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RESEARCH ARTICLE

YIELD, NUTRIENT CONTENT, UPTAKE AND AVAILABLE NUTRIENT STATUS OF FINGER MILLET AS INFLUENCED BY NUTRIENT MANAGEMENT IN AGRI-SILVI CULTURE SYSTEM

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ABSTRACT

Finger millet was grown under three year old *Melia azedarach* in red sandy loam soil with different management options viz., application of FYM @ 10 t ha^{-1}, 100% RDF (40:20:20 NPK kg ha^{-1}) alone, and in conjunction with 75% RD N with 25% N through FYM, Vermicompost, Poultry manure; also with biofertilizers @ 5 kg ha^{-1}*Azospirillum* and PSB along with finger millet alone as sole cropping with 100% RDF. Maximum yield, NPK content, nutrient uptake, OC and available NPK of finger millet in agri-silvi system was observed with sole crop without trees on par 100% RDF and 75% RD N + 25% N through poultry manure which was significantly superior over 75% RD N + 25% N through vermicompost > 75% RD N + *Azospirillum* + PSB > 75% RD N + *Azospirillum* >75% RD N + PSB > 75%N + 25% N through FYM. 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 (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 through 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 through poultry manure closely followed by 100% RDF (0.87%) and on par sole crop (0.92%). Regarding available nitrogen, phosphorus and potassium were increased significantly in 75% RD N + 25% N through 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, 366.1 kg ha^{-1}) compared to control (213.3, 27.9, 322.6 kg ha^{-1}).

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INTRODUCTION

Agroforestry is an appropriate and efficient land use system in dry lands, for site improvement and also for optimization of productivity of agricultural crops as well as forest crops. Cultivation of finger millet (*Eleusine coracana* L.) as one of the multipurpose intercrops in the alleys of young plants of Melia is desirable to maximize the dry lands and space use efficiency to generate supplemental income during the initial juvenile phase of Melia silviculture system. In view of diversity of the problems in rainfed areas, an integrated approach of land management to utilize the natural resources more efficiently in dryland agriculture is essential to meet the requirements of farming community and their deteriorating livestock, both to enhance the land productivity and also to generate continuous and stable income.

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In order to achieve an intensive production of grain and good quality of finger millet in low fertile red sandy loam 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 the above facts an attempt was made through field experiment to find out the effect of organic manures, biofertilizers along with chemical fertilizer on nutrient content, uptake, soil properties, yield and available nutrient status of finger millet in agrisilviculture system.

MATERIALS AND METHODS

Field experiment was conducted with finger millet variety (PRS-2) at agroforestry research block, Acharya N.G Ranga Agricultural University campus, Rajendranagar, Hyderabad during *kharif*, 2013. The weekly mean maximum temperature during the crop growth period ranged from 27.8 to 33.5^{o}C with an average of 30.5^{o}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 437.1 mm distributed in 30 rainy days. The experimental soil was Alfisol with sandy loam texture with pH (7.57), EC (0.195 dSm^{-1}) and OC (0.75 %). The soil was medium in available nitrogen (259.2 kg ha^{-1}), phosphorus (40.85 kg ha^{-1}) and high in available potassium (352.1 kg ha^{-1}).

The experiment was laid out in a Randomized Block Design and replicated thrice with 9 treatments comprised of T_1 FYM 10 t ha^{-1}, T_2 100% RDF (40:20:20 - N: P_2O_5: K_2O kg ha^{-1}), T_3 75% RD N + 25% N through FYM, T_4 75% RD N + 25% N Vermicompost, T_5 75% RD N + 25% N Poultry manure, T_6 75% RD N + *Azospirillum* @ 5 kg ha^{-1}, T_7 75% RD N + PSB @ 5 kg ha^{-1}, T_8 75% RD N + *Azospirillum* + PSB @ 5 kg ha^{-1} and T_9 Sole crop without trees. The initial and post harvest soil samples at 0-15 cm depth and organic manures were analysed or different parameters by following standard methods (AOAC, 1980). Grain and straw samples after harvest were analysed for total NPK as described by Piper (1966). The uptake of N, P and K by the crop was computed by standard formula i.e., by multiplying nutrient content fraction with dry matter yield (kg ha^{-1}).

RESULTS AND DISCUSSION

Yield

Perusal of the data on grain and straw yield significantly affected by the judicious use of inorganic fertilizer with organic manures., Poultry manure, Vermicompost, FYM and biofertilizers i.e., Azospirillum and PSB (Table1). The highest grain yield (2681 kg ha^{-1}) was recorded with sole crop on par with 75% RD N (2405 kg ha^{-1}) + 25% N through poultry manure (2394 kg ha^{-1}) and 100% RDF significantly superior over 75% RD N + 25% N through vermicompost and 75% RD N + *Azospirillum* + PSB. The percentage increase in grain yield with sole crop, 75% RD N + 25% N poultry manure and 100% RDF over control was 65.39%, 48.37% and 47.69% respectively. Among the nutrient management practices followed, biofertilizers combination treatments also performed better than control where only FYM @ 10 t ha^{-1} was applied. Among them 75% RD N + *Azospirillum* + PSB (2126 kg ha^{-1}) was significantly superior to control (1621 kg ha^{-1}). In terms of percentage, the increase of 34.30, 24.89 and 23.44% with 75% RD N + *Azospirillum* + PSB, 75% RD N + *Azospirillum* and 75% RD N + PSB respectively.

Finger millet as sole crop (5063 kg ha^{-1}) resulted on par yields with 100% RDF (4745 kg ha^{-1}) and 75% RD N + 25% N throughpoultry manure (4733 kg ha^{-1}) significantly superior over 75% RD N + 25% N throughvermicompost (4377 kg ha^{-1}) and 75% RD N + *Azospirillum* + PSB (4241 kg ha^{-1}). The percentage increase in grain yield with sole crop, 75% RD N + 25% N throughpoultry manure and 100% RDF over control was 48.82%, 39.12% and 39.12% respectively. The conjunctive use of organic and inorganic sources has beneficial effect on physiological process of plant metabolism and growth, there by leading to higher grain yield. The easy availability of nitrogen due to mineralization of organics there by influence the shoot and root growth favouring absorption of other nutrients. Similar results were obtained by Yakadri and Reddy (2009), Umesh *et al.* (2006), Basavaraju and Purushotham (2009). Reduced yield in finger millet compared to sole crop may be ascribed due to competition for light, moisture and nutrients with suppressing effect on crops, reduced solar radiation on crop canopy. Similar results were reported by Deswal and Nandal (2008), Prasad *et al*. (2011) and Kumar *et al*. (2013).

Nutrient content and uptake

Perusal data on macronutrient content and uptake in grain and straw was significantly affected by different nutrient combinations (Table 2). Significant increase in nitrogen content (1.32%) in grain of sole crop was observed over control (1.15%). Among different integrated nutrient sources, the highest nutrient content with integration of 75% RD N + 25% N through poultry manure (1.31%) was found to be the best nutrient management practice which resulted in significantly higher NPK content in grain and straw (1.31, 0.264, 0.47 and 0.77, 0.151, 2.64%) and uptake (31.58, 6.35, 11.31 and 32.82, 7.10, 125.33kg ha^{-1}) respectively in comparision with 100% RDF among the agri-silvi system and sole crop. The higher content and uptake of nutrients by finger millet in both grain and straw by conjoint application of fertilizer and poultry manure together and fertilizer alone may be attributed due to better crop growth and higher removal of nutrients may be due to positive effect and impact of Poultry manure. Similar findings were reported by Khan (2012) and Rajamani (2009).

Among three manurial combinations the superiority of poultry manure over vermicompost and FYM is well established in increasing the nutrient concentration, and uptake may be due to its higher nutrient content and easy mineralization with low C:N ratio. With regard to biofertilizer combinations tested, inoculation of mixed biofertilizers *i.e.* Azospirillum + PSB each @ 5 kg ha^{-1}along with 75% RD N was significantly better than non-inoculation and individual application of FYM 10 t ha^{-1} both in nutrient content and uptake. This significant improvement in content and removal of nutrients as a consequence of 25% reduction of inorganic fertilizer with biofertilizers was important in increasing the nutrient availability pattern of soil which might have reflected on biological yield and resulted ultimately in nutrient content and uptake of nutrients. Similar findings were reported by Gawai and Panwar (2007) and Arbad *et al*. (2008).

Soil properties

pH and EC of surface soil at harvest of finger millet crop did not differ significantly over initial values (Table1). As the duration of the crop is less, the basic properties like pH and EC will not change by application of low quantities of manures and fertilizers. These results are in line with the findings of Reddy *et al.* (2007) and Arbad *et al.* (2008). Whereas soil organic carbon was significantly influenced by the type of manure and biofertilizer applied. Among different sources in agri-silvi culture system, the organic carbon content was superior to other two combinations and biofertilizer treatments. The increase in OC content may be attributed to addition of organic materials and biofertilizers might have enhanced the

OC content in the soil. Similar results were reported by Rajamani (2009). Lowest OC content was recorded in control (0.74%), where only FYM @ 10 t ha^{-1} was applied before sowing and continued upto harvest stage. Hence, the root growth, spread and decomposition was low which led to less addition of organic matter to soil.

Available nutrients status

The available nitrogen status was significantly altered by different manurial and biofertilizer combinations with conjoint use of 75% RD N and followed the order as 25% N through poultry manure> 25% through vermicompost > 25% through FYM (Table1). Highest buildup of available N found in poultry manure (291.8 kg ha^{-1}) followed by Vermicompost (263.4 kg ha^{-1}), among the integration which might be due to higher amount of N and OC content present in poultry manure and vermicompost might have hastened the process the process of mineralization during crop growth period. Another reason for higher availability of N may be attributed due to the addition of mineral fertilizer N along with organic sources which have contributed to reduction of C:N ratio and thus increased the rate of decomposition resulting in faster availability of nutrients from manures.

levels. Inoculation of Azospirillum increased the microbial activity in the rhizosphere, while other microbes like fungi and actinomycetes also might have simulated by inoculation, resulting in more amount of N fixation from atmosphere (Prabhu *et al.,* 2002).

Available phosphorus status was significantly affected by different treatments over control (Table 1). Among them 75% RD N + 25% N through poultry manure was the best practice (39.04 kg ha^{-1}) followed by 75% RD N + 25% Nthrough vermicompost (35.15 kg ha^{-1}) and 75% RD N + 25% N through FYM (29.96kg ha^{-1}). The higher available phosphorus might be due to the release of organic acids during microbial decomposition of organic matter which helped in the solubility of native phosphates thus increasing available phosphorus. The applied organic matter may have led to formation of coating on the sesquioxide clay minerals, because of which the phosphate fixing capacity of soil is reduced in manure treated plots compared to inorganic fertilizer alone. Similar results were observed by Varalakshmi (2005). Among the biofertilizer treatments results further revealed that inoculation of PSB and Azospirillum along with 75% RD N significantly increased the available P_2O_5 (34.53kg ha^{-1}) was relatively better than individual FYM 10 t ha^{-1} (27.94kg ha^{-1}).

Table 1. Yield, soil properties and available nutrient status of finger millet as influenced by nutrient management in agri-silvi system

Treatments	Yield (kg ha^{-1})		Soil properties			Available (kg ha^{-1})		
	Grain	Straw	pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O
T_1 FYM @ 10 t ha^{-1}	1583	3402	7.12	0.132	0.74	213.3	27.94	322.6
T_2 100% RDF	2393	4745	7.41	0.172	0.87	283.9	38.72	354.8
T_3 75%N + 25% N FYM	1828	3745	7.28	0.131	0.75	225.8	29.96	344.2
T_4 75% RD N + 25% N Vermicompost	2216	4377	7.31	0.172	0.86	263.4	35.15	352.1
T_5 75% RD N + 25% N Poultry manure	2405	4733	7.37	0.191	0.88	291.8	39.04	355.3
T_6 75% RD N + *Azospirillum*	1977	4014	7.28	0.158	0.83	247.4	32.35	344.7
T_7 75% RD N + PSB	1954	4006	7.35	0.157	0.80	234.8	32.28	342.1
T_8 75% RD N + *Azospirillum* + PSB	2126	4241	7.33	0.167	0.83	259.2	34.53	349.1
T_9 Sole crop without trees	2681	5063	6.92	0.122	0.92	317.0	37.76	366.1
Mean	2129	4258	7.26	0.156	0.83	259.6	34.19	346.8
S.Em.±	102	205	0.10	0.001	0.04	13.5	1.98	7.7
CD (P=0.05)	310	619	NS	NS	0.11	40.9	5.98	23.5

Table 2. Nutrient content and uptake of finger millet as influenced by nutrient management in *Melia azedarach* based agri-silvi system

Treatments	Nutrient content (%)						Uptake (kg ha^{-1})					
	Grain			Straw			Grain			Straw		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1 FYM @ 10 t ha^{-1}	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	30.56	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*	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	1.22	0.247	0.45	0.71	0.142	2.35	23.85	4.84	8.79	28.93	5.65	94.35
T_8 75% RD N + *Azospirillum* + PSB	1.26	0.253	0.46	0.72	0.146	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	0.152	2.68	35.47	7.10	12.68	41.47	7.71	135.83
Mean	1.25	0.252	0.46	0.73	0.145	2.46	26.81	5.39	9.77	31.21	6.20	106.33
S.Em.±	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	0.01	0.09	0.007	0.09	4.17	0.89	1.34	7.63	0.80	16.99

The significant inferiority of FYM 10t ha^{-1} alone application is due to low content of NPK (0.49, 0.26, 0.32%) in FYM. Combined application of biofertilizers either Azospirillum or PSB or both increased the availability of N due to enhanced microbial activity and consequent increases in mineral N

Inoculation of PSB and Azospirillum with inorganic fertilizer showed better synergistic effect by resulting root exudates and organic acids to solubilize the native insoluble Ca phosphate, thus made available to plants. Rhizosphere colonization of PSB may have enhanced the uptake of nutrients from lower layers and mobilizes into the plant system (Khan and Begum, 2007). It is well known fact that cereal crops in general sorghum and maize in particular had great affinity with PSB as these crops have good fibrous root system and it responds better when soil has low initial available P status. In addition, application of PSB also may have favoured the microbial activity of bacteria and actinomycetes which in turn acted as phosphate solubilizers (Khan *et al.,* 2011).

Available potassium differed significantly by different treatment combinations over control (Table1). Out of which 75% RD N + 25% N through poultry manure (355.34 kg ha^{-1}) was significantly superior on comparision with other manurial combinations i.e., 75% RD N + 25% N throughvermicompost (352.1 kg ha^{-1}) and 75% RD N + 25% N throughFYM (344.2kg ha^{-1}). The beneficial effect of organics (poultry manure, vermicompost, FYM)on available potassium may be ascribed to the reduction of K fixation and release of potassium due to the interaction of organic matter with clay minerals besides the direct potassium addition to the potassium pool of the soil. Similar beneficial effect of organics on available K was reported in case of poultry manure by Talanur and Badanur (2003).

Conclusion

From the study, it was inferred that integrated use of 75% RD N + 25% N through poultry manure and 100% RDF is the best nutrient management practice that can be adopted for agri-silvi system on par with sole crop, which was significantly superior over 75% RD N + 25% N through FYM, 75% RD N + 25% N through Vermicompost, 75% RD N + *Azospirillum* @ 5 kg ha^{-1},75% RD N + PSB, 75% RD N + *Azospirillum* + PSB and control in red sandy loam soils to obtain higher nutrient content, uptake and available nutrient status of NPK.

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