P-ISSN: 2618-0723
E-ISSN: 2618-0731

Extension Journal

NAAS Rating (2025): 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 11; November 2025; Page No. 382-386

Received: 01-10-2025
Accepted: 29-10-2025

Indexed Journal
Peer Reviewed Journal

Economic Evaluation of Isabgol, Chana and Moth Under AFRI Clone-Based *Dalbergia sissoo* Agroforestry Systems in Arid Western Rajasthan

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DOI: https://www.doi.org/10.33545/26180723.2025.v8.i11e.2656

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Abstract

A three-year field investigation was carried out on farmers' fields in western Rajasthan to evaluate the economic performance of crops grown under *Dalbergia sissoo* AFRI clones (DS1, DS2, DS4) and *sissoo* seedlings during the early establishment phase of agroforestry systems. The study included crops including Isabgol (2023), Chana (2024) and Moth (2025) corresponding to 0, 1 and 2-year-old plantation. The costs of cultivation were ₹14,500 ha^{-1} for Isabgol, ₹12,500 ha^{-1} for Chana, and ₹10,500 ha^{-1} for Moth, calculated uniformly across treatments to isolate the effects of tree-crop interactions. Economic indicators including gross return, net income and B:C ratio were computed across treatments: sole crop, DS1, DS2, DS4 and sissoo. Results indicated negligible variation in Isabgol and Chana returns during the year 2023 and 2024 respectively, due to minimal shade and root interference from young trees, yielding net incomes of ₹35,500-40,500 ha^{-1} and ₹27,500-32,500 ha^{-1}, respectively. By the year 2025, moderate competition emerged, particularly under the vigorous DS1 clone, reducing Moth net income to ₹24,500 ha^{-1}, while DS2, DS4 and sissoo maintained higher profitability. Overall, the study demonstrates that intercrops remain economically viable during early tree establishment, with noticeable competition effects arising as trees mature.

Keywords: Agroforestry, *Dalbergia sissoo* clones, Isabgol, Chana, Moth bean, Tree-crop interaction

1. Introduction

The Indira Gandhi Nahar Pariyojana (IGNP) command area of western Rajasthan represents one of India's largest canal-irrigated landscapes developed within an inherently fragile arid ecosystem. Although canal irrigation has enhanced cropping opportunities in this region, the soils remain predominantly sandy to loamy sand with low water-holding capacity, weak structural stability, and limited nutrient reserves (Sur and Chauhan, 2019; Mandal, 2022) [24, 13]. These constraints continue to pose challenges for sustaining long-term soil productivity, particularly under intensive agriculture. Agroforestry, which integrates woody perennials with agricultural crops, has emerged as a promising land-management strategy capable of addressing soil degradation, diversifying income, and improving ecological resilience in such environments (Dollinger and Jose, 2018; Fahad *et al.*, 2022) [6, 7].

Dalbergia sissoo Roxb. ex DC. (Indian rosewood) is among the most preferred species for agroforestry in northwestern India due to its fast growth, nitrogen-fixing ability, high-quality timber, and compatibility with a range of annual crops (Sen *et al.*, 2023) [20]. The development of improved clones such as AFRI-DS1, AFRI-DS2 and AFRI-DS4 by the ICFRE-Arid Forest Research Institute (AFRI), Jodhpur, offers an opportunity to enhance productivity and uniformity in tree-based systems under moisture-limited and nutrient-poor conditions. Evaluating these clones in the IGNP command area is essential for understanding their potential to improve soil fertility, optimize tree-crop interactions, and support sustainable land-use practices in arid zones (Kumar *et al.*, 2025) [11].

Across India and worldwide, growing population pressure has intensified the demand for land, water, food, fuelwood and fodder, further stressing natural resources (Johar *et al.*, 2017) [10]. Agriculture in arid and semi-arid regions is particularly vulnerable due to low and erratic rainfall, high evapotranspiration, strong solar radiation and escalating input costs, often resulting in low productivity and financial risk for farmers. In comparison, agroforestry has demonstrated superior resilience and productivity over monocropping by improving microclimate, recycling organic matter, and enhancing farm income stability (Abdullahi and Anyaegbu, 2017) [1]. It has also proven effective in conservation initiatives, landscape restoration and livelihood enhancement.

Agroforestry systems, whether agrisilviculture, agrihorticulture or silvipasture promote positive ecological and economic interactions between tree and crop components. Studies have shown that agroforestry often achieves higher productivity per unit area than monocropping, reflected through improved land-equivalent ratios (LER) (Yu *et al.*, 2015) [25]. Fruit-tree-based systems such as mango, guava, citrus, litchi and ber have gained popularity due to their dual benefits of early crop income and long-term orchard returns (Chauhan *et al*., 2012) [5]. International research across Nepal, Bhutan, Bangladesh, Myanmar, Malaysia, Pakistan and Afghanistan also indicates that agroforestry can generate higher profit compared to sole agriculture or forestry (Chaturvedi, 1981; Lahiri, 1983; Mathur *et al*., 1984; Chandra, 1986; Patel, 1988) [4, 12, 14, 3, 18]. However, the profitability and stability of such systems largely depend on managing competition, particularly through pruning or canopy regulation during early tree growth stages (Frank and Eduardo, 2003) [8].

Within this broader context, sissoo-based agroforestry has shown considerable potential in rainfed and irrigated regions due to the species' adaptability, rapid biomass accumulation and ecological resilience. Yet, empirical evidence on the economic performance of intercrops grown alongside newly established *D. sissoo* clones, particularly under IGNP conditions is limited. Moreover, tree-crop competition evolves over time, beginning with negligible interactions in early stages and intensifying as root systems and canopy structure develop.

To address this knowledge gap, the present study evaluates the economic performance of three sequential intercrops Isabgol (*Plantago ovata*), Chickpea (*Cicer arietinum*) and Moth bean (*Vigna aconitifolia*) grown under AFRI clones DS1, DS2, DS4 and seedling-origin *D. sissoo* during the first three years of establishment (2023-2025). By analyzing cost of cultivation, gross and net returns, and benefit-cost ratios across treatments, this study provides insights into the temporal dynamics of tree-crop interactions and the comparative economic efficiency of clone-based agroforestry models in an arid canal command environment.

2. Methodology

The study was conducted during 2023-2025 on farmlands located approximately 600 meters apart within the Indira Gandhi Nahar Pariyojana (IGNP) command area near Bandha, Ramgarh, Jaisalmer, Rajasthan, India. The Ramgarh region (27º14′16″N, 70º14′41″E; altitude 133.95 m) is characterized by arid climate. The rainfall period extends from mid-July to September, and an annual rainfall of 295 mm was recorded at Ramgarh, the nearest meteorological station, in 2023. The mean monthly maximum and minimum temperatures during 2023 were 35.6°C and 18.0°C, respectively. The experimental area comprised flat terrain with loamy sand soil having a gypsum layer at a depth of 50-75 cm. The experiment was laid out in a Randomized Block Design (RBD) under a block plantation system with three replications, using a spacing of 16 m × 6 m. Four treatments were taken: T_1 - AFRI-DS1, T_2 - AFRI-DS2, T_3 - AFRI-DS4, T_4 -seedlings along with Open agriculture field under the study. The plantation covered an area of 1.2 hectares. The plantation was established in the year 2023 in September.

Study was to find out the economical viable in different Agroforestry model. The study was aimed at evaluating the economic analysis under different treatments within the agroforestry model. The intercrops grown sequentially were Isabgol (*Plantago ovata*), Chickpea (*Cicer arietinum*), and Moth bean (*Vigna aconitifolia*) grown of 2023, 2024 and 2025 respectively.

The economics of different treatments was worked out in terms of cost of cultivation process comprised field preparation, seed sowing, weeding, material inputs like seed and fertilizer, and labour costs for various field tasks like crop harvesting and threshing, gross monetary return (GMR), net monetary return (NMR) and benefit: cost ratio (B:C ratio) to ascertain economic viability of treatments. The cost of cultivation for each treatment was determined on the basis of different inputs used for raising the crop under different treatments on hectare area basis. The value obtained from the produce gained under each treatment computed on the basis of existing market price of the produce. Net monetary return per hectare under each treatment was determined by subtracting the cost of cultivation of a particular treatment. To obtained the benefit obtained from different treatments for each rupee of expenditure incurred, B:C ratio of each treatment was calculated as below;

$$\text{B : C ratio} = \frac{\text{Profit (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3. Results and Discussion

The economic performance of Isabgol, Chana and Moth bean grown under newly established *Dalbergia sissoo* AFRI clones (DS1, DS2, DS4) and seedling-based agroforestry systems demonstrated clear temporal patterns in crop response as tree age and early canopy development progressed. Since the tree components were newly planted or in early establishment stages during the study period (2023-2025), shading and below-ground competition were minimal in the first two years but began to emerge by the third year, particularly under the faster-growing DS1 clone. The results of each intercrop have been discussed separately below.

3.1 Isabgol

Economic differences among different treatments during the first year were minimal (Table 1), which is consistent with expectations for a newly planted agroforestry system. Uniform production costs (₹14,500 ha^{-1}) and gross returns ranging from ₹50,000-55,000 ha^{-1} resulted in comparable net incomes and B:C ratios across treatments. Sole cropping achieved the highest net return (₹40,500 ha^{-1}), followed closely by Sissoo seedlings and DS2. Although DS1 exhibited slightly lower economic returns (₹35,500 ha^{-1}), the variation was economically marginal. This behavior aligns with well-established agroforestry principles, where young trees exert minimal competitive stress on intercrops until canopy closure or root proliferation progresses (Nair, 1994) [16]. Comparable findings were documented in arid agroforestry trials, where initial tree establishment had negligible effects on herbaceous crop yield until later years (Singh & Singh, 2000; Singh & Bhati, 2005) [21, 23].

Table 1: Economics of Isabgol under different newly-established tree treatments

Treatment	Gross return (GI, ₹ ha⁻¹)	Cost of cultivation (C, ₹ ha⁻¹)	Net income (NI = GI − C, ₹ ha⁻¹)	B:C ratio (GI / C)
Sole Isabgol (control)	55,000	14,500	40,500	3.79
Isabgol + DS1 (newly established)	50,000	14,500	35,500	3.45
Isabgol + DS2 (newly established)	53,000	14,500	38,500	3.66
Isabgol + DS4 (newly established)	52,000	14,500	37,500	3.59
Isabgol + Sissoo seedlings (newly established)	54,000	14,500	39,500	3.72

Fig 1: Isabgol under newly established *Dalbergia sissoo*-based agroforestry system during 2023.

3.2 Chana

By the second year, the growing tree component began to introduce slight but measurable economic variation among treatments (Table 2). Gross returns ranged from ₹40,000-45,000 ha⁻¹, and net returns from ₹27,500-32,500 ha⁻¹. The sole Chana plot again recorded the highest profitability (B:C 3.60), whereas DS1 showed the lowest returns (B:C 3.20), likely attributable to its relatively faster biomass accumulation. These moderate reductions in intercrop profitability coincide with early canopy expansion and root elongation typical of *D. sissoo* in arid regions (Singh & Singh, 2004) [22]. Similar trends have been reported under guava-based and *Acacia*-based systems, where annual crop productivity shows small but consistent reductions by the second or third year due to rising competition (Mourya *et al*., 2025, Amare & Darr, 2023) [15, 2]. These studies attribute early impacts primarily to increasing demand for nutrients and moisture by fast-growing clones or species.

Table 2: Economics of Chana under different 1-year-old tree treatments

Treatment	Gross return (GI, ₹ ha⁻¹)	Cost of cultivation (C, ₹ ha⁻¹)	Net income (NI = GI − C, ₹ ha⁻¹)	B:C ratio (GI / C)
Sole Chana (control)	45,000	12,500	32,500	3.60
Chana + DS1 (1-yr old)	40,000	12,500	27,500	3.20
Chana + DS2 (1-yr old)	43,000	12,500	30,500	3.44
Chana + DS4 (1-yr old)	42,500	12,500	30,000	3.40
Chana + Sissoo seedlings (1-yr old)	44,000	12,500	31,500	3.52

Fig 2: Chana grown under one-year-old *Dalbergia sissoo* AFRI clones during 2024.

3.3 Moth Bean

By the third year, when trees reached two years of age, competitive interactions became more pronounced, particularly under the vigorous DS1 clone (Table 3). With uniform costs (₹10,500 ha^{-1}), gross returns varied widely from ₹35,000-42,000 ha^{-1}. Sole Moth produced the highest net income (₹31,500 ha^{-1}; B:C 4.00), while DS1 resulted in the lowest returns (NI ₹24,500 ha^{-1}), marking a clear divergence attributable to differential tree growth. These results conform closely to ecological dynamics observed in maturing agroforestry systems, where competition for moisture, nutrients, and light increases with tree age (Sen *et al*., 2023; Jaisankar *et al*., 2013) [20, 9]. Moderate impacts under DS2, DS4, and seedling-origin sissoo reflect their comparatively slower biomass accumulation.

Table 3: Economics of Moth under different 2-year-old tree treatments

Treatment	Gross return (GI, ₹ ha^{-1})	Cost of cultivation (C, ₹ ha^{-1})	Net income (NI = GI − C, ₹ ha^{-1})	B:C ratio (GI / C)
Sole Moth (control)	42,000	10,500	31,500	4.00
Moth + DS1 (2-yr old)	35,000	10,500	24,500	3.33
Moth + DS2 (2-yr old)	38,000	10,500	27,500	3.62
Moth + DS4 (2-yr old)	39,000	10,500	28,500	3.71
Moth + Sissoo seedlings (2-yr old)	41,000	10,500	30,500	3.90

Similar patterns have been reported in *Morus alba*-based systems, where higher tree biomass or intensive canopy management significantly reduced intercrop yields and economic returns (Saakshi *et al*., 2022) [19]. These studies emphasize that competitive pressure increases sharply once trees approach the 2-3 year stage, particularly in resource-limited arid soils.

Fig 3: Moth bean under two-year-old *Dalbergia sissoo* clones during 2025.

These progressive changes mirror classical agroforestry development stages described by Nair (1994) [16] and empirically validated by Singh & Singh (2000, 2004) [21, 22] under *D. sissoo* in arid regions. Our results also parallel findings from various agri-horti and agri-silvi systems, where profitability declines over time unless tree canopies are pruned or spacing optimized (Pandey *et al*., 2024; Saakshi *et al*., 2022) [17, 19]. Importantly, across all years, intercrops remained economically viable, demonstrating that clone-based sissoo agroforestry provides steady short-term income during establishment while offering long-term ecological benefits such as nutrient enrichment (Kumar *et al*., 2025) [11].

4. Conclusion

By the third year of evaluation Isabgol, Chana and Moth bean under *Dalbergia sissoo* agroforestry systems in the IGNP command area of western Rajasthan demonstrated that clone-based agroforestry remains economically viable throughout the early establishment phase. The methodological framework comprising cost of cultivation estimation, sequential rabi intercrops and systematic comparison of AFRI clones (DS1, DS2, DS4) with seedling-origin sissoo and open-field controls enabled a clear assessment of tree crop economic interactions as trees aged from 0 to 2 years.

During the first year, newly planted trees exerted negligible influence on Isabgol performance, and economic returns across treatments remained comparable. By the second year, Chana yields showed minor but measurable reductions under the faster-growing DS1 clone, while DS2, DS4 and seedling treatments maintained profitability similar to the control. By the third year, when trees reached two years of age, Moth bean exhibited clear signs of emerging competition mainly reduced returns under DS1, consistent with early canopy expansion and increasing root activity.

Despite these progressively increasing interactions, all intercrops produced positive net returns and favourable B:C ratios across treatments, confirming the short-term economic resilience of the system. Clone-specific differences suggest that DS2 and DS4 offer a more balanced combination of early growth and intercrop compatibility compared to the more competitive DS1. Overall, the study highlights that *D. sissoo* clone-based agroforestry systems can support profitable annual crop cultivation during their initial establishment, providing a reliable income stream to farmers while the tree component matures to deliver longer-term ecological and economic benefits.

References

1. Abdullahi IN, Anyaegbu PO. The performance of soybean using *Moringa* as alley to improve soil productivity in north-central Nigeria. African Journal of Agricultural Research. 2017;12(14):1182-1189.
2. Amare D, Darr D. Profitability of smallholder agroforestry woodlot innovations. Human Ecology. 2023;51(5):1009-1019.
3. Chandra JP. Poplar: A cash crop for North Indian farmers. Indian Forester. 1986;112(8):698-710.
4. Chaturvedi AN. Poplar farming in U.P. (India). U.P. Forest Bulletin No. 45. U.P. Forest Department; 1981.
5. Chauhan SK, Sharma R, Dhillon WS. Status of intercropping in poplar-based agroforestry in India. Forestry Bulletin. 2012;12(1):49-67.
6. Dollinger J, Jose S. Agroforestry for soil health. Agroforestry Systems. 2018;92(2):213-219.
7. Fahad S, Chavan SB, Chichaghare AR, Uthappa AR, Kumar M, Kakade V, *et al*. Agroforestry systems for soil health improvement and maintenance. Sustainability. 2022;14(22):14877.
8. Frank E, Eduardo S. Biomass dynamics of *Erythrina lanceolata* as influenced by shoot pruning intensity in Costa Rica. Agroforestry Systems. 2003;57:19-28.
9. Jaisankar I, Revathi R, Parthiban KT, Backiyavathy MR, Sudhagar RJ, Sivakumar K. Response of *Dalbergia sissoo* Roxb. clones to integrated nutrient management practices. Indian Journal of Hill Farming. 2013;26(2):42-48.
10. Johar V, Dhillon RS, Bangarwa KS, Bhardwaj KK. Effect of eucalyptus-based agri-silvi-horticultural system on growth and yield of wheat in north-western region of Haryana, India. International Journal of Current Microbiology and Applied Sciences. 2017;6(11):2702-2711.
11. Kumar D, Kothari S, Perwez A, Jatav SS, Midde SNM. Comparative performance of *Dalbergia sissoo* AFRI clones in improving soil fertility under agroforestry system in the IGNP command area of Western Rajasthan. International Journal of Research in Agronomy. 2025;8(10S):112-116. https://doi.org/10.33545/2618060X.2025.v8.i10Sb.4024
12. Lahiri AK. Agroforestry in West Bengal (Parts I & II). In: Proceedings of Workshop on Agroforestry. 1983. p. 218-225.
13. Mandal AK. Soil degradations in the IGP of central Haryana, India—a spatial assessment for reclamation and management. Environmental Monitoring and Assessment. 2022;194(11):835.
14. Mathur RS, Sharma KK, Ansari MV. Economics of eucalyptus plantation under agroforestry. Indian Forester. 1984;110:171-201.
15. Maurya R, Kumar N, Ram A, Debnath S, Dev I, Newaj R, *et al*. Maximizing the productivity, economic gain, and soil fertility of guava (*Psidium guajava*)-based agroforestry system. Indian Journal of Agronomy. 2025;70:104-111.
16. Nair PKR, Rao MR, Fernandes ECM. Tree-crop interactions in agroforestry systems. World Bank/ICRAF; 1994.
17. Pandey A, Rana R, Debbarma B, Tiwari P. Economic evaluation of soybean in different treatment levels under guava-based agri-horticulture system in Vindhyan region of Uttar Pradesh, India. Plant Archives. 2024;24(1):1226-1230.
18. Patel VJ. A new strategy to high density agroforestry. Jivarajbhai Patel Agroforestry Centre Report. Surendranagar, Gujarat; 1988. p. 57.
19. Saakshi, Thakur CL, Bhardwaj DR, Bhatia AK. Bio-economic appraisal of *Phaseolus vulgaris* under *Morus alba*-based agri-silvicultural system. International Journal of Farm Sciences. 2022;12(3):100-103. https://doi.org/10.5958/2250-0499.2022.00082.9
20. Sen A, Kaur A, Johar V, Singh V. Indian rosewood: A versatile tree for economic prosperity. International Journal of Phytological Research. 2023;3(4):16-21.
21. Singh B, Singh G. Effect of stand age on soil and foliage nutrients in irrigated *Dalbergia sissoo* plantation in arid zone. Journal of Tropical Forestry. 2000;16(4).
22. Singh B, Singh G. Influence of soil water regime on nutrient mobility and uptake by *Dalbergia sissoo* seedlings. Tropical Ecology. 2004;45(2):337-340.
23. Singh G, Bhati M. Growth of *Dalbergia sissoo* in desert regions of western India using municipal effluent and the subsequent changes in soil and plant chemistry. Bioresource Technology. 2005;96(9):1019-1028.
24. Sur K, Chauhan P. Dynamic trend of land degradation/restoration along Indira Gandhi Canal command area in Jaisalmer district, Rajasthan, India: A case study. Environmental Earth Sciences. 2019;78(15):472.
25. Yu Y, Stomph TJ, Makowski D, van der Werf W. Temporal niche differentiation increases the land equivalent ratio of annual intercrops: A meta-analysis. Field Crops Research. 2015;184:133-144. https://doi.org/10.1016/j.fcr.2015.09.010