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Economic Analysis of Cluster Bean under Teak based Agroforestry System

Govind [a*], V. M. Prajapati [a], M. B. Tandel [a], N. K. Patel [a], Y. A. Garde [a], Subhaprada Behera [b] and David Camus [c]

[a] Navsari Agricultural University, Navsari, Gujarat, India.
[b] ICFRE- Bamboo and Rattan Centre, Aizawl, Mizoram, India.
[c] ICAR- Central Soil Salinity Research Institute, Regional Research Station, Bharuch, Gujarat, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agroforestry systems (AFs) maintain biodiversity and provide valuable services by promoting ecological, social, and economic stability. Quantification of agroforestry system economics is associated with farmer's livelihood. Considering this, the present study was carried out at Navsari Agricultural University, Navsari, Gujarat. The experiment was laid out in Randomized Block Design with Factorial concept consisting of 3 factors having 2 level each *viz*., varieties of cluster bean, foliar application of micronutrient iron and foliar application of micronutrient zinc on cluster bean grown separately under teak based agroforestry system and in open condition. The study has reported the economics of cluster bean which was grown under teak based agroforestry system and open condition. Further, economics was carried out for the cluster bean teak based agroforestry system as whole. The study has found that yield of cluster bean crop provided higher net return and BC ratio with variety Pusa Navbahar and foliar application of iron and zinc, when grown in open

**Corresponding author: Email: bosegovindsaf@gmail.com;*

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condition and under agroforestry system. In comparison to open condition, teak based agroforestry system as whole was found superior in terms of economically feasible.

Keywords: Agroforestry systems; cluster bean; economic analysis; Net return and BC ratio.

1. INTRODUCTION

Among all land management techniques, agroforestry has shown itself to be highly promising. Agroforestry is a farming technique that integrates agriculture plants with forestry or other types of plants. Activities related to agroforestry might be carried out on farms, in forests, or outside of them. Agroforestry is a type of social forestry or community forestry that has the potential to improve community welfare in the future by increasing land productivity across a large area [1]. There is a massive mismatch in supply and demand for the purpose of meeting the fundamental needs of the steadily growing populations of humans and cattle.

Tectona grandis Linn. (Family - Lamiaceae) is one of the most well-known woods in the world, renowned for its dimensional stability, extreme durability and hardness, as well as its resistance to decay even when unprotected by paints and preservatives*.* This tree is commonly called as teak and locally known as sagon, sagwan *etc*. It is one of the most important heartwoods of the world over. Teak is the most often planted timber tree in Gujarat, including block plantations, social forestry, farm forestry and mixed plantations with fruit trees [2].

Cluster bean [*Cyamopsis tetragonoloba* (L.)] is a robust annual herb having long tap root and well-developed laterals. The semi-arid regions of North and North-West India (mostly Rajasthan) and South-East Pakistan are the primary growing regions for cluster bean [3].In addition to being used as a vegetable, cluster beans can also be utilized as green manure and livestock feed. Its tender green pods are economical and a good source of nutrition. Cluster bean is primarily grown during the rainy (kharif) season, but it can also be grown under irrigation during the summer. During the rainy season, from the second week of July to the first week of August, sowing can be made; in the summer, from the final week of February to the first week of March.

Ong and Kho [4] summarized the benefits of tree-crop interactions, including enhanced productivity, improved soil fertility and microclimate, nutrient cycling, soil conservation, and weed and insect control. This highlights the multifunctional significance of agroforestry. Agroforestry benefits must be demonstrated through actual field-based evidence.

Many economic studies of agroforestry systems have been conducted in different countries. These studies often look at the financial expenses associated with establishing, managing, and producing different kinds of timber and agricultural products, as well as the potential earnings from various agroforestry options and the viability of implementing agroforestry methods.

Due to the lengthy teak rotation, agroforestry approaches involving the intercropping of suitable intercrops are necessary in order to get the benefits of vegetable production early on.

The objective of this research was to examine the economic implications of applying micronutrients topically to cluster bean cultivars grown as intercropping plant in an agroforestry system relying on teak.

2. MATERIALS AND METHODS

The present study was conducted under 24 years old teak based agroforestry system and open condition in the summer season of year 2021 and 2022 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat. The location of study is between $20^0$55'25"N latitude and $72^0$54'29"E longitude with an average elevation of 10 m above mean sea level.

The study employed a Randomized Block Design with Factorial concept, incorporating 3 factors: variety, foliar treatment of micronutrients (zinc and iron) at 2 levels each in four replications separately in teak-based agroforestry system and open condition. Two distinct varieties of cluster bean *viz*., Pusa Navbahar (V_1) and Local Variety (V_2); Iron application *viz*., No foliar application of iron (F_0), foliar application of iron [0.5 % $FeSO_4$ (F_1)] at 30 and 45 days after sowing (DAS) and zinc application *viz*., No foliar

application of zinc (Z_0), foliar application of zinc [0.5 % $ZnSO_4$ (Z_1)] at 30 and 45 DAS were tested for yield of cluster bean.

2.1 Economic Analysis

In economics, cost of cultivation is the total expenditure incurred right from sowing to harvest of the crop, including the field preparation. It is worked out from the cost of input materials such as seeds, fertilizers, insecticides, pesticides, *etc*. and labor cost for total man days needed, and is expressed in rupees per hectare. Gross return from cluster bean production and timber of teak was worked out on the basis of prevailing market rate of cluster bean pod and timber of teak and is expressed in rupees per hectare.

Net return

Net return is obtained by subtracting cost of cultivation from gross return and expressed in rupees per hectare. The Net return computed following standard formula.

Net Return = Gross return – Total cost of cultivation

Benefit cost ratio

The benefit:cost (B:C) analysis was carried out to evaluate the profitability of teak based agroforestry practices in comparison to open condition (cluster bean crop) and sole teak plantation. For the purpose of performing the benefit cost analysis, all costs incurred and revenues received under teak based agroforestry system and open condition were considered. Benefit Cost Ratio **(**BCR) is the ratio of net return and cost of cultivation. It can be expressed as under

$$BCR = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

Besides examining the viability of intercropping of cluster bean under teak based agroforestry, a comparison with open condition (cluster bean crop) and sole teak plantation was also conducted to determine the financially optimal teak based agroforestry system.

3. RESULTS AND DISCUSSION

The implementation of an agroforestry system necessitates material purchases, equipment depreciation and labor costs. The major consideration with the vegetable grower for adoption of research based production technology is economics. The economics for the different components were worked out.

3.1 Economic of Cluster Bean Crop in Open Condition

The data pertaining to economic of cluster bean in open condition are presented in Table 1.

3.1.1 Gross returns (Rs. ha^{-1})

The maximum gross returns (2,76,506.17 Rs. ha^{-1}) on account of cluster bean pod production was obtained with treatment combination $V_1F_1Z_1$ followed by $V_1F_0Z_1$. Minimum gross returns of 1,87,864.50 Rs. ha^{-1} were earned from V_2 F_0 Z_0.

3.1.2 Net returns (Rs. ha^{-1}) and BCR

Study reported that among different treatment combinations, treatment combination $V_1F_1Z_1$ [Variety Pusa Navbahar + Foliar Iron (0.5 %) + Foliar Zinc (0.5 %)] registered highest net return (1,99,823.14 Rs. ha^{-1}) and BCR (1:2.61) followed by treatment combination $V_1F_0Z_1$ (Variety Pusa Navbahar + No Iron + Foliar Zinc (0.5 %) with net return of 1,87,141.35 Rs. ha^{-1} and 2.58 BCR. Lowest net realization (1,20,229.52 Rs. ha^{-1}) and BCR (1.78) was observed with treatment combination of $V_2F_0Z_0$ (Local Variety + No Iron + No Zinc).

3.2 Economic of Cluster Bean Crop (alone) Under Teak Based Agroforestry System

Data regarding to economic of cluster bean (alone) under teak based agroforestry system are furnished in Table 1.

3.2.1 Gross returns (Rs. ha^{-1})

Result shows that highest gross returns (98,548.83 Rs. ha^{-1}) was obtained with treatment combination of $V_1F_1Z_1$ [Variety Pusa Navbahar + Foliar Iron (0.5%) + Foliar Zinc (0.5 %)]. Lowest gross returns (52,392.73 Rs. ha^{-1}) was obtained with treatment combination of $V_2F_0Z_0$ (Local Variety + No Iron + No Zinc).

Table 1. Gross return, net return and BCR of cluster bean crop (alone) in open condition and under teak based agroforestry system

Treatments	Yield (kg ha^{-1})	Fixed cost	Variable cost	Total cost of cultivation	Gross Realization (Rs. ha^{-1})	Net Realization (Rs. ha^{-1})	BCR
Open condition							
$V_1 F_0 Z_0$	8817	65134.99	5000.00	70134.99	220433.51	150298.52	2.14
$V_1 F_0 Z_1$	10387	65134.99	7397.60	72532.59	259673.94	187141.35	2.58
$V_1 F_1 Z_0$	9908	65134.99	9150.44	74285.43	247698.76	173413.33	2.33
$V_1 F_1 Z_1$	11060	65134.99	11548.04	76683.03	276506.17	199823.14	2.61
$V_2 F_0 Z_0$	7515	65134.99	2500.00	67634.99	187864.50	120229.52	1.78
$V_2 F_0 Z_1$	8604	65134.99	4897.40	70032.39	215097.84	145065.46	2.07
$V_2 F_1 Z_0$	8172	65134.99	6650.44	71785.43	204300.97	132515.54	1.85
$V_2 F_1 Z_1$	9262	65134.99	9048.04	74183.03	231550.96	157367.93	2.12
Under Teak							
$V_1 F_0 Z_0$	3021	39908.52	3000.00	42908.52	75515.88	32607.36	0.76
$V_1 F_0 Z_1$	3623	39908.52	4438.56	44347.08	90564.18	46217.10	1.04
$V_1 F_1 Z_0$	3385	39908.52	5490.26	45398.78	84634.08	39235.30	0.86
$V_1 F_1 Z_1$	3942	39908.52	6928.82	46837.34	98548.83	51711.50	1.10
$V_2 F_0 Z_0$	2096	39908.52	1500.00	41408.52	52392.73	10984.21	0.27
$V_2 F_0 Z_1$	2716	39908.52	2938.56	42847.08	67903.96	25056.88	0.58
$V_2 F_1 Z_0$	2632	39908.52	3990.26	43898.78	65793.67	21894.89	0.50
$V_2 F_1 Z_1$	3044	39908.52	5428.82	45337.34	76095.16	30757.82	0.68

Selling price of cluster bean pod - Rs. 25

V_1 – Variety Pusa Navbahar *V_2 – Local variety*

F_0 – No application of Iron *F_1 – Foliar Iron application (0.5 % $FeSO_4$)*

Z_0 – No application of Zinc *Z_1 – Foliar Zinc application (0.5 % $ZnSO_4$)*

Table 2. Economic feasibility of cluster bean teak-based agroforestry system

	Cluster bean					Teak		Cluster bean teak-based agroforestry system			
Treatments	**Yield (kg ha^{-1})**	**Fixed Cost (Rs. ha^{-1})**	**Variable Cost (Rs. ha^{-1})**	**Total Cost (Rs. ha^{-1})**	**Gross Realization (Rs. ha^{-1})**	**Cost (Rs.ha^{-1})**	**Gross Realization (Rs. ha^{-1})**	**Total Gross Realization (Rs. ha^{-1})**	**Total Cost of Cultivation (Rs. ha^{-1})**	**Net Realization (Rs. ha^{-1})**	**BCR**
$V_1 F_0 Z_0$	3020.64	39908.52	3000.00	42908.52	75515.88	27000.00	412729.26	488245.14	69908.52	418336.63	5.98
$V_1 F_0 Z_1$	3622.57	39908.52	4438.56	44347.08	90564.18	27000.00	334339.46	424903.63	71347.08	353556.56	4.96
$V_1 F_1 Z_0$	3385.36	39908.52	5490.26	45398.78	84634.08	27000.00	296225.87	380859.95	72398.78	308461.17	4.26
$V_1 F_1 Z_1$	3941.95	39908.52	6928.82	46837.34	98548.83	27000.00	468271.63	566820.47	73837.34	492983.13	6.68
$V_2 F_0 Z_0$	2095.71	39908.52	1500.00	41408.52	52392.73	27000.00	376773.18	429165.91	68408.52	360757.39	5.27
$V_2 F_0 Z_1$	2716.16	39908.52	2938.56	42847.08	67903.96	27000.00	377456.86	445360.81	69847.08	375513.74	5.38
$V_2 F_1 Z_0$	2631.75	39908.52	3990.26	43898.78	65793.67	27000.00	427891.35	493685.02	70898.78	422786.25	5.96
$V_2 F_1 Z_1$	3043.81	39908.52	5428.82	45337.34	76095.16	27000.00	469034.09	545129.25	72337.34	472791.91	6.54
Sole tree						27000.00	326931.44	326931.44	27000.00	299931.44	11.11

3.2.2 Net returns (Rs. ha^{-1}) and BCR

It is revealed that in case of growing condition, open condition (For cluster bean crop only) recorded highest net realization as compared to teak-based agroforestry system. Under teak based agroforestry system, highest net realization (51,711.50 Rs. ha^{-1}) and BCR (1.10) was observed with treatment combination of $V_1F_1Z_1$ (Variety Pusa Navbahar + Foliar Iron + Foliar Zinc). Meanwhile, treatment combination $V_2F_0Z_0$ (Local Variety + No Iron + No Zinc) registered lowest net realization (10,984.21 Rs. ha^{-1}) and BCR (0.27).

3.3 Financial Feasibility of Cluster Bean Teak Based Agroforestry System

3.3.1 Gross returns (Rs. ha^{-1})

Highest total gross returns (5,66,820.47 Rs. ha^{-1}) was observed under $V_1F_1Z_1$ and minimum (3,26,931.44 Rs. ha^{-1}) was observed under sole teak tree (Table 2).

3.3.2 Net returns (Rs. ha^{-1}) and BCR

Teak based agroforestry system (teak + cluster bean crop) recorded more net returns as compared to open condition (cluster bean crop only). Treatment combination $V_1F_1Z_1$ registered maximum net returns (4,92,983.13 Rs. ha^{-1}) followed by $V_2F_1Z_1$ (4,72,791.91 Rs. ha^{-1}). However, minimum net return was obtained in sole teak (2,99,931.44 Rs. ha^{-1}).

The Benefit to Cost Ratio (BCR) was registered maximum (11.11) in sole teak as compare to agroforestry system. In agroforestry system, maximum BCR (6.68) was reported in $V_1F_1Z_1$ and minimum (4.26) in $V_1F_1Z_0$. (Table 2).

The B:C ratio was recorded highest in variety Pusa Navbahar as compared to local variety. It might be due to higher yield under variety Pusa Navbahar which ultimately reflected in terms of gross realization and net realization. Similar result was earlier reported by Nanthakumar *et al.* [5].The maximum BCR was noticed in foliar application of Zinc and Iron as compared to no foliar application might be due to higher yield in the same which reflected in BCR. Anitha *et al.* [6] obtained maximum net return and benefit cost ratio with combined spraying of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$at 45 DAS. Gross return, net return and B:C ratio was registered highest in combined application of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$ in black gram [7]. The similar result was also reported by Vasava *et al.* [8] and Ramanjaneyulu *et al.* [9].

Despite lower cluster bean yield, teak based agroforestry system produced the highest gross returns and B:C ratio when compared to open condition. It was due to the significant additional contribution of teak under agroforestry system, whereas additional benefit was absent in open condition. Performance metrics indicate that in the research region, monocropping land use system is less profitable than teak-based agroforestry land use system.

Franzel [10] conducted a study in southern Africa and found that agroforestry practices generate a net present value (NPV) of US$388 per hectare, which is six times more than the net benefit received in traditional maize fallow systems. Net return and Benefit Cost (B:C) ratio ($876.29/ha and 1.83) was higher in agroforestry system than open farming system ($700.91/ha and 1.82) [11]. The economic analysis of boundary systems indicate that in semi-arid environments where traditional cropping is not economically viable (BCR of 1.05 from sorghum-wheat crop rotation), the adoption of a tree-based system would help farmers to increase their total income (BCR: 1.29 from north–south and 1.67 from east–west plantings) [12].

This Economics finding of cluster bean teak-based agroforestry system is unswerving with the study conducted by Bari and Rahim [13], Nayak *et al.* [14], Panchal *et al.* [15], Patel *et al.* [16] and Jilariya*et al.* [17].

4. CONCLUSION

Economic evaluation of agroforestry systems is vital for their adoption due to land pressure and diversification of traditional cropping systems. Economic analysis reflects that treatment combination of variety Pusa Navbahar + Foliar application of 0.5 % $FeSO_4$+ Foliar application of 0.5 % $ZnSO_4$ registered maximum net realization and BC ratio for both growing conditions. In comparison of growing conditions, the higher net realization and BC ratio of cluster bean crop was reported in open condition.

Further, wood from teak compensated the reduction in crop yield and resulted in higher returns in association with cluster bean crop under teak based agroforestry system.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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