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Micronutrients uptake and soil nutrients status affected by different nutrient management practices under fodder pearl millet cultivation

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ABSTRACT

The study was undertaken during kharif season of 2019-20 at Agronomy research farm of ICAR-NDRI, Karnal (Haryana). The experiment was laid out in Randomized Complete Block Design with eight treatments viz., Absolute control; 100% RDF; 100% RDF + Cow urine foliar spray (10% at 30 and 45 DAS); 100% RDF + PGPR; 100% RDF + PGPR + Cow urine foliar spray; 75% RDF + Cow urine foliar spray; 75% RDF + PGPR and 75% RDF + PGPR + Cow urine foliar spray with three replications of each treatment. Study indicated that maximum iron (347.6 ppm), manganese (44.6 ppm), copper (12.9 ppm) and zinc (38.3 ppm) content as well as uptake of iron (3938.6 g ha^{-1}), manganese (506.8 g ha^{-1}), copper (146.1 g ha^{-1}) and zinc (433.8 g ha^{-1}) by fodder pearl millet recorded with 100% RDF + PGPR + Cow urine foliar spray. Soil macro and micronutrients status was found higher with application of 100% RDF + PGPR + Cow urine foliar spray, which may further strengthen and sustain fodder quality and soil fertility.

Keywords: Cow urine, fodder, nutrients, pearl millet, quality, soil

INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is gifted crop for tropical and sub-tropical regions to provide fodder and stover to millions of livestock animal of poor resources farmer. It has high degree of tolerance to drought and heat as well as high growth rate, tillering potential and water use efficiency. Pearl millet has potential to produce good quality palatable green fodder in low fertile soils with lower nutrients demand to produce satisfactory amount of yield (Ayub *et al.*, 2007). Nutrient management is an important aspect to achieve sustainable crop production. Scenario from green revolution era, shows productivity of cereals largely increased with the use of high yielding variety, intensive agronomic practices and indiscriminate use of chemical fertilizers at higher rate with little or no use of organic source of nutrients, that creates adverse effects on soil *viz.,* inadequacy in one or more nutrients and deterioration of soil fertility which leads to stagnating or even declining of crop productivity and quality (Shormy *et al.*, 2013). Deficiency of nutrients in soils leads to produce mineral deficient food and fodder. However, animal and humans depending on such fodder and foods have also shown symptoms of nutrients deficiency (Shukla *et al.*, 2015). Judicious use of inorganic and organic sources of nutrients may sustain and enhance fodder quality and soil fertility.

Among different organic source of nutrients for plant, cow urine and Plant growth promoting *rhizobacteria* (PGPR) are excellent and important for agriculture uses. Cow urine contains nitrogen, phosphorus, potassium, sulphur, sodium, manganese, iron, carbolic acid, silicon, chlorine, enzyme and hormones (Saunders, 1982). It strengthens the fact that cow urine is not a toxic effluent content about 95% of water, 2.5% urea and 2.5% a mixture of minerals, salts, hormones and enzymes (Kishore *et al.*, 2015). The beneficial effect of cow urine application has been reported in different crops *viz.*, wheat (Abraham and Lal, 2004), maize (Devakumar *et al.*, 2014), mustard (Pradhan, 2016) and rice (Sahare and Mahapatra, 2015). PGPR is a consortium of bacteria that actively colonize around plant roots and enhances plant growth and yield (Wu *et al.*, 2005). PGPR strains belongs to a wide range of genera *viz.*, *Pseudomonas Azospirillum, Bacillus, Serratia* and *Azotobacter* (Bashan *et al.*, 2004). The beneficial effects of PGPR due to their ability to produce various organic compounds *viz.*, auxins, gibberellins, cytokinin, ethylene, organic acids, siderophores, nitrogen fixation, solubilization of

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insoluble inorganic soil phosphate to available form, sulphur oxidation, extra cellular production of antibiotics, increases in root permeability, enhancement of essential plant nutrients uptake (Enebak and Carey, 2000 and Pal *et al.,* 1999). Considering above facts in view the present study was proposed to finds out a suitable combination of nutrient source to sustain and enhance fodder quality and soil fertility.

MATERIALS AND METHODS

The experiment was conducted during *kharif* season of 2019-20 at Agronomy Research Farm, ICAR-NDRI, Karnal (Haryana) located at 29º45' North latitude and 76º58' East longitude and at an altitude of 245 m above mean sea level. The climate of the area is semi-arid with a mean annual rainfall is 707 mm. The mean minimum and maximum temperature during this study was 20.49 and 34.54°C, respectively. The initial soil sample was collected before sowing of fodder pearl millet from experimental site and analysed by adopting standard methods. The soil of experimental site was clay loam in texture (Piper, 1942) with neutral reaction (pH 7.35). Electrical conductivity (EC) of soil is 0.37 dSm^{-1} (Jackson, 1967); low in organic carbon (0.49%) and available nitrogen (215 kg ha^{-1}); medium in available phosphorus (24.70 kg ha^{-1}) and available potassium (285 kg ha^{-1}); available iron of 11.54 ppm, manganese of 10.60 ppm, copper of 0.96 ppm and zinc of 0.66 ppm.

The experiment was laid out in randomized complete block design with eight treatments *viz*., $T_{1:}$ Absolute control; $T_{2:}$ 100% RDF; $T_{3:}$ 100% RDF + Cow urine foliar spray; $T_{4:}$ 100% RDF + PGPR; T_5: 100% RDF + PGPR + Cow urine foliar spray; $T_{6:}$ 75% RDF + Cow urine foliar spray; $T_{7:}$ 75% RDF + PGPR; T_8: 75% RDF + PGPR + Cow urine foliar spray with three replications of each treatment. The land preparation involved one deep ploughing with disc plough followed by two cross harrowing with disc harrow and planking. Recommended dose of fertilizers (80 kg N + 13.10 kg P + 25 kg K ha^{-1}) were applied as per treatment. The half of N and full doses of P and K were applied before final harrowing and remaining half dose of nitrogen was top-dressed in two split doses as per the treatment. The PGPR (100 ml ha^{-1} seeds) liquid culture was diluted in water, and applied on seeds. Thereafter, inoculated seeds were dried in shade for 60-90 minutes, and then manually sown. The "Nutrified" variety of fodder pearl millet was sown using 10 kg seed per hectare with maintaining spacing 30 cm × 10 cm from row to row and plant to plant, respectively. Others package of practices was followed as per standard for cultivation of fodder pearl millet. The 10% cow urine was applied as foliar spray in early morning hours, when the dew has been evaporated at 30 and 45 DAS as per treatments. The crop was harvested manually at 50% flowering stage. The harvested chopped plant samples from net plot area were dried in hot air oven at 70º C for at least 72 hours until a constant weight was reached. Further, these oven-dried plant samples were grounded to pass through two mm sieve in a Wiley mill. The sieved samples were used for micronutrient analysis (Tandon, 2001). Thereafter, the uptake of micronutrient by plant was computed by multiplying dry matter yield with nutrient content of dry fodder. After harvesting of crop, soil samples randomly collected from five spot at 0-15 cm depth in each net plot area, and taken 500g soil from composite sample after quartering for further analysis of organic carbon (Walkley and Black's, 1934); available nitrogen (Subbiah and Asija, 1956); available phosphorus (Olsen *et al.*, 1954); available potassium (Jackson, 1967); available iron, manganese, copper and zinc (Lindsay and Norvell, 1978). All the data recorded were processed in Microsoft excel 2010 and analysed with the help of analysis of variance (Gomez and Gomez, 1984) at 5% level of significance (P=0.05). Simple Pearson's correlation coefficient was computed by using mean values with the help of SPSS 23.0 Version.

RESULTS AND DISCUSSION

Dry matter yield

Study indicated (Table 1) that dry matter yield of pearl millet was significantly influenced with different nutrient management practices and recorded significantly higher dry matter yield (113.3 q ha^{-1}) at harvest with application of 100% RDF+PGPR+CU, which was found statistically at par with 100% RDF+PGPR and both were significantly higher over rest of the treatments. Balanced and regular supply of essential plant nutrients, PGPR produce phytohormones

(Enebak and Carey, 2000) and cow urine supply enzyme and hormones (Saunders, 1982) that attributed to stimulate plant physiological processes leads to increase leaf area index that responsible for higher interception of solar radiation and produce more photosynthates and nutrients acquired, resulted in to increase dry matter assimilation in different part of plant leads to increase dry matter content. Further, higher biomass production and dry matter content attributed to increase dry matter yield. The similar results also reported by Chattha *et al.* (2017).

Table 1: Effect of nutrient management practices on micronutrients content and uptake by fodder pearl millet

Treatment	DMY (q/ha)	Micronutrient content (ppm)				Macronutrient uptake (g/ha)			
		Fe	Mn	Cu	Zn	Fe	Mn	Cu	Zn
T_1	55.6	283.0	29.0	8.5	23.3	1575.4	161.3	47.2	129.7
T_2	98.9	308.3	36.6	11.4	32.5	3048.5	363.2	112.9	320.9
T_3	100.2	312.0	37.5	11.7	33.9	3129.7	376.0	117.5	340.3
T_4	111.7	343.6	43.6	12.8	38.2	3840.4	488.2	143.8	426.9
T_5	113.3	347.6	44.6	12.9	38.3	3938.6	506.8	146.1	433.8
T_6	82.3	308.0	36.6	11.5	32.5	2535.0	301.9	94.6	268.2
T_7	94.0	333.0	42.0	12.7	37.0	3134.9	395.0	119.5	348.0
T_8	96.1	335.0	42.5	12.8	37.1	3220.8	408.7	123.1	357.6
SEm (±)	1.9	6.0	0.9	0.2	0.9	66.4	14.4	3.7	8.8
CD (P=0.05)	5.7	18.2	2.7	0.8	2.8	201.3	43.7	11.3	26.8

DMY: Dry matter yield; T_1: Absolute control; T_2: 100% RDF; T_3: 100% RDF+CU; T_4: 100% RDF+PGPR; T_5: 100% RDF+PGPR+CU; T_6: 75% RDF+CU; T_7: 75% RDF+PGPR; T_8: 75% RDF+PGPR+CU

Micronutrient's content and uptake

The chemical analysis of pearl millet fodder showed (Table 1) that micronutrients content significantly influenced with different nutrient management practices and recorded maximum iron (347.6 ppm), manganese (44.6 ppm), copper (12.9 ppm) and zinc (38.3 ppm) contents in pearl millet fodder on dry matter basis with application of 100% RDF+PGPR+CU, which was found statistically at par with 100% RDF+PGPR followed by 75% RDF+PGPR+CU and 75% RDF+PGPR. Nutrients supplied with 100% RDF+PGPR+CU improved iron by 1.16, 11.43, 12.76 and 22.85%; manganese by 2.29, 19.11, 21.82 and 54.02%; copper by 0.26, 10.26, 13.16 and 51.76% and zinc by 0.35, 12.80, 17.95 and 64.29% over 100% RDF+PGPR, 100% RDF+CU, 100% RDF and absolute control, respectively. The PGPR produce siderophore that chelates Fe and make available from Fe^{+3} to Fe^{+2} for plant, leads to increase uptake and assimilation of Fe in plant tissue (Rana *et al.*, 2012). Synthesis of siderophore and organic acids such as gluconate or its derivative (2-ketogluconate) leads to increase availability of zinc in soil by Zn solubilization (Rana *et al.*, 2012). Bacillus species in PGPR are capable of synthesizing organic acids *via*., cinnamic acid, ferulic acid, chlorogenic acid, gallic acid and caffeic acid. These components acidifying soil micro-environment around rhizosphere that increase availability of micronutrients such as copper, zinc and manganese becomes more assimilable for plants leads to increase micronutrients content in plant tissues (Rana *et al.*, 2012). Another way cow urine spray additionally supplies Fe, Mn, Cu and Zn to plant foliage leads to quickly supply of nutrients to plant. Optimum and continues availability of micronutrients to plant increase uptake as well as assimilation in plant tissue, leads to increase nutrients content.

The micronutrients uptake (Table 1) by fodder pearl millet significantly influenced with different nutrient management practices and reported maximum iron (3938.6 g ha^{-1}), manganese (506.8 g ha^{-1}), cupper (146.1 g ha^{-1}) and zinc (433.8 g ha^{-1}) uptake with application of 100% RDF+PGPR+CU, which was found statistically at par with 100% RDF+PGPR and both were significantly higher than other treatments. Higher assimilation of micronutrients in plant tissue as well as higher biomass production attributed to increase micronutrients uptake.

Soil chemical properties

The data pertaining to soil pH, EC and organic carbon (OC) were not significantly affected by different nutrient management practices (Table 2), but numerically lowest soil pH (7.32), EC (0.35 dSm^{-1}) and highest OC (0.54%) was recorded with 100% RDF+PGPR+CU. However, slightly higher pH (7.38), EC (0.38 dS/m) and lower OC (0.47%) was recorded with absolute control. Study indicated (Table 2) that soil nutrients status significantly influenced with different nutrient management practices under fodder pearl millet cultivation and recorded higher available nitrogen (207.3 kg ha^{-1}), available phosphorus (24.7 kg ha^{-1}) and available potassium (213.4 kg ha^{-1}) at harvest with application of 100% RDF+PGPR+CU, which was found statistically at par with 100% RDF+PGPR and both were significantly higher than other treatments. While, higher available iron (10.74 ppm), available manganese (9.49 ppm), available copper (0.85 ppm) and available zinc (0.64 ppm) at harvest found with application of 100% RDF+PGPR+CU, which was found statistically at par with 100% RDF+PGPR followed by 75% RDF+PGPR+CU and 75% RDF+PGPR. Application 100% RDF increase N, P and K concentration in soil solution. Additionally, PGPR increased N by biological fixation, P by solubilizing of fixed inorganic soil phosphate to available form and K by secretion organic acid that increase availability (Cakmakci *et al.*, 2007). PGPR produce siderophore that chelates Fe leads to increase availability. Synthesis of different organic acids, solubilize copper, zinc and manganese by acidifying soil microenvironment around rhizosphere leads to increase available micronutrients (Rana *et al.*, 2012).

Table 2: Effect of nutrient management practices on soil chemical properties and nutrients status under fodder pearl millet cultivation

Treatment	pH	EC (dSm^{-1})	OC%	Soil available nutrients						
				Macronutrients (kg ha^{-1})			Micronutrients (ppm)			
				N	P	K	Fe	Mn	Cu	Zn
T_1	7.38	0.38	0.47	162.5	16.4	170.9	8.73	6.17	0.61	0.48
T_2	7.36	0.37	0.50	193.2	22.7	201.8	9.69	7.90	0.69	0.56
T_3	7.35	0.37	0.50	194.8	22.7	202.5	9.70	7.94	0.70	0.56
T_4	7.33	0.35	0.53	206.1	24.7	212.6	10.70	9.47	0.85	0.63
T_5	7.32	0.35	0.54	207.3	24.7	213.4	10.74	9.49	0.85	0.64
T_6	7.37	0.37	0.49	175.2	20.2	181.8	9.50	7.37	0.68	0.55
T_7	7.34	0.36	0.52	190.9	22.1	194.3	10.50	8.97	0.82	0.62
T_8	7.34	0.36	0.52	191.1	22.1	194.5	10.55	9.00	0.83	0.62
SEm (±)	0.18	0.01	0.02	3.46	0.6	2.8	0.22	0.23	0.02	0.02
CD (P=0.05)	NS	NS	NS	10.5	1.8	8.6	0.67	0.69	0.06	0.05

OC: Organic carbon

Correlation study

The correlation between Fe, Mn, Cu and Zn uptake and dry matter yield of fodder pearl millet (Table 3) revealed that Fe uptake (r = 0.986), Mn uptake (r = 0.974) Cu uptake (r = 0.985) and Zn uptake (r = 0.982) showed significantly higher positive correlation with dry matter yield of fodder pearl millet. However, dry matter yield increased with nutrients uptake.

Table 3: Correlation coefficient (r) between dry matter yield and nutrients uptake by fodder pearl millet

Pearson	Correlations				
	DMY	Fe	Mn	Cu	Zn
DMY	1				
Fe	.986**	1			
Mn	.974**	.998**	1		
Cu	.985**	.995**	.994**	1	
Zn	.982**	.997**	.997**	.999**	1

*DMY: Dry matter yield; **=Correlation is significant at the 0.01 level (2-tailed)*

Regression study

The regression analysis exhibited (Fig. 1) a significant polynomial correlation between nutrients uptake and dry matter yield of fodder pearl millet at harvest. The R^2 value between dry matter yield and iron, manganese copper and zinc uptake were 0.98, 0.96, 0.97 and 0.96, respectively. Which indicated that iron, manganese, copper and zinc uptake at harvest accounted 98, 96, 97 and 96% of total variation in dry matter yield of fodder pearl millet, respectively.

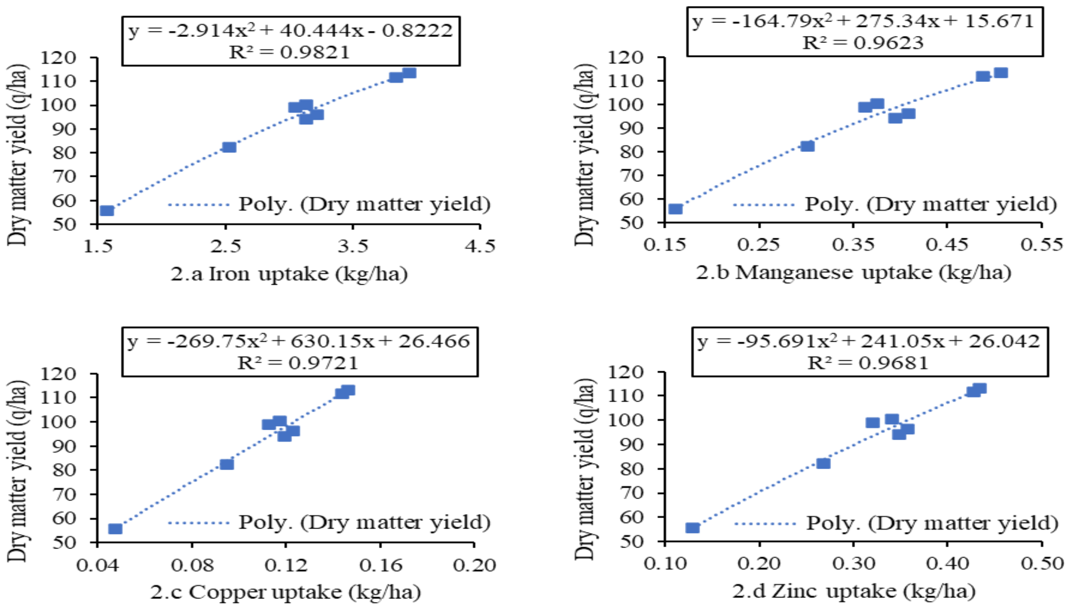

Fig. 1: Relationship between nutrient uptake and dry matter yield of fodder pearl millet

From the results, it was concluded that combined application of 100% RDF+PGPR+CU showed positive effect on nutrient content, uptake and soil nutrient status under fodder pearl millet cultivation.

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