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Effect of nutrient management on soil properties after harvest of Indian bean in Indian bean-summer sorghum cropping sequence

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Abstract
A field experiment entitled, "Effect of nutrient management on soil properties after harvest of Indian bean in Indian bean-summer sorghum cropping sequence" was conducted at College farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during kharif and rabi season of 2019-20 and 2020-21. The field experiment consisted of nutrient management treatments viz., T_1:- RDF (25 N-50 P_2O_5-00 K_2O kg/ha), T_2:- 75% RDF, T_3:- 75% RDF + Vermicompost @ 2 t/ha, T_4:- 75% RDF + FYM @ 5 t/ha, T_5:- 75% RDF + Biocompost @ 5 t/ha, T_6:- 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment, T_7:- 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment and T_8:- 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment to Indian bean in rabi season and all these treatments replicated three times in randomized block design. On the basis of two-year pooled results, it was observed that soil physical, chemical and biological properties after harvest of Indian bean showed significant improvement through integration of inorganics, organics as well as biofertilizer.

Keywords: Indian bean, nutrient management, soil physical, chemical and biological properties

1. Introduction
Pulses are the cheapest source of dietary protein; valuable animal feed, also plays a key role in improving and sustaining soil productivity on account of biological nitrogen fixation and addition of huge amounts of organic matter. Pulses are integral part of the cropping system because these crops fit well in the crop rotation and crop mixture and are most suited diversifying crops in cropping systems. In India pulses are grown in an area of 29.15 million hectares with total production of 25.41 million tonnes with productivity of 853 kg/ha during the year 2017-18 (Anonymous, 2018a) [2]. While, in Gujarat these are grown over an area of 6.6 lakh hectares with an annual production of 6.81 million tonnes with the productivity of 1029 kg/ha during the year 2018-19 (Anonymous, 2019) [3].

Among the pulses, Indian bean (*Dolichos lablab* L.) or dolichus bean or lablab bean or hyacinth bean is a native of India. It is commonly grown in almost all the states *viz.*, Madhya Pradesh, Uttar Pradesh, Maharashtra, Arunachal Pradesh, Tamil Nadu and Gujarat. Besides India, it also grown throughout the tropical regions of Asia, Africa and America. It is commercially grown for pods used as vegetable and for dry seeds used as pulses, however, regional preferences are existed in the cultivation of Indian bean. For instance, green shelled seeds are mostly preferred in south India, whereas white pods are liked in eastern India. In north India plains people like green pods has its own importance as tender immature green pods, cooked as vegetable alone or with potatoes. Dry seeds are used for pulse purpose. The foliage of Indian bean is used as hay, silage and green manure.

In Gujarat, Indian bean is the most important crop particularly grown in Navsari, Surat and Valsad districts. In South Gujarat, it is highly grown during *rabi* season in field vacated by *kharif* crops like rice, maize and millets. In Gujarat, Indian bean was cultivated in an area of 8.1 lakh ha with production of 15.6 lakh MT and productivity of 871 kg/ha during the year 2014-15 (Anonymous, 2016) [1]. To increase the production of any crops, a proper management practice has very much importance. Among the various practices, nutrient management has prime important as under absence of nutrients, plant growth is affected and ultimately resulted in poor yield.

Nutrient management is an age-old practice but its importance was not very much realized in pre green revolution era due to low nutrient demands of the contemporary subsistence agriculture. This approach of nutrient management aims at judicious use of all the major sources of plant nutrients in an integrated manner, so as to get maximum economic yield without any deleterious effect on physical, chemical and biological properties of the soil. Thus, the basic concept underlying the principles of nutrient management is the maintenance and possible improvement in soil fertility for sustained crop productivity on long term basis (Harisudan *et al*., 2009) [8].

2. Material and Methods

The investigation was conducted during *rabi* and *kharif* season of 2019-20 and 2020-21 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) to study the “Effect of nutrient management on soil properties after harvest of Indian bean in Indian bean-summer sorghum cropping sequence”. The soil of experimental field is having flat topography. The soil is characterized by medium to poor drainage and good water holding capacity. The field experiment consisted of nutrient management treatments *viz*., T_1:- RDF (25 N-50 P_2O_5-00 K_2O kg/ha), T_2:- 75% RDF, T_3:- 75% RDF + Vermicompost @ 2 t/ha, T_4:- 75% RDF + FYM @ 5 t/ha, T_5:- 75% RDF + Biocompost @ 5 t/ha, T_6:- 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment, T_7:- 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment and T_8:- 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment to Indian bean in *rabi* season and all these treatments replicated three times in randomized block design.

The Indian bean *cv*. Gujarat Wal- 2 was sown with spacing 60 × 30 cm in the month of October and harvested in the month of February during both the years. The recommended dose of fertilizers for Indian bean was 25 N + 50 P_2O_5 + 00 K_2O kg/ha. The Indian bean was fertilized as per treatments. The inorganic source of nitrogen was applied through urea whereas phosphorus was applied through DAP. The full dose of nitrogen and phosphorus were applied at the time of sowing as per the treatment. While the organic manure such as FYM, biocompost and vermicompost were applied to respective plot before the sowing of Indian bean as per the treatment. The remaining amount of the NPK consortia as soil treatment was mixed thoroughly with the organic manure and applied in the field as per treatment during both the years.

The composite soil samples were drawn from 0-22.5 cm depth before starting of experimentation and after harvest of each crop during both the years. The soil samples were dried under shade, ground and then sieved through 2 mm size sieve. The initial soil samples were analyzed for different physical, chemical and biological properties. The soil samples collected after harvest of Indian bean were used to determine bulk density, organic carbon, available nitrogen, phosphorus, potassium and microbial count by following prescribed standard method, which is depicted in Table 1.

Table 1: Physical, chemical and biological properties of soil (Initial)

Sr. No.	Particulars	Values (0-22.5 cm)	Methods adopted	Reference
I.	**Physical properties**			
1.	Mechanical composition		International pipette method	(Piper, 1966) [12]
	Fine sand (%)	20.24		
	Course sand (%)	1.76		
	Silt (%)	16.03		
	Clay (%)	61.57		
	Textural class	Clayey		
2.	Bulk density (g/cc)	1.38	Core method	(Black, 1986) [6]
II.	**Chemical properties**			
1.	pH (1:2.5 soil: water ratio)	8.2	Potentiometry pH meter	(Jackson, 1973) [9]
2.	EC at 25^0 C (dS/m) (1:2.5 soil: water ratio)	0.30	Conductometry EC meter	(Jackson, 1973) [9]
3.	Organic carbon (%)	0.41	Walkley and Black titration Method	(Jackson, 1973) [9]
4.	Available N (kg/ha)	198	Alkaline $KMnO_4$ method	(Subbiah and Asija, 1956) [13]
5.	Available P_2O_5 (kg/ha)	37.98	Olsen’s method	(Jackson, 1973) [9]
6.	Available K_2O (kg/ha)	314	Flame photometric method	(Jackson, 1973) [9]
III.	**Biological properties (Microbial population)**		**Media Used**	
1.	*Azotobacter* (× 10^7 cfu/g of soil)	5.36	Mannitol ashby agar	Serial dilution and spread plate count method
2.	*Acetobactor* (× 10^7 cfu/g of soil)	4.98	Mannitol ashby agar	
3.	*Rhizobium* (× 10^5 cfu/g of soil)	2.14	YEMA	
4.	PSB (× 10^7 cfu/g of soil)	4.93	Pikovsky’s	
5.	KSB (× 10^7 cfu/g of soil)	9.38	Aleksandrow agar	
6.	*Pseudomonas* (× 10^7 cfu/g of soil)	10.57	King’s B	

*PSB: Phosphate solubilizing bacteria and KSB: Potash mobilizing bacteria

3. Results and Discussion

That data pertaining to physical, chemical and biological properties of soil after harvest of Indian bean are presented in Tables 2, 3, 4 and 5.

3.1 Physical properties

Data furnished in Table 2 indicated that bulk density of soil decreased slightly with increasing level of manure application along with biofertilizer over initial (1.38 g/cc) as compared to application of inorganic fertilizer alone during both the years of investigation but different treatments of nutrient management did not exert any significant variation in bulk density. However, numerically maximum decrease in bulk density of soil was recorded with the application of 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_7) during both the years.

From the below results it indicates that reduction in bulk density was slightly decreased over initial (1.38 g/cc) in most of the treatments this may be due to various nutrient management treatments. It is a well-known fact that adding organic manures enhances soil aggregation resulting into more number of pore spaces in soil which improved the aeration in rhizosphere that promote the root growth and ultimately it increase the root biomass may also reduce the bulk density of soil. The results are in agreement with the findings of Barkha (2020) [5] and Joshi (2020) [10] with respect to greengram.

3.2 Chemical properties

The data on soil organic carbon, available nitrogen, phosphorous and potassium at 0-22.5 cm profile depth after harvest of Indian bean as influenced by various treatments are presented in Table 2 and 3.

The soil organic carbon, available nitrogen and phosphorous registered after harvest of Indian bean was significantly higher due to application of 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_8) and being remained at par with treatment 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_6), 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_7), 75% RDF + Biocompost @ 5 t/ha (T_5), 75% RDF + Vermicompost @ 2 t/ha (T_3) and 75% RDF + FYM @ 5 t/ha (T_4) during both the years. Significantly the lower organic carbon, available nitrogen, phosphorous was noted under the treatment receiving 75% RDF (T_2). However, different treatments had no significant effect on available potassium after harvesting of Indian bean during both the years.

This may be due to application of higher quantity of value-added organic sources in the form of vermicompost, FYM and biocompost and their complementary effects as well as due to biofertilizer positive effect. Moreover, Indian bean being is a leguminous crop which fixes atmospheric nitrogen in the soil, thus adding available N to soil. These findings are in close conformity with the results of Baldaniya *et al*. (2019) [4] and Desai *et al*. (2020) [7] with regards to Indian bean.

Table 2: Bulk density and organic carbon of soil as affected by different treatments after harvest of Indian bean

Treatments	Bulk density (g/cc)		Organic carbon (%)	
	2019-20	2020-21	2019-20	2020-21
T_1: RDF (25 N-50 P_2O_5-00 K_2O kg/ha)	1.412	1.407	0.403	0.413
T_2: 75% RDF	1.410	1.396	0.416	0.428
T_3: 75% RDF + Vermicompost @ 2 t/ha	1.402	1.394	0.431	0.440
T_4: 75% RDF + FYM @ 5 t/ha	1.394	1.383	0.453	0.462
T_5: 75% RDF + Biocompost @ 5 t/ha	1.397	1.387	0.461	0.466
T_6: 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment	1.398	1.392	0.444	0.455
T_7: 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment	1.373	1.370	0.470	0.475
T_8: 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment	1.382	1.375	0.482	0.488
SEm$\pm$	0.03	0.05	0.02	0.01
CD (P=0.05)	NS	NS	0.05	0.05
CV (%)	4.03	5.65	6.30	5.70
Initial	1.38		0.41	

Table 3: Available Nutrient status of soil as affected by different treatments after harvest of Indian bean

Treatments	Available Nutrient (kg/ha)					
	N		P_2O_5		K_2O	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1: RDF (25 N-50 P_2O_5-00 K_2O kg/ha).	200	205	37.58	40.29	296	308
T_2: 75% RDF.	196	199	36.83	37.56	288	300
T_3: 75% RDF + Vermicompost @ 2 t/ha.	216	218	40.13	43.36	309	317
T_4: 75% RDF + FYM @ 5 t/ha.	208	213	39.83	41.93	305	313
T_5: 75% RDF + Biocompost @ 5 t/ha.	221	224	41.99	44.29	313	320
T_6: 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment.	233	235	45.00	46.25	327	330
T_7: 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	229	230	43.89	45.92	319	326
T_8: 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	235	236	46.06	47.84	335	339
SEm$\pm$	8.90	8.28	2.04	1.90	14.13	11.69
CD (P=0.05)	27.01	25.12	6.19	5.77	NS	NS
CV (%)	7.10	6.52	8.53	7.58	7.86	6.35
Initial	198.40		37.98		313.83	

3.3 Biological properties

A perusal of data provided in Table 4 and 5 indicated that different nutrient management treatments exerted significant effect on *Azotobacter*, *Rhizobium*, phosphate solubilizing bacteria and potash solubilizing bacteria population after harvest of Indian bean. Significantly the higher population were noted under the application of 75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_6) during both the years and it remained statistically at par with treatments receiving 75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_7), 75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment (T_8), 75% RDF + Vermicompost @ 2 t/ha (T_3) and 75% RDF + FYM @ 5 t/ha (T_4). While, significantly lower population was noted under treatment receiving 100% RDF (T_1) during both the years. However, *Acetobacter* and *Pseudomonas* count was not affected significantly by different nutrient management practices during individual year.

The significant increase in microbial counts was observed with the addition of organic manures and inorganic fertilizer in combination with liquid biofertilizer. This could be due to cumulative effect of various sources of organic manures in increasing organic carbon content of soil which acted as carbon and energy source for microbes and their quick build up in the soil. Lower microbial population was noticed in chemical fertilizer treatment alone. Because it did not cause significant changes in the soil microbial population, growth and functioning of soil microbial counts as carbon substrate availability is limited. These results are in line with the findings of Meti *et al.* (2019) [11] in chickpea and Umadevi *et al.* (2019) [14] with respect to cowpea.

Table 4: *Azotobacter, Acetobactor and Rhizobium* population (cfu-Colony forming unit/g of soil) as affected by different treatments after harvest of Indian bean

Treatments	*Azotobacter* ($\times 10^7$)		*Acetobactor* ($\times 10^7$)		*Rhizobium* ($\times 10^5$)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1:RDF (25 N-50 P_2O_5-00 K_2O kg/ha).	6.36	6.48	5.33	5.91	5.35	5.57
T_2:75% RDF.	6.55	6.65	5.57	6.19	5.43	5.63
T_3:75% RDF + Vermicompost @ 2 t/ha.	7.24	7.54	5.88	6.60	5.95	6.07
T_4:75% RDF + FYM @ 5 t/ha.	7.16	7.39	5.81	6.47	5.83	6.01
T_5:75% RDF + Biocompost @ 5 t/ha.	6.91	7.30	5.71	6.31	5.72	5.91
T_6:75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment.	7.83	8.01	6.33	6.89	6.40	6.52
T_7:75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	7.67	7.85	6.23	6.80	6.23	6.36
T_8:75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	7.55	7.78	6.14	6.75	6.09	6.16
SEm$\pm$	0.23	0.21	0.21	0.20	0.22	0.20
CD (P=0.05)	0.68	0.62	NS	NS	0.67	0.60
CV (%)	5.45	4.84	6.08	5.42	6.55	5.66
Initial	5.36		4.98		2.14	

Table 5: *Phosphate solubilizing bacteria, Potash mobilizing bacteria and Pseudomonas* population (cfu-Colony forming unit/g of soil) as affected by different treatments after harvest of Indian bean

Treatments	*Phosphate solubilizing bacteria* ($\times 10^7$)		*Potash mobilizing bacteria* ($\times 10^7$)		*Pseudomonas* ($\times 10^7$)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1:RDF (25 N-50 P_2O_5-00 K_2O kg/ha).	6.06	6.55	10.73	11.13	10.51	11.52
T_2:75% RDF.	6.14	6.83	11.32	11.77	10.58	11.60
T_3:75% RDF + Vermicompost @ 2 t/ha.	6.67	7.12	12.23	12.74	11.46	12.36
T_4:75% RDF + FYM @ 5 t/ha.	6.55	7.01	11.93	12.48	11.28	12.25
T_5:75% RDF + Biocompost @ 5 t/ha.	6.44	6.96	11.66	12.25	10.93	12.15
T_6:75% RDF + Vermicompost @ 2 t/ha + NPK consortia @ 1 litre/ha soil treatment.	7.08	7.55	13.24	13.71	12.05	12.94
T_7:75% RDF + FYM @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	6.97	7.41	12.97	13.40	11.89	12.76
T_8:75% RDF + Biocompost @ 5 t/ha + NPK consortia @ 1 litre/ha soil treatment.	6.88	7.26	12.75	13.11	11.76	12.55
SEm$\pm$	0.21	0.20	0.48	0.48	0.35	0.31
CD (P=0.05)	0.63	0.59	1.46	1.45	NS	NS
CV (%)	5.42	4.77	6.91	6.60	5.42	4.34
Initial	4.93		9.38		10.57	

4. Conclusions

On the basis of two year experimental results, it can be concluded that integration of inorganic fertilizers (18.75 N-37.5 P_2O_5-00 K_2O kg/ha) with organic manure *viz.*, vermicompost @ 2 t/ha, FYM @ 5 t/ha and biocompost @ 5 t/ha as well as biofertilizer *viz.*, NPK consortia @ 1 litre/ha soil treatment to Indian bean crop enhanced soil physical, chemical and biological properties of soil after harvest of Indian bean crop in Indian bean-summer sorghum sequence under south Gujarat condition.

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