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Evaluation of multi-season intercropping in cassava (*Manihot esculenta*)

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ABSTRACT

A multi-season intercropping study based on cassava (*Manihot esculenta* Crantz) was conducted at Sadanandapuram during 1988–89 and 1989–90. The mean of land-equivalent ratio + area–time equivalent ratio proved superior in measuring the efficiency of the intercropping system than land-equivalent ratio, land-equivalent coefficient or area–time equivalent ratio. It could assess both the area and duration of each crop, was free from problems of overestimation or underestimation of resource utilization and was able to record not only the agronomic advantage but also the economic advantage in the intercropping system.

Intercropping is effective in optimizing the use of resources by growing 2 or more crops simultaneously on the same field. Measurement of production efficiency has always presented conceptual problems in intercropping (Pal *et al.* 1985). In multi-season intercropping, many of the indices overestimate or underestimate the actual land-use efficiency. Hence the present study was undertaken to find out the best index in measuring the efficiency of cassava (*Manihot esculenta* Crantz)-based multi-season intercropping systems.

MATERIALS AND METHODS

The study was conducted at Sadanandapuram, situated at 9° 16′ N and 76° 37′ E at 91.44 m above mean sea-level, with a rainfall of 2 100 mm per annum in the midlands of south Kerala. The soil was gravelly clay-loam and lateritic in origin (Oxisol), with bulk density 1.24 g/cm^3, water-holding capacity 43.67%, *p*H 5.3, electrical conductivity 0.07 mmhos/cm at 25°C, available N 360 kg/ha, available P 5.40 kg/ha and available K 70 kg/ha. The experiment was laid out in randomized block design and was replicated thrice for April–May planting of rainfed 'M4' cassava during 1988–89 and 1989–90. The main crop of cassava was planted by 2 systems, viz normal equidistance planting with a spacing of 0.90 m x 0.90 m and paired row planting with a spacing of 1.35 m x 0.90 m x 0.45 m. In the first intercrop 'TMV 2' groundnut (*Arachis hypogaea* L.) and 'Kanakamoni' cowpea [*Vigna unguiculata* (L.) Walp.] were taken, and in the second intercrop 'Kanakamoni' cowpea and 'KM 1' blackgram (*Phaseolus mungo* L.) were taken. The treatment combinations were: T_1, cassava

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normal equidistance planting + groundnut; T_2, cassava normal equidistance planting + cowpea; T_3, cassava paired row + groundnut; T_4, cassava paired row + cowpea; T_5, cassava paired row + groundnut + cowpea; T_6, cassava paired row + groundnut + blackgram; T_7, cassava paired row + cowpea + cowpea; T_8, cassava paired row + cowpea + blackgram; T_9, cassava normal equidistance; T_{10}, cassava paired row; T_{11}, groundnut; T_{12}, cowpea (first and second crops), and T_{13}, blackgram (second crop). All the recommended packages of practices were followed for the main crops and the intercrops (KAU, Mannuthy 1988). Cassava was harvested 300 days after planting, whereas cowpea, groundnut and blackgram were harvested at 105, 90 and 85 days after sowing respectively.

Land-equivalent ratio (LER) was calculated as per Mead and Willey (1980). Land-equivalent coefficient (LEC) is the product of LER of intercrops (Adetiloye *et al.* 1983) and was calculated as:

$$LEC = \frac{Ya}{Y_a} \times \frac{Yb}{Y_b} \quad \ldots \times \quad \frac{Yi}{Y_i}$$

where Ya, yield of crop 'a' in intercropping; Y_a, yield of crop 'a' in sole cropping; Yb, yield of crop 'b' in intercropping; Y_b, yield of crop 'b' in sole cropping; Yi, yield of crop 'i' in intercropping; and Y_i, yield of crop 'i' in sole cropping. In land-equivalent coefficient the advantage in production efficiency was from 0.25–1 and 0.037–1 in 2 and 3 crop mixtures.

Area-time equivalency ratio (ATER) was worked out by the formula suggested by Hiebsch and McCollum (1987):

$$ATER = \sum_{i=1}^{n} (t_i^M / t_i^I) \times (Yi^I / Yi^M)$$

where ti^M, duration of crop 'i' in sole cropping; ti^I, total duration of intercropping system; Yi^I, yield of crop 'i' in intercropping; Yi^M, yield of crop 'i' in monocropping; and n, total number of crops in intercropping system.

The mean of LER + ATER was calculated to counterbalance the overestimation or underestimation of probabilities of each value (Mason *et al.* 1986). The coefficient of correlation of benefit : cost ratio was computed according to Snedecor and Cochran (1967), with LER, LEC, ATER and mean of LER + ATER to find out the economic and agronomic advantages in intercropping.

As there was no pronounced seasonal variation during the 2 years, the pooled average was considered for analysis.

RESULTS AND DISCUSSION

The production efficiency of intercropping system using LER showed that T_4 was the best system, followed by T_7 and T_8 (Table 1). These treatments recorded 70, 63 and 56% more land-use efficiency than T_{10}. The highest LEC was also noticed in T_4 (which was better than T_2), indicating the superiority of paired row planting of cassava + cowpea (Table 2). In T_5 and T_8 the LEC was less than 0.25, indicating interspecific competition. Thus a second crop was not found viable in cassava due to shade effect even in paired row planting. The LEC of T_6 could not be calculated due to failure of second intercrop, showing the limitation of LEC for measuring production efficiency. When LER of the second intercrop becomes 0, LEC of the whole mixture becomes 0. The LEC of the mixture excluding the second intercrop was worked out to be 0.34. It corroborates the finding of Adetiloye *et al.* (1983) that the LEC of productivity of the mixture depends more on increase in productivity of less productive or dominated component of the mixture.

Area–time equivalency ratio was also highest in T_4, followed by T_7. In all the treatments ATER values were lesser than LER

Table 1 Yield of cassava and intercrops under different intercropping systems (pooled mean data of 2 years)

Treatment	Cassava yield (tonnes/ha)	Yield of I intercrop (kg/ha)		Yield of II intercrop (kg/ha)	
		Groundnut	Cowpea	Cowpea	Blackgram
T_1	21.92	657			
T_2	19.65		1 746		
T_3	22.57	942			
T_4	23.14		1 815		
T_5	22.69	860		21	
T_6	20.17	817			N
T_7	21.70		1 627	44	
T_8	20.22		1 801		N
T_9	20.48				
T_{10}	20.91				
T_{11}		2 327			
T_{12}			3 097	782	
T_{13}					852
CD (P = 0.05)	NS				

T_1, Cassava normal equidistance planting + groundnut; T_2, cassava normal equidistance planting + cowpea; T_3, cassava paired row planting + groundnut; T_4, cassava paired row planting + cowpea; T_5, cassava paired row planting + groundnut + cowpea; T_6, cassava paired row planting + groundnut + blackgram; T_7, cassava paired row planting + cowpea + cowpea; T_8, cassava paired row planting + cowpea + blackgram; T_9, cassava normal equidistance planting (sole crop); T_{10}, cassava paired row planting (sole crop); T_{11}, groundnut (sole crop); T_{12}, cowpea (first and second crop, sole crops); and T_{13}, blackgram (second crop, sole crop)

N, Negligible

Table 2 Efficiency of cassava-based intercropping systems using different indices

Treat-ment	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	LER	LEC	ATER	Mean of LER + ATER	Benefit : cost
T_1	20 135	25 864	5 729	1.35	0.30	1.14	1.25	1 : 1.28
T_2	17 139	24 890	7 751	1.52	0.54	1.12	1.32	1 : 1.45
T_3	19 276	28 225	8 949	1.48	0.43	1.18	1.33	1 : 1.46
T_4	17 319	28 584	11 265	1.70	0.65	1.28	1.49	1 : 1.65
T_5	20 748	27 911	7 163	1.49	0.01	1.19	1.34	1 : 1.35
T_6	20 679	25 870	4 391	1.31	*	1.09	1.20	1 : 1.21
T_7	18 008	25 712	7 704	1.63	0.03	1.21	1.42	1 : 1.43
T_8	18 241	25 643	7 402	1.56	1.01	1.14	1.35	1 : 1.41
T_9	13 853	20 480	6 626					1 : 1.48
T_{10}	13 890	20 907	7 017					1 : 1.51
T_{11}	11 340	13 961	2 621					1 : 1.23
T_{12}	11 613	10 135	—1 478					1 : 0.87
T_{13}	5 239	3 358	—1 881					1 : 0.64

*Second intercrop failed

The returns from cassava @ Re 1/kg, groundnut and blackgram @ Rs 6/kg and cowpea @ Rs 3/kg

Details of treatments are given with Table 1

values, indicating the underestimation of resource utilization. Mason *et al.* (1986) also made similar observations. The mean of LER + ATER and the benefit : cost ratio was the highest in T_4, giving a return of Rs 1.65/Re invested. The mean of LER + ATER was very closely correlated with benefit : cost ratio than with LEC, ATER and LER. Hence LER + ATER was a better measure of resource-utilization efficiency, as it correlates both agronomic and economic advantages in multi-season intercropping. The coefficients of correlation of LER, LEC, ATER and mean of LER + ATER with BCR were 0.8977^{*}, 0.6206^{NS}, 0.8035^{*} and 0.9210^{**} respectively.

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