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Effect of nitrogen management on chemical and biological properties of soil on kharif pearl millet

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Abstract
A field experiment was carried out during the *kharif* seasons of the year 2021 and 2022 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, with a view to study the effect of nitrogen management on chemical and biological properties of soil on *kharif* pearl millet. The experiment was laid out in a Randomized Block Design with six treatments and four replications. The results revealed that the chemical properties of soil *viz.*, organic carbon, EC, pH, available N, P, K and biological property like total microbial count were recorded significantly higher in treatment with 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium.

Keywords: Pearl millet, protein, content, uptake, RDN, castor cake, bio NPK consortium

Introduction
Pearl millet (*Pennisetum glaucum* L.) is the fourth most important cereal crops and widely grown in India because of its tolerance to drought, high temperatures and low soil fertility. Pearl millet grain is the staple diet and nutritious source of vitamins, minerals and protein, while pearl millet stover is a valuable livestock feed. The productivity of pearl millet is quite low in Agra region mainly due to sub-optimal application of fertilizers and cultivation on marginal lands in rainfed condition. In plant nutrition, organic matter of a soil is the key property that decides the availability status of essential nutrients. Integrated nutrient management system through efficient use of organic matter, besides improving soil physical condition and conservation of moisture, can substantially enhance crop production. The nutrient supply, the flows and the nutrient added should be managed properly to achieve as high yield as possible under the climatic circumstances while minimizing environmental pollution (Finck, 1998) [5]. The use of organic matter (FYM) or green manure (Dhaincha) is the tool to improve physical, chemical and biological properties of the soil. Farmyard manure being the source of all essential elements, improves soil organic matter and humus part of soil. FYM also plays important role in habitation beneficial bacteria, thus, making the nutrients available to crops. Integrated plant nutrition involves judicious and integrated use of chemical fertilizers along with organic manure and green manure. Keeping this in view, present investigation was undertaken to find out the effect of INM on productivity and economics of pearl millet.

Pearl millet is a principal food crop in marginal environments, it is the only cereal crop that gives unswerving yield and at the same time, it responds to high management practices. Pearl millet grains are nutritious and are a vigorous component for the daily human diet and its stover acts as the primary maintenance ration for ruminant livestock in the dry season.

In India, it is annually grown on 76.52 lakh ha. area producing 108.63 lakh tonnes of grains with productivity of 1420 kg/ha (Anon., 2021-22). India is the second-largest producer of pearl millet after China both in term of area and production. Out of the total area under pearl millet, nearly 92% lies in the Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. Rajasthan is a largest producing state in India having 51%area under cultivation of pearl millet followed by Maharashtra 15.3%, Gujarat 10.6%, Uttar Pradesh 9.2% and Haryana 6.2%.

Gujarat occupies an area of 4.60 lakh ha. and production of 10.08 lakh tonnes with productivity of 2192 kg/ha (Anon., 2021-22). Kutch, Banaskantha, Sabarkantha, Patan, Bhavnagar, Mehsana, Kheda, Anand and Gandhinagar are major pearl millet growing district.

One of the perilous challenges of the 21st century is to feed the 9.1 billion peoplein 2050 through sustainable production of food grains under limited water resources and scarce land availability (Selvaraju *et al.*, 2011) [14].

From a plant nutrition point of view, nitrogen is a greatest crucial component; amino acids, proteins, enzymes, carriers, nucleic acids, alkaloids, regulators, pigments and other metabolites involve N in their biosynthesis and inter-conversions (Srivastava and Singh, 1999) [15]. Up to a variable degree, the soils are universally deficient in N; hence N is the most applied nutrient from external sources (Wade, 2009) [19]. Nitrogen also plays a major role in early establishment of the leaf area and root development which enable efficient use of available inputs. To sustain the productivity of crops, today's agricultural system heavily depends on the high application of N fertilizer (Evenson and Gollin, 2003) [4].

In recent years, excessive use of chemical fertilizers in India, have led to large scale deficiencies of N, P, S and Zn (Subba Rao *et al*., 1998; Ramesh *et al*., 2017) [16, 13]. Low soil organic carbon is one more major cause of deteriorating soil health and affecting sustainable productivity in this soil (Ghosh *et al*., 2003; Tomar and Dwivedi, 2007; Bandyopadhyay *et al*., 2010) [7, 17, 3]. In this region, the farmers mostly grow crops with less or imbalanced use of fertilizers without organics causing decline in crop yield and soil fertility. The application of organic manure is a widely accepted strategy to improve the soil fertility through increasing SOC stock and supplying more nutrients to crops (Manna *et al*., 2003; Meena *et al*., 2015) [9, 10]. However, neither organic manures nor chemical fertilizers alone can increase the crop productivity over the years (Prasad and Power, 1997) [12]. Therefore, the integrated nutrient management is crucial for maintaining higher crop productivity, sustainability and environmental quality (Narayan *et al*., 2014; Venkatesh *et al*., 2017) [11, 18].

Materials and Methods

A field experiment was carried out during the *kharif* seasons of the year 2021 and 2022 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The soil of experimental site was loamy sand in texture, having low in organic carbon (0.487%), available N (205.57 kg/ha), medium in available P_2O_5 (38.65 kg/ha) and available K_2O (265.48 kg/ha) with slightly alkaline condition (pH 8.01) and EC (0.250 dS/m). The soil was free from any kind of salinity and sodicity hazard. Pearl millet variety Gujarat Hybrid Bajra 1225 (GHB 1225) was used as a test crop in the study. Crop was sown on 9th June, 2021 and 16th June, 2022, respectively. The experiment was arranged in randomized block design with four replications, consisting of six treatments *viz*., T_1 (100% RDN through urea), T_2 (100% RDN through castor cake), T_3 (75% RDN through urea + Bio NPK consortium), T_4 (75% RDN through castor cake + Bio NPK consortium), T_5 (50% RDN through urea + 75% RDN through castor cake) and T6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium), each plot being 3.6 m × 6.0 m. Inorganic sources of N and P is urea and SSP, respectively. Whereas, organic sources are castor cake and Bio NPK consortium. Application of Bio NPK consortium as seed treatment (5 mL/kg) at the time of sowing and soil drenching of Bio NPK consortium (1 L/ha) of water at 31 and 38 DAS during the year 2021 and 2022, respectively. The crop was harvested on 3rd September, 2021 and 6th September, 2022, respectively. The ring lines were harvested first and aloofed from the experimental plots.

Results and Discussion

Effect on Chemical Properties of Soil Organic Carbon (%), EC (dS/m) and pH

An inspection of data presented in Table 1 showed that different nitrogen management treatments had a non-significant effect on organic carbon content (%), EC (dS/m) and pH of the soil after harvest of pearl millet crop.

Available N (kg/ha)

Mean data on available N status of soil after harvest of the crop as influenced by different nitrogen management treatments utilized their significant influence. Significantly higher available N was observed under treatment T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) which was at par with T_5, T_2, T_4 and T_1 during both the years. While, treatments T_5 and T_2 at par on the basis of pooled analysis.

Increase in available N might be due to combine application of organic and inorganic nutrient sources in which application of organic manure *i.e*., castor cake was decomposed slowly and release nutrient during the crop as well as due to Bio NPK consortium application helped out to fix more atmospheric nitrogen into the soil, which stimulates root development and growth of pearl millet. Further, direct addition of nitrogen through inorganic fertilizers and inoculation with Bio NPK consortium enhanced the activity of nitrogenase and nitrate reductase enzyme in the soil foremost to greater biological nitrogen fixation (BNF) by *Rhizobium* bacteria and facilitated in the mineralization of soil nitrogen leading to higher build-up of available N in soil. These results were in close conformity with results reported by Yadahalli *et al*. (2014) [20] and Bana *et al*. (2016) [2] in pearl millet.

Available P_2O_5 (kg/ha)

With respect to available P2O5 in soil as influenced by different nitrogen management treatments are presented in Table 2. Data indicated that the treatments have significant influence on available phosphorus in soil. Significantly higher available P_2O_5 in soil was obtained under treatment T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) which was statistically at par with treatment T_5 and T_2 during the year 2021 while statistically at par with treatment T_5 during the year 2022 as well as on pooled basis.

It might be due to addition of recommended nutrient doses along with organic manures like castor cake and Bio NPK consortium in soil through adequate quantity which increased efficiency of applied nutrients resulted in higher available phosphorus in soil. Present results are in conformity with findings of Fulpagare *et al*. (2018) [6] and Gudadhe *et al*. (2020).

Available K2O (kg/ha)

Data furnished in Table 2 indicated that different treatments exerted their non-significant effect on available K2O of soil after harvest of the pearl millet crop during both years and on pooled base analysis.

Significantly lower available N, P_2O_5 and K_2O were observed under treatment T_3 (75% RDN through urea + Bio NPK consortium).

Effect on Biological Property of Soil Microbial Count (CFU/g)

Outcome of various nitrogen management treatments on total microbial count (CFU/g) in soil after harvest of pearl millet crop is reported in Table 2.

Mean data on total microbial count (CFU/g) status of soil after harvest of the pearl millet as influenced by different

nitrogen management treatments utilized their significant influence on total microbial count status of soil. Significantly higher total microbial count was observed under treatment T_2 (100% RDN through castor cake) which was at par with treatments T_4, T_6 and T_5 during both the individual years as well as on the base of pooled analysis. Significantly lower microbial count was observed under treatment T_1 (100% RDN through urea).

Organic manure *viz*., castor cake releases nutrients more slowly than mineral nutrients which might contribute to the residual pool of organic nitrogen, phosphorus and potassium in the soil and reduced nutrient loss from the soil by improving soil organic matter. Organic manure of plant nutrients thus exerted long lasting residual effect on next crop by improving physico- chemical and biological properties of the soil. Moreover, total microbial count a resultant cumulative impact of applied combined application of castor cake and Bio NPK consortium. These findings are in line with the result reported by Yadahalli *et al*. (2014) [20].

Table 1: Organic carbon, EC and pH of pearl millet as influenced by various nitrogen management treatments

Treatments		Organic carbon (%)			EC (dS/m)			pH		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Initial value in soil		0.487			0.250			8.01		
T_1	100% RDN through urea	0.521	0.526	0.523	0.283	0.273	0.277	8.034	8.043	8.038
T_2	100% RDN through castor cake	0.537	0.539	0.538	0.268	0.266	0.266	8.058	8.075	8.066
T_3	75% RDN through urea + Bio NPK consortium	0.515	0.514	0.514	0.292	0.294	0.292	8.013	8.015	8.013
T_4	75% RDN through castor cake + Bio NPK consortium	0.528	0.531	0.529	0.273	0.270	0.271	8.013	8.148	8.080
T_5	50% RDN through urea + 75% RDN through castor cake	0.544	0.552	0.547	0.262	0.264	0.263	8.290	8.058	8.173
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium	0.558	0.559	0.558	0.259	0.263	0.260	8.050	8.055	8.052
S.Em.		0.019	0.019	0.013	0.011	0.010	0.007	0.340	0.333	0.238
C. D. at 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Y × T)		-	-	NS	-	-	NS	-	-	NS
C. V. (%)		7.17	7.16	7.17	8.56	7.87	8.22	8.43	8.26	8.35

Table 2: Available N, P2O5, K2O and microbial count of pearl millet as influenced by various nitrogen management treatments

Treatment		Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)			Microbial count (CFU/g)		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Initial value in soil		205.57			38.65			265.48			107.29×10^7		
T_1	100% RDN through urea	235.00	239.95	237.47	42.20	42.88	42.53	275.36	274.37	274.86	108.64	110.72	109.68
T_2	100% RDN through castor cake	243.98	246.19	245.08	45.16	44.68	44.92	278.16	279.45	278.80	135.05	136.33	135.69
T_3	75% RDN through urea + Bio NPK Consortium	217.22	221.56	219.38	40.84	41.42	41.12	272.60	273.66	273.12	120.08	122.19	121.13
T_4	75% RDN through castor cake + Bio NPK consortium	240.24	242.73	241.48	43.83	43.61	43.72	276.63	277.75	277.19	131.83	134.46	133.14
T_5	50% RDN through urea + 75% RDN through castor cake	252.50	254.41	253.45	48.18	47.69	47.93	282.90	281.47	282.18	126.40	127.64	127.01
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK Consortium	260.58	261.87	261.22	50.09	51.25	50.66	285.62	288.37	286.99	129.63	130.80	130.21
S.Em.		8.76	7.91	5.90	1.74	1.70	1.22	10.21	10.18	7.21	4.45	4.53	3.17
C. D. at 5%		26.43	23.85	17.05	5.27	5.13	3.52	NS	NS	NS	13.42	13.68	9.18
Interaction (Y × T)		-	-	NS	-	-	NS	-	-	NS	-	-	NS
C. V. (%)		7.26	6.47	6.87	7.76	7.52	7.64	7.33	7.29	7.31	7.11	7.14	7.12

Conclusion

It was concluded from the two years of experimentation that the chemical properties of kharif pearl millet in terms of organic carbon, EC, pH, available N, P_2O_5 and K_2O can be improved significantly by application of 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium while, in case of biological property like microbial count recorded higher with application of 100% RDN through castor cake. Thus, increment in growth and development was inturn enhance the yield and productivity of kharif pearl millet crop.

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