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Economic analysis of *Ocimum sanctum* under peach and apricot based agroforestry system

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Abstract
The study was carried out at experimental farm of Department of Silviculture and Agroforestry, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP. The experiment was laid out in randomized block design with seven treatments and three replications. The cost of cultivation, gross return and net return of three different agroforestry systems was determined separately in the presence and absence of trees to know the economic profitability of tree-crop combination. The results of the study revealed that among different treatments, maximum (233361.11 Rs/ha) cost of cultivation was recorded in T_6 (420 ml/plant Jeevamrut) with cultivation of *Ocimum sanctum* under peach tree. Considering gross return, same application of Jeevamrut (420ml/plant) resulted in higher gross return (311044.44 Rs/ha) under peach based agroforestry system and minimum (205755.56 Rs/ha) gross return was recorded in T_7 where *Ocimum sanctum* was grown as a sole crop without organic manure. However, highest B:C ratio ((1.87) was observed under peach tree where, 25t/ha FYM was applied as organic manure. In comparison to sole crop, agroforestry system under peach and apricot was found to be viable and profitable.

Keywords: Benefit cost ratio, agroforestry, fruit trees, Jeevamrut, *Ocimum sanctum*

Introduction
Agriculture faces the unprecedented task of feeding a world population of 9 billion by 2050 while simultaneously avoiding harmful environmental and social effects. One of the efforts to meet this challenge is organic farming, an integrated system that strives for sustainability, enhancement of soil fertility and biological diversity. Due to certain challenges in organic farming, the intentional combination of trees and shrubs with crops or livestock could be the next step in sustainable agriculture. By implementing system that mimics nature's function, agroforestry has the potential to remain productive while supporting a range of ecosystem services. Thus, agroforestry is one of the best land use strategies to contribute to food security while simultaneously limiting environmental degradation and is considered as a panacea for maladies of intensive agriculture [1]. In the recent years, there has been emphasis on diversification and a shift from growing traditional agricultural crops towards high value cash crops such as medicinal and aromatic plants which are in great demand by the pharmaceutical and cosmetic industries. Due to over exploitation and unscientific collections, the genetic resources of valuable medicinal plants are being exhausted [2]. In this situation it is imperative to adopt cultivation of medicinal and aromatic plant species in various agroforestry systems at commercial level to boosts up the production of medicines. Agroforestry as a viable option for commercial cultivation of medicinal and aromatic plants in India and incorporating medicinal and aromatic plants under horti-medicinal agroforestry system will promote sustainable agricultural land use, increased productivity and income to the farmers [3]. Beside, tree plantations, fruit orchards and home gardens also seem to be the viable option for commercial cultivation. Out of these fruit trees could be more potential land use. Fruit trees have long gestation period of 8-10 years and till canopy development, the interspaces can be conveniently used for cultivation of medicinal and aromatic crops to get additional income. Even at later stages of orchard development trees have minimal adverse affect on the growth and yields of a number of medicinal plants grown as intercrops compared to the yields in the open [4], in some instances there may be reduction of yield of MAP's and fruit component, but the combined returns from both the components are greater than from sole cultivation. Many tropical medicinal plants are well adapted to partial shading, moist soil, high relative humidity and mild temperatures [5, 6] and can be intercropped with timber, fuel wood plantations, fruit trees as well as plantation crops. Few examples are *Chlorophytum borivilianum*), *Rauwolfia serpentina*, *Curcuma longa* and *Zingiber officinale* that have been successfully intercropped with fuel wood trees such as *Acacia auriculiformis*, *Albizia lebbeck*, *Eucalyptus tereticornis*, *Gmelina arborea* and *Leucaeana leucocephala* in India [7, 8, 9].

Nowadays, the fruit species are preferred over other species by the farmers in their agriculture systems involving fruit crops as major component. Thus, there is also dire need to promote the cultivation of medicinal plants under temperate fruits trees. The stone fruits namely peach, plum, apricot, almond and cherry of genus Prunus have attained a prime position amongst all the temperate fruit crops as delicious edible drupe and many species have ornamental values as well. Agroforestry systems based on peach (*Prunus* spp.), pear (*Pyrus* spp.), apricot (*Prunus armeniaca*) and plum (*Prunus saliciana*) are common in northern regions and these agroforestry system can be viable option to intercrop medicinal and aromatic plants in order to get more returns. With this view, the present study was carried out to analyse the economics of *Ocimum sanctum* under peach and apricot based agroforestry system.

Materials and Methods

Study area

The experimental site i.e. experimental farm of Department of Silviculture and Agroforestry, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) is located in the mid-hill zone of Himachal Pradesh at 30° 51' N latitude and 76° 11' E longitude, with an elevation of 1200 m above mean sea level having slope of 7-8 per cent.

Experimental methodology

The study comprised of seven treatments *viz.*, T_1 (15t/ha FYM), T_2 (20t/ha FYM), T_3 (25t/ha FYM), T_4 (180ml/plant Jeevamrut), T_5 (300ml/plant Jeevamrut), T_6 (420ml/plant Jeevamrut) and T_7 (no manure-control). The experiment was laid out in randomized block design with three replications. Peach var. nectarine (*Prunus persica*) and Apricot (*Prunus armeniaca*) as a tree component and *Ocimum sanctum* as intercrop was used in this experiment. Apricot and Peach trees were planted in East to West direction at a distance of 9m x 4m. While, the plot size of 3m x 3m and spacing of 45cm x 45cm was maintained for *Ocimum sanctum.* Organic manures *viz*. FYM @ 15t/ha, 20t/ha, 25t/ha and Jeevamrut @ 180ml/plant, 300ml/plant and 420ml/plant was applied to all the plots except control. FYM was evenly spread and thoroughly mixed with the soil before transplanting/sowing. Jeevamrut (5%) was applied as soil drench @ 30, 50, 70ml per plant after the 30 days of transplanting and same dose was applied after 15 days interval till the final harvesting (full bloom stage of flowering) with total 6 applications. Thus total application of 180ml [10], 300ml and 420ml [11] per plant was given. Thereafter, plant basins were prepared and transplanting of tulsi was done in the month of June. Observations for different parameters were recorded after harvesting. The cost of cultivation of medicinal herb and harvest of its produce was calculated on the basis of net cropped area per hectare. The requirements of labour and mechanical power for different operations such as ploughing, harrowing, weeding and harvesting were calculated per hectare as per the rates prevalent at experimental farm. Cost of inputs such as seeds, farm yard manure and Jeevamrut were calculated based on the actual amounts applied to the land use system. Similarly, cost of cultivation of trees (*Prunus armeniaca* and *Prunus persica*) and harvest of its produce was computed with respect to variable cost involved in harvesting of fruits on per hectare basis during the year of study. The prevailing local market prices were used to convert yield of *Ocimum sanctum* plant into gross return in rupees per hectare. Gross returns were obtained by multiplying the quantity of produce with the prevailing prices in the market. Net returns were worked out by subtracting the cost of cultivation from the gross returns.

Net returns (Rs. ha^{-1}) = Gross returns – Cost of cultivation

The net returns per rupee invested ratio were calculated as per following formula:

Net returns (Rs. ha^{-1}) = Benefit cost ratio/Cost of cultivation (Rs. ha^{-1}).

The entire data of the present study were statistically analyzed by using analysis of variance (ANOVA) for Randomized Block Design (RBD) in accordance with the procedure outlined by [12], where effects exhibited significance at 5 per cent level of probability and then critical difference (CD) was calculated.

Results and Discussion

The data of the present investigation have been presented in tables 1, 2 and 3. The results revealed that under peach based agroforestry system, higher (417719.44 Rs/ha) total gross return was recorded in T_6, where 420 ml/plant Jeevamrut was applied as organic manure. While, lowest (288377.78 Rs/ha) total gross return was recorded in T_7, where plants were grown without organic manure (Table 1). Under apricot based agroforestry system the values varied from minimum total gross return 217783.34 Rs/ha (T_7) to maximum 319333.33 Rs/ha (T_6) (Table 2). Similar trend was followed for sole crop with higher (279355.56 Rs/ha) gross return in T_6 (420 ml/plant Jeevamrut) and lowest (179522.22 Rs/ha) gross return in T_7 (no organic manure) (Table 3). Higher returns from M&APs based agroforestry system have also been reported by authors Chauhan (2000) [13], Singh and Ramesh (2002) [14] and Karikalan *et al.* (2002) [15]. Likewise, Chandarkala (2011) [16] has also reported significantly higher gross returns and net returns with application of liquid manures, Beejamrut + Jeevamrut + Panchagavya and Panchagavya over control. Maximum net monetary return with application of organic manure (FYM + vermicompost (50% each) + Jeevamrut 2 times (30 and 45 DAS) followed by Jeevamrut 2 times (30 and 45 DAS) has also been reported by another authors (Patil and Udmale, 2016) [17].

Considering cost of cultivation under peach and apricot based agroforestry system, minimum (188027.78 Rs/ha, 188027.78 Rs/ha) cost of cultivation was recorded in T_7, respectively (where plants were grown without organic manure) as compared to maximum (233361.11 Rs/ha, 228481.60 Rs/ha), respectively in T_6 (where 420ml/plant Jeevamrut was applied as organic manure). Similar trend was followed for sole crop of Tulsi with minimum (151361.11 Rs/ha) cost of cultivation in T_7 (no organic manure) and maximum (191814.93 Rs/ha) in T_6 (420ml/plant Jeevamrut). As far as net return was concerned, treatment T_6 (420ml/plant Jeevamrut) was found to be superior for obtaining higher (87540.63 Rs/ha) net return over T_7 with minimum (22850.00 Rs/ha) net return of sole crop of *Ocimum sanctum* grown in open conditions (without peach and apricot) (Table 3).

The results pertaining to B:C ratio indicated that among different treatments, maximum (1.87) B:C ratio was recorded in T_3 (25t ha^{-1} FYM) as compared to minimum (1.48) in treatment T_1 (15t/ha FYM) when *Ocimum sanctum* was cultivated under peach. On the other hand, under apricot based agroforestry system, maximum (1.42) B:C ratio was recorded in T_3, where 25t ha^{-1} FYM was applied as organic manure and minimum (1.16) BC ratio was recorded in T_7, where plants were grown without organic manure. Similar trend was followed for sole crop of Tulsi with maximum

(1.50) B:C ratio under treatment T_3 (25t ha^{-1} FYM) and minimum (1.18) BC ratio in T_7 (no organic manure). On the other hand, significantly higher B:C ratio has been reported with the combined application of Beejamrut + Jeevamrut + Panchagavya and Panchagavya in Chilli. The treatment receiving Beejamrut + Jeevamrut recorded higher net returns but noticed lower B:C ratio which could be due to higher cost of ingredients used for preparing liquid manures [16]. Kuttimani *et al*. (2013) [18] have reported maximum B: C ratio with application of 75% RDF along with 40% Wellgro organic manures in banana.

Table 1: Bio-economic appraisal of *Ocimum sanctum* under Peach based agroforestry system.

Particulars		Peach based agroforestry system			
	Gross return from intercrop (Rs/ha)	Gross return from Tree(Rs/ha)	Cost of cultivation (Rs/ha)	Total gross return from AGF system (Rs/ha)	BC ratio
T_1 (15 t/haFYM)	242800.00	91675.00	225297.57	334475.00	1.48
T_2 (20t/ha FYM)	269444.44	90000.00	202427.78	359444.44	1.78
T_3 (25t/ha FYM)	290800.00	95000.00	206027.78	385800.00	1.87
T_4 (180ml/plant Jeevamrut)	257200.00	90825.00	207227.78	348025.00	1.68
T_5 (300ml/plant Jeevaamrut)	284400.00	90825.00	220027.78	375225.00	1.71
T_6 (420ml/plant Jeevamrut)	311044.44	106675.00	233361.11	417719.44	1.79
T_7 (No manure)	210877.78	77500.00	188027.78	288377.78	1.53

Table 2: Bio-economic appraisal of *Ocimum sanctum* under Apricot based agroforestry system.

Particulars	Apricot based agroforestry system				
	Gross return from intercrop (Rs/ha)	Gross return from Tree (Rs/ha)	Cost of cultivation (Rs/ha)	Total gross return from AGF system (Rs/ha)	BC ratio
T_1 (15 t/haFYM)	234722.22	13888.89	200037.15	248611.11	1.24
T_2 (20t/ha FYM)	258077.78	12027.78	202703.82	270105.56	1.33
T_3 (25t/ha FYM)	278077.78	13416.67	205703.82	291494.45	1.42
T_4 (180ml/plant Jeevamrut)	261122.22	14361.11	206703.82	275483.33	1.33
T_5 (300ml/plant Jeevaamrut)	292000.00	14361.11	217370.49	306361.11	1.41
T_6 (420ml/plant Jeevamrut)	305444.44	13888.89	228481.60	319333.33	1.40
T_7 (No manure)	205755.56	12027.78	188027.78	217783.34	1.16

Table 3: Bio-economic appraisal of *Ocimum sanctum* in open condition (Sole crop).

Particulars	Sole crop			
	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	BC ratio
T_1 (15 t/haFYM)	194722.22	163370.49	31351.74	1.19
T_2 (20t/ha FYM)	218233.33	166037.15	52196.18	1.31
T_3 (25t/ha FYM)	253444.44	169037.15	84407.29	1.50
T_4 (180ml/plant Jeevamrut)	214722.22	170037.15	44685.07	1.26
T_5 (300ml/plant Jeevaamrut)	247355.56	180703.82	66651.74	1.37
T_6 (420ml/plant Jeevamrut)	279355.56	191814.93	87540.63	1.46
T_7 (No manure)	179522.22	151361.11	22850.00	1.18

Conclusion

The results of economics of all three agroforestry systems showed that the intercropping of M&APs with peach was found to be more profitable as compared to apricot based agroforestry and sole cropping system. Among three systems, peach-based agroforestry system provided better returns. Thus, results concluded that agroforestry system is more profitable and the use of organic manures gear up the growth by improving soil physico-chemical properties, enhancing microbial activity and increasing nutrient availability to plants which helps in enhancing the net returns of medicinal herb under agroforestry system. We recommended that herbal medicinal crop i.e *Ocimum sanctum* can be grown as intercrops under peach agroforestry system for good financial gain.

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