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# Economic Feasibility of Gamhar Based Agroforestry Systems in Jharkhand

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**ABSTRACT**

An agroforestry field trial was carried out during 2020-21 at agroforestry farm of Faculty of Forestry in Birsa Agricultural University, Ranchi, Jharkhand, India. The study aimed to evaluate the performances of two years old Gamhar (*Gmelina arborea*) trees intercropped with leguminous crops *viz*. Pigeon pea (*Cajanus cajan*), Cowpea (*Vigna unguiculata*) and Urad (*Vigna mungo*) in agroforestry system as well as sole cropping. The experiment was laid out in Randomized Block Design (RBD) with seven treatments *viz*. $T_1$ (*G. arborea* + *C. cajan*), $T_2$ (*G. arborea* + *V. unguiculata*), $T_3$ (*G. arborea* + *V. mungo*), $T_4$ (Sole *G. arborea*), $T_5$ (Sole *C. cajan*), $T_6$ (Sole *V. unguiculata*) and $T_7$ (Sole *V. mungo*) replicated thrice. Economic feasibility of Gamhar based agroforestry system was evaluated with the following parameters; Cost of cultivation (₹ $ha^{-1}$), Gross return (₹ $ha^{-1}$), Net return (₹ $ha^{-1}$), Benefit Cost Ratio (BCR) and Land Equivalent Ratio. Economic analysis revealed that the system fetches more economic worth under agroforestry as compared to sole cropping. The highest annual gross return (₹ 62176 $ha^{-1}$), net return (₹ 36808 $ha^{-1}$), B:C ratio (2.45) and Land equivalent ratio (2.32) of the system were obtained under $T_1$ (*G. arborea* + *C. cajan*). Thus, the study indicated that *G. arborea* + *C. cajan* agroforestry systems was found to be most profitable and economically viable option for the farmers of Jharkhand in order to improve their income and uplifting their livelihood status.

**Keywords:** Agroforestry, economics, Gmelina arborea, livelihood

Agroforestry is a type of land-use system where woody perennial plants are purposefully integrated into the same land-management units as agricultural crops, either in a spatial arrangement or a temporal sequence. There are interactions between the multiple components in agroforestry systems that are both ecological and economically beneficial (Lundgren, 1983). The improvement of agroforestry systems (AFS) under rainfed conditions is crucial for ensuring the livelihood security of tribal farmers in the eastern Plateau and Hill region. Based on the agroclimatic conditions in the area, the capacity of the local population, and market accessibility, a variety of agroforestry practises have been adopted. Agroforestry systems

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and practices have changed and/or been adjusted to meet market requirements, and some of them have grown over time, but this is due to the market for products is unstable. Gamhar (*Gmelina arborea*) a multipurpose fast-growing agroforestry tree, the average growth rate is 40–50 $m^3$/ha/year with good soils and rainfall (Zeaser, 1998). It is native to India, Bangladesh, Sri Lanka, Myanmar, China, Thailand and Indonesia (Nayak *et al.* 2011). *G. arborea* tree produces good quality wood which is greyish white in colour, even-grained, soft, light weight, and strong and is very useful for planking, panelling, furniture and carpentry of all kinds. In view of the good quality of its wood and of its rapid growth the tree is well worth more attention for plantation purposes, as a substitute for teak and often called as White teak. Besides providing high-quality timbers, the wood is also used for fuelwood (calorific value ~ 4800 kcal $kg^{-1}$), pulp, plywood, particle board, matches, and packing boxes. The leaves and fruits of Gamhar are used as a fodder, and also used for rearing silkworms. The species is also planted as a shade tree for coffee and coco. It is preferred species by farmers, forest departments and industries due to the multipurpose utility, rapid growth, and maximum economic returns. The tree can be harvested after 4-5 years for pulpwood use, for timber production it is commercially harvested after 10-12 years of plantation. Average wood biomass of 250-300 t $ha^{-1}$ can be obtained after 10 years rotation. There is very scarce information available on the species and its socio-economic and environmental values were hardly given any importance while comparing with the other agroforestry species.

Keeping in view the unique condition of this region and the potential of this species, a study was carried out at Agroforestry field of Birsa Agricultural University, Ranchi, Jharkhand (India) to evaluate the Gamhar based agroforestry system considering the market value of timber and fuelwood, and to sort out the best combination of leguminous intercrop for this region based on their growth potential, yield and preferences of the species by the farmers as well as quick and high revenue generation. The present paper focused on economics of the Gamhar based agroforestry system in terms of cost-benefit analysis for Eastern India and also discussed challenges and opportunities for its sustainable development.

## MATERIALS AND METHODS

The present study was carried out during 2020-21 at the agroforestry farm of Faculty of Forestry, Birsa Agricultural University, Ranchi, Jharkhand (23°17′ N latitude and 85°19′ E longitude with an elevation of 651m above mean sea level) during 2020-21. The site experienced a warm humid tropical climate, with a mean rainfall of 1358 mm, most of which was received during August. The maximum and minimum temperatures during the cropping period were 35.22° and 5.29° respectively during 2020-21. The experiment was conducted in Randomized Block Design with nine treatments replicated thrice. Two years old Gamhar (*Gmelina arborea*) trees intercropped with leguminous crops *viz*. Pigeon pea (*Cajanus cajan*), Cowpea (*Vigna unguiculata*) and Urad (*Vigna mungo*) in agroforestry system as well as sole cropping. Economic feasibility of Gamhar based agroforestry systems in Jharkhand were evaluated with the following parameters; Cost of cultivation (` $ha^{-1}$), Gross return (` $ha^{-1}$), Net return (` $ha^{-1}$), Benefit Cost Ratio (BCR) and Land Equivalent Ratio.

### Species Description

*Gmelina arborea* Roxb., is a straight bole, medium to large-sized deciduous tree in the Verbenaceae family. It is a multipurpose fast-growing tree that, after 15 years of planting in ideal conditions, reaches a height of about 30m and a DBH of 60 cm. With good soil and rain, it grows at a rate of 40–50 $m^3$ $ha^{-1}$ $y^{-1}$ on average. Although it spreads to relatively dry areas like Central India, it grows to its largest proportions in the mixed forests of moist regions like the eastern sub-Himalayan tract. It thrives in fertile alluvial soils with good drainage and prefers moist, rich valleys. The average annual rainfall in its natural habitat ranges from 1200 mm to 4500 mm, and the temperature ranges from 20°C to 45°C. The *G. arborea* tree yields high-quality wood that is even-grained, soft, lightweight, and strong.

Pigeon pea [*Cajanus cajan* (L.) Millsp.], commonly known as Red gram, Tur or Arhar, is a perennial legume that is primarily grown in semi-arid areas of India. It covers about 2.5 million hectares on average each year, and it produces almost 13 million tonnes of grain. The average temperature in its natural environment ranges from 26° to 30°C during the rainy season (June to October) and from 17° to 22°C during the post-rainy season (November to March). The ripening of pods and flowering require bright, sunny weather. The average annual rainfall requirement is between 600 and 1400 mm, with 80–90% of that total falling during the rainy season. Its green pods can be used as vegetables and it is widely used as dal. Plants' tops and green leaves are fed to animals or used as green manure.

Cowpea [*Vigna unguiculata* (L.) Walp.] (Syn: Lobia, Barbati, Black eyed pea), is a significant grain legume crop that is raised all over the world. It is a promising alternative pulse crop grown primarily in Punjab, Haryana, Delhi, and West UP, as well as in significant amounts in Rajasthan, Karnataka, Kerala, Tamilnadu, Maharashtra, and Gujarat. It is a warm-weather crop that grows luxuriously in a temperature range of 20º to 30º Celsius. It is a crucial part of dryland farming systems due to its capacity to enrich marginal soils through nitrogen fixation and as a cover crop.

Black gram (*Vigna mungo* L. Hepper), commonly known as Urd or Mash, is a highly prized pulse crop, grown throughout the country during *kharif* season. The main areas of production are Madhya Pradesh, Uttar Pradesh, Punjab, Maharashtra, West Bengal, Andhra Pradesh and Karnataka. Although black gram can be grown on a wide range of soils, including heavy clay and sandy loam, it prefers well-drained stiff loamy or heavy soils with a pH of 6.5 to 7.8. It is grown as a rain-fed crop up to 2,000 meters above sea level in both the cool hills and the warm plains. The crop is resistant to unfavorable weather, and by incorporating atmospheric nitrogen into the soil, it increases soil fertility. It is a significant part of the Indian diet because it is high in phosphoric acid, lysine, vitamins, and minerals and contains 26% easily digestible protein, which is almost three times as much as cereals.

## Description of Agroforestry Systems

The experimental design followed in the agroforestry system was Randomized Block Design (RBD) with seven treatment combinations as, $T_1$ - *G. arborea* + *C. cajan*, $T_2$ - *G. arborea* + *V. unguiculata*, $T_3$ - *G. arborea* + *V. mungo*, $T_4$ - Sole *G. arborea*, $T_5$ - Sole *C. cajan*, $T_6$ - Sole *V. unguiculata* and $T_7$ - Sole *V. mungo.* replicated thrice.

## Economic Analysis

The data for economic analysis of the Gamhar based agroforestry system was computed during the year 2020. Cost of Inputs for establishing agroforestry system was calculated which includes costs for buying seeds, seedlings, fertilizers, pesticides, labor costs for planting, tending, and harvesting. While, incomes from agroforestry system calculated which includes benefits from selling products as pulses, fuel wood and timber products. Benefit Cost Ratio (BCR) was calculated as the ratio of discounted value of benefit and discount value of cost from the following formula and expressed as ₹ ha$^{-1}$;

$$\text{Benefit Cost Ratio (BCR)} = \frac{\sum \frac{B_t}{(1+i)t}}{\sum \frac{C_t}{(1+i)t}}$$

where, $B_t$ = benefits in each year, $C_t$ = costs in each year, $n$ = number of year and $i$ = interest rate.

## RESULTS AND DISCUSSION

Economic analysis of the system in terms of gross return, net return and B:C ratio under different treatments were calculated with the rate locally admissible of different inputs-outputs and presented in Table 1. as well its graphical presentation in Fig. 1, 2, 3 and 4. The cost of cultivation was calculated to be highest in *G. arborea* + *C. cajan* (25368 ₹ ha$^{-1}$) followed by *G. arborea* + *V. mungo* (24168 ₹ ha$^{-1}$) and minimum cost of cultivation was estimated in Sole *G. arborea* (2628 ₹ ha$^{-1}$). The total gross return was estimated to be maximum in *G. arborea* + *C. cajan* (62176 ₹ ha$^{-1}$), followed by Sole *C. cajan* (55684 ₹ ha$^{-1}$) and was estimated least in Sole *G. arborea* (6092 ₹ ha$^{-1}$). The selling price of *G. arborea* wood biomass was taken at ₹ 8000/- per ton (Mayavel *et al.* 2014) and the selling price of *C. cajan* grain were observed at ₹ 104/- per q, *V. unguiculata* grain at ₹ 86/- per q, and *V. mungo* grain at ₹ 128/- per q, and all crop straw at ₹ 50/- per q in Ranchi district of Jharkhand for the year 2021-22. The net returns of Gamhar based agroforestry system was observed to be highest in *G. arborea* + *C. cajan* (36808 ₹ ha$^{-1}$) followed by Sole *C. cajan* (33184 ₹ ha$^{-1}$) and was found lowest in Sole *G. arborea* (3224 ₹ ha$^{-1}$). The maximum B:C ratio was evaluated in Sole *C. cajan* (2.47) followed by *G. arborea* + *C. cajan* (2.45) and was evaluated minimum in Sole *G. arborea* (2.12).

In terms of land equivalent ratio it was observed that one hectare land of *G. arborea* + *C. cajan* agroforestry would require 2.32 hectares of monoculture plantation to offset the difference in yield. Similarly in order to offset the difference in yield in one hectare land under *G. arborea* + *V. unguiculata* agroforestry, it would require 2.21 hectares of monoculture planation. In case of *G. arborea* + *V. mungo* to offset the difference in yield there is need of 2.15 hectares of monoculture plantation compared to one hectare of intercrop plantation.

The data on total cost of production, net income and benefit cost ratio as influenced by sole crop and intercrop under Gamhar based agroforestry system are presented in Table 1 and Fig. 1,2,3 & 4. It is evident from the results that the intercropping of Gamhar with Arhar recorded higher gross and net return as compare to its sole. Compared to all respective treatment, sole Arhar recorded higher benefit cost ratio among all treatments. It may

**Table 1:** Cost of cultivation (₹ ha$^{-1}$), Gross return (₹ ha$^{-1}$), Net return (₹ ha$^{-1}$), B:C ratio and L:E ratio under Gamhar based Agroforestry system

| Treatments | Cost of cultivation (₹ ha$^{-1}$) | Total Gross return (₹ ha$^{-1}$) | Net return (₹ ha$^{-1}$) | Benefit Cost Ratio (No unit) | Land Equivalent Ratio* (No Unit) |
|---|---|---|---|---|---|
| *G. arborea* + *C. cajan* | 25368 | 62176 | 36808 | 2.45 | 2.32 |
| *G. arborea* + *V. unguiculata* | 22368 | 44743 | 22375 | 2.00 | 2.21 |
| *G. arborea* + *V. mungo* | 24168 | 53500 | 29332 | 2.21 | 2.15 |
| Sole *G. arborea* | 2868 | 6092 | 3224 | 2.12 | – |
| Sole *C. cajan* | 22500 | 55684 | 33184 | 2.47 | – |
| Sole *V. unguiculata* | 19500 | 38286 | 18786 | 1.96 | – |
| Sole *V. mungo* | 21300 | 47991 | 26691 | 2.25 | – |

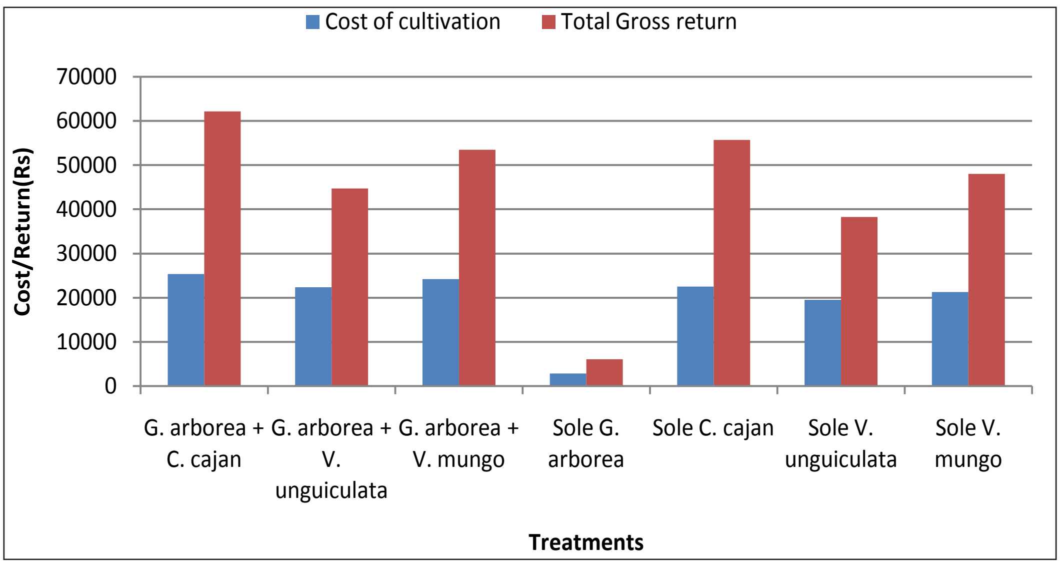


**Fig. 1:** Cost of cultivation and Gross return (₹/ha) from Gamhar (*Gmelina arborea* Roxb.) based Agroforestry system during 2020-21

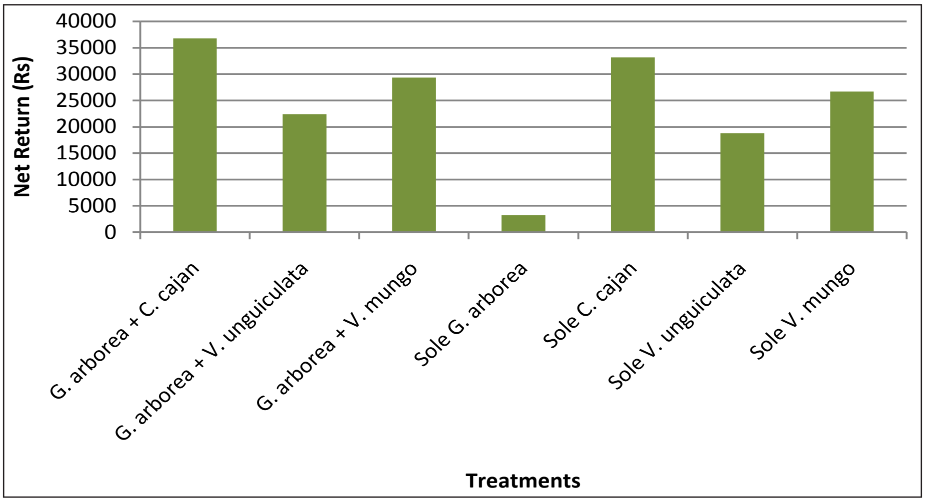


**Fig. 2:** Net return (₹/ha) from Gamhar (*Gmelina arborea* Roxb.) based Agroforestry system during 2020-21

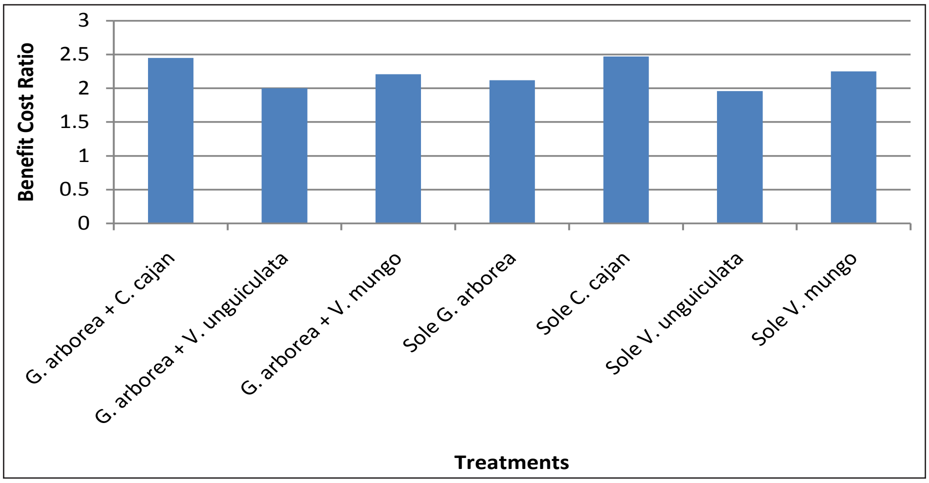


**Fig. 3:** Benefit: Cost ratio of Gamhar (*Gmelina arborea* Roxb.) based Agroforestry system during 2020-21

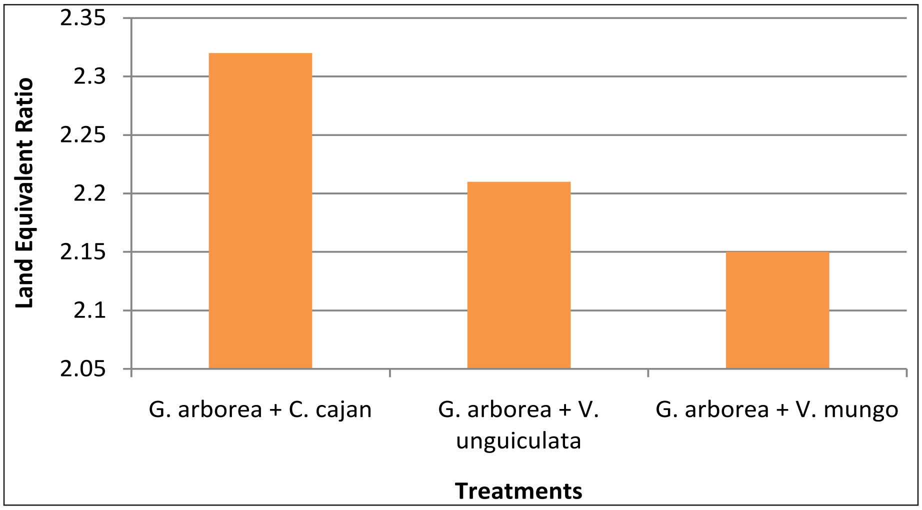


**Fig. 4:** Land Equivalent ratio of Gamhar (*Gmelina arborea* Roxb.) based Agroforestry system during 2020-21

be due to the compatibility of these crops under investigation with regard to their growth habit, nutrient requirement as well as light and moisture conditions which ultimately reflected in terms of better productivity and higher economic returns. Similar results were also observed by Kumar *et al.* (2017) that, agroforestry practices with Gamhar and fruit trees can be more profitable than sole-crop cultivation within a few years. Integration of Gamhar with Arhar is essential to ensure quick returns.

## CONCLUSION

The leguminous crops intercropped with fast growing multipurpose tree Gamhar in Agroforestry system have clearly helped to improve our understanding of some of the economic dimensions of agroforestry systems. It can be concluded that Gamhar + Arhar intercropping in agroforestry system can be best combination among all intercrops for the farmers of Jharkhand. However, they also helped identify some of the research gaps, which can be addressed so that the economic and environmental sustainability of agroforestry can be enhanced and its social acceptability can be increased. Each agroforestry system is only suitable to establish in its ecological region, since each species cannot grow well outside its ecological region. Unstable market leads to unsustainability of these agroforestry systems. Therefore, it is recommended that farmers, the local government, business sector, and researchers collaborate and work together in developing an agroforestry development strategy before establishment.

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