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Effect of Integrated Nutrient Management Practices on Nutrient Uptake, Yield of Finger Millet (*Eleusine coracana* L. Gaertn.) and Post-Harvest Nutrient Availability under Rainfed Condition of Jharkhand

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ABSTRACT

A field experiment entitled "Performance of finger millet (*Eleusine coracana* L. Gaertn.) under integrated nutrient management practices" was conducted at Agronomical research farm of Birsa Agricultural University, Ranchi during *Kharif* 2016 to study the effect of integrated nutrient management practices on nutrient uptake, yield of finger millet and post-harvest availability of nutrients in soil. The experiment was laid out in Randomized Block Design with 10 treatments replicated thrice. The soil of experimental site was low in available nitrogen (232.47 Kg/ha), medium in phosphorus (14.30 Kg/ha) and potassium (131.84 Kg/ha). Result reveled that total uptake of NPK by the crop was higher with application FYM (10t/ha) + Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Psuedomonas flurosence* @ 20 g/kg seed each) + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF and was followed by application of FYM (10 t/ha) + Biofertilizers (*Azospirillum brasilense*+ *Bacillus* spp. + *Psuedomonas flurosence* @ 20 g/kg seed each) + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF. Available nitrogen, phosphorus were found highest with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100 % RDF whereas available potassium was found non-significant.

Introduction

Millet is a group of small-grained cereal grown around the world for food and fodder. Millets is known to be "crops of the future" as it is well adapted and cultivated under harsh environment of arid and semi-arid region (Resmisa, 2012). Among various millets, finger millet is one of the important millet crops of the country as it provides staple food in relatively short period and dry tracts of the country. Its name is derived from the seed head, which has the shape of human fingers. Locally, the crop is called *ragi* or *marua* in India (National Research Council, 1996).

In India it is cultivated over an area of 1.61 million hectares with total production of about 2.1 million tonnes and productivity 1661 kg per hectare (AICSMIP, 2013-14). In Jharkhand, it is cultivated over an area of 0.490 mha with total production of about

27412 ton and productivity 684 kg per hectare (SAMETI GOJh, 2012-13).

In the present system of intensive agriculture, mostly farmers are using exhaustive high yielding varieties of the crops, leading to heavy withdrawal of nutrients from the soil during past few years. So crop yield and its quality can be improved by adequate soil nutrient and crop management practices (Pathak *et al.,* 2012). Majorly poor management of fertilizer has key role to play in obtaining low yield productivity, in order to achieve optimum crop productivity management of nutrients through judicious application of organic sources, bio-fertilizers and micro-nutrients is required (Ghaffari *et al.,* 2011). Beside nutrients availability, FYM also improves soil physical characteristics such as structure, porosity and water-holding capacity through increased organic matter content of soil. FYM when applied in conjunction with biofertilizers, supplies energy to beneficial microorganisms (Jat *et al.,* 2013). Application of biofertilizer not only fixes the biological nitrogen but also solubilizes the insoluble phosphates in soil and thus improves nutrient availability. Since fertile soil is the fundamental resource for higher production, its maintenance is a prerequisite for long term sustainable crop production which cannot be maintained by using chemical fertilizers alone and similarly, it is not possible to obtain higher crop yield by using only organic manure (Bair, 2000). Hence, integrated use of manure and fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status (Nambiar, 2000). Keeping these points in view a field study on integrated nutrient management practices was conducted under poor soil conditions and uneven rainfall distribution pattern of Jharkhand to study the effect of INM on nutrient uptake and yield of finger millet and post-harvest available NPK.

Materials and Methods

A field experiment was conducted on sandy loam soil of Birsa Agricultural University Farm, Kanke, Ranchi ($23^0 17'$ North latitude, $85^0 19'$ East longitudes and at an altitude of 625 meter above mean sea level) during *Kharif* 2016. The soil of the experimental site was sandy loam (sand 55.4%, silt 28.3% and clay 16.3%), having bulk density 1.37 Mg/m^3, organic carbon 4.23 g/kg, acidic in reaction (pH 5.4), low in available nitrogen (232.47 kg/ha), medium in available phosphorus (14.30 kg/ha) and potassium (131.84 kg/ha). The *Ragi* cultivar A-404 was of medium duration with seed rate 10 kg/ha and spacing of 30 cm ×10 cm. The experiment was laid out in a Randomized Block Design (RBD) and replicated thrice with ten treatments. The treatments consisted of: T_1. Absolute control, T_2. FYM (10 t/ha), T_3. Recommended dose of fertilizers (NPK @ 50:30:25 kg/ha, respectively), T_4. FYM (10t/ha) + Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Psuedomonas flurosence* @ 20 g/kg seed each), T_5. T_4 + $ZnSO_4$ (12.5 kg/ha), T_6. T_4 + Borax (5 kg /ha), T_7. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha), T_8. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 50% RDF, T_9. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF, T_{10}. T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF.

Organic source of nutrients used in the experiment was farm yard manure (FYM). Inorganic sources were N, P and K containing fertilizers such as Urea, Single super phosphate, Murate of potash. Zinc and Boron was applied in the form of Zinc sulphate and Borax respectively. The biofertilizers used for seed inoculation were *Azospirillum brasilense, Bacillus* spp. and *Psuedomonas flurosence.* In case of organic nutrient management, the requisite quantity of FYM was applied as per the treatments and incorporated well in advance i.e. two weeks before sowing of the crop. One third of urea, full dose of SSP, Murate of Potash along with Zinc sulphate and Borax were applied at the time of sowing as basal dose and remaining urea was applied in two split doses *viz.*, 1/3 at tillering stage (30 DAS) and 1/3 before ear head initiation (55 DAS) as per various treatments. The grain and straw yield of finger millet were recorded treatment wise from net plot area at harvest and converted into quintal per hectare basis. For plant nutrient uptake plant samples collected for recording dry matter estimation at harvest were oven dried, grinded and digested for chemical analysis. The nutrient uptake (kg/ha) was calculated by using their nitrogen, phosphorus and potassium concentration (%) values and yield of crop plant on hectare basis. Nutrient uptake was calculated as:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient concentration (\%)} \times \text{Grain/Straw yield (kg/ha)}}{100}$$

Pre-sowing and post-harvest soil of experimental plot were subjected to analysis for which soil samples (0-15 cm depth) were collected from five different places from each treatment plots and mixed thoroughly for preparing composite soil sample. The composite samples were air dried, grinded, sieved and used for the estimation of residual nutrient status of soil by adopting standard methods. The collected data for various parameters were statistically analysed using the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984).

The significance of comparison was tested. The significant difference values were computed for 5 percent probability of error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means (Table 1).

Results and Discussion

Yield

Grain and straw yield of finger millet (Table 2 and Fig. 1) significantly differed with varying level of inorganic fertilizers in association with FYM and biofertilizers over control. Maximum grain yield (3773 kg/ha) was recorded with the combined application of organic, inorganic and biofertilizers i.e., application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF followed by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100 % RDF (3542 kg/ha) but significantly superior to rest of the treatments. Higher grain yield with combined application of FYM, biofertilizer and increasing level of inorganics may be due to increased availability of nutrients and improved the soil properties.

This in turn, increased absorption and translocation of nutrient by crop leading to increased production of photosynthates by the crop. Organic manure provided favourable environment for microorganism i.e. *Azospirillum* which fixes atmospheric nitrogen available to plants. Further, PSB is one of the most important nutrient solubilizing microorganisms, which convert insoluble phosphate into soluble forms by secreting several organic acids. These results are in line with the findings of Khan *et al.*, (2012) and Jat *et al.*, (2013).

Maximum straw yield (7695 kg/ha) was recorded with application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100 % RDF followed by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF (6983 kg/ha). Higher straw yield was recorded under combined use of biofertilizers, organics and 100% RDF due to higher vegetative growth as a result of greater nitrogen dose in T_{10} than rest of treatments. The increased availability of the nutrients especially nitrogen due to combined application of FYM, inorganic fertilizers and biofertilizers, lead to enhancement of the photosynthetic rate resulting in more vegetative growth and dry matter production. These results are in conformity with the results of Pratap *et al.*, (2008).

Fig.1 Grain yield (kg/ha) and Straw yield (kg/ha) of finger millet as affected by Integrated Nutrient Management practices

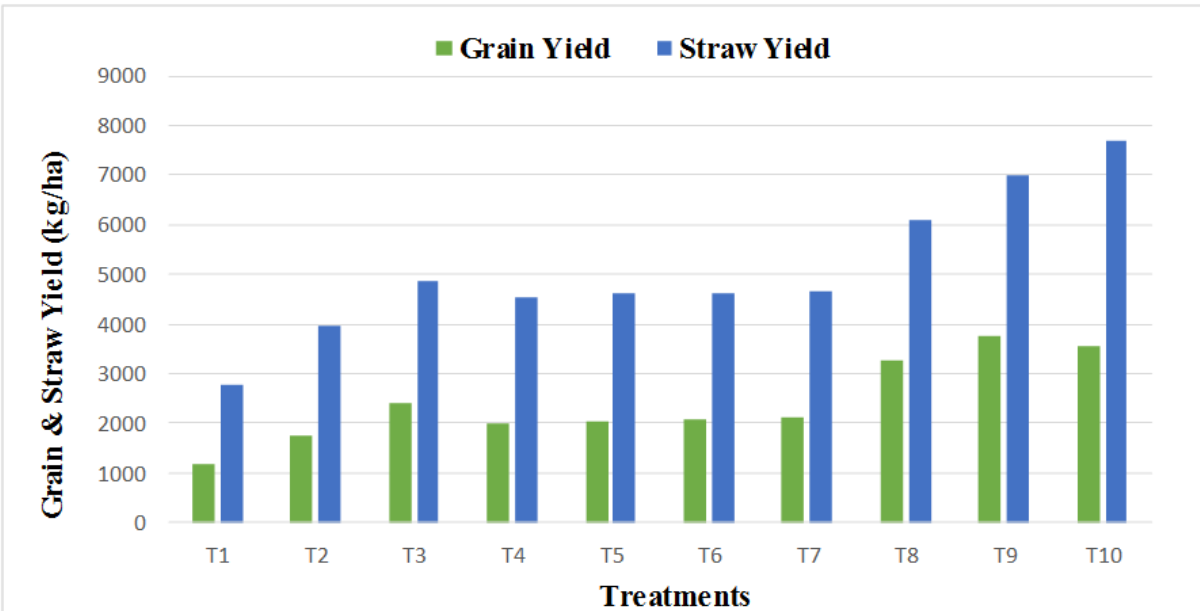

Fig.2 NPK uptake (kg/ha) by finger millet as affected by Integrated Nutrient Management practices

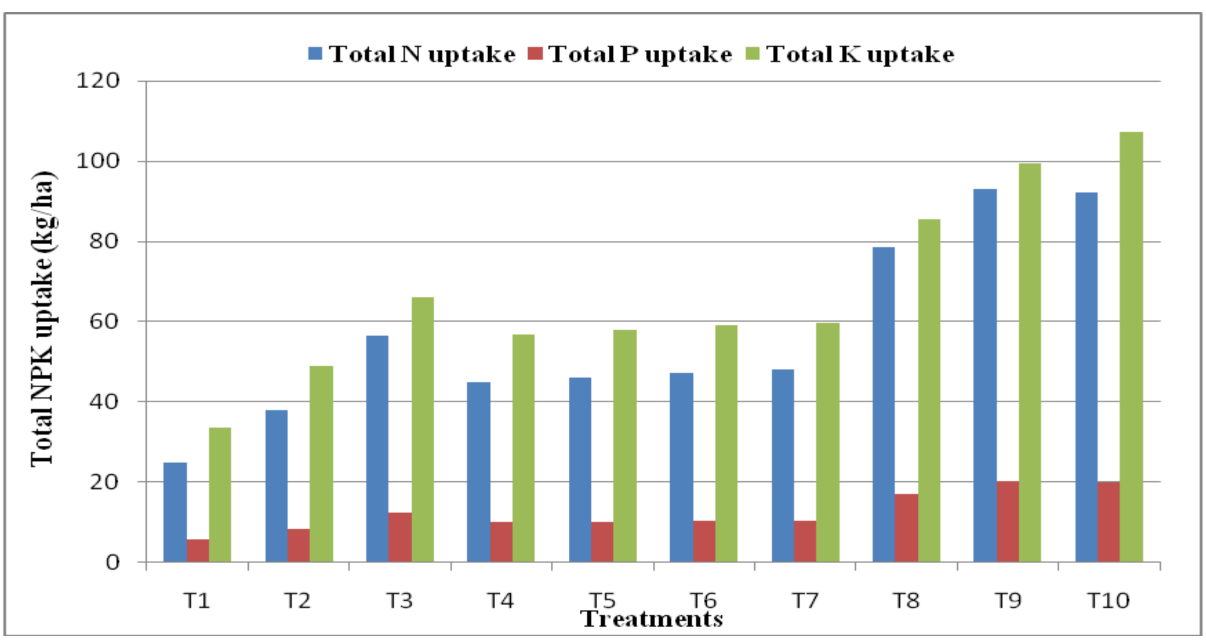

Table.1 Nitrogen, phosphorus and potassium content in finger millet grain and straw as affected by integrated nutrient management practices

Treatments	Nitrogen %		Phosphorus %		Potassium %	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
T_1: Absolute control	1.22	0.37	0.319	0.069	0.411	1.04
T_2: FYM (10 t/ha)	1.25	0.41	0.327	0.072	0.423	1.06
T_3: Recommended dose of fertilizers (NPK @50:30:25 kg/ha, respectively)	1.34	0.46	0.353	0.083	0.497	1.11
T_4: FYM (10 t/ha)+ Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Psuedomonas flurosence* @20 g/kg seed each)	1.28	0.42	0.331	0.074	0.427	1.07
T_5: T_4 + $ZnSO_4$ (12.5 kg/ha)	1.29	0.43	0.331	0.074	0.427	1.07
T_6: T_4 + Borax (5 kg/ha)	1.30	0.43	0.332	0.075	0.428	1.08
T_7: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha)	1.31	0.44	0.332	0.075	0.429	1.09
T_8: T_4 +$ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha) + 50% RDF	1.39	0.51	0.362	0.089	0.501	1.13
T_9: T_4 + $ZnSO_4$ (12.5 kg/ha)+Borax (5 kg/ha) + 75% RDF	1.45	0.55	0.367	0.092	0.507	1.15
T_{10}: T_4 + $ZnSO_4$ (12.5 kg/ha)+Borax (5 kg/ha) + 100% RDF	1.43	0.58	0.365	0.094	0.504	1.16
SE m ±	0.05	0.02	0.010	0.003	0.018	0.04
CD (P = 0.05)	0.14	0.05	0.031	0.008	0.053	0.12
CV%	6.11	6.85	5.273	5.876	6.768	6.38

Table.2 NPK uptake (kg/ha) and yield (kg/ha) of finger millet as affected by Integrated Nutrient Management practices

Treatments	Nutrient uptake (kg/ha)									Yield (kg/ha)	
	Nitrogen			Phosphorous			Potassium				
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw
T_1:	14.60	10.24	24.84	3.82	1.91	5.73	4.92	28.81	33.73	1197	2770
T_2:	21.72	16.18	37.90	5.68	2.84	8.52	7.35	41.84	49.11	1738	3947
T_3:	32.03	24.44	56.47	8.44	4.05	12.49	11.89	54.16	66.05	2391	4879
T_4:	25.81	19.10	44.91	6.68	3.37	10.05	6.61	48.67	56.83	2017	4549
T_5:	26.29	19.78	46.07	6.75	3.40	10.15	8.70	49.23	57.93	2038	4601
T_6:	27.20	19.93	47.13	6.95	3.47	10.43	8.96	50.07	59.02	2093	4637
T_7:	27.60	20.42	48.02	6.99	3.48	10.47	9.03	50.61	59.64	2107	4643
T_8:	45.28	31.19	78.47	11.79	5.44	17.23	16.32	69.11	85.43	3258	6116
T_9:	54.70	38.40	93.10	13.85	6.51	20.36	19.13	80.31	99.43	3773	6983
T_{10}:	50.65	41.63	92.28	12.93	6.98	19.91	17.85	89.26	107.14	3542	7695
SE m ±	1.41	1.18	2.24	0.32	0.17	0.47	0.46	3.08	2.78	143	313
CD (P = 0.05)	4.18	3.51	6.64	0.94	0.51	1.39	1.36	9.15	8.26	432.16	929.74
CV%	7.48	8.49	6.81	6.52	7.14	6.45	7.15	9.50	7.15	10.43	10.66

Table.3 Available NPK (kg/ha) in soil after harvest as affected by Integrated Nutrient Management practices

Treatment	Available N	Available P	Available K
T_1: Absolute control	187.64	7.07	95.48
T_2: FYM (10 t/ha)	199.57	11.78	102.65
T_3: Recommended dose of fertilizers (NPK @50:30:25 kg/ha, respectively)	204.74	14.81	99.79
T_4: FYM (10 t/ha) + Biofertilizers (*Azospirillum brasilense* + *Bacillus* spp. + *Psuedomonas flurosence* @20 g/kg seed each)	206.64	14.25	106.01
T_5: T_4 + $ZnSO_4$ (12.5 kg/ha)	206.44	14.15	104.91
T_6: T_4 + Borax (5 kg/ha) @ 5 kg/ha	205.34	13.87	103.82
T_7: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha)	204.48	13.83	103.20
T_8: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha)+50% RDF	228.11	17.07	107.43
T_9: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha) +75% RDF	230.43	18.94	108.32
T_{10}: T_4 + $ZnSO_4$ (12.5 kg/ha) + Borax (5 kg/ha) + 100% RDF	233.83	19.68	108.96
SE m ±	8.18	0.54	4.62
CD (P = 0.05)	24.29	1.60	NS
CV%	6.72	6.43	7.70
Initial Soil Status	232.47	14.30	131.84

NPK uptake by grain

The nutrient uptake is a function of yield and nutrient concentration in plant. Uptake of NPK by grain was higher with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF which was at par with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF (Table 2 and Fig. 2). This is due to higher grain yield in T_9 treatment i.e. application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF. Combined application of organic, inorganic fertilizers and biofertilizers created favourable nutritional environment to the plant rhizosphere which enhanced the photosynthetic activity and translocation of nutrients thus increasing the grain yield and nitrogen uptake by grain. Moreover, increased availability and uptake of phosphorus was due to solubilizing effect of PSB. The enhanced uptake of potassium in the corresponding treatment could be due to the higher grain yield and sustained availability of nutrients through organic and inorganic fertilizers along with *Bacillus* spp. Results obtained were in close conformity of Rathore *et al.,* (2006), Choudhary and Gautam (2007).

NPK uptake by straw

Uptake of NPK by straw was higher with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF which was at par with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF (Table 2 and Fig. 2). This is due to higher straw yield in T_{10} treatment. Due to higher nitrogen dose there was excessive vegetative growth and hence greater straw yield in T_{10} treatment i.e., application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF. As due to in general, the trend of nutrient uptake very well resembled with dry matter accumulation and per hectare straw yield data of various treatments hence higher nutrient content in the produce and higher biomass production of finger millet might be the relevant reason for higher uptake of NPK. Results obtained were in close conformity of Kalibhavi *et al.,* (2003) and Rathore *et al.,* (2006).

Total NPK uptake

Total uptake of N and P was higher with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF which was at par with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF whereas K uptake was found higher with application of FYM (10 t/ha) + Biofertilizer + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF (Table 2 and Fig. 2). The significant improvement in content and removal of nutrients as a consequence of organic and inorganic fertilizer with biofertilizer was important in improving nutrient availability pattern of soil which might have reflected on grain and straw yield and resulted ultimately in nutrient content and uptake of nutrient by grain and straw. Results obtained were in close conformity of Choudhary & Gautam (2007).

Post-harvest available NPK (kg/ha)

Higher available nitrogen content was observed with application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF followed by application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF > application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 50% RDF (Table 3). The higher available N was observed with integrated use of FYM, inorganic fertilizers and biofertilizers. Higher availability of N may be attributed to the addition of N by FYM, *Azospirillum* by biological nitrogen fixation and increasing level of N fertilizers. Similar findings were reported by Sarma *et al.,* (2007). In case of Phosphorus, higher available phosphorus in soil was observed with application of FYM (10 t/ha) + Biofertilizers + $ZnSO_4$ (12.5 kg/ha) + Borax (5kg/ha) + 100% RDF followed by application of FYM (10 t/ha) + Biofertilizers + ZnSO4 (12.5 kg/ha) + Borax (5kg/ha) + 75% RDF (Table 3). This 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. Further, PSB application resulted in greater mobilisation of insoluble inorganic phosphate and mineralization of organic P. Hence it may be concluded that the increased availability of nutrients was due to improvement in soil physical, chemical and biological health through application of organic and inorganic fertilizers along with biofertilizer under integrated nutrient management. Similar results were observed by and Tolanur and Badanur (2003) and Dass *et al.,* (2008). Available potassium status was not significantly influenced by different combination of nutrient sources (Table 3).

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