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Economic Feasibility of Finger Millet (*Eleusine coracana*) under Multitier Agroforestry Systems in South Gujarat

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Abstract: Economics of Finger Millet Eleusine coracana Gaertn. under the multi-tier bamboo-malabar neem (*Melia dubia*) and bamboo–mahogany (*Swietenia mahagoni*) agroforestry system was evaluated during *kharif* – 2022 and 2023 at Hill Millet Research Station, Waghai, Dang's, Navsari Agricultural University, Gujarat. The two multi-tier agroforestry systems namely bamboo-malabar neem (M_1) and bamboo-mahogany (M_2) were considered as main plot treatments and four finger millet varieties GN-5 (V_1), GNN-7 (V_2), GN-9 (V_3), and GN-10 (V_4) were selected as sub-plot treatments. The experiment followed in a split-plot design, with three replicates. Agroforestry system bamboo-malabar neem-GN-7 was the best multi-tier agroforestry combination achieving the highest grain yield (2,659 kg ha^{-1}), straw yield (4,279 kg ha^{-1}), gross return (₹1,62,878 ha^{-1}), net return (₹82,550 ha^{-1}) and benefit to cost ratio (2.03). The lowest economic gains were from bamboo-mahogany-GN-9, with a grain yield of 1,860 kg ha_{-1} and B:C ratio of 1.45.

Keywords: Finger millet, Economics, Multi-tier agroforestry, Bamboo, *Melia dubia, Swietenia mahagoni*

Increased demand for food, fuel, and fodder to fulfill the need for rapidly increasing human and livestock population requires enhanced productivity per unit area. In regions with limited resources, such as hilly areas, including scarce good-quality land and water, this task becomes more challenging. Agroforestry is a viable alternative for land utilization to achieve the National Forest Policy (1988) goal that 33 per cent of the country's geographical area under forest and tree cover. For short-to medium-term benefits, timber trees and bamboos can be intercropped with food or cash crops and livestock to design and test agroforestry systems in such areas. Integration of bamboo in a multi-tier agroforestry systems can maximize its functionality with other productive crops. The bamboo-based agroforestry models improve the ecological parameters of the highly degraded basaltic tracts (Behari et al., 2000). Bamboo is a group of beautiful and useful woody plants belonging to the sub-family Bambusoideae of the family Gramineae. Bamboo is a valuable alternative because of its multiple uses and short rotation (3-5 years). Known to be fast-growing, bamboo can reach its maximum height in four to six months with a daily increment of 15 to 18 cm. Among the different tree species, *Melia dubia* is one of the best alternative pulpwood species (Bharti 2006, Dhaka et al., 2020, Thakur et al., 2021). It belongs to the family *Meliaceae* and is commercially known as “Malabar neem”. It is a fast-growing short-rotation multipurpose deciduous tree indigenous to India, Southeast Asia, and Australia, growing to a height of 30 m with a spreading crown and clear bole of 9 m. It is found scattered in natural forests of south Gujarat region and framers have adopted it as multifarious species without any deleterious effect on associated crops and soil (Parmar et al., 2019, Sukhadiya et al., 2021, Thakur et al., 2023,). *Swietenia mahagoni* (L.) Jacq. is a tall tree, up to 30 m high, with a short buttressing base, up to 1 m in diameter, and a spherical crown. The bark is smooth gray on young trees, turning to scaly dark reddish-brown on large trees. Although bamboo and *M. dubia* are short rotation components as compared to *S. mahagoni* even then to make these species based agroforestry systems economically viable there is need to develop cash crop based systems for early returns. Among several compatible intercrops, millets too can be viable option to resolve this issue.

Millets are warm-weather grasses belonging to the C_4 group of plants and are considered to be physiologically efficient. Their cultivation in India extends from sea level up to 2000 m above the mean sea level and often grows in diverse soils, climates, and harsh environments. India is considered one of the major millet producers in the world. The predominant millets grown in India are sorghum, pearl millet, finger millet, kodo millet, proso millet, little millet, foxtail millet and barnyard millet of which barnyard millet, little millet and kodo millet are endemically domesticated in Indian subcontinent. Finger millet (*Eleusine coracana* Gaertn.), is an important crop and a major food source in many parts of the dry farming region in India. It is grown in a dry farming region, where the annual rainfall ranges between 400 mm and 1000 mm. In India, finger millet ranks third among millets, after sorghum and pearl millet. In Gujarat, finger millet is the most important traditional millet crop grown over an area of 11,000 hectares with a productivity of 1335 kg/ha and provides food and nutritional security to marginal farmers in

rainfed dry lands and hilly tribal areas. In Gujarat, it is mainly cultivated as a rainfed crop in the less fertile hilly soils of the Dangs, Valsad, and Navsari districts of South Gujarat and Panchmahal district of middle Gujarat in kharif season (Patil et al., 2016). Therefore, this study reports the economic feasibility of finger millet under bamboo, *M. dubia* and mahogany in hilly district of south Gujarat The Dangs.

MATERIAL AND METHODS

The research area is located in the southeastern part of Gujarat state and northern zone of Western Ghats situated at 20.7737 ^{0} North latitude, 73.4976 ^{0} East longitude, and at an altitude of 122.11 meter above the mean sea level (Fig. 1). The climate is typically tropical subhumid, characterized by a fairly hot summer, moderately cold winter, and warm humid monsoon. Generally, the monsoon in this region commences during the second week of June and ends in September. The total annual rainfall in this region is approximately 2134 mm and the number of rainy days is 65 - 70 days. The lowest temperature of the season was recorded in either December or January (10 °C to 23.8 °C). Gujarat Nagli - 5 (GN - 5), Gujarat Navsari Nagli - 7 (GNN - 7), Gujarat Nagli - 9 (GN - 9) and Gujarat Nagli - 10 (GN-10) varieties of finger millet were selected. These varieties were developed by Hill Millet Research Station, Waghai, Dang's, Gujarat. Seeds of Finger millet [*E. coracana*] varieties were procured from Hill Millet Research Station (HMRS), Waghai, Dang's, Gujarat treated with thiram 2 g/kg of seed for 24 hours before sowing and sown by line sowing method in the open space of field for each variety separately than after 30 DAS plants were transplanted under Bamboo-Malabar neem and Bamboo-Mahogany multi-tier plots as an intercrop at spacing of 22.5 x 10 cm in 12 plots each of 1.8 x 3.0 m in size during kharif season of 2022 and 2023. Observations on grain yield and straw yield were recorded, and economics in terms of cost of cultivation (Table 1), gross return, net return, and benefit-to-cost ratio were determined.

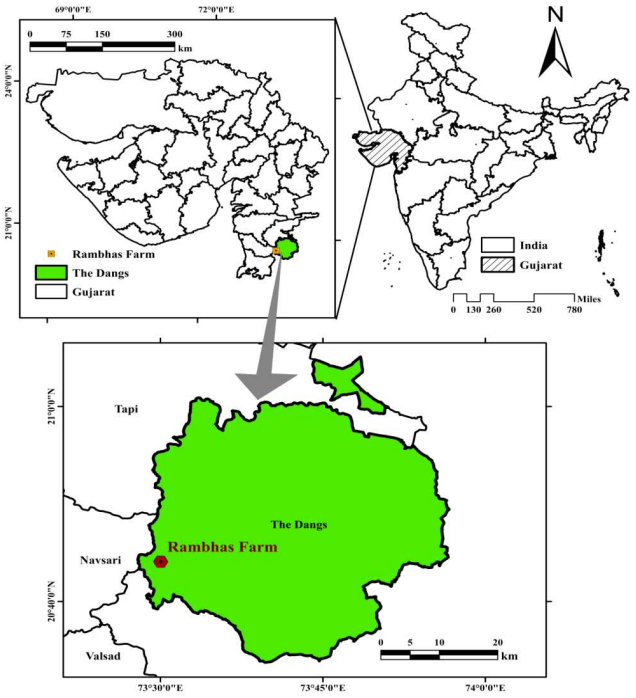

Fig. 1. Study area

RESULTS AND DISCUSSION

Economic analysis of multi-tier combinations in the agroforestry system showed considerable variation in grain yield, straw yield, gross return, net return, and benefit–cost (B:C) ratio (Table 1). Across all multi-tier combinations, the highest grain yield (2659 kg ha^{-1}) was obtained under bamboo-malabar neem-GNN-7 system, which fetched gross returns from grain of ₹ 132,927 per hectare. The corresponding straw yield (4279 kg ha^{-1}) contributed an additional gross returns of ₹ 29,951 per hectare, resulting in the maximum gross return (₹ 1,62,878 ha^{-1}). After deducting the cost of cultivation (₹ 80,328 ha^{-1}), the net return was ₹ 82,550 per hectare, with the highest B:C ratio of 2.03, indicating superior economic viability.

Other promising multi-tier combinations were bamboo–malabar neem-GN-10 and bamboo–mahogany-GNN-7, both yielding gross benefits above ₹ 1,32,000 per hectare and net return exceeding ₹ 52,000 per hectare, with B:C ratios of 1.66 each. In contrast, the lowest economic returns were from bamboo-mahogany-GN-9, which had the lowest grain yield (1860 kg ha^{-1}), net return (₹ 36,207 ha^{-1}) and B:C ratio (1.45).

These results suggest that bamboo, tree species and crop varieties significantly influenced system profitability, and malabar neem–based agroforestry systems generally outperformed mahogany-based agroforestry systems. The superior performance of M_1V_2 can be attributed to higher grain and straw yields due to more availability of light under malabar neem–based agroforestry system. Malabar neem have sparse crown which allow more sunlight as compared to Mahogany. Moreover, higher returns in V_2 (GNN-7) might be due to genetic makeup of the variety which allow it to grow under multi-tier agroforestry system as compared to other varieties. The higher B:C ratios in M_1V_2, M_1V_4, and M_2V_2 highlight the potential of these combinations for sustainable and profitable agroforestry adoption.

Economic feasibility of other intercrops (pulse and fodder grasses) under *M. dubia* based agroforestry systems (*M. dubia*-hybrid napier/Sorgham Sudan grass) evaluated by

Table 1. Cost of cultivation of finger millet (₹ ha^{-1})

Particular	Unit	Rate	Cost (₹)
A. Land preparation			
Ploughing with tractor (hrs)	6	@ ₹ 600 hr^{-1}	3600
Cultivator with tractor (hrs)	6	@ ₹ 600 hr^{-1}	3600
Bed preparation (labours /day)	10	@ ₹ 268 $labour^{-1}$ day^{-1}	2680
		Total (A)	9880
B. Planting material			
Seeds cost (4 varieties) (4kg)	4	@ ₹ 120 kg^{-1}	480
Seed sowing (labours/day)	2	@ ₹ 268 $labour^{-1}$ day^{-1}	536
Transplanting (labours/ 2 day)	15	@ ₹ 268 $labour^{-1}$ day^{-1}	8040
		Total (B)	8788
C. Manures and fertilizers			
FYM (tonne) or (₹5/kg)	10	@ ₹ 500 t^{-1}	5000
Neem cake (kg)	500	@₹ 35 kg^{-1}	17500
Vermicompost (kg)	1000	@ ₹ 7 kg^{-1}	7000
Application of manures / compost / neem cake (Labours/day)	15	@ ₹ 268 $labour^{-1}$ day^{-1}	4020
		Total (C)	33520
D. Intercultural operations			
Weeding (labours/day) x 3 times	15	@₹ 268 $labour^{-1}$ day^{-1}	12060
		Total (D)	12060
E. Harvesting, threshing and marketing			
Harvesting of ear heads (labours/day) x 2 times	10	@ Rs. 268 $labour^{-1}$ day^{-1}	5360
Threshing (labours/day) x 2	10	@ Rs. 268 $labour^{-1}$ day^{-1}	5360
Harvesting of straw (labours/day) x 2 times	10	@ Rs. 268 $labour^{-1}$ day^{-1}	5360
		Total (G)	16080
		Total fixed cost (A+B+C+D+E)	80328
		Gross Total	80328

Table 2. Economics of finger millet under bamboo-malabar neem and bamboo-mahogany based multi-tier agroforestry system

Multitier AFS	Grain yield (kg/ha)	Gross returns from grain (₹/ha)	Straw yield (kg/ha)	Gross returns from straw (₹/ha)	Cost of cultivation (₹)	Total gross return (₹)	Total net return (₹)	B:C Ratio
M_1V_1	1929	96451	3331	23314	80328	119764	39436	1.49
V_2	2659	132928	4279	29951	80328	162878	82550	2.03
V_3	1965	98245	3471	24296	80328	122541	42213	1.53
V_4	2144	107223	3712	25984	80328	133207	52879	1.66
M_2V_1	1932	96599	3289	23026	80328	119625	39297	1.49
V_2	2191	109556	3417	23921	80328	133477	53149	1.66
V_3	1860	93025	3359	23511	80328	116535	36207	1.45
V_4	1978	98896	3325	23278	80328	122175	41847	1.52

AFS= agroforestry systems, M_1V_1= Bamboo-malabar neem-GN-5, M_1V_2= Bamboo-malabar neem-GNN-7, M_1V_3= Bamboo-malabar neem-GN-9, M_1V_4= Bamboo-malabar neem-GN-10, M_2V_1= Bamboo- mahogany-GN-5, M_2V_2= Bamboo- mahogany-GNN-7, M_2V_3= Bamboo- mahogany-GN-9, M_2V_4= Bamboo- mahogany-GN-10

The price of grain was ₹ 50/kg and of straw was ₹7/kg per kg

Prajapati et al., (2020, 2022) in this region and are in line with present economic analysis. Bioeconomic compatibility of pulse crop based Malabar neem systems profitable in south Gujarat (Bhusara et al., 2018a, 2018b). Similarly, trend was observed by Hemalatha et al. (2023) in cluster bean variety MDU1 under *M. Dubia* and Mehta et al. (2024) in finger millet under Bhimal and Mulberry and these findings are in agreements with present agroforestry systems.

These findings align with previous studies conducted by Banerjee et al. (2009) in Bamboo with black gram, groundnut, cowpea and paddy; Kumar et al. (2010) in safedmusli under tamarind (*Tamarinus indica*); Anusha (2012) in finger millet under *M. dubia*; Anusha et al. (2015) in finger millet under *M. dubia*; Himshikha et al. (2017) in wheat + millet under poplar, Bhaskar et al. (2019) in finger millet under *M. dubia*; Batham et al. (2020) in finger millet under guava, Dalvi et al. (2020) in finger millet and black gram under cashew. Meshram et al. (2020) recorded highest BC ratio in the cashew + black gram, followed by cashew + finger millet, while the lowest ratio was seen in the cashew + proso millet.

CONCLUSION

The bamboo-Malabar neem-based multi-tier agroforestry system, especially with variety GNN-7, offered the highest profitability due to superior grain and straw yields, resulting in the highest gross and net returns with the highest B:C ratio. The bamboo-malabar neem-GNN-7 is the most productive and profitable multi-tier agroforestry combination with a higher B:C ratio.

AUTHORS' CONTRIBUTION

Patel, H. S.- Research implementation, data compilation; Tandel, M. B.-Planning, management of trials and manuscript writing, Jayesh Pathak-Management of research trial; Patel, S. M.-Data analysis and cost of cultivation; Vadodariya, G. D.-data collection and management; Prajapati, D. H. - filed operations management.

REFERENCES

Anusha S 2012. *Performance of Finger millet and carbon sequestration in agroforestry system*. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Bengaluru.

Anusha SN, Mallikarjuna GB, Bhaskar V, Kombali G and Vishwanath BR 2015. Performance of Finger millet (*Eleusine coracana* (L.) Gaertn.) in association with different MPTs in agroforestry system. *Indian Journal of Agroforestry* **17**(2): 82-85.

Banerjee H, Dhara PK and Mazumdar D 2009. Bamboo (*Bambusa* spp.) based agroforestry systems under rainfed upland ecosystem. *Journal of Crop and Weed* **5**(1): 286-290.

Batham L, Singh MK, Yadav A, Das S and Kumar S 2020. Effect of agri-horti systems and weed management practices on growth and yield of Finger millet (*Eleusine coracana* L.). *International Journal of Current Microbiology and Applied Sciences* **9**(7): 1707-1716.

Behari B, Agarwal R, Singh AK and Banerjee SK 2000. Vegetation development in a degraded area under bamboo based agro-forestry system. *Indian Forester* **126**(7): 710-720.

Bharti AK 2006. *Screening alternate pulp wood species and establishment of tree improvement strategies for the screened species*. M.Sc. (For.) Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

Bhaskar V, Hanumanthappa DC, Bhavya VN and Somashekar KS 2019. Growth, yield and economics of Finger millet (*Eleusine coracana*) in *Melia dubia* based agroforestry system. *International Journal of Current Microbiology and Applied Sciences* **8**(5): 1945-1950.

Bhusara JB, Dobriyal MJ, Thakur NS, Gunaga RP and Tandel MB 2018a. Performance of okra (*Abelmoschus esculentus* L. Moench) under different spatial arrangements of *Melia composita* based agroforestry system. *International Journal of Current Microbiology and Applied Sciences* **7**(05): 3533-3542.

Bhusara JB, Dobriyal MJ, Thakur NS, Sondarva RL and Prajapati DH 2018b. Growth and yield performance of green gram under *Melia composita* plantations. *Journal of Pharmacognosy and Phytochemistry* **7**(3): 1490-1494.

Dalvi VV, Meshram NA, Shigwan AS and Rane AD 2020. Efficient and economical agricultural intercrops growing under Cashew-based agroforestry system under rainfed condition in Konkan region of Maharashtra. *Advanced Agricultural Research and Technology Journal* **4**(2): 180-182.

Dhaka RK, Gunaga RP, Sinha SK, Thakur NS, Dobriyal M J. 2020. Influence of tree height and diameter on wood basic density, cellulose and fibre characteristics in *Melia dubia* Cav. families. *Journal of The Indian Academy of Wood Science* **17**: 138-144.

Hemalatha P, Rajendran P, Ravi R, Vijayabhama M and Sekar I 2023. Assessment of suitability of vegetable cluster bean genotypes for *Melia dubia* based agroforestry system. *The Pharma Innovation Journal* **12**(5): 2559-2563.

Himshikha CS, Dhawan AK, Chauhan SK and Chandel RS 2017. Economics of poplar-based agroforestry models adopted by the farmers in Haridwar, Uttarakhand. *Indian Journal of Ecology* **44**(6): 804-811.

Kumar RD, Sreenivasulu GB, Prashanth SJ, Jayaprakashnarayan RP, Nataraj SK and Hegde NK 2010. Performance of safedmusli (*Chlorophytum borivilianum*) in tamarind plantation as intercrop and sole crop in open area. *International Journal of Agriculture Science* **6**(1): 359-360.

Mehta H, Rathore AC, Tomar JMS, Mandal D, Kumar P, Kumar S and Madhu M 2024. Minor millets-based agroforestry of multipurpose tree species of Bhimal (*Grewia optiva* Drummond JR ex Burret) and Mulberry (*Morus alba* L.) for resource conservation and production in North Western Himalayas-10-year study. *Agriculture Ecosystems and Environment* **359**: 108761.

Meshram NA, Dalvi V, Shigwan AS and Rane DA 2020. Efficient and economical agricultural intercrops growing under Cashew-based agroforestry system under rainfed condition in Konkan region of Maharashtra. *Advanced Agricultural Research and Technology Journal* **4**(2): 180-182.

Parmar AG, Thakur NS and Gunaga RP. 2019. *Melia dubia* Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. *Agroforestry Systems* **93**(4): 1347-1360.

Patil HE, Patel JV, Vavdiya PA, Naghera, Yogeshkumar V and Intwala CG 2016. A high yielding white coloured Finger millet variety GNN-7 for cultivation in South and Middle Gujarat. *International Journal of Tropical Agriculture* **34**(6): 1407-1411.

Prajapati DR, Thakur NS, Singh N, Gunaga RP, Bhuva DC and Mevada RJ 2022. Economics of cultivation of *Melia dubia*-Hybrid Napier Silvi-pasture models. *Indian Journal of Agroforestry* **24**(1): 60-64.

Prajapati DR, Thakur NS, Singh Narendra, Gunaga RP and Patel VR

2020. Economic feasibility of *Melia dubia*-Sorgham Sudan grass based Silvi-pasture systems. *Indian Journal of Ecology* **47**(2): 502-506.

Sukhadiya ML, Thakur NS, Patel VR, Gunaga RP, Kharadi, VB, Tyagi KK and Singh S 2021. Provenance variations in proximate principles, mineral matter, total phenols and phytochemicals of *Melia dubia* drupes: An unexplored alternate livestock feed stock. *Journal of Forestry Research* **32**(1): 119-131.

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Thakur NS, Hegde HT, Chauhan RS, Gunaga RP and Bhuva DC 2021. Root sucker technique for successful clonal multiplication of *Melia dubia* Cav. without sacrifice of mother tree. *Current Science* **121**(9): 1235-1237.

Thakur NS, Hegde HT, Chauhan RS, Gunaga RP, Kumar A, Bhusara JB and Bhuva DC 2023. Growth, productivity, and genetic variability of some *Melia dubia* Cav. open pollinated families in Gujarat, India. *Indian Journal of Ecology* **50**(5): 1294-1301