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EVALUATION OF THE ECONOMIC VIABILITY OF VARIOUS LEMONGRASS INTERCROPPING VARIETIES IN MANGIUM-BASED AGROFORESTRY SYSTEMS IN THE CHHATTISGARH PLAINS OF INDIA

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ABSTRACT

One of the most promising land use methods is agroforestry, which not only affects soil characteristics and dynamic soil biodiversity but also preserves agricultural sustainability. Lemon grass, belongs to the poaceae family. It is a medicinal plant that contains chemicals that can increase herbal resistance to pathogenic illnesses and inhibit infections. Lemongrass is frequently used in food confections, herbal teas, and other beverages that are not alcoholic. Lemongrass essential oil is frequently used as a scent in cosmetics like lotions and soaps as well as fragrances. In the context an experiment was laid out to study the economics of intercropping lemongrass and *Acacia mangium* in an agroforestry system in Chhattisgarh Plain, with an emphasis on the financial feasibility and performance of different lemongrass varieties. The results indicated a uniform cost of cultivation across all varieties, which was attributed to standardized inputs and labour expenses, with lower costs in later years due to the reusability of plant materials. T_1 (Krishna) showed to be one of the most economically feasible of the varieties, with the highest gross return (Rs. 780,242 ` /ha), net return (Rs. 637,874 ` /ha), and B:C ratio (5.48) as compare to other variety while T_6 (CKP-25) had the lowest gross return, net return and B:C ratio. The results emphasize the significant role of varietal selection in enhancing profitability and resource efficiency in agroforestry systems. This study emphasizes the possibility of *Acacia mangium* -based agroforestry systems to enhance economic sustainability and diversify farm income.

Key words : Agroforestry, *Acacia mangium*, Lemongrass, Essential oil, Sustainable cultivation, Diversify Farming.

Introduction

One of the most popular fast-growing tree species in plantation forestry programs in Asia and the Pacific *is Acacia mangium* Willd, commonly referred to as mangium. Fast growth, high-quality wood, and adaptability to a variety of soil types and conditions are among of its favorable qualities (National Research Council, 1983). In order to maintain the commercial supply of tree products, fast-growing plantation trees, such as *A. mangium*, were used as a substitute due to the recent strain on Indonesia's natural forest ecosystems. *A. mangium* was selected as the best plantation species for marginal locations, including alang-alang grasslands, after 46 species were tested by the Indonesian Ministry of Forestry in Subanjeriji, South Sumatra (Arisman, 2002, 2003). This versatile species is valued for its ability to thrive in poor soils, its nitrogen-fixing capability and its role in agroforestry systems, reforestation and land rehabilitation projects. *Acacia mangium* is a medium- to large-sized tree that typically grows to a height of 15–30 meters and can attain a diameter at breast height (DBH) of up to 60 cm under favourable conditions. Its straight bole, often free of branches for 50–60% of the tree height, makes it highly suitable for timber production. The tree is characterized by its phyllodes—modified leaf structures—which are elongated, leathery, and adapted for efficient photosynthesis under drought conditions (Midgley *et al*., 2010). The wood of *Acacia mangium* is highly valued for its quality, being used for pulp, furniture, veneer, and construction. Furthermore, its fast growth and adaptability to various environments have made it a popular choice for plantation forestry. In agroforestry systems, it acts as a nurse tree, providing shade and windbreaks while improving crop yields through microclimatic modification (Nair, 2012). Additionally, *A. mangium* plantations contribute to carbon sequestration, which is increasingly significant in the context of climate change mitigation (Santos *et al*., 2020).

Agroforestry systems are deliberately designed to maximize the positive interactions between tree and non-tree components encompassing a wide range of practices (Dutta *et al.*, 2023). The fundamental idea behind the practice of agroforestry is that the trees are integral part of natural ecosystems providing a range of benefits in the agricultural domain (Dutta *et al*., 2023; Castle *et al*., 2022; Murthy *et al.*, 2016). According to International Centre for Research in Agroforestry (ICRAF), the term agroforestry can be defined as a land use system that integrates trees with agricultural crops and/or animals, simultaneously or sequentially, to get higher productivity, more economic returns, better social and ecological benefits on a sustained yield basis, than are obtainable from monoculture on the same unit of land, especially under conditions of low levels of technological inputs and on marginal sites (Cialdella *et al*., 2023). Lemongrass, scientifically known as *Cymbopogon*, is a genus of aromatic, perennial grasses belonging to the family Poaceae. Native to tropical and subtropical regions of Asia, Africa, and Australia, lemongrass is widely cultivated for its essential oil and culinary uses. The plant is renowned for its lemon-like aroma, which is attributed to its high content of citral, an essential oil component. Lemongrass is primarily cultivated for its essential oil, which is rich in citral, geraniol and limonene. These compounds are widely used in perfumery, cosmetics, pharmaceuticals, and food industries. The global demand for lemongrass oil has driven its cultivation in many tropical and subtropical countries, contributing significantly to the livelihoods of smallholder farmers.

Materials and Methods

The present investigation was carried out at Herbal Garden of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), India. The research was conducted in the years 2023-2024 on the 24-year-old *Acacia mangium* plantation. The plantation is spaced at 5 × 3 meters and spacing of lemongrass is 40 × 30 cm. Economic analysis were applied to evaluate the performance of the system based on the returns derived from the inputs used. This approach helps determine the economic returns from various crop variety combinations in an agroforestry system. In economics, cost of cultivation refers to the total expenditure incurred from transplanting to harvesting the crop, including field preparation. It is calculated based on the cost of input materials such as slips, fertilizers, pesticides, crop processing charges (e.g., oil extraction), transportation and labour costs for the total man-days required. The cost of cultivation is expressed in Rs/ha. Gross return represents the total income obtained from the selling price of the main product as well as by-products and is also expressed in Rs/ha. Market price plays a crucial role in portraying the economic overview of agroforestry systems. Net return is calculated by subtracting the cost of cultivation from the gross return and is expressed in Rs/ha. The formula for net return is:

Net Return (Rs/ha) = Gross Return (Rs/ha) –Cost of Cultivation (Rs/ha)

The Benefit: Cost (B:C) ratio, based on the current price of inputs and yield-derived revenue, was calculated using the formula:

$$\text{Benefit : Cost ratio} = \frac{\text{Gross return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Results and Discussion

The economic analysis of *Acacia mangium* -based agroforestry system with different crop varieties of lemongrass. The data includes cost of cultivation (Rs/ha), gross return (Rs/ha), net return (Rs/ha) and the benefit-cost ratio (B: C ratio). The economic analysis of the *Acacia mangium* -based agroforestry system with different lemongrass varieties reveals that the cost of cultivation remains constant at 142,368 `/ha across all varieties. This uniformity is due to the variety-based treatments, where costs for planting materials, labour, and other inputs are consistent. Additionally, the cost of cultivation is lower in the second year because the planting materials established in the first year are available for transplantation. Prasad *et al*. (2010) also found that the returns from agroforestry systems in the first years are negative due to higher initial investment costs.

The economic evaluation of lemongrass varieties under the *Acacia mangium* -based agroforestry system revealed significant differences in gross and net returns, as well as benefit-cost (B:C) ratios, having a uniform cost of cultivation of 142,368 `/ha across all treatments. This uniformity is due to the variety-based treatments, where costs for planting materials, labour, and other inputs are consistent. Additionally, the cost of cultivation is lower in the second year since the planting materials established in the first year are ready for transplantation. Among the varieties, T_1 (Krishna) had the highest gross return (780,242 `/ha) and net return (637,874 `/ha), as well as the best B:C ratio (5.48), indicating higher economic performance. T_7 (Praman) also performed well, with a gross return of 778,790 `/ha and a B:C ratio of 5.47. In contrast, $T_6$ (CKP-25) recorded the lowest gross return (745,571 `/ha), net return (603,203 `/ha), and B:C ratio (5.24), reflecting its relatively lower productivity and economic viability. Other varieties, such as T_2 (CG-1) and T_4 (Neema), demonstrated moderate economic returns, suggesting their potential as alternative choices based on specific site conditions or resource availability. Overall, the findings show the importance of varietal selection in improving profitability and resource efficiency in *Acacia mangium* -based agroforestry systems, with T_1 (Krishna) showing as the most promising variety.

The analysis of the benefit cost ratio for the *Acacia mangium* -based agroforestry system reveals significant variability among the different varieties of lemongrass over the two growing seasons. This fluctuation in the benefit cost ratio indicates not only the economic viability of these varieties but also highlights the influence of specific management practices and environmental factors on their performance. Similar findings were reported by Mahata *et al.* (2018), Parewa *et al.* (2019) and Singh *et al.* (2020), who recorded the highest B:C ratios under agroforestry system management. Thumbar *et al.* (2023) observed that the potential of eucalyptus-based agroforestry systems in enhancing productivity and economic returns compared to sole agricultural cropping systems. These systems not only provide substantial wood yields and biomass but also exhibit greater economic viability, as indicated by their higher gross return, net return and benefit-cost ratios.

The higher benefit cost ratio was recorded under agroforestry compared to open condition. The present results are in the consonance with the Pandey *et al.* (2016), Padma *et al.* (2018), Akter *et al.* (2020) and Keprate (2021), where they recorded higher B:C ratio under agroforestry systems as compared to sole agriculture cropping. Similar results were reported by Chavan and Dhillon (2019), who also recorded higher B:C ratio in agroforestry system as compared to sole cropping of sorghum-berseem and cowpea-wheat.

Table 1 : Cost of cultivation of lemongrass under Mangium-based agroforestry system.

S. no.	Operations/Particulars	Value in ` /Ha
A	Variable cost	121023
B	Plantation maintenance charge	10415
C	Fixed cost	10930
D	Total cost (A+ B + D)	142368

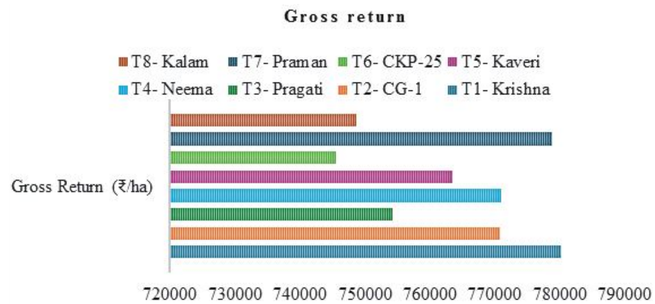

Fig. 1 : Gross return of Lemongrass under Mangium-based agroforestry system.

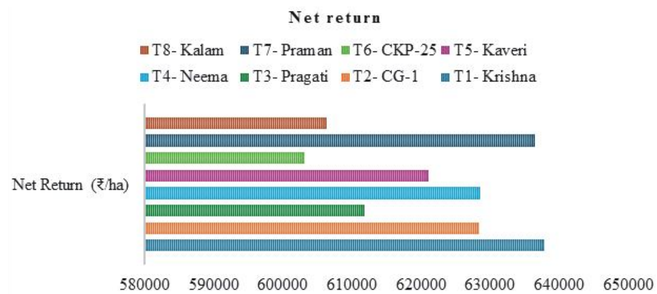

Fig. 2 : Net return of Lemongrass under Mangium-based agroforestry system.

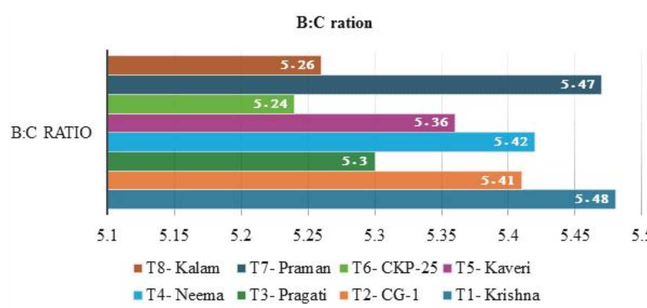

Fig. 3 : B: C ration of Lemongrass under Mangium-based agroforestry system.

Table 2 : Economics of Lemongrass under *Acacia mangium* -based agroforestry system.

Treatments	Gross return (`/ha)	Net Return (`/ha)	B:C Ratio
T_1- Krishna	780242	637874	5.48
T_2-CG-1	770760	628392	5.41
T_3- Pragati	754260	611892	5.30
T_4- Neema	770978	628610	5.42
T_5- Kaveri	763484	621116	5.36
T_6-CKP-25	745571	603203	5.24
T_7- Praman	778790	636422	5.47
T_8- Kalam	748649	606281	5.26

Note: Price of lemongrass oil 1500 `/l, mangium wood 600 `/ cubic feet and fuel wood 550 `/q based on local market price.

Variable cost comprises ploughing, preparation of bed, Planting material, planting, manure and fertilizer and miscellaneous whereas fixed cost comprises rental value of land, description charge, land revenue and interest.

Conclusion

The economic analysis of lemongrass intercropping in an *Acacia mangium*-based agroforestry system underscores the system's financial viability and its potential for sustainable income generation. The uniform cost of cultivation, combined with the reduced costs in subsequent years, shows the efficiency of this agroforestry model. T_1 (Krishna) and T_7 (Praman) were identified as the most economically rewarding lemongrass varieties, with T_1 achieving the highest gross return, net return and B:C ratio, making it the most suitable choice for maximizing profitability. In contrast, T_6 (CKP-25) exhibited the lowest economic performance, indicating the need for careful variety selection to optimize returns. This study confirms the economic advantages of integrating high-value crops like lemongrass with fast-growing tree species such as *Acacia mangium*. Furthermore, it emphasizes the role of agroforestry systems in enhancing resource efficiency, diversifying income sources and promoting sustainable land use in tropical regions.

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