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Residual effect of nitrogen management and direct application of fertilizer on chemical and biological properties of soil of chickpea under pearl millet-chickpea cropping sequence

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Abstract
A field experiment was carried out during the *rabi* seasons of the year 2021-22 and 2022-23 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, with a view to study the residual effect of nitrogen management and direct application of fertilizer on chemical and biological properties of soil of chickpea under pearl millet-chickpea cropping sequence. The experiment was laid out in a Split Plot Design (SPD) with twelve treatment combinations. The results obtained from the experiment the significantly higher chemical properties of soil *viz*., available N and P_2O_5 were recorded higher in treatment combination with 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium to preceding *kharif*-pearl millet and 100% RDF direct application to succeeding chickpea. The organic carbon, EC, pH and available K_2O does not influenced by any treatment in chickpea. Biological property like total microbial count were recorded higher under treatment combination of 100% RDN through castor cake applied to previous pearl mill*et al*ong with 0% RDF to chickpea.

Keywords: Chickpea, SPD, RDN, RDF, castor cake, bio NPK consortium

Introduction
Pulses as a candidate crop, contributes immensely towards doubling farmers' income through diminishing cost of production, scaling per unit productivity, efficient marketing networks and successful technology delivery mechanisms by giving emphasis sustainable intensification and crop diversification, climate resilient production technologies backed with strong research outputs in pulses can contribute towards doubling the farmers' income (Singh, 2018) [11]. Pulses occupy a very important place in Indian diet because they constitute the major source of protein to the predominantly vegetarian population. About 65% of global area with 68% of global production of chickpea is contributed by India. In India, chickpea accounts for about 45% of total pulses production. India is the major chickpea producing country with 106 lakh ha. area and the production of more than 119 lakh tons and productivity of 1192 kg/ha (Anon., 2020-21). It is basically grown in the dried region of India. In Gujarat, it is grown in about 11.01 lakh ha. area with the production of 21.01 lakh tons and productivity of 1908 kg/ha (Anon., 2020-21) [1].
Chickpea (*Cicer arietinum* L.) is an important pulse crop with synonym Bengal gram, garbanzo (Spanish), chana (Hindi) and chanaka (Sanskrit). Chickpea is the largest produced food legume in South Asia and the third largest produced food legume globally, after the common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.). It is an important pulse crop grown and consumed all over the world. It is a good source of vitamins such as riboflavin, niacin, thiamin, folate, A precursor, β-carotene and the protein quality are considered to be better than other pulses. Chickpea is rich in nutritionally important unsaturated fatty acids like linoleic and oleic acid. It could have beneficial effects on some of the important human diseases like cardiovascular disease, type 2 diabetes, digestive diseases and some cancers.
Pearl millet-chickpea is one of the most prevalent cropping sequences followed in middle Gujarat. Nitrogen management give the valuable information about the effect of chemical fertilizer alone and in combination with organic manure on the soil fertility and crop productivity under intensive cropping. Integration of inorganic with organic manures will not only sustain the crop production, but also will be effective in improving soil health and

enhancing the nutrient use efficiency. Integrated use of organic manure and chemical fertilizers in sesame helps maintaining stability in crop production, besides improving soil physical conditions.

The basic concept of nitrogen management is the maintenance of soil fertility and supply plant nutrients to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. Nitrogen, phosphorus and bio-fertilizers like *Rhizobium* and phosphate solubilizing bacteria play a vital role in the nutrition of plants. In fact, these fertilizer nutrients are lacking mostly in the soils. Fertility analysis of Indian soils has indicated that the soils are deficient in micro-organisms and nutrients. Therefore, application of bio-fertilizers and inorganic fertilizers becomes essential to raise the crop yield. *Rhizobium* has an enormous potential to fix atmospheric nitrogen. Phosphate solubilizing bacteria (PSB) solubilize the unavailable bound phosphates of the soil and make them available to plants which increase overall plant growth resulting in 10 to 15% increase in yield.

The foresaid beneficial effects of symbiotic and free-living nitrogen fixing microbes, an attempt has been made to evaluate the associative effect of *Rhizobium* and Azotobacter on chickpea. Besides these bacteria, phosphate solubilizing microbes of different genus/species were also included in order to assess their effect on plant growth and yield under integrated farming. The extensive use of chemical fertilizers in agriculture is currently under debate due to environmental concern and fear for consumer health. Consequently, there has recently been a growing level of interest among the people to develop and adopt eco-friendly sustainable agricultural practices. In this context, increasing and extending the role of bioinoculants (Bio NPK consortium) may reduce the need of chemical fertilizers and thereby decrease adverse environmental effects (O'Connell 1992) [8].

Materials and Methods

The field experiment was carried out during *rabi* seasons of the year 2021-22 and 2022-23 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 reaction (pH 8.01), EC (0.250 dS/m). The soil was free from any kind of salinity and sodicity hazard. Chickpea variety "Gujarat Gram 5" (GG 5) was used as a test crop in the study. Crop was sown on 17th November, 2021 and 14th November, 2022, respectively. Twelve treatment combinations comprising six levels of nitrogen management (*Kharif*-Pearl millet) *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 T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) as main plot treatments as well as two levels of nitrogen management (*Rabi*-Chickpea) *viz*., S_1 (0% RDF) and S_2 (100% RDF) were relegated in sub plot treatments tested under split plot design which was replicated four times, each plot being 3.6 m × 3.0 m. Inorganic sources of N and P is urea and SSP, respectively. The crop was harvested on 9th March, 2022 and 28th February, 2023, respectively. The ring lines were harvested first and separated from the experimental plots.

Results and Discussion

Effect on Chemical Properties of Soil

Residual effect of nitrogen management

The data presented in table 1 revealed that effect of nitrogen management treatments and various fertilizer levels found non-significant result in the years 2021-22 and 2022-23 while, it influenced significantly with respect to organic carbon content in pooled analysis.

A perusal of data in Table 1 revealed that the effect of residual nitrogen management treatments influenced on organic carbon content found non-significant during the year 2021-22 and 2022-23. The treatment T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) was recorded significantly higher organic carbon content (0.588% on pooled basis) and treatment T_3 (75% RDN through urea + Bio NPK consortium) was recorded lower content of organic carbon (0.540% on pooled basis) in soil after harvest of crop.

These might be due to higher accumulation of organic carbon through application of castor cake and more turn-over of root biomass in castor cake and Bio NPK consortium along with fertilizer treatment which resulted in higher organic carbon in soil. These results are confirming the findings of Jangir *et al*. (2021) [4] and Dotaniya *et al*. (2022) [2].

The data on electrical conductivity and soil pH after harvest of chickpea are summarized in Table 1 designated that effect of residual nitrogen management treatments was found non-significant during the year 2021-22 and 2022-23.

Soil EC does not directly affect plant growth but has been used as an indirect indicator of the amount of nutrients available for plant uptake and salinity levels. In general, higher EC hinders nutrient uptake by increasing the osmotic pressure of the nutrient solution, wastes nutrients, and the increases discharged of nutrients. Higher EC may severely affect plant health and yield. Similar results find out by Meena *et al*. (2019) [6] and Dotaniya *et al*. (2022) [2].

Residual nitrogen management treatment T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) recorded significantly higher available N in soil and it was remained at par with the treatments T_5, T_2 and T_4 during the first year and remained at par with treatments T_5 and T_2 during the second year.

These findings might be due to collaborative effect of inorganic fertilizers and organic manures addition of passable quantity in soil. In addition of castor cake and Bio NPK increase the supply of easily assimilated major as well as micronutrient to plant and mobilizing unavailable nutrients into available forms. These results are in line with the findings of Gudadhe *et al*. (2015) [3] and Lakum *et al*. (2020) [5].

Analysis of data furnished in Table 2 indicated that the effect of residual nitrogen management treatments was found non-significant during the individual year whereas, it found significant in pooled analysis with respect to available P_2O_5 in soil after harvest of the chickpea.

Treatment T_6 (50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium) recorded significantly the highest available P_2O_5 (51.52 kg/ha) in soil after harvest of the crop on the pooled basis.

These might be due to synergistic effect of inorganic fertilizers and organic manures accumulation of adequate quantity in soil. In addition of castor cake and Bio NPK increase the supply of easily assimilated major as well as micronutrient to plant and mobilizing unavailable nutrients into available forms. These results further supported by Motaka *et al*. (2016) [7], Meena *et al*. (2019) [6] and Jangir *et al*. (2021) [4].

The data on available K_2O after harvest of chickpea are summarized in Table 2 indicated that residual nitrogen management treatments was found non-significant during the year 2021-22 and 2022-23 as well as in pooled analysis. The lower available N, P_2O_5 and K_2O were recorded under treatment T_3 (75% RDN through urea + Bio NPK consortium) during the year 2021-22, 2022-23 and on the base of pooled analysis, respectively.

Effect of fertilizer levels

It is apparent from the data presented in Table 1 and 2 that the organic carbon content, EC, pH, available P_2O_5 and K_2O after harvest of the crop were not influenced significantly due to various fertilizers levels treatment during the investigation period of both individual years as well as on their pooled analysis.

Analysis of data summarized in Table 2 further indicated that effect of various fertilizer levels on available N in soil after harvest of the crop was obtain significant during the year 2021-22, 2022-23 and on pooled basis. Treatment S_2 (100% RDF) recorded significantly higher available N while, treatment S_1 (0% RDF) revealed lower available nitrogen after harvest of chickpea.

It might be due to addition of RDF in soil through adequate quantity of inorganic fertilizers and residual organic manures like castor cake and Bio NPK consortium which in turn increased efficiency of applied nutrient which resulted in higher available N in soil. Similar results were reported by Shukla *et al*. (2013) [10] and Patel and Thanki (2020) [9] in chickpea.

Interaction effect

Interaction effect of residual nitrogen management treatments and various fertilizer levels had non-significant influence with respect to organic carbon content, EC, pH, available N, P_2O_5 and K_2O after harvest of chickpea.

Biological Property of Soil

Microbial count (CFU/g)

Residual effect of nitrogen management

It is apparent from the mean data presented in Table 2 that the total microbial count (CFU/g) after harvest of chickpea differed due to the influence of various nitrogen management treatments in both the years as well as on pooled basis. The treatment T_2 (100% RDN through castor cake) was recorded significantly higher total microbial count than rest of treatments followed by treatment T_4 and T_6 during both the individual years. The lowest microbial count was registered under the treatment T_1 (100% RDN through urea).

This might be attributed to the fact of various C: N ratio of the added organic sources of fertilizers *viz*., castor cake and Bio NPK consortium and their differential rate of decomposition to increase the microbial count of soil. The increases in microbial count of soil with the application of organics in aggregation with fertilizers might be due to the fact that it provides a composed supply of nutrients and the carbon for microbial cell proliferation, which was reflected in higher total microbial count. Similar results reported by Meena *et al*. (2019) [6] and Dotaniya *et al*. (2022) [2].

Effect of fertilizer levels

The mean data presented in Table 2 further designated that total microbial count (CFU/g) in soil after harvest of chickpea was affected non-significantly due to diverse fertilizer levels treatment during the individual years and on pooled basis.

Interaction effect

Interaction effect of residual nitrogen management treatments and various fertilizer levels treatment was found non-significant result of total microbial count after harvest of chickpea.

Table 1: Organic carbon, EC and pH of chickpea as influenced by residual effect of nitrogen management and fertilizer levels

Treatment		Organic carbon (%)			EC (dS/m)			pH		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot treatments (*Kharif*-Pearl millet)										
T_1	100% RDN through urea	0.545	0.557	0.551	0.147	0.149	0.148	8.207	8.208	8.207
T_2	100% RDN through castor cake	0.564	0.575	0.569	0.143	0.144	0.143	8.178	8.176	8.177
T_3	75% RDN through urea + Bio NPK consortium	0.536	0.543	0.540	0.150	0.151	0.150	8.230	8.231	8.230
T_4	75% RDN through castor cake + Bio NPK consortium	0.556	0.567	0.561	0.145	0.146	0.145	8.191	8.191	8.191
T_5	50% RDN through urea + 75% RDN through castor cake	0.575	0.583	0.579	0.140	0.141	0.141	8.163	8.164	8.163
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium	0.585	0.592	0.588	0.138	0.139	0.139	8.136	8.138	8.137
S. Em. ±		0.012	0.013	0.002	0.003	0.003	0.0006	0.240	0.249	0.043
C. D. at 5%		NS	NS	0.006	NS	NS	0.0019	NS	NS	NS
C. V. (%)		6.49	6.71	6.60	7.65	7.24	7.45	8.30	8.63	8.47
Sub plot treatments (*Rabi*-Chickpea)										
S_1	0% RDF	0.557	0.567	0.562	0.144	0.146	0.145	8.186	8.190	8.188
S_2	100% RDF	0.563	0.572	0.567	0.143	0.144	0.144	8.181	8.179	8.180
S. Em. ±		0.007	0.009	0.0008	0.001	0.001	0.0001	0.128	0.137	0.013
C. D. at 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Y × T)		NS	NS	NS	NS	NS	NS	NS	NS	NS
C. V. (%)		6.65	7.88	7.30	6.75	6.44	6.59	7.70	8.23	7.97

Table 2: Available N, P_2O_5, K_2O and microbial count of chickpea as influenced by residual effect of nitrogen management and fertilizer levels

Treatment		Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)			Microbial count ($\times 10^7$ CFU/g)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot treatments (*Kharif*-Pearl millet)													
T_1	100% RDN through urea	243.48	244.34	243.91	46.02	46.39	46.21	280.61	281.02	280.81	119.60	120.57	120.09
T_2	100% RDN through castor cake	256.46	257.68	257.07	48.19	48.67	48.43	284.96	285.52	285.24	143.23	144.09	143.66
T_3	75% RDN through urea + Bio NPK consortium	235.82	235.32	235.57	43.49	43.89	43.69	279.18	279.66	279.42	124.18	124.69	124.43
T_4	75% RDN through castor cake + Bio NPK consortium	250.32	252.03	251.18	47.66	48.08	47.87	283.13	283.61	283.37	140.00	140.43	140.21
T_5	50% RDN through urea + 75% RDN through castor cake	263.24	265.03	264.14	49.74	50.28	50.01	286.75	287.23	286.99	128.15	128.75	128.45
T_6	50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium	270.57	273.02	271.80	51.30	51.73	51.52	289.32	290.00	289.66	134.34	134.82	134.58
S. Em. ±		6.89	6.70	1.20	1.64	1.64	0.29	7.51	7.40	1.32	3.85	3.90	0.68
C. D. at 5%		20.76	20.19	3.47	NS	NS	0.84	NS	NS	NS	11.59	11.74	1.98
C. V. (%)		7.68	7.44	7.56	9.73	9.61	9.67	7.48	7.35	7.41	8.26	8.33	8.30
Sub plot treatments (*Rabi*-Chickpea)													
S_1	0% RDF	247.05	248.46	247.75	47.35	47.86	47.61	283.59	284.06	283.82	132.59	133.24	132.92
S_2	100% RDF	259.58	260.68	260.13	48.11	48.48	48.30	284.39	284.95	284.67	130.57	131.20	130.89
S. Em. ±		4.14	4.03	0.42	0.69	0.69	0.07	2.47	2.46	0.25	2.44	2.52	0.25
C. D. at 5%		12.30	11.99	1.20	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Y × T)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. V. (%)		8.00	7.76	7.88	7.11	7.06	7.08	4.25	4.23	4.24	9.09	9.33	9.21

Conclusion

In light of results obtained from the field experiment, it could be concluded that the crop should be fertilized with 50% RDN through urea + 75% RDN through castor cake + Bio NPK consortium to previous *kharif*-pearl mill*et al*ong with 100% RDF to succeeding chickpea securing the higher organic carbon, available N and P_2O_5 on soil parameters of chickpea.

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