Intercropping with Cassava

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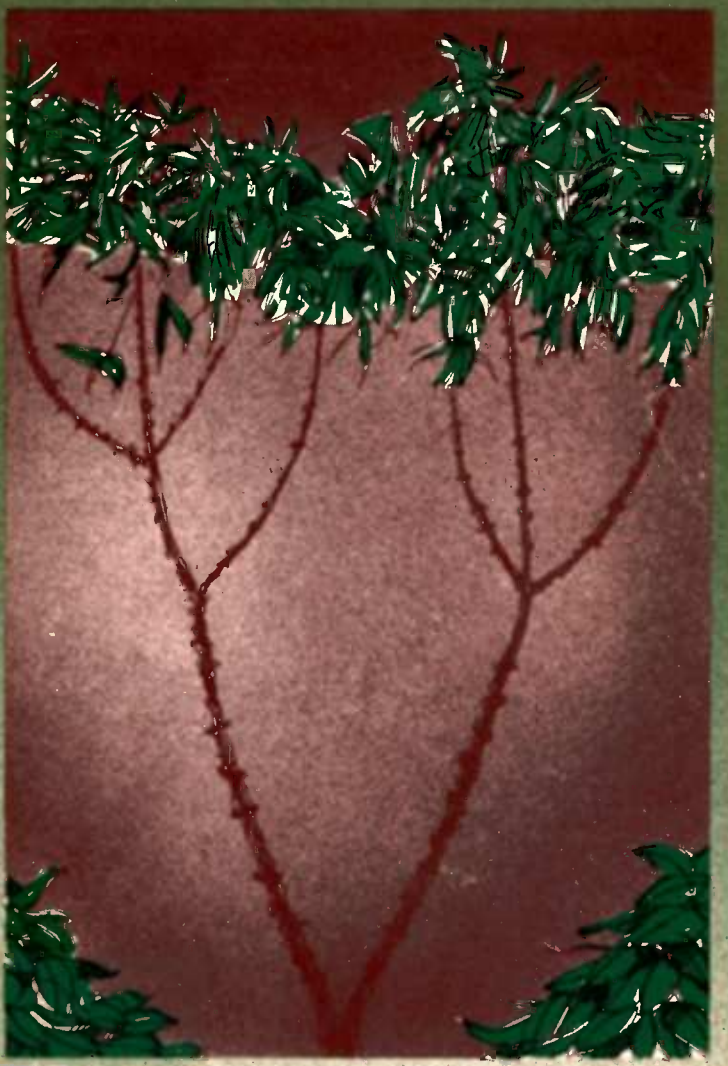

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Contents

Cassava and Cassava-Based Intercrop Systems in Thailand

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Thailand is the principal cassava exporting country in the world, earning over U.S. $370 million in 1977. Cassava is Thailand's second major export crop, next only to rice.

Cassava has become popular with farmers because it is easy to grow and has higher yield stability. Even in years of severe drought such as 1972–73 and 1977–78 the crop does not fail. In fact the range of yields is from 16.30 t/ha in 1969–70 (best year) to 12.12 t/ha in 1972–73 (the worst year) (Table 1). Other advantages are a high flexibility in planting time (May to November) and no major pests or diseases; as well, the farmers can wait up to a month for better prices even after the tops are cut, and the harvesting time is from 8 to 14 months after planting.

It is for these reasons that the area under cassava has progressively increased from about 100 000 ha in 1965–66 to well over 800 000 ha in 1977–78 (Table 1). Next to rice and corn, cassava occupies the largest area. The minor fluctuations from year to year are due to the price differential between cassava and sugarcane in the East or kenaf in the Northeast. When the price of cassava goes down relative to kenaf or sugarcane, the area under cassava comes down.

In the past, the main cassava area was in the East Region of Thailand. Today, the major cassava area is in the Northeast Region accounting for 64% of the area, followed by the East Region (29%), and the rest of the country (7%).

Cassava Intercropping Patterns and Management Practices

Crop Combinations and Arrangement

Cassava is grown in Thailand essentially as a sole crop. The crop is planted square 1 m × 1 m. The planting date is from May to as late as November; the majority of the area is planted in May–June.

Intercropping of cassava is practiced to a very limited extent: with corn in the uplands and with young coconut or rubber plantations. A 1:1 row ratio of cassava–corn is most frequently used, the corn

Table 1. Cassava-planted area, production, and farm value, 1965/66–1977/78.

Year	Planted area ('000 ha)	Avg yield (t/ha)	Production ('000 t)	Far price ($/t)	Farm Value (million $)
1965/66	101	14.59	1475	-	-
1966/67	129	14.67	1892	-	-
1967/68	140	14,33	2000	20.0	40.0
1968/69	170	15.39	2611	16.5	43.1
1969/70	189	16.30	3079	27.0	83.1
1970/71	224	15.32	3431	23.5	80.6
1971/72	220	14.15	3114	26.0	81.0
1972/73	328	12.12	3974	23.5	93.4
1973/74	432	13.12	5668	17.0	96.4
1974/75	473	13.19	6240	15.0	93.6
1975/76	593	13.65	8100	20.5	166.0
1976/77	697	14.54	10138	23.0	233.2
1977/78[a]	960	12,88	12372	17.28	213.8

[a]Preliminary figures.
Source: Division of Agricultural Economics.

row being 50 cm from the adjacent rows of cassava. A population density of 10 000 plants of cassava per ha and of 10 000 plants or less of corn per ha is common. Both cassava and corn are planted simultaneously either in May or June.

Current research on cassava-based cropping systems using mungbean, peanut, and soybean as component crops is described later in this paper.

Characteristics of Cassava used in Intercropping

Almost all the cassava grown in Thailand is the "bitter type" for processing as animal feed. The most popular variety is Rayong, a local variety, which grows to a height of 3 m; none of the introduced varieties have proved superior.

The variety produces one to two branches close to the ground level. The expression, however, is influenced by spacing. The wider the row spacing, the higher is the number of branches.

"Diameter" of the canopy increases from 34 cm at the end of 1 month to 66, 104, and 138 cm at the end of 2, 3, and 4 months respectively. Subsequent canopy increases are small.

The crop is ready for harvest 12 months after planting and may be kept in the field up to 14 months, beyond which the roots become too fibrous for processing.

At harvest, there are three to seven marketable roots per plant; their average diameter is 6.3 cm, length varies from 20 to 50 cm, and specific gravity is 1.10. Harvest index is 0.50.

Potential yield is about 37 t/ha.

Land Preparation and Agronomic Practices

Field preparation starts with rains in the month of May and consists of ploughing 15–20 cm deep with a tractor once or twice, followed by one or two disc harrowings. Hills, 1 m apart, are marked by hoes.

Cuttings 25 cm long taken from suberized (not green) stem excluding the lowest 20 cm are planted one per hill. Planting may be vertical, inclined, or horizontal. In slightly heavy texture soils, vertical planting is preferred as it facilitates harvesting of the roots.

Intercrop is planted by hand dibbling in furrows between the cassava rows.

Interculture and weeding is done manually, the first one about 1 month after planting and the second 45–60 days later. Some farmers practice earthing up the individual plants by hand or the entire row using animal power.

Harvesting is also done manually around 12 months after planting.

Common Inputs and their Levels

Cassava is rarely fertilized. If any, fertilizers are applied immediately after the first interculture. The crop does not need and, therefore, does not receive any plant protection measures. The inputs are mainly the family labour, except for hired labour at planting, weeding, and harvesting. Planting material is obtained from the previous crop. Thus cassava is a low monetary input cash crop in Thailand.

Major Problems, their Effect and Control

The most serious field problem is weeds; this has been aggravated by a rapid increase in the area under cassava and a consequent labour shortage. This is perhaps one of the main reasons why farmers are averse to intercropping cassava.

Another serious field problem is the declining soil fertility as the crop is rarely fertilized and the yield of cassava is steadily declining. Fertilizer costs are prohibitively high. Till recently, farmers made use of cleared virgin lands but such lands are becoming scarcer.

The low price of cassava, dictated by foreign markets, is a problem over which neither the individual farmer nor the individual country has any control. Prices dropped from U.S. $23.00 per metric tonne in 1977 to $17.28 in the early part of 1978.

Some of the more recent approaches to meet the problems of weeds and declining soil fertility are described later in the paper. The price problem remains unsolved. Price negotiations held between Thailand and the importing countries have not proved beneficial to the producers.

Environmental Description

Rainfall

Climatic data for the 25-year period 1951–75 for the two major cassava-growing regions are given in Table 2.

In both major cassava-growing regions, the normal onset of major rains (over 100 mm/month) is in May and termination is in October. The rainfall is heavier and more reliable in the East Region than the Northeast Region. Both the regions are dominantly dry with 6 consecutive months (November to April) receiving less than 100 mm rainfall per month.

Temperature and Solar Radiation

In no month is the mean temperature less than 20 °C either in the East Region or in the Northeast Region, although the latter tends to be cooler in the winter months.

In both the regions cloudiness is 6.0 or more from May to September. The East is cloudier (mean 5.4) than the Northeast Region (4.9), the maximum difference being in October.

Table 2. Climatological data of cassava-growing area in the Northeast Region of Thailand (6 stations)[a] for the period 1951–75.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)													
Mean	23.3	25.9	28.4	29.8	29.1	28.2	27.9	27.7	27.1	26.6	25.0	23.2	26.8
Mean max	30.3	32.7	35.0	36,1	34.6	33.0	32.5	31.9	31.4	31.0	30.3	29.6	32.4
Mean min	16.0	18.8	21.8	23.7	24.4	24.3	23.9	23.8	23.7	22.4	19.6	13.6	21.6
Ext. max	37.8	41.0	41.8	43.9	42.6	40.1	38.0	37.7	38.0	35.9	37.2	35.8	43.9
Ext. min	2.5	9.4	10.0	11.8	20.0	19.7	19.6	20.0	19.3	14.0	8.4	5.5	2,5
Relative humidity (%)													
Mean	63.7	61.8	61.1	64.4	73.1	76.4	77.6	79.9	82.1	77.9	71.5	66.9	71.4
Mean max	86.6	84.3	83.0	84.5	89.5	91.1	91.4	92.7	94.0	91.5	89.3	88.0	88.8
Mean min	42.9	41.5	41.0	44.2	54.4	60.6	61.8	64.5	66.7	61.6	53.1	46.9	53.3
Ext. min	11.0	10.0	12.0	18.0	23.0	28.0	36.0	37.0	36.0	26.0	21.0	15.0	10.0
Cloudiness (0–8)													
Mean	2.9	3.2	3.6	4.4	5.8	6.5	6.6	6.9	6.4	5.0	3.9	3.2	4.9
Rainfall (mm)													
Mean	5.2	18.6	42.1	77.4	180.3	175.5	178.5	200.5	290.1	110.0	17.9	2.4	1303.5
Mean rainy days	1.1	2.5	4.8	7.5	15.2	15.6	16.8	18.2	19.5	10.1	2.4	0.7	114.0

Source: Meteorological Department, Ministry of Communications.

[a]Udon Thani, Khon Kaen, Roi Et, Surin, Nakhon Ratchasima, Chaiyaphum.

Soil Characteristics

The major Great Soil Group on which cassava is grown in Thailand is Gray Podzolic Soils. In the Gray Podzolic Soils, the Korat Soil Series is the most extensive.

As a rule the cassava soils are light, moderate to excessively drained, with level to undulating topography.

pH is 5.0–6.0 in the surface soil and decreases with depth. The pH of subsoil ranges from 4.5–5.0 in the subsurface to as low as 3.8–4.0 at the lowest depth.

The soils are highly leached with low base saturation (35–50%) and with low N, available P, and possibly K.

Soils are droughty. Available moisture storage ranges from 60 to 80 mm per metre of soil.

Location of Area

The Eastern area is located between 12° 30′ and 14°N, 101° and 103°E. Rayong, the main cassava research centre, is situated in this area (12° 40′, 101° 15′). The Northeast Region lies between 14° and 18°N, 101° 30′ and 105° 30′E.

Socioeconomic Factors

Farm Size and Area Cropped

The average farm holding in the Northeast increased from 3.5 ha in 1962 to 5.1 ha in 1974, of which about 70% is planted.

Information on the proportion of farm in cassava and its associates is not easily available. In the Northeast Region about 10% of the cropped area is under cassava; among the upland field crops, cassava occupies 30% of the area.

Rural Population Density

The population of the Northeast Region was 14.7 million in 1976. Of this, 95.7% is rural population. The density works out to about 88/km^2. Khon Kaen and Nakhon Ratchasima are the only two cities in the Region.

Capital Investment

The major input for crops in Thailand including cassava is labour. Cassava is more labour intensive.

Power Input

Power input consists of the following: mechanical power for primary tillage and transport; animal power for some of the secondary tillage; and hand labour for planting, weeding, and harvesting.

Markets for Output

Cassava in Thailand is predominantly for sale, mostly as pellets. The farmer sells all his cassava. Thailand exports about 95% of the production; domestic use is about 5% as animal feed, flour etc. (Table 3).

Research Highlights

None of the cassava introductions outyielded Rayong No. 1, a selection from the local variety. Hybrids have been developed and are in the testing stage. Screening of cassava varieties suitable for intercropping will be initiated.

Spacings of 80 × 100 cm^2, 100 × 100 cm^2, and 120 × 100 cm^2 were not significantly different. Recommended spacing is 100 × 100 cm^2 for a sole crop. Best planting time is from May to June and from September to October. If moisture is adequate, cassava may be planted from April to November.

Yield remained the same whether the cuttings were planted vertically, inclined, or horizontally. The roots were easier to harvest in slightly heavy soils when cuttings were planted vertically.

The root yields progressively increased from 6 to 16 months. The recommended harvest time is 12 months after planting, although the highest marketable yield is obtained at 14 months.

Harvest at 14 months shifted the planting date of the crops in the following year and if the crop came to harvest at the end of October no crop could be taken that year. Thus three crops of 14 months' duration used, in effect, 4 years. From Table 4 it is clear that four 12-months' crops planted in June yielded (31.50 × 4) 126.0 of root whereas three 14 months' crops yielded (38.69 × 3) 116.1. Even if this difference was not statistically significant, a 14 months' crop upsets the normal schedule of operations and may have peak labour demand at times when it was not available or when it was needed for rice, the staple food crop.

Rapid propagation methods are under study.

Highest response was obtained to N, medium response to P, and least to K. Up to 50–50–25 kg N, P_2O_5, K_2O per ha were recommended for medium fertility soils and twice these levels for poor soils. The exact levels of P and K depended upon soil tests.

Recent Approaches and Current Research

Year-round tillage for effective weed control and preparation of land well in advance, making use of the off-season rains are recent approaches to improving cultivation. Tillage just before the heavy

Table 3. Volume (tonnes) and values (U.S. $'000) of cassava products exported, 1968–77.

Year	Chips		Pellets		Flour		Other		Total	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
1968	323209	11040	–	–	532416	2 167	33229	997	888854	38184
1969	56394	2115	752751	30462	148939	10089	17057	608	975141	43274
1970	8111	361	1163985	49353	148681	10430	6088	263	1326865	60407
1971	2500	122	962294	48148	151558	12573	5338	329	1121169	61172
1972	2404	106	1177422	64567	129797	11652	1415	84	1311038	76409
1973	18198	1240	1638677	104191	176793	19624	2568	206	1836236	125261
1974	105328	7090	2031484	143768	253190	38415	2153	167	2392155	189440
1975	70594	5946	2168742	198909	144703	22015	1407	114	2385446	2$6984
1976	42544	4004	3441327	329228	236517	38422	322	77	3720710	371731
1977	65604	5799	3678530	342999	201263	32250	827	182	3946224	381230

Source: Division of Agricultural Economics.

Table 4. Yield of cassava fresh root planted from May to October and harvested at 6–16 months (1974).

Planting date	Harvested ages (*months*)						Avg
	6	8	10	12	14	16	
			t/ha				
May	13.00	15.87	19.87	28.25	40.44	43.87	26.87b
Jun	11.06	17.31	24.12	31.50	42.25	52.56	29.81a
Jul	9.56	13.50	21.06	26.50	41.12	50.12	27.00b
Aug	6.75	10.31	17.00	20.87	35.81	42.12	22.12c
Sep	3.44	8.44	14.81	23.12	41.81	44.75	22.75c
Oct	0.94	5.37	13.19	24.81	30.50	36.37	18.56d
Avg	7.44 f	11.81 e	18.37 d	25.87 c	38.69 b	44.94 a	C.V. = 11.93%

L.S.D. (0.05) for planting date × harvested ages = 5.44 t/ha.

Table 5. Intercropping of cassava with food legumes (mean of 9 locations, 1973–75).

Planting pattern	Yield		Relative to sole cassava (%)
	Intercrop (*kg/ha*)	Cassava (*t/ha*)	
Sole cassava	-	27.64a	
Cassava + mungbean	767	26.42a	95.58
Cassava + soybean	686	26.74a	96.74
Cassava + peanut	910	24.51b	88.67

rains merely redistributes the weeds without controlling them.

Studies on restoration of soil fertility and productivity through cropping systems with major emphasis on intercropping were initiated in 1970. The first 2 years were devoted to identification of suitable intercrops. From 1972 to 1976 cassava-based systems using peanut, soybean, mungbean, and corn were studied using 50–50–25 kg N, P_2O_5, and K_2O/ha with two rows of legume or one row of corn between two rows of cassava 100 cm apart. The spacing of legumes within the row was 20 cm and of corn 50 cm. There was no significant reduction of cassava yield with mungbean or soybean (Table 5). The yield reduction was highest with corn for grain (Table 6).

However, the most promising intercrop systems for the Northeast and East Region appeared to be cassava–peanut and cassava–mungbean.

Having established promising cropping systems, the next step will be to recycle the legume residues either through an animal or to incorporate them directly into the soil.

Crop Geometry and Planting Patterns

Interculture of an intercropped cassava is difficult particularly when the row number of intercrops increases. To overcome this, planting the intercrop in the same row as cassava (leaving interrow space vacant for easy interculture by using animal power) was tested alone and in combination with intercrops between two cassava rows.

Table 6. Intercropping of cassava with corn for cobs and for grain.

Planting pattern	Yield		% relative to sole
	Intercrop	Cassava (*t/ha*)	
Sole cassava	-	25.89a	
Cassava + corn (cob)[a]	27144 cobs/ha	24.17a	93.35
Sole cassava	-	28.26a	
Cassava + corn (grain)[b]	1117 kg/ha	22.56b	79.83

[a]Mean of 4 experiments (1974–76).
[b]Mean of 2 experiments (1973).

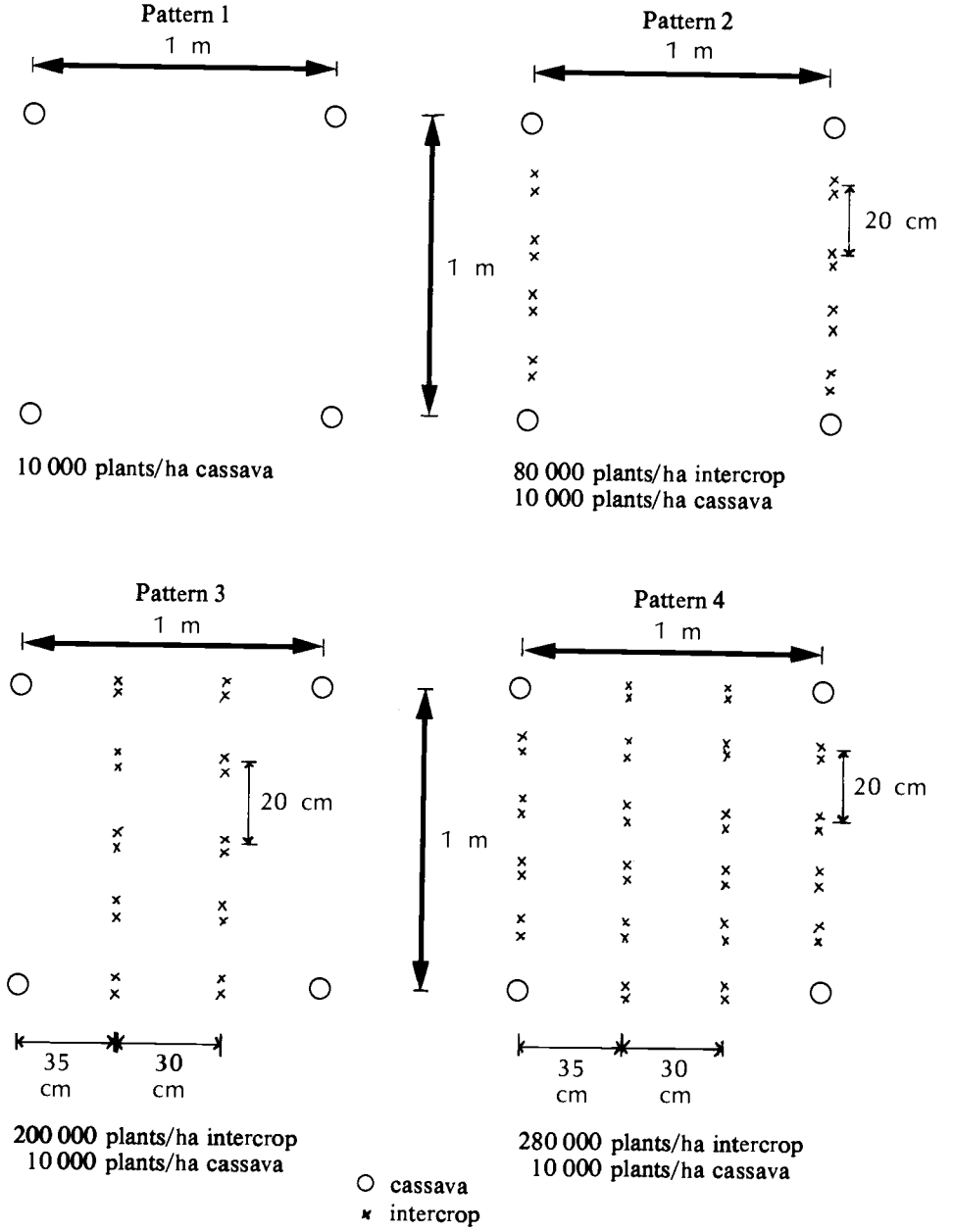

Fig. 1. Planting patterns.

The four planting patterns are given in Fig. 1. The intercrops were mungbean, soybean, and peanut; yield data are given in Table 7. The yield of cassava was not significantly reduced by the planting pattern of mungbean or peanut, unlike soybean. The data also bring out clearly the need for increasing the plant population density (or row number) of mungbean and peanut to make the system more productive. For mungbean, the density may be higher than 280 000 plants/ha and for peanut at least 200 000 plants/ha. Optimum plant density of soybean needs confirmation.

In all these studies, square planting (1×1 m^2) of cassava was adopted, which imposes a severe re-

Table 7. Planting patterns of mungbean (mean of three experiments, 1975–76), soybean (mean of four experiments, 1975–76), and peanut (mean of four experiments, 1975–76) with cassava.

Planting patterns	Yield				% Relative to sole cassava
	Mungbean (*kg/ha*)	Soybean (*kg/ha*)	Peanut (*kg/ha*)	Cassava (*t/ha*)	
Mungbean					
Sole cassava	–	–	–	27.55a	–
Cassava+1-row mungbean	425a	–	–	26.08a	94.66
Cassava+2-row mungbean	679b	–	–	24.16a	87.69
Cassava+3-row mungbean	809c	–	–	24.62a	89.36
Soybean					
Sole cassava	–	–	–	32.35a	–
Cassava+1-row soybean	–	584a	–	26.37b	81.51
Cassava+2-row soybean	–	648a	–	26.21b	81.02
Cassava+3-row soybean	–	745a	–	27.77b	85.84
Peanut					
Sole cassava	–	–	–	30.46a	–
Cassava+1-row peanut	–	–	467a	30.42a	99.86
Cassava+2-row peanut	–	–	722b	28.94a	95.01
Cassava+3-row peanut	–	–	752b	27.22a	89.36

striction on crop geometry of the intercrops. A new approach will be to determine how much widening of the cassava rows is possible without significantly affecting its yield and superimpose the best crop geometry of the intercrop. The population density of all the component crops will be maintained as close to the optimum as possible.

Relay Cropping

Existing information shows that it is best to plant both the component crops simultaneously. This is because of the general reduction in yield with delayed planting. However, as cassava has a flexible planting time (unlike most other crops), it was felt that there would be some advantage in planting the intercrop first and delay the planting of cassava. Peanut, soybean, and mungbean were planted in May, July, and August respectively and cassava was planted 0, 20, and 40 days after planting the legumes.

Data are given in Table 8. The C.V.'s are high and it is difficult to draw valid conclusions. However, the indications are that mungbean and cassava or soybean and cassava may be planted simulta-

Table 8. Cassava–mungbean, cassava–soybean, and cassava–peanut relay crop system.

Planting of cassava after other crop (*days*)	Yield			
	Mungbean (*kg/ha*)	Soybean (*kg/ha*)	Peanut (*kg/ha*)	Cassava (*t/ha*)
Mungbean				
0	1106a	–	–	27.44a
20	753a	–	–	18.87b
40	925a	–	–	24.50ab
C.V. (%)	23.10	–	–	28.30
Soybean				
0	–	612a	–	24.00a
20	–	837a	–	12.56b
40	–	650a	–	3.19c
C.V. (%)	–	27.8	–	33.38
Peanut				
0	–	–	719b	23.12ab
20	–	–	1262a	24.56a
40	–	–	1212a	20.50b
C.V. (%)	–	–	25.4	26.30

Table 9. Yield and gross income of cassava and cassava intercrop systems.[a]

Intercrop system	Yield		Gross income ($/ha)		
	Intercrop	Cassava	Intercrop	Cassava	Total
	kg/ha	*t/ha*			
Sole cassava	-	27.64	-	635.72	635.72
Cassava + mungbean	767	26.42	230.10	607.66	837.76
Cassava + soybean	686	26.74	226.38	615.02	841.40
Cassava + peanut	910	24.51	209.30	563.73	733.03
Sole cassava	-	28.26	-	649.98	649.98
Cassava + grain corn	1117	22.56	99.41	518.88	618.29
	cob/ha	*t/ha*			
Sole cassava	-	25.85	-	594.55	594.55
Cassava + cob corn	27144	24.17	670.46	555.91	1226.37

[a]Farm price (1976/77): Cassava $23.00/t; Mungbean $0.30/kg; Soybean $0.33/kg; Peanut $0.23/kg; Corn grain $0.089/kg; Corn cob $2.47/100 cobs

neously and peanut may be planted 20 days earlier than cassava. The indications await confirmation.

Testing of Cropping Systems

On the Experiment Stations, land equivalent ratios (LER) of 1.50–1.75 have been obtained with some of the intercrop systems of cassava (Table 10).

Table 10. Land equivalent ratio (LER) of three patterns of planting of mungbean, soybean, and peanut in cassava intercropping.

Planting pattern	LER of the system		
	Mungbean	Soybean	Peanut
Sole cassava	1.00	1.00	1.00
Cassava + 1-row	1.46	1.02	1.45
Cassava + 2-row	1.51	1.32	1.60
Cassava + 3-row	1.75	1. 2	1.44
Sole legume	1.00	1.00	1.00

They are also shown to generate more gross income than sole crops (Table 9). How these systems would perform in farmers' fields and under farmers' conditions needs to be ascertained. Operational difficulties at the farmers' level have to be solved before the cropping systems could be extended on a large scale.

Intercropping of cassava with mungbean or peanut has been tested on farmers' fields in large plots. The selected farmers have been growing a sole crop of cassava for years. According to them intercropping with legumes needs more attention because of pests and diseases than a sole crop of cassava. Weed management is particularly difficult. Besides, the season 1974–75 was not favourable for the legumes and the farmers could not see the economic advantage.

Acknowledgment

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