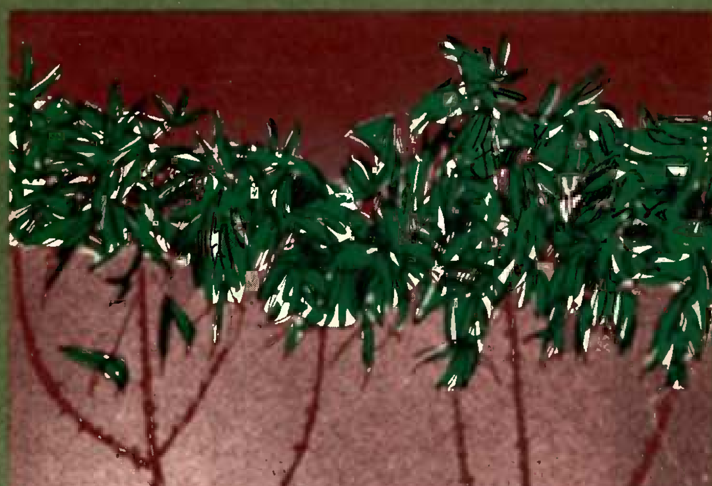
Intercropping with Cassava

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

Editors: Edward Weber,
Barry Nestel, and Marilyn Campbell



CANADA

IDRC-142e

The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in five sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; and communications. IDRC is financed solely by the Government of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

Weber, E.
Nestel, B.
Campbell, M.

IDRC, Ottawa, CA
Central Tuber Crops Research Institute, Trivandrum, IN

IDRC-142e

Intercropping with cassava : proceedings of an international workshop held at Trivandrum, India, 27 Nov-1 Dec 1978. Ottawa, Ont. IDRC, 1979. 144 p.: ill.

/IDRC publication/, /conference paper/, /cassava/, /intercropping/, /crop diversification/, /agricultural research/, /research centres/, /Latin America/, /Asia/, /Africa/ - /agricultural management/, /plant protection/, /soil fertility/, /economic aspects/, /CIAT/, /IRRI/, /agricultural statistics/, bibliography.

UDC: 631.584:635.23 ISBN: 0-88936-231-9

Microfiche edition available

IDRC-142e

Intercropping with Cassava

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

Editors: Edward Weber,[1] Barry Nestel,[2] and Marilyn Campbell[3]

Cosponsored by the

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

and the

International Development Research Centre

[1]Senior Program Officer, Agriculture, Food and Nutrition Sciences Division, IDRC.
[2]Consultant to the AFNS Division of IDRC.
[3]Communications Division, IDRC.

Contents

Intercropping with Cassava in Central America

Raúl A. Moreno and Robert D. Hart

Annual Crops Program, Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica

In Central America, cassava is grown mainly by small farmers. Most of its production is for direct consumption, although there is some industrial use of the crop. Cassava is an important plant component of some of the crop production systems practiced by small farmers. These production systems vary throughout Central America and depend on the local ecological and socioeconomic conditions.

In the humid lowland tropics, cassava may be intercropped with perennial or semiperennial crops, usually during the establishment phase of the latter, and frequently intercropped with maize in areas of lesser rainfall. Hernandez (cited by Rogers 1965) states that the area between southern Mexico and eastern Guatemala, where cassava is intensively grown, coincides with the distribution of certain primitive types of maize. Mayan farmers in this area cultivated cassava in a well-organized rotation with maize, in which the cultivars with a low cyanogen glucoside content were interplanted with maize, whereas bitter cultivars (with a high cyanogen glucoside content) were planted alone and away from the sweet cultivars. The tubers were normally harvested at a time when maize was out of season. As Maya civilization penetrated into the southern part of Meso-America, it seems likely that the cassava–maize association has its origin in this ancient Mayan agriculture.

Cassava is intercropped with common beans (*Phaseolus vulgaris* L.) and some horticultural crops (normally in areas of more than 700 m above sea level).

In subsistence agriculture, cassava is often intercropped with any of several different crops in a homestead garden and serves as a food source for the family. According to Wagner (1958) the majority of the homesteads in Nicoya, Costa Rica, include cassava in association with plantain (*Musa acuminata* × *M. balbisiana*), pigeon peas (*Cajanus* sp.), maize, and sugarcane (*Saccharum officinarum*). In semi-arid areas, its ability to survive prolonged dry periods is utilized; there it is planted on small plots of land in monoculture or intercropped, as a subsistence crop. Cassava is usually intercropped if it is to be used for semicommercial purposes. This reduces some of the risk involved in its production because of the unstable cassava market conditions prevailing in local markets throughout Central America. If the market tends to be stable and production resources are diverse, cassava is grown by itself and not intercropped, but always in rotation with other species.

Traditionally, agricultural research in Central America has been directed toward resolving the technical problems of the export crops such as coffee, cacao, banana, cotton, etc., while basic food crops have received comparatively little attention. There has been a tendency in the last few years for this to change. In Central America the majority of food crops, with the exception of rice, are produced by small farmers (SIECA 1972). These small farmer production systems and their relative importance have only recently been studied (Moreno et al. 1976) but there is a paucity of data on the ecological and socioeconomic variables that determine the predominance of a given system in a specific area.

From the purely technical point of view, the production potential of cassava, whether intercropped or in monoculture, is high. Agronomic problems do not seem to limit increased production and productivity but the lack of an adequate commercialization policy on cassava is the principal obstacle to the expansion of its cultivation. Cassava will remain a subsistence crop in Central America unless new marketing alternatives open up.

Some Cropping Systems including Intercropped Cassava used by Small Farmers

Cassava as an Intercrop in the Establishment of Perennial Plantations

The establishment of a perennial species in the humid lowland tropics is a challenge for the small farmer. From the ecological viewpoint, it is necessary to cover an area with shade-providing plants to reduce a high rate of weed biomass production. From an economic standpoint, few perennial species show any yield for several years, so that the necessary additional income must be obtained through intercropping other plants within the perennials. For the management of some perennial species, notably cacao and coffee, shade is required at certain stages of development to regulate their growth. Cassava, because of its rooting characteristics, has to be planted a short distance away from young cacao plants, unlike other shade crops like castor bean (*Ricinus* sp.) and pigeon pea (*Cajanus* sp.), which are planted closer. However, cassava still gives effective shade and produces a yield.

In Central America, cassava is frequently planted during the first year in the establishment of a plantain or banana plantation in order to occupy all the available land area until the plantain or banana plantation reaches maturity.

Cassava and Maize

Cassava interplanted with maize is a commonly used system in the lowland humid tropics, when both are sown at the same time at the beginning of the rainy season. Planting distances depend on the characteristics of the varieties used, erect varieties of cassava needing less distance between plants. The maize is ''doubled'' at 120–150 days after planting, by which time the canopy of the cassava occupies all available space. The main problems of this cropping system are weeds at the establishment stage and later on interspecific competition between the crops evidenced by some leaf fall by the cassava and occasionally by slight chlorosis of the maize.

A variation on this production system is also practiced in the lowland tropics. Maize is grown in monoculture until it is near its physiological maturity, when the lower leaves and the tassle are removed and left as mulch on the ground. Cassava is then planted in rows between the maize, immediately after this practice. The maize is doubled-over at approximately 150 days and the cassava occupies the available space. Farmers frequently mention that the doubled-over maize under the cassava is not as vulnerable to bird attack as maize in monoculture, and gives greater flexibility for the harvest to be planned to coincide with times of greater labour availability.

If the market conditions for fresh corn are favourable, the young ears may be harvested in either of these cropping systems. Generally, the ears that look the best are selected for this harvest, and the maize plant is then immediately doubled-over. Occasionally, young ears are harvested from alternate rows and the stand density halved after doubling.

Cassava and Beans

Beans harvested either fresh or dry are intercropped with cassava at higher elevations (approximately 700 m above sea level). Bush bean varieties are normally used for harvest as dry beans and are planted at the same time at one or two rows between the cassava rows, depending on the varieties used. A few farmers plant beans for dry grain at the end of the vegetative period of the cassava. These farmers use the cassava stems as a support for climbing beans and normally cultivate cassava varieties that begin to lose part of their foliage at approximately 200 days after planting. Beans planted within the cassava can also be snap beans, but as with fresh maize, market conditions are an important factor. Snap beans are almost always fast-growing bush-type varieties and a maximum of two harvests between the cassava rows can be obtained. This system is largely restricted to farmers living close to the market and frequently requires relatively large amounts of inputs. The extra fertilizers and fungicides required to control diseases attacking the young bean pods are also beneficial to the cassava remaining in the field after the harvest of the snap beans.

Cassava, Maize, and Rice

A common pattern of land use in Panama is a pasture-crop rotation. The large cattle rancher often has difficulty maintaining pastures over a long period of time. When removing weeds from pastures becomes too difficult or expensive, the pasture is allowed to return to secondary successional natural vegetation. To return the land to pasture, the owner permits neighbouring small farmers or landless farmers to use the land for a 3-year period, on the condition that the farmer plant pasture at the end of the cropping period. The 3-year cropping system often consists of 1-year cycles of maize intercropped with rice, followed by cowpea or maize planted in monoculture. Cassava may be planted with the maize and rice during the first 2 years, but this three-crop cropping system is more commonly planted during the 3rd year. The farmer plants pasture in the cassava after the maize and rice have been harvested.

Cassava and Other Tuber Crops

One of the most interesting intercroppings with cassava is practiced in medium-sized farms in the southern part of Nicaragua close to the Costa Rican border where rows of cassava are interplanted with rows of taro (*Colocasia esculenta*), yam (*Dioscorea* spp.), and sweet potatoes (*Ipomoea batatas*). Cassava is an important constituent of the Nicaraguan's diet and this intercropping practice provides a significant part of the national cassava consumption.

Research Review

Very little research has been carried out on cassava in Central America. A review of the papers presented at the Annual Meeting of the Central American Cooperative Program for the Improvement of Food Crops (PCCMCA) reveals that in 24 years, only five papers have been concerned with cassava. Two of these papers were presented by scientists from CATIE and described multispecies systems including cassava. The three papers not from CATIE all reported experiments with cassava in monoculture. Although national research institutions have conducted research on cassava not reported at the PCCMCA meetings, the overall paucity of papers on this crop suggests that very little research has been done on cassava in Central America. Moreover, research on cropping systems including cassava has been largely confined to cassava and maize systems.

Oelsligle et al. (1974) conducted an experiment in Costa Rica on different levels of nitrogen applied to cassava alone, maize alone, and cassava and maize intercropped. Land Equivalent Ratios (LER) of over 2.0 were obtained for the intercropped systems indicating a high level of land utilization potential.

The Agricultural Research Program of the Ministry of Natural Resources of Honduras conducted an experiment with cassava and maize cropping systems in conjunction with CATIE's Central American Small Farmer Cropping System Project (CATIE 1976–77). Two varieties of cassava were intercropped with two varieties of maize at two planting distances (spatial arrangement). Monocultures of both varieties of cassava and maize were also planted. The results indicate that there is interaction between the morphological characteristics of the varieties and the spatial arrangement of the crops.

An experiment with cassava and maize intercropped on the Atlantic Coast of Costa Rica (CATIE 1977–78) was conducted as part of CATIE's Small Farmer Cropping System Research Project. A Land Equivalent Ratio (LER) of 1.71 was obtained when intercropped cassava yielded 78% as much as cassava planted alone, and intercropped maize yielded 93% as much as maize planted alone.

An economic analysis of cassava and maize planted in 0.7-ha plots was conducted as part of CATIE's Annual Crops Program in Turrialba, Costa Rica (Mateo et al. 1975). It costs U.S. $223 to produce 1 ha of cassava intercropped with maize. The system produced a total output valued at U.S. $909, of which 63% was from cassava and 37% from maize production. The maize in this system was harvested half for fresh consumption and half for dry grain. Approximately 50% of the total maize value was from the fresh maize.

Research has also been conducted with cassava intercropped with maize and another crop in a three-crop system. Hart (1975a, b) compared three cassava, maize, and common bean intercropping systems to the three crops planted in monocultures. Two fertilizer and two weeding treatments were applied to each system. The highest net economic return was obtained from an intercropping system of the three crops planted at the same time with no fertilizer applied and no weeding of the system. The morphological characteristics of the system were such that the beans did not allow weed invasion during the first 2 months, the maize successfully excluded the weeds during the 3rd and 4th months, and from the 5th through the 8th month when the cropping period ended, the cassava canopy was developed enough to exclude weed invasion.

Holle (1976) compared four cropping systems with cassava, maize, and snap beans. The maize and snap beans were planted both at the same time as the cassava and 3 months before harvesting the cassava. Cropping systems with only maize or only snap beans intercropped with cassava were compared with both crops intercropped with cassava. Snap bean varieties were also evaluated. Snap beans did not reduce cassava yields and yielded 80% as much as the bean monoculture. Adding maize to the cassava and snap beans reduced bean yield to 70% of the monoculture. When all three crops were intercropped, maize had to be harvested fresh rather than as dry grain.

Dos Santos (1978) intercropped cassava with maize, maize and snap beans, maize and lima beans, and maize, snap beans, and lima beans. Cassava yields were not reduced by maize alone, but were reduced by approximately 30% when either snap beans or lima beans were added to the cassava and maize. Maize yields were reduced by 60% when intercropped with cassava and snap beans or lima beans as compared to the maize yields obtained in the systems without cassava. A comparison of total food energy and protein produced by the different cropping systems shows that the cassava, maize, and lima beans cropping system produced the most carbohydrates and that the maize and snap beans cropping system produced the most protein. The highest protein total from cropping systems including cassava was obtained when it was intercropped with maize and beans.

A few experiments have compared different cassava legume cropping systems. In El Salvador, the Multiple Cropping Program of CENTA (a research institute of the Ministry of Agriculture) conducted experiments comparing cassava intercropped with common bean and cowpea (Bieber 1975). Cassava yields were reduced more by cowpea than by common bean, and intercropping with cassava reduced the yield of cowpea more than that of beans.

In Turrialba, Costa Rica, CATIE's Annual Program (CATIE 1977–78) conducted an experiment to evaluate the possibility of intercropping snap beans, lima beans, and cowpea with cassava during the last 3 months of the cassava growth period. None of the legumes significantly lowered cassava yields. Cowpea and lima bean yields were 67% and 65% of their respective monoculture yields. One common bean variety produced as high a yield when intercropped as when planted alone.

Very few experiments evaluating the potential of cassava intercropped with perennials have been reported in Central America. However, preliminary results from an experiment in progress in Turrialba, Costa Rica, suggest that more research should be conducted with this type of cropping system. Cassava intercropped with plantain yielded only 23% less than a cassava monoculture (Enriquez 1978). The cassava–plantain association was planted at a density of 8890 plants/hectare, compared with the monoculture at 10 000 plants/hectare. Based on weight per plant the intercropped cassava produced only 13% less than the cassava monoculture.

Morales et al. (1949) investigated the economics of using cassava or maize in the establishment of rubber (*Hevea* sp.) on the Atlantic coast of Costa Rica. During early development of the rubber seedlings, maize offered less competition than the cassava. However, after the 3rd year of seedling development, cassava was preferred as an intercrop because it produced higher economic returns on investment than maize. An important advantage of intercropping the rubber was a saving of U.S. $24/ha on the usual total weed control costs.

All of the experiments described above involve only short-term cropping periods of 1 year or less. A long-term evaluation and comparison of up to 4 years of different intercropping systems with cassava was conducted in Turrialba by CATIE's Annual Crops Program. All land preparation and weeding was done by hand and the only "fossil fuel" inputs used were insecticides and fertilizer. The cropping patterns tested that included cassava are shown in Fig. 1. The crop species. varieties, planting distances, and densities are summarized in Table 1.

The average yields over a 3-year period of the different crops in the different cropping systems are summarized in Table 2. The yield of cassava intercropped with maize was only 50% of that in monoculture. Maize yields were also reduced when intercropped with cassava. Cassava and beans may be intercropped with no reduction in yield of either crop, but when maize is included in the system the yields of both beans and cassava are reduced to half their monoculture yield, whereas that of maize is not affected.

When cassava was intercropped with sweet potato and both crops are planted at the same time, cassava yields are 58% and sweet potato yields 60% of their respective yields in monoculture. When sweet potato was planted during the later half of the cassava vegetative period, sweet potato yields were not reduced, and cassava yields were actually increased.

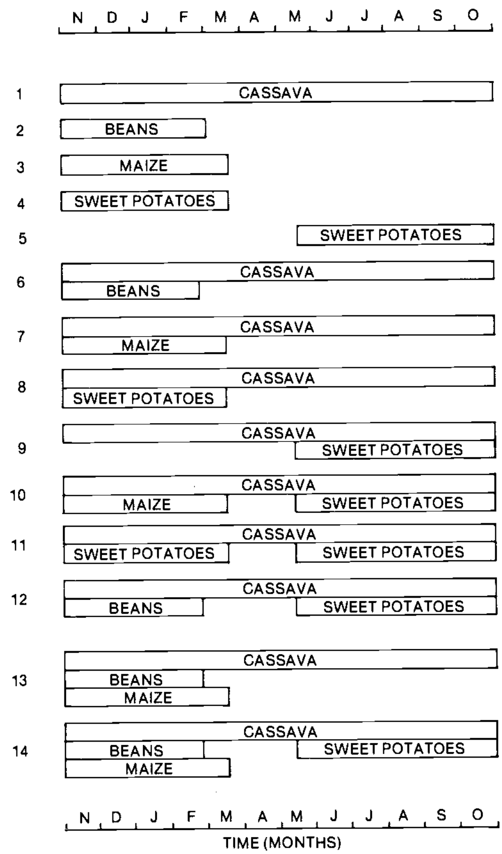


Fig. 1. Cropping patterns tested at Turrialba, Costa Rica, 1974–78.

Table 1. Species, varieties, planting distances, and density of planting of different cropping systems tested from 1974 to 1978 in Turrialba, Costa Rica.

Species	Varieties	Planting distance (m) On the row		Between rows	Density plants/ha
Beans (*Phaseolus vulgaris*)	CATIE-1	0.5	×	0.2	100000
Maize (*Zea mays*)	Tuxpeño	1.0	×	0.5	40000
Sweet potatoes (*Ipomoea batatas*)	C-15	0.5	×	0.4	50000
Cassava (*Manihot esculenta*)	Valenca	1.0	×	0.5	20000

An economic analysis of the cropping systems including cassava is presented in Table 3. Economic data were obtained at the experimental station but later modified using field data from small farmers cultivating similar cropping systems. An estimate of the energy inputs in terms of GJ/ha (GJ = Gigajoule, or 10^9 joule) from labour, fertilizers, and insecticides and output energy of the edible yield of the plant components of each cropping system is also summarized in Table 3.

One important advantage of conducting long-term experiments with different types of cropping systems is that it is possible to use the experimental results to formulate general principles for cropping system design. The relationships between number of crops in a system, efficiency of resource use, and stability of yield are shown in Fig. 2 and 3. The LER, a measure of efficiency in resource use, has been reported for these cropping systems (Soria et al. 1975) and a positive linear relationship between LER and number of crops up to three in a cropping system is shown in Fig. 2. Stability of the different cropping systems, as measured by the coefficient of variability of total biomass produced by a cropping system, is summarized in Table 4 and graphically related to number of crops in a cropping system in Fig. 3. Stability is greatly increased by changing from one to two crops, but does not seem to be affected by increasing this to three crops.

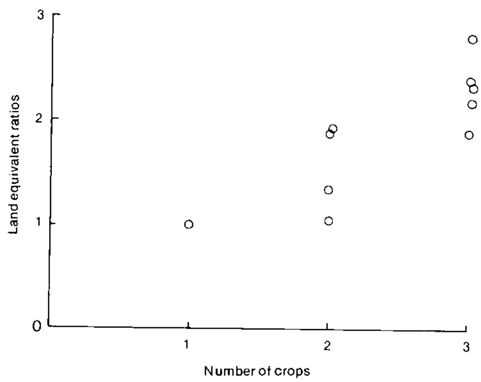


Fig. 2. Land equivalent ratio values and number of crops in different cropping systems tested at Turrialba, Costa Rica, 1974–78.

Suggestions for Future Research

Most of the research on cassava intercropping in Central America has been done at CATIE in Turrialba during the last 5 years. Most emphasis has been placed on studying the agronomic characteristics of the many existing traditional cropping systems to more fully understand them. Studies in depth of the interactions among the components of the systems are largely lacking, although plant pathology seems to be the exception to this situation (Moreno 1978). The switch from a disciplinary or crop-oriented approach to a more integrated or systems-oriented type of research has only recently begun at

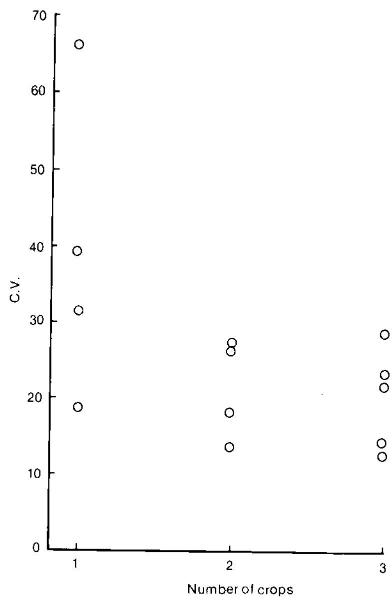


Fig. 3. Coefficient of variability of cassava, common bean, sweet potato, and maize in monoculture and different intercropping of these cultivars, Turrialba, Costa Rica, 1974–78.

Table 2. Yield (metric tonnes/ha) per plant component and Land Equivalent Ratios (LER) of 14 cropping systems, Turrialba, Costa Rica, 1974–78.

Cropping systems	Cassava	Beans	Maize	Sweet potato[e]	Sweet potato°[f]	% monocrop					LER
						C	B	M	SP	SP°	
01C[a]	16.827					100					1.0
B		1.389					100				1.0
M			2.955					100			1.0
SP				10.536					100		1.0
SP°					4.718					100	1.0
02C+B[b]	15.230	1.448				90.51	104.25				1.95
03C+M	7.801		2.766			46.36		93.60			1.40
04C+SP	9.719			6.282		57.76			59.62		1.17
05C+ → SP°[c]	18.671				4.171	110.96				88.41	1.99
06C+M → C+SP°[d]	8.684		3.475		3.595	51.61		117.60		76.20	2.45
07C+SP → C+SP°	11.497			5.560	3.496	68.33			52.77	74.10	1.95
08C+B → C+SP°	18.570	1.259			1.914	110.36	90.64			40.57	2.42
09C+B+M	11.088	0.775	2.911			65.89	55.80	98.51			2.20
10C+B+M → C+SP°	7.832	0.766	2.938		3.826	46.54	55.15	99.43		81.09	2.82

[a]C = cassava; B = common bean; M = maize; SP = sweet potato planted at first planting season; SP° = sweet potato planted at second planting season.
[b]+ = association of crops.
[c]→ = double cropping.
[d]Sweet potato intercropped in cassava.
[e]Planted at first planting season.
[f]Planted at second planting season.

Table 3. Economic evaluation and energy analysis of cassava-based cropping systems tested at Turrialba, Costa Rica, during 1974–78.

Variables	Cropping systems									
	01	02	03	04	05	06	07	08	09	10
Man-days/ha	127.51	167.09	153.38	145.12	182.97	197.79	170.30	248.54	175.57	214.88
Cost of labour (CA $/ha)[a]	447.93	586.97	538.81	509.79	642.75	694.81	598.24	873.09	616.76	754.85
Cost of inputs (CA $/ha)										
Fertilizer	179.7	141.74	148.59	193.42	179.47	237.69	235.54	237.71	215.62	281.91
Insecticide	0.9	11.32	13.47	17.45	5.93	26.48	19.04	17.25	19.28	7.92
Total inputs cost	180.6	153.06	162.06	210.87	185.40	264.17	254.58	254.96	234.90	289.83
Other										
Interest and depreciation 10%	62.85	74.00	70.09	72.07	82.82	95.90	85.28	112.81	85.17	104.47
Cost of land	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Total other costs	112.85	124.00	120.09	122.07	132.82	145.90	135.28	162.81	135.17	154.47
Total costs	293.45	277.06	282.15	332.94	318.22	410.07	389.86	417.77	370.07	444.30
Income										
Gross income (CA $/ha)	771.01	1527.21	850.30	1244.91	1655.09	1916.98	1679.38	1230.14	1470.65	1456.81
Net income (CA $/ha)	477.56	1250.15	568.15	911.97	1336.87	1506.91	1289.52	812.37	1100.58	1012.51
Family income (CA $/ha)	590.41	1374.15	688.24	1034.04	1469.69	1652.81	1424.80	975.18	1235.75	1166.98
Efficiency index (gross income/total costs)	2.63	5.51	3.01	3.74	5.20	4.67	4.31	2.94	3.97	3.28
Input energy GJ/ha[b]	13.23	13.60	14.40	15.41	15.19	23.04	22.34	27.83	22.12	29.50
Output energy GJ/ha	107.09	118.01	89.47	92.36	139.07	117.13	122.77	145.81	123.77	118.00
Energy out/in	8.09	8.68	6.21	5.99	9.16	5.08	5.50	5.24	5.60	4.00

[a] 1 CA $ = U.S. $1.
[b] 1 GJ = 10^9 joules.

Table 4. Variability (coefficient of variability) registered in different cropping systems during 3 years and three replicates each year, Turrialba, Costa Rica, 1974-77.

Cropping system	Average individual crops	Crop association
Cassava monoculture	39.93	-
Beans monoculture	18.78	-
Maize monoculture	13.46	-
Sweet potato monoculture	30.29	-
Sweet potato monoculture[a]	65.78	-
Cassava + beans[b]	33.04	27.54
Cassava + maize	28.76	18.09
Cassava + sweet potato	23.87	13.42
Cassava + sweet potato[a]	41.14	27.45
Cassava + maize + sweet potato[a]	31.05	21.44
Cassava + sweet potato → cassava + sweet potato[c]	26.91	23.79
Cassava + beans → cassava + sweet potato	35.34	28.51
Cassava + maize + beans	25.04	14.95
Cassava + maize + beans → cassava + sweet potato	27.57	13.25

[a]Sweet potato cultivated at the second planting season.
[b]+ = association of crops.
[c]→ = Sweet potato cultivated at the second planting season and intercropped in the cassava; └─┘ = same crop.

CATIE. The initial field experiments with cassava intercropped with other species were designed mainly to develop a methodology to study systems of mixed crop production rather than to improve on existing systems in the short term or to develop new ones.

Small farmers are the most important cassava producers in Central America. Studies of the ecological as well as the socioeconomic determinants of cassava-based production systems in specific locations are required to identify and delimit specific complexes and to evaluate their production potential throughout Central America. Simultaneously, alternative marketing channels should be investigated for each production complex both at the farm community and at the Central American level.

The integration of cassava-based systems and animal production has not been thoroughly investigated and consequently has not been promoted in Central America. Most of the rural population of this area (85%) live in regions under the climatic influence of the Pacific Ocean (IDB 1977). As a consequence, they suffer dry periods ranging from 5 to 7 months when no grass is available for animal feed. The potential of cassava as a food source under these circumstances, combined with forage trees, should be also investigated.

The role of cassava as an intercrop in the establishment of perennial plantations in the lowland tropics also deserves greater attention. Alternative mixed cropping systems including cassava should be developed for rural communities facing an unstable market as a means of reducing production risk.