The Pharma Innovation Journal 2022; SP-11(9): 2198-2202

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(9): 2198-2202

www.thepharmajournal.com
Received: 21-07-2022
Accepted: 24-08-2022

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Cost-benefit analysis for agroforestry systems in Jharkhand

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Abstract
Agroforestry has been practiced for a long time in Jharkhand. Bakain (*Melia azedarach* L., F: Meliaceae) is identified as a potential agroforestry tree species whose leaves are looped for highly nutritive fodder. In the present investigation, the cost-benefit was analyzed in Bakain based agroforestry system with four fodder crops viz., Stylo, Charabadam, Brachiaria, and NB Hybride, (together abbreviated as SCBN) during 2019-20 and 2020-21. Cost-Benefit Analysis for Agroforestry Systems in Jharkhand were computed with the following parameters; Cost of cultivation (Rs. ha^{-1}), Gross return (Rs. ha^{-1}), Net return (Rs. ha^{-1}) and Benefit Cost Ratio (BCR). Among all the combinations, Bakain + Stylo recorded highest gross return (Rs ha^{-1} 1,86,705) and maximum B:C ratio (2.59) which were significantly superior over all other treatments. It has been found that Bakain + stylo intercropping in agroforestry system can be a better and economically viable combination among all intercrops for the farmers of Jharkhand. However, even with such economic benefits, the adaptation of Bakain based agroforestry model in Jharkhand is still in its incipient stage, which need to be explored. Collaboration of farmers, researchers and local government in developing such an economically viable agroforestry model is need of the hour for sustained production and environmental benefits.

Keywords: Fodder tree, *Melia azedarach*, fodder grasses, economics of agroforestry

Introduction
Agroforestry is a land-use system where woody perennial plants are deliberately used on the same land- management units as agricultural crops, in form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren & Raintree 1982) [1]. Mono-culture systems have led to rapid soil fertility decline through erosion, reduced cultivation time for crops to several years (Do DS., 1994; Kardell O., 1993) [2] and in one to two rotations in the case of Eucalyptus plantation. Agroforestry systems (AFS) play important role in improving under rainfed condition in ensuring livelihood security of tribal farmers of eastern Plateau and Hill region. A range of agroforestry practices have been adopted based on local agro-climatic conditions, capacity of local people and market availability. However, due to unstable market for products, agroforestry systems and practices have been changed and/or adjusted to meet market requirements and some of them have expanded overtime. Among many such prevailing agroforestry systems in the region *viz*., Agrihorticultural system (fruit trees like Mango, Guava, Litchi, Jamun, etc.), agri-silvi pastoral system (trees dominated by Gamhar, Teak, Eucalyptus, etc.) etc., agroforestry with Bakain (*Melia azedarach*), a potential fodder tree species of the region, could hardly draw any attention or interest of the farmers. It is found to grow along boundaries or in home-garden, whose leaves are looped for highly nutritive fodder. The species has the potential to not only can improve environmental health but also to provide livelihood security to the farmers of the region because of its multiple uses like timber, fuelwood, fodder, etc. The fuelwood of this species has been reported to have as high calorific value as 5100 kcal kg^{-1} (Orwa *et al*., 2009 and Sharma and Paul, 2013) [3, 4]. There is very scarce information available on the species and it's 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 Bakain based agroforestry system considering the market value of timber and fuelwood, and to sort out the best combination of fodder intercrops for this region based on their growth potential, fodder availability, preferences of the species by the farmers as well as quick and high revenue generation.

The present paper focused on economics of the Bakain 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 2019-20 at the agroforestry field 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 2019-20. 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 °C and 5.29 °C respectively during 2019-20. The experiment was conducted in Randomized Block Design with nine treatments replicated thrice. Stylo Charabadam, Brachiaria, and NB Hybride, (together abbreviated as SCBN) were intercropped with six-year-old *Melia azedarach* spaced at 4m x 4m, and each grass was maintained under sole cropping as control, representing each as a treatment. Cost-Benefit Analysis for Agroforestry Systems in Jharkhand were computed with the following parameters; Cost of cultivation (Rs. ha^{-1}), Gross return (Rs. ha^{-1}), Net return (Rs. ha^{-1}) and Benefit Cost Ratio (BCR).

Species Description

Bakain (*Melia azedarach* L., F: Meliaceae) is identified as a potential fodder tree species whose leaves are looped for highly nutritive fodder. It is a small to medium sized deciduous tree attaining an average height of 7 -12 m and average diameter of 30-60 cm, with a spreading crown and sparsely branched limbs. In India it is mainly grown in Assam, Bihar, Karnataka, Maharashtra, Odisha and Punjab. In its natural locality, the mean annual temperature ranges from 23^{0}C to 26^{0}C, mean annual rainfall from 600-2400 mm, and it prefers well drained, deep, sandy loam soil with pH range 5 to 6. Besides providing nutritive leave fodder, it also provides good timber which is used to produce agricultural implements, furniture, plywood, boxes, poles, tool handles etc.

Stylo (*Stylosanthes hamata* L., F: Fabaceae), also known as Caribbean Stylo, is a semi-erect, annual or short-lived perennial tropical legume grass, grows up to 75 cm high. It is found in India, West Africa and Northern Australia, where it grows better in areas with 700 to 900 mm rainfall (Cameron, 2010) [6]. Caribbean Stylo is drought-resistant, can grow on a wide range of soils, except heavy clays, with a pH ranging from 5.5 to 8 (Cook *et al*., 2005) [5]. Successive harvesting can be done at 45 days of interval or in accordance to the growth of the crop and a maximum of 4-5 harvests can be taken in a year for a perennial crop. The crop yield 25-30 t ha^{-1} green fodder per year. Generally, *S. hamata* is used to boost the flora of natural pastures and leys and for enhancing the creation of forage banks (Coulibaly *et al*., 1996) [7].

Charabadam (*Arachis glabrata* Benth. F: Fabaceae), also known as Rhizoma peanut, is a summer growing perennial tropical legume and a relative of the annual peanut (*Arachis hypogea*). It is a high-quality forage plant native to Argentina, Brazil and Paraguay. It does well where annual rainfall is between 1000 and 2000 mm and where average monthly temperature is over 20 °C (FAO, 2017; Cook *et al*., 2005) [8, 5]. It is well adapted to acidic infertile soils having pH down to 4.5 but also reported to grow on pH as high as 8.5 of alkaline soil (Cook *et al*., 2005) [5]. The species can yield about 10-16 tons dry matter per ha under ideal conditions. For hay production, three cuttings are possible in favourable season at an interval of 7 to 8 weeks (Cook *et al*., 2005) [5].

Brachiaria (*Brachiaria mutica* (Forssk.) Stapf, F: Poaceae), also known as Para grass, Angola grass or Buffalo grass (Miles *et al*., 1996), is a semi-aquatic, palatable and good quality forage grass particularly suited to poorly drained soil. It is native to Sub-Saharan flood plains. It can be found from sea level up to an altitude of 1000 m (FAO, 2017) [8]. It thrives in moist soils of humid and sub-humid areas with annual rainfall of 1200-4000 mm, or in swampy areas of drier environments down to 900 mm rainfall. Para grass is a warm climate grass that grows effectively at temperatures around 22 °C and stops growing under 15 °C. It does well on acidic soils (pH 4-5) (Cook *et al*., 2005) [5]. First harvest can be done about three months after planting when the grass attains a height of about 60 to 75 cm. Subsequent cuts can be taken at 30 to 40 days interval, usually yielding 5-12 t DM/ha/year. The yield is about 70 t ha^{-1} annually.

NB Hybrid (*Pennisetum purpureum* x *Pennisetum glaucum*, F: Poaceae) (updated name: *Cenchrus purpureus* Schumach) (Paudel *et al*., 2018), commonly known as Elephant grass, Napier grass, originated from sub-Saharan tropical Africa. It is a summer growing grass that grows from sea level up to an altitude of 2000 m (Francis, 2004) [4]. It thrives better in places where temperatures range from 25 °C to 40 °C (FAO, 2015) and where annual rainfall is over 1500 mm. It does better on drained sandy soils with a pH ranging from 4.5 to 8.2 (FAO, 2015; Cook *et al*., 2005; Duke, 1983) [5]. The biomass production of the species is high i.e., about 40 tons/ha/year and can be harvested 4-6 times per year (Kabirizi *et al*., 2017) [11]. After 65 days of plantation first cut is obtained and the successive cuts are obtained after the interval of 25 to 30 days. At least 6-8 cuts are possible annually (Karforma, J. 2018) [12].

Description of Agroforestry Systems

The experimental design followed in the agroforestry system was randomized block design with nine treatment combinations replicated thrice as, T_1– *Melia azedarach* + Stylo (*Stylosanthes hamata*), T_2– *Melia azedarach* + Charabadam (*Arachis glabrata*), T_3– *Melia azedarach* + Brachiaria grass (*Brachiaria mutica)*, T_4– *Melia azedarach* + NB hybrid grass (*Pennisetum purpureum x Pennisetum glaucum)*, T_5 - Sole *Melia azedarach*, T_6 - Sole Stylo, T_7 - Sole Charabadam, T_8 - Sole Brachiaria grass, T_9 - Sole NB hybrid grass.

Cost Benefit Analysis

The data for cost- benefit economic analysis of the system collected from the first cut of fodder from first year of the establishment. Cost of Inputs for establishing agroforestry system was calculated which includs 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 fodder, leaves, 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 Rs. ha^{-1}

$$\text{Benefit Cost Ratio (BCR)} = \Sigma B_t/(1+i)t \,/\, \Sigma C_t/(1+i)t$$

Where,

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

Results

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 and 3. Data showed that, the Bakain + Stylo recorded more gross return (Rs ha^{-1} 1,86,705 only) during second year, however, H. Napier grown as sole recorded more gross return during both the years (Rs ha^{-1} 1,19,038 & 1,56,730 only). Further, Sole H. Napier (Rs ha^{-1}. 91,388 & 1,29,081 only) and Bakain + Stylo (Rs ha^{-1}. 22,689 & 1,34,632 only) recorded at par net return during second year, however during first year H. Napier was significantly superior over other treatment combination. Net return under Bakain+ Charabadam and sole Para grass was at par to each other. While, in other hand the highest B:C ratio was recorded under H. Napier (4.97) during second year which was significantly superior over all other treatments. Bakain + Stylo recorded B:C ratio (2.59) which was more over Bakain + Charabadam (1.57) which was at par with sole Bakain (1.61).

Table 1: Economic of Bakain (*Melia azedarach* L.) based Sivi-Pastoral Agroforestry system.

Treatments	Cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)		Net Return (Rs/ha)		B:C ratio	
		2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Bakain + Stylo	52073	74762	186705	22689	134632	0.44	2.59
Bakain + Charabadam	55242	58250	141713	3008	86471	0.05	1.57
Bakain + Para grass	54770	59527	94642	4757	39873	0.09	0.73
Bakain+ Hybrid Napier	54975	96400	127246	41425	72272	0.75	1.31
Sole Bakain	27325	17880	71235	-9445	43910	-0.35	1.61
Sole Stylo	24748	51335	77735	26587	52987	1.07	2.14
Sole Charabadam	27917	41196	55332	13279	27415	0.48	0.98
Sole Para grass	27445	68080	107992	40635	80548	1.48	2.93
Sole Hybrid Napier	27650	119038	156730	91388	129081	3.31	4.67
SEm ±		2943	4526	1176	2962	0.02	0.06
LSD at 5%		9037	13895	3610	9095	0.07	0.17
CV %		7.89	6.98	7.89	6.98	4.56	4.78

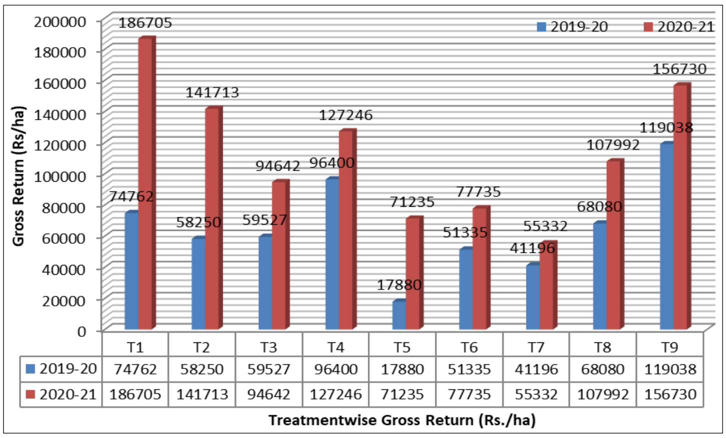

Fig 1: Gross return (Rs/ha) from Bakain (*Melia azedarach* L.) based Sivi-Pastoral Agroforestry system during 2019-20 and 2020-21.

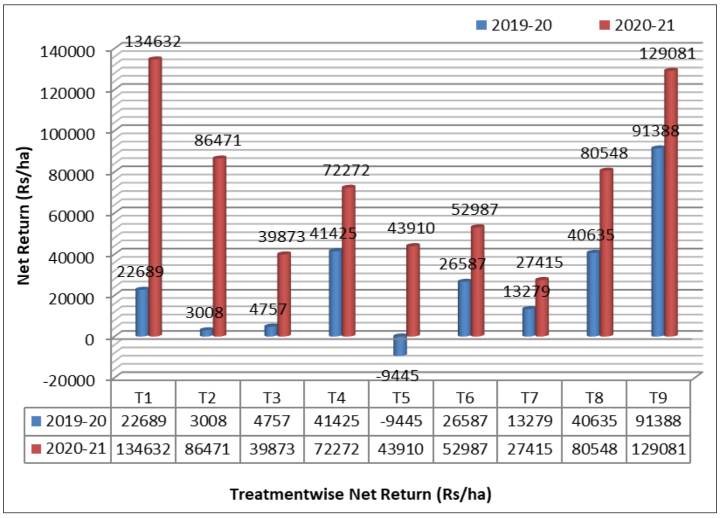

Fig 2: Net return (Rs/ha) from Bakain (*Melia azedarach* L.) based Sivi-Pastoral Agroforestry system during 2019-20 and 2020-21

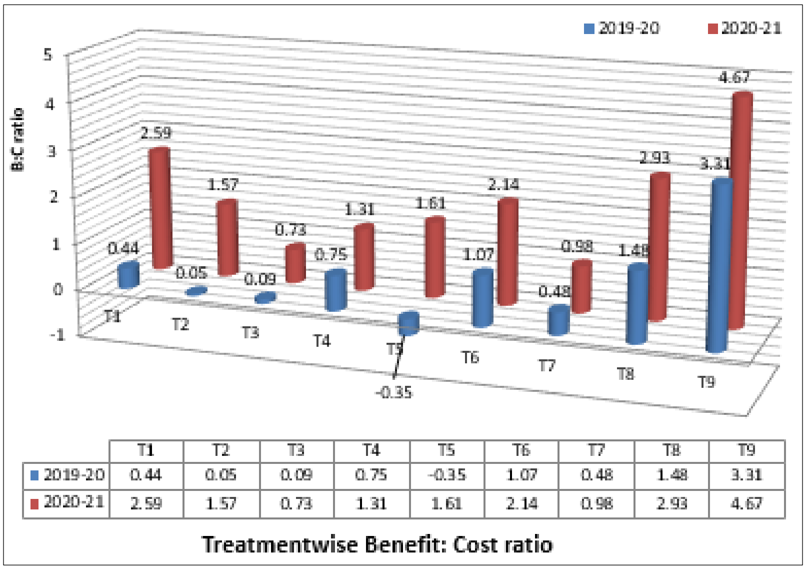

Fig 3: Benefit: Cost ratio of Bakain (*Melia azedarach* L.) based Sivi-Pastoral Agro-forestry system during 2019-20 and 2020-21.

Discussion

The data on total cost of production, net income and benefit cost ratio as influenced by sole crop and intercrop under Bakain based agroforestry system are presented in Table 1 and Figure 1, 2 & 3. It is evident from the results that the intercropping of Bakian with Stylo recorded higher benefit cost ratio as compare to its sole. However, maximum benefit cost ratio was recorded in the sole H. Napier. Compare to all respective treatment as per different fodder crops, sole H. Napier recorded higher benefit cost ratio among all treatments. It may 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 Do. H. V. *et al*., (2022), that, agroforestry practices with fruit trees can be more profitable than sole-crop cultivation within a few years. Integration of fodder tree Bakian with seasonal and fast-growing perennial grass Stylo is essential to ensure quick returns.

Conclusion

The four different fodder crops intercropped with fodder tree Bakain in Agroforestry system have clearly helped to improve our understanding of some of the economic dimensions of agroforestry systems. It can be concluded that Bakain + stylo 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.

Acknowledgements

This study was funded by NAHEP-CAAST, BAU, Ranchi, Jharkhand, India. We gratefully acknowledge the support provided by Birsa Agricultural University, Ranchi, India to carry out the study. We thank the anonymous reviewers for their constructive comments to the manuscript.

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