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RESEARCH ARTICLE

AGROFORESTRY INTERVENTIONS FOR MITIGATING CLIMATE CHANGE IN SEMI-ARID REGIONS OF TELANGANA STATE, INDIA

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ABSTRACT

The field experiments were conducted in pearl millet *kharif,* 2010, *rabi*, 2010-11 and 2013-14 in young plantations of *Pongamia pinnata* and *Meila azedarach* at Agroforestry research block, Professor Jayashankar Telangana State Agricultural University, Hyderabad, T.S. All field experiments were laid out in randomized block design, replicated thrice with nine treatment combinations in Sweet Sorghum, pearl millet and finger millet. The experimental soil was red sandy loam in texture, neutral, non saline and medium in organic carbon, low to medium in available NPK. In pearl millet *kharif* 2010, the results showed that, integrated use of 80 kg N along with 10 t ha^{-1} pongamia green leaf manure (PGLM) was significantly influenced the grain (2345 kg ha^{-1}) and stover yield (3600 kg ha^{-1}) in Pongamia based agri-silvi system. The combined application of 80 kg N ha^{-1} + PGLM 10 t ha^{-1} significantly the NPK content in both grain (1.54, 0.51, 0.53%) and stover (0.40, 0.22, 2.7%). Pertaining to soil parameters significant and higher available N (171 kg ha^{-1}) and P (27.86 kg ha^{-1}) was found with 80 kg N + PGLM 10 t ha^{-1}, where as higher available K (292.0 kg ha^{-1}) was found with by fertilizer alone i.e. 80 N kg ha^{-1}. In *rabi* pearlmillet 2010-2011, the grain (2167 kg ha^{-1}) and stover yield was significantly affected by the conjunctive use of 75% RD N + 25% N through Poultry manure. Regarding soil parameters the highest content of OC (0.73%) and available N and P (219.8 and 24.53 kg ha^{-1}) was found with same nutrient management practice. In case of finger millet the highest grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) was recorded in sole crop without trees and on par with agroforestry system, where conjunctive use of inorganics and organics i.e. 75% RD N+ 25% N poultry manure (2405 and 4733 kg ha^{-1}) and 100% RDF (2393 and 4745 kg ha^{-1}). The same treatment resulted higher nutrient content (1.32, 0.265, 0.47 and 1.31, 0.264, 0.47%), OC (0.92 and 0.88%) and available NPK (317.0, 37.76, 366.0 and 291.8, 39.04, 355.3 kg ha^{-1}).

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INTRODUCTION

Due to global warming there was change in climate and impact is moderate to very serious in many countries in general and particular in African and Asian continents. The climate change can be mitigated by many ways. Among them Agroforestry is one of the best ways to mitigate the climate change. Off late agroforestry is an appropriate and efficient land use systems for dry lands, site improvement and also for optimization of productivity of agricultural crops as well as forest crops (Dagar and Singh, 2001). Low and erratic rainfall with recurrent droughts has been the deciding factor for the various cropping pattern. Nutrient management, recycling, soil quality improvement and land productivity as a holistic approach is good efficient indication will be achieved through cropping system studies rather than single season crop. There is a great risk of growing food grains in degraded and cultivable wastelands.

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The ever growing demands of the increasing population for food, fodder, fuel wood, fruit, fibers, timber, pulpwood, etc. requires emphasis on checking land degradation for which agroforestry practices are considered a most vital technology and a potential farming system for minimizing the land degradation (Sharma, 2014). In view of diversity of the problems in rainfed areas, an integrated approach of land management to utilize the natural resources more efficiently in dry lands is essential to meet the requirements of farming community and their deteriorating live stock, enhances land productivity and also to generate continuous and stable income. There is lot of scope to increase the productivity and sustainability in semi-arid areas of newly formed Telangana State by adopting different agroforestry models. Among the systems, the important are agri-silvi, agri-horti, silvi-pastoral, horti-pastoral, silvi-medicinal, block plantations, boundary plantations. Keeping in view of above facts an attempts were made through field experiments to find out the effect of organic manures, biofertilizers along with chemical fertilizer on yield, nutrient content and available nutrients of different

intercrops in agri-silvi systems. *Pongamia pinnata* a nitrogen fixing tree besides multipurpose is very much suitable for semi-arid region of Telangana state. Off late the plantations were raised in variety of soils for biodiesel purpose. *Melia azedarach* is a fast growing tree suitable in different type of soils considered as a multipurpose tree because of its multi directional and wide uses in agriculture and agroforestry. It has medicinal properties besides timber and fire wood value (Prasad *et al.,* 2011 and Dhyani *et al.,* 2013). Millet crops Sorghum, pearlmillet and fingermillet are multipurpose for grain and fodder were very important, suitable and economical rainfed crops with short duration in semi-arid areas of Telangana state (Agricultural Statistics, 2012).

MATERIALS AND METHODS

The field experiments on nutrient management was conducted in pearlmillet both in *kharif* 2010, *rabi* 2010-2011 and fingermillet in *kharif* 2013 in young plantations of Pongamia and Melia at Agroforestry research block, Professor Jayashankar Telangana State Agricultural University, Rajendranagar campus, Hyderabad, T.S. All three experiments were laid out in randomized block design, replicated thrice with nine treatment combinations in pearl millet and finger millet. The sources of organic manures were FYM, vermicompost, poultry manure, biofertilizers as Azospirillum, Azotobactor, PSB, VAM, green leaf manure and inorganic fertilizers as urea, single super phosphate, muriate of potash. The varieties of crops selected are PHB-3 (Pearl millet) and PRS-3 (Finger millet). The experimental soil was red sandy loam in texture, neutral, non-saline and medium in organic carbon, low to medium in available NPK. The soil parameters and plant nutrient contents were analysed by adopting standard procedures (AOAC, 1980).

RESULTS AND DISCUSSION

Agri-silvi culture system

Pearlmillet (*Kharif*, 2010): The perusal data in (Table 1) revealed that, the integrated use of 80 N kg ha^{-1} along with 10 t ha^{-1} of pongamia green manure leaf manure (PGLM) was significantly influenced the grain (2345 kg ha^{-1}) and stover yield (3600 kg ha^{-1}) of rainfed pearlmillet in pongamia based agri silvi culture system followed by 80 N kg ha^{-1} (2267.8 and 3883.3 kg ha^{-1}). Combined application of 80 N kg ha^{-1} + PGLM 10 t ha^{-1} significantly influenced the NPK content over control in both grain (1.54, 0.51, 0.53%) and stover (0.40, 0.22, 0.70%) and was on par with 60 N kg ha^{-1} + PGLM 10 t ha^{-1} and 80 N kg ha^{-1} alone (Sumantha Kundu, *et al.,* 2010; Rajesh, 2012 and Aariff Khan *et al.,* 2015). Regarding soil data (Table 2), significantly higher available N (171.0 kg ha^{-1}) and P (27.86 kg ha^{-1}) was found with the application of conjoint use of 80 N kg ha^{-1} + 10 t ha^{-1} pongamia green leaf manure, where as higher available K (292.0 kg ha^{-1}) was found by alone 80 N kg ha^{-1} (Panwar *et al.,* 1996 and Thakur *et al.,* 2010).

Pearlmillet (*Rabi*, 2010-2011): The grain and stover yield of pearlmillet (Table 3) was significantly influenced by nutrient management practices over control. Among them, conjoint use of 75 % RD N + 25 % N poultry manure recorded highest grain (2167 kg ha^{-1}) and stover (3033 kg ha^{-1}) yield followed by 75 % RD N + 25 % N vermicompost (2013 and 2866 kg ha^{1}). This might be due to more availability of nutrients and better soil conditions by combined application of organics and inorganics (Arbad *et al.,* 2008 and Aariff Khan *et al.,* 2012). Regarding soil parameters (Table 4) there was no significant effect by pH and EC by the treatments.

Table 1. Effect of pongamia green leaf manure and N levels on yield and nutrient content of rainfed pearl millet in Pongamia based agri silvi system (*Kharif*, 2010) Age of the trees 4 years

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Nutrient content (%)					
			Grain			Stover		
			N	P	K	N	P	K
T_1 Control (No fertilizer and manure)	891.7	1520.0	1.21	0.45	0.45	0.34	0.16	2.40
T_2 Pongamia Green Leaf Manure (PGLM) 10 t ha^{-1}	923.3	2200.0	1.25	0.47	0.46	0.36	0.17	2.47
T_3 80 N kg ha^{-1}	2267.8	3883.3	1.54	0.51	0.52	0.41	0.21	2.69
T_4 60 N kg ha^{-1}	1684.2	3066.7	1.53	0.51	0.53	0.39	0.20	2.68
T_5 40 N kg ha^{-1}	1297.7	2859.3	1.51	0.49	0.51	0.38	0.19	2.68
T_6 80 N kg ha^{-1} + PGLM 10 t ha^{-1}	2345.0	3916.7	1.54	0.51	0.53	0.40	0.22	2.70
T_7 60 N kg ha^{-1} + PGLM 10 t ha^{-1}	2187.5	3600.0	1.54	0.51	0.52	0.39	0.20	2.68
T_8 40 N kg ha^{-1} + PGLM 10 t ha^{-1}	1708.3	3350.0	1.53	0.50	0.51	0.37	0.19	2.67
T_9 Sole crop Pearl millet with out trees	1953.3	3533.3	1.53	0.51	0.51	0.40	0.21	2.69
CD (P= 0.05)	145.7	335.9	0.02	0.010	0.016	0.02	0.015	0.04

Table 2. Effect of pongamia green leaf manure and levels on soil properties and available nutrients of rainfed pearl millet in Pongamia based agri silvi system (*Kharif*, 2010)

Treatment	pH	EC (dSm^{-1})	OC (%)	Available Nutrient (kg ha^{-1})		
				N	P	K
T_1 Control	7.55	0.41	0.38	132.4	21.53	268.7
T_2 Pongamia green leaf manure 10 t ha^{-1}	7.42	0.39	0.45	137.3	22.80	273.5
T_3 80 N kg ha^{-1}	7.49	0.39	0.43	162.6	26.73	292.0
T_4 60 N kg ha^{-1}	7.54	0.41	0.43	157.5	25.50	281.3
T_5 40 N kg ha^{-1}	7.51	0.45	0.40	153.7	23.80	272.7
T_6 80 N kg ha^{-1} + PGLM 10 t ha^{-1}	7.31	0.44	0.52	171.0	27.80	281.7
T_7 60 N kg ha^{-1} + PGLM 10 t ha^{-1}	7.40	0.39	0.49	165.4	27.07	281.0
T_8 40 N kg ha^{-1} + PGLM 10 t ha^{-1}	7.34	0.40	0.45	154.4	26.77	275.0
T_9 Pearl millet as sole crop	7.36	0.38	0.42	165.0	22.50	277.0
CD (P= 0.05)	NS	NS	0.08	15.1	3.73	9.45
Initial soil	7.46	0.47	0.39	138.7	23.67	270.0

Table 3. Effect of nutrient management on yield of pearlmillet in Pongamia based agri silvi system (*Rabi,* 2010-2011) Age of the trees 5 years

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1 Control (No manure and no Fertilizer)	1330	2400
T_2 FYM 10 t ha^{-1}	1422	2683
T_3 100% RD N 80 kg ha^{-1}	1729	2883
T_4 75% RD N + 25% N Vermicompost.	1840	2833
T_5 75% RD N + 25% N FYM	2013	2866
T_6 75% RD N + 25% N Poultry manure	2167	3033
T_7 75% RD N + Azospirillum 5 kg ha^{-1}	1400	2583
T_8 75% RD N + VAM 5 kg ha^{-1}	1498	2617
T_9 75% RD N + Azospirillum + VAM each 5 kg ha^{-1}	1505	2650
CD (P=0.05)	212	269

Table 4. Effect of nutrient management on soil physico-chemical properties and available nutrients of pearl millet in Pongamia based agri silvi system (*Rabi*, 2010-2011)

Treatment	pH	EC (dSm^{-1})	OC (%)	N	P
				(kg ha^{-1})	
T_1 Control (No manure and no fertilizer)	7.06	0.34	0.43	165.8	12.58
T_2 FYM 10 t ha^{-1}	7.02	0.31	0.66	173.5	14.00
T_3 100% RD N 80 kg ha^{-1}	7.08	0.38	0.62	214.7	21.57
T_4 75% RD N + 25% N Vermicompost	7.00	0.30	0.70	217.0	22.95
T_5 75% RD N + 25% N FYM	7.04	0.32	0.65	211.5	18.08
T_6 75% RD N + 25% N Poultry manure	6.98	0.33	0.73	219.8	24.53
T_7 75% RD N + Azospirillum 5 kg ha^{-1}	7.01	0.35	0.53	171.0	15.07
T_8 75% RD N + VAM 5 kg ha^{-1}	7.04	0.31	0.55	169.7	19.84
T_9 75% RD N + Azospirillum + VAM each 5 kg ha^{-1}	7.05	0.33	0.57	179.5	18.70
CD (P=0.05)	NS	NS	0.08	6.9	2.75
Initial soil	7.05	0.32	0.40	163.0	11.77

Table 5. Effect of nutrient management on yield, NPK content and economics of finger millet in *Melia azaderach* based agri-silvi system (*Kharif,* 2013) Age of the trees 3 years

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Grain (%)			B:C ratio
			N	P	K	
T_1 FYM 10 t ha^{-1}	1583	3402	1.15	0.238	0.42	1.30
T_2 100% RDF (40-20-20 NPK kg $^{-1}$)	2393	4745	1.28	0.257	0.47	2.53
T_3 75%N + 25% N FYM	1828	3745	1.20	0.245	0.44	1.77
T_4 75% RD N + 25% N Vermicompost	2216	4377	1.27	0.255	0.46	2.03
T_5 75% RD N + 25% N Poultry manure	2405	4733	1.31	0.264	0.47	2.25
T_6 75% RD N + *Azospirillum*	1977	4014	1.24	0.248	0.45	2.17
T_7 75% RD N + PSB 5 kg ha^{-1}	1954	4006	1.22	0.247	0.45	2.14
T_8 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	2126	4241	1.26	0.253	0.46	2.26
T_9 Sole crop without trees	2681	5063	1.32	0.265	0.47	2.71
Mean	2129	4258	1.25	0.252	0.46	--
CD (P=0.05)	310	619	0.06	0.009	0.01	--

Table 6. Effect of nutrient management on OC and available nutrients of finger millet in *Melia azaderach* based agri-silvi system (*Kharif,* 2013)

Treatment	Organic carbon (%)	Available (kg ha^{-1})		
		N	P_2O_5	K_2O
T_1 FYM 10 t ha^{-1}	0.74	213.0	27.94	323.0
T_2 100% RDF	0.87	284.0	38.72	355.0
T_3 75%N + 25% N FYM	0.75	226.0	29.96	344.0
T_4 75% RD N + 25% N Vermicompost	0.86	263.0	35.15	352.0
T_5 75% RD N + 25% N Poultry manure	0.88	292.0	39.04	355.0
T_6 75% RD N + *Azospirillum*	0.83	247.0	32.35	345.0
T_7 75% RD N + PSB 5 kg ha^{-1}	0.80	235.0	32.28	342.0
T_8 75% RD N + *Azospirillum* + PSB kg ha^{-1}	0.83	259.0	34.53	349.0
T_9 Sole crop without trees	0.92	317.0	37.76	366.0
Mean	0.83	259.6	34.19	346.8
CD (P=0.05)	0.11	40.9	5.98	23.5

However, OC content was significantly influenced by the integrated use of 75% RD N along with 25% N poultry manure with highest content (0.73%), closely followed by 75 % RD N + 25 % N vermicompost (0.70%). Same trend was found with available N (219.8 kg ha^{-1}) and P (22. 95 kg ha^{-1}) (Ramana Reddy, 2002 and Jadho *et al.,* 2002).

Fingermillet (*Kharif*, 2013): The results revealed that maximum yield and NPK content of finger millet in agri-silvi system was observed with sole crop without trees which was on par 75% RD N+ 25% N poultry manure and 100% RDF in agroforestry system i.e. with trees, which was significantly superior over 75% RD N + 25% N vermicompost > 75% RD N + Azospirillum + PSB > 75% RD N+ Azospirillum 75% RD N

+ PSB > 75% N + 25% N FYM. Perusal of data (Table 5) on grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) resulted the highest with sole crop on par with 75% RD N + 25% N poultry manure (2405 and 4733 kg ha^{-1}) and 100% RDF (2393 and 4745 kg ha^{-1}). The lowest grain (1583 kg ha^{-1}) and straw yield (3402 kg ha^{-1}) was found with control FYM 10 t ha i.e. farmers practice. Similar results were reported by (Kumar *et al.,* 2013; Aariff Khan and Krishna, 2016). The NPK content in grain at harvest was found significant with integrated use of 75% RD N + 25% N poultry manure (1.31, 0.264, 0.47%) and 100% RDF (1.28, 0.257, 0.47%) on par with sole crop (1.32, 0.265, 0.43%). The B:C ratio was maximum (Rs.2.71) with sole crop without trees followed by 100% RDF (Rs.2.53), 75% RDN + Azospirillum + PSB (2.26), 75% RD N + 25% N poultry manure (Rs 2.25) and the lowest in FYM 10 t ha^{-1} being Rs 1.30 (Nandal and Ravikumar, 2010). In case of OC content (Table 6) slight built up (0.88%) was found with conjoint use of 75% RD N + 25% N poultry manure closely followed by 100% RDF (0.87%) and on par with sole crop (0.92%). Regarding available NPK were increased significantly in 75% RD N + 25% N poultry manure (292.0, 39.0, 355.0 kg ha^{-1}) and 100% RDF (284.0, 38.7, 355.0 kg ha^{-1}) on par with sole crop (317.0, 37.8, 366.0 kg ha^{-1}) compared to control (213.0, 27.9, 323.0 kg ha^{-1}) (Kumar *et al.,* 2013).

Conclusion

It is finally conclude that the agroforestry system such as agri silvi culture is also as good as sole agriculture and it is one of the best alternate land use system. Integrated use of 75% RD N + 25% N poultry manure is the best nutrient management among other practices adopted for sustaining optimum yields, organic carbon content and available nutrients in pearl millet and fingermillet in Pongamia and Melia based agroforestry systems in semi-arid regions of Telangana State. It is further revealed that other combined nutrient management practices i.e. inorganics + organics/biofertilizers are also comparatively better than absolute control or farmers practice or alone biofertilizers.

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