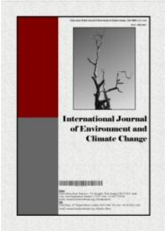

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Nutrient Content, Uptake and Yield of Finger Millet (*Eleusine coracana* l.) Influenced by Phosphorus Management Practices

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out at Agricultural Research Station, Perumalapalle, Tirupati, Acharya N. G. Ranga Agricultural University during *kharif* season of 2018 on sandy loam soil to study the response phosphorus fertilizer, PSB and VAM on yield and nutrient content and uptake of fingermillet. The experiment used a Randomized Block design with nine treatments and was reproduced three times. Among the phosphorus management practices, application of RDF + PSB @ 750 ml ha-1 + VAM@ 12.5 kg ha-1 (T_9) showed its best results with respect to nutrient content and uptake at flowering and harvesting stage as compared to other treatments.

Keywords: Phosphorus fertilizer; PSB; VAM; nutrient content; uptake; yield and finger millet.

1. INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn) is a popular tiny millet crop in India, boasting the highest production among millets. It's also known as ragi, frican millet, or bird's foot millet, and it's a primary food crop in parts of eastern and central Africa, as well as India. It is, in fact, the principal cereal crop of the monsoon season in some hilly locations, where it is grown for both grain and fodder [1,2]. It is grown in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand,

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Uttaranchal, Maharashtra, and Gujarat in India. The annual farmed area for millets is around 29 million hectares, with little millets accounting for approximately 3.5 million hectares. Among small millets, finger millet alone accounts for 50% of total area and contributes more than two-thirds of total production (2.8 million tonnes). This crop's wide adaptability, ease of cultivation, lack of major pests and diseases, and drought tolerance have made it an essential component of the dry farming system. In many areas where the finger millet crop is grown, no other crop worth noting can provide a fair harvest.

"Most of the phosphorus sources are gets fixed in the soil become unavailable to plants. So, availability and absorption of phosphorus are induced by the utilization of phosphorus solubilizing microbes. Biofertilizer is a natural input that can be applied as a complement to, or as a substituent of chemical fertilizer in sustainable agriculture" [3]. "Integrated use of bio-fertilizers offers a cheaper low capital intensive and eco-friendly route to boosting farm productivity" [3]. Moreover, Mycorrhiz fungi which constitute a group of important soil micro-organisms are ubiquitous throughout the world are known to improve the plant growth through better uptake of nutrients [4,5]. Keeping this in view, an investigation was planned to study comprehensively the role of phosphatic fertilizer and biofertilizers (PSB + VAM) in improving soil properties and to critically examine the efficiency of applied phosphatic fertilizer and biofertilizers on nutrient content and uptake of fingermillet.

2. MATERIALS AND METHODS

The experiment was conducted during *kharif*, 2018 at Agricultural Research Station, Perumallapalli, Tirupati, Acharya N.G.Ranga Agricultural University (13° 36'761''N latitude and 79° 20' 704''E longitude with an altitude of 182.9 m above the mean sea level), Andhra Pradesh, India. During the crop growth period the weekly maximum temperatures ranged from 32.0 to 37.2°C with an average of 34.6°C, while the weekly minimum temperatures ranged from 22.2 to 27.1°C with an average of 24.6°C. The relative humidity ranged from 50.0 to 73.6 per cent. The total sunshine hours were 66 hours with an average of 3.9 h day^{-1}. The total rainfall received during the crop growth period was 272.7 mm in rainy days during 2018. The soil of the experimental field was sandy loam in texture The experiment was laid out in a Randomized Block Design and replicated thrice with 9 treatments. The treatment details are furnished below

T_1 : No Phosphorus, T_2 : 100% Recommended dose of phosphorus (RDP), T_3 : 125% RDP, T_4 : 100% RDP + Phosphorus Solubilizing Bacteria (PSB), T_5 : 100% RDP + Vesicular Arbuscular Mycorrhizae (VAM), T_6 : 100% RDP + PSB + VAM, T_7 : 75% RDP + PSB, T_8 : 75% RDP + VAM, T_9 : 75% RDP + PSB + VAM.

2.1 Soil Characteristic of the Experimental Area

The experimental soil was sandy loam in texture. The soil samples were collected randomly from 0 to 15cm depth. The soil samples were shade dried, pounded and sieved through 2 mm sieve and analysed for its physico-chemical properties and available nutrients by using standard procedures. Soil was pH of 7.6, low in organic carbon (0.23%), available N (120 kg ha-1) and medium in available phosphorus (43 kg ha-1) andavailable potassium (218 kg ha-1).

2.2 Cultivation Details

2.2.1 Nursery

Carbendazim @ 2 g kg^{-1} treated seeds of finger millet were broadcasted on a well prepared fine nursery seed bed of 5 m × 1.5 m size and 15 cm height. The seed rate used was 4 kg ha^{-1}. After sowing, the seeds on nursery bed were covered with fine powdered FYM and paddy straw upto germination of finger millet seedlings was visible (*i.e.* 3 DAS). Irrigation to the nursery bed was done with rose cans. Monocrotophos @ 1.6 ml l^{-1} of water was sprayed as a prophylactic measure on 15 days old seedlings to check the incidence of insect pests.

2.3 Main Field Preparation

The field was ploughed and harrowed twice using a tractor-drawn cultivator before being levelled with a plank. The field was then divided into plots, and each plot was carefully microleveled before transplanting.

2.4 Transplanting

Water was let into the plots and 25 days old seedlings were transplanted with an inter and intra row spacing of 22.5 cm x 10 cm with one seedling hill^{-1}.

2.5 Statistical Analysis

The data collected on various growth characters, yield parameters and yield were subjected to statistical scrutiny by following the analysis of variance for randomized block design as outlined by Panse and Sukhatme (1985). Statistical significance was tested with 'F' test at 5 percent and 1 per cent level of probability. Further multiple comparision tests have been done using Duncan's multiple range test (DMRT) to identify the homogenous groups of treatments using SPSS-20.

3. RESULTS AND DISCUSSION

3.1 Nutrient Content and Uptake by Plant

Significantly the highest N uptake by plant was observed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) at flowering. However, application of 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) resulted in the highest N uptake followed by 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) at harvest. The lowest N uptake was noticed with no phosphorus (T_1) at both stages of crop growth. The highest N uptake was noticed with PSB @ 750 ml ha^{-1} and VAM @ 12.5 kg ha^{-1} along with inorganic P fertilizer was due to increased N availability in the soil ascribed to synergistic effect between nitrogen and phosphorus [6]. Application of PSB which stimulate the nitrogen efficiency through production of harmones such as auxins, cytokinins and gibberellins. VAM fungal hyphae are better able to penetrate decomposing organic material than plant roots and therefore better competitors for recently mineralized N. and Babu et al. [7].

The P content and uptake by plant was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) which was on par with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6). The lowest P content and uptake was noticed with no phosphorus (T_1) at both stages of crop growth.Higher P content in plant with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} may be due to higher availability of P in soil with application of inorganic P, PSB and VAM. "The improvement of P content in plants may be due to improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrients from large area and depth. Moreover, application of PSB and VAM solubulize and mobilizes the nutrients which became available to plants and thus increased P concentration" [8].

Significantly the highest K content in plant was noticed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) at harvest, whereas, the highest K uptake was observed with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) at flowering. However, application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) was recorded the highest K uptake followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) at harvest. The lowest K content and uptake was noticed with no phosphorus (T_1) at both stages. Application of 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} showed highest K content and uptake. This may be ascribed to application of P in integrated manner help to release of K from the K bearing minerals and organic acids produced by PSB resulting in more available K in soil which led to more content and uptake by crop (Mohapatra et al., 2008).

Treatments did not show positive effect on Ca uptake by crop at flowering and harvest stages. At flowering, Maximum Ca uptake by plant was noticed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) and the lowest Ca uptake was recorded with no phosphorus (T_1).At harvest, higher Ca uptake by crop was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) and the lowest Ca uptake was obtained with no phosphorus (T_1). The Ca content and uptake was not significantly effected by treatments at both stages.

The highest Mg uptake by plant was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) which was found to be at par with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) while, the lowest Mg uptake was noticed with no phosphorus (T_1) at both stages.Higher Mg uptake might be due to higher dry matter production which is important component in nutrient uptake.

The highest S content in plant was noticed with 125% RDP (T_3). Where as the highest S uptake was obtained from 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). The lowest S content and uptake was observed with no phosphorus (T_1) at both stages of crop. Highest S content with 125% RDP at both stages might be due to increased supply of S nutrition through SSP to the crop (Pramanik and Bera et al., 2013).

Table 1. N, P and K content (%) and uptake (kg ha^{-1}) by finger millet at different growth stages as influenced by phosphatic fertilizer and biofertilizers

Treatments	N content		N uptake		P content		P uptake		K content		K uptake	
	F	H	F	H	F	H	F	H	F	H	F	H
T_1	1.07	0.83	57.22^{d}	67.92^{c}	0.20^{d}	0.19	10.68^{d}	15.62^{d}	0.43	0.39^{c}	24.22^{d}	30.05^{e}
T_2	1.13	0.85	61.38^{c}	73.06^{bc}	0.24^{abcd}	0.23	11.73^{c}	18.26^{abc}	0.48	0.44^{bc}	27.63^{c}	35.71^{cd}
T_3	1.10	0.94	62.22^{b}	77.59^{abc}	0.23^{cd}	0.22	11.96^{c}	18.60^{abc}	0.51	0.47^{b}	28.72^{b}	36.95^{cd}
T_4	1.05	0.86	59.42^{c}	75.66^{bc}	0.23^{bcd}	0.22	13.74^{b}	18.48^{abc}	0.51	0.46^{b}	28.78^{b}	39.40^{bc}
T_5	1.07	0.89	61.49^{c}	73.81^{bc}	0.24^{abc}	0.22	13.90^{b}	17.92^{bc}	0.47	0.43^{bc}	26.71^{c}	34.12^{de}
T_6	1.09	0.90	65.47^{a}	78.89^{ab}	0.24^{abcd}	0.20	15.89^{a}	19.20^{ab}	0.53	0.51^{a}	29.18^{b}	48.35^{a}
T_7	1.12	0.86	62.21^{b}	75.86^{bc}	0.25^{ab}	0.21	15.50^{a}	16.54^{cd}	0.49	0.45^{b}	32.43^{a}	39.43^{bc}
T_8	1.12	0.90	61.73^{c}	72.47^{bc}	0.25^{abc}	0.21	14.53^{ab}	17.85^{bc}	0.45	0.40^{bc}	31.36^{a}	36^{cd}
T_9	1.16	0.91	63.42^{b}	86.84^{a}	0.25^{a}	0.24	16.40^{a}	20.36^{a}	0.51	0.45^{b}	33.76^{a}	42.97^{b}
F value	0.54	0.69	1.71*	3.09*	2.69*	0.668	5.98**	4.26**	1.54	4.23**	6.00**	11.68**
p-value	0.811	0.689	0.048	0.026	0.044	0.0712	0.001	0.007	0.219	0.007	0.001	0.000

** Significant at p=0.05 level ** Significant at p=0.01 level*

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT)

F: flowering, H: harvest

Table 2. Ca, Mg and S content (%) and uptake (kg ha^{-1}) by finger millet at different growth stages as influenced by phosphatic fertilizer and biofertilizers

Treatments	Ca content		Ca uptake		Mg content		Mg uptake		S content		S uptake	
	F	H	F	H	F	H	F	H	F	H	F	H
T_1	0.22	0.208	11.99	16.69	0.16	0.141	8.31^{c}	10.63^{e}	0.215^{d}	0.199^{d}	12.28^{c}	13.65^{d}
T_2	0.24	0.234	13.28	19.02	0.17	0.160	9.12^{bc}	14.22^{abc}	0.356^{b}	0.292^{bc}	19.38^{ab}	22.80^{c}
T_3	0.25	0.231	13.61	18.15	0.16	0.151	9.13^{bc}	11.86^{de}	0.407^{a}	0.386^{a}	21.17^{ab}	27.36^{bc}
T_4	0.24	0.234	13.48	20.06	0.16	0.147	8.87^{bc}	12.59^{cd}	0.369^{ab}	0.319^{bc}	20.92^{ab}	27.34^{bc}
T_5	0.24	0.235	13.36	18.65	0.16	0.144	11.18^{a}	11.57^{de}	0.346^{bc}	0.334^{abc}	19.89^{ab}	26.67^{bc}
T_6	0.24	0.231	16.19	21.88	0.17	0.150	11.20^{a}	14.54^{ab}	0.354^{b}	0.343^{ab}	23.44^{a}	35.01^{a}
T_7	0.26	0.232	15.44	20.11	0.17	0.148	10.20^{ab}	12.92^{bcd}	0.307^{c}	0.283^{bc}	18.82^{b}	24.58^{c}
T_8	0.23	0.222	12.10	17.54	0.18	0.157	10.25^{ab}	13.22^{bcd}	0.325^{bc}	0.303^{bc}	18.85^{b}	25.43^{bc}
T_9	0.25	0.234	16.16	22.33	0.19	0.179	11.98^{a}	15.27^{a}	0.306^{c}	0.276^{c}	22.56^{ab}	31.21^{ab}
F value	0.72	0.32	2.23	2.12	1.78	5.25	2.79*	7.09**	15.85**	8.01**	6.44**	10.24**
p-value	0.67	0.944	0.072	0.095	0.154	0.201	0.038	0.000	0.000	0.000	0.001	0.000

** Significant at p=0.05 level ** Significant at p=0.01 level*

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT)

F: flowering, H: harvest

The Mn content in plant did not differ significantly with treatments at flowering. Maximum Mn content was recorded with 125% RDP (T_3) and the lowest Mn content in crop was noticed with no phosphorus (T_1). The treatment showed non significant effect on Mn uptake at flowering. The higher Mn uptake was recorded with application of 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) and the lowest Mn uptake by crop was noticed with no phosphorus. At harvest highest Mn uptake (170 g ha^{-1}) was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). lowestMn uptake by crop was noticed with no phosphorus.The maximum Mn uptake might be due to higher dry matter production. Furthermore, PSB and VAM also played an important role in increasing Mn content and uptake due to secreting the enzymes, organic acids which makes fixed micro nutrients mobile and are available for the plants. The present findings are in accordance with findings of [9].

At both stages of crop growth, the treatments showed non significant effect on Cu content. At flowering, maximum Cu content in plant was recorded with application of 100% RDP + VAM @ 12.5 kg ha^{-1} (T_5) and the lowest Cu content was resulted with no phosphorus (T_1). At flowering, significantly the highest Cu uptake was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} At harvest, significantly the highest Cu uptake (139 g ha^{-1}) was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). The lowest Cu uptake by crop was noticed with no phosphorus (T_1) lowest Cu content was resulted with no phosphorus (T_1). Higher Cu uptake recorded with application of 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} might be due to higher dry matter production.

At both stages of crop growth, Zn content was not significantly effected by treatments. At flowering and harvest application of 125% RDP (T_3) recorded higher Zn contentand lowest Zn content by crop was noticed with no phosphorus (T_1).The treatmental effect on Zn uptake at flowering was found to be not significant but it was significant at harvest. The maximum Zn uptake at flowering was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) and the lowest Zn uptake by crop was noticed with no phosphorus (T_1).At harvest, significantly the highest Zn uptake (176 g ha^{-1}) by crop was recorded with application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) and lowest Zn uptake by crop was noticed with no phosphorus (T_1).Higher Zn uptake with75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} might be due to higher dry matter production.

And application of VAM and PSB also significantly increased Zn, Fe, Cu &Mn and made them available to the plants.

3.2 Nutrient Content and Uptake bY Finger Millet Grain

The highest N uptake by grain was noticed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). The lowest N uptake was observed with no phosphorus (T_1). The highest N uptake by grain was recorded with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} might be due to combined effect of PSB and VAM leads to better exploration of rhizosphere by hyphal network, leading to greater nutrient use efficiency, by way of nutrient dynamic mechanism in soil plant continuum and also due to uptake of P which is known to be positively related with N uptake (Sharma et al., 2012).

The highest P content in grain was recorded with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). However, the highest P uptake was noticed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) which was on par with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). The lowest P content and uptake was observed with no phosphorus (T_1). Highest P content and uptake by grain was noticed with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} might be to application of inorganic P which might be important to nutritional environment in rhizosphere as well as in plant leading to increased uptake and translocation of nutrients especially N, P and K in reproductive structures. This led to higher P content and uptake in grain and also PSB and VAM increased concentration of N and P in grain due to increases solubilization and mineralization of organic P and availability of N and P.

The highest K content and uptake by grain was noticed with 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) which was on par with 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9). The lowest K content and uptake was observed with no phosphorus (T_1) Highest K content and uptake by grain was recorded with

Table 3. Cu, Mn, Fe and Zn content (mg kg^{-1}) and uptake (g ha^{-1}) by finger millet grain as influenced by phosphatic fertilizer and biofertilizers

Treatments	Fe content	Fe uptake	Mn content	Mn uptake	Zn content	Zn uptake	Cu content	Cu uptake
T_1	35.59	130^{c}	32.82	129^{c}	22.12	81.12^{d}	11.43	42.37^{c}
T_2	38.77	148^{bc}	35.08	135^{ab}	22.97	88.22^{c}	11.51	44.00^{bc}
T_3	40.63	165^{b}	35.18	144^{ab}	22.78	92.99^{b}	11.53	47.05^{bc}
T_4	39.28	155^{b}	38.49	152^{a}	25.94	91.68^{b}	11.60	45.59^{bc}
T_5	38.52	149^{bc}	35.18	135^{ab}	23.86	91.93^{b}	11.97	45.99^{bc}
T_6	41.50	178^{a}	35.35	153^{a}	23.79	102.73^{a}	12.23	53.20^{a}
T_7	41.33	156^{b}	36.17	136^{ab}	22.39	84.29^{c}	13.37	50.18^{b}
T_8	41.21	162^{b}	37.11	137^{ab}	27.01	86.67^{c}	12.58	49.54^{b}
T_9	40.20	167^{b}	33.79	141^{ab}	23.61	98.29^{a}	12.20	52.46^{a}
F value	1.48	3.50*	1.13	2.48*	0.49	5.46**	0.49	3.79*
p-value	0.239	0.016	0.391	0.058	0.840	0.002	0.840	0.011

** Significant at p=0.05 level ** Significant at p=0.01 level*

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT)

Table 4. N, P, K, Ca, Mg and S content (%) and uptake (kg ha^{-1}) by finger millet grain as influenced by phosphatic fertilizer andbiofertilizers

Treatments	N content	N uptake	P content	P uptake	K content	K uptake	Ca content	Ca uptake	Mg content	Mg uptake	S content	S uptake
T_1	0.98	36.05^{c}	0.228^{c}	9.01^{c}	0.378^{d}	14.20^{c}	0.329	13.29	0.194	7.22	0.205	7.78^{c}
T_2	1.00	38.63^{bc}	0.293^{a}	11.28^{ab}	0.384^{c}	14.53^{bc}	0.360	13.86	0.195	7.45	0.226	8.70^{bc}
T_3	1.02	41.88^{abc}	0.299^{a}	12.24^{ab}	0.408^{abc}	16.66^{ab}	0.375	15.30	0.209	8.54	0.247	10.11^{a}
T_4	1.00	39.74^{bc}	0.291^{a}	11.57^{ab}	0.395^{bc}	15.59^{bc}	0.361	14.29	0.220	8.67	0.229	9.06^{abc}
T_5	1.05	40.36^{bc}	0.301^{a}	11.66^{ab}	0.424^{ab}	16.33^{ab}	0.380	14.66	0.228	8.83	0.221	8.53^{bc}
T_6	1.07	47.55^{a}	0.301^{a}	13.04^{a}	0.433^{a}	17.99^{a}	0.354	15.35	0.211	9.14	0.241	10.42^{a}
T_7	1.05	39.79^{bc}	0.268^{b}	10.21^{bc}	0.421^{ab}	15.96^{bc}	0.352	13.33	0.203	7.68	0.220	8.11^{bc}
T_8	1.02	40.43^{bc}	0.291^{a}	10.81^{abc}	0.386^{c}	15.20^{bc}	0.339	13.36	0.205	8.07	0.246	9.69^{ab}
T_9	1.09	45.54^{ab}	0.307^{a}	12.74^{a}	0.411^{abc}	17.74^{a}	0.363	13.66	0.198	8.25	0.245	10.19^{a}
F value	1.23	3.33*	3.28*	3.45*	3.22*	4.24**	1.38	1.77	1.20	2.34	1.80	4.70**
p-value	0.339	0.019	0.021	0.017	0.022	0.007	0.274	0.156	0.355	0.070	0.149	0.004

** Significant at p=0.05 level ** Significant at p=0.01 level*

Note : Same set of alphabets indicates no significant difference or at par with each other (DMRT) application of PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} along with 100% RDP. This might be due to combined effect of inorganic P fertilizer and phosphorus biofertilizers. Increases uptake due to synergistic effect between P and K and also phosphorus biofertilizers which makes solubilizing K from K bearing minerals through organic acids released that could have increased K content in grain.

Application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) recorded the highest S, Fe, Mn, Zn and Cu uptake by grain followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_9) while, the lowest S, Fe, Mn, Zn and Cu uptake was noticed with no phosphorus (T_1).

3.3 Grain Yield

Grain yield of finger millet was significantly influenced ($P<0.05$) by phosphatic fertilizer and bio-fertilizers. The highest grain yield was recorded with application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} (T_6) The lowest grain yield (3692 kg ha^{-1}) was recorded with no phosphorus (T_1).

The highest grain yield was recorded with application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} might be attributed to better supply of nutrients along with conducive physical environment leading to better root activity and higher nutrient absorption, which resulted in more plant growth and superior yield attributes responsible for higher yield. Due to the controlled release of nutrients in the soil caused by microbial activity, the application of biofertilizers (PSB and VAM) boosted the effectiveness of chemical fertilisers and may have promoted greater crop development. The current findings concur with those of Abbasi and Yousra [10].

Table 5. Grain yield and straw yield (kg ha^{-1}) of finger millet as influenced phosphatic fertilizer and biofertilizers

Treatments	Grain yield
T_1	3692^{d}
T_2	3846^{bc}
T_3	4083^{abc}
T_4	3946^{bc}
T_5	3858^{bc}
T_6	4328^{a}
T_7	3783^{cd}
T_8	3942^{bc}
T_9	4157^{ab}
F value	3.54*
p-value	0.015

4. CONCLUSION

The present study indicated that combined application of 100% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1} is the most efficient phosphorus management practice for the better growth, yield, nutrient content, uptake in both plant and grain yield of finger millet, followed by 75% RDP + PSB @ 750 ml ha^{-1} + VAM @ 12.5 kg ha^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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