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Intercropping of Young Cashew (*Anacardium occidentale* L.) and Its Effects on Crop Productivity and Land Utilization

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ABSTRACT. *Experiments evaluated the feasibility of intercropping young cashew plantations with annual food crops. Newly planted, two-year-old and five-year-old cashew plantations were intercropped with pigeonpea, maize, groundnut, cowpea and mungbean in Maha* season and *pigeonpea, sesame, cowpea and mungbean in Yala season. Growth of cashew in all intercropping plots was comparable to that of sole cashew, except when pigeonpea was intercropped with newly planted cashew. The growth and yield of annual food crops, which were intercropped with newly planted cashew, and two-year old cashew were not significantly different to sole annual food crops tested. In contrast, growth and yields of annual food crops were affected when intercropped with five-year-old cashew plants. This suggests that intercropping with annual food crops is not possible in older cashew plantations. Land Equivalent Ratio (LER) of all intercropping systems were greater than 1, indicating high yield advantages and efficient land use. Higher LER values were observed in cashew/maize and cashew/groundnut in the Maha season and cashew/sesame in the Yala season, respectively. Cost/benefit analysis indicated that intercropping with newly planted and two year old cashew with maize and groundnut in the Maha season and sesame in the Yala season is a profitable venture.*

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is found in almost all the districts of Sri Lanka, although more than half of the cultivation is confined to the dry areas of the Island. In 1999, the cultivated extent of cashew was 25,961 ha, which included 8320 ha of young plantations. Approximately 34% of cultivated extent of cashew is grown in pure stands, which has a potential for intercropping (Anon, 1997).

Cashew has a long gestation period compared to annuals. Therefore, income is not generated from cashew fields until bearing, which takes 3 to 5 years from planting. During this period, a considerable amount of money has to be spent for maintenance of cashew plantations. Therefore, the growers incur high expenditure without any income during this gestation period, even though subsidies are available from the Sri Lanka Cashew Corporation.

The dry zone of Sri Lanka has a vast potential with respect to production of cereals and grain legumes. In Sri Lanka, over 80% of grain legumes are grown under rainfed conditions in the dry zone and in some parts of the intermediate zone (Jayasekera *et al.*, 1992). As the inter-row space of cashew is 7.6 meters, these lands

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could be utilized to plant annuals such as maize, cowpea, mungbean, groundnut, pigeon pea and sesame until the land is fully covered by the cashew canopy. This will enable farmers gain a considerable income during the unproductive, early periods of 3-5 years. Therefore, intercropping cashew can be a profitable venture. However, studies have not been conducted to evaluate the growth of annual food crops when intercropped with cashew in Sri Lanka.

This study was conducted to evaluate growth and yield of selected food crops (maize, pigeonpea, groundnut, cowpea, mungbean and sesame) grown under young cashew and their impact on cashew plants.

MATERIALS AND METHODS

Location

The experiment was carried out at the Achchigewatta Estate, Karadipuval in the Puttalam district (8^0 10' N, 79^0 50' E, 15 m above sea level) located in the dry zone (DL3) of Sri Lanka.

The experimental site has a tropical monsoonal climate with a mean annual rainfall of 1172 $\pm$ 14.56 mm, mean monthly relative humidity of 76% and mean monthly temperature of 32 $\pm$ 2.14 ^{0}C. The soil of the site was Regosols with pH ranging between 5.4 – 5.6 and organic matter content of 0.77%.

Treatments

Three different age groups *viz.* a new planting field, a two-year-old cashew plantation and a five-year-old cashew plantation, were selected for the intercropping experiment. Six inter cropping treatments were used for each age group as given below;

T1 Pigeonpea (*Cajanus cajan*) variety ICPL 87 in *Maha season* and ratoon crop in *Yala* season.

T2 Maize (Zea mays) variety Ruwan in *Maha season* and sesame (*Sesame indicum*) local variety in *Yala season.*

T3 Groundnut (*Arachis hypogaea*) variety Tissa in *Maha season* and Cowpea (*Vigna unguiculata*) variety Waruni in *Yala season.*

T4 Cowpea (*Vigna unguiculata)* variety MI 35 in both *Maha season* and *Yala season.*

T5 Mungbean (*Vigna radiata*) variety MI 5 in both *Maha season* and *Yala season.*

T6 Sole cashew (*Anacardium occidentale)* without intercropping.

Treatments were laid out in a randomized complete block design with three replicates. The size of the experiment plot was 15.2 m x 22.9 m to accommodate six cashew plants per plot. All annual food crops included in the experiment were also planted in an adjacent field as monocultures in both seasons for determination of land equivalent ratio (LER).

Crop establishment

With the onset of North-East monsoon in October 1998, the land was ploughed, harrowed and leveled using tractors. The three and half month old grafted cashew plants were transplanted in the new planting field at a spacing of 7.6 m x 7.6 m in November 1998.

Annual food crops were seeded with the onset of monsoonal rains both in *Maha* and *Yala* seasons. The varieties, spacing and fertilizer rates used are shown in Table 1. At 14 days after sowing, seedlings of these food crops were thinned to one seedling per hill, except maize, which had two seedlings per hill. After harvesting in *Maha*, pigeonpea was ratooned.

Table 1. The variety, spacing and fertilizer rates for annual food crops.

Crop	Variety	Spacing (cm)	Fertilizer applied (kg ha^{-1})			
			Basal Dressing			Top Dressing
			N	P_2O_5	K_2O	N
Pigeonpea	ICPL87	30X 15	16	65	45	14
Maize	Ruwan	60 X 60	19	45	30	46
Groundnut	Tissa	45 X 15	16	65	45	14
Cowpea	MI 35	30 X 15	16	65	45	14
Cowpea	Waruni	45 X 15	16	65	45	14
Mungbean	MI 5	30 X 8	16	65	45	14
Sesame	Local	30 X 15	23	55	36	28

Management

Fertilizer rates recommended by the Sri Lanka Cashew Corporation [2:1 P, K mixture at 60 g $plant^{-1}$ as basal dressing and a top dressing of Urea (46% N) at 60 g$plant^{-1}$, two months after planting] were applied to the newly planted cashew. The two-year-old and five-year old cashew plants were fertilized with 11.5: 23: 15 N, P, K mixture at 250 and 1000 g $plant^{-1}$ $year^{-1}$, respectively. Plots were weeded 3 weeks after planting of the food crops. No weeding was necessary thereafter. Earthing-up was done in groundnut plants at the time of flowering. No irrigation was provided since farmers do not depend on irrigation water. The experiment was conducted under rain fed conditions.

Chlorofluazuron (Atabron®, 50% a.i) was applied to pigeonpea on four occasions (8 ml of Atabron® diluted in 10 L of water per application) at 10–day intervals starting from onset of flowering to control the damage by pod borers (*Maruca testularis*) in both seasons. During the *Maha* season, Oxydemeton-methyl (Metasistox®) was sprayed (46 ml of Metasistox diluted in 10 L of water per application) onto cowpea and mungbean at the seedling stage to control bean fly (*Ophiomyia phaseoli*).

Measurements

Growth of cashew was evaluated by measuring the girth (at 15 cm from stem base) and plant height, before the experiment was established and at the end of each cultivation season. Plant height and leaf area were recorded at the time of pod setting of annual food crops. Leaf area was measured using a portable leaf area meter (AM 100 ADC Ltd., EN 11, OAQ, U.K.).

During April to May 1999, the yield of cashew was collected in the five-year-old cashew plots. The crop yield of annual food crops in both sole and intercropping were harvested from a 2X4 m^2 sub plots from each plot. The grains were sundried and weights were recorded at 14% moisture content.

Incident solar radiation in each plot was measured by a Tube Solarimeter (TSL, Delta-T Device Ltd., Cambridge, CB5 OEJ, U.K.). The Land Equivalent Ratio (LER) was calculated for annual food crops with five-year-old cashew to assess its productivity (Willey, 1979). Cost / benefit analysis was carried out to determine the profitability of intercropping of annual food crops with cashew. The average market prices of annual food crops during the season were used in each instance. Data were statistically analyzed using an ANOVA and treatment differences were tested for significance, using DMRT.

RESULTS AND DISCUSSION

Incident solar radiation

The available incident solar radiation at the top of canopies of annual food crops was comparatively lower in the five-year-old cashew plots when compared to others (Table 2).

Table 2. Percentage of incident solar radiation available at the top of the canopy of annual food crops in different age groups grow under cashew plantations.

Groups of cashew	Available solar radiation (%)
Newly planted cashew plots	99.7 ± 0.27
Two year old cashew plots	89.4 ± 0.39
Five year old cashew plots	64.3 ± 1.57

Annual food crops, when intercropped with newly planted and two-year-old cashew, received 99.7% and 89.4% incident radiation, respectively. This was because cashew plants were not tall enough to provide shade during first two years. These results suggested that inter-row space of newly planted and two-year-old cashew plots could be used for cultivation of other crops.

Impact of intercropping on growth of cashew

The girth and height of newly planted cashew were affected by intercropping with annual food crops both in *Yala* and *Maha* seasons (Table 3). The impact of intercropping was significant only when pigeonpea was planted in between cashew plants. This could be attributed to the high shade provided by pigeonpea when compared to other annual food crops. Similarly Njoroge and Kimemia (1995) reported the adverse impacts of intercropping coffee with maize, which is also a taller species when compared to young coffee.

The girth and height of two-year-old and five-year-old cashew plants intercropped with annual food crops were similar to that of the sole crop. The exception was when two-year-old cashew was intercropped with cowpea and mungbean in both *Yala* and *Maha* seasons (Table 3). The beneficial impact of intercropping on the girth and height of cashew plants could be attributed to the better overall environment due to tillage, weeding and application of fertilizers for annual crops. Beneficial effects on trees in intercropping have also been reported by Yomoah *et al.* (1986) and Singh *et al.* (1997).

Table 3. Increment in girth and height of cashew plants at the end of *Maha* and *Yala* seasons.

Growth parameter	Cropping systems	Newly planted cashew		Two-year-old cashew		Five-year-old cashew	
		End of *Maha*	End of *Yala*	End of *Maha*	End of *Yala*	End of *Maha*	End of *Yala*
Girth increment (cm)	Cashew/pigeonpea	2.9	5.7*	8.6	12.0	7.6	7.0
	Cashew/maize/sesame	3.1	6.8	9.1	12.7	8.0	7.2
	Cashew/groundnut/cowpea	3.3	7.2	8.7	12.2	7.8	7.1
	Cashew/cowpea	3.2	7.0	8.5	11.7	7.5	7.0
	Cashew/mungbean	3.1	7.1	8.0	11.5	7.6	6.9
	Sole cashew (Control)	3.3	7.2	8.5	11.8	7.5	6.9
	CV%	6.4	3.7	7.1	7.6	10.7	10.0
Height increment (cm)	Cashew/pigeonpea	36.2	38.2	58.5	32.0	25.3	20.6
	Cashew/maize/sesame	36.8	39.8	59.0	32.1	26.1	21.0
	Cashew/groundnut/cowpea	37.8	41.6	58.7	31.8	24.7	20.1
	Cashew/cowpea	37.5	41.2	58.4	31.4	24.4	19.8
	Cashew/mungbean	37.0	40.0	58.0	31.4	24.2	19.5
	Sole cashew (Control)	37.3	40.8	58.0	31.3	24.1	19.3
	CV%	5.2	3.4	5.5	5.1	4.9	5.9

* Significant at p= 0.05

Impact of intercropping on yield of cashew

The yield of the cashew monocrop was higher than in intercropped cashew plots (Table 4). The lowest yield of cashew (452 kg ha^{-1}) was observed in the cashew/pigeonpea intercropping system when compared to the other intercropping systems. Although the soil moisture content was not measured, this could be due to

the competition for water between cashew and pigeonpea, as pigeonpea is a high water requiring and vigorously growing crop (Singh *et al.*, 1983). Between two seasons pigeonpea plant survived, which also needs water, whereas all other annuals completed their life cycles after harvesting. This could also be attributed to low yield of cashew in cashew/pigeonpea intercropping plots. Since there were no significant differences in the yield of cashew among the treatments, intercropping systems did not have significant detrimental effects on the cashew yield.

Table 4. Yield of cashew and Land Equivalent Ratio (LER) in different intercropping systems.

Cropping system	Yield (kg ha^{-1})	Land equivalent ratio (LER)	
		Maha season	*Yala* season
Cashew/pigeonpea	452	1.33	1.11
Cashew/maize/sesame	482	1.51	1.53
Cashew/groundnut/cowpea	487	1.54	1.31
Cashew/cowpea	496	1.39	1.35
Cashew/mungbean	510	1.37	1.37
Sole cashew	528		
CV%	15.0	8.4	11.5

Impact of intercropping on growth of annual food crops

When annual food crops were intercropped with newly planted and two-year-old cashew, the plant height and leaf area index were similar to those of the sole crop (Table 5). This could be associated with the availability of light for annual food crops when intercropped with cashew. Since young cashew (during the first two years) intercepts a lower quantum of light due to the smaller canopy (Table 2), the growth of annual food crops is affected to a lesser extent.

Plant height and leaf area index of annual food crops cultivated with five-year-old cashew were significantly lower than that of sole crops. This could probably be due to the root competition for moisture and shade provided by cashew (Table 2). Katayama *et al.* (1998) observed that leaf area and plant height were low in maize and mungbean under shade.

Impact of intercropping on yield of annual food crops

Intercropping annual food crops in the newly planted and two-year-old cashew plots had no significant impact on yield of all species (Table 5). This is because the cashew plants were too small during the first two years to compete with annual food crops for light and moisture (Table 2). Dhyani *et al.* (1994) reported that the yields of intercropped annuals were not affected when they were cultivated with perennials during early stages of establishment of the latter.

The yield of annual food crops was significantly lower than in the sole crops when intercropped with five-year-old cashew in both seasons. The low yield could also be due to the reduction of the rate of canopy photosynthesis associated with the decrease in the leaf area and light interception. Many researchers reported that yields of intercropped annuals were lower than sole crop due to shade. Samaranayake and

Gunasena (1992) observed a yield reduction in intercropped winged bean compared to sole crop due to shade. The yield components of mungbean were considerably low when associated with the tall species which provide shade (Sangakkara, 1987).

Land equivalent ratio (LER)

The LER values of all intercropping systems were greater than 1 in both seasons (Table 4). This indicates that when cashew is intercropped with annual food crops, efficiency of land resource utilization was greater than growing this species as a sole crop. The lowest LER values of 1.33 and 1.11 were recorded in cashew/pigeonpea intercrop in *Maha* and *Yala* season, respectively. This could be attributed to low growth, yield and poor ratoon yield of pigeonpea when intercropped with cashew. Cashew/maize and cashew/groundnut intercropping systems in the *Maha* season and cashew/sesame intercropping system in the *Yala* season had higher LER values than other cropping systems, suggesting that these three intercropping systems had a greater productivity. LER values of intercropping systems in the *Maha* season were higher than in the *Yala* season. This suggested that except in sesame, other selected annual food crops gave poor growth and yield in the *Yala* season due to low rainfall in this season. Sesame could produce an acceptable yield even in water stress conditions due to its strong and deep tap root system (Arnon, 1972).

Table 6. Benefit : cost ratio of annual food crops in *Maha* and *Yala* seasons.

Cropping systems	Newly planted cashew		Two-year-old cashew		Five-year-old cashew	
	Net return (Rs ha^{-1})	Benefit: cost ratio	Net return (Rs ha^{-1})	Benefit: cost ratio	Net return (Rs ha^{-1})	Benefit: cost ratio
Maha season						
Cashew/pigeon pea	1045	0.04	317	0.01	-11,305	0.46
Cashew/maize	3,290	0.14	2,204	0.10	-6,501	-0.29
Cashew/groundnut	19,461	0.64	17,863	0.59	2,412	0.08
Cashew/cowpea (var.MI35)	-366	-0.01	-1,825	-0.07	-14,157	-0.53
Cashew/mungbean	1,134	0.04	370	0.01	-15,323	-0.54
Yala season						
Cashew/pigeon pea	2,638	0.20	1,838	0.14	-8,962	-0.68
Cashew/sesame	4,095	0.26	3,263	0.21	-2,626	-0.17
Cashew/cowpea (Var. Waruni)	-8,440	-0.41	-8,758	-0.43	-14,990	-0.73
Cashew/cowpea (var.MI35)	-8,352	-0.39	-8,485	-0.39	-15,513	-0.72
Cashew/mungbean	-7,029	-0.31	-7,480	-0.32	-15,778	-0.68

Table 5. Plant height, leaf area index (LAI) and yield of annual food in intercropping and sole cropping.

Growth parameters and Yield	Crop	Intercropping						Sole cropping	
		Newly planted cashew		Two year old cashew		Five year old cashew			
		Maha	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*	*Maha*	*Yala*
Plant height (cm)	Pp	95.8 ± 0.80	82.5 ± 0.69	94.2 ± 0.75	81.8 ± 0.83	90.1 ± 1.88 *	77.8 ± 0.92 *	96.4 ± 0.35	83.1 ± 0.80
	Ma	185.4 ± 1.47	87.4 ± 1.04	182.7 ± 1.57	86.5 ± 1.01	175.7 ± 1.49 *	80.0 ± 1.20 *	187.6 ± 1.45	88.5 ± 0.85
	Gn	31.8 ± 0.98	29.2 ± 0.75	31.5 ± 1.24	28.3 ± 0.73	27.1 ± 1.29 *	26.2 ± 1.27 *	32.2 ± 1.15	30.5 ± 0.71
	Cp	41.6 ± 0.61	34.2 ± 0.54	41.2 ± 0.99	33.5 ± 0.64	39.6 ± 0.53 *	31.7 ± 0.75 *	42.4 ± 0.75	34.6 ± 0.45
	Mb	37.5 ± 0.87	30.0 ± 0.65	36.2 ± 0.76	28.5 ± 0.72	35.2 ± 0.71 *	26.4 ± 0.52 *	38.2 ± 0.64	29.3 ± 0.70
LAI	Pp	3.28 ± 0.07	2.89 ± 0.02	3.05 ± 0.15	2.84 ± 0.03	2.46 ± 0.15 *	2.25 ± 0.12 *	3.47 ± 0.09	2.93 ± 0.03
	Ma	2.46 ± 0.04	2.02 ± 0.04	2.43 ± 0.04	1.97 ± 0.05	1.93 ± 0.05 *	1.39 ± 0.06 *	2.57 ± 0.05	2.12 ± 0.05
	Gn	2.02 ± 0.04	0.94 ± 0.04	1.97 ± 0.04	0.88 ± 0.04	1.42 ± 0.04 *	0.65 ± 0.03 *	2.05 ± 0.03	0.98 ± 0.03
	Cp	2.35 ± 0.09	1.46 ± 0.05	2.21 ± 0.06	1.32 ± 0.06	1.95 ± 0.10 *	0.83 ± 0.06 *	2.48 ± 0.09	1.52 ± 0.06
	Mb	2.23 ± 0.08	1.41 ± 0.07	2.09 ± 0.08	1.31 ± 0.06	1.54 ± 0.08 *	0.76 ± 0.03 *	2.36 ± 0.07	1.49 ± 0.07
Yield (kg ha^{-1})	Pp	994 ± 40.50	632 ± 26.18	966 ± 32.20	600 ± 28.87	519 ± 27.18 *	168 ± 15.10 *	1058 ± 46.40	654 ± 22.84
	Ma	2749 ± 48.68	600 ± 28.03	2632 ± 84.05	575 ± 26.27	1694 ± 33.55 *	398 ± 34.59 *	2875 ± 75.37	653 ± 25.47
	Gn	1400 ± 41.39	452 ± 23.92	1355 ± 3.79	440 ± 25.89	920 ± 37.10 *	205 ± 12.66 *	1477 ± 31.35	525 ± 22.91
	Cp	995 ± 28.39	501 ± 18.49	940 ± 30.90	496 ± 17.24	475 ± 17.68 *	231 ± 13.32 *	1050 ± 28.87	560 ± 16.29
	Mb	850 ± 25.17	462 ± 17.64	828 ± 25.71	448 ± 24.89	375 ± 11.10 *	209 ± 9.60 *	920 ± 22.37	525 ± 19.19

* Significant at p= 0.05, Pp= Pigeonpea, Ma= Maize, Gn= Groundnut, Cp= Cowpea, Mb= Mungbean.

Benefit : cost ratio

All selected annual food crops in five-year-old cashew plots in the *Yala* season had low benefit : cost ratio when compared to those in newly planted and two-year-old cashew plots (Table 6). Thus, intercropping in five-year-old cashew plantations does not seem to be economically viable in both seasons. In contrast, this study has shown that maize and groundnut in the *Maha* season and pigeonpea and sesame in the *Yala* season can be profitably intercropped with young cashew plantations (first 2-3 years of establishment).

CONCLUSIONS

Intercropping with selected annual food crops has no deleterious effects on growth, development and yield of young cashew (2-3 years from planting) except when intercropped with pigeonpea.

The growth and yields of selected annual food crops are significantly low when they were intercropped with five-year-old cashew plants. The results of this study show that if annual food crops are intercropped with newly planted and two-year-old cashew plots, the growth and yield reduction could be minimal. Productivity in terms of the LER was higher in all the intercropping systems than sole cashew, suggesting that intercropping is a more efficient land use system in cashew.

Hence, this study shows the possibility of growing maize and groundnut in *Maha* season and sesame in *Yala* season as intercrops with young cashew without affecting growth and development of cashew. Further studies are recommended to ascertain the feasibility of intercropping older stands of cashew with annual food crops.

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