***Original Research Article***

**Agroforestry-Based Economic Evaluation of Sole Turmeric and Eucalyptus-Turmeric Intercropping Systems with Performance Assessment of Turmeric Varieties Under Uniform Cultivation Costs**

**Abstract**

A study was carried out during the year 2022-23 at the Herbal Garden, College of Agriculture, IGKV, Raipur, Chhattisgarh, to assess two production systems-sole turmeric (F1) and turmeric intercropped with eucalyptus (F2)-using eight turmeric varieties: T1 – Suranjana, T2 – Selam, T3 – Chhattisgarh Haldi-1, T4 – Chhattisgarh Haldi-2, T5 – Roma, T6 – Ranga, T7 – NDH-98, and T8 – Sonali. The study compares the economic viability of two turmeric production systems—sole turmeric cultivation (F1) and an intercropping system with eucalyptus and turmeric (F2)—along with eight different turmeric varieties (T1 to T8). Results indicate that while F1 involves a lower cultivation cost of ₹1,70,714 per hectare with a modest benefit-cost (B:C) ratio of 1.50, the F2 system, despite its higher investment of ₹4,70,714 per hectare, delivers a significantly higher net return of ₹12,80,136 and a superior B:C ratio of 3.72, making it a more profitable option for farmers. Additionally, the evaluation of turmeric varieties, all cultivated at a uniform cost of ₹3,20,714 per hectare, highlights substantial differences in economic returns. Chhattisgarh Haldi-2 (T4) emerged as the most profitable variety with the highest gross return (₹10,56,871), net return (₹7,36,157), and B:C ratio (2.82), followed closely by NDH-98 (T7) and Selam (T2). These varieties consistently offered higher profitability. In contrast, Sonali (T8) recorded the lowest economic performance, with the lowest gross return, net return, and B:C ratio of 2.38. Despite all varieties providing positive returns, the findings emphasize that both the choice of cropping system and turmeric variety play a critical role in maximizing farm profitability. Intercropping eucalyptus with turmeric and selecting high-yielding varieties like Chhattisgarh Haldi-2 significantly enhance economic outcomes.

**Keywords: Turmeric, Eucalyptus, Economic, Varieties, Farmers**

**1. Introduction:**

Agroforestry may restore ecosystems and soil quality, which is essential for expanding the amount of forest area to 33% from the existing 24.39%, as suggested by the National Forest Policy (1988) (Sarvade et al., 2019; Patra 2022). In places where they have lived for a long time, rural residents have adapted trees with productive systems and possess extensive indigenous knowledge (Evans and Alexander, 2004). Sequence systems, in which trees and crops grow on the same plot of land at different periods, and parallel systems, in which trees and crops are cultivated on the same plot of land at the same time, are two examples of intercropping agroforestry trees with crop plants. Complex systems can differ greatly in the quantities of trees and plants and how they are arranged in space (Young, 1989; Singh et al., 2015).

A proper mix of trees, perennials, and/or animals on one plot of ground is called agriculture, and it serves the local population's needs for wood, fuel, feed, and other auxiliary products. This enhances the village's habitat and biodiversity, soil fertility, nutrient recovery, land degradation and depletion, soil and water consistency, and acts as a significant carbon sink. With an emphasis on the sustainability of food soil enrichment in agroforestry (López et al., 1999 and Andrade, 1999; Sarvade et al., 2014a; Sarvade et al., 2014b; Sarvade and Singh 2014), well-managed AFS increases overall efficiency (Bustamanate et al., 1998).

In Turmeric (*Curcuma longa* L.) different crop varieties used may have also had varying rhizome yield potential, with some varieties producing heavier rhizome per plant due to genetic traits such as tuber size and weight. The fresh weight of rhizome per plant serves as an indicator of the suitability of the various production systems and crop varieties for supporting turmeric yield formation. Heavier rhizome crops point to treatments that conditioned the plant growth environment in a way that promoted higher rhizome yield. Other factors such as soil fertility, water availability, and pest and disease pressure may have also influenced the fresh weight of tuber plant (Mankur et al., 2024).

In grouped plantations, including those that value shade and are susceptible to it, tree shadow is thought to be the reason for lower crop yields. This problem worsens if the tree is not trimmed. The production of rice crops is significantly influenced by shade. Grain yield is decreased along with the height, panicle/hill, and panicle/grain. Shade enhances the length and height of the plant blade and encourages rapid cell division and growth (Schoch, 1972). According to Miah et al. (1999), the lowest plants are found in areas without shadow, whereas the tallest plants are found in areas with shade. Less rice production next to the border plantation trees may be the cause of the trees' shadowing effect.

Because of the symbiotic link between the trees and the crops or animals, agroforestry systems yield more per hectare than monocultural systems. Compared to trees in forests or orchards, trees in agroforestry often stand further apart. As a result, there is less rivalry amongst trees, allowing each tree to develop more effectively. In contrast to monoculture systems, trees enhance the microclimate and offer cover for crops and animals, increasing their output.

**2. Material and methods:**

The field experiment was conducted at the Herbal Garden of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), during the year 2022–23. The study was laid out in a Factorial Randomized Block Design (FRBD) consisting of eight treatments and three replications. Turmeric (*Curcuma longa* L.) was cultivated as an intercrop beneath Eucalyptus trees. Turmeric rhizomes were manually planted following the experimental layout within a cropping system, maintaining a row-to-row spacing of 40 cm and plant-to-plant spacing of 30 cm. The experiment involved eight varieties and three replications. A total of 48 plots, each measuring 2.5 m × 2.5 m, were used for sowing under the agroforestry system and the sole production systems. Whereas economical calculation has done by following formula:

**Total cost:** Total variable cost + Total fixed cost

**Gross returns:** Output (kg) \* price per kg of output (Rs.)

**Net returns:** Gross return-total cost

**Benefit cost ratio:** Gross return/Total cost

**3. Result and discussion:**

The Fig. 1 shows that the comparison between two production systems, namely F1: Sole Turmeric and F2: Eucalyptus + Turmeric, reveals significant differences in economic performance. In the sole turmeric treatment (F1), the cost of cultivation is ₹1,70,714 per hectare, resulting in a gross return of ₹2,55,611 and a net return of ₹84,897 per hectare. The benefit-cost (B:C) ratio for this treatment is 1.50, indicating moderate profitability. This means that for every rupee invested, the farmer gains ₹1.50 in return.

In contrast, the F2 treatment, which involves intercropping eucalyptus with turmeric, incurs a much higher cost of cultivation at ₹4,70,714 per hectare. However, this higher investment yields a significantly greater gross return of ₹17,50,850 and a net return of ₹12,80,136 per hectare. The benefit-cost ratio in this case is an impressive 3.72, showing a strong return on investment. For every rupee spent, the farmer receives ₹3.72, making this a highly profitable option. Overall, while the initial investment in the eucalyptus and turmeric intercropping system (F2) is substantially higher than sole turmeric cultivation (F1), the returns far outweigh the costs. The high net return and superior B:C ratio make F2 a more economically viable and efficient farming practice. Therefore, farmers aiming for better income and resource utilization should consider adopting the Eucalyptus + Turmeric intercropping system.

Fig. 1: Economical attributes of Turmeric (*Curcuma longa*) as affected by production system under Eucalyptus-based agroforestry system

The Table 1 clearly shows that the compares eight different turmeric varieties (T1 to T8) based on economic indicators such as cost of cultivation, gross return, net return, and benefit-cost (B:C) ratio per hectare. All treatments have a uniform cost of cultivation of ₹3,20,714/ha, which helps provide a clear comparison of their economic performance. The net return and B:C ratio vary, reflecting differences in yield potential and market value among the varieties.

Among the treatments, T4 – Chhattisgarh Haldi-2 recorded the highest gross return (₹10,56,871) and net return (₹7,36,157), along with the highest B:C ratio of 2.82, indicating it is the most profitable variety. Close behind are T7 – NDH-98 and T2 – Selam, with B:C ratios of 2.80 and 2.75, respectively, and net returns exceeding ₹7 lakhs. These varieties stand out for their high profitability and better economic returns for turmeric growers.

On the other hand, T8 – Sonali reported the lowest gross return (₹9,45,809), net return (₹6,25,095), and B:C ratio (2.38), making it the least profitable among the options tested. Similarly, T1 – Suranjana and T5 – Roma had the same B:C ratio of 2.46, with moderate net returns. Overall, while all varieties provide returns well above the cultivation cost, Chhattisgarh Haldi-2, NDH-98, and Selam emerge as the most economically rewarding choices for turmeric cultivation based on the data.

Table 1: Economical attributes of Turmeric (*Curcuma longa*) as affected by turmeric varieties under Eucalyptus-based agroforestry system

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Cost of cultivation****( ha-1)** | **Gross return****( ha-1)** | **Net return****( ha-1)** | **B:C Ratio** |
| T1 –Suranjana | 320714 | 965218 | 644504 | 2.46 |
| T2 –Selam | 320714 | 1038286 | 717572 | 2.75 |
| T3 -Chhattisgarh Haldi-1 | 320714 | 1001933 | 681219 | 2.60 |
| T4 -Chhattisgarh Haldi-2 | 320714 | 1056871 | 736157 | 2.82 |
| T5 –Roma | 320714 | 966847 | 646133 | 2.46 |
| T6 –Ranga | 320714 | 1000413 | 679699 | 2.60 |
| T7 -NDH-98 | 320714 | 1050466 | 729752 | 2.80 |
| T8 –Sonali | 320714 | 945809 | 625095 | 2.38 |

*Note: Gross return is calculated based on the prevailing market price of turmeric at ₹55 per kg. Net return is derived by subtracting the cost of cultivation from the gross return for each treatment. The Benefit-Cost (B:C) Ratio indicates the return per rupee invested. A B:C ratio above 2.0 suggests high profitability. Whereas Eucalyptus wood price was Rs. 700 cubic feet during the year 2022-23 in Raipur local market.*

The economic analysis compares two turmeric production systems—F1: Sole Turmeric and F2: Eucalyptus + Turmeric intercropping—alongside eight turmeric varieties (T1 to T8) cultivated under uniform cost conditions. The F2 intercropping system, despite requiring a higher investment on per hectare basis, delivers significantly better economic returns with a gross return of ₹17,50,850, net return of ₹12,80,136, and a high benefit-cost (B:C) ratio of 3.72. In contrast, F1 has a lower cost of cultivation (₹1,70,714/ha) but also results in a lower net return of ₹84,897 and a B:C ratio of only 1.50. For the turmeric variety comparison, all treatments had the same cultivation cost (₹3,20,714/ha), allowing for direct comparison. Chhattisgarh Haldi-2 (T4) emerged as the top performer with the highest gross and net returns, and the best B:C ratio of 2.82. NDH-98 (T7) and Selam (T2) also performed well, each achieving net returns over ₹7 lakhs. On the other hand, Sonali (T8) showed the lowest profitability, followed by Suranjana (T1) and Roma (T5), which had moderate returns.

**4. Conclusion**

The findings clearly demonstrate that intercropping eucalyptus with turmeric (F2) is significantly more profitable than sole turmeric cultivation (F1) due to its higher returns and better B:C ratio. Similarly, among the turmeric varieties evaluated, Chhattisgarh Haldi-2, NDH-98, and Selam offer the highest profitability, making them preferable options for farmers in Chhattisgarh Plain Region. Therefore, for maximizing income and improving farm efficiency, the adoption of the Eucalyptus + Turmeric intercropping system along with high-yielding turmeric varieties like Chhattisgarh Haldi-2 is strongly recommended to farmers.

**5. FUTURE SCOPE**

To maximize output and financial returns in an agroforestry system, it is essential to optimize the plant shape and spatial arrangement of eucalyptus trees and the turmeric crop. When intercropping turmeric with eucalyptus, careful planning of tree spacing and canopy management can minimize shading and competition, enhancing crop performance. Selecting high-yielding turmeric varieties such as Chhattisgarh Haldi-2 or NDH-98 further boosts rhizome production, ensuring better productivity and profitability from the intercropping system.

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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