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Economic and Land Equivalent Ratio Performance of Herbal Medicinal Crops under Three-Tier Agroforestry System

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A B S T R A C T

An field experiments were conducted to find out economic and land equivalent ratio performance of herbal medicinal crops (basil, kalmegh and mint) under Sapota-Jatropha based three-tier agroforestry system at the Agronomy Farm (Block-E), ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat) during rainy season of 2011 and 2012. The experiments were laid out in randomized block design with six treatments and four replications. Three medicinal plants *viz*., Basil (*Ocimum sanctum* L.), Kalmegh (*Andrographis paniculata* Well.) and Mint (*Mentha arvensis* L) were selected for the present study. The higher BCR recorded in basil, kalmegh and mint intercroped with Sapota-Jatropha in both the years. While Mint, Basil and Kalmegh recorded higher LER when grown as intercrop.

Introduction

In the rehabilitation of degraded forest lands, participating, planning and implementation with local communities and economic benefits from an early stage onwards will ensure commitment of the people. The intensity of shade experienced by the under storey medicinal plants growing in forests and tree plantation affects their growth and chemical composition. In recent year's attention has focused on the diversified medicinal plant production system for maximizing utilization of resources as compared to the monoculture cropping systems. The improved use of resources results in greater total intercrop yields as compared to sole crops of the same species grown on the same area (Oraon *et al.*, 2005). This allows judicious use of the internal spaces of the trees and crops promoting diversification, enhancing per capita land productivity and cultivation of the crops in demand (Willey, 1979). Medicinal plants in the nature are now under great pressure due to their excessive collection and exploitation (Laloo *et al.*, 2000). Continuous exploitation of several medicinal plant species and substantial loss of their habitats have resulted in the population decline of many high value medicinal plant species over the years (Kala and Sajwan, 2003). The global importance of medicinal plant materials is

evident at national and international markets. The Sapota fruit is a good source of digestible sugar (12-18%), protein, fat, fiber and minerals *viz.*, Ca, P and Fe. The fruit skin can also be eaten and is richer than the pulp in nutritive value (Gopalan *et al.,* 1977).

In the recent past Jatropha has evoked much interest all over the world as potential petrocrop (Martin and Mayeux, 1985). Ocimum species are used as the antifungal, bactericidal and insecticidal properties and various economically important essential oil used in perfumery and cosmetic industries (Sehgal and Thakur, 2008). Kalmegh is used for cough, headache, edema, earache, pain conditions, inflammation and muscular pain, arthritis, rheumatism, multiple sclerosis, depression, diarrhoea, dysentery, cholera, candida, lupus, diabetes, piles, fevers, fatigue, hepatitis, herpes, leprosy. It can be used as a replacement for quinine in treatment of malaria (Kumar *et al.,* 2008). Mint was originally used as a medicinal herb to treat stomach ache and chest pains, and it is commonly used in the form of tea as a home remedy to help alleviate stomach pain. Menthol from mint essential oil (40–90%) is an ingredient of many cosmetics and some perfumes. To increase the production per unit area and net income of the farmer with the developed suitable three-tier agroforestry system and to analyze the cost and benefits of the silvicultural, horticultural and medicinal crops association.

Materials and Methods

The present field experiments were conducted during *kharif* season 2011 and 2012 at Agronomy farm, Navsari Agricultural University, Navsari, Gujarat. Geographically, Navsari is situated at 20^0 95'N latitude, 75^0 90'E longitude and at altitude of 10 metres above the mean sea level. The college farm is located 12 kilometres away in the East from the Arabian Sea shore. The climate of the area is characterized by three well defined seasons *viz*., monsoon, winter and summer. The monsoon commences from the middle of June and ends by the second fortnight of September. Pre monsoon rains in the last week of May or in the first week of June are not uncommon. Most of the precipitation is received from South West monsoon, concentrated during the month of June, July and August. The climate of this area is humid and the mean relative humidity remained above 68.27 per cent throughout the year. The weather condition was favorable for growing rainy, winter and summer crops during this study. The seven year old plantation of Sapota (*Manilkara acharas* (Mill) Fosberg.) at 10.0m x 10.0m spacing, inter cropped with five year old plantation of Jatropha (*Jatropha curcus* L.) at 2.5m x 2.5m spacing were used for intercropping study.

Three medicinal plants *viz*. Basil (*Ocimum sanctum* L.) at 50cm x 40cm, Kalmegh (*Andrographis paniculata* Well.) at 50cm x 40cm, Mint (*Mentha arvensis* L) at 30cm x 45cm were selected for the present study. The experiment was laid out in randomized block design with replicated four times. There were 6 treatments- T_1 – *Manilkara achras* + *Jatropha curcas* + *Ocimum sanctum*, T_2 – *Manilkara achras* + *Jatropha curcas* + *Andrographis paniculata*, T_3 – *Manilkara achras* + *Jatropha curcas* + *Mentha arvensis*, T_4 – *Ocimum sanctum* sole, T_5 – *Andrographis paniculata* sole, T_6 – *Mentha arvensis* sole. Farm Yard manure was applied @ 20t/ha to all the plots uniformly and was incorporated into the soil at the time of land preparation. Nitrogen, phosphorus and potash were applied at the rate of 40:15:15 Kg per hectare (for Basil), 40:20:40 kg per hectare (for Kalmegh), 120:50:60 kg per hectare (for Mint) respectively. Weeding and hoeing were done five times at 30, 60, 90 120 and 150 days after planting. Irrigations were applied at an

interval of 15 days after the post-monsoon. The total cost of production, gross income, net income, BCR and LER were workout.

Land equivalent ratio

Originally proposed to help judge the relative performance of a component of a crop combination to sole stands of that species, the term Land Equivalent Ratio is derived from its indication of relative land requirements for intercrops versus monocultures (Mead and Willey, 1980). LER is the sum of relative yields of the component species; i.e.

$$LER = \sum_{i=1}^{m} \frac{Yi}{Yii}$$

Where,

Yi is the yield of the "i" th component from a unit area of the intercrop;

Yii is the yield of the same component grown as a sole crop over the same area;

Yi/Yii is the relative yield of component i.

In simple Agroforestry situations, LER can be expressed,

LER = Ci/Cs + Ti/Ts

Where,

Ci = crop yield under intercropping
Cs = crop yield under sole cropping
Ti = tree yield under intercropping
Ts = tree yield under sole system

Statistical analysis

Statistical analysis of the data of various characters studied in present investigation was carried out through the procedure of randomized block design (RBD) by computer system at Information Technology Centre, Department of Agricultural Statistics, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat. The treatment differences were tested by 'F' test for significance based on null hypothesis. The appropriate standard error (S.Em.±) was calculated in each case and critical difference at 5 per cent level of probability was worked out to compare the treatment means, where the treatment effects were significant (Panse and Sukhatme, 1967). Suitable graphical presentations based on the data is given at the appropriate places.

Results and Discussion

The maximum economic yield was recorded in sole cropping as compared to intercropping of all herbal crops grown under Sapota-Jatropha (Table 1). The data corresponding to the economic yield, the sole crop of basil treatment T_4 (27.05 q/ha) noted significantly higher economic yield when compared to basil intercrop under Sapota-Jatropha (T_1, 9.23 q/ha).

Sole kalmegh and mint (T_5, 13.30 q/ha and T_6, 23.25 q/ha) was recorded higher economic yield as compared to kalmegh and mint grown under Sapota-Jatropha (T_2, 3.74 q/ha and T_3, 8.04 q/ha) respectively. In the second year sole herbal crops of basil (27.30 q/ha), kalmegh (13.55 q/ha) and mint (23.62 q/ha) was recorded significantly higher economic yield when compared to basil (9.56 q/ha), kalmegh (3.86 q/ha) and mint (8.26 q/ha) intercrop under Sapota-Jatropha. Further perusal of data reveals that pooled data showed the similar trends as of the first year and second year results. In case of percent reduction of economic yield in pooled data it was minimum in mint (65.23 %) which was followed by basil (65.42 %) and kalmegh (71.71 %).

Table.1 Economics and LER of growing herbal crops (Basil, Kalmegh and mint) under Sapota-Jatropha based three-tier agroforestry system (First year, 2011)

Treatments Treatments	Yield (q/ha)			Cost of various products (₹/ha)			Total cost of production (₹/ha)	Gross income (₹/ha)			Grand total (₹/ha)	Net income (₹/ha)	BCR	LER
	Sapota	Jatropha	Herbal	Planting material	NPK	Cost of cultivation		Sapota	Jatropha	Herbal				
T_1	70	2.25	9.23	8800	11173.30	22000	41973.30	70000	5625	50765	126390	84416.70	1:3.01	1.28
T_2	70	2.25	3.74	1000	11836.80	22000	34836.80	70000	5625	24310	99935	65098.20	1:2.86	1.22
T_3	70	2.25	8.04	16000	13982.20	22000	51982.20	70000	5625	44220	119845	67862.80	1:2.31	1.29
T_4	-	-	27.05	25000	11173.30	29080	65253.30	-	-	148775	148775	83521.70	1:2.28	-
T_5	-	-	13.30	1200	11836.80	29080	42116.80	-	-	86450	86450	44333.20	1:2.02	-
T_6	-	-	23.25	37037	13982.20	29080	80099.20	-	-	127875	127875	47775.80	1:1.60	-

1. Rate of basil seedling : 1 Rs /2 plant
2. Rate of kalmegh seeds : 2000Rs/kg
3. Rate of mint cutting : 1 Rs / 2cutting
4. Whole sale price of basil : 55 Rs/kg
5. Whole sale price of kalmegh : 65 Rs/kg
6. Whole sale price of mint : 55 Rs/kg
7. Sapota : 10 Rs/kg
8. Jatropha : 25 Rs/kg
9. Labour charge : 120 Rs/day
10. Price of Nitrogen : 9.75 Rs/kg
11. Price of Phosphorus : 32.10 Rs/kg
12. Price of Potassium : 20.12 Rs/kg

Table.1 Economics and LER of growing herbal crops (Basil, Kalmegh and mint) under Sapota-Jatropha based three-tier agroforestry system (Second year, 2012)

Treatments	Yield (q/ha)			Cost of various products (₹/ha)			Total cost of production (₹/ha)	Gross income (₹/ha)			Grand total (₹/ha)	Net income (₹/ha)	BCR	LER
	Sapota	Jatropha	Herbal	Planting material	NPK	Cost of cultivation		Sapota	Jatropha	Herbal				
T_1	75	2.25	9.56	8800	11641.95	24100	44541.95	75000	5625	57360	137985	93443.05	1:3.10	1.27
T_2	75	2.25	3.86	1000	12608.20	24100	37708.20	75000	5625	27020	107645	69936.80	1:2.87	1.20
T_3	75	2.25	8.26	16000	15598.10	24100	55698.10	75000	5625	49560	130185	74486.90	1:2.34	1.27
T_4	-	-	27.30	25000	11641.95	33250	69891.95	-	-	163800	163800	93908.05	1:2.34	-
T_5	-	-	13.55	1200	12608.20	33250	47058.20	-	-	94850	94850	47791.80	1:2.05	-
T_6	-	-	23.62	37037	15598.10	33250	85885.10	-	-	141720	141720	55834.90	1:1.65	-

1. Rate of basil seedling : 1 Rs /2 plant
2. Rate of kalmegh seeds : 2000Rs/kg
3. Rate of mint cutting : 1 Rs / 2cutting
4. Whole sale price of basil : 60 Rs/kg
5. Whole sale price of kalmegh : 70 Rs/kg
6. Whole sale price of mint : 60 Rs/kg
7. Sapota : 10 Rs/kg
8. Jatropha : 25 Rs/kg
9. Labour charge : 150 Rs/day
10. Price of Nitrogen : 12.68 Rs/kg
11. Price of Phosphorus : 46.25 Rs/kg
12. Price of Potassium : 29.40 Rs/kg

It might be due to reduction in light intensity as a result of shading the photosynthetic ability of the secondary canopy for reducing the total photosynthate output from the plants. These results are in line with Rathod *et al.*, (2010), Kumar *et al.,* (2008), Sehgal and Thakur (2008), Venugopal *et al.,* (2008), Thakur and Dutt (2007), Thakur and Kumar (2006), Mohsin (2005) in mint, Parekh *et al.*, (2005), Saroj *et al.*, (2003), Shinde (2001), Singh *et al.*, (1997) and George and Nair (1987). The data on cost of cultivation, gross returns, net returns and benefit cost ratio (B: C) as influenced by sole herbal medicinal crops and intercropping with Sapota-Jatropha (Table 1) in 2011 and 2012. During first year of experiment, the maximum cost of cultivation were recorded under treatment T_6 (INR 80099.20) followed by T_4 (INR 65253.30) as compared to minimum under T_2 (INR 34836.80) followed by T_1 (INR 41973.30). The maximum gross income was noted in treatment T_4 (INR 148775) followed by T_6 (INR 127875) as compared to minimum under T_5 (INR 86450) followed by T_1 (INR 99935), whereas maximum net income was recorded from treatment T_1 (INR 84416.70) followed by T_4 (INR 83521.70) as compared to minimum under T_5 (INR 44333.20) followed by T_6 (INR 47775.80). The maximum BCR was recorded under treatment T_1 (3.01) followed by treatment T_2 (2.86) whereas, minimum under treatment T_6 (1.60) followed by T_5 (2.02). The maximum LER was recorded from T_1 (1.28), followed by T_3 (1.29) and T_2 (1.22). In the year 2012, the maximum cost of cultivation were recorded under treatment T_6 (INR 85885.10) followed by T_4 (INR 69891.95) as compared to minimum under T_2 (INR 37708.20) followed by T_1 (INR 44541.95). The maximum gross income was noted in treatment T_4 (INR 163800) followed by T_6 (INR 141720) as compared to minimum under T_5 (INR 94850) followed by T_1 (INR 107645) whereas, maximum net income was recorded from treatment T_4 (INR 93908.05) followed by T_1 (INR 93443.05) as compared to minimum under T_6 (INR 55834.90) followed by T_5 (INR 47791.80). The maximum BCR was recorded under treatment T_1 (3.10) followed by treatment T_2 (2.87) whereas, minimum under treatment T_6 (1.65) followed by T_5 (2.05). The maximum LER was recorded from T_1 and T_3 (1.27) followed by T_2 (1.20). Economically intercropping of Basil > Kalmegh > Mint as well as in sole crop also same trend was seen. The reason may attributed to the compatibility of these crops under investigation with regard to their growth habit, nutrient requirement as well as light and moisture conditions and ultimately reflected terms of better productivity and higher economic yields and returns. Similar result was observed by Kumar *et al.,* (2010) in safed musli, Kumar *et al.*, (2008).

Significantly higher economic returns were observed under Sapota-Jatropha intercrop as compared to sole crops. So far as trend of economics is concerned in sole crop it was Basil > Kalmegh > Mint; whereas the same herbal crops when grown as inter crop under Sapota-Jatropha, the trend was again Basil > Kalmegh > Mint. On the basis of present investigation we recommended that herbal medicinal crops (basil, kalmegh and mint) can be grown as intercrops under Sapota-Jatropha for good financial gain.

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