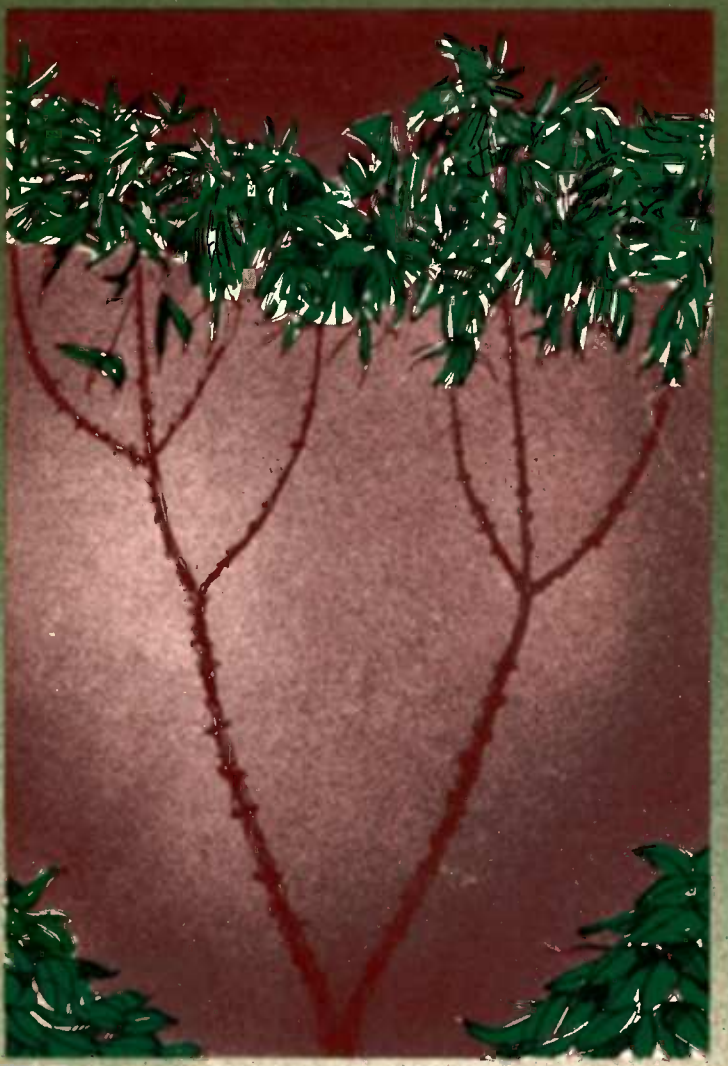
# Intercropping with Cassava

## Proceedings of an international workshop held at Trivandrum, India, 27 Nov – 1 Dec 1978

Editors: Edward Weber, Barry Nestel, and Marilyn Campbell





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Central Tuber Crops Research Institute (Indian Council for Agricultural Research)

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# Contents

# Cassava Intercropping in Brazil

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Brazil is the world's greatest cassava producer, accounting for 30% of all cassava root production. Cassava is grown throughout the country's 8.5 million km², from the south at 33° latitude to the equator. In area planted, cassava ranks sixth behind other crops in Brazil (Table 1).

Table 1. Areas planted for main crops in Brazil, 1975.

| Crop | Area (*'000 ha*) |
|---|---|
| Corn | 10473 |
| Soybean | 5824 |
| Rice | 5150 |
| Beans | 4052 |
| Coffee | 2251 |
| Cassava | 2082 |
| Sugarcane | 1899 |
| Cotton | 1410 |

Source: IBGE 1976.

The Northeast Region of Brazil grows 51% of the country's cassava (Table 2), the greatest amount being produced in the section with 650–1000 mm annual average rainfall. A long dry season occurs for one in each cycle of 4 or 5 years, and the annual average temperature is 24–26 °C with annual sunlight of 2700 hours.

Cassava is grown in this region on small farms using family labour and is either consumed by the family or made into cassava flour and sold at the local market.

It is usually grown in two or three crop associations, probably to reduce the risk of harvest loss by a prolonged absence of rain and to improve the intensive use of a small area and family labour force. It is usually intercropped with beans (*Phaseolus* or *Vigna*) and corn, and sometimes with cotton, rice, tobacco, coco palm, rubber trees, and *Opuntia* sp. (forage cactus). In the typical multiple crops association in this area, advanced agricultural practices, such as selected cultivars, pest and disease control, and the use of fertilizer, are not used.

Generally, the planting has been done by family labour at the same time or in the interval of weeks or months between the planting of different species. Farmers most commonly plant intercropped species simultaneously to take advantage of soil moisture conditions. The irregular rainfall distribution is not predictable enough to permit the general use of separate planting periods for each intercropped species. Plant distribution in the area has varied according to the species combination.

## Cassava Intercropping Types

### Cassava and Beans

This crop combination has been the one most used by farmers in the Northeast Region because it produces protein and carbohydrate in the same area. *Phaseolus* or *Vigna* species have been chosen according to regions and seasons.

Generally, beans are planted between the cassava rows. Cassava row spacings are in the range of 1.00 m × 0.50 m to 2.00 m × 1.00 m, depending on the bean species and the number of rows used. Commonly, there are one or two bean rows between the cassava rows, and 15 seeds per linear metre or 0.50 × 0.20 m with two seeds in each hole. Sometimes beans are planted 0.5–3 months before the cassava planting.

### Cassava and Corn

Corn is seeded in row spacings of 1.00 m between two cassava rows, and 0.50 m between corn plants.

### Cassava, Corn, and Beans

Cassava, corn, and bean crop combinations are widespread in Brazil. Cassava plant spacing is 1.00 m × 0.50 m, 2.00 m × 1.00 m, with one or two

Table 2. Areas planted in cassava, production, and yield by region and by state in Brazil, 1975.

| Region | State | Area ('000 ha) | Production ('000 t) | Yield (t/ha) |
|---|---|---|---|---|
| North | Pará | 83 | 835 | 10 |
| | Amazonas | 13 | 256 | 20 |
| | Acre and Territórios | - | 134 | - |
| | | 96 | 1225 | 12.7 |
| Northeast | Bahia | 301 | 5110 | 17 |
| | Maranhão | 217 | 1843 | 8 |
| | Pernambuco | 157 | 1575 | 10 |
| | Ceará | 145 | 1451 | 10 |
| | Piauí | 144 | 1136 | 8 |
| | Paraíba | 73 | 642 | 9 |
| | Alagoas | 48 | 493 | 10 |
| | Rio Grande do Norte | 62 | 488 | 8 |
| | Sergipe | 35 | 416 | 12 |
| | | 1182 | 13154 | 11.1 |
| Southeast | Minas Gerais | 138 | 2246 | 16 |
| | São Paulo | 38 | 720 | 19 |
| | Espírito Santo | 43 | 608 | 14 |
| | Rio de Janeiro | 25 | 344 | 13 |
| | | 244 | 3918 | 16.0 |
| Central west | Goiás | 35 | 487 | 14 |
| | Mato Grosso | 74 | 479 | 6 |
| | | 109 | 966 | 8.8 |
| South | Rio Grande do Sul | 266 | 3166 | 12 |
| | Paraná | 99 | 1953 | 19 |
| | Santa Catarina | 86 | 1430 | 16 |
| | | 451 | 6549 | 14.5 |
| Totals | | 2082 | 25812 | 12.3 |

Source: IBGE, 1976.

corn rows between two cassava rows. Beans are planted alternately with corn rows. To guarantee good plant stands, three bean or three corn seeds are put in each hole.

### Cassava and Rubber Trees

The agricultural finance institutions do not recommend the use of cassava in association with rubber tree plantations due to the risk of increasing the damage potential of insects like "mandarova" (*Erinnyis ello*). However, biological control of the "mandarova" will make this type of crop association feasible if such control is balanced so that an adequate population of "mandarova" is available to support the control insects that are introduced.

Observations have been made on rubber tree plantations in the State of Bahia where cassava has been cultivated between rows of young rubber trees for 2 years. Those rubber trees that are associated with cassava have shown higher growth than the rubber trees without cassava intercropping.

### Cassava and Coco Palm

In 1975, in the state of Sergipe, a cassava starch factory was built, and this has given farmers the incentive to grow cassava. This crop has been extended into coco palm plantations and has occupied the space between the coco palm rows in the zone due to the commercial influence of the factory.

### Cassava, Tobacco, and Cowpea

In some areas in the Northeast Region, small farmers have used manure, castor bean cake, and chemical fertilizer to grow tobacco that is planted in April. Before the tobacco harvest ends in October–November, farmers have planted cassava or cassava and cowpeas. These crops have been improved by the residual effect of fertilizer applied to tobacco.

### Other Cassava Intercropping Types

In some areas, rice, cotton, and *Opuntia* sp. (forage cactus) have been employed in intercropping with cassava. Also, cassava has been used to shade young cocoa plants.

## Cassava Plantations and Intercropping

The increase in 1973 in the international price of oil prompted the Brazilian Government to establish in 1975 the National Alcohol Program, an endeavour to replace a great portion of imported oil with alcohol to be used in motorcars and for industrial purposes.

This program has given incentive to private enterprise to produce alcohol from biomass. Sugarcane, cassava, sweet potato, and sweet sorghum have been mentioned as important raw materials for the alcohol industry. The first large cassava alcohol plant was built recently by PETROBRAS, a government enterprise, who constructed this factory to promote alcohol production from cassava. The factory production capacity is 60 000 litres of ethyl alcohol per day.

As of September 1978, the National Alcohol Committee approved 12 agro-industrial projects for alcohol production from cassava. The total production capacity (the total of the 12 projects) is 1.14 million litres of cassava alcohol per day. These projects must be established within 2 or 3 years.

These recent events are changing cassava production from a peasant crop to a plantation crop. On this scale, agricultural cropping systems involving short plants such as beans, soybeans, and rice, in alternate multiple rows with cassava will permit frequent inspections for pests, diseases, and general management conditions. As well, the row space occupied by cassava will be intensive in capital (machinery, fertilizer, herbicides, etc.) and probably will make better use of the soil, water, and light, and will reduce tillage and soil erosion and contribute to better the income of the farmer.

## Research

The Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA; the Brazilian Enterprise for Agricultural Research), created in 1972, is a government institution in charge of the planning, coordination, and execution of agricultural research in Brazil. In 1975, EMBRAPA founded the Centro Nacional de Pesquisa de Mandioca e Fruticultura (CNPMF; the National Research Center for Cassava and Fruit Crops), which is responsible for the programing, coordination, and execution of cassava, citrus, banana, pineapple, and mango research in Brazil. The CNPMF is located at Cruz das Almas, State of Bahia, at 12°40′19″S and 39°06′22″W. The local altitude is 220 m above sea level; the annual average rainfall is 1200 mm, the annual average temperature 24 °C, and the relative humidity 80%. The land is level to undulating with well-drained sandy clay loam red-yellow latosol soils. The soils present low to medium natural fertility, are acid, and have a very low phosphorus content.

There are 42 researchers at the CNPMF, half of whom work with cassava in cooperation with about 35 other researchers in selected areas in Brazil.

The intercropping with cassava research project is directed basically at improving the use of scarce production factors and at intensifying the use of abundant production factors to increase income for farmers and to intensify cropping systems by adequate use of production factors available on large farms.

The trials on intercropping with cassava will evaluate the cultural practices effects that were determined formerly on each crop that is integrated with the cassava intercropping.

EMBRAPA's Agriculture Research Center for Humid Tropics (CPATU), Agriculture Research Center for Semi-Arid Tropics (CPATSA), and Agriculture Research Center for the "Cerrado" Region are responsible for developing farming systems for the Amazon, semi-arid, and "Cerrado" regions, respectively. These three have worked with EMBRAPA's other centres, such as the National Research Center for Cassava and Fruit Crops (CNPMF). These centres have carried out some field trials and are preparing designs for new experiments during the next 5 years on cassava in association with perennial and annual crops.

In 1977/78, the CNPMF performed one field experiment to evaluate effects of double row planting on cassava yields, combining double rows of 7000–16 000 cassava plants per hectare. The results indicate that a spacing of 2.00 × 0.60 × 0.60 m produces the greatest root yield, approximately 37 metric tonnes (t) per hectare.

## Experiments with Intercropping in the Amazon Region[1]

The Manaus Experimental Station is located in the Amazon Region of Brazil at 02°54′01″S and 60°01′03″W with an altitude of 40 m, an annual average precipitation of 2.1 mm, an annual average temperature of 26.7 °C, and predominately yellow latosol soils. The soil texture is clay of low fertility. The research of the unit involved the intercropping of cassava with other crops, and results were as follows.

[1]This work was planned and executed by UEPAE/Manaus, under the coordination of Engº Agrº Expedito Ubirajara Peixota Galvao.

The experiment was composed of combinations of cassava, rice, beans, and corn, in 15 intercropping systems that followed a random block design with three replications (Table 3).

Table 3. Treatment, population of plants per area, and spacing used in the experiments at Manaus, 1975/76.

| Treatments | Plants/ha | Spacing (*m*) |
|---|---|---|
| 1. Cassava | 10000 | 1.00 × 1.00 |
| 2. Cassava | 10000 | 1.00 × 1.00 |
| Beans | 100000[a] | 1.00 × 0.20 |
| 3. Cassava | 10000 | 1.00 × 1.00 |
| Corn | 40000 | 1.00 × 0.50 |
| 4. Cassava | 10000 | 1.00 × 1.00 |
| Rice | 40000 | 1.00 × 0.25 |
| 5. Cassava | 6666 | 1.50 × 1.00 |
| Beans | 66666[a] | 1.50 × 0.20 |
| Corn | 26666[a] | 1.50 × 0.50 |
| 6. Cassava | 6666 | 1.50 × 1.00 |
| Corn | 26666[a] | 1.50 × 0.50 |
| Rice | 26666 | 1.50 × 0.25 |
| 7. Cassava | 6666 | 1.50 × 1.00 |
| Beans | 66666 | 1.50 × 0.25 |
| Rice | 26666 | 1.50 × 0.25 |
| 8. Beans | 200000[a] | 0.50 × 0.20 |
| 9. Beans | 100000[a] | 1.00 × 0.20 |
| Corn | 40000[a] | 1.00 × 0.50 |
| 10. Beans | 100000[a] | 1.00 × 0.20 |
| Rice | 40000 | 1.00 × 0.25 |
| 11. Beans | 66666[a] | 1.50 × 0.20 |
| Corn | 26666[a] | 1.50 × 0.50 |
| Rice | 26666[a] | 1.50 × 0.25 |
| 12. Corn | 40000[a] | 1.00 × 0.50 |
| 13. Rice | 160000 | 0.25 × 0.25 |
| 14. Corn | 40000[a] | 1.00 × 0.50 |
| Rice | 40000 | 1.00 × 0.25 |
| 15. Cassava | 5000 | 2.00 × 1.00 |
| Rice | 20000 | 2.00 × 0.25 |
| Corn | 20000[a] | 2.00 × 0.50 |
| Beans | 50000[a] | 2.00 × 0.20 |

[a]After the planting, each hole had two plants.
Source: UEPAE/Manaus.

The natural fertility of the soil was maintained and no fertilizer was added to the experimental area. Planting was by hand and was done according to the following criteria of distribution and quantity of seeds in the holes: cassava, one stake per hole; beans, three seeds per hole; corn, three seeds per hole; rice, five seeds per hole.

The results presented in Table 4 show that the cassava crop when intercropped with corn and rice decreased in yield by 450 kg of table flour per hectare or 1286 kg of fresh roots per hectare (considering that 1 t of roots produces about 350 kg of flour), compared with production obtained when monocropped. Nevertheless, in the intercropping of cassava with beans an increase in flour yield of 800 kg/ha, or 2286 kg/ha of roots, was noted. Production of rice and bean crops decreased when intercropped with cassava, and corn increased production by 570–1102 kg/ha when intercropped with cassava.

The best land use equivalent value was obtained with double intercropping with a combination of cassava and corn (275), followed by cassava and beans (147), and rice and cassava (106). The best food production was obtained with the intercropping of cassava and beans.

When cassava was planted with rice + corn or rice + beans there were yield losses in cassava flour. When planted with beans + corn, this reduction was only 250 kg/ha of flour compared to cassava monoculture; this indicates a reduction of 10%. The other crops, in general, also suffer in their production when grown in association, with rice being especially affected when interspecifically associated, with losses up to 90% in association of rice + cassava + corn, and rice + beans + corn. Corn when planted with rice and beans had its best production of grain when compared to monoculture, with an increase of 40%.

The best land use equivalent value of triple intercropping was obtained with the combination of cassava + beans + corn (209), followed by the combination of cassava + rice + corn (140), and cassava + rice + beans (113).

When cassava was utilized in quadruple intercropping, that is, planted with rice + corn + beans, the production of flour fell by 1250 kg/ha, a 50% decrease in production in monoculture. The other crops also decreased in production, with rice again being the crop that suffered most.

The economic analysis of the different treatments is presented in Table 5. Within the intercropping systems for two crops, the combination of cassava + beans, cassava + corn, and cassava + rice were the most efficient, in decreasing order, considering total production, and this shows that in all these systems, cassava is the major component crop.

The highest economic efficiency index, as a function of gross weight yield, was obtained with the combination of cassava + beans; this index was 1771% compared to 1222% for cassava alone and 238% for beans alone.

The results obtained show that the best percentage of participation of total production of food was due to the cassava crop.

The intercropping system giving the best return was cassava + beans, which presented a return of approximately U.S. $600/ha. The intercropping with

Table 4. Production of rice, beans, cassava, and corn under diverse systems at Manaus, 1975/76.

| Production system | Total production of food | Production (*kg/ha*) | | | | LER[a] |
|---|---|---|---|---|---|---|
| | | Rice | Beans | Cassava flour | Corn | |
| Rice | 1378 | 1378 | | | | 100 |
| Beans | 268 | | 268 | | | 100 |
| Cassava | 2500 | | | 2500 | | 100 |
| Corn | 570 | | | | 570 | 100 |
| Rice + cassava | 2385 | 335 | | 2050 | | 106 |
| Cassava + corn | 3152 | | | 2050 | 1102 | 275 |
| Cassava + beans | 3475 | | 175 | 3300 | | 197 |
| Rice + corn | 394 | 139 | | | 255 | 54 |
| Rice + beans | 876 | 540 | 336 | | | 164 |
| Corn + beans | 989 | | 161 | | 828 | 205 |
| Rice + cassava + corn | 2569 | 139 | | 2175 | 255 | 140 |
| Rice + beans + cassava | 2438 | 292 | 21 | 2125 | | 113 |
| Beans + cassava + corn | 2815 | | 103 | 2250 | 462 | 209 |
| Rice + beans + corn | 1155 | 139 | 66 | | 950 | 200 |
| Cassava + rice + beans + corn | 1850 | 70 | 53 | 1250 | 477 | 157 |

[a]Land use equivalent ratio.

Table 5. Gross income per system,[a] with its formation percentage and economic efficiency index, Manaus, 1975/76.

| | Cassava | | Beans | | Rice | | Corn | | Total per system | | Economic efficiency index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gross income | % | Gross income | % | Gross income | % | Gross income | % | Gross income | % | |
| Cassava | 8240 | 100 | | | | | | | 8240 | 100 | 1222 |
| Beans | | | 1608 | 100 | | | | | 1608 | 100 | 238 |
| Rice | | | | | 2893 | 100 | | | 2893 | 100 | 429 |
| Corn | | | | | | | 855 | 100 | 855 | 100 | 127 |
| Cassava + rice | 6765 | 90.58 | | | 703 | 9.41 | | | 7468 | 100 | 1108 |
| Cassava + corn | 6765 | 80.36 | | | | | 1635 | 19.42 | 8418 | 100 | 1249 |
| Cassava + beans | 10890 | 91.20 | 1050 | 8.79 | | | | | 11940 | 100 | 1771 |
| Rice + cassava | | | | | 292 | 43.32 | 382 | 56.67 | 674 | 100 | 100 |
| Rice + beans | | | 2016 | 64 | 1134 | 36 | | | 3150 | 100 | 467 |
| Corn + beans | | | 966 | 43.75 | | | 1242 | 56.25 | 2208 | 100 | 327 |
| Cassava + rice + corn | 2177 | 76.35 | | | 292 | 10.24 | 382 | 13.39 | 2851 | 100 | 423 |
| Cassava + rice + beans | 7012 | 90.46 | 126 | 1.62 | 613 | 7.9 | | | 7751 | 100 | 1150 |
| Cassava + corn + beans | 7276 | 84.73 | 618 | 7.19 | | | 693 | 8.07 | 8587 | 100 | 1274 |
| Rice + corn + beans | | | 396 | 18.74 | 292 | 13.81 | 1425 | 67.43 | 2113 | 100 | 313 |
| Cassava + rice + corn + beans | 4125 | 77.75 | 318 | 5.99 | 147 | 2.77 | 715 | 13.47 | 5305 | 100 | 787 |

[a]Actual prices: Cassava flour, Cr$3.30/kg; bean, 6.00/kg; rice, 2.10/kg; corn, 1.50/kg. (1 Brazilian cruzeiro (Cr$) = ca. U.S. $0.14).
Source: UEPAE/Manaus.

the cassava crop produces more than when grown alone.

There is an equal economic disbursement of cultural practices in intercropping and monoculture. As well, there is better use of family labour when the intercropping system includes cassava, and this better use is in the postharvest stage, during the preparation of table flour. Another factor that contributes is the use of family labour over longer periods and the staggering of crop cycles for the different components of the intercropping system studied.

Table 6. Yields (*t/ha*) of cassava roots and soybean, sorghum, peanut, corn, rice, and bean intercropping, Felixlandia, 1976/78.

| | Treatments[a] | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Mean |
| Cassava | 21.49 | 22.37 | 18.34 | 19.19 | 20.35 |
| Cassava | 15.73 | 15.42 | 16.80 | 15.22 | 15.79 |
| Soybean | - | - | - | - | |
| Cassava | 16.85 | 18.19 | 13.47 | 9.05 | 14.39 |
| Sorghum | 0.89 | 0.73 | 0.71 | 0.31 | |
| Cassava | 15.82 | 18.94 | 13.92 | 19.45 | 17.03 |
| Peanut | 0.04 | 0.63 | 0.10 | 0.12 | |
| Cassava | 16.82 | 21.16 | 17.50 | 13.25 | 17.18 |
| Corn | - | - | - | - | |
| Cassava | 16.31 | 21.36 | 14.48 | 12.31 | 16.11 |
| Rice | - | - | - | - | |
| Cassava | 17.59 | 20.28 | 16.98 | 18.67 | 18.38 |
| Bean | 0.04 | 0.19 | 0.14 | 0.19 | |

[a]Treatments: 1, without fertilizer and lime; 2, with fertilizer and without lime; 3, with fertilizer and lime, 3 t/ha; 4, with fertilizer and lime 6 t/ha.

## Intercropping Experiment with Cassava carried out by EPAMIG

The intercropping experiment of cassava with soybean, sorghum, peanut, corn, rice, and bean was carried out by the Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG) and the Escola Superior de Agricultura de Lavra - MG (ESAL), at the Felixlandia Experimental Station in Minas Gerais.

The soil fertility conditions varied according to the treatments:

1 — No fertilizer or lime
2 — 300 kg simple superphosphate/ha
100 kg potassium chloride/ha
150 kg ammonium sulfate/ha (dressing)
40 kg aldrin/ha (2.5%)
3 — The same as no. 2, plus 3 lime/ha
4 — The same as no. 2, plus 6 lime/ha

The cassava was planted in double rows, 2.00 m × 0.50 m × 0.60 m apart, corresponding to 13 330 plants/ha.

The crops planted with cassava were as follows: (*a*) bean, soybean, rice, and peanut: three rows 0.50 m apart between each double row; (*b*) sorghum and corn: 2 rows 1.00 m apart between each cassava double row.

The quantities of seeds used per 1-m furrow were: (*a*) bean, 12; (*b*) soybean, 20; (*c*) rice, 50; (*d*) peanut, 15; (*e*) corn, 7; (*f*) sorghum, 18.

The total plot area was 600 $m^2$ (24 m × 25 m), while the utilized cassava plot was 420 $m^2$ (20 m × 21 m), and the other crop plots were 472.5 $m^2$ (21.0 m × 22.5).

The lack of humidity in the soil drastically affected the results, especially for soybean, corn, and rice; it was caused by a "veranico" (lack of rain) in the period from 31 Jan to 19 Mar (Table 6).

With cassava, the best yields were obtained with treatment 2. The addition of 3 t of lime reduced the yields and with 6 t these yields were even more reduced, except for the treatments: cassava monocrop, cassava + peanut, and cassava + bean.

The median yield of monocrop cassava was 20.35 t/ha. The intercrop experiencing the least reduction was the one with bean (18.38 t/ha), followed by those with peanut (17.03) and sorghum (14.39).

Due to the problems that occurred in the experiment, we cannot draw conclusions about it, but we can say that cassava, when intercropped, had its yield reduced by 18.43% when competition occurred, and by 19.61% when this competition was affected by the lack of production of the interplanted crops.