

INTERCROPPING WITH CASSAVA

IN CENTRAL AMERICA

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INTRODUCTION

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 socio-economic conditions.

In the humid lowland tropics, cassava may be intercropped with perennial or semi-perennial crops, usually during the establishment phase of the latter; and frequently intercropped with maize in areas of lesser rainfall. Hernández, X. 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. Since 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* x *M. balbisiana*), pigeon peas (*Cajanus* sp.), maize and sugar cane (*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 semi-commercial 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 towards 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*, 1975) but there is a paucity of data on the ecological and socio-economic 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 CASSAVA INTERCROPPED USED BY SMALL FARMERS
IN CENTRAL AMERICA

1. 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 point of view 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.

2. 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 up 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 inter-specific 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 tassel 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 labor availability.

If the market conditions for fresh corn are favorable, 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 turns halved after doubling.

3. 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 upon 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.

4. 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. In order to return the land to pasture, the owner permits

neighboring small farmers or landless farmers to use the land for a three-year period, on the condition that the farmer plant pasture at the end of the cropping period. The three-year cropping system often consists on one-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 two years, but this three-crop cropping system is more commonly planted during the third year. The farmer plants pasture in the cassava after the maize and rice have been harvested.

5. Cassava and other tuber crops

One of the most interesting intercroppings with cassava is practiced in medium-size 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 concerned with cassava. Two of these

papers were presented by scientists from CATIE which described multi-species 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 largely been confined to cassava and maize systems.

Oelsligle, *et al* (1975) 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. An 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 hectare plots was conducted as part of CATIE's Annual Crops Program in Turrialba, Costa Rica^{1/}. It costs \$223 (U.S. Dollars) to produce one hectare of cassava intercropped with maize. The system produced a total output valued at \$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, 1975b) 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 two months, the maize successfully excluded the weeds during the third and fourth months, and from the fifth through the eighth month when the cropping period ended, the cassava canopy was developed enough to exclude weed invasion.

Holle^{2/} compared four cropping systems with cassava, maize, and snap beans. The maize and snap beans were planted both at the same time as the

1/ MATEO, N., BARRANTES, A. and MORENO, R. 1975. Unpublished results, CATIE, Department of Crops and Soils, Turrialba, Costa Rica.

2/ HOLLE, M. 1976. Unpublished results. Department of Crops and Soils. Turrialba, Costa Rica.

cassava and three 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 beans, maize and cowpea, and maize, beans and cowpea. Cassava yields were not reduced by maize alone, but were reduced by approximately 30% when either beans or cowpea was added to the cassava and maize. Maize yields were reduced by 60% when intercropped with cassava and beans or cowpea as compared to the maize yields obtained in the system without cassava. A comparison of total food energy and protein produced by the different cropping systems shows that the cassava, maize and cowpea cropping system produced the most carbohydrates and that the maize and bean cropping system produced 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, (Bieber 1975) the Multiple Cropping Program of CENTA (a research institute of the Ministry of Agriculture) conducted experiments comparing cassava intercropped with common beans, and cowpea. Cassava yields were reduced more by cowpea than by common beans, 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 three 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^{1/}. The cassava-plantain association was planted at a density of 8.890 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 third 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 savings of \$24/ha on the usual total weed control costs.

All of the experiments described above involve only short-term cropping periods of one year or less. A long-term evaluation and comparison of up to

1/ ENRIQUEZ, G. 1978. Unpublished results. Perennial Plants Program CATIE, Turrialba, Costa Rica.

4 years of different intercropping systems with cassava was conducted in Turrialba, Costa Rica 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 which included cassava are shown in Figure 1. The crop species, varieties, planting distances, and densities are summarized in Table 1.

The average yields over a three-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 while 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.

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 Figures 2 and 3. The Land Equivalent Ratio (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 3 in a cropping system is shown in Figure 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 3 and graphically related to number of crops in a cropping system in Figure 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.

SUGGESTIONS FOR FUTURE RESEARCH

Most of the research on cassava intercropping in Central America has been done at CATIE in Turrialba, Costa Rica, during the last five years. Most emphasis have been placed on studying the agronomic characteristics of the many existing traditional cropping systems in order 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 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 socio-economical determinants of cassava-based production systems in specific locations are required to

identify and delimit specific production 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 5-7 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.

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Table 1. Species, varieties, planting distances and density of planting of different cropping systems tested from 1974-78 in Turrialba, Costa Rica.

Species	Varieties	Planting distance (m) on the row	between rows	Density plants/ha
Beans (<u>Phaseolus vulgaris</u>)	CATIE-1	0.5	x 0.2	100.000
Maize (<u>Zea mays</u>)	Tuxpeño	1.0	x 0.5	40.000
Sweet Potatoes (<u>Ipomoea batatas</u>)	C-15	0.5	x 0.4	50.000
Cassava (<u>Manihot esculenta</u>)	Valenca	1.0	x 0.5	20.000

Table 2. Yield (TM/ha) per plant component and Land Equivalent Ratios of 14 Cropping Systems.

Turrialba, Costa Rica. 1974-1978

Cropping Systems	Cassava	Beans	Maize	Sweet Potato	Sweet Potato ^{6/}	% Monocrop				LER ^{7/}
						C	B	M	SP ^o	
1 C ^{1/}	16.827				100					1.0
2 B		1.389				100				1.0
3 M			2.955				100			1.0
4 SP				10.536				100		1.0
5 SP ^o					4.718				100	1.0
6 C+B ^{2/}	15.230	1.448				90.51	104.25			1.95
7 C+M	7.801		2.766			46.36		93.60		1.40
8 C+SP	9.719			6.282		57.76			59.62	1.17
9 C+ ^{3/} SP ^o	18.671				4.171	110.96				88.41
10 C+M + C+SP ^o ^{4/}	8.684		3.475		3.595	51.61		117.60		76.20
11 C+SP + C+SP ^o	11.497			5.560	3.496	68.33			52.77	74.10
12 C+B + C+SP ^o	18.570	1.259			1.914	110.36	90.64			40.57
13 C+B+M	11.088	0.775	2.911			65.89	55.80	98.51		2.20
14 C+B+M + C+SP ^o	7.832	0.766	2.938		3.826	46.54	55.15	99.43		81.09

1/ C = cassava; B = common beans; M = maize; SP = sweet potato planted at first planting season; SP^o = sweet potato planted at second planting season.

2/ + = association of crops 3/ = → double cropping. 4/ sweet potato intercropped in cassava.

5/ Planted at first planting season. 6/ Planted at second planting season. 7/ Land Equivalent Ratio.

Table 3. Variability (coefficient of variability C.V.) registered in different cropping system during three year and three replicates each year. Turrialba, Costa Rica 1974-1977.

Cropping Systems	Average Individual crops	Crop Association
Cassava Monoculture	39.92	-
Beans Monoculture	18.78	-
Maize Monoculture	13.46	-
Sweet Potato Monoculture	30.29	-
Sweet Potato Monoculture ^{1/}	65.78	-
Cassava + Beans ^{2/}	33.04	27.54
Cassava + Maize	28.76	18.09
Cassava + Sweet Potato	23.87	13.42
Cassava + Sweet Potato ^o	41.14	27.45
Cassava + Maize + Sweet Potato ^o	31.05	21.44
Cassava + Sweet Potato → Cassava + Sweet Potato ^{3/}	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

1/ Sweet Potato cultivated at the second planting season

2/ + = association of crops

3/ → = Sweet Potato cultivated at the second planting season and intercropped in the cassava.

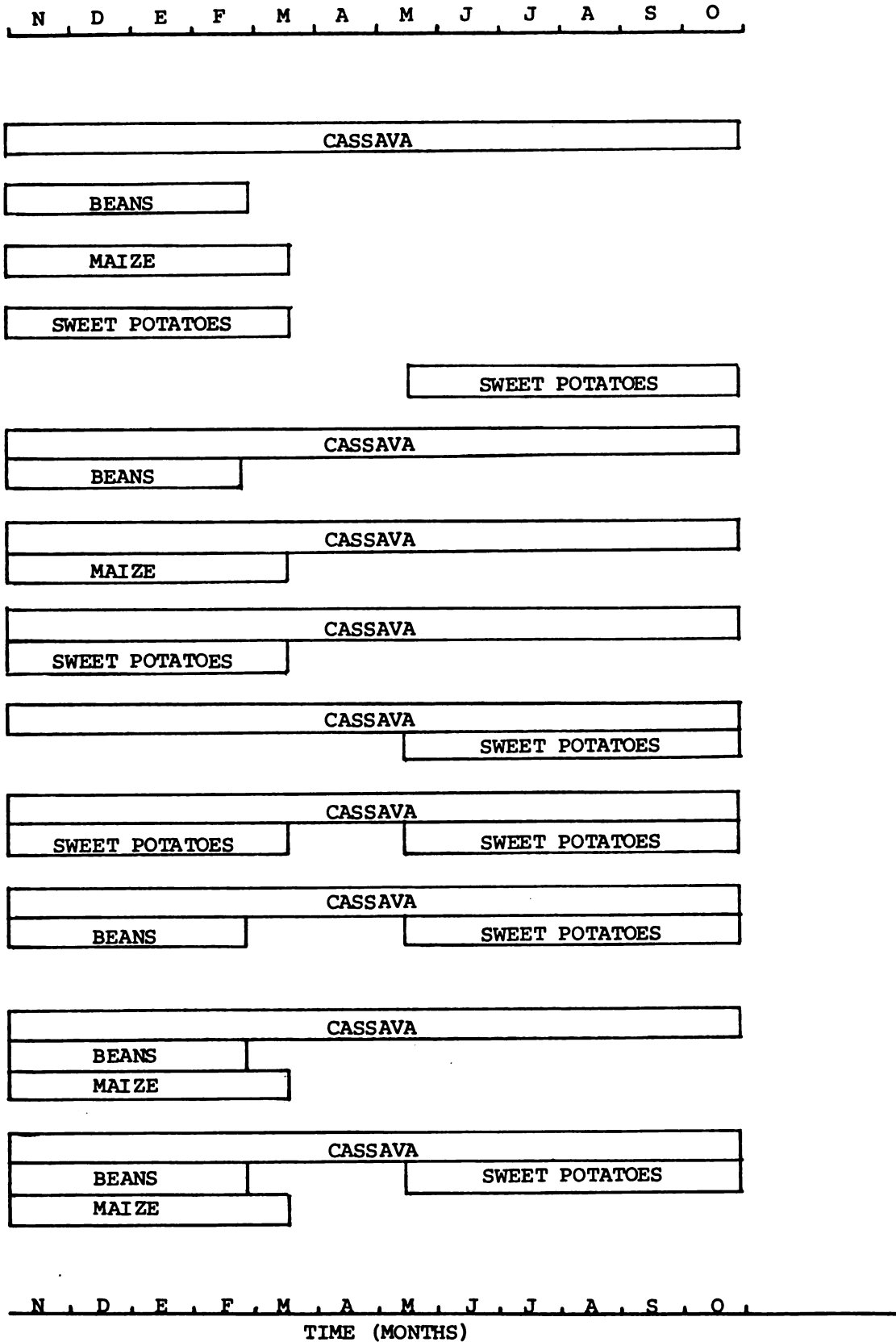


Fig. 1. Cropping patterns tested at Turrialba 1974-1978

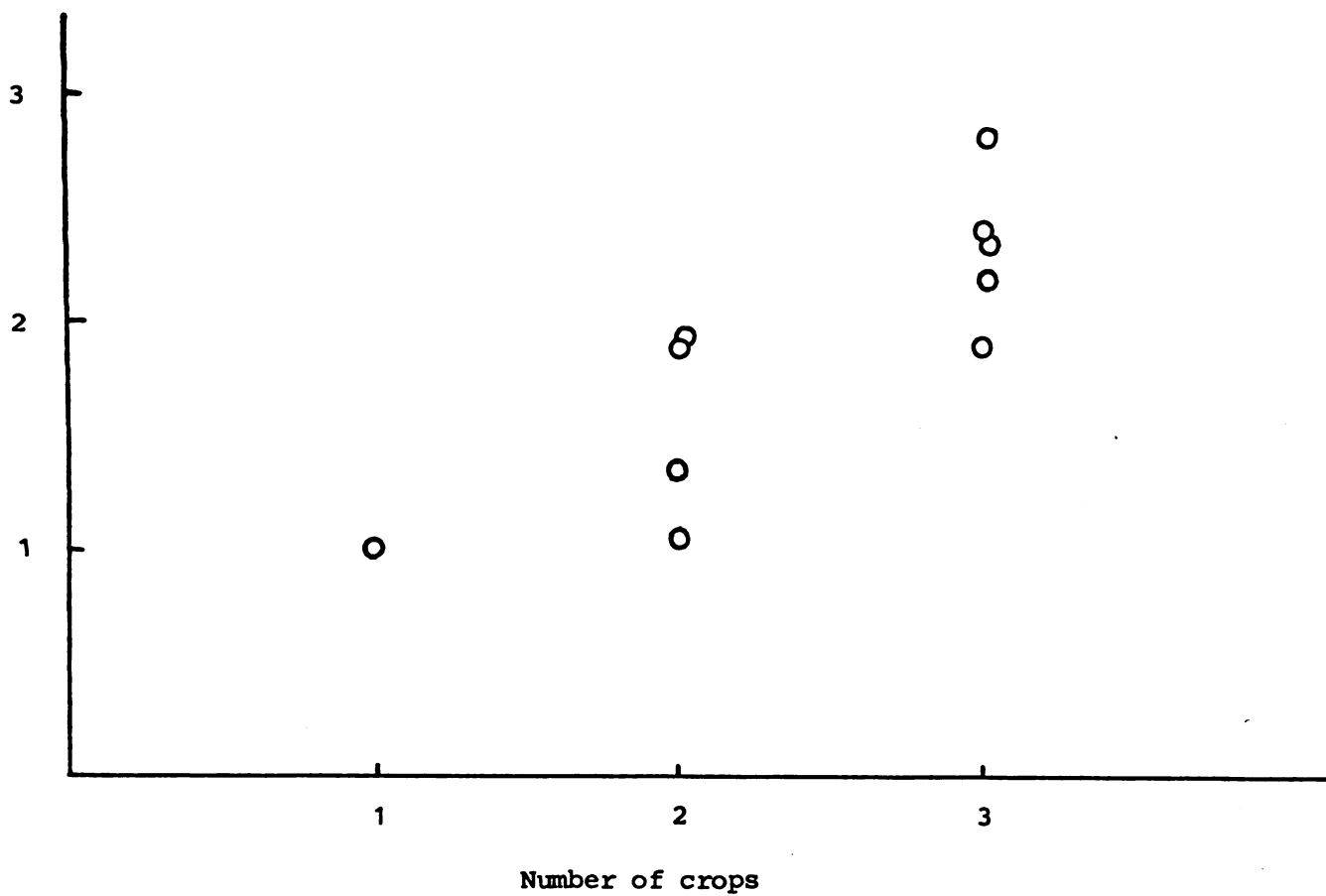


Fig. 2. Land equivalent ratios values and number of crops in different cropping systems tested at Turrialba, Costa Rica 1974-1978

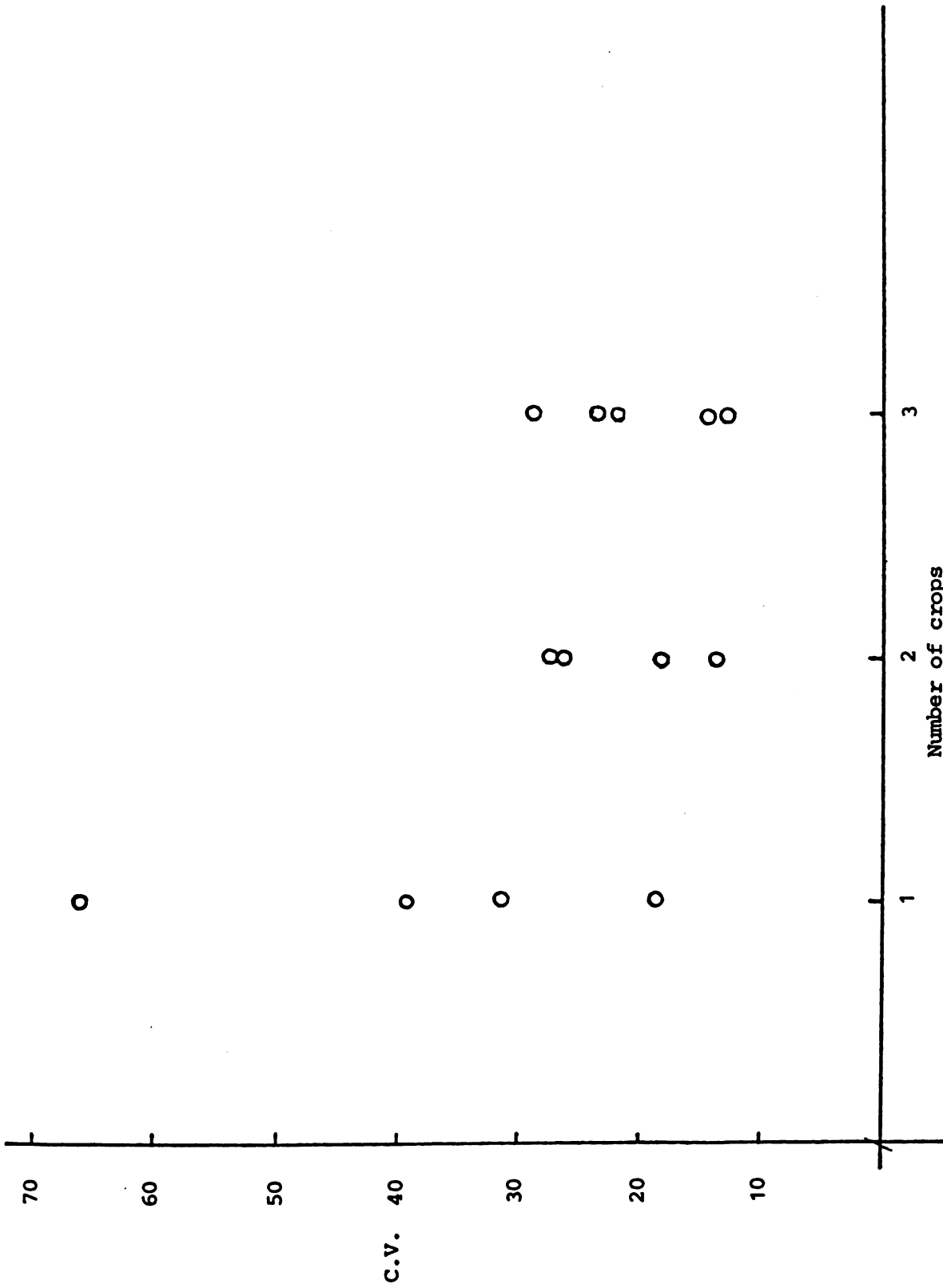


Fig. 3. Coefficient of variability of cassava, common bean, sweet potato and maize in monoculture and different intercropping of these cultivars. Turrialba, Costa Rica 1974-1978