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Nutrient content and uptake of vegetable Indian bean (*Dolichus lablab* L.) as influenced by integrated nutrient management in Indian bean (V) - pearlmillet (F) sequence

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Abstract
A field experiment entitled "Nutrient content and uptake of vegetable Indian bean (*Dolichus lablab* L) as influenced by different INM treatments in Indian bean (v) - pearlmillet (f) sequence" was conducted at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the years 2019-20 and 2020-21. The field experiment consisted of integrated nutrient management treatments *viz.*, T_1 - 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM, T_2 - 75% RDN through chemical fertilizer + 25% RDN through biocompost, T_3 - 75% RDN through chemical fertilizer + 25% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers, T_4 - 50% RDN through chemical fertilizer + 50% RDN through biocompost, T_5 - 50% RDN through chemical fertilizer + 50% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers and T_6 - 100% RDN through biocompost to vegetable Indian bean in *rabi* season and replicated four times in randomized block design. On the basis of two year pooled results, the N content as well as N, P and K uptake by green pod and stover of vegetable Indian bean was significantly recorded higher values with respect to the treatment T_1while, P and K content in both green pod and stover was found to be non significant. However, the treatment T_6 recorded lower values with respect to N, P and K content and uptake by both green pod and stover. Significantly higher organic carbon content, available N, P_2O_5 and K_2O in soil after harvest of vegetable Indian bean was recorded in the treatment consisting of 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM (T_1) during both the years whereas, INM treatments failed to exert their significant influence on bulk density of the soil.

Keywords: Indian bean**,** integrated nutrient management, biocompost, FYM, biofertilizers

Introduction
The Indian bean (*Dolichus lablab* L.) belongs to the family leguminaceae and considered as nutritious vegetable as they contain high amount of vegetable protein, besides carbohydrates and vitamins. The green tender pods are used as vegetable and commonly known as 'Balar' and 'Valpapdi'. Indian bean is supposed to have originated in India as wild forms. From India, it might have been introduced in China, Western Asia and Egypt. In India, it is grown in almost all the states *viz.*, Gujarat, Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh and Tamil Nadu.

Indian bean is grown throughout the India and it needs cool climate and can be grown in any kind of soils. It is nutritious pulse food, being a good source of carbohydrates (6.7 g), protein (7 mg), thiamine (0.1 mg), riboflavin (0.06 mg) and vitamin 'C' (9 mg) 100 g^{-1} of its weight. It is also a good source of minerals as it contains 210 mg calcium, 74 mg potassium, 68 mg phosphorus, 55.4 mg sodium, 40 mg sulphur, 34 mg magnesium, 17 mg iron, 1 mg oxalic acid and 0.13 mg copper per 100 g of its weight (Choudhury, 1967) [6]. In Gujarat, Indian bean is the most important crop particularly grown in Navsari, Surat and Valsad districts of south Gujarat and is highly grown during *rabi* season when field vacated by *kharif* crops like rice, maize and millets.

In Gujarat, *rabi* Indian bean was cultivated in an area of 8.1 lakh ha with production of 15.6 lakh tonnes and productivity of 871 kg ha^{-1} during the year 2014-15 (Anon., 2016) [1]. Apart from recommended or cultivated varieties like Gujarat wal-1, Navsari wal-125-36, katargampapdi, kapasi and GNIB-21. A new variety GNIB-22 released in year 2017 and it became popular among the farmers of south Gujarat and found most promising for vegetable purpose due to its short stature plants, early picking and short maturity with higher sugar (24.1 mg g^{-1}) and better optimistic test and suitable as an intercrop.

As a result, the current trend is to investigate the option of supplementing fertilizers with organic manures and biofertilizers. Many nutrients are supplied to plants by biocompost and FYM and the carbon containing compounds provide food for soil flora and fauna. It also increases aeration and promotes healthy root development by providing sufficient pores in the rhizosphere. Biofertilizers are a relatively inexpensive source of nitrogen for crop production and they help to improve soil fertility by accelerating biological nitrogen fixation from the atmosphere, solubilizing insoluble nutrients in the soil, stimulating plant growth and development, maintaining soil reaction and improving the physico-chemical properties of the soil and thereby making nutrients easily available to the plants.

Material and Methods

A field experiment was carried out on "Nutrient content and uptake of vegetable Indian bean (*Dolichus lablab* L) as influenced by integrated nutrient management in Indian bean (vegetable) - pearlmillet (fodder) sequence" at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the year 2019-20 and 2020-21. The soil of the experimental field was clayey in texture and showed low in organic carbon (0.41%) and available N (198 kg ha^{-1}), medium in available P_2O_5 (38 kg ha^{-1}), very high in available K_2O (314 kg ha^{-1}), respectively. The soil was slightly alkaline in reaction (pH 8.03) with normal electrical conductivity (0.30 dSm^{-1}). The field experiment consisted of integrated nutrient management treatments *viz.*, T_1 - 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM, T_2 - 75% RDN through chemical fertilizer + 25% RDN through biocompost, T_3 - 75% RDN through chemical fertilizer + 25% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers, T_4 - 50% RDN through chemical fertilizer + 50% RDN through biocompost, T_5 - 50% RDN through chemical fertilizer + 50% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers and T_6 - 100% RDN through biocompost and replicated four times in randomized block design. The recommended dose of fertilizers for *rabi* vegetable Indian bean is 20 N + 40 P_2O_5 + 00 K_2O kg ha^{-1}.

The Indian bean cv. GNIB-22 was sown with spacing of 45 × 20 cm in the month of November and harvested in the month of February during both the years. The required quantity of organic manures *viz.*, well decomposed FYM and biocompost was incorporated and mixed well within the soil at the time of land preparation during both the years while, nitrogen was applied through urea (46% N) as per the treatments and common dose of 40 kg P_2O_5 was applied through single super phosphate (16% P_2O_5) as well as required quantity of both the fertilizer was applied as a basal dose in previously opened shallow furrows and seeds were inoculated with biofertilizers (*Rhizobium* + PSB each of 10 ml kg^{-1}) and dried under shade and were sown as per the treatments during both the years. The observations on N, P and K content (%) N, P and K uptake (kg/ha), Organic carbon (%), Available N, P_2O_5 and K_2O (kg/ha) was recorded. Plant samples of green pods and stover of Indian bean collected at harvest form each plot during both the years and were ground in willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen, phosphorus and potassium content from green pod and stover were estimated using standard procedures given by Jackson (1973) [9].

The nutrient (NPK) uptake of green pods and stover of Indian bean was worked out by using following formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)}}{100} \times \text{Yield (kg ha}^{-1})$$

The composite soil samples were drawn from 0-22.5 cm depth before starting of experimentation while, after harvest soil samples were taken separately from each net plots for 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 physico - chemical properties. The soil samples collected after harvest of Indian bean and fodder pearlmillet were used to determine available nitrogen, phosphorus and potassium.

Results and Discussion

That data pertaining to content and uptake of green pod and stover of vegetable Indian bean are presented in Tables 1 and 2 and graphically plotted in Figures 1 and 2. The results revealed that the N content in green pod and stover of Indian bean was found to be significant. While, P and K content was found to be non significant during both the years and in pooled analysis but the higher values of N, P and K content was observed in treatment T_1 (100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM). Similarly, uptake of N, P and K by green pod and stover were significantly influenced by various INM treatments and the higher values of all nutrients were found with treatment T_1 (100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM). Lower values of N, P and K content and uptake of N, P and K by green pod and stover was found under the treatment T_6 (100% RDN through biocompost).

The results presented in (Tables 1 and 2) were observed that the nutrient content and uptake improved through the integration of organic and inorganic sources. Among the various INM treatments investigated, treatment T_1 (100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM) was found to be effective in improving the nutrient content. The higher N, P and K content in green pod and stover was may be due to addition of both organic and inorganic sources, which resulted in the formation of clay-humus complexes in the soil, which promotes lower and prolonged availability to the crop. However, common phosphorous application and from organic sources such as FYM improved the available N, P_2O_5 and K_2O of the soil and thus, higher availability of nutrients to the plant and enhance root and early vegetative growth which increase photosynthetic activity in plant as evident from improvement of growth attributes recorded higher availability of metabolites from root to shoot and especially in the reproductive structure of vegetable Indian bean resulting in higher N, P and K content by crop.

Table 1: Nutrient content and uptake of vegetable Indian bean as influenced by different INM treatments (Two year pooled results)

Treatments	Nutrient content in green pod (%)			Nutrient uptake in green pod (kg/ha)		
	N	P	K	N	P	K
T_1: 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM	2.66	0.89	2.92	91.31	30.60	99.96
T_2: 75% RDN through chemical fertilizer + 25% RDN through BC	2.39	0.79	2.82	64.78	21.42	76.64
T_3: 75% RDN through chemical fertilizer + 25% RDN through BC + biofertilizers (PSB + *Rhizobium*) as a seed treatment	2.48	0.82	2.89	75.93	25.00	88.23
T_4: 50% RDN through chemical fertilizer + 50% RDN through BC	2.34	0.78	2.77	60.80	20.14	71.94
T_5: 50% RDN through chemical fertilizer + 50% RDN through BC + biofertilizers (PSB + *Rhizobium*) as a seed treatment	2.46	0.81	2.87	69.28	22.83	80.66
T_6: 100% RDN through BC	2.26	0.76	2.51	56.70	19.00	62.89
SEm±	0.05	0.02	0.07	2.63	0.98	2.63
CD (P=0.05)	0.13	NS	NS	7.59	2.82	7.59
CV (%)	5.25	8.15	7.25	10.64	11.92	9.29
General mean	2.44	0.81	2.80	69.80	23.16	80.05
Interaction (Y × T)						
SEm±	0.06	0.03	0.10	3.71	1.38	3.72
CD (P=0.05)	NS	NS	NS	NS	NS	NS

*RDN - Recommended dose of nitrogen, FYM - Farmyard manure, BC - Biocompost, PSB - Phosphorous solubilizing bacteria, CD - Critical Difference, CV – Co-efficient of Variation

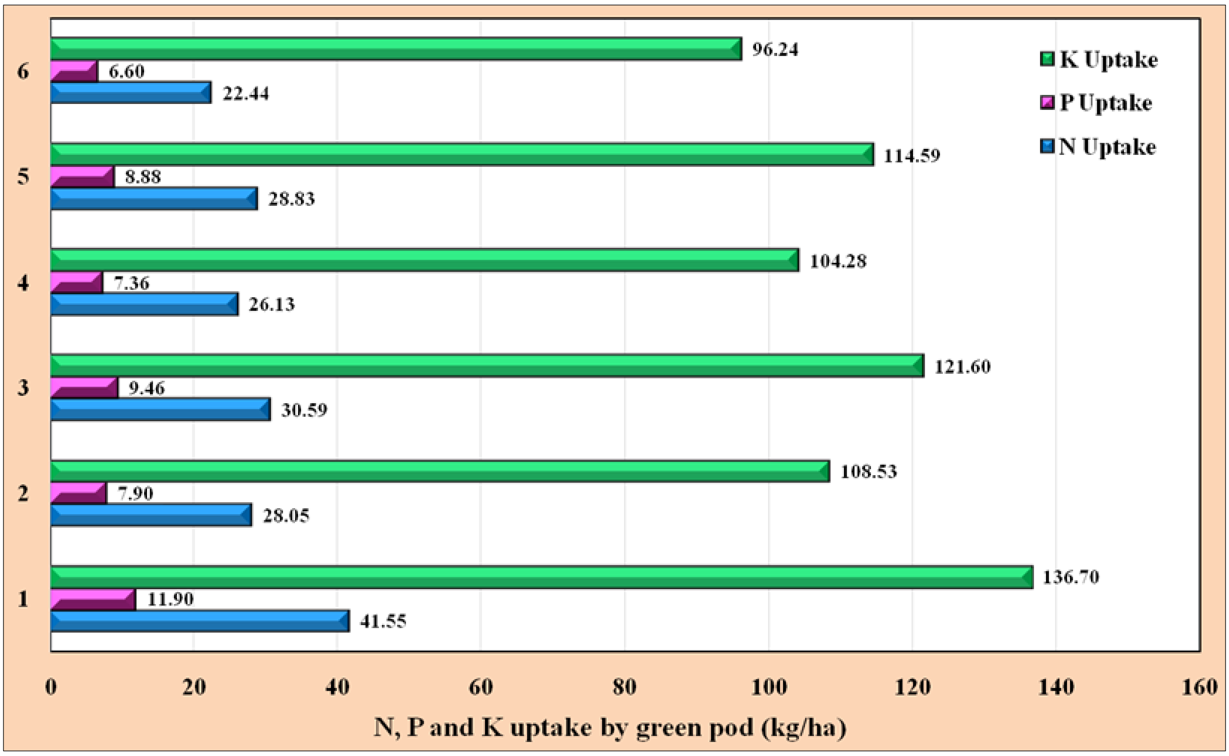

Fig 1: Nutrient uptake by green pod of vegetable Indian as influenced by different INM treatments

Table 2: Nutrient content and uptake of vegetable Indian bean as influenced by different INM treatments (Two year pooled results)

Treatments	Nutrient content in stover (%)			Nutrient uptake in stover (kg/ha)		
	N	P	K	N	P	K
T_1: 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM	1.18	0.34	3.88	41.55	11.90	136.70
T_2: 75% RDN through chemical fertilizer + 25% RDN through BC	0.95	0.27	3.67	28.05	7.90	108.53
T_3: 75% RDN through chemical fertilizer + 25% RDN through BC + biofertilizers (PSB + *Rhizobium*) as a seed treatment	0.98	0.30	3.87	30.59	9.46	121.60
T_4: 50% RDN through chemical fertilizer + 50% RDN through BC	0.90	0.25	3.61	26.13	7.36	104.28
T_5: 50% RDN through chemical fertilizer + 50% RDN through BC + biofertilizers (PSB + *Rhizobium*) as a seed treatment	0.94	0.29	3.74	28.83	8.88	114.59

T_6: 100% RDN through BC	0.83	0.25	3.58	22.44	6.60	96.24
SEm±	0.03	0.02	0.08	1.31	0.28	3.31
CD (P=0.05)	0.10	NS	NS	3.78	0.80	9.57
CV (%)	9.69	19.14	6.21	12.49	8.97	8.25
General mean	0.96	0.28	3.73	29.60	8.68	113.66
Interaction (Y × T)						
SEm±	0.05	0.03	0.12	1.85	1.76	4.69
CD (P=0.05)	NS	NS	NS	NS	NS	NS

*RDN - Recommended dose of nitrogen, FYM - Farmyard manure, BC - Biocompost, PSB - Phosphorous solubilizing bacteria, CD - Critical Difference, CV – Co-efficient of Variation

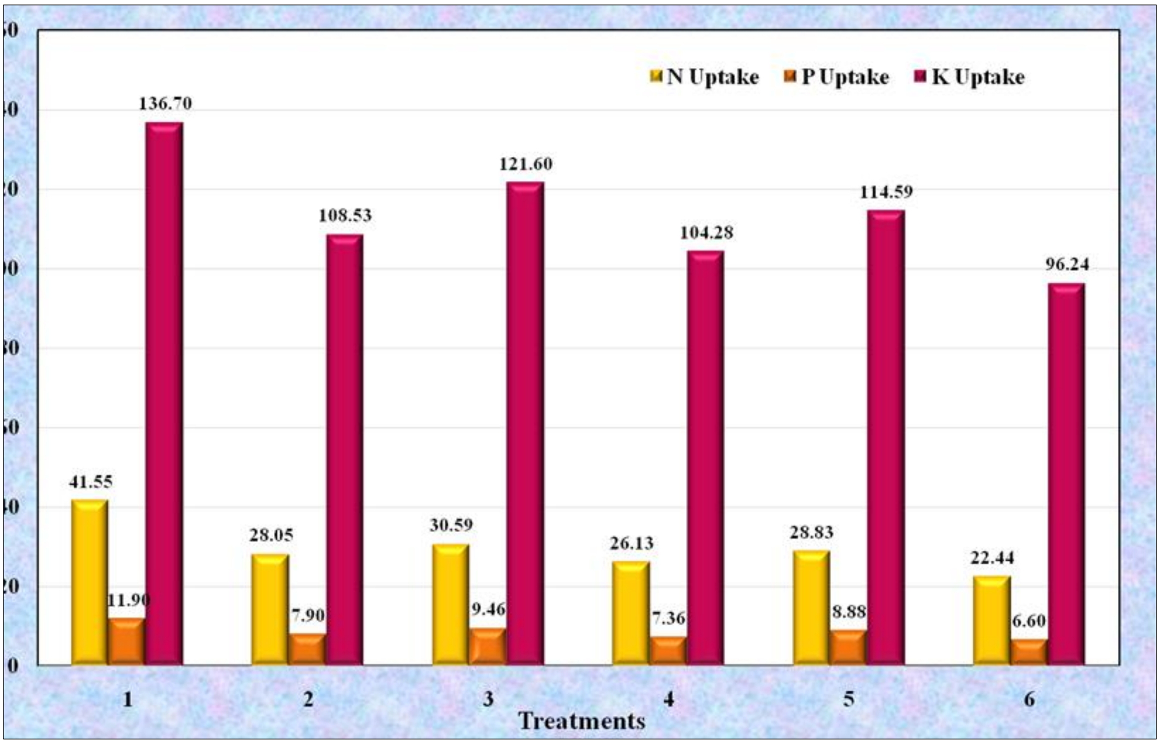

Fig 2: Nutrient uptake by stover of vegetable Indian as influenced by different INM treatments

Similarly, treatment T_1 was found to be effective in nutrient uptake as compared to other INM treatments. The uptake of nutrients by the crop is a function of nutrient content and yield/biomass produced. When organic manures are combined with chemical fertilizers, the pattern of nutrient release changes. Normally, they release nutrients at a slower rate at first, but when fertilizers like urea are applied, the C:N ratio decreases resulting in faster mineralization of nutrients from organic manures. Hence, greater amount of nutrients is available for uptake by the crop. Probably, due better nourishment of crop resulted in higher crop biomass production leads to higher uptake of N, P and K. The results are in close conformity with the findings of Talati (2004) [17, 18], Shete *et al.* (2010) [14], Upperi *et al.* (2011) [21], Kumar and Singh (2014) [10], Desai *et al.* (2020) [7] and Tyagi *et al.* (2014) [19].

The data on physical properties of soil *viz.*, bulk density, organic carbon and soil nutrient status after the harvest of vegetable Indian bean as influenced by different INM treatments are presented in Table 3 and revealed that different INM treatments failed to exert their significant influence on bulk density of soil after harvest of vegetable Indian bean in both the years. However, numerically lower value of bulk density of soil was recorded in the treatment involving 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM (T_1) during individual years of experimentation. The bulk density was slightly decreased over initial (1.386 g cc^{-1}) in most of the treatments this may be due to various INM 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) [4], Upperi *et al.* (2011) [21] and Prabhoo *et al.* (2017) [13].

The data pertaining to organic carbon content of the soil after the harvest of vegetable Indian bean are presented in Table 4.3. The data revealed that higher organic carbon content was recorded in the treatment consisting of 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM (T_1) during both the years, respectively. Although, it remained at par with treatment T_6(100% RDN through biocompost) in first year and with regards to second year it remained on par with treatments T_6 and T_5 (50% RDN through chemical fertilizer + 50% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers). However, lower organic carbon content was noticed under the treatment T_6 (100% RDN through biocompost) during both the years and in pooled results.

From the data presented in Table. 3, it is clear that organic carbon content in soil after the harvest of vegetable Indian bean was significantly influenced by the various INM treatments. All treatments of INM significantly improved the organic carbon content in the soil as compared to the initial

(0.41). This higher organic C value under INM treatments was primarily due to the use of biocompost and FYM, which increased root biomass in soil, may be due to favourable condition of rhizosphere, which increased nutrient availability and finally root growth, which also contributes to the soil organic C pool during decomposition. Almost similar results were observed by Babhulkar *et al*. (2000) [2] in soybean, Meena *et al*. (2016) [11] in green gram, Prabhoo *et al*. (2017) [13] in cowpea and Ullasa *et al*. (2018) [20] with respect to Indian bean.

The available nitrogen, phosphorus and potassium in soil significantly influenced by different INM treatments applied to vegetable Indian bean (Table 3) and revealed that the application of 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM (T_1) recorded significantly higher values with respect to available nitrogen, phosphorus and potassium in soil but it remained statistically at par with treatments T_3 (75% RDN through chemical fertilizer + 25% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers) and T_5 (50% RDN through chemical fertilizer + 50% RDN through biocompost + seed treatment with PSB and *Rhizobium* biofertilizers) during both the years while, in case of available nitrogen in soil it also remained at par with treatment T_3 in the year 2020-21. Although, lower values were obtained under the treatment T_6 (100% RDN through biocompost) during both the years.From the above results (Table 3), it indicates that the different INM treatments marked their significant influence on available N, P_2O_5 and K_2O status in soil after the harvest of vegetable Indian bean during both the years of experimentation. All treatments of INM were found comparatively good and appreciably improved soil available N, P_2O_5 and K_2O status over its initial status. This is most likely due to the incorporation of organic manures such as FYM, which contains nitrogen, phosphorous and potassium as well as nitrogen and phosphorous from inorganic sources. Moreover, Indian bean being a leguminous crop fixes atmospheric nitrogen in the soil, thus adding available N to soil. These findings are in close conformity with the results of Babhulkar *et al.* (2000) [2], Solanki (2003) and Talati (2004) [17, 18] with regards to soybean, Gorade *et al*. (2014), Meena *et al.* (2016) [11] and Patel *et al*. (2016) with respect to green gram, Prabhoo *et al.* (2017) [13] in cowpea, Sodavadiya (2017) [15], Baldaniya (2019) [3], Ullasa *et al.* (2018) [20] and Desai *et al.* (2020) [7] with respect to Indian bean.

Table 3: Physical properties and available nutrient status of soil as influenced by different INM treatments after harvest of vegetable Indian bean

Treatments	Bulk density (g cc^{-1})		Organic carbon (%)		Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	1.375	1.374	0.464	0.480	256	272	44	47	365	431
T_2	1.407	1.399	0.410	0.433	222	230	39	42	318	372
T_3	1.402	1.391	0.425	0.439	233	247	42	44	353	404
T_4	1.391	1.389	0.426	0.442	218	223	39	42	308	368
T_5	1.384	1.382	0.428	0.458	228	237	41	44	346	396
T_6	1.379	1.377	0.433	0.463	195	200	37	41	298	349
SEm±	0.020	0.017	0.010	0.010	11.21	13.99	1.25	1.37	15.25	15.95
CD (P=0.05)	NS	NS	0.031	0.029	33.78	42.18	3.77	4.14	45.97	48.08
CV (%)	2.859	2.491	4.706	4.199	9.94	11.92	6.22	6.35	9.20	8.25
General mean	1.390	1.385	0.431	0.453	225	235	40	43	331	387
Initial status	1.386		0.41		198		38		314	

T1: 100% RDN through chemical fertilizer + 5 t ha-1 of FYM, T2: 75% RDN through chemical fertilizer + 25% RDN through BC, T3: 75% RDN through chemical fertilizer + 25% RDN through BC + biofertilizers (PSB + Rhizobium) as a seed treatment, T4: 50% RDN through chemical fertilizer + 50% RDN through BC, T5: 50% RDN through chemical fertilizer + 50% RDN through BC + biofertilizers (PSB + Rhizobium) as a seed treatment, T6: 100% RDN through BC

Conclusion

On the basis of two year pooled results, it can be concluded that vegetable Indian bean should be fertilized with 100% RDN through chemical fertilizer + 5 t ha^{-1} of FYM along with 40 kg P_2O_5 for getting higher nutrient uptake and to maintain the physico-chemical properties of soil in vegetable Indian bean - fodder pearlmillet sequence under south Gujarat condition.

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