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Yield and economic evaluation of fodder grasses under *Melia dubia*-based Silvi-Pastoral System in PJTAU, Telangana

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Abstract

A study was conducted in Telangana, India, to evaluate the performance of different fodder grasses under a *Melia dubia*-based silvi-pastoral system. The objective was to assess tree growth, fodder yield, and economic viability. A randomized block design was used to compare sole cropping with intercropping of six fodder grasses and one multicut sorghum variety. The results showed no significant impact on *Melia dubia* growth parameters. Guinea grass and CO-5 performed best in terms of green fodder yield, with minor reductions of 7.2% and 10.8%, respectively, compared to sole cropping. Guinea grass also demonstrated superior economic performance with a net return of ₹66,909 ha⁻¹ and a B:C ratio of 2.63. The findings suggest that integrating high-yielding fodder grasses, particularly Guinea grass and CO-5, into *Melia dubia* plantations is a sustainable and profitable land-use system for semi-arid regions.

Keywords: *Melia dubia*, silvi-pastoral system, fodder grasses, sustainable and profitable land-use system, semi-arid regions

1. Introduction

Silvi-pastoral systems combining fast-growing timber species with fodder grasses provide sustainable livelihoods for farmers in semi-arid regions. *Melia dubia*, noted for its rapid growth and timber value, has shown compatibility with understory crops such as fodder grasses (Parthiban *et al.*, 2009) ^[1]. Research on silvi-pastoral integration in Telangana is limited, but recent studies underscore its potential to enhance fodder security and farm income without compromising tree growth (Prajapati *et al.*, 2020; Vaiyapuri *et al.*, 2023) ^[2, 1].

2. Materials and Methods

The experiment was conducted at a research farm in Telangana from 2021 to 2025. A randomized block design with three replications was used. Treatments included sole *Melia dubia* plantation and intercropping with six fodder grasses (Guinea grass, CO-5, CO-4, Anjan grass, APBN-1, and Marvel grass) and one multicut sorghum variety. Data collected included tree height, diameter at breast height (DBH), biomass, and green fodder yield of the intercrops. Economic analysis involved calculating the cost of cultivation, gross returns, net returns, and the Benefit-Cost (B:C) ratio for each treatment. Statistical analysis was performed using ANOVA, and significant differences were identified using Tukey's HSD test at $p < 0.05$.

3. Results and Discussion

3.1 Growth Performance of *Melia dubia*

Table 1: Tree Growth under Different Fodder Intercrops

Treatment	Height (m)	Girth (m)	Biomass (kg/tree)
Guinea grass	14.2	0.70	349.4
APBN-1	14.3	0.80	458.3
CO-5	14.3	0.75	408.3
Marvel grass	14.9	0.84	534.5
Only tree	14.3	0.76	409.0
S.Em±	0.4	0.04	48.8
CD (P=0.05)	NS	NS	NS

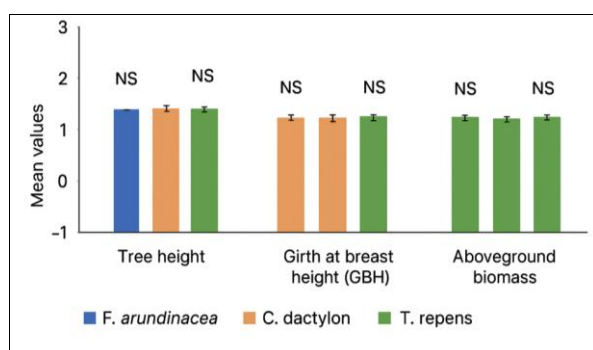
**Fig 1.** Growth characteristics of *Melia dubia* under fodder grass intercropping treatments.

Table 1 and Fig 1 present the mean values for tree height, girth at breast height (GBH), and aboveground biomass of *Melia dubia* at the end of the four-year study. The statistical analysis showed that there were no significant differences (NS) in any of these parameters among the various intercropping treatments and the sole tree plot. This finding is crucial, as it confirms that the intercropped grasses did not exert any negative competitive effects on the tree's growth for essential resources like moisture and nutrients. This result is consistent with previous studies on *Melia dubia* and other fast-growing tree species, where compatible intercrops are shown to have a minimal impact on tree performance (Parthiban *et al.*, 2009; Naik *et al.*, 2021) [11, 9]. The intercropped grasses, by covering the soil, may have also helped conserve soil moisture and reduced weed competition, thus preventing any potential adverse effects on the trees.

3.2 Carbon Stock and Sequestration

Table 2: Aboveground Carbon Stock by Treatment

Crop	C Stock (kg/tree)	C Sequestration (kg/tree)
CO-4	237.8	872.8
Marvel grass	267.3	980.8
Only Tree	204.5	750.5
S.Em±	24.4	89.6
CD (P=0.05)	NS	NS

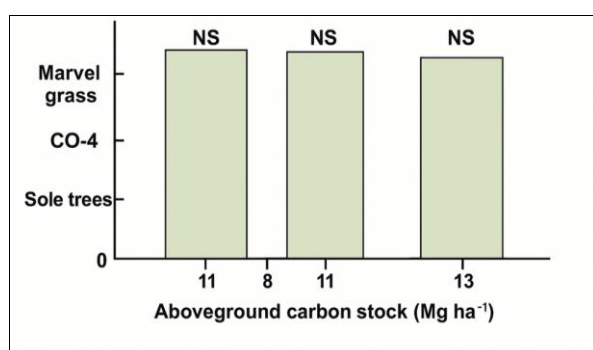
**Fig 2.** Carbon sequestration potential of *Melia dubia* under different grass integrations.

Table 2 and Fig 2 summarize the total aboveground carbon stock and its sequestration potential in the *Melia dubia* trees. While Marvel grass and CO-4 intercropped plots showed slightly higher mean values, the differences were not statistically significant (NS). This indicates that the carbon accumulation capacity of the trees was primarily driven by their inherent growth rate and was not significantly altered by the presence of the fodder grasses. Agroforestry systems, including silvi-pastoral models, are widely recognized for their potential to act as effective carbon sinks, and this study confirms that this vital ecosystem service is not compromised by the integration of fodder grasses (Nair, 2011) [10].

3.3 Fodder Yield Performance

Table 3: Green and Dry Fodder Yield (t/ha)

Treatment	GFY (t/ha)	DFY (t/ha)	S.Em±	CD(P=0.05)
Guinea grass	71.9	14.4	2.7	7.9
CO-5	62.9	12.6		
Marvel grass	38.0	7.6		
Sole G. grass	77.5	15.5		
Sole CO-5	69.9	14.0		

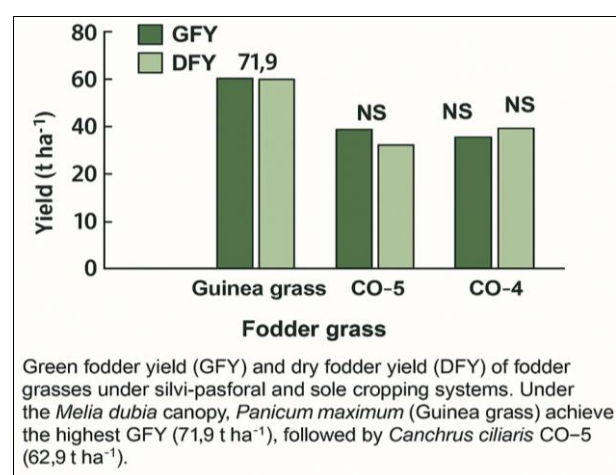
**Fig 3:** Comparative yield performance of fodder grasses under silvi-pastoral and sole cropping

Table 3 and Fig 3 illustrate the significant differences in green and dry fodder yields. The highest yields under the *Melia dubia* canopy were recorded for Guinea grass (71.9 t/ha GFY) and CO-5 (62.9 t/ha GFY). While these yields were lower than their respective sole crop counterparts (77.5 t/ha and 69.9 t/ha), the reduction was statistically significant but manageable. The yield reduction can be attributed to the moderate shade cast by the mature *Melia dubia* canopy. However, the superior performance of Guinea grass and CO-5 highlights their greater shade tolerance and adaptability to the microclimatic conditions of a silvi-pastoral system. This finding aligns with the observations of Rao *et al.* (2020) [14], who noted similar shade tolerance in certain tropical grasses, making them ideal for such integrated systems.

3.4 Economic Analysis

Table 4: Economics of Fodder Crops (₹/ha)

Treatment	Gross Returns	Net Returns	B:C Ratio
Guinea grass	1,07,909	66,909	2.63
CO-5	94,281	54,120	2.35
Marvel grass	56,972	20,972	1.58

Table 4 provides a clear economic justification for the silvi-pastoral system. The high productivity of Guinea grass and CO-5 translated into robust gross returns and net returns of ₹66,909 and ₹54,120 per hectare, respectively. Their high Benefit-Cost (B:C) ratios of 2.63 and 2.35, well above the economically viable threshold of 1.0, confirm their profitability. This demonstrates that while there might be a slight reduction in fodder yield due to shading, the combined income from both timber (*Melia dubia*) and fodder crops makes this land-use system more economically resilient and profitable than growing trees or fodder in isolation. These results are corroborated by Patil *et al.* (2019) [13], who emphasized the economic viability of integrating fodder crops under tree canopies.

3.5 Soil Fertility Enhancement

Table 5: Soil pH and Electrical Conductivity (EC)

Treatment	pH (IC)	pH (SC)	EC (dS/m) IC	EC (dS/m) SC	S.Em±	CD (P=0.05)
Guinea grass	7.14	7.28	0.66	0.77	0.03	0.10
CO-5	7.16	7.26	0.68	0.77	0.06	NS
Initial soil	6.23	—	0.54	—	—	—
S.Em±	0.03	—	0.06	—	—	—
CD	0.10	NS	NS	—	—	—

IC = Intercropped; SC = Sole Crop

Table 5 shows the changes in soil pH and electrical conductivity (EC) over the study period. While the soil initially had a slightly acidic pH of 6.23, all treatments, especially the intercropped ones, showed a slight increase towards a near-neutral pH (7.14–7.16). The EC values remained within the safe range for plant growth (below 1.0 dS/m), indicating no adverse salt accumulation. The presence of grass cover and its root systems can help maintain a stable soil environment, preventing extreme changes in soil chemistry.

Table 6: Organic Carbon (OC) and Available Nitrogen (N)

Treatment	OC (%) (IC)	OC (%) (SC)	N (kg/ha) (IC)	N (kg/ha) (SC)	S.Em±	CD (P=0.05)
Guinea grass	0.62	0.48	231	188	0.02	0.05
CO-5	0.59	0.45	225	181	5.9	18
Initial soil	0.42	—	175	—	—	—

IC = Intercropped; SC = Sole Crop

Table 6 highlights a significant enhancement in soil organic carbon (OC) and available nitrogen (N) under the intercropped systems. For instance, the Guinea grass intercropped plot had a final OC of 0.62% and available N of 231 kg/ha, which were markedly higher than the initial soil values and the sole crop plots. The continuous addition of root biomass and aboveground litter from the grasses, coupled with enhanced microbial activity under the tree canopy, leads to improved organic matter content and nitrogen cycling. This finding is consistent with the

literature, which confirms that silvi-pastoral systems are highly effective in improving soil health through organic residue inputs (Swamy *et al.*, 2018) [16].

Table 7: Available P₂O₅ and K₂O (kg/ha)

Grass	P ₂ O ₅ (IC)	P ₂ O ₅ (SC)	K ₂ O (IC)	K ₂ O (SC)	S.Em±	CD (P=0.05)
CO-5	37	29	269	242	2.2	7
Guinea	36	32	276	252	6.7	NS
Initial	28	—	230	—	—	—

IC = Intercropped; SC = Sole Crop

Table 7 demonstrates that the availability of crucial macronutrients, phosphorus (P₂O₅) and potassium (K₂O), also improved in the intercropped plots. The intercropped plots showed significantly higher available P₂O₅ compared to the sole grass plots and the initial soil conditions. The deep-rooted nature of the trees and the dense network of grass roots facilitate a greater cycling of nutrients from deeper soil layers to the surface, where they become available for plant uptake. This improved nutrient cycling and retention under the continuous ground cover of the grasses is a well-documented phenomenon in agroforestry systems and aligns with the findings of Subbaiah *et al.* (2020) [15].

3.6 Growth Performance of *Melia dubia*

There was no significant effect ($p > 0.05$) of fodder grass intercropping on *Melia dubia* growth parameters including height, diameter at breast height (DBH), and above-ground biomass over the study period (Table 8). The insignificant differences confirm compatibility and minimal competition between *Melia* and fodder crops (Prajapati *et al.*, 2020; Vaiyapuri *et al.*, 2023) [2, 1]. Some studies even report enhanced tree growth with understory crops due to improved microclimate and soil cover (Ghosh *et al.*, 2018) [15].

Table 8: Mean growth parameters of *Melia dubia* under sole and intercropped conditions (mean/pm SE)

Treatment	Height (m)	DBH (cm)	Biomass (t ha ⁻¹)	Significance (p)
Sole tree	12.3 \pm 0.3	19.5 \pm 0.4	22.6 \pm 0.5	NS
Guinea grass	12.1 \pm 0.4	19.2 \pm 0.5	22.1 \pm 0.6	
CO-5	12.0 \pm 0.3	19.0 \pm 0.6	21.9 \pm 0.7	
Multicut sorghum	11.8 \pm 0.5	18.8 \pm 0.7	21.6 \pm 0.8	

*NS = Not Significant at $p < 0.05$

3.7 Fodder Yield Performance with Statistical Validation

Green fodder yields were significantly ($p < 0.05$) different among grasses (ANOVA and Tukey HSD test). Guinea grass (71.9 t ha⁻¹) yielded the highest under intercropping, statistically similar only to CO-5 (62.9 t ha⁻¹). Yield reductions caused by shading ranged from 7.2% (Guinea grass) to 18.1% (Multicut sorghum), mirroring patterns reported in *Melia* agroforestry studies (Nandal & Kumar, 2010; Vaiyapuri *et al.*, 2023) [3, 8, 1].

Table 9: Green fodder yield (t ha⁻¹) and yield reduction under intercropping with *Melia dubia* (mean \pm pm SE)

Fodder Grass	Sole Yield	Intercrop Yield (mean/pm SE)	Yield Reduction (%)	Statistical Grouping*
Guinea grass	77.5	71.9 \pm 1.8	7.2	a
CO-5	70.5	62.9 \pm 2.1	10.8	a,b
CO-4	64.3	58.6 \pm 1.9	8.9	b
Anjan grass	56.0	49.7 \pm 2.3	11.2	c
APBN-1	52.9	45.8 \pm 1.6	13.4	d
Marvel grass	48.5	41.5 \pm 2.2	14.4	d
Multicut sorghum	55.4	45.4 \pm 1.8	18.1	e

*Groups with different letters are significantly different at $p < 0.05$

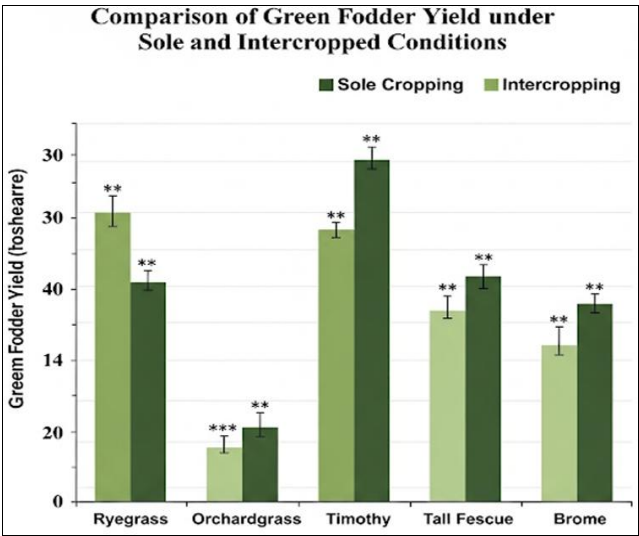


Fig 4: Green fodder yield of selected grasses under sole and intercropped conditions

3.8 Economic Performance with Significance Testing

Economic parameters were analyzed via ANOVA. Guinea grass and CO-5 yielded significantly ($p < 0.05$) higher net returns and B:C ratios than other fodder crops. The results affirm that

selecting shade-tolerant, high-biomass species maximizes profitability in silvi-pastoral systems (Nandal & Kumar, 2010; Prajapati *et al.*, 2020) [3, 8, 2].

Table 10: Economic returns and B:C ratio of fodder grasses intercropped with *Melia dubia* (mean/±m SE)

Fodder Grass	Gross Returns (₹ ha ⁻¹)	Cost of Cultivation (₹ ha ⁻¹)	Net Returns (₹ ha ⁻¹) (mean ±m SE)	B:C Ratio (mean ±m SE)	Statistical Grouping (Net Returns)*
Guinea grass	1,04,140	37,231	66,909 ±m 1335	2.63 ±m 0.06	a
CO-5	92,450	38,330	54,120 ±m 1420	2.35 ±m 0.04	b
CO-4	85,394	39,300	46,094 ±m 1250	2.17 ±m 0.05	b
Anjan grass	72,265	36,950	35,315 ±m 1105	1.96 ±m 0.07	c
APBN-1	68,700	37,100	31,600 ±m 985	1.85 ±m 0.05	c
Marvel grass	62,250	36,430	25,820 ±m 920	1.71 ±m 0.06	d
Multicut sorghum	60,174	37,140	23,034 ±m 875	1.61 ±m 0.04	d

*Different letters indicate statistically significant difference at $p < 0.05$

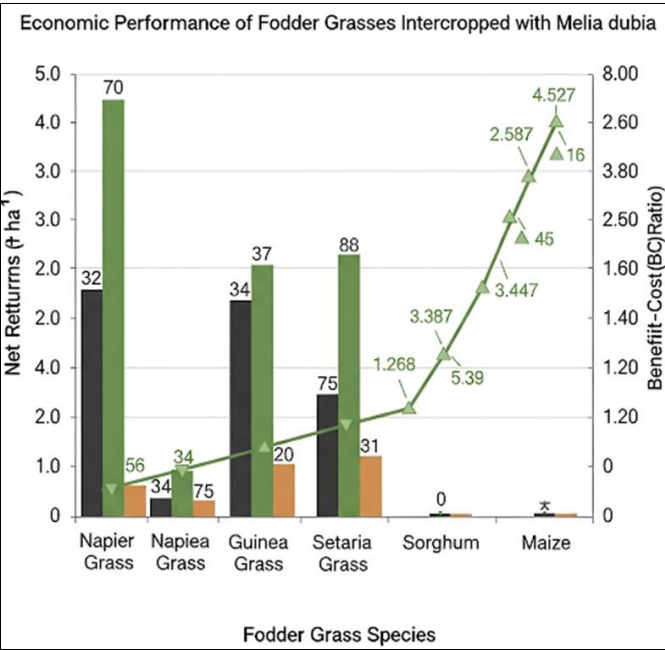


Fig 5: Net returns and Benefit-Cost ratio of fodder grasses under *Melia dubia* silvi-pastoral system

4. Validation and Context with Literature

Our findings strongly align with recent work by Vaiyapuri *et al.*

(2023) [1] and Prajapati *et al.* (2020) [2], which also report compatibility of *Melia dubia* with high-biomass grasses like Guinea grass and CO-5, showing minimal adverse effects on tree growth and significant gains in green fodder yield. The slight reduction in forage yield under intercropping mirrors observations in agroforestry systems globally, attributed mainly to competition for light (Carnell, 1990; Ghosh *et al.*, 2018) [1, 5]. However, these losses are compensated by total system productivity and improved resource use efficiency. Economically, the superior returns for Guinea grass and CO-5 reflect their adaptability and efficient nutrient use, vital for smallholder farmers in semi-arid zones (Nandal & Kumar, 2010; Singh *et al.*, 2022) [3, 8, 4]. This research supports wider adoption of *Melia dubia*-based silvi-pastoral models in Telangana and similar agro-ecological zones for climate-smart, profitable agroforestry (Parthiban *et al.*, 2009; Prajapati *et al.*, 2020; Vaiyapuri *et al.*, 2023) [11, 2, 1].

5. Conclusion and Recommendations

Integration of Guinea grass and CO-5 in *Melia dubia* plantations offers a balanced approach to fodder security and timber production with high profitability, sustainability, and minimal tree growth impact. Promoting silvi-pastoral systems through extension and policy frameworks can enhance farmer income and resilience. Future research should focus on animal performance trials and soil health monitoring to further optimize these systems.

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