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Effect of Cattle Urine Application on Soil Properties of Lateritic Soils under Spinach Cultivation

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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 undertaken to study effect of soil application of cattle urine on growth and yield of spinach in Lateritic soil at wire house of Division of Soil Science and Agriculture Chemistry RCSM College of Agriculture Kolhapur during *rabi*- 2020. There are total seven nitrogen substitution treatments through urea and cattle urine. The treatment consist of absolute control, recommended dose of fertilizers (40:40:40 kg ha^{-1}N, P_2O_5 and K_2O), general recommended dose of fertilizers (40:40:40 kg ha^{-1} N, P_2O_5 and K_2O + FYM @ 10 t ha^{-1}), 75% RDN-urea + 25% N- cattle urine, 50% RDN-urea + 50% N-cattle urine, 25% RDN-urea + 75% N- cattle urine, 100% RDN-cattle urine replicated thrice in complexly randomized design.

It could be observed from the data that pH and EC of lateritic soil was increased with the application of cattle urine for nitrogen substation. Significantly higher pH (7.67) and EC (1.01dsm^{-1}) of lateritic soil was reported with the application of 100% RDN through cattle urine at first of spinach (46 DAS). Decreasing trend in soil EC was observed at second ut of spinach in all the treatments under study while non-significant results were obtained for soil reaction (pH) at second cut. Significantly higher (1.40%) and (1.07%) organic carbon in lateritic soil was reported with the application of 100% RDN through cattle urine at first and second cut of spinach. Calcium carbonate content in lateritic soil at both the cuts of spinach were recorded non- significant result due to the application of nitrogen through fertilizer and cattle urine. Significantly higher (253.93 kg ha^{-1}) soil available nitrogen (253.93 and 184.97 kg ha^{-1}), phosphorus (30.72 and 29.10 kg ha^{-1}) and potassium (313.43 and 303.00 kg ha^{-1}) were recorded at first and second cut of spinach with the

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application of 100% RDN through cattle urine respectively. Significantly higher DTPA Fe (26.55 and 24.30 mg kg^{-1}), Mn (23.39 and 21.70 mg kg^{-1}), Zn (7.09 and 3.84 mg kg^{-1}) and Cu (12.01 and 9.12 mg kg-1) were recorded with the application of 100 % RDN thorough cattle urine. Further it can be seen from the data that DTPA availability of metallic micronutrients were higher in those treatments received cattle urine for either substitution of nitrogen @ 25,50, 75 or 100 percent.

Keywords: Cattle urine; nutrient availability spinach; lateritic soil.

1. INTRODUCTION

In the present scenario, depletion of soil organic matter, declining soil fertility, physical and chemical degradation of soil, biological sickness in soil, increasing multi nutrient deficiencies on various crops, mining of nutrients, imbalanced fertilization, etc are the important challenges under intensive cultivation system. These constraints related to soil are persisted due to the use of nutrients only through chemical fertilizers without manures and bio fertilizers. Therefore integrated nutrient management is the important way to enhance nutrient use efficiency, soil fertility and to mitigate the multi nutrient deficiencies. Integrated Nutrient Management refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. Among the different components of integrated nutrient management, organic sources of nutrients need to be focused considering region wise availability of crop residues. In the Integrated nutrient management, organic component may be either solid or liquid that too locally and easily available in every state of the country need to be included after assessing their composition. In case of liquid organic sources waste like cattle urine, pig urine, sheep and goat urine or even human urine can also be used under integrated nutrient management. The cattle urine can be included in the integrated nutrient management component as a source of not only nutrients but also growth promoting substances.

In India farmers pay good attention for the collection and utilization of cattle dung in the form of farm yard manures but very little or no attention has been given in collection and utilization of cattle urine. Further in India almost every farmer is having cow, buffalo, goat, sheep, etc. for his daily livelihood. Therefore, with 2 cows per farmer approximately 10-15 liters of urine is being produced daily which contains 1 kg nitrogen, 0.5 kg phosphorus and 1 kg potassium so, the liquid waste from cattle must be assessed for its utilization either through soil or foliar application for different crops in various soils. Hence it is necessary to tap this important source of nutrients along with growth promoting substances. Cattle urine contains 95 per cent water, 2.5 per cent urea and 2.5 per cent minerals, hormones and enzymes. Total nitrogen in cattle urine ranged from 6.8 to 21.1 gm N lit^{-1} of which on an average 69% was urea 7.3% allontoin, 5.8% uric acid, 0.5% zanthin + hypozanthinnitrogen and% as ammonia [1]. Mostly pH of cattle urine reported to be alkaline in nature so it can be used as source of nutrient and overall growth promoting substances on slightly acidic soil. The use of urine as source of nutrients has been tested, gaining popularity and accepted partially in Finland, South Africa, Israel, Sweden and China [2].

Therefore, this study was undertaken to study the effect of cattle urine on properties of lateritic soils under spinach cultivation.

2. MATERIALS AND METHODS

The experiment was undertaken to study effect of soil application of cattle urine on growth and yield of spinach in Lateritic soil at wire house of Division of Soil Science and Agriculture Chemistry RCSM College of Agriculture Kolhapur during*rabi*- 2020. There are total seven nitrogen substitution treatments through urea and cattle urine. The treatment consist of absolute control, recommended dose of fertilizers (40:40:40 kg ha^{-1}N, P_2O_5 and K_2O), general recommended dose of fertilizers (40:40:40 kg ha^{-1}N, P_2O_5 and K_2O + FYM @ 10 t ha^{-1}), 75% RDN-urea + 25% N-cattle urine, 50% RDN-urea + 50% N-cattle urine, 25% RDN-urea + 75% N- cattle urine, 100% RDN-cattle urine replicated thrice in complexly randomized design.

The lateritic soil was procured from Agricultural Research Station, Radhanagari Tal. Radhanagari Dist. Kolhapur. The soil was processed by pounding, grounding and allowed to pass through 2mm sieve. Total numbers of earthen pots were 21 with 33 cm diameter and 26 cm height were filled with 15 kg soil in each pot.

The experimental soil was characterized by red colour dominated by kaolinite clay which comes under *Alfisol* soil order. The soil was slightly acidic (pH: 6.2), EC: 0.23 dS m^{-1}, $CaCO_3$: 2.67%, organic carbon: 0.87%. The $KMNO_4$-N [3], Bray-Kurtz-P [4] and NH_4OAC-K [5] in experimental soil was 235.2 kg ha^{-1}, 14.13 kg ha^{-1} and 204.96 kg ha^{-1} respectively. However, metallic micronutrients like Fe, Mn,Zn and Cu from soil were estimated by using DTPA extractant as per the method quoted by Lindsay and Norvell [6].

The nitrogen levels were formulated as 25, 50, 75 and 100 per cent by considering recommended dose of nitrogen (40 kg ha^{-1}). The phosphorus through single super phosphate and potassium via muriate of potash were mixed thoroughly in soil before sowing. Further 50% N either through urea or cattle urine was applied as basal dose and remaining at 30 DAS. The substitution of cattle urine was done on the basis of nitrogen concentration. The quantity of cattle urine were 67, 135, 202 and 270 mls were used for the substitution of 25, 50, 75 and 100 per cent nitrogen. As per the treatments, calculated quantity of cattle urine was diluted ten times with tap water and applied uniformly over the soil. Sowing with ten seeds of spinach (Cv.All green) completed equidistantly in each pot. Plant height and number of leaves were measured periodically at 15, 30, 45 and 60 DAS. While chlorophyll content was also analyzed periodically at 15, 30, 45 and 60 DAS by selecting third leaf from top. Leaf area of fully grown and opened functional leaves from five randomly selected spinach plants per pot were measured by using graph paper tracing technique and expressed in cm^2. Further fully grown spinach leaves for yield and dry matter were harvested at 45 and 60 DAS.

3. RESULTS AND DISCUSSION

3.1 pH and Electrical Conductivity

Soil reaction (pH) of lateritic soil was measured at first (46 DAS) and second (70 DAS) cut of spinach and it was ranged from 5.67 to 7.67 and 5.6 to 6.40 however for EC 0.79 to 1.01 and 0.32 to 0.48 d Sm^{-1} respectively (Table 2). It can be observed from the data that soil pH at first cut was decreased in absolute control (6.13), RDF (5.90), GRDF (5.67) over initial (6.2). However, in those treatments where cattle urine was applied for nitrogen substitution recorded increase in the pH of lateritic soil. Significantly higher pH (7.67) of lateritic soil reported with the application of 100% RDN through cattle urine which was closely followed and statistically on par with 25% RDN + 75% RDN through cattle urine (7.10) Non-significant result for pH at second cut of spinach were reported for treatment under study. Increase in soil pH was reported in cattle urine applied treatments which might be due to high pH (7.9) of cattle urine at the time of application. Further cattle urine also contains appreciable amount of basic cations like calcium, magnesium, sodium and potassium. Bristow et al., [7], Bhadauria [8] and Nwite [9]. Sredevi and, Srinivasmurthy [10] also reported higher pH and EC of lateritic soil with the sole application of human urine.

Table 1. Chemical composition of cattle urine

Sr. no.	Parameters	Content
1	pH	7.90
2	EC (dS m^{-1})	20.41
3	Nitrogen (%)	0.05
4	Phosphorus (%)	0.004
5	Potassium (%)	0.03
6	Calcium (%)	0.08
7	Magnesium (%)	0.062
8	Sulphate (%)	0.035
9	Iron (ppm)	27.92
10	Manganese (ppm)	8.52
11	Zinc (ppm)	2.38
12	Cupper (ppm)	1.78
13	Chloride (ppm)	240

Application of 100% RDN through cattle urine recorded significantly higher (1.01dsm^{-1}) electrical conductivity of soil which was closely followed and statistically at par with application of 25% RDN + 75 RDN through cattle urine (1.00 d Sm^{-1}), GRDF (40:40:40 Kg ha^{-1} N, P2O5 and K2O + 10 t ha^{-1} FYM) (0.95 dsm^{-1}) and 50% RDN + 50% RDN through cattle urine (0.90 d Sm^{-1}). Decreasing trend and non-significant result for electrical conductivity was recorded at second cut. The electrical conductivity of soil was higher at first cut (46 DAS) and thereafter it was reduced in second cut. Magnitude of increase in electrical conductivity was found higher in those treatment received cattle urine for nitrogen substitution. This might be due to higher electrical conductivity of cattle urine (20 d Sm^{1}) at the time of application. However, increase in the electrical conductivity of soil other than cattle urine application might be ascribed to irrigation water having EC 0.2 d Sm^{-1}. Increase in the soil EC of treatment received cattle urine for nitrogen substitution might be due to the presence of appreciable amount of basic cations and salts of bicarbonate of calcium, magnesium, sodium, and potassium. Similar results were also reported by Swati et al. [11].

3.2 Organic Carbon and Calcium Carbonate

Application of nitrogen through urea and cattle urine significantly influenced organic carbon in lateritic soil at first and second cut of spinach (Table 3). The range of organic carbon content was 0.88 to 1.40 percent and 0.57 to 1.07 percent at first cut (45 DAS) and second cut (70 DAS) of spinach in lateritic soil respectively. Significantly higher (1.40%) and (1.07%) organic carbon in lateritic soil was reported with the application of 100% RDN through cattle urine at first and second cut of spinach. Which was found to be on par with the application of 25% RDN + 75% RDN (1.32 and 1.00%) and GRDF (1.27 and 1.04%) at first and second cut of spinach respectively? Organic carbon content in lateritic soil was found to be increased in all the treatment except absolute control (0.88%) and RDF (0.93) over initial (0.87%) at first cut of spinach but reduced at second cut of spinach. In case of GRDF (1.27 and 1.04%) organic carbon was found to be higher at first and second cut of spinach. Higher organic carbon in cattle urine applied treatment at first cut of spinach due to higher suspended organic matter present in the cattle urine. Further reduction trend in organic carbon at second cut of spinach might be due to the loss of CO2 during the oxidation of organic matter. However, in case of GRDF treatment higher organic carbon at first and second cut might be due to ascribed by the application of FYM @ 10 t ha^{-1}. Cattle urine contains suspended organic matter which might be the reason for higher organic carbon in soil at first cut. However, application of GRDF (40:40:40 Kg ha^{-1} N, P2O5 and K2O + 10 t ha^{-1} FYM) also reported higher organic carbon in soil due to FYM. Reduction trend in soil organic carbon at second cut in all cattle urine applied treatment also reported due to the loss of carbon in the form of CO_2 during tillage operation and decomposition of organic matter [12]. Calcium carbonate content in lateritic soil at both the cuts of spinach were recorded non- significant result due to the application of nitrogen through fertilizer and cattle urine.

3.3 Soil Available Nutrients

Significantly higher (253.93 kg ha^{-1}) soil available nitrogen (253.93 and 184.97 kg ha^{-1}), phosphorus (30.72 and 29.10 kg ha^{-1}) and potassium (313.43 and 303.00 kg ha^{-1}) were recorded at first and second cut of spinach with the application of 100% RDN through cattle urine respectively (Table 4). Soil available nitrogen was found increased in all the treatment except absolute control (155.73 Kg ha^{-1}), RDF (176.60 kg ha^{-1}) and GRDF (187.06 kg ha^{-1}) over initial (235.2.kg ha^{-1}). While soil available phosphorous was increased in all the treatment over initial (14.13 kg ha^{-1}) at first cut of spinach. Similar increase in trend in soil available potassium reported in all the treatment except absolute control at first cut. Further it could be noticed from the data that availability nitrogen, phosphorus and potassium in soil were decreased at second cut of spinach taken at 45 DAS which might be ascribed to uptake by spinach.

Significant improvements for total nitrogen available phosphorus and exchangeable calcium and magnesium with the application of urine in maize cultivation were reported by Veeresha et al., [13]. They concluded that application of FYM @ 12 t ha^{-1} along with cattle urine @ 34.300 lit ha^{-1} was found superior for higher soil availability of nitrogen, phosphorous, and potassium. Powell et al., [14] studied urine effect on soil properties under pear millet cultivation and concluded that urine application for nitrogen substitution had positive effect on pH, nutrient availability and yield of pearl millet. Increase in the soil availability of nitrogen and potassium with the application of cattle urine was reported by Khanal et al. [15].

DTPA Fe, Mn, Zn and Cu in lateritic soil as influenced by nitrogen application through cattle urine and urea were ranged from 8.39 to 24.30 and 17.81 to 21.70 mg kg^{-1},16.94 to 23.39 mg kg^{-1} and 17.81 to 21.70 mg kg^{-1}, 3.06 to 7.09 and 2.41 to 3.84mg kg^{-1} and 10.22 to 12.01 and 6.32 to 9.12 mg kg^{-1} at first and second cut of spinach respectively. (Tables 5 and 6) Significantly higher DTPA Fe (26.55 and 24.30 mg kg^{-1}), Mn (23.39 and 21.70 mg kg^{-1}), Zn (7.09 and 3.84 mg kg^{-1}) and Cu (12.01 and 9.12 mg kg^{-}1) were recorded with the application of 100% RDN thorough cattle urine (Table 5). Further it can be seen from the data that DTPA availability of metallic micronutrients were higher in those treatments received cattle urine for either substitution of nitrogen @ 25,50, 75 or 100 percent.

The concentration of DTPA extractable Fe, Mn, Zn and Cu was higher at first cut while it was decreased at harvest (second cut) which might be due to the uptake by spinach crop and alkalinity formed by the application of cattle urine for the substitution of nitrogen. Addition of cattle urine containing Fe (27.92 mg kg^{-1}), Mn (8.52 mg kg^{-1}), Zn (2.38 mg kg^{-1}) and Cu (1.78 mg kg^{-1}) for the substitution of nitrogen might have increased their concentration at first cut over initial. Further organic carbon content in the cattle urine might have enhanced microbial population in the soil which leads to higher DTPA metallic micronutrient availability at first cut.

Further the increase in soil pH (Table 6) followed by urine application may have enhanced soil organic matter degradation [16,17]. Stevenson and Cole [18] also reported release of metallic micronutrient in soil from organo metallic complex. Further they concluded that the addition of cations through urine could have

Table 2. Effect of soil application of cattle urine and nitrogen levels on pH and electrical conductivity of lateritic soil under spinach cultivation

Treatment	pH(1:2.5)		EC(dSm^{-1})	
	Ist Cut	IInd Cut	Ist Cut	IInd Cut
Absolutecontrol	6.13	6.03	0.79	0.32
RDF(40:40:40 kgha^{-1})	5.90	6.17	0.78	0.45
GRDF(40:40:40kg ha^{-1})+ 10t ha^{1}	5.67	5.6	0.95	0.43
75%RDN+25% RDN: CU	6.20	5.67	0.80	0.38
50%RDN+50% RDN: CU	6.43	5.77	0.90	0.39
25%RDN+75% RDN: CU	7.10	6.03	1.00	0.40
100% RDN: CU	7.67	6.40	1.01	0.48
SE±	0.283	0.236	0.057	0.075
CDat 5%	0.867	N/S	0.174	N/S
Initial–soil(1:2.5)	6.2	-	0.23	-
Cattle urine (d Sm^{-1})	7.9	-	20.00	-

Table 3. Effect of soil application of cattle urine and nitrogen levels on organic carbon and calcium carbonate content of lateritic soil under spinach cultivation

Treatment	Organiccarbon(%)		$CaCO_3$(%)	
	Ist Cut	IInd Cut	Ist Cut	IInd Cut
Absolutecontrol	0.88	0.57	4.00	2.67
RDF(40:40:40 kgha^{-1})	0.93	0.70	5.53	4.93
GRDF(40:40:40kgha^{-1})+ 10t ha^{1}	1.27	1.04	5.30	4.83
75%RDN +25% RDN: CU	1.12	0.95	4.13	3.13
50%RDN +50% RDN: CU	1.27	0.97	4.50	3.60
25%RDN +75% RDN: CU	1.32	1.00	5.57	5.20
100% RDN: CU	1.40	1.07	8.57	5.57
SE +	0.078	0.041	1.282	0.818
CDat5%	0.24	0.127	N/S	N/S
Initial–soil(%)	0.87	-	2.67	-
-Cattleurine(Cappm)	1.67	-	800	-

Table 4. Effect of soil application of cattle urine and nitrogen levels on available nitrogen, phosphorus and potassium in lateritic soil under spinach cultivation

Treatments		Nitrogen (kg ha^{-1})		Phosphorous (kgha^{-1})		Potassium (kgha^{-1})	
		I^{st} Cut	II^{nd} Cut	I^{st} Cut	II^{nd} Cut	I^{st} Cut	II^{nd} Cut
Absolutecontrol		155.73	142.83	15.35	12.93	141.53	115.17
RDF(40:40:40 kgha^{-1})		176.60	145.60	16.98	14.55	247.71	291.60
GRDF(40:40:40 kgha^{-1})+10tha^{1}		187.06	166.87	24.25	20.21	349.63	334.67
75%RDN+25%RDN: CU		236.20	165.13	26.68	22.64	266.00	239.80
50%RDN+50% RDN: CU		246.77	168.30	28.29	28.29	279.43	263.67
25%RDN+75% RDN: CU		245.63	174.53	29.86	29.11	282.70	274.67
100% RDN: CU		253.93	184.97	30.72	29.10	313.43	303.00
SE	+	6.227	5.736	1.858	1.756	33.172	19.611
CDat5%		19.071	17.567	5.689	5.378	101.59	60.06
Initial soil (kgha^{-1})		235.2	-	14.13	-	204.96	-
Cattle urine (%)		0.05	-	0.004	-	0.03	-

Table 5. Effect of soil application of cattle urine and nitrogen levels on iron and manganeses availability in lateritic soil under spinach cultivation

Treatment	Fe(mgkg^{-1})		Mn(mg kg^{-1})	
	I^{st} Cut	II^{nd} Cut	I^{st} Cut	II^{nd} Cut
Absolutecontrol	18.39	20.92	16.94	17.81
RDF(40:40:40 kgha^{-1})	20.62	22.80	20.36	18.61
GRDF(40:40:40kgha^{-1})+ 10t ha^{1}	25.09	26.39	22.87	20.36
75%RDN +25% RDN: CU	20.84	22.56	21.48	18.82
50%RDN +50% RDN: CU	21.62	25.54	21.84	19.43
25%RDN +75% RDN: CU	22.73	25.81	22.61	20.09
100% RDN: CU	24.30	26.55	23.39	21.7
SE ±	0.697	0.99	0.54	0.441
CD at 5%	2.135	3.032	1.655	1.352
Initial-Soil	32.40	-	26.2	-
Cattle urine	27.92	-	8.52	-

Table 6. Effect of soil application of cattle urine and nitrogen levels on Zinc and copperavailabilityinlateritic soilunderspinachcultivation

Treatment	Zn (mgkg^{-1})		Cu (mg kg^{-1})	
	I^{st} Cut	II^{nd} Cut	I^{st} Cut	II^{nd} Cut
Absolutecontrol	3.06	2.41	10.22	6.32
RDF(40:40:40kgha^{-1})	4.25	2.51	10.52	7.96
GRDF(40:40:40 kg ha^{-1})+10t ha^{1}	6.43	2.83	11.31	8.74
75%RDN+25% RDN: CU	3.85	2.67	10.92	8.37
50%RDN+50% RDN: CU	5.70	2.69	11.16	8.63
25%RDN+75% RDN: CU	5.95	2.92	11.31	8.67
100% RDN: CU	7.09	3.84	12.01	9.12
SE	0.082	0.233	0.136	0.31
CDat5%	0.252	0.714	0.416	0.95
Initial–Soil(ppm)	2.8	-	17.5	-
cattleurine(ppm)	2.38	-	1.78	-

displaced some metal ions from soil cation exchange sites so that they were temporarily solubilized before being reabsorbed on exchange site or taken up by plant or microbes. Micronutrients availability and buildup in soil was higher with cattle urine application which might be due to enhanced microbial population. Further cattle urine used in experiment was rich in organic carbon which acts as a food for microbes thereby acceleration in native microbial population which enhances the rate of decomposition resulting in better transformation of nutrient and thereby enhanced its buildup in soil. [19]**.** Similar results were also recorded by Kansal et al. [20].

4. CONCLUSIONS

It could be concluded from the present study that cattle urine can be used as a liquid source of nitrogen in lateritic soil. Application of 100% RDN through cattle urine was found beneficial for soil available nutrients and DTPA extractable metallic micronutrients.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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