Research Article

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Intercropping of medicinal and aromatic crops in adult coconut garden under Brahmaputra valley region of Assam

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Abstract

A field experiment conducted at Horticultural Research Station, Kahikuchi of Assam Agricultural University revealed the performance of medicinal and aromatic plants grown as intercrops in 32 year old Assam Green Tall coconut garden. There were three medicinal plants *viz*., sarpagandha (*Rauvolfia serpentina*), pipali (*Piper longum*) and vedailota (*Paederia foetida*) and two aromatic plants *viz*., citronella (*Cymbopogon winterianus*) and patchouli (*Pogostemon cablin*) in the experiment. The yield of all the medicinal and aromatic plants grown as intercrop in coconut garden were found to be reduced compared to their sole crop yields. The reduction in yield was less in patchouli (5.2%), followed by vedailota (7.0%), sarpagandha (8.9%), pipali (9.0%) and citronella (16.8%). The nut yield of coconut improved with intercropping with medicinal and aromatic crops. The piperine content in pipali, alkaloids in sarpagandha and essential oil content in patchouli were significantly reduced when grown as intercrops in coconut garden as compared to sole crop. However, the iridoid glycosides in vedailota and essential oil content in citronella were not significantly influenced by intercropping. Intercropping system of growing with patchouli under coconut recorded the highest net income (₹178,089 ha^{-1}) and B:C ratio (3.26) followed by sarpagandha (₹157,484 ha^{-1} and 3.09), pipali (₹113,118 ha^{-1} and 2.62), citronella (₹ 107,432 ha^{-1} and 2.40) and vedailota (₹100,382 ha^{-1} and 2.36). Hence, intercropping of patchouli, sarpagandha and pipali with coconut can be recommended for Assam condition.

Keywords: Coconut, intercropping, medicinal and aromatic plants

Introduction

In recent years, the importance of medicinal and aromatic plants is well recognized as they constitute a major segment of the flora, which provides raw materials for use in pharmaceuticals, cosmetics and drug industries. Medicinal and aromatic plants are also the source of natural antioxidants (Singer *et al*., 2003). The demands for herbal medicines, health products, pharmaceuticals, food supplements and cosmetics are increasing day by day both in domestic and international market (Ved and Goraya, 2008). As a result, collection of medicinal and aromatic herbs from natural forest has increased and hence many of such plants have become rare or endangered. Problems arising out of rapid genetic loss of these plants forced the need for conservation and cultivation of medicinal and aromatic plants to ensure the availability for future use.

Coconut (*Cocos nucifera* L.) is usually planted with a spacing of 7.5 m x 7.5 m offering ample scope for intercropping with suitable perennial, biennial and seasonal crops including medicinal and aromatic plants leading to considerable increase in the production and productivity per unit area, cropping intensity by more efficient utilization of sunlight, soil, water and labour. Although many crops can be grown well under coconut garden (Rethinam, 2001), profitability of growing MAPs as intercrops under adult coconut garden has been reported by some workers (Suneetha and Chandrakanth, 2003; Basavaraju *et al*., 2011;

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Mohandas, 2011). However, location specific research studies on MAPs as intercrops in coconut growing areas are limited. Hence, a field experiment was carried out to identify suitable medicinal and aromatic crops for intercropping in coconut garden under Assam condition.

Materials and methods

A field experiment was carried out from 2006-07 to 2010-11 in 32 year old Assam Green Tall coconut garden at the Horticultural Research Station, Kahikuchi, Guwahati, Assam under All India Co-ordinated Research Project on Palms, which is situated at 26.3^0 N latitude and 91.7^0 E longitude with an altitude of 64 m above mean sea level. The station enjoys a sub-tropical climate, with an annual rainfall of about 1500 mm. The soil of the experimental site was alluvial clay-loam with a pH of 4.9, low in available nitrogen (236 kg ha^{-1}), medium in available phosphorus (26 kg ha^{-1}), medium in available potassium (162 kg ha^{-1}) with an organic carbon of 0.45 per cent. The experiment consisting of three medicinal plants *viz*., sarpagandha (*Rauvolfia serpentina*), pipali (*Piper longum*) and vedailota (*Paederia foetida*) and two aromatic plants *viz*., citronella (*Cymbopogon winterianus*) and patchouli (*Pogostemon cablin*) was laid out in randomized complete block design with four replications taking four palms per treatment. The MAPs were grown in 84 per cent of the area in the interspaces of coconut leaving 16 per cent in the coconut basins. The intercrops received only organic manure *viz*., FYM @ 25 tonnes ha^{-1} and other intercultural operations as per the package for herbal plants. No serious pest or disease was noticed in the experimental crops. For minor seasonal pests neem oil was sprayed based on the need. The crops were harvested at full bloom stage/mature green berry stage/maturity stage depending on the economic part required for medicinal or essential oil purpose and yield data were recorded. The reduction in yield of MAPs was calculated considering the area of both MAPs and coconut basins. The medicinal and aromatic contents like alkaloids, glycosides and essential oil in the economic parts were determined following standard procedures (AOAC, 1984).

Coconut equivalent yield was calculated as per formula given below:

$$\text{Coconut equivalent yield} = \frac{\text{(yield of intercrop x price of intercrop)}}{\text{Price of coconut}}$$

The cost of cultivation, economics and benefit cost ratio were worked out based on the prevailing market prices (Table 6). Intercrops yield were converted to coconut equivalent yield in order to test for statistical significance. Land equivalent ratio (LER) was computed to quantify the land use efficiency of the intercropping system.

Land equivalent ratio (LER) was calculated as per formula described by Mead and Willey (1980).

$$LER_{ab} = Y_{ab}/Y_{aa} + Y_{ba}/Y_{bb} = L_a + L_b$$

Where, LER_{ab} is the land equivalent ratio for ab intercrop; Y_{ab} is the yield of crop a in the ab intercrop; Y_{ba} is the yield of crop b in the ab intercrop; Y_{aa} and Y_{bb} are the yields of crop a and b in monoculture; L_a and L_b are the component LERs for crops a and b.

The data were statistically analyzed for variance by the procedure of Panse and Sukhatme (1985).

Results and discussion

Yield of medicinal and aromatic plants (MAPs) in coconut garden

There was a reduction in yields of all medicinal and aromatic plants when grown as intercrop in coconut garden compared to their sole crop yields (Table 1). The reduction in yield was minimum with patchouli (5.2%), followed by vedailota (7.0%) and sarpagandha (8.9%) whereas, the highest reduction in yield was recorded in citronella (16.8%). The decrease in yield of MAPs can be attributed to the effect of coconut on intercrops coupled with loss in area due to coconut. Citronella needs a good quantity of chemical fertilizers especially nitrogenous fertilizers for their proper growth and yield. The yield of citronella declined over the years in both intercrops and sole crop situation which might be due to non-application of chemical fertilizers in the crop during the experimentation. The poor availability of light to the understorey crop in intercropping system reduced the photosynthetic efficiency and resulted in lower yield of crops (Chundawat *et al*., 1983). Similarly, the available reports indicated reduction in yield of different

Table 1. Yield of medicinal and aromatic plants as intercrop in coconut garden as compared to sole crop during 2006-07 to 2010-11

Sl. No.	Crop	Economic part	Yield as intercrop (kg ha^{-1})					Mean	Yield as sole crop (kg ha^{-1})					Mean	Reduction (-) or increase (+) in yield of intercrop (%)*
			2006-07	2007-08	2008-09	2009-10	2010-11		2006-07	2007-08	2008-09	2009-10	2010-11		
1.	Pipali	Dry spike	573	814	791	698	560	687	694	920	847	728	588	755	-9.0 (+7.0)
2.	Sarpagandha	Dry root	932	1306	1390	1326	1516	1294	1180	1384	1486	1470	1584	1421	-8.9 (+7.1)
3.	Vedailota	Green leaves	3880	3924	3780	3690	3711	3797	4126	4308	3998	3921	4067	4084	-7.0 (+9.0)
4.	Patchouli	Dry herbage	4100	4420	4200	4502	4078	4260	4320	4628	4510	4430	4592	4496	-5.2 (+10.8)
5.	Citronella	Green leaves	28407	26548	24807	21240	17418	23684	30230	32481	30692	27486	21411	28460	-16.8 (-0.8)

* Of the total reduction in yield of intercrops, (16%) was due to loss in area as intercrops were grown in the interspaces of coconut occupying area (84%). The values in parentheses indicate the reduction or increase in yield of intercrops due to effect of coconut

intercrops under poplar (Chauhan, 2000), teak (Pujar *et al*., 2007) and coconut (Singh, 2003; Basavaraju *et al*., 2011).

Content and yield of principal constituents in medicinal or aromatic plants

The effect of intercropping on the principal medicinal or aromatic constituents in MAPs varied with the crop. The principal medicinal constituents like piperine in pipali (3.1 to 2.9%) and alkaloids content in sarpagandha (2.1 to 1.7%) were significantly reduced with intercropping in coconut garden (Table 2). However, iridoid glycosides content in vedailota did not significantly differ between sole and intercrop of this medicinal plant. The essential oil content significantly decreased in patchouli when intercropped in coconut (3.5 to 3.12 %), while in citronella, the intercropping had no significant influence on the essential oil content. The variation in the principal medicinal or aromatic constituents in MAPs between sole crop and intercrop could be attributed to the role of light in altering photosynthesis and respiration (Biscoe and Gallagher, 1977), thereby changing the flux of metabolites and reducing power generation through the light reaction which may in turn modify the synthesis and accumulation of principal constituents in MAPs (Saravanan *et al*., 2008).

The yield of principal medicinal or aromatic constituents of all the MAPs was significantly reduced in intercropping situation in coconut garden (Table 2). The reduction in the yield of piperine in pipali (23.4 to 19.6 kg ha^{-1}), alkaloids in sarpagandha (29.8 to 21.4 kg ha^{-1}), iridoid glycosides in vedailota (7.4 to 6.0 kg ha^{-1}) and essential oil in patchouli (157.4 to 132.9 kg ha^{-1}) was due to reduction in yield of economic parts and also the content of principal constituents (Table 2). Similarly, Hegde *et al*. (2006) reported decreased essential oil yield of lemon grass, Java citronella and Japanese mint under poplar. Basavaraju *et al.* (2011) observed no significant influence of

Table 2. Quality parameters of medicinal and aromatic plants as sole crop and as intercrops in coconut garden (Mean of 5 years: 2006-07 to 2010-11)

Sl. No.	Crop	Economic part	Quality parameter	Content of active principle (%)		Yield of active principle (kg ha^{-1})	
				Sole crop	Intercrop	Sole crop	Intercrop
1.	Pipali	Dry spike	Piperine	3.10	2.85 *	23.4	19.6*
2.	Sarpagandha	Dry root	Total alkaloids	2.10	1.65 *	29.8	21.4*
3.	Vedailota	Green leaves	Iridoid glycosides	0.18	0.16 NS	7.4	6.0*
4.	Patchouli	Dry herbage	Oil content	3.50	3.12 *	157.4	132.9*
5.	Citronella	Green leaves	Oil content	1.25	1.17 NS	355.8	277.1*

* Significant at P=0.05 NS: Not significant

intercropping in coconut garden on essential oil content in citronella, lemon grass, tulsi, vetiver grass and kacholam. However, Gunathilake *et al*. (2002) observed increased piperine content of pepper and essential oil content of kacholam under coconut. Similarly, Channabasappa *et al*. (2007) reported increased essential oil content in citronella, lemon grass and palmarosa and alkaloid content in kalmegh under shade trees.

Yield of coconut

The nut yield of coconut increased in the intercropping situation (75 nuts ha^{-1}) compared to sole crop (58 nuts ha^{-1}). This can be attributed to better growth as indicated by increase in the number of functional leaves from 29.0 to 33.4 (Table 3). The congenial microclimate due to intercropping associated with increased microbial activities, improvement in soil fertility might have favoured the growth and yield of coconut. The improvement in nut yield of the main crop by intercropping was also reported by many workers (Maheswarappa, 1997, Ghosh *et al*., 2007, Nath *et al*., 2008 and Basavaraju *et al*., 2011).

Coconut equivalent yield and land equivalent ratio (LER)

The coconut equivalent yield was significantly higher in intercropping system of MAPs with coconut compared to yield of sole crops of MAPs and coconut (Table 4). Among the intercropping systems, coconut + patchouli recorded significantly the highest coconut equivalent yield (29083 nuts ha^{-1}) followed by coconut + sarpagandha (26048 nuts ha^{-1}), coconut + pipali (19549 nuts ha^{-1}), coconut + citronella (19029 nuts ha^{-1}) and coconut + vedailota (17854 nuts ha^{-1}). This can be attributed to better performance of coconut with intercrops and additional crop of MAPs in intercropping situation and also better market prices for their economic plant parts.

With regard to LER, no significant differences were observed between different intercropping systems of MAPs with coconut. However, all the intercropping systems recorded significantly higher LER compared to sole crop of coconut (Table 4). The LER of more than 1 indicates greater biological efficiency of intercropping system. The intercropping

Table 3. Growth and yield of coconut with medicinal and aromatic plants as intercrops during 2006-07 to 2010-11

Sl. No.	Parameter	Initial	Experimental period					Mean
			2006-07	2007-08	2008-09	2009-10	2010-11	
1.	No. of functional leaves	29.0	31.6	32.5	32.9	35.2	34.6	33.4
2.	Nut yield $palm^{-1}$ $year^{-1}$	58.0	62.8	69.7	72.4	80.0	89.6	74.9
3.	Nut yield ha^{-1} $year^{-1}$	10150	10990	12198	12670	14000	15680	13108

Table 4. Coconut equivalent yield of medicinal and aromatic plants grown as sole crop and intercrop in coconut garden (Mean of 5 years: 2006-07 to 2010-11)

Sl. No.	Crop	Coconut equivalent yield of sole crops of MAPs (Nuts ha^{-1})	Coconut (Nuts ha^{-1})	Coconut equivalent yield in inter-cropping system (Nuts ha^{-1})	Total (Nuts ha^{-1})	Land equivalent ratio (LER)
1.	Coconut + pipali	7078	13108	6441	19549	1.90
2.	Coconut + sarpagandha	14210	13108	12940	26048	1.91
3.	Coconut + vedailota	5105	13108	4746	17854	1.93
4.	Coconut + patchouli	16860	13108	15975	29083	1.94
5.	Coconut + citronella	7115	13108	5921	19029	1.83
6.	Coconut as sole crop		10150		10150	1.00
	S.Em (±)	2017	193	1274	1246	0.04
	C.D. (P=0.05)	6351	619	4007	3907	0.14

Table 5. Economics of medicinal and aromatic plants as intercrops in coconut garden (Mean of 5 years: 2006-07 to 2010-11)

Sl. No.	Crop	Economics of intercropping system			
		Gross income (₹)	Cost of production (₹)	Net income (₹)	B:C ratio
1.	Coconut + pipali	156368	43250	113118	2.62
2.	Coconut + sarpagandha	208384	50900	157484	3.09
3.	Coconut + vedailota	142832	42450	100382	2.36
4.	Coconut + patchouli	232664	54575	178089	3.26
5.	Coconut + citronella	152232	44800	107432	2.40
6.	Coconut as sole crop	81200	28450	52750	1.85
	S.Em (±)	17922	2951	14952	0.08
	C.D. (P=0.05)	56371	9520	46725	0.25

systems of coconut with MAPs resulted in higher LER (1.83 -1.94) than sole crop of coconut (1.00) indicating yield advantages (Table 5). The LER was higher with coconut + patchouli (1.94) followed by coconut + vedailota (1.93), coconut + sarpagandha (1.91), coconut + pipali (1.90) and coconut + citronella (1.83).

Economics of intercropping system of MAPs with coconut

The intercropping system of coconut + patchouli recorded the highest net income (₹ 178,089 ha^{-1}) and B: C ratio (3.26) followed by coconut + sarpagandha (₹ 157,484 ha^{-1} and 3.09) whereas, the lowest net income (₹ 52,750 ha^{-1}) and B:C ratio (1.85) was recorded under sole crop of coconut (Table 5). The higher net income and B:C ratio in the intercropping systems can be attributed to the additional crop of MAPs besides improved main crop yield leading to increased gross income from the crops per unit area. Mohandas (2011) and Basavaraju *et al*. (2011) also reported increased economic returns in the intercropping systems of coconut with MAPs. The economic advantages of intercropping systems of coconut with arrowroot, kacholam, brahmai and sarpagandha were reported by Maheswarappa (1997) and Ghosh *et al.* (2007).

Table 6. Prevailing market prices of MAPs and coconut

Name of crop	Economic produce	Price (₹ kg^{-1})
Pipali	Dry spike	75.00
Sarpagandha	Dry root	80.00
Vedailota	Green leaves	10.00
Patchouli	Dry herbage	30.00
Citronella	Green leaves	2.00
Coconut	Nuts	8.00 per nut

Conclusion

Based on the performance and economics of intercropping medicinal and aromatic plants (MAPs) in adult coconut garden, patchouli was found to be the best followed by sarpagandha and pipali. Hence, intercropping of patchouli, sarpagandha and pipali with coconut can be recommended for Assam condition.

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