Journal of Root Crops, 2013, Vol. 39 No. 2, pp. 242-246
Indian Society for Root Crops
ISSN 0378-2409

Multiple Cropping Systems Involving Cassava and Elephant Foot Yam in Coconut Gardens

In the homesteads of Kerala, normally the main crop is coconut along with other annual crops, trees and shrubs. Since the pressure on land is mounting day by day the allocation of open space becomes limiting for the cultivation of annual crops like tuber crops, banana, vegetables, annual spices etc. However perennial tree species particularly coconut which occupies the topmost layer ensures ample scope for intercropping annuals in their inter spaces. The intercrops should be planted in a planned manner with a view to make the best use of interspaces, sunlight, nutrients and moisture available in the homestead. There is a possibility of saving nutrients for the individual crops in the cropping system. Besides there is scope for exploiting the unutilized natural resources in a coconut garden and enhance the income of coconut farmer. Ravindran (1997) reported nutrient-moisture-light interactions in coconut based cropping systems. The present study was conducted to find out the most economical cropping system in coconut garden.

The field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, during the year 2004–2005. The soil of the experimental site is red loam. The experimental area was under robusta banana intercropped with other annual crops under coconut garden during the previous years. The experiment was conducted in RBD with three replications. The treatments consisted of ten cropping systems in coconut garden in the following crop combinations. The gross plot size was 7.6 m x 7.6 m.

T_1 : 12 banana + 20 elephant foot yam + 72 vegetable cowpea as border around the plot (banana was planted at a spacing of 2 m x 2 m and in the interspaces elephant foot yam was planted at 90 cm x 90 cm spacing).

T_2 : 20 cassava + 20 elephant foot yam + 72 vegetable cowpea (cassava and elephant foot yam planted at 90 cm x 90 cm spacing).

T_3 : 12 banana plants + 200 ginger plants + 72 vegetable cowpea (banana at 2 m x 2 m spacing, ginger 25 cm x 25 cm spacing in four inner corners of 2 m beds).

T_4 : 10 cassava + 10 elephant foot yam + 200 ginger plants + 72 vegetable cowpea (cassava 90 cm x 90 cm, elephant foot yam 90 cm x 90 cm, ginger 25 x 25 cm).

T_5 : 12 banana + 200 turmeric plants + 72 vegetable cowpea (banana 2 m x 2 m, turmeric 25 cm x 25 cm in four inner corners of 2 m beds).

T_6 : 10 cassava + 10 elephant foot yam + 200 turmeric plants + 72 vegetable cowpea (cassava 90 cm x 90 cm, elephant foot yam 90 cm x 90 cm, turmeric 25 cm x 25 cm in beds).

T_7 : 12 banana + 20 cassava + 72 vegetable cowpea (banana 2 m x 2 m, cassava 90 cm x 90 cm).

T_8 : 12 banana + 10 cassava + 10 elephant foot yam + 72 vegetable cowpea (banana 2 m x 2 m, elephant foot yam 90 x 90 cm, cassava 90 cm x 90 cm).

T_9 : 12 banana + 10 cassava + 100 ginger + 72 vegetable cowpea (banana 2 m x 2 m, cassava 90 cm x 90 cm, ginger 25 cm x 25 cm, in four corners of 1 m beds).

T_{10} : 12 banana + 10 cassava + 100 turmeric + 72 vegetable cowpea (banana 2 m x 2 m, cassava 90 cm x 90 cm, turmeric 25 cm x 25 cm in the four corners of 1 m beds).

Sole crops of banana, cassava, elephant foot yam, ginger, turmeric and vegetable cowpea were raised separately and simultaneously in open.

The fertilizers were applied as per the package of practices recommendations of Kerala Agricultural University for the respective crops. The population of individual crops in each cropping system compared to sole cropping is given in Table 1.

Table 1. Population of coconut and intercrops in different treatments

Treatments	Population of coconut and intercrops (ha^{-1})						
	Coconut	Banana	Elephant foot yam	Ginger	Turmeric	Cassava	Vegetable cowpea
T_1	175	2132	3555	-	-	-	12800
T_2	175	-	3555	-	-	3555	12800
T_3	175	2132	-	35555	-	-	12800
T_4	175	-	1777	35555	-	1777	12800
T_5	175	2132	-	-	35555	-	12800
T_6	175	-	1777	-	35555	1777	12800
T_7	175	2132	-	-	-	3555	12800
T_8	175	2132	1777	-	-	1777	12800
T_9	175	2132	-	17777	-	1777	12800
T_{10}	175	2132	-	-	17777	1777	12800
Sole crop	175	2500	12345	100000	100000	12345	111110

The yield data of all the crops tried in the various cropping systems were statistically analysed and the results are presented in Table 2. Economic analysis of the different cropping systems were made, the benefit: cost (B:C) ratio and the net return were computed. Land equivalent ratios (LER) were also computed.

There was significant difference between cropping systems and between cropping system and sole cropping with respect to the bunch yield in banana (Table 2). The maximum per plant yield was observed in the sole crop banana (10.12 kg $plant^{-1}$), followed by banana in the cropping system, T_3 (9.14 kg $plant^{-1}$), T_1 (8.51 kg $plant^{-1}$) and T_{10} (8.35 kg $plant^{-1}$) respectively but the differences were not statistically significant.The maximum bunch yield in banana could be attributed to the highest incident radiation in sole crop banana when compared to banana in cropping system. The maximum incidence of photosynthetically active radiation (PAR) was in the sole crop banana followed by banana in the cropping system, T_3 (1220 $\mu E\ m^{-2}\ s^{-1}$ and 1039.43 $\mu E\ m^{-2}\ s^{-1}$, respectively). The lowest incidence of PAR and hence the lowest bunch yield was in the cropping system, T_9. Banana being a sun loving crop, the leaves have large amount of Calvin cycle enzymes per unit leaf, which might have enhanced the photosynthetic capacity of the banana crop and enhanced the bunch yield. The lowest incident PAR under shade

Table 2. Yield of banana, cassava, elephant foot yam, ginger, turmeric and vegetable cowpea as influenced by cropping systems and sole cropping (kg $plant^{-1}$)

Treatments	Bunch yield of banana	Corm yield of elephant foot yam	Rhizome yield of ginger	Rhizome yield of turmeric	Tuber yield of cassava	Fresh pod yield of cowpea
T_1	8.5^{abc}	2.8^{c}	-	-	-	0.076^{bc}
T_2	-	4.1^{ad}	-	-	2.9^{a}	0.088^{abc}
T_3	9.1^{ab}	-	0.16^{b}	-	-	0.152^{a}
T_4	-	3.5^{abc}	0.11^{c}	-	3.4^{a}	0.087^{abc}
T_5	7.9^{bc}	-	-	0.08^{a}	-	0.129^{ab}
T_6	-	3.7^{abc}	-	0.08^{a}	2.8^{a}	0.082^{abc}
T_7	7.7^{bc}	-	-	-	2.1^{a}	0.132^{ab}
T_8	7.7^{bc}	3.2^{ac}	-	-	2.3^{a}	0.055^{c}
T_9	7.1^{c}	-	0.13^{c}	-	1.8^{a}	0.051^{c}
T_{10}	8.4^{abc}	-	-	0.11^{a}	2.1^{a}	0.055^{c}
Sole crop	10.12^{a}	4.3^{a}	0.19^{a}	0.12^{a}	3.8^{a}	0.149^{ab}

Values with the same superscript in a coloumn are not significantly different might have caused stress on the plant, as irradiance limits photosynthesis and thus net carbon gain and dry matter accumulation (Lambers et al., 1998). In the present study since the intercrops were planted in a planned geometry without causing any mutual shade there was not much reduction in the incident PAR (75% PAR) and hence there was less reduction in bunch yield (10%) in cropping systems in coconut garden when compared to the open.

In the case of ginger, though it is a shade loving crop, the rhizome yield was lowest in the coconut garden. This might be due to the increased shade in cropping systems in coconut garden compared to sole cropping. In ginger, various studies indicated that the rhizome yield increased up to 25% shade and there after declined. In the present study, where ginger was a companion crop with nendran banana, cassava and elephant foot yam in coconut garden the shade was more than 25% resulting in decline in rhizome yield. The photosynthetic efficiencies were found to increase up to 25% shade. This indicated that at 25% shade the photosynthetic area was utilized efficiently. At shade levels above this, the leaf area was found to increase, which might have resulted in mutual shading. Under such situations the rate of dark respiration also increases (Bjorkman, 1981), leading to reduced photosynthetic efficiency under 50 and 75% shade. In ginger, Aclan and Quisumbing (1976) found that yield under full sunlight was just as high as those obtained under 25 and 50% light attenuation.

In elephant foot yam, the sole cropping resulted in maximum corm yield of 4.35 kg plant^{-1} and was on par with the corm yield in cropping systems, T_2, T_6 and T_4, whereas it was significantly superior to the corm yield in cropping systems, T_8 and $T_{1.}$ The lowest corm yield was observed in the cropping system, T_1 (2.85 kg plant^{-1}). The maximum corm yield was obtained under full sunlight and only marginal reduction in yield was noticed in the cropping systems, T_2, T_3 and T_4. Prameela (1990) reported that taro yield was maximum under 25% shade followed by a reduction in yield with further increase in shade intensity. In cropping systems, T_8 and $T_{1,}$ one of the companion crop was nendran banana, which was a taller crop in the combination and might have caused more than 25% shade resulting in yield reduction in elephant foot yam in these cropping systems. From the present study, it can be inferred that elephant foot yam is a shade tolerant crop and can be grown in association with another tuber crop like cassava, which forms a best companion crop for getting reasonable yield. Togari (1950) reported that in 50% shade, cambial activity and tuberization were suppressed in sweet potato tubers. Studies conducted elsewhere in four sweet potato cultivars showed that tuber yield was not affected under 25% shade, but under 50% shade, yields were noticeably lower, whereas under 73% shade, tuberization was almost completely suppressed in all cultivars. The responses resulted from slower tuber growth under 50% shade and from delayed tuber initiation and slower tuber growth under 73% shade (Laura et al., 1986).

The yield of cassava and turmeric were unaffected by the cropping systems. The fresh pod yield of vegetable cowpea was found significantly influenced by the cropping systems and the highest fresh pod yield was observed in the cropping system, T_3 (152.1 g plant^{-1}) followed by sole cropping (148.7 g plant^{-1}) and the cropping systems, T_7 , T_5 , T_2, T_4 and T_6 were on par (82 g plant $^{-1}$ to 132.68 g plant^{-1}). The lowest pod yield was in the cropping system, T_9 (50.5 g plant^{-1}) and was on par with the yield in the cropping systems, T_8, T_{10}, T_1, T_6 and T_2. Since vegetable cowpea was planted as border row around all the other crops and away from coconut crown portion, the PAR interception was high in all the cropping systems. Also vegetable cowpea is a sun loving crop and this might be the reason for almost similar yield of vegetable cowpea in cropping systems and sole cropping.

Economic analysis of the study revealed the superiority of cropping systems with B:C ratio of more than 1 (Table 3). The highest B:C ratio of 1.74 was in the cropping system, T_4, involving cassava, elephant foot yam, ginger and vegetable cowpea in the coconut garden. The net income was the highest in cropping system, T_3, involving banana, ginger and vegetable cowpea. When cassava was included in the system, the net income decreased due to the low value of the crop (T_4) when compared to the cropping system, T_3. But cassava increased the food value/calorie or energy value of the cropping systems. Similar results were obtained by Ravindran (1997) and Girijadevi and Wahab (2007). Cropping systems involving banana and cassava produced the lowest B:C ratio of 1.02 and the net income were also the lowest in the cropping systems, T_7 and T_9. From the present study it is concluded that banana, ginger and

Table 3. Economics of different cropping systems in coconut garden (₹ ha^{-1})

Cropping system	Intercrop	Expenditure (Rs)	Produce (t ha^{-1})	Value of individual crop (₹ ha^{-1})	Gross income (₹ ha^{-1})	Gross expenditure (₹ ha^{-1})	Net income (₹ ha^{-1})	B:C ratio	LER
T_1	B (12)	190000	18.12	219464	308896	269000	39896	1.15	1.97
	EFY (20)	54000	9.95	79632					
	VC (72)	25000	0.98	9800					
T_2	C (20)	25000	10.31	41240	169080	104000	65080	1.63	1.57
	EFY (20)	54000	14.58	116640					
	VC (72)	25000	1.12	11200					
T_3	B (12)	190000	19.4	232812	366088	245000	121088	1.49	2.19
	G (200)	30000	5.69	113776					
	VC (72)	25000	1.95	19500					
T_4	C (10)	12500	6.04	24160	163240	94000	69240	1.74	1.53
	EFY (10)	27000	6.22	49760					
	G (200)	30000	3.91	78220					
	VC (72)	25000	1.11	11100					
T_5	B (12)	190000	16.84	202116	235680	230000	5680	1.02	2.01
	T (200)	15000	2.84	17064					
	VC (72)	25000	1.65	1650					
T_6	C (10)	12500	4.98	19920	100124	79500	20624	1.26	1.53
	EFY (10)	27000	6.58	52640					
	T (200)	15000	2.84	17064					
	VC (72)	25000	1.05	10500					
T_7	B (12)	190000	16.42	196992	243872	240000	3872	1.02	1.91
	C (20)	25000	7.47	29880					
	VC (72)	25000	1.7	17000					
T_8	B (12)	190000	16.42	196992	265872	254500	11372	1.04	2.69
	C (10)	12500	4.09	16360					
	EFY (10)	27000	5.69	45520					
	VC (72)	25000	0.7	7000					
T_9	B (12)	190000	15.12	181644	247164	242500	4664	1.02	1.83
	C (10)	12500	3.2	12800					
	G (100)	15000	2.31	46220					
	VC (72)	25000	0.65	6500					
T_{10}	B (12)	190000	17.91	214896	248546	235000	13546	1.06	1.84
	C (10)	12500	3.73	14920					
	T (100)	7500	0.11	11730					
	VC (72)	25000	0.7	7000					

B: banana; C: cassava; T: turmeric; VC: vegetable cowpea; EFY: elephant foot yam

elephant foot yam constituted the ideal companion crops in coconut gardens.

The LER value presented in the Table 3 indicates the biosuitability and agronomic advantages of the intercropping systems and it was observed that the intercropping system T_8, consisting of coconut, banana, cassava, elephant foot yam and vegetable cowpea was agronomically advantageous over the other systems with a LER value of 2.69. LER, one of the most effective indices of biological advantage for evaluating efficiency and productivity of intercropping system was more than 1.0 in all the systems tried indicating the advantage of intercropping compared to sole cropping.

References

Aclan, F. and Quisumbing, E.C. 1976. Fertilizer requirement, mulch and light attenuation on the yield and quality of ginger. *Philt. Agricst.*, **60**: 183 – 191.

Bjorkmam, O. 1981. Response to different quantum flux densities. *Encyclopedia of Plant Physiology.* Lange, O.L., Noble, P.S., Osmund, C.B. and Ziegler, H. (Eds.). Springer- Verlag, Berlin. pp. 57 – 107.

Girijadevi, L. and Wahab, K. 2007. Economic analysis of coconut based cropping systems. *J. Plantn. Crops*, **35**(2): 82-83.

Lambers, H., Chaplin, F. and Pens, T.L. 1998. *Plant Physiological Ecology*. Springer- Verlag, New York. 540 p.

Laura Roberts, B., Nkrumah, L.B., Ferguson, T.V. and Wilson, L. 1986. Response of four sweet potato cultivars to levels of shade. *Trop. Agric.*, **63**: 265.

Prameela, P. 1990. Screening different morphotypes of Colocasia (*Colocasia esculenta*) for shade tolerance. *M.Sc. (Ag.) Thesis*, Kerala Agricultural University, Thrissur. pp. 62.

Ravindran, C. S. 1997. Nutrient-moisture-light interactions in a coconut based cropping system. *Ph.D. Thesis*, Kerala Agricultural University, Thrissur, Kerala.

Togari, Y. 1950. A study in tuberous root formation in sweet potatoes. *Bull. Agric. Extension Studies*, **3**: 1 – 96.

[1] College of Agriculture, Vellayani 695 522, Thiruvananthapuram, Kerala, India

[2,3]College of Agriculture, Padanakkad 671 314, Kasaragod, Kerala, India

Corresponding author: R. Gladis,

e-mail: bijugladis@yahoo.co.in

Received: 16 August 2013; Accepted: 14 December 2013

L. Girijadevi[1]
R. Gladis[2]
Biju Joseph[3]