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Response of Minor Millet Crops by Nutrient Management Practices in Marginal lands of *Melia azedarach* Based Agri-silvi System

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Abstract: *The climate change can be mitigated to some extent by adopting millet crops as well as Agroforestry systems when compared to routine agriculture. The field experiments was conducted on finger millet and foxtail millet in Melia azedarach (two and three years age old) based agri-silvi system. The response of finger millet and foxtail millet to different nutrient management practices was studied in marginal soils. The field experiments were conducted in randomized block design with three replications nine treatments in finger millet and seven treatments in foxtail millet during kharif 2014 and 2015 respectively at Agroforestry research block, Professor Jayashankar Telangana State Agricultural University, Hyderabad, Telangana State. The treatments consists of alone and combinations of organic manures, biofertilizers, chemical fertilizers in agroforestry system and without tree system i.e. sole crop. The highest grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) of finger millet recorded in sole crop on par 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^{-1} i.e. farmers practice. 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%). In case of OC content slight built up (0.88%) was found with conjoint use of 75% RD N and 25% N though poultry manure closely followed by 100% RDF (0.87%) and on par sole crop (0.92%). Regarding available NPK were increased significantly in 75% RDN + 25% N though poultry manure (291.8, 39.0, 355.3kg ha^{-1} and 100% RDF (283.9, 38.7, 354.8 kg ha^{-1}) on par sole crop (317.0, 37.8, 366.0 kg ha^{-1}). The grain and straw yield (2100.0 and 3570.8 kg ha^{-1}) of foxtail millet was significantly influenced by the conjoint use of 75% RD N + 25% N poultry manure in agroforestry system was followed by sole crop without tree system (2080.7 and 3507.2 kg ha^{-1}) over control. The B:C ratio is highest (1.84) in 75% RD N + Azospirillum + PSB each 5 kg ha^{-1} followed by conjunctive use of 75% RD N + 25% N poultry manure (1.72). Regarding nutrient content in grain and straw the same treatment resulted the highest NPK in grain (1.30, 0.36, 0.49%) and straw (0.63, o133, 2.52%) followed by 100% RDF (1.28, 0.236, 0.46 and 0.60, 0.133, 2.36%). Similar trend was also continued in case of NPK uptake by grain and straw (25.14, 5.00 10.24 and 22.47, 4.24, 90.12 kg ha^{-1}). Pertaining to soil properties there is no significant effect on pH and EC but there is a significant effect and the highest OC (0.59%) and available NPK (149.7, 24.95, 219.0 kg ha^{-1}) by the integrated use of 75% RD N + 25% N poultry manure.*

Keywords: *Agri-silvi system, marginal lands, millet, nutrient management.*

INTRDUCTION

Agroforestry is one of the 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. It combines agriculture and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land use systems. There is a great risk of growing food grains in degraded and cultivable wastelands. The ever growing demands of the increasing population for food, fodder, fuel wood, fruit, fibers, timber, pulpwood, etc. requires

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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 (Dutta and Thakur, 2004).

Small millets are predominantly grown in marginal and sub marginal lands by poor farmers. Among small millets the finger millet (*Eleusine coracana L.*) and foxtail millet (*Setaria italica L.*) locally known as ragi and korra remains to be the staple diet of rural people and best suitable on marginal soils by poorest and marginalized communities. The crops can with stand harsh climate to the challenge of climate change. Finger millet and foxtail millet are versatile crops, with less input use, can be grown in any season of the year with the shortest crop cycle of 60 to 90 days. No other food crop can be grown in such a short period. The yield level and income of farmers could be substantially increased by the adoption of recommended technology such as nutrient management. Time has come to recognize millets as well as agroforestry as climate change compliant crops and system and there is need to promote their cultivation and consumption.

In order to achieve an intensive production of grain with good quality of millet in low fertile red sandy loam marginal soils, it is necessary to follow simultaneously all management practices through integrated nutrient management to sustain the productivity and to improve the soil fertility. Keeping in view of above facts an attempt was made through field experiment to find out the effect of organic manures, biofertilizers along with chemical fertilizer on yield, nutrient content, uptake and available nutrient status of finger millet and foxtail millet in *Melia azedarach* based agri silvi culture system.

Melia azedarach is a fast growing tree species gaining importance by agroforestry farmers in semi-arid conditions. It can be grown in variety of soils having moderate crop rotation with multipurpose use as wood, timber, fodder etc., The shape of tree canopy is moderate and conical and at initial years of growth the shade effect is less as such millets as inter crops can be grown successfully (Patil *et al*. 2012).

MATERIALS AND METHODS

The field experiments conducted with variety (PRS-2) in finger millet and Suryanandini finger millet in foxtail millet at different sites in agroforestry research block, Professor Jayashankar Telangana State Agricultural University, Rajendranagar campus, Hyderabad during *kharif* 2014 and 2015. The weekly mean maximum temperature during the crop growth period ranged from 27.8 to 33.5°C an average of 30.5°C, while the weekly mean minimum temperature ranged from 17.7°C to 25.0°C with an average of 21.6°C. The total rainfall received during the crop growth period was 437.5 and 570.0 mm distributed in 30 to 35 rainy days. The experimental soil at two sites was Alfisol with sandy loam texture with pH (6.97 - 7.57), EC (0.195 - 0.024 dSm^{-1}) and OC (0.38 - 0.75 %). The soil was medium in available N (138.8 - 259.2 kg ha^{-1}), P low to medium (18.80 - 40.85 kg ha^{-1}) and medium to high in available K (210.0 - 352.0 kg ha^{-1}).

The experiments laid out in Randomized Block Design, replicated thrice with 9 treatments in finger millet (T1 to T9) and seven treatments (T1 to T7) in foxtail millet. The treatments consists of alone and combinations of organic manures, biofertilizers, chemical fertilizers in agroforestry system and

Table 1
Yield and B:C ratio of finger millet as influenced by nutrient management in marginal lands of *Melia azedarach* agroforestry system

	Yield (kg ha^{-1})		
Treatment	*Grain*	*Straw*	*B:C Ratio*
T_1 FYM 10 t ha^{-1} with trees	1583	3402	1.30
T_2 100% RDF	2393	4745	2.53
T_3 75%N + 25% N FYM	1828	3745	1.77
T_4 75% RD N + 25% N Vermicompost	2216	4377	2.03
T_5 75% RD N + 25% N Poultry manure	2405	4733	2.25
T_6 75% RD N + *Azospirillum* 5 kg ha^{-1}	1977	4014	2.17
T_7 75% RD N + PSB *5* kg ha^{-1}	1954	4006	2.14
T_8 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	2126	4241	2.26
T_9 Sole crop without trees	2681	5063	2.71
Sem ±	102	205	–
CD (P = 0.05)	310	619	–

Table 2
Nutrient content and uptake of finger millet as influenced by nutrient management in marginal lands of *Melia azedarach* agroforestry system

	Nutrient content (%)						*Uptake (kg ha^{-1})*					
	Grain			*Straw*			*Grain*			*Straw*		
Treatment	*N*	*P*	*K*	*N*	*P*	*K*	*N*	*P*	*K*	*N*	*P*	*K*
T_1 FYM 10 t ha^{-1} with trees	1.15	0.238	0.42	0.66	0.130	2.05	18.17	3.77	6.71	27.55	4.69	74.10
T_2 100% RDF	1.28	0.257	0.47	0.76	0.150	2.62	30.57	6.14	11.25	35.25	6.98	121.87
T_3 75%N + 25% N FYM	1.20	0.245	0.44	0.69	0.141	2.35	21.96	4.48	8.04	25.71	5.27	88.12
T_4 75% RD N + 25% N Vermicompost	1.27	0.255	0.46	0.75	0.148	2.54	28.25	5.56	10.27	33.12	6.52	110.97
T_5 75% RD N + 25% N Poultry manure	1.31	0.264	0.47	0.77	0.151	2.64	31.58	6.35	11.31	32.82	7.10	125.33
T_6 75% RD N + *Azospirillum* 5 kg ha^{-1}	1.24	0.248	0.45	0.72	0.143	2.36	24.64	4.91	8.95	28.42	5.71	100.04
T_7 75% RD N + PSB *5* kg ha^{-1}	1.22	0.247	0.45	0.71	0.146	2.35	23.85	4.84	8.79	28.93	5.65	94.35
T_8 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	1.26	0.253	0.46	0.72	0.152	2.51	26.79	5.39	9.92	27.61	6.17	106.39
T_9 Sole crop without trees	1.32	0.265	0.47	0.82	0.145	2.68	35.47	7.10	12.68	41.47	7.71	135.83
Sem±	0.02	0.003	0.004	0.03	0.002	0.03	1.38	0.29	0.44	2.52	0.27	5.62
CD (P = 0.05)	0.06	0.009	0.010	0.09	0.007	0.09	4.17	0.89	1.34	7.63	0.80	16.99

without tree system *i.e.* sole crop. The initial and post harvest soil samples at 0-15 cm depth and organic manures were analyzed or different parameters by following standard methods (AOAC, 1980). Grain and straw samples after harvest were analyzed for total NPK as described by Piper (1966). The uptake of NPK by the crop was computed by standard formula *i.e.* by multiplying nutrient content fraction with dry matter yield (kg ha^{-1}).

RESULTS

Finger Millet (Kharif, 2014)

The results revealed that maximum yield, NPK content, OC and available NPK of finger millet in agri-silvi system was observed with sole crop without trees which was on par 100% RDF and 75% RD N +25% N through poultry manure 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 (Table 1). The highest grain (2681 kg ha^{-1}) and straw yield (5063 kg ha^{-1}) resulted 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 and straw yield (1583 and 3402 kg ha^{-1}) was found with control FYM 10 t ha^{-1} *i.e.* farmers practice. The reduced yields in agroforestry system compared to sole crop without tree system may be ascribed due to competition for sunlight, moisture and available nutrients with suppressing effect on crops, reduced solar radiation on crop canopy. Similar results were reported by Prasad *et al*. (2011) and Kumar *et. al*. (2013). The highest B:C ratio (2.71) was recorded with sole crop followed by 100% RDF (2.53), 75% RD N+ Azospirillum + PSB (2.26), 75% RD N + 25% N poultry manure (2.25) > 75% RD N + 25% N vermicompost > 75% RD N + Azospirillum > 75% RD N + PSB > 75% RD N + 25% N FYM. The control treatment registered the lowest B:C ratio 1.30 (Prabhu *et al*. 2002 and Pallavi *et al*. 2015) .

The NPK content and uptake in grain and straw (Table 2) at harvest found significant with integrated use of 75% RD N + 25% N poultry manure (1.31, 0.264, 0.47% and 0.82, 0.152, 2.68%) and (31.58, 6.35, 11.31 and 32.82, 7.10, 125.33 kg ha^{-1}) on par sole crop (1.32, 0.265, 0.43 and 0.82, 0.152, 2.68 %)

Table 3
Soil properties and available nutrients of finger millet as influenced by nutria management in *Melia azedarach* based agroforestry system

		Available nutrient (kg ha^{-1})		
Treatment	*OC (%)*	*N*	*P*	*K*
T_1 FYM 10 t ha^{-1} with trees	0.74	223.3	27.94	322.6
T_2 100% RDF	0.87	283.9	38.72	354.8
T_3 75%N + 25% N FYM	0.75	225.8	29.96	344.2
T_4 75% RD N + 25% N Vermicompost	0.86	263.4	35.15	352.0
T_5 75% RD N + 25% N Poultry manure	0.88	291.8	39.04	355.3
T_6 75% RD N + *Azospirillum* 5 kg ha^{-1}	0.83	247.4	32.35	344.7
T_7 75% RD N + PSB 5 kg ha^{-1}	0.80	234.8	32.28	342.0
T_8 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	0.83	259.2	34.53	349.0
T_9 Sole crop without trees	0.92	317.0	37.76	366.0
Sem±	0.04	13.5	1.58	7.7
CD (P = 0.05)	0.11	40.9	5.98	23.5

and 35.47, 7.10, 12.68 and 41.47, 7.71, 135.83 kg ha^{-1} respectively. The higher content and uptake of nutrients in both grain and straw by conjoint application of fertilizers of poultry manure may be attributed due to better crop growth and higher removal of nutrients . Similar findings were reported by Rajamani (2009) in sorghum and Aariff Khan *et al.* (2015) in pearl millet.

Regarding soil OC content (Table 3) slight built up (0.88%) found with conjoint use of 75% RD N and 25% N poultry manure closely followed by 100% RDF able (0.87%) and on par sole crop (0.92%). The available NPK increased significantly in 75% RD N + 25% N poultry manure (291.8, 39.0, 355.3 kg ha^{-1}) and 100% RDF (283.9, 38.7, 354.8 kg ha^{-1}) on par sole crop (317.0, 37.8, 366.0 kg ha^{-1}) compared to control (213.3, 27.9, 322.6 kg ha^{-1}). The findings are in agreement with Varalakshmi (2005) and Aariff Khan *et al*. (2012).

Foxtail millet (Kharif, 2015)

Perusal data (Table 4) revealed that the grain and straw yield significantly influenced by 75% RD N + 25% N poultry manure (2100.0 and 3570.8 kg ha^{-1})

Table 4
Yield and B:C ratio of foxtail millet as influenced by nutrient management in *Melia azedarach* based agri-silvi culture system. *Kharif* 2015 (Age of the trees 2 years old)

	Yield (kg ha^{-1})		
Treatment	*Grain*	*Straw*	*B:C Ratio*
T_1 FYM 10 t ha^{-1} with trees	1610.5	2254.7	1.13
T_2 100% RDF (40-20-20 NPK kg ha^{-1})	1995.0	3491.5	1.48
T_3 75%N + 25% N FYM	1860.8	2976.0	1.61
T_4 50% RD N + 25% N FYM	1775.0	2612.5	1.52
T_5 75% RD N + 25% N Poultry manure	2100.0	3570.8	1.72
T6 75% RD N + Azospirillum + PSB each 5 kg ha^{-1}	1795.0	2692.5	1.84
T_7 Sole crop without trees	2080.7	3507.2	2.71
Sem±	98.9	137.8	–
CD (P = 0.05)	304.6	424.5	–

closely followed by sole crop without tree system (2080.7 and 3507.2 kg ha^{-1}). This could be ascribed to over all improvement in plant growth and contribution of yield attributes, which in turn resulted in higher production and translocation of photosynthates and nutrients ultimately reflected into higher grain and straw yield (Sumantha Kundu *et al*. 2010 and Prabhakar Reddy, 2007). The highest B:C ratio (1.84) registered in 75% RD N + Azospirillum + PSB 5 kg ha^{-1}). Even though the yields are less the B:C ratio is maximum might be due to less cost inputs involved. The next better B:C ratio is 1.72 in 75% RD N + 25% N poultry manure.

The grain and straw nutrient content (Table 5) and uptake (Table 6) was significantly affected by integrated use of 75% RD N + 25% N poultry manure (1.30,0.236, 0.44 and 0.53, 0.127, 2.35%) very closely followed by sole crop without tree system (1.28, 0.234, 0.45 and 0.59, 0.130, 2.42%). The reasons attributed may be better crop growth and higher removal of nutrients due to positive effect and impact of poultry manure (Naphade *et al*. 1995 and Guled *et al*. 2003). Similar trend observed in the same treatment in both grain and straw uptake (25.14, 5.00, 10.24 and 22.47, 4.24, 90.12 kg ha^{-1}).

Regarding soil properties (Table 7) there is no significant effect on pH and EC by different treatments over control. However, there is significant effect by treatments and the highest OC

Table 5
Nutrient content of foxtail millet as influenced by nutrient management in *Melia azedarach* based agri-silvi culture system

	Nutrient content (%)					
	Grain			*Straw*		
Treatment	*N*	*P*	*K*	*N*	*P*	*K*
T_1 FYM 10 t ha^{-1} with trees	1.02	0.225	0.38	0.48	0.125	2.05
T_2 100% RDF (40-20-20 NPK kg ha^{-1})	1.28	0.236	0.46	0.60	0.133	2.36
T_3 75%N + 25% N FYM	1.25	0.232	0.40	0.60	0.130	2.40
T_4 50% RD N + 25% N FYM	1.10	0.228	0.42	0.55	0.129	2.20
T_5 75% RD N + 25% N Poultry manure	1.30	0.236	0.49	0.63	0.133	2.52
T_6 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	1.18	0.230	0.44	0.53	0.127	2.33
T_7 Sole crop without trees	1.28	0.234	0.45	0.59	0.130	2.42
Sem±	0.03	0.002	0.016	0.029	0.004	0.051
CD (P = 0.05)	0.09	0.007	0.049	0.090	NS	0.157

Table 6
Nutrient uptake of foxtail millet as influenced by nutrient management in *Melia azedarach* based agri-silvi culture system

Treatment	*Uptake (kg ha^{-1})*						*Total Plant uptake (kg ha^{-1})*		
	Grain			*Straw*					
	N	*P*	*K*	*N*	*P*	*K*	*N*	*P*	*K*
T_1 FYM 10 t ha^{-1} with trees	17.58	3.63	6.14	10.90	2.81	46.16	28.48	6.44	52.30
T_2 100% RDF	23.44	4.70	8.99	20.85	4.65	82.45	44.29	9.35	91.44
T_3 75% RD N + 25% N FYM	20.05	4.31	7.46	17.80	3.87	71.49	37.85	8.18	78.95
T_4 50% RD N + 25% N FYM	20.64	4.04	7.44	14.41	3.67	57.56	35.05	7.71	65.00
T_5 75% RD N + 25% N Poultry manure	25.14	5.00	10.24	22.47	4.24	90.12	47.61	9.24	100.36
T_6 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	19.94	4.13	7.93	14.23	3.41	63.40	34.17	7.54	71.33
T_7 Sole crop without trees	25.02	4.87	9.38	20.67	4.55	84.97	45.69	9.42	94.35
Sem±	1.21	0.211	0.53	0.95	0.25	6.41	–	–	–
CD (P = 0.05)	3.73	0.651	1.62	2.94	0.77	13.58	–	–	–

content found with 75% RD N + 25% N poultry manure (0.59%) followed by 100% RDF (0.55%). The increase in OC content may be attributed to addition of poultry manure rich in nutrients with less C:N ratio (Gopal Reddy and Suryanaranyan, 1998; Arbad *et al*. 2008). The available NPK significantly influenced by combined treatment 75% RD N + 25% N poultry manure (149.7, 24.95, 219.0 kg ha^{-1}). Followed by 100% RDF (146.7, 24.60, 216.5 kg ha^{-1}).

The reason for higher availability of nutrients might be due to integrated use of mineral fertilizer along with organic manure have the influence on reduction of C:N ratio and thus increased the rate of decomposition resulting in faster availability of nutrients (Aariff Khan *et al*. 2011).

Finally it is concluded that, in marginal lands the crop productivity and soil enrichment can be improved by adopting agroforestry systems. Selecting minor millets crops as finger millet and foxtail millet and Melia azedarach plantation in marginal soils is good choice foe present climate change conditions. To obtain higher yields, nutrient content, B:C ratio and better soil sustainability in terms of OC and available NPK. The integration of

Table 7
Soil properties and available nutrients of foxtail millet as influenced by nutrient management in *Melia azedarach* based agroforestry system

				Available Nutrient (kg ha^{-1})		
Treatment	*pH*	*EC (dSm^{-1})*	*OC (%)*	*N*	*P*	*K*
T_1 FYM 10 t ha^{-1} with trees	6.85	0.019	0.42	134.3	19.75	209.0
T_2 100% RDF	6.92	0.022	0.55	146.7	24.60	216.5
T_3 75% RD N + 25% N FYM	6.78	0.029	0.50	140.5	22.95	211.8
T_4 50% RD N + 25% N FYM	6.90	0.018	0.46	138.6	21.78	207.0
T_5 75% RD N + 25% N Poultry manure	7.03	0.028	0.59	149.7	24.95	219.0
T_6 75% RD N + *Azospirillum* + PSB each 5 kg ha^{-1}	6.88	0.032	0.49	138.8	23.00	212.5
T_7 Sole crop without trees	6.79	0.025	0.51	143.0	24.15	217.5
Sem±	0.07	0.004	0.029	1.67	0.86	1.70
CD (P = 0.05)	NS	NS	0.089	5.15	2.65	5.20

75% RD N + 25% N poultry manure is better over other combinations tried with trees and on par sole crop without tree system.

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