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Performance of medicinal plants under fast growing timber trees in coastal ecosystem of Odisha

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Abstract
The performance of three medicinal crops viz. *Aloe vera, Andrographis paniculata* (Kalmegh), *Curcuma amda* (Mango ginger) was studied in agrisilvicultural system involving two timber species (*Acacia mangium* and *Gmelina arborea*). This experiment was conducted at Agroforestry Research Station Bhubaneswar from 2016-18 in RBD. The two years mean data revealed that overall growth of *Aloe vera* crops was better when intercropped with trees than when grown in pure stand. Shade had absolutely no effect on the growth and economic yield of *Aloe vera.* The initial investment in *Aloe vera* was high due to cost of planting materials but the return was high. The *Aloe vera* recorded net returns of Rs. 70,430 and 62,892/ha with B:C 3.00 and 2.80 when intercropped with *Acacia mangium* and *Gmelina arborea*, respectively in the system, as against a net return of only Rs. 52,902 with B:C 2.51 when grown as a sole crop. High net returns and B:C were due to returns from sale of planting materials and there was no cost for planting material which was included in the cost of cultivation during second year of planting. Mango ginger and kalmegh recorded higher B:C when grown as sole crops than in the system. Soil analysis after annual harvesting from medicinal crops indicated that lower values of available N with mango ginger followed by *Aloe vera* and kalmegh, lower values of available P with *Aloe vera* followed by mango ginger and kalmegh and lower values of available K with kalmegh followed by *Aloe vera* and mango ginger the trend was similar in both the tree species grown. Mango ginger was found to be more exhaustive with higher uptake values of N, *Aloe vera* with P and kalmegh with K . Organic carbon in this system varied from 3.10 g/kg in *Gmelina arborea* + mango ginger to 4.70 g/kg in Acacia mangium + *Aloe vera* combination. Increase in soil reaction and organic carbon was evident due to tree species and crop combination. The available soil moisture content was found to be minimum with *Acacia mangium*. Better moisture storage was evident with *Gmelina arborea*. This corroborates competitiveness of *Acacia mangium* with its growth rate and higher soil moisture utilization as compared to other tree species. In agri-silvi system, minimum soil moisture content was observed with the annual crop kalmegh and maximum with *Aloe vera*. So this crop utilized available rainfall more efficiently than other crops.

Keywords: Silvihorticultural system, *Aloe vera*, *Andrographis paniculata*, *Curcuma amda*, *Acacia mangium* and *Gmelina arborea*

Introduction
Medicinal plants are the backbone of the traditional medicine, which means more than 3.3 billion people in the developing countries utilize medicinal plants on regular basis (Davidson, 2000) [3] About 12.5% of the total known plant species are documented as medicinal and aromatic plants (MAP) out of it only a few hundred are known to be in cultivation, with dwindling supplies from the natural sources and increasing global demand these medicinal plants will need to be cultivated to ensure their regular supply. Since many medicinal and aromatic plants are grown under the forest cover and are shade tolerant, Agroforestry offers a convenient strategies for promoting their cultivation and conservation. Medicinal and Aromatic plants taken as inter crops in the existing fast growing timber species where tree species are the shade provider. Growing demand for MAPs require research attention to make these valuable plants as remunerative alternative intercrops for small holder in our country (Chadar, 2001) [2]

Materials and Methods
Location and Soil characteristics
The experimental site is situated inside the All India Coordinated Research Project (AICRP) on Agroforestry Station of O.U.A.T., Bhubaneswar. The study area falls in the sub-tropical zone, which is about 60 km away from the Bay of Bengal. The experimental field is fairly levelled and well drained. Soil is sandy loam texture, acidic in reaction and poor in di-basic cations. Soil samples were taken for appropriate physical and chemical analysis.

Experimental Details

The experiment was laid out in a Randomised Block Design (RBD) with three replications, during 2016-2018 It consisted of nine treatments combinations comprising of six silvihorticultural systems involving two silvi tree species (*Acacia mangium* and *Gmelina arborea)* Three control plots of sole cropping of medicinal plants were also maintained for comparing the performance of intercrops under sole and silvihorti systems. The planting geometry of silvi trees was 8 x 2 m^2.At the time of final land preparation well decomposed FYM @ 10 t ha^{-1} and recommended dose of fertilizer was applied in the form of Di Ammonium phosphate (DAP) and Murate of potash (MOP). The cost involved in production of different silvihorti systems was estimated and converted to per hectare value, then the return obtained from each treatment were evaluated and the net return (Rs ha^{-1}) was worked out by subtracting the cost of cultivation from the gross return obtained. The benefit cost ratio was calculated by dividing the gross return by the cost of cultivation and presented to assess the profitability of different treatments. To determine the significance between the treatment means and to draw valid conclusion, statistical analysis was made. Data obtained from various observations were subjected to statistical analysis by adopting appropriate method of "Analysis of Variance". The difference of the treatments mean was tested using Critical Difference (C.D.) at 5% level of probability (Gomez and Gomez, 1984) [4].

Result and Discussion

Relative performance of three medicinal crops - *Aloe vera*, *Andrographis paniculata*, *Curcuma amda* was studied in silvihorti system involving two timber species (*Acacia mangium* and *Gmelina arborea*). The crops were grown in the alley space between tree rows in the first fortnight of June during the experimental years, 2016-2018. Recommended doses of fertilizer were applied to intercrops.

Mango ginger and kalmegh recorded higher B:C when grown as sole crops than in the The effect of tree (126 months old) on growth and yield of intercrops were assessed in relation to their sole crop yields. Overall growth of *Aloe vera* crops were better when intercropped with trees than when grown in pure stand (Table 1). Shade had absolutely no effect on the growth and economic yield of these crops. Leaves/plant and weight/leave in *Aloe vera* in agroforestry system during dry months were more than in sole crops. Yield recovery for *Curcuma amda* was below 80%.

In *Aloe vera*, sucker (planting material) harvesting was started from second year, The initial investment in *Aloe vera* was high due to cost of planting materials but when leaves suckers of the crops was ready for sale, the return was high. The return from the tree component was not considered for the economic analysis. *Aloe vera* recorded net returns of Rs. 70430 and 62892/ha with B:C ratios 3.00 and 2.80 when intercropped with *Acacia mangium* and *Gmelina arborea*, respectively in the system (Table 1), as against a net return of only Rs. 52902 with B:C ratio 2.51 when grown as a sole crop. High net returns and B:C ratios were due to returns from sale of planting materials and there was no cost for planting material which was included in the cost of cultivation during second year of planting in this system. Mango ginger and kalmegh recorded higher B:C ratios when grown as sole crops than in the system.(Table 2) Our findings are in agreement with those of Bari and Rahim 2012 [1]

Analysis of soil after growing of inter crops (Table 3) *such as Aloe vera*, mango ginger and kalmegh grown with the tree species in silvihorti system indicated lower values of available N with mango ginger, followed by *Aloe vera* and kalmegh, lower values of available P with *Aloe vera* followed by mango ginger, kalmegh and lower values of available K with kalmegh followed by *Aloe vera*, mango ginger and the trend was similar in both the tree species grown. Mango ginger was found to be more exhaustive with higher uptake values of N, *Aloe vera* with P and kalmegh with K. Organic carbon in this system varied from 3.10 g/kg in *Gmelina arborea* + mango ginger to 5.70 g/kg in *Acacia mangium* + pine apple combination. Increase in soil reaction and organic carbon was evident due to tree species and crop combination. Results suggested that soil fertility was either maintained or improved due to agroforestry intervention.

Table 1: Yield of *Aloe vera* (fresh leaves), kalmegh (dry plants) and mango ginger (rhizomes) from the Silvihorti system, Mean data 2016-2018

Tree species	*Aloe vera* leaves (kg/ha)	Kalmegh dry plant (kg/ha)	Mango ginger rhizome (kg/ha)
Acacia mangium	7640	616	3084
Gmelina arborea	7024	720	3010
Control	6244	812	3460

Table 2: Economics analysis of the Silvihorti system, (in rupees/ha) Mean data of 2016-2018

Tree species	Intercrops	Fruits/fresh leaves/ dry plants/ rhizomes*	Sucker+	Gross return	Net return	B:C ratio
Acacia mangium	*Aloe vera*	61120	44310	105430	70430	3.00
	Kalmegh	36960		36960	16960	1.85
	Mango ginger	61680		61680	31680	2.06
Gmelina arborea	*Aloe vera*	56192	41700	97892	62892	2.80
	Kalmegh	43200		43200	23200	2.16
	Mango ginger	60200		60200	30200	2.00
Control	*Aloe vera*	49952	37950	87902	52902	2.51
	Kalmegh	48720		48720	28720	2.44
	Mango ginger	69200		69200	39200	2.31

*Returns (in rupees) from sale of, fresh leaves in *Aloe vera*, dry plants in kalmegh and rhizomes in mango ginger

+Returns (in rupees) from sale of planting materials of *Aloe vera*

Cost of cultivation (in rupees/ha)

Aloe vera	-	35000 (includes cost of raising planting materials for sale)
Kalmegh	-	20000
Mango ginger	-	30000

		Unit sale price (in rupees)
Aloe vera fresh leaves	-	8/kg
Aloe vera sucker	-	3/sucker
Kalmegh dry plants	-	60/kg
Mango ginger rhizome	-	20/kg

Table 3: Soil fertility status as influenced by trees and crops in silvihorti system, Mean data of 2016-2018

Sl. No	Description of samples	pH	Organic carbon (g/kg)	Available N(kg/ha)	Available P (kg/ha)	Available K (kg/ha)
	Tree with Crop					
1	*A. mangium* + *Aloe vera*	4.50	4.7	121.17	45.00	152.8
2	*A. mangium* + Mango ginger	4.53	4.4	114.59	46.57	169.6
3	*A. mangium* + Kalmegh	4.69	4.1	123.81	49.55	128.6
4	*G. arborea* + *Aloe vera*	4.54	4.0	150.15	42.26	109.3
5	*G. arborea* + Mango ginger	4.90	3.1	135.66	43.75	125.2
6	*G. arborea*+ Kalmegh	4.87	3.7	156.13	58.25	103.5

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