ARECANUT BASED CROPPING SYSTEMS

S. Sujatha and Ravi Bhat*

Arecanut (*Areca catechu* L.) is highly economical among the plantation crops grown in humid tropics of India. The traditional arecanut growing regions in India are coastal Karnataka and Kerala, parts of Maharashtra, Assam and West Bengal. It is essentially a crop of small and marginal holders cultivated in 0.42 million hectares in India with a production of 0.52 million tons and productivity of 1249 kg ha^{-1} which gives insufficient income to sustain dependent families. So, the emphasis should be to increase the productivity per unit area. The practice of well planned and executed inter/mixed cropping is fundamental for increasing the productivity and income per unit area. The research work towards the same is being done at Central Arecanut Research Station and Central Plantation Crops Research Institute since 1950s. However, upgradation of existing technologies to develop highly productive, remunerative and farmer friendly cropping system is of prime importance. It becomes necessary to grow value added and export oriented inter/mixed crops in this era of WTO as arecanut has limited alternative uses and export potential.

Scope for cropping systems in arecanut plantation

Arecanut as a sole crop does not utilize fully the natural resources such as soil, space and light. Rooting pattern revealed that arecanut palms planted at a spacing of 2.7 x 2.7 m could use only 30 % of the land area and cultural operations are also confined to 75 cm radius from the base of the palm. About 61% of all the roots and 51% of fine roots are concentrated within a radius of 50 cm from the trunk of the palm. Thus, the arecanut palm exploits only 2.27 m^2 of land area out of 7.29 m^2 area available to each palm. Recent studies with adoption of better management practices indicated that arecanut roots are concentrated with in 50 cm distance and depth from the base of the palm and utilize only 40 % of the land space (Table 1, Bhat and Sujtha, 2008). Studies on light interception carried out at CPCRI, RS, Vittal indicated only 43 per cent light interception by arecanut monocrop, while, it can be increased to 95 per cent with mixed crops in arecanut. The compact nature of arecanut crown, raised well above the ground (10 to15 m), allows more sunlight to transmit to ground and maintains high humidity which, in turn, favours excellent growth of shade loving intercrops/mixed crops. The space occupied by component crops (47 per cent) was higher than that occupied by arecanut (16 per cent). These findings indicate that there is an excellent opportunity for temporal and spatial distribution of crop species in arecanut gardens for achieving higher resource use efficiency. More over the potential for multiple cropping in arecanut is greater because it is raised mainly as an irrigated crop.

Compatible crops for multiple cropping

For the success of multiple cropping from biological point of view, proper choice of crops is a pre-requisite. The choice of component crops

* Central Plantation Crops Research Institute, Regional Station, Vittal-574243

Table 1. Root distribution of arecanut palms as influenced by drip fertigation, basin and sprinkler irrigation methods

Parameter	100 % NPK fertigation	75 % NPK fertigation	50 % NPK fertigation	100 % NPK soil application + drip	Basin irrigation	Sprinkler irrigation
Maximum rooting length (cm)	135	144.5	128	115	121	127
Maximum rooting depth(cm)	136	116	101	117	78	77
Total root weight (kg/palm)	8.23	7.99	4.84	5.28	3.25	3.94
% of fine roots	34	37	43	33	22	21
% of total roots within 50 cm distance and depth	87	87	83	83	100	97

(Source: Bhat and Sujatha, 2008)

mainly depends up on it's ability to grow under the shade of arecanut palm and to withstand heavy dripping during monsoon. A large number of annuals, biennials and perennial crops have been tried at CPCRI, Regional station and research centres to evolve suitable crop combinations. Earlier studies have indicated that crops like banana, ginger, chilli, colocasia, paddy, turmeric, elephant foot yam and dioscorea are found more adopted for intercropping in arecanut garden in initial stages. However, it is found that as the age of the garden advances, only few crops can be grown profitably as mixed crops viz., pepper, cocoa, banana, acid lime and betel vine. Banana is a general preference in all arecanut growing regions. Pepper is a highly profitable and suitable mixed crop for all agro-climatic regions of arecanut growing tract. Cocoa, a shade loving crop, is an ideal mixed crop with arecanut. Instances of cardamom being grown as suitable mixed crop with arecanut are reported. Cardamom has served as a most remunerative and quick yielding spice crop in arecanut tract of North kanara and Wynad districts. In general, arecanut yield is not affected by intercropping. There was perceptible increase in arecanut yield (7-21 per cent) with intercropping. This can be attributed to the favourable microclimate created by intercropping and recycling of large quantities of organic matter resulting in improved soil fertility.

From studies on high density multispecies cropping system at different agro-climatic regions, crops like pineapple and coffee are found not remunerative. Output-input ratio is only 0.6 in case of pineapple. It may be due to excessive shade under arecanut, banana, pepper and cocoa resulting in less yields. Coffee variety (San Ramon) tried is not suitable for low altitude regions. However, with the release of suitable coffee varieties for low altitudes, it can be tried again. Clove is also found to be not remunerative.

Management of cropping systems

The success of cropping system depends on proper choice of varieties i.e., for low light

intensities, planting geometry, fertilizer management and irrigation management. There is a need to screen varieties for tolerance to low light intensities, diseases and pests for mixed cropping in arecanut plantations. Fertilizer recommendations for cropping systems have been so far generally based on the fertilizer schedule for sole crops to avoid any competition for nutrients. The trials on high density multispecies cropping system involving arecanut, pepper, cocoa and banana at CPCRI, Regional Station, Vittal indicated that recycling of organic matter from the system could meet 50 per cent N and 50 per cent K requirement of the system. Similarly, a six year study to quantify the feasibility of economising the fertilizer use in the cropping model involving arecanut- banana - cocoa - pepper revealed that the fertilizer requirement could be scaled down to 66 per cent of the recommended dose.

Generally, mixed cropping/multiple cropping does not increase the water requirement. The transpiration losses may increase in mixed cropping. While, evaporation and run off losses are likely to be reduced because of crop cover and presence of residues with increased soil moisture storage and water use efficiency. General recommendation is that irrigation should be based on the moisture depletion in case of base crop. The drip irrigation requirement is found to be same for both component crops in arecanut + cocoa cropping system.

No serious pest and disease problems are observed due to inter/mixed cropping in areca plantations. However, infestation of root-knot and burrowing nematodes is an important problem in high density multispecies cropping system in arecanut. Banana and pepper are the most affected crops.

Arecanut +cocoa mixed cropping system

Systematic research on cocoa was initiated at CPCRI under ICAR at Regional Station, Vittal in the late 1960's with the introduction of this species as mixed crop in arecanut gardens with the main objective of crop diversification. The investigations at CPCRI showed that the mixed cropping has profound influence on evaporation, wind velocity, soil and air temperature and relative humidity. Experimental results showed that arecanut +cocoa at 50: 50 ratio registered higher yield (pods per tree per year) of 81.7 than cocoa as border crop with 30.9 pods during 4th year of planting. This implies that cocoa performs better under arecanut than as border crop due to partial shade requirement of cocoa. With regard to suitability of planting material, both seedlings and grafts performed uniformly as mixed crops in arecanut plantation (Table 2, Balasimha, 2007 and 2009). For optimum productivity of both arecanut and cocoa in mixed cropping system, ideal spacing and pruning regime are important to avoid competition. Studies have been conducted to standardize the spacing for cocoa under arecanut. Shama Bhat (1988) advocated that combination of 2.7 m x 2.7 m for arecanut and 2.7 m x 5.4 m for cocoa is preferable over 2.7 m x 2.7 m for both the crops in view of the operational advantages and the yield difference between these two is not appreciable (Table 3). Experimental results at Kannara indicated that there are no significant differences between quincunx and square methods of alignment and arecanut yield is not affected by these cropping systems (Balasimha, 2004). It was concluded from a long term study at Vittal that a spacing of 2.7 x 5.4 m and pruning regime of 16-20 m canopy is recommended for grafts both from th

Table 2. Dry bean yield of mixed cropped cocoa (kg/ ha)

Spacing in m (S)	Pruning regime (P)							
	Seedlings				Grafts			
	P1	P2	P3	Mean	P1	P2	P3	Mean
S1 (2.7 x 2.7)	165	746	881	597	489	727	975	730
S2 (2.7 x 5.4)	354	661	729	581	530	705	828	688
S3 (5.4 x 5.4)	490	428	516	478	-	-	-	-
Mean	336	612	709	-	509	716	902	-
CD (P=0.05)								
S			92.8			NS		
P			71.0			97		
S x P						257		

Note: P1: 10m^3; P2: 10-15m^3; P3: 16-20m^3 (Source : Balasimha, 2007 and 2009)

Table 3. Average yield of inter planted cocoa and arecanut (7th to 11th year)

Spacing (m)		Cocoa pod yield (t/ha)	Arecanut yield (t/ha)
Arecanut	Cocoa		
2.7 x 2.7	2.7 x 2.7	17.7	6.6
2.7 x 2.7	2.7 x 5.4	15.0	7.8
2.7 x 2.7	5.4 x 5.4	9.2	9.6
3.9 x 3.9	3.9 x 3.9	13.6	4.5
3.3 x 3.3	3.3 x 3.3	19.2	5.9
1.8 x 5.4	3.6 x 5.4	13.0	6.2
CD(P=0.05)		3.14	1.89

(Source: Shama Bhat, 1988)

yield point of view and agronomic advantage (Balasimha, 2009). This can be attributed to higher net photosynthesis and increased light interception up to 90 %. From the above results,

it is clear that spacing and pruning become important determinants of yield in cocoa. The fertilizer recommendation for cocoa under average management is 100:40:140 g of N, P_2O_5 and K_2O per plant for a year, which tallies with the crop removal figures (Shama Bhat, 1988). Systematic study for 10 years on drip irrigation and fertilizer requirement of cocoa mixed cropped in arecanut revealed that drip irrigation at E_0 of unity and a fertilizer dose of 100: 40: 140 g of N P_2O_5 and K_2O per tree per year would be optimum for cocoa (Abdul Haris *et al*., 1999).

Arecanut + banana intercropping system

Banana is usually grown as nurse or shade crop in arecanut plantations. From a field study at Kannara on suitability of banana cultivars for intercropping, Robusta, Mysore poovan, Red banana and Karpuravally were found suitable for intercropping (Nayar *et al.*, 1985), while the variety Red banana gave maximum net returns without any adverse effect on yield of arecanut. Banana fetches interim revenue in the initial years, which will help the farmers in cash flows.

Arecanut + pepper intercropping system

Pepper is raised exclusively as mixed crop in homestead gardens in Kerala and Karnataka and over 90 % pepper is trained on coconut and arecanut trunks. Studies carried out at CPCRI have also revealed that pepper is the most compatible perennial spice crop with arecanut and can be profitably grown as mixed crop. Experimental data from mixed cropping of arecanut and black pepper for a duration of 10 years showed that there is no detrimental effect on the yield of arecanut palms due to training black pepper on them. Further, it helps to augment the income of the farmer by mixed cropping of black pepper (Nayar, 1982).

The performance of pepper cultivars, Panniyur-1 and Karimunda, were better compared to others in all the spacing treatments at Vittal (Nair, 1982). A study was conducted to investigate the performance of four varieties of pepper as a mixed crop in a 19-year-old arecanut garden with six planting densities (Table 4). The results revealed that, in arecanut garden with

Table 4. Average yield of pepper (green berries and ripe arecanut)

Spacing (m) for arecanut	Arecanut yield (t/ ha)	Pepper yield (t/ ha)	
		Panniyur-1	Karimunda
1.8 x 1.8	20.0	4.82	7.26
1.8 x 2.7	13.8	6.09	9.48
1.8 x 3.6	10.8	3.34	6.43
2.7 x 2.7	9.2	7.12	6.05
2.7 x 3.6	9.3	3.96	4.55
3.6 x 3.6	5.7	2.43	3.47
Mean	11.5	4.63	6.21

recommended spacing of 2.7 x 2.7 m, 43 % of sunlight is available to other crops. Pepper as a mixed crop does not influence the yield of arecanut. With respect to the yield of pepper, 1.8 m x 2.7 m spacing had given significantly more yield per plot (7.09 kg) followed by 1.8 x 3.6 m spacing. Among the cultivars of pepper, Karimunda gave the highest yield (8.92 kg/plot) followed by Panniyur-1 (6.68 kg/plot). The cultivars Uddakare and Malligesara had resulted in poor yield (Abdul Khader et al. 1993). Reduction in economic yield of pepper due to *Phytophthora* diseases was reported. This necessitates the need for testing new varieties of pepper as mixed crop for tolerance to shade and diseases in arecanut plantation.

Intercropping of medicinal and aromatic plants

Experimental results of four year trial at Vittal by (Sujatha *et al.,* 2011) revealed that medicinal and aromatic plants like Shatavari (*Asparagus racemosus*), Vetiver (*Vetiver zizanoides*), Long pepper (*Piper longum*), Brahmi (*Bacopa monnieri*), *Nilagirianthus ciliatus*, Periwinkle (*Catharanthus roseus*), Aloe (*Aloe vera* or *barbadensis*), Lemon grass (*Cymbopogon flexuous*), Palmarosa (*Cymbopogon martinii*), Basil (*Ocimum basilicum*), Davana (*Artemisia pallens*) and Patchouli (*Pogostemon cablin*) performed better as intercrops in arecanut. However, Senna (*Cassia anguistifolia*), Safed musli (*Chlorophytum borivillianum*), aswagandha (*Withania somnifera*) and geranium (*Pelargonium* sp) did not come up well as intercrops in arecanut. Shatavari produced fresh root yield of 14.3 t/ha of arecanut garden and contributed maximum kernel equivalent yield (2045 kg/ ha). Aromatic plants like lemon grass, patchouli, davana, palmarosa and basil performed better with chali equivalent varying between 406 kg/ ha in the case of basil to 1,286 kg/ ha in lemon grass. All the medicinal and aromatic crops contributed to productivity increase of 10.7 % in basil to 53 % in shatavari in terms of kernel equivalent per hectare of arecanut garden. All the medicinal and aromatic plants are superior and system productivity can be considerably enhanced with intercropping (Table 5, Sujatha *et al.*, 2011). Based on all advantages and disadvantages noticed in cultivation of Medicinal & Aromatic plants in arecanut plantation, farmers are advised to grow aromatic plants in large areas on a community basis to meet the industrial demand and variety of medicinal crops in small areas based on local demand.

High Density Multi Species Cropping System

It is a system where more than two crops are grown simultaneously with main crop. Arecanut based high density cropping systems having component crops like cocoa, pepper, banana and clove is self-sustainable and application of N and P through inorganic fertilizers could be reduced or skipped when the recyclable wastes from the system are recycled as vermicompost. The system improved the soil physic-chemical and biological properties of the soil which enhanced the productivity from unit area of land. But the system proved exhaustive with respect to K availability. The exhaustion of K indicates the necessity of including K in the fertilizer schedule of the system, as organic matter cannot supplement K requirement of crops and all the component crops are heavy feeders of K (Bhat and Sujatha 2007).

Based on studies by different workers at different agro-climatic regions of arecanut growing belt, the following models are found to be boilogically suitable and economically feasible.

Table 5. Production and productivity components of intercropping of medicinal and aromatic plants in arecanut

Crop	Production components (kg ha^{-1})				Net return per rupee investment	Production efficiency (kg/ ha/ day)
	Yield of intercrop*	Kernel equivalent of intercrop	Arecanut kernel	System productivity		
Vetiveria zizanoides	1006	706	2515	3231	2.42	3.7
Asparagus racemosus	10666	1524	3343	4359	2.59	6.0
Piper longum	231	272	2718	2990	2.22	4.1
Bacopa monnieri	2070	739	3586	4325	3.64	5.9
Nilagirianthus ciliatus	7087(leaf)	1429			2.88	
	1017(root)		1884	3313		4.0
Catharanthus roseus	2194(leaf)	704	3440	4144	2.54	7.6
	115(root)					
Aloe vera	15490	471	3081	3552	1.99	4.9
Cymbopogon flexuous	8460	1218	3121	4338	4.25	5.9
Cymbopogon martini	3249	485	2678	3164	1.95	4.3
Ocimum basilicum	8130	398	3311	3708	3.46	8.2
Pogostemon cablin	9082	863	3362	4225	2.18	5.8
Artemisia pallens	5248	629	3595	4224	3.12	7.8
LSD (P=0.05)	-	162.5	756	553	-	-

Note: For crops like Asparagus racemosus and Cymbopogon martini, two years data was available. Asparagus racemosus and Aloe vera yields were expressed on fresh weight basis

Region	Efficient cropping model
Maidan parts of Karnataka	Arecanut-pepper-cocoa
	Arecanut-banana-acid lime
Costal Karnataka and Kerala	Arecanut-pepper-cocoa-banana
North Bengal region	Arecanut-pepper-banana
	Arecanut-pepper-acid lime
Wynad dist. of Kerala and Uttara Kannada dist. of Karnataka	Arecanut-cardamom

References

Abdul Haris, A., Balasimha, D., Sujatha, S., Bhat Ravi and Khader, K. B. A. (1999). The influence of drip irrigation and fertilizer on yield and photosynthetic characteristics of cocoa in mixed cropping system with arecanut. *J. Plantation Crops* 27, 131-135.

Abdul Khader, K.B., Nair, M.G.K. and Yadukumar, N. (1993). Performance of four varieties of black pepper (*Piper nigrum* L) as mixed crop with arecanut (*Areca catechu* L) under different planting densities. *J. Plantation Crops* 21, 7-11.

Balasimha, D. (2004). Cropping Systems. In "Arecanut" (D. Balasimha and V. Rajagopal Eds.), CPCRI, Kasaragod. pp. 103-130.

Balasimha, D. (2007). Efficacy of pruning in enhancing bean yield of cocoa. *J. Plantation Crops* 35, 201-202.

Balasimha, D. (2009). Effect of spacing and pruning regimes on photosynthetic characteristics and yield of cocoa in mixed cropping with arecanut. *J. Plantation Crops 37(1)*, in press.

Bhat Ravi and Sujatha, S. (2007). Soil fertility status as influenced by arecanut based cropping system and nutrient management. *J. Plantation Crops* 35(3): 158-165.

Bhat Ravi and Sujatha, S. (2008). Root distribution of arecanut (Areca catechu L.) as influenced by drip fertigation in a laterite soil. *Indian J. Agric. Sci.* 78, 804-807.

Nair, M.G. (1982). Inter Cropping with Pepper. *Indian Farming* 32, 17-19.

Nayar, T.V.R. (1982). Grow pepper in arecanut gardens. *Indian Farming*. 32, 27-31.

Nayar, T.V.R., Muralidharan, A. and Shama Bhat, K. (1985). Evaluation of banana varieties for intercropping in arecanut gardens. *In* : Proceedings of Silver Jubilee Symposium on Arecanut Research and Development, (K Shama Bhat and C.P.R. Nair Eds.) pp 70-73. CPCRI, RS, Vittal.

Shama Bhat, K. (1988). Growth and performance of cacao (*Theobroma cacao* L.) and arecanut (*Areca catechu* L.) under mixed cropping system. *In* "Proc. 10th Intern. Cocoa Res. Conf.", pp. 15-19. Santo Domingo, Dominican Republic.

Sujatha, S., Bhat Ravi, Kannan, C. and Balasimha, D. (2011) Impact of intercropping of medicinal and aromatic plants with organic farming approach on resource use efficiency in arecanut (*Areca catechu* L.) plantation in India. *Industrial Crops and Products*. 33(1), 78-83.

****