Research Article
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PERFORMANCE OF *Pongamia pinnata – Costus igneus* SILVI-MEDICINAL AGROFORESTRY SYSTEM UNDER SEMI-ARID ALFISOLS

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ABSTRACT

A field experiment entitled **"Integrated nutrient management studies in Pongamia + Insulin (*Costus igneus*) silvi-medicinal system"** was conducted during *kharif*, 2018 at Students Farm, Professor Jayashankar Telangana State Agricultural University campus, Rajendranagar, Hyderabad, Telangana. The soil of the experimental site was sandy loam with a pH (7.34), EC (0.48 dS m^{-1}) and organic carbon (0.29%). Soil was low in available nitrogen (148.98 kg ha^{-1}) and medium in available phosphorus (59.14 kg ha^{-1}) and potassium (286.68 kg ha^{-1}). The experiment was laid out in Randomized block design with three replications and nine treatments *viz.,* T_1 Control (no fertilizer and manure), T_2 100% RDF (75:50:50 NPK), T_3 75% RD N + 25% N through neem cake, T_4 75% RD N + 25% N through Biochar, T_5 75% RD N + Pongamia green leaf manure @10 t ha^{-1}, T_6 50% RD N + 50% N through neem cake, T_7 50% RD N + 50% N through Biochar, T_8 50% RD N + Pongamia green leaf manure @10 t ha^{-1} and T_9 Sole insulin crop without trees. Results showed that Gross monetary returns (₹ 78024 ha^{-1}) and net monetary returns (₹ 47575 ha^{-1}) were higher with 50% RD N + 50% N through neem cake followed by 50% RD N + PGLM @10 t ha^{-1}. However, B:C ratio was highest in 50% RD N + PGLM @10 t ha^{-1} due to the low cost of cultivation incurred. From the present investigation, it can be concluded that, among nutrient management practices tested, 50% RD N + 50% N through neem cake (T_6) and 50% RD N + PGLM @10 t ha^{-1} (T_8) in silvi-medicinal system was better for realizing higher yields and economic returns apart from sustaining better available nutrient status in soil.

Keywords: Silvi-medicinal *Pongamia pinnata;* Neem cake; Biochar; Pongamia green leaf manure.

Silvi medicinal system is a new paradigm of integration of trees and medicinal plants which can provide an array of products ranging from food, fodder, fruit, fibre,pulp and medicinal plants etc. for consumption and trade on one hand and conserving the biodiversity and reducing the pressure on the natural resources on the other hand. Among different tree species, *Pongamia pinnata* (L.) commonly known as 'Karanja' or 'Indian beech' is an important leguminous tree that can be successfully grown in arid and semi-arid regions. It has been reported that Pongamia has a carbon sequestration potential of about 13 t C $ha^{-1.}$ *Costus igneus,* commonly known as 'insulin plant' or 'fiery costus' is such a medicinal plant which can sustain shade and can be intercropped with tree species. It is a perennial herb belonging to the family *Costaceae*, and is widely known for its anti- diabetic properties. The leaves are rich in fibres (Annie *et al*, 2007), Flavonoid and Sapogenin (Meena, 2014) which helps in lowering the blood glucose levels.

In order to increase the quality of crops especially, medicinal and aromatic plants (MAPs), organic fertilization is more acceptable than chemical fertilizers. However, complete replacement of inorganic fertilizers by the organic manures is not advisable owing to their low nutrient concentration. In this regard, an integrated application of both organic and inorganic fertilizers can be practiced not only for increasing the yield and quality of crops but also for sustaining the soil health on long term basis. Integrated nutrient management using locally available resources such as organic manures and green leaf manures reduce the production cost and improve the resilience of the farm system by improving soil fertility in rainfed areas (Ravi and Divya, 2009).

The present study was therefore designed to evaluate the economic viability of different INM regimes and identify superior treatments for practical recommendation under semi-arid alfisol conditions. The outcomes are expected to provide science-based guidelines for optimizing INM in silvi-medicinal systems and contribute to the broader evidence base for sustainable agroforestry in semi-arid India.

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MATERIAL AND METHODS

The present experiment was carried out at the Students Farm of Professor Jayashankar Telangana State Agricultural University Campus, Rajendranagar, Hyderabad situated at 17°19' N latitude, 78°28' E longitude and at an altitude of 555 m above mean sea level which is situated in the Southern Telangana Agro-climatic zone of Telangana state. Weather data were recorded from Standard Meteorological Weeks (SMW) 33 (13–19 August 2019) to 51 (17–23 December 2019) at the university meteorological observatory. Total seasonal rainfall during the study period was 157.4 mm distributed over 12 rainy days. Mean minimum and maximum temperatures were 16.8°C (range: 9.5–21.1°C) and 30.5°C (range: 24.6–33.3°C), respectively. Mean relative humidity was 88.8% at 07:00 h and 53.3% at 14:00 h. Mean sunshine duration was 6.1 h day-1, wind speed 4.1 km h-1, and mean evaporation 3.9 mm day-1.

The experimental plots were established on Typic Rhodustalf (semi-arid alfisol). Initial soil samples were collected from a depth of 0–30 cm before treatment imposition and analyzed using standard procedures: organic carbon (Walkley and Black 1934), available nitrogen (Subbaiah and Asija 1956), available phosphorus (Olsen *et al*. 1954), and available potassium (Jackson 1967). Baseline soil pH was 7.35, EC 0.56 dS m-1, organic carbon 0.34%, available N 177.7 kg ha^{-1}, available P2O5 73.8 kg ha^{-1}, and available K2O 298.7 kg ha^{-1} indicative of medium-fertility semi-arid alfisol.

Design and layout

The experiment was laid out in a randomized block design (RBD) with eight treatments replicated thrice and the layout plan is depicted in Fig 1 &2

Location	: Students Farm, PJTAU, Rajendranagar
Season	: *Kharif*, 2018
Design	: Randomized Block Design
Treatments	9
Replications	3
Main tree	: *Pongamia pinnata*
Age of tree	: 11 years
Tree spacing	: 6.0 m × 6.0m
Crop	: Insulin plant (*Costus igneus* L.)
Spacing	: 60 cm × 90 cm
Plot size	: 6 m x 6 m
Recommended Dose of Fertilizers	: 75:50:50 N:P2O5:K2O ha^{-1}

Nine INM treatments were imposed on *Costus igneus* (insulin plant) intercropped under *Pongamia pinnata* in a randomized complete block design (RBD) with three replications. The recommended dose of fertilizer (RDF) for Costus igneus was 75:50:50 kg N:P2O5:K2O ha^{-1}.Treatments were:

T1 – Control (no fertilizer)

T2 – 100% RDF (75:50:50 kg N:P2O5:K2O ha^{-1})

T3 – 75% RDN + 25% N through neem cake

T4 – 75% RDN + 25% N through biochar

T5 – 75% RDN + PGLM @ 10 t ha^{-1}

T6 – 50% RDN + 50% N through neem cake

T7 – 50% RDN + 50% N through biochar

T8 – 50% RDN + PGLM @ 10 t ha^{-1}

T9 – Sole crop of *Costus igneus* with 100% RDF (75:50:50 kg N:P2O5:K2O ha^{-1})

Cost of cultivation (Rs. ha^{-1}) was computed considering prevailing market prices for inputs. Gross return (Rs. ha^{-1}) was calculated based on fresh herbage yield multiplied by the prevailing market price of Costus igneus leaf. Net return = gross return " cost of cultivation. Benefit-cost ratio (BCR) = gross return / cost of cultivation. Monetary returns were calculated separately for Costus igneus, Pongamia pinnata (pod yield), and the combined *Pongamia pinnata* + Costus igneus system.

RESULTS AND DISCUSSION

The conjoint use of organic and inorganic sources of fertilizers increased the net returns and B:C ratio of insulin plant. The highest gross returns (₹ 78024 ha^{-1}) was recorded with 50% RD N + 50% N through neem cake followed by 50% RD N + PGLM @10 t ha^{-1} (₹ 52919 ha^{-1}), 50% RD N + 50% N

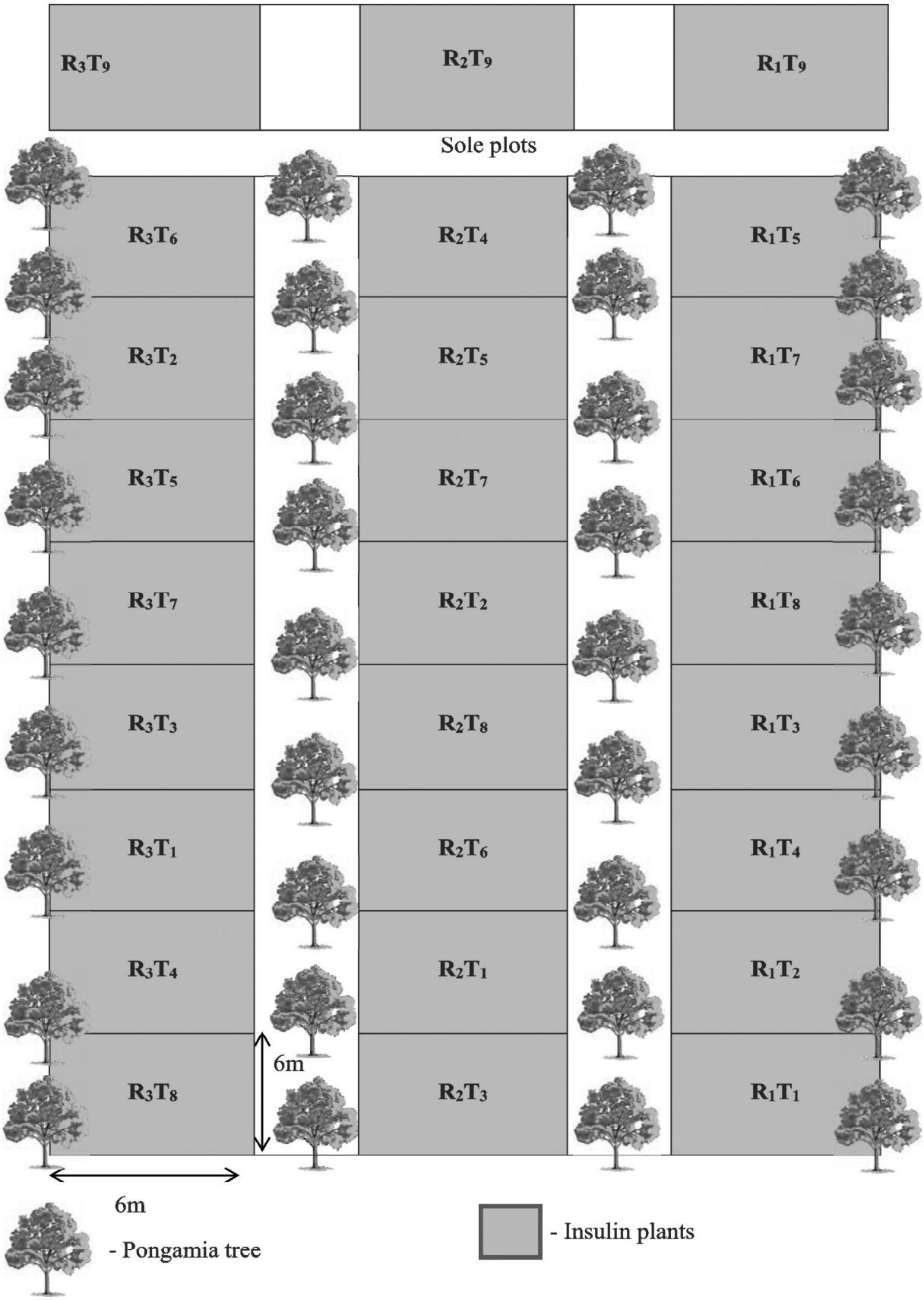

Fig 1: Layout plan of Experimental site

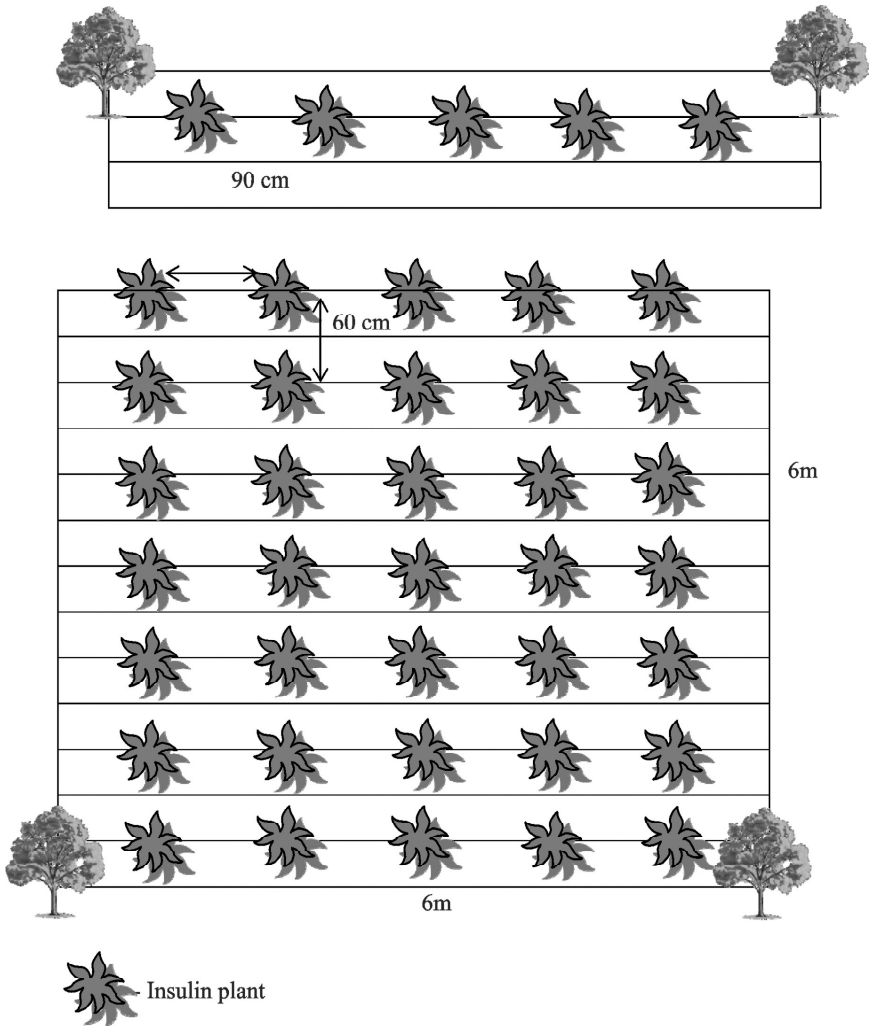

Fig2. Layout plan of individual plot of insulin plants in already existing Pongamia systems.

through Biochar (₹ 52238 ha^{-1}), 75% RD N + 25% N through neem cake (₹ 51728 ha^{-1}), 75% RD N + PGLM @10 t ha^{-1} (₹ 44328 ha^{-1}) and 75% RD N + 25% N through Biochar (₹ 42019 ha^{-1})

The highest net returns (₹ 47575 ha^{-1}) were recorded with 50% RD N + 50% N through neem cake followed by 50% RD N + PGLM @10 t ha^{-1} (₹ 34970 ha^{-1}). However the highest B:C (2.95) ratio was recorded in 50% RD N + PGLM @10 t ha^{-1} due to the less cost of cultivation in that treatment followed by 50% RD N + 50% N through neem cake (2.56). The sole plot registered the lowest gross returns (₹ 19347 ha^{-1}), net returns (₹ 310 ha^{-1}) and B:C ratio (1.02).

Higher level of biomass accumulation with adequate supply of nutrients might be responsible for the increased yield, which resulted in higher monetary returns and B:C ratio. Similar results were also reported by Kumar *et al.* (2013). These results were in agreement with the findings of Patil *et al*. (2014).

Gross returns from the tree at the age of eleven years ranged from ₹ 11357 ha^{-1} to

₹ 14127 ha^{-1} (Table 4.24). The highest net returns from agri-silvi system (tree + crop) was recorded with 50% RD N + 50% N through neem cake (₹ 58302 ha^{-1}) followed by 50% RD N + PGLM @10 t ha^{-1} (₹ 44866 ha^{-1}). Least net returns from the system were observed in control (₹ 13420 ha^{-1}).

CONCLUSION

This study establishes the agronomic and economic viability of Pongamia pinnata–Costus igneus silvi-medicinal system in the semi-arid Deccan Plateau region, with direct policy relevance for agroforestry promotion in dryland India.

Table 1. Economics of *Pongamia pinnata* + *Costus igneus* system as influenced by integrated nutrient management

Treatments	Cost of Cultivation (ha^{-1}) of crop	Tree			Tree + Crop			
		(₹ha^{-1})			(₹ha^{-1})			
		Cost of cultivation	Gross returns	Net returns	Cost of cultivation	Gross returns	Net returns	B:C ratio
T_1- Control	13400	5400	11357	5957	18800	30820	13420	1.59
T_2-100% RDF (75:50:50 NPK)	19037	5800	13850	8050	24837	48638	26201	1.96
T_3- 75% RD N + 25% N through neem cake	24431	5800	12465	6665	30231	64193	36362	2.12
T_4- 75% RD N + 25% N through Biochar	30081	5800	13573	7773	35881	57901	24420	1.61
T_5- 75% RD N + PGLM @10 t ha^{-1}	18181	5400	11911	6511	23581	53930	32749	2.29
T_6- 50% RD N + 50% N through neem cake	30449	5800	14127	8327	36249	92151	58302	2.54
T_7- 50% RD N + 50% N through Biochar	41749	5400	11634	6234	47149	63872	19123	1.35
T_8- 50% RD N + PGLM @10 t ha^{-1}	17949	5800	13296	7496	23749	66215	44866	2.79
T_9- Sole crop (RDF 75:50:50 NPK kg ha^{-1})	19037	-	-	-	19347	19037	310	1.02

Cost of Pongamia cultivation (₹ ha^{-1}): 5000 (FYM .₹ 2500 + Application cost . ₹ 1000 + Plant protection ₹1500) + Labour charges (₹ 400 day^{-1})

Table 2. Cost of cultivation (₹ ha^{-1}) of insulin as influenced by integrated nutrient management practices

S. No.	Particulars		Control	100% RDF	75% RDN			50% RDN			Sole crop without trees (100% RDF)
					25% N Neem cake	25% N Biochar	PGLM @ 10 t ha^{-1}	50% N Neem cake	50% N Biochar	PGLM @ 10 t ha^{-1}	
1.	Land preparation		2000	2000	2000	2000	2000	2000	2000	2000	2000
2.	Planting material		3000	3000	3000	3000	3000	3000	3000	3000	3000
3.	Neem cake		-	-	6250		-	12,500			-
4.	Biochar		-	-		11,900		-	23,800		-
5.	Application cost of manures		-	-	500	500	500	500	500	500	-
6.	Application cost of fertilizers		-	1125		-	-	-	-	-	1125
7.	Sowing		2400	2400	2400	2400	2400	2400	2400	2400	2400
8.	Weeding		4000	4000	4000	4000	4000	4000	4000	4000	4000
9.	Irrigation		1000	1000	1000	1000	1000	1000	1000	1000	1000
10.	Harvesting and drying (4 labours)		1000	1000	1000	1000	1000	1000	1000	1000	1000
11.	Fertilizers	Urea	-	926	695	695	695	463	463	463	926
		SSP	-	2625	2625	2625	2625	2625	2625	2625	2625
		MOP	-	961	961	961	961	961	961	961	961
	Total cost of cultivation		13400	19037	24431	30,081	18181	30449	41,749	17949	19037

Urea ₹ 5.4 /kg
SSP ₹ 8.4 per kg
MOP ₹18.2 /kg
Neem cake ₹ 10/kg
Biochar ₹ 14/kg
Labour wages ₹ 400/day
Cost of dried insulin herbage: ₹ 100/Kg
Cost of pongamia pod: ₹ 10/kg

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