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Economic Analysis of Foxtail Millet- Melia Dubia Based Agroforestry Under Organic Production System in Northern Dry Zone of Karnataka

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ABSTRACT

To meet rising population demand for food and timber wood, there is intense pressure on cultivable land and existing forests. The escalating demand of food, fooder and timber wood can be attained either by increasing the farm area or the productivity. Since the former option has limited scope, the only economic and viable option left out for enhancing the productivity of agricultural field is with integration of trees in agroforestry systems. To study the monetary benefit from the agroforestry system, a field experiment on foxtail millet- Melia dubia based agroforestry under an organic production system was conducted during 2018-19 and 2020-21 in the northern dry zone of Karnataka. The experiment comprised eleven treatments with different nutrient management practices through organics in medium black soil in existing Melia dubia based agroforestry plantation system with foxtail millet as an intercrop and sole crop (without tree) under rainfed conditions. The economic analysis in the agroforestry system indicated that, the application of FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher net returns and benefit-cost ratio (Rs. 28,631 ha^{-1} and 2.31, respectively) when compared with all the treatments except FYM + poultry manure + vermiwash spray (Rs. 26402 ha$^{-1)}$ and FYM + vermicompost + panchagavya alternated with vermiwash spray (Rs. 26205 ha^{-1}). In system economic analysis (Foxtail millet + tree), crop associated with a tree with the application of and FYM + poultry manure + panchagavya alternated with vermiwash spray and FYM + poultry manure + panchagavya recorded significantly higher net returns (Rs 3,21,056 ha^{-1} and 3,20,715 ha^{-1} respectively) and benefit-cost ratio (4.81 and 4.78, respectively) over all other treatments.

Keywords: *Agroforestry, rainfed, Melia dubia, organics, economics, vermicompost, poultry manure, panchagavya, vermiwash*

1. INTRODUCTION

The prosperity generated by the green revolution in irrigated areas made the general scarcity of fuel and all the more troublesome. The farmers therefore are in the habit of progressive step of planting fast growing trees around their homesteads, along field boundaries, irrigation channels and also within fields. The preferred tree species are *Eucalyptus*, *Poplar*, *Sissoo*, Neem, *Subabul etc*., which cast low amount of shade and have least root effect. The cash value realized from sale of trees within a short period is very high and more than compensates for any marginal adverse effects that planting of such trees may have on crop yields. The trees normally, do not directly compete with shallow rooted agricultural crops either for irrigation water or for nutrients nor do these selected species cast enough shade to be detrimental to the crop growth.

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On the contrary, trees add a significant amount of litter to the soil and enrich it with organic matter and since they absorb nutrients from the lower depths of soil and also aid in recycling the plant nutrients to the top soil. Trees do attract birds, but perhaps the loss in grain is more than compensated for by the elimination of insect pests. Environmentally and economically, trees are boon to the farmers. In this context, agroforestry, a concept developed in recent decades, but traditionally practiced in Indian sub-continent and elsewhere as a low-cost input farming system, will be of much help to combat the situation. There are many tree species that are found to be suitable for agroforestry systems but recently *Melia dubia* has gained more importance and is most preferred. *Melia dubia* belongs to Meliaceae family, is a promising tree highly suitable for farm forestry and agroforestry for generating higher income in the semi-arid regions. Recently *Melia dubia* tree species has been introduced in north northeastern part of the state which is popularly known as Kalyana Karnataka region. Though it has multiuse, farmers are reluctant to adopt forestry system because of a lack of knowledge on scientific cultivation, its advantages and fear of wastage of arable land [1].

Whether annual crop spices can be grown economically under woody perennials itself is by and large an unsettled question.

Not much research work has been done on the combination of trees and annual crops, especially in Kalyana Karnataka area. The reason for this paucity of information appears to be the dominance of the entrenched notion that trees and annual crops are mutually incompatible. The practical and convincing research information to the farmers about the benefits of agroforestry systems needs to be generated. The transformation of agriculture to more productive systems has often been accompanied by increased production in fewer crop species. Concurrently, the area and production of a great diversity of traditional crops have declined. Yet in many parts of the world, traditional crops play an important role in maintaining stable and sustainable forms of agriculture. Among the crops, minor millets which are cultivated on low fertile lands are completely neglected. Millets are important cereals that play a significant role in the food and nutritional security of developing countries in the semi-arid tropics of Asia and Africa especially countries like India. Among the eight millets, foxtail millet (*Setaria italica*) is extensively cultivated in the Kalyana Karnataka region and it is an indigenous crop known for its rich nutritive value and fairly drought tolerant. Due to its quick growth, it can be grown as short-term catch crop either as a sole crop or intercrop with least management practices *viz*., without applying nutrient fertilizers or with less quantity of organic manures alone. The yield of this crop is not stable under rainfed conditions due to its cultivation on marginal or low fertile soils with less input use. The potential yields are yet to be achieved. In this context, either under sole cropping or with an agroforestry system, it is worth mentioning that nutrient management through organics plays a major role in exploiting the potential crop yields apart from maintaining soil health as a result of buildup of soil organic matter, beneficial microbes and enzymes thus improving soil physical and chemical properties under organic production system [2] . A sound nutrient management schedule comprising proper use of all the available organic manures in the system is of utmost importance. Foxtail millet sustain in poor and marginal soils and more responsive to organic fertilizers rather than inorganic fertilizers.

The focus to utilize the available resources including interspace more efficiently in tree based farming system in general and *Melia dubia* based agri-silvi system in particular with sound nutrient management practices in the region is need of the hour. Research on the influence of *Melia dubia* on associated crops is very meagre. To know the system economics of foxtail millet-*Melia dubia* agroforestry system, research was conducted for two years.

2. MATERIAL AND METHODS

To know the monitory returns from the agroforestry system, a field experiment on foxtail millet-*Melia dubia* agroforestry under the organic production system, was conducted for two years (2018-19 and 2019-20) in the northern dry zone of Karnataka. The experiment was conducted with eleven treatments comprising of different nutrient management practices through organics medium black soil in an existing *Melia dubia* based agroforestry plantation system with foxtail millet (*Setaria italica*) as an intercrop and sole crop (without tree) under rainfed conditions. The experiment was laid out in five year old *Melia dubia* plantation spaced at 9 m x 3 m under organic field which has been in practice for 12 years since 2006. Foxtail millet was sown as an inter-crop in *Melia dubia* during *Kharif* season of 2018 and 2019 on 25.08.2018 and 04.07.2019 as per the treatments, respectively.

Variety HN-46 seeds were dibbled at 4-5 cm depth in the shallow furrows opened at 30 cm apart with the help of a wooden marker. Organic manures *viz*., FYM, vermicompost, and poultry manure were applied equivalent to the recommended dose of nitrogen *i.e.,* 30 kg N ha^{-1} by considering their nutrient composition two weeks before sowing as per the treatments. Liquid organic manures, panchagavya @ 3 %, and vermiwash @ 5 % were prepared and sprayed as per the treatments at 30 and 45 days after sowing (DAS). Sole foxtail millet without tree component was cultivated as per the organic package of practices of UAS, Raichur. Economic analysis of foxtail millet cultivation with tree and without tree component and system analysis was calculated. For system economic analysis, tree wood volume was used for the calculation of gross return, net returns and benefit-cost ratio. The price of the crop products prevailing in the market after the harvest was obtained from the Agriculture Produce Market Committee (APMC) and was used for the calculation of gross returns. For the wood market price, Rs 125 per cubic foot was considered. The net returns per hectare were calculated by deducting the cost of cultivation from the gross returns. Benefit Cost ratio was obtained by dividing gross returns by cost of cultivation. The observations recorded in these studies were analyzed statistically for test of significance following Fisher's method of analysis of variance (ANOVA) as outlined by [3]. The level of significance on 'F' test was tested at 5 percent. The results have been discussed based on the critical difference at P = 0.05.

3. RESULTS AND DISCUSSION

3.1 Grain yield of foxtail millet

Grain yield of foxtail millet differed significantly due to various organic manurial treatments in *Melia dubia* based agroforestry system during both the years of study and in pooled data. In pooled data, sole foxtail millet cultivation with recommended organic nutrient practices without *Melia dubia* tree component recorded significantly higher grain yield (1656 kg ha^{-1}) when compared to all other organic manurial treatments with *Melia dubia* plantation systems (801 to 1487 kg ha^{-1}). In the agroforestry system with *Melia dubia* plantation, application of FYM + poultry manure **+** panchagavya alternated with vermiwash spray resulted in significantly higher grain yield (1487 kg ha^{-1}) and it was found on par with FYM + vermicompost + panchagavya alternated with vermiwash spray (1440 kg ha^{-1}), FYM + poultry manure + panchagavya (1412 kg ha^{-1}), FYM + vermicompost + panchagavya spray (1406 kg ha^{-1}) and FYM + poultry manure + vermiwash (1403 kg ha^{-1}) which in turn were on par with each other. The next best treatment was FYM + vermicompost + vermiwash spray (1389 kg ha^{-1}), which was significantly superior to rest of the treatments. All organic manurial treatments recorded significantly higher grain yield over the treatment that received no organic manure application (801 kg ha^{-1}). The treatments receiving FYM alone and with vermicompost and poultry manure (T_2, T_3 and T_4) showed their significant inferiority with respect to recording grain yield of foxtail millet over their applications along with liquid organic manures *viz*., panchagavya and vermiwash (T_5 to T_8). Similar results were recorded during 2018 and 2019 except FYM + vermicompost and FYM + poultry manure with foliar spray of panchagavya and vermiwash alone or in alternate sprays with tree component ($T_{5\ to}$ T_{10}) were on par with each other in 2019. The grain yield was higher in 2019 than 2018. This is a common phenomenon in organic agriculture fields during initial years of the conversion period. Some period would be required to

multiply the agriculturally beneficial microorganisms in sufficient numbers to act upon in the soil. The mean grain yield of foxtail millet cultivated along with organic nutrient management schedule without tree component was 360 kg ha^{-1} higher than in association with tree component, indicating 28 percent reduction with the agroforestry system. This might be due to better utilization of solar energy without any shading effect of trees in open conditions. Yield reduction in foxtail millet when intercropped with *Melia dubia* compared to sole crop without trees as an intercrop was due to reduced photosynthetic active radiation on crop canopy. These results were in conformity with the findings [4, 5, and 6 in finger millet and 7 in Blackgram, 8 in pearl millet when these crops were grown with *Melia dubia* species in agroforestry system].

3.2 Economic analysis

3.2.1Cultivation of foxtail millet

In pooled data, significantly higher net returns were realized in sole foxtail millet with nutrient management through organics without tree association (Rs.34,002 ha^{-1}) over tree association with *Melia dubia* under different organic nutrient management practices (Rs 13,978 to 28,631 ha^{-1}). In agroforestry system, application of FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher net returns (Rs. 28,631 ha^{-1}) when compared with all the treatments except FYM + poultry manure + vermiwash spray (Rs. 26402 $ha^{-1)}$ and FYM + vermicompost + panchagavya alternated with vermiwash spray (Rs. 26205 ha^{-1}). No organic manurial treatment recorded significantly lower net returns (Rs. 13,978 ha^{-1}) compared to all treatments except FYM (Rs. 16,337 ha^{-1}). Application of FYM or in combination with vermicompost or poultry manure showed significant inferiority over their corresponding treatments with liquid organic manures. The benefit-cost ratio followed similar trend as that of gross and net returns. A significantly higher benefit cost ratio was realized with sole foxtail millet grown organically with the recommended nutrient schedule without tree component (2.50) when compared with foxtail millet as an inter crop in *Melia dubia*-based agroforestry systems under different organic nutrient management practices (1.76 to 2.31). In the agroforestry system, FYM + poultry manure + panchagavya alternated with vermiwash spray recorded significantly higher benefit cost ratio (2.31) over all the treatments except FYM + poultry manure + vermiwash spray (2.24). Application of FYM alone (1.76) resulted in a significantly lower benefit-cost ratio when compared to all treatments. Reduced gross and net returns from foxtail millet cultivation in agroforestry system compared to sole crop without tree combination was mainly attributed to significant reduction in yield due to shade effect. This can be recuperated from the income obtained through *Melia dubia* trees. The results were in accordance with the findings [9 and 10].

3.2.2 System economic analysis

At the end of sixth year of the plantation (2019), in pooled data, net returns were significantly influenced by the cultivation of foxtail millet with and without tree component. Significantly higher system net returns were obtained in all organic manurial treatments with agroforestry system (From Rs. 2,40,937 to 3,21,056 ha^{-1} with an average of Rs. 289920 ha^{-1}) over the treatment foxtail millet cultivation with the recommended organic nutrient schedule in nonagroforestry system (Rs. 37,111 ha^{-1}).

In agroforestry system, significantly higher net returns of the system of Rs. 3,21,056 ha^{-1} were obtained with FYM+ poultry manure + panchagavya alternated with vermiwash spray except FYM + poultry manure + foliar spray of 3% panchagavya (Rs. 3,20,715 ha^{-1}) over all other treatments. The next best organic manurial treatment was FYM + vermicompost + vermiwash (Rs. 3,15,179 ha^{-1}). Treatments which received FYM + vermicompost and FYM + poultry manure showed significantly lower net returns from the system (Rs. 2,80,369 and Rs. 3,01,153 ha^{-1}, respectively) when compared to their corresponding treatment with foliar spray of panchagavya (Rs. 2,85,937 and Rs. 3,15,179 ha^{-1}, respectively), vermiwash (Rs. 3,20,715 and Rs. 2,70,214 ha^{-1}, respectively). No organic manurial treatment recorded significantly lower net returns from the system (Rs. 2, 40,937 ha^{-1}). In pooled data, significantly higher benefit-cost ratio from the whole system was realized with application of FYM + poultry manure + panchagavya alternated with vermiwash spray (4.81) followed by application of FYM + poultry manure + panchagavya (4.78) and FYM + vermicompost + vermiwash spray (4.73), which were significantly superior over all other treatments. No organic manurial treatment recorded a significantly lower benefit-cost ratio in the agroforestry system (4.16) compared to all the treatments except FYM alone (4.19) and FYM + vermicompost + vermiwash spray (4.23). Foxtail millet cultivated organically with a nutrient management schedule without tree components recorded a significantly lower benefit-cost ratio (2.63) over all other treatments.

Intercropping of foxtail millet with *Melia dubia* showed maximum gross and net monetary returns when compared to sole cropping without tree components. Improved monetary returns from the system (tree + crop) are mainly due to higher biomass production from the tree in the form of timber with better performance of foxtail millet under organic nutrient management practices. This clearly shows that arable crops like foxtail millet when grown as an intercrop with the trees exhibit compatibility with the trees in mutual sharing of the natural resources available. Agroforestry practices fetched higher returns when compared to sole crop. These results are following results obtained [11] in groundnut and sorghum with teak, [12] in sunflower with *Hardwickia* system, [13] in greengram with *Melia* species, [14] in soybean with *Madhuca latifolia*, [15] in green gram with bamboo species and [8] in pearl millet with *Melia dubia* based agroforestry systems. Among the organic manurial treatments with tree association, higher net returns from the system were noticed with FYM + poultry manure + panchagavya alternated with vermiwash, FYM+vermicompost + panchagavya alternated with vermiwash, FYM + poultry manure + panchagavya, FYM + poultry manure + vermiwash and FYM + vermicompost + panchagavya than FYM + vermicompost, FYM + poultry manure, FYM alone and no organic manurial practice, thus reflecting that the reduction in yield of foxtail millet can be minimized for obtaining higher net returns with *Melia dubia* based system when organic manures (FYM, vermicompost and poultry manure) and liquid fermented organics (Panchagavya and vermiwash) were combined and utilized in integrated manner.

4. CONCLUSION

For higher and sustainable system productivity and income in agroforestry practice consisting of foxtail millet with *Melia dubia* plantation, combined application of FYM (50 %) + poultry manure (50 %) equivalent to 100 % recommended 'N' along with a foliar spray of 3 per cent panchagavya at 30 and 45 DAS or

foliar spray of 3% panchagavya at 30 DAS alternated with 5 per cent vermiwash at 45 DAS could be advised under organic production system.

Conflict of interest: Author has declared that there was no conflict of interest

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Table 1. Economic analysis of foxtail millet cultivation and system analysis of Melia dubia based agroforestry under organic nutrient management practices

Treatments	Wood volume (t ha^{-1})	Grain yield (Kg ha^{-1})			Crop									
					Gross returns (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})			B : C ratio		
		2018	2019	Pooled	2018	2019	Pooled		2018	2019	Pooled	2018	2019	Pooled
T_1 : No organic manure (Control)	49.99	787	815	801	26316	29145	27730	13752	12564	15393	13978	1.91	2.12	2.02
T_2 : FYM equivalent to 100 % RDN	54.13	1072	1136	1104	35462	40116	37789	21452	14010	18664	16337	1.65	1.87	1.76
T_3 : FYM (50%) + Vermicompost (50%) equivalent to 100 % RDN	55.45	1183	1271	1227	38759	44712	41736	21357	17402	23355	20379	1.81	2.09	1.95
T_4 : FYM (50%) + Poultry manure (50%) equivalent to 100 % RDN	58.46	1228	1354	1291	40303	47360	43832	20562	19741	26798	23270	1.96	2.30	2.13
T_5 : T_3 + Foliar spray of Panchagavya @ 3 % at 30 and 45 DAS	55.67	1366	1447	1406	44518	50843	47680	23157	21361	27686	24523	1.92	2.20	2.06
T_6 : T_4 + Foliar spray of Panchagavya @ 3 % at 30 and 45 DAS	61.48	1369	1455	1412	44789	51317	48053	22362	22427	28955	25691	2.00	2.29	2.15
T_7 : T_3 + Foliar spray of Vermiwash @ 5 % at 30 and 45 DAS	60.44	1299	1479	1389	42664	51498	47081	22057	20607	29441	25024	1.93	2.33	2.13
T_8 : T_4 + Foliar spray of Vermiwash @ 5 % at 30 and 45 DAS	54.55	1342	1464	1403	44122	51206	47664	21262	22860	29944	26402	2.08	2.41	2.24
T_9 : T_3 + Foliar spray of Panchagavya @ 3 % at 30 DAS and Vermiwash @ 5 % at 45 DAS	57.04	1395	1486	1440	45642	51981	48812	22607	23035	29374	26205	2.02	2.30	2.16
T_{10} : T_4 + Foliar spray of Panchagavya @ 3 % at 30 DAS and Vermiwash @ 5 % at 45 DAS	61.04	1447	1528	1487	47219	53667	50443	21812	25407	31855	28631	2.16	2.46	2.31
T_{11} : Sole foxtail millet	-	1617	1695	1656	53596	59813	56704	22702	30894	37111	34002	2.36	2.63	2.50
S.Em ±	-	41	40	31	1235	1299	949	-	1235	1299	949	0.05	0.06	0.05
C. D. at 5%	-	121	118	90	3645	3833	2800	-	3645	3833	2800	0.17	0.18	0.14

Table 2. Economic analysis of foxtail millet cultivation and system analysis of Melia dubia based agroforestry under organic nutrient management practices

Treatments	Agroforestry system (Crop + *Melia dubia*) at the end of 6th year of plantation (2019)			
	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B : C ratio
T_1 : No organic manure (Control)	317189	76252	240937	4.16
T_2 : FYM equivalent to 100 % RDN	352032	83952	268080	4.19
T_3 : FYM (50%) + Vermicompost (50%) equivalent to 100 % RDN	364226	83857	280369	4.34
T_4 : FYM (50%) + Poultry manure (50%) equivalent to 100 % RDN	384215	83062	301153	4.63
T_5 : T_3 + Foliar spray of Panchagavya @ 3 % at 30 and 45 DAS	371593	85657	285937	4.34
T_6 : T_4 + Foliar spray of Panchagavya @ 3 % at 30 and 45 DAS	405577	84862	320715	4.78
T_7 : T_3 + Foliar spray of Vermiwash @ 5 % at 30 and 45 DAS	399735	84557	315179	4.73
T_8 : T_4 + Foliar spray of Vermiwash @ 5 % at 30 and 45 DAS	353976	83762	270214	4.23
T_9 : T_3 + Foliar spray of Panchagavya @ 3 % at 30 DAS and Vermiwash @ 5 % at 45 DAS	380662	85107	295555	4.47
T_{10} : T_4 + Foliar spray of Panchagavya @ 3 % at 30 DAS and Vermiwash @ 5 % at 45 DAS	405368	84312	321056	4.81
T_{11} : Sole foxtail millet without tree component	59813	22702	37111	2.63
S.Em ±	1299	-	1299	0.03
C. D. at 5%	3833	-	3833	0.09

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