applied research and in teaching. Some are members of the Graduate Faculty. Their type of experience would be invaluable in developing cohesion among research, teaching, and extension programs. These extension faculty members would, of course, be expected to have faculty appointments at Brazilian universities. Actually a critical need exists in Northeast Brazil for an extension education program in one or more of the universities. Students selected for the exchange program should do as much of the course work and research in Northeast Brazil as possible. In the beginning this might be minimal in some areas, but should increase as more and more students return with advanced training.

It should be emphasized that any advanced degree program should be designed for the student and the position he is expected to occupy when he returns to N.E. Brazil. Unfortunately, in the developing countries of the world, there are a large number of indigenous scientists who have acquired their Ph.D. in the U. S. or elsewhere without an appreciation for applied research. Frequently, such individuals become frustrated misfits because developing nations cannot afford the luxury of highly basic research at the expense of the very necessary applied research. An effort should also be made to select students for graduate study who have had some farm experience or background. In instances where such is not the case, the student should be encouraged to spend a period of time working on a farm or experiment station before entering a graduate program.

It would not be sensible to consider an expanding research program, without considering at the same time an expanding extension program. There is a strong indication that much of the research information already available is not finding its way to the farmer. Ideally, each county of the Northeast should have its own county agent. At the present time each county agent has responsibility for a number of counties. As would be expected, he spends most of his time in the county where he is located. Insufficient travel funds also place restrictions on the programs of extension personnel.

An intensive program of advanced training should be provided for all extension personnel. This group should also be increased in number and provided with more adequate travel support. Those having the competence and desire to do so should be encouraged to seek advanced training.

For the extension staff trainee, a Master of Agriculture degree would be recommended. Many Colleges of Agriculture offer their Masters of Agriculture degree without a research thesis, but require a manuscript to be written on some subject in the student's area of interest. Material for most papers of this type could be collected by the student from information pertaining specifically to a section of Northeast Brazil. For example, he might be interested in the cultural techniques of farmers producing manioc, marketing outlets for manioc, etc.

Because of the language problem, short term programs of study for extension personnel might best be conducted at an appropriate institution within Brazil or at such locations as CIAT in Cali, Colombia. Also, there is the possibility of bringing extension faculty and staff from the U. S. for short term assignments to conduct intensive programs of study for extension personnel, particularly for programs involving extension techniques and procedures.

Close cooperation among the University faculty, the Federal and State research personnel and the Extension Service should be encouraged. The team was very impressed with cooperation between the faculty and the Federal and State research personnel at the University of Ceará. This approach not only provides a more rapid flow of information for the solution of problems, but also strengthens the programs of instruction. Close cooperation among all the scientists in Northeast Brazil will be necessary for the development of a graduate program. For example, the Institute of Nutrition provides the only nucleus at the present time for the development of graduate work in nutrition. Therefore, close cooperation between Dr. Álvaro de Mello and appropriate faculty members at U.F.R.Pe. and elsewhere would be very necessary in a nutrition program. Because of the extreme shortage of nutritionists in the Northeast, it is suggested an AID representative contact Dr. Álvaro and explore the possibility of developing a graduate program in nutrition.

I. DEVELOPMENT ACTION PROGRAMS

Until yields per hectare are increased or until cost per kilogram of roots is decreased there appears to be little possibility of expanding into export markets. Research and extension are the keys to attaining these means. However, there are several activities that could be initiated without awaiting further research results. Among these are:

(1) Develop extension programs for the entire N.E. and specific programs for each State and County. These should include programs in home development as well as strictly agricultural programs. Establish priorities based on the objectives of improving yields/ha. and concentrate on those programs which have the greatest need. When this has been accomplished, provide the additional extension staff that will be required to conduct the programs.

(2) Establish a communications group to work with research, teaching, and extension personnel in preparing research and extension publications and other educational materials. One of the groups should be located at each agricultural college or university in N.E. Brazil. The Extension Service has such groups in each state of Northeast Brazil, but these are grossly understaffed with the possible exceptions of Pernambuco and Ceará. Perhaps these could be expanded to work with research teaching, and extension personnel.

(3) Establish demonstration plots (plants and animals) with selected progressive farmers and apply the latest research findings.

(4) Increase the allocation of funds for research publications and encourage rapid publication.

(5) Establish a cooperative for manioc producers in selected areas in order for them to take advantage of mass purchasing of agricultural inputs such as fertilizer, lime, small equipment, etc., and mass marketing. The cooperative management personnel could act as dissemination agents for production and marketing information.

(6) Develop a credit program with one or more banks exclusively for manioc producers and processors.

(7) Send some qualified young men for technical training in the management and operation of starch processing plants.

(8) Initiate an educational and technological program with selected manioc flour mills to introduce work simplification methods, low cost machinery and sanitation control.

(9) Develop a manioc fortification program and combine it with a consumer acceptability study.

(10) Import and field evaluate the high protein varieties of manioc for adaptability to environmental conditions of the N.E. This could be initiated at the University of Bahia since they already have a large selection of varieties, adequate facilities, and qualified personnel.

(11) Initiate an extension education program within the Rural University utilizing staff from ANCAR-Pe and UFRPe. Efforts to do this in the past may have been abandoned because of opposition.

J. BUDGET ESTIMATE

To initiate the training programs and the accompanying research, it is suggested that the following team be established at the University selected for this purpose:

| Positions | Number |
|---|---|
| Chief of Party | 1 |
| Plant Scientists<br>Plant Breeder<br>Soil Scientist<br>Extension Plant Specialist | 3 |
| Food Scientist | 1 |
| Economist, Production | 1 |
| TOTAL | 6 |

With the exception of the Chief of Party, each faculty member on the team is proposed on an exchange basis. That is, he will replace a faculty member at the University while that faculty member is seeking a degree in the same general field of study at a university in the United States. Other graduate students would be sent to the United States in the conventional manner.

In addition to the regular team, a number of short term assignments (2-6 months) are proposed. Four of these are in the animal area and are suggested not as research inputs but more as extension inputs. It is obvious that the livestock industry in Northeast Brazil is plagued with many problems directly associated with management. Dr. Paulo Ponce de Leon Filho of IPEANE lists these in order of importance as: nutritional stress and management, parasite infestation, hoof and mouth disease, rabies, and brucelosis.

Short term assignments are suggested as follows:

| Position | Number |
|---|---|
| Animal Science | 4 |
| Extension Veterinarian | |
| Silage Specialist | |
| Livestock Specialist | |
| Dairy Scientist | |
| Food Science | 3 |
| Bacteriologist | |
| Mycologist | |
| Product Development Specialist | |
| Communication Specialists | 3 |
| Editor for Research Publications | |
| Editor for Extension Publications | |
| Editor for News, Radio, and T. V. Releases | |
| Plant Scientists | 4 |
| Forage Specialist | |
| Soil and Tissue Analysis Specialist | |
| Plant Pathologist | |
| Entomologist | |
| Economist | 4 |
| Marketing Economist | |
| Statistician | |
| Cooperative Economist | |
| Economic Development | |

| | | |
|---|---|---|
| | Total budget for each member of the team (on exchange basis) and Chief of Party. Estimates allow for support of exchange faculty member and provides expenses for exchange student ... | $300,000 |
| 5 | graduate assistantships for extension .......... | 25,000 |
| 5 | regular graduate assistantships for new undergraduates .............................. | 25,000 |
| 18 | short term assignees on request ............... | 180,000 |
| | | $530,000 |

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