A review of banana/plantain cropping systems.

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LES SYSTEMES DE PRODUCTION EN ASSOCIATION AVEC BANANIER/PLANTAIN.

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RESUME - Le concept de cultures associées est précisé. On présente les avantages, exigences et possibilités de réalisation d'association du bananier ou plantain avec diverses cultures vivrières à cycle court, dans différents environnements. Exposé des résultats des effets des associations sur le rendement, le cycle, les concentrations en éléments nutritifs en relation avec les changements de propriétés chimiques du sol, l'enherbement, les ravageurs et les maladies. Les expérimentations démontrent que l'adoption de cultures associées aux bananiers/plantains peuvent tendre à optimiser les ressources naturelles et le travail.

INTRODUCTION

On a world wide basis, most export bananas are grown in large acreages in pure stand viz monoculture. In the Windward Islands on the other hand, where numerous small farmers contribute a substantial quantity of fruit for export (30 %), intercropping banana with a variety of permanent fruit trees, food crops and vegetables is a common practice (HENDERSON and GOMES, 1979 and RAO, 1979). This is also true for small farmers in the humid tropics of Africa (KARIKARI 1972 ; DEVOS and WILSON, 1979), Asia (RANDHAWA and SHARMA, 1972 and SUBBAIAH et al., 1980) and the Pacific (RATHEY R., 1982, personal communication). The primary reasons given for plantain/banana intercropping are (a) to have extra food and cash return (DEVOS and WILSON, 1979) (b) to reduce the cost of plantation establishment (RUTHENBERG, 1976) and to suppress weed growth (FONGYEN, 1976).

From Nigeria, DEVOS and WILSON (1978) reported that intercropping of plantain with cocoyam did not reduce the plantain yield or delay harvest. However, in another study it was observed that the associated growth of maize and cassava with plantain, extended days to harvest significantly with no reduction in the yield (DEVOS and WILSON, 1979). In India, SUBBAIAH et al. (1980), noted that growing short duration pulses like greengram and blackgram increased the bunch yield of banana significantly.

Over the past few years, the main objectives of banana intercropping research at WINBAN has been to improve the existing banana land use by more intensive cropping and to enhance the nutritional base of banana farmers.

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This paper highlights some basic concepts, feasibilities and experimental evidences of banana/plantain intercropping in different production environments.

PRINCIPLE

The principle of intercropping is in line with ecological systems in nature where the niches created by the larger species are successfully utilised by the ecologically smaller ones ; this progressive accommodation ensures a high and efficient utilisation of the energy in the ecosphere and leads to maximum production.

CONCEPT

Intercropping in effect is a synonym to «parallel multiple cropping» where two or more crops of dissimilar growth habits are made to grow simultaneous in such a way that they do not adversely affect the performance of each other. Thus, there should exist a situation of zero competition between the crops to be grown parallel, ensuring better utilisation of the natural resources in time and space.

ADVANTAGE OF INTERCROPPING

Intercropping permits more intensive cropping with crops which are traditionally grown in «single cropping». Banana, sugarcane and cassava are some of the examples of such crops. The optimum row spacing of banana is usually 2.5 m or more because the plants have a large lateral spread when fully grown. Much of this space remains unutilised for a period of 150 days, as the initial rate of growth is rather slow. The vacant space, in between the rows, can quickly be covered by weeds, which, when allowed to grow eventually compete with the main crop. Instead of such waste of available space, intercropping offers an opportunity for profitable utilisation of such space while cutting down on the direct cost of weed control in the cultivation of the main crop.

Increase total net returns due to intercropping could thus encourage farmers to follow this practice over pure banana cultivation.

REQUIREMENTS OF INTERCROPPING

The practice of intercropping (in this report, reference is only made to the plant crop situation) would require raising short duration, quick growing crop(s) in the space left in between the rows of a long duration main crop. The short duration crop(s) should require, for its (their) full growth and production only that much space as is left unoccupied by the main crop in point of time. Such an intercropping situation would theoretically give a growth and production of associated crops with no competition between them. The concept can diagramatically be illustrated by Fig. 1. The situation illustrated can find its practical example in parallel growth of cowpeas or tomato and maize with banana/plantain.

The leaf area of cowpeas reaches its maximum in about 40 days and is ready for harvest by about 70 days (Fig. 1). Maize takes over the cowpeas at this time and continues up to 120 days. At this stage, the banane canopy may cover the interspaces completely. From the figure it can be seen that it is also possible to grow two short duration crops of cowpeas one after the other before complete interception of the light by banana.

EXPERIMENTAL RESULTS AND DISCUSSION

Effect of Cropping Systems on Banana/Plantain yield :

DEVOS and WILSON (1979) reported from Nigeria that intercropping of plantain with maize, cocoyam, cassava and their mixtures did not influence the plantain yield significantly (Table 1). However, the associated growth of intercrops increased the yield slightly viz. by 5.4 % and 5.8 % respectively on a cycle basis and on a day basis over sole plantain. Earlier findings by the same authors (DEVOS and WILSON, 1978) showed non-significant differences in plantain yield when intercropped with cocoyam.

A banana intercropping trial was carried out by SUBBAIAH et al. (1980) for two years (1976-1977 and 1977-1978) in South India with greengram, blackgram, onion, okra and cowpeas (Table 2). The results indicated that the associated growth of greengram and blackgram significantly increased the banana yield. This increase in banana yield was attributed to increase in available nitrogen content of the soil owing to the ability of these intercrops to successfully fix atmospheric nitrogen (Table 8). Cowpeas, though a legume, did not significantly affect the bunch yield of banana. This is probably because under shaded conditions, nodulation was poor in this crop. This was confirmed by the smaller amount of available nitrogen in the soil in this treatment (Table 8).

SEEYAVE and BAYNES (1974) conducted a classical experiment involving intercropping of banana with cowpeas once and twice in succession, cowpeas followed by maize, maize once and sweetpotato once at varying intercrop densities (2 rows at 60 cm and 3 rows at 60 cm) on two volcanic soils in St. Lucia and Grenada. The intercrops received fertilizer at recommended rates. At both sites, the differences in banana yield due to various treatments were non-significant (Table 3). In fact, the banana yield in monoculture was slightly lower as compared to the yield in different intercrop associations. Intercrop densities did not significantly influence the banana yield at both locations. The banana yield of the first ratoon in St. Lucia was also unaffected by different cropping systems.

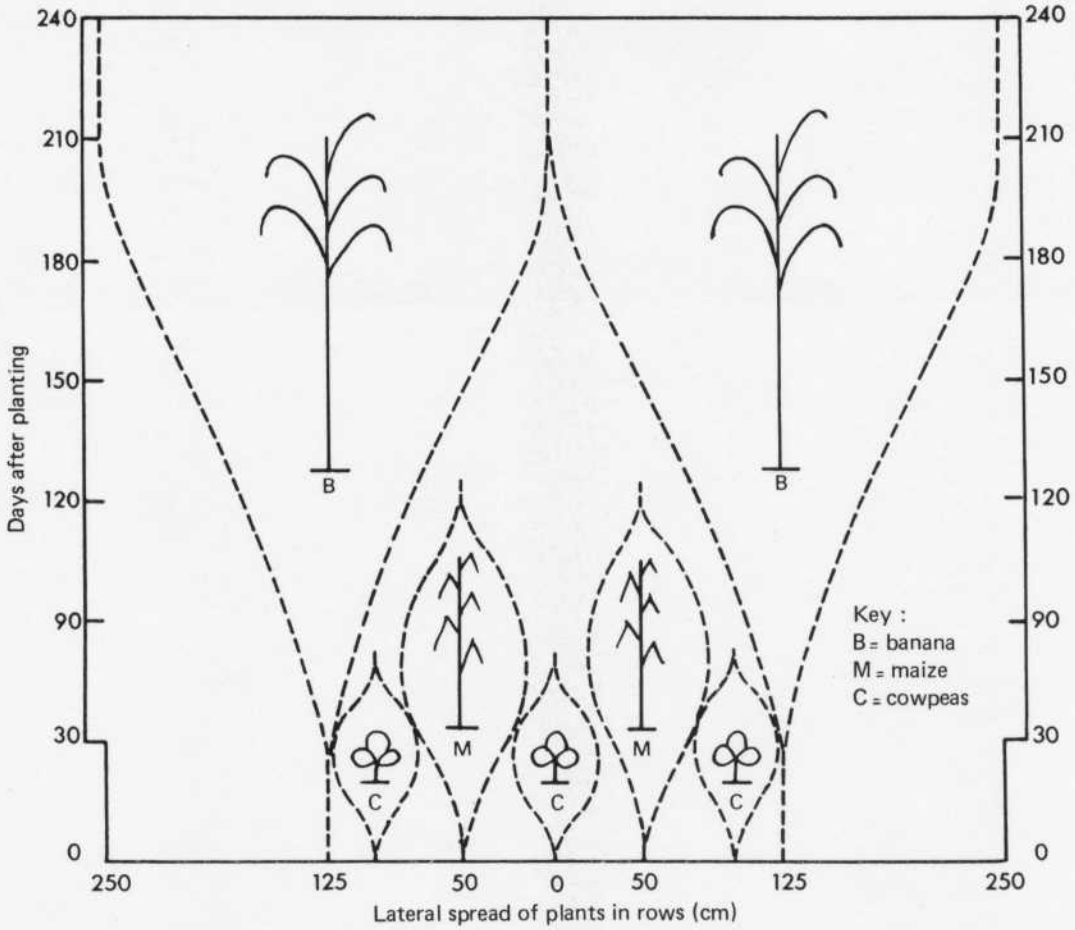

Fig. 1 - LATERAL SPREAD OF BANANA AND INTERCROPS AS A FUNCTION OF TIME.

TABLE 1 - Effect of intercropping on yield (t/ha) of plantain and intercrops. (DEVOS and WILSON, 1979).

Treatments	Plantain						
	Planting distance m	Days to 50 % shooting	Days to 50 % harvest	Yield	Cocoyam	Maize	Cassava
Sole plantain	2 x 3	267 ab*	375	17.5b	-	-	-
Plantain + Cocoyam (1)	2 x 3	256 a	355	18.2b	2.96	-	-
Plantain + Maize (2) + Cassava (3)	2 x 3	279 bc	394	18.7b	-	2.94a	2.58a
Plantain + Maize + Cassava	2 x 6	283 c	394	9.8a	-	3.35a	10.24b

* Means within each column followed by the same letter are not significantly different at the 5 % level using Duncans Multiple Range Test.

1. Cocoyam : *Xanthosoma sagittifolium*
2. Maize : *Zea mays*
3. Cassava : *Manihot utilissima*

Small farmers in the Windward Islands often intercrop banana with a mixture of short-term crops in order to have food and cash returns at different times of the year. With this objective in mind, banana performance was studied with different intercrop associations and their mixtures during a post-rainy season in St. Lucia (EDMUNDS and

TABLE 2 - Yield (t/ha) of banana and intercrops in different cropping systems (SUBBAIAH et al., 1980).

Treatments	1976-77		1977-78		Mean	
	Banana	Intercrops	Banana	Intercrops	Banana	Intercrops
Banana alone (control)	11.81	-	13.31	-	12.56	-
Banana + Greengram (1)	12.10	0.60	14.06	0.59	13.00	0.59
Banana + Blackgram (2)	12.13	0.39	13.82	0.36	12.98	0.37
Banana + Onion (3)	11.07	1.68	11.87	1.90	11.47	1.79
Banana + Okra (4)	11.15	3.27	12.44	3.37	11.80	3.32
Banana + Cowpeas (5)	10.87	3.81	11.09	3.73	10.98	3.77
S. Ed	0.031		0.234			
LSD (P = 0.05)	0.066		0.500			

1. Greengram : *Vigna radiata*
2. Blackgram : *Phaseolus mungo*
3. Onion : *Allium cepa*
4. Okra : *Hibiscus esculentus*
5. Cowpea : *Vigna unguiculata*

TABLE 3 - Yield (t/ha) of banana and intercrops from different cropping systems, in St. Lucia and Grenada (SEEYAVE and BAYNES, 1974).

Treatments	Banana		Intercrops		
	Days to harvest	Yield	Cowpeas	Maize	Sweetpotato
St. Lucia					
Sole Banana	328 a*	40.2a	-	-	-
Banana + Cowpeas	348 bc	43.2a	0.91a	-	-
Banana + Cowpeas → Cowpeas	338 ab	41.9a	0.87a	-	-
Banana + Cowpeas → Maize	356 bc	42.8a	0.81a	1.84a	-
Banana + Maize	362 c	43.5a	-	3.26b	-
Banana + Sweetpotato (1)	353 bc	44.7a	-	-	9.23
Grenada					
Sole Banana	377 a	31.3a	-	-	-
Banana + Cowpeas	361 a	33.8a	0.63a	-	-
Banana + Cowpeas → Cowpeas	371 a	33.5a	0.47a	-	-
Banana + Cowpeas → Maize	360 a	34.9a	0.61a	-	-
Banana + Maize	356 a	34.5a	-	0.76	-
Banana + Sweetpotato (1)	378 a	33.0a	-	-	7.22

* Means within each column followed by the same letter are not significantly different at P = 0.05
1. Sweetpotato : *Ipomoea batatas*

RAO, 1981). The results indicated that the banana yield was unaffected by different cropping systems on a cycle basis, however, on a time basis, sole banana yielded significantly higher than those intercropped with either maize, sweetpotato or their mixtures. Interplanting banana with cowpeas alone did not significantly affect the yield even on a time basis and inclusion of the cowpeas component in the intercrop mixture tended to reduce the yield difference.

Intercropping of banana with cowpeas, maize, groundnuts and sweetpotato at a high altitude (370 m above mean sea level) on a farmers holding in St. Lucia showed that the associated growth of intercrops increased the banana yield significantly as compared to monoculture (RAO and EDMUNDS, 1981 b). This increase in yield was perharps due to the beneficial effect of the fertilizer added to the intercrops. However, at 16 months the total banana yield in plots intercropped with groundnuts was significantly higher than the remaining treatments which in turn were non-significant. RAO and MURRAY (1983) studied the performance of banana on a sandy clay loam in St. Vin-

cent in which farmers' existing practice (control) was compared against more intensive intercropping treatments (Table 6). The results showed that the banana yield was not affected significantly by various cropping systems.

Effect of Cropping Systems on production cycle of banana/plantain.

Experimental data showed that in general the associated growth of intercrops adversely influenced the production cycle of banana/plantain as compared to monoculture. DEVOS and WILSON (1979) observed that, on the average, harvesting occurred 20 days earlier for plantain intercropped with cocoyam than for plantain in pure stand and about 40 days for plantain intercropped with maize and cassava (Table 1). SEEYAVE and BAYNES (1974) noted that intercropping of banana with various food crops delayed the production cycle significantly at one site only (Table 3). They further showed that in general growing maize or sweetpotato in association with banana, had a more adverse effect on days to harvest as compared to cowpeas. These findings are in agreement with those reported by RAO and EDMUNDS (1983). Increasing the density of sweetpotato from 2 to 3 rows did not effect the crop cycle significantly (Table 6) and inclusion of cowpeas in the farmers' existing intercropping system (Banana + 2 rows sweetpotato) reduced days to harvest of banana by about 18 days. This reduction was probably due to the beneficial effects of nitrogen fixation by the legume. The available literature so far indicated that the effect of intercrops on production cycle of banana/plantain depended on (a) rainfall pattern and (b) type, duration and height of intercrop. Intercrops had a greater adverse effect on production cycle under conditions of water stress (Table 4). short duration

TABLE 4 - Yields (t/ha) obtained from various banana cropping systems in St. Lucia (EDMUNDS and RAO, 1981).

Treatments	Days to harvest of banana	Yield				
		Banana		Cowpeas	Maize	Sweetpotato
		plant crop	at 20 months			
Sole banana	318 a*	30.9 a	75.9 e	-	-	-
Banana + 4 Cowpeas	323 a	29.7 a	73.3 de	1.21 a	-	-
Banana + 4 Maize	355 c	31.5 a	67.9 bc	-	4.03a	-
Banana + 4 Sweetpotato	379 e	31.1 a	63.8 a	-	-	11.2 a
Banana + 3 Cowpeas + 2 Sweetpotato	372 d	31.4 e	70.9 cd	0.83 b	-	6.8 b
Banana + 3 Cowpeas + 2 Maize	344 b	29.8 a	70.0 c	0.78 b	2.34 b	-
Banana + 2 Cowpeas + 3 Sweetpotato	380 e	31.6 a	65.3 ab	0.61 b	-	9.6 a
Banana + 2 Maize + 3 Sweetpotato	383 e	31.9 a	62.6 a	-	1.97 c	11.4 a

* - Means within each column followed by the same letter are not significantly different P = 0.05.

TABLE 5 - Effect of intercropping on banana and intercrop yield (RAO and EDMUNDS, 1981 b)

Cropping System	Days to banana harvest	Banana yield (t/ha)		Intercrop yield (kg/ha)
		plant crop	at 16 months	
Sole Banana	293 a	36.6 a	48.6 a	-
Banana + 4 Cowpeas	306 b	40.9 b	44.7 a	1114 ± 120
Banana + 4 Maize	308 b	42.2 b	46.4 a	1764 ± 178
Banana + Groundnuts *	302 ab	41.6 b	54.0 b	828 ± 126
Banana + Sweetpotato	324 c	42.9 b	45.1 a	5606 ± 614
C.V.	2.7	5.1	8.7	

* - Groundnuts : *Arachis hypogaea*

TABLE 6 - Effect of cropping systems on production cycle and crop yields in St. Vincent (RAO and MURRAY, 1983).

Treatments	Days to banana harvest	Yield t/ha		
		Banana	Sweetpotato	Cowpeas
Banana + 2 Sweetpotato (Control)	388 a*	25.18 a	9.95 a	-
Banana + 3 Sweetpotato	392 a	26.40 a	9.16 ab	-
Banana + 2 Sweetpotato + 4 Cowpeas	370 b	25.42 a	7.29 b	0.57
C.V. (%)	2.5	2.3	15.2	

* - Means within each column followed by the same letter are not significantly different at P = 0.05.

TABLE 7 - Effect of intercropping on nutrient concentrations in banana leaves (MADDINENI and EDMUNDS, 1982).

Treatments	Girth (cm) of pseudo-stem at 9 months	Days to banana shooting	Percentage					ppm
			N	P	K	Ca	Mg	Mn
Sole banana (control)	56	188	3.27	0.195	2.87	0.87	0.348	202
Banana + 4 Cowpeas	55	200	3.29	0.205	3.08	0.81	0.349	200
Banana + 6 Groundnuts	55	214	3.22	0.196	3.03	0.81	0.307	186
Banana + 4 Sweetpotato	52	229	3.04	0.221	3.35	0.68	0.330	145
LSD (P = 0.05)	NS	22	NS	0.009	0.23	0.12	NS	NS

TABLE 8 - Effect of cropping systems on available N (kg/ha) in post harvest soil (SUBBAIAH et al., 1981).

Treatments	Available N			% increase over control
	1976-77	1977-78	Mean	
Banana alone (control)	267	265	266	-
Banana + Greengram	317	323	320	20.3
Banana + Blackgram	287	321	304	14.2
Banana + Onion	273	277	275	3.4
Banana + Okra	268	263	266	0.0
Banana + Cowpeas	282	295	289	8.6

low growing crops (cowpeas and groundnuts) prolonged the crop cycle only marginally as compared to either fast growing crop (maize) or long duration crops (sweetpotato and cassava) (Table 5).

Effect of Cropping Systems on nutrient concentrations in banana leaves :

MADDINENI and EDMUNDS (1982) reported that the cropping systems significantly influenced the concentrations of various nutrients (Table 7). The percentage P and K contents in banana leaves intercropped with sweetpotato were significantly higher than that in other systems. The banana in pure stand registered the lowest P and K contents.

A reverse trend in the concentration (%) of Ca was observed with intercropping, that is, the bananas interplanted with the tuber crop recorded the lowest Ca content (0.68 %) whereas the sole banana had the highest (0.87 %). The authors interpreted that the significantly lower concentration (%) of P and K in sole banana and those intercropped with cowpeas and groundnuts than those interplanted with sweetpotato was perhaps due first to the early translocation of these nutrients from the leaves («source») to the bunch («sink») owing to early floral initiation as evidenced by less number of days to shooting and secondly to the «dilution effect» as indicated by the bigger plant size. The lower Ca content in banana leaves associated with sweetpotato was probably due to a greater requirement for that nu-

trient by the intercrop, thereby causing severe competition with the main crop (Similar results were also reported by RAO and EDMUNDS, 1981 a).

Effect of Cropping Systems on some chemical properties of soil :

SUBBAIAH et al. (1980) reported a substantial increase in available nitrogen in post-harvest soil when banana was intercropped with pulses viz greengram and blackgram (Table 8). An average increase of 20.3 %, 14.2 % and 8.6 % in available nitrogen was observed in plots where banana was associated with greengram, blackgram and cowpeas respectively over pure stand.

In a plantain x intercrop experiment in St. Lucia, RAO and MURRAY (1983) noted non-significant differences in soil pH, electrical conductivity and exchangeable K due to plantain varieties, however, the above soil chemical properties were significantly affected by the intercrops (Table 9). Analyses of soil samples on three occasions at monthly intervals after harvesting of intercrops revealed that the observed variations in soil pH and electrical conductivity were only temporary. However, the exchangeable K was significantly lower under dasheen at all sampling dates, indicating that the tuber crop depleted the soil of this monovalent cation because of its (dasheen) greater requirement. Nevertheless, the exchangeable K tended to approach to the initial value (0.62 me/100 g) in different treatments.

TABLE 9 - Effect of cropping systems on soil pH, electrical conductivity and exchangeable K (RAO and MURRAY, 1983).

Treatments	ph	E.C. (µmhos per cm)	Exch. K. (me/100 g soil)
		9.12.82	
Mainplot (Plantain varieties)			
Dwarf	4.88	62	0.55
Horn	4.85	51	0.42
Ordinary	4.82	59	0.40
Dominique	4.92	58	0.45
LSD	NS	NS	NS
Subplot (Intercrops)			
Cowpeas	4.92	60	0.46
Groundnuts	4.79	67	0.36
Dasheen (1)	4.89	56	0 36
LSD	0:07	9	0.08
		12.1.83	
Mainplot (Plantain varieties)			
Dwarf	4.97	52	0.44
Horn	4.87	55	0.40
Ordinary	4.98	54	0.38
Dominique	4.92	55	0.37
LSD	NS	NS	NS
Subplot (Intercrops)			
Cowpeas	4.90	56	0.43
Groundnuts	4.93	54	0.44
Dasheen	4.97	51	0.33
LSD	NS	NS	0.03
		11.2.83	
Mainplot (Plantain varieties)			
Dwarf	4.75	85	0.58
Horn	4.64	90	0.46
Ordinary	4.72	74	0.40
Dominique	4.73	75	0.53
LSD	NS	NS	NS
Subplot (Intercrops)			
Cowpeas	4.77	84	0.50
Groundnuts	4.69	83	0.59
Dasheen	4.67	76	0.40
LSD	NS	NS	0.11

(1) - Dasheen : *Colocasia antiquorum.*

Effect of Cropping Systems on Weed growth :

CHACKO and REDDY (1981) showed that by adopting high planting density (4440 to 6950 suckers/ha) and intercropping with cowpeas, sown 20 days after planting suckers, uprooted two months later and used as a mulch, suppressed weed growth completely for three and a half months. In addition, the cowpeas mulch reduced soil moisture loss and provided humus and some nutrients.

RAO and MURRAY (1983) observed that by either increasing the density of intercrop (dasheen) or inclusion of cowpeas in the existing intercropping practice of banana + 2 dasheen, the weed growth was drastically curtailed (Table 10). This reduction in weed growth was due to better light interception by the intercrop.

Effect of Cropping Systems on nematode and borer population :

Cropping Systems is one of the oldest and most important approaches to the control of nematodes that feed on the roots of crop plants. Intercrops and their varieties may enhance, decrease or maintain nematode and borer population according to the ecosystem stability. A cropping system should be selected so that the intercrop does not produce a population of nematodes larger than the economic threshold density of the main crop in the system. NUSBAUM and FERRIS (1973) states that multiple cropping adds organic matter to the soil, increases the cycling of nutrients, and improves soil structure. All of these practices tend to decrease population densities of nematodes on a crop of a particular genotype. Without careful selection of a cropping system, soil-improvement benefits may be negated by increases in nematode populations (BRODIE et al., 1969).

In a preliminary assessment of effect of intercropping plantain with cowpeas, maize, groundnuts, sweetpotato and dasheen against pure stand (Plantain) showed non-significant differences in both nematode and borer populations (AMBROSE, E. 1983 personal communication). The author further noted that the nematode population in the plantain root sample was more stable and increased at a slower rate in the intercropped plots than in the pure stand.

TABLE 10 - Effect of intercropping on weed growth in banana (RAO and MURRAY, 1983)

Treatments	Weight (g) of weeds/m^2			
	Fresh *	% decrease over control	Dry	% decrease over control
Banana + 2 Dasheen (control)	122 (11.05)	-	30.0 (5.48)	-
Banana + 2 Dasheen + 3 Cowpeas	38 (6.18)	- 68.8	8.9 (2.98)	- 70.3
Banana + 3 Dasheen	43 (6.56)	- 64.7	11.4 (3.38)	- 62.0
Banana + 3 Dasheen + 4 Cowpeas	17 (4.13)	- 86.0	4.7 (2.18)	- 84.3
LSD at 5 %	(3.46)		(2.04)	

* - Values given in the parenthesis are transformed to $\sqrt{n+1}$

TABLE 11 - Import of selected agricultural products into St. Lucia, St. Vincent and Grenada

Agricultural Product	St. Lucia (1)		St. Vincent (2)		Grenada (3)		Total	
	Quantity (t)	Value (US$)	Quantity (t)	Value (US$)	Quantity (t)	Value (US$)	Quantity (t)	Value (US$)
Corn and corn products	208.8	129,500	58.1	47,300	19.8	12,900	286.7	189,700
Peanuts (shell and canned)	38.7	80,200	15.9	41,200	25.9	73,500	80.5	194,900
Blackeye peas, lentils and dry beans	170.3	116,100	108.0	48,320	90.5	48,000	368.8	212,420
Pigeonpeas	3.1	1,900	-	-	26.8	19,700	29.9	21,600

1. Average of 4 years (1974-77),
2. Average of 9 years (1972-80).
3. Average of 6 years (1976-81).

Effect of Cropping Systems on disease of banana/plantain.

The associated growth of intercrops on possible occurrence of diseases in banana/plantain were not studied in detail. However, SEEYAVE and BAYNES (1974) observed an outbreak of cucumber mosaic virus on banana in St. Lucia at about 4 months after planting in a banana-intercropping trial. They noted that the disease was associated with insect vectors on the intercrops, especially aphids, which were not controlled by the weekly pest control sprays. In interplanting, efforts should be made so that the associated minor crop should not act as an alternate host of any major banana/plantain diseases such as moko disease caused by *Pseudomonas solanacearum.*

Available literature showed that the yields from different crops in various cropping systems were encouraging. In the Windward Islands (excluding Dominica), the average annual import bill for some of the food crops grown in different banana/plantain cropping systems was US $ 0.6 million (Table 11).

In the Windward Islands, bananas are grown on an area of approximately 14,500 ha and an estimate 10 % of the total is replanted to bananas every year. A programmed banana intercropping can not only reduce the food imports but also assist the small farmer economically. This intercropping practice is best appreciated where there is a pressure on land as is the case with small growers.

Therefore, the concept of intercropping banana/plantain with short-term crops can be developed as one of the methods leading towards optimisation of natural and man-made resources and improvements in the nutritive base of our world population. The economics of the exercice will be covered by WINBAN economist in a separate paper at this meeting. It is left to our respective Governments to formulate the necessary policies to put this concept into practice.

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REFERENCES

BRODIE (B.), GOOD (J.M.) and ADAMS (W.E.). 1969.
Population dynamics of plant nematodes in cultivated soils : effect of soil - bases rotations in Cecil Sandy loam.
J. Nematol., 1, 309-312.

CHACKO (E.K.) and REDDY (A.). 1981.
Effect of planting distance and intercropping with cowpea on weed growth in banana.
Proc. 8th Asian-Pacific Weed Sci. Soc. Conf. pp. 137-142
in *Tropical Pest Management*, 28, pp. 202.

DEVOS (P.) and WILSON (G.F.). 1978.
Productivity and efficiency of plantain/cocoyam intercropping.
Paradisiaca, 3, 6-11.
in *Horticultural abstracts*, 50, 8500.

DEVOS (P.) and WILSON (G.F.). 1979.
Intercropping of plantains with food crops : maize, cassava and cocoyams.
Fruits, 34, 169-174.

EDMUNDS (J.E.) and RAO (M.M.). 1981.
Banana intercropping research in the Windward Islands.
A paper presented at the 5th ACORBAT Conference held at Guayaquil, Ecuador, 22-26 June, 1981.

FONGYEN (A.D.). 1976.
The problems of plantain production in Cameroon.
Fruits, 31, 692-694.

HENDERSON (T.H.) and GOMES (P.I.). 1979.
A profile of small farming in St. Vincent, Dominique and St. Lucia. Report of a baseline survey.
Dept. Agric. Ext. Faculty of Agric. U.W.I. St. Augustine, Trinidad.

KARIKARI (S.K.). 1972.
Plantain growing in Ghana.
World crops, 24, 22-24.

MADDINENI (M.R.) and EDMUNDS (J.E.). 1982.
Studies on banana intercropping with different food and vegetable crops in the Windward Islands.
A paper presented at the 18th Annual Caribbean Food Crop Soc. Meeting held in Barbados from the 22nd to 27th August, 1982.

NUSBAUM (C.J.) and FERRIS (H.). 1973.
The role of cropping systems in nematode population management.
Annu. Rev. Phytopathol., 11, 423-440.

RANDHAWA (G.C.) and SHARMA (C.B.). 1972.
Possibilities of intercropping in banana. In Multiple cropping.
Proc. Sym. held at Haryana Agric. Univ. Hissar. Indian Soc. Agron. Indian Agric. Res. Inst. New Delhi, 110012 pp. 326-327.

RAO (M.M.). 1979.
Report on Banana-intercropping survey.
Windward Islands Banana Growers Association, Res. Dev. Div. July 1979, pp. 1-23.

RAO (M.M.). and EDMUNDS (J.E.). 1981 a.
Studies on intercropping of banana with food crops : I - Results of Trials at Research Station.
Paper presented at «Workshop on Banana Intercropping in the Windward Islands» Castries, St. Lucia, June 1-4, 1981.

RAO (M.M.) and EDMUNDS (J.E.). 1981 b.
Studies on intercropping of banana with food crops : II - Results of Trials on Farmers' Holdings.
Paper presented at «Workshop on Banana Intercropping in the Windward Islands» Castries, St. Lucia, June, 1-4, 1981.

RAO (M.M.) and EDMUNDS (J.E.). 1983.
Intercropping of banana with food crops : cowpeas, maize and sweetpotato.
Trop. Agric. (Trinidad), in press.

RAO (M.M.) and MURRAY (H.). 1983.
Banana-plantain cropping systems.
2nd Annual Report, Phase II. Windward Islands Banana Growers' Association, Res. Dev. Div. In preparation.

RUTHENBERG (H.). 1976.
Farming systems in the Tropics.
2nd Ed. Clarendon Press, Oxford, 1976, p. 247.

SEEYAVE (J.) and BAYNES (R.A.). 1974.
Intercropping of bananas on two volcanic soils in the Caribbean.
Windward Islands Banana Growers' Association. Res. Dev. Div. (unpublished), p. 1-12.

SUBBAIAH (K.K.), RAMACHANDRA BOOPATHI (S.N.M.) and KOLANDAISWAMY (S.). 1980.
Intercropping in Banana.
Madras Agric. J. 67, 712-715.