

Full Length Research Paper

Research on the effect of organic, inorganic and included use of nutrients on symbiotic parameters, yield, and quality of French-bean (*Phaseolus vulgaris* L.) vis-à-vis soil properties of an acid alfisol

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A field experiment was conducted on French bean with eight treatments in a randomized block design during the four years starting from 2005 to 2008 at the research farm of CSKHPKV, Palampur to assess the impact of different management practices on symbiotic parameters yield, and quality of French bean and soil properties. Organic and integrated nutrient management practices increased symbiotic parameters, green pod yield each year whereas yield decreased under chemical treatment. Both the strains of *Rhizobium phaseoli* found equally good under organic and integrated management practices. Soil chemical, physical and biological properties were found to be better under organic management practices than integrated nutrient management practices and chemical management practices. Soil chemical, physical and biological parameter decreased from its initial status under absolute control.

Key words: Organic, inorganic and integrated inputs, yield, *Phaseolus vulgaris*.

INTRODUCTION

Nutrient balance is the key component to increase crop yields. Excess and imbalanced use of nutrients has caused nutrient mining from the soil, deteriorated crop productivity and ultimately soil health. Replenishment of these nutrients through organics and in combination with organics and inorganics has a direct impact on soil health and crop productivity. In commercial agriculture, the use of chemical fertilizers can not be ruled out completely. However, there is a need for integrated application for alternate sources for nutrient for sustaining the desired crop productivity (Tiwari, 2002). It has been revealed from the studies on long-term fertilizer experiments that farmyard manure along with chemical fertilizers results in yield improvement and maintenance of soil fertility (Swarup, 1998). Integrated farming system is an agricultural system conceived so as to have least impact

on the environment. The importance of combating environmental degradation on one hand and awareness of food quality on the other has lead to increase calls for a shift in our farming system based on organic inputs. Organic inputs include organic manures, crop residues and Biofertilizers. These are low-cost and eco friendly inputs have tremendous potential for supplying nutrients which can reduce the dependence of chemical fertilizers. The use of organic soil amendments has been associated with desirable soil properties including higher plant available water holding capacity and cation exchange capacity and lower bulk density, and can foster beneficial microorganisms (Doran, 1995; Drinkwater et al., 1995). Benefits of compost amendments to soil include pH stabilization and faster infiltration rate due to enhanced soil aggregation (Stamatiadis et al., 1999).

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Table 1. Details of various treatments.

Treatment	Detail
T ₁	Organic (10 t of farmyard manure per ha +nitrogen fixer-A, phosphate solubilizer and chopped crop residues of same plot)
T ₂	Organic (10 t farm yard manure per ha +nitrogen fixer-B, Phosphate solubilizers and chopped crop residues of same plot)
T ₃	Integrated (5 t of farmyard manure per ha+nitrogen fixer-A phosphate solubilizer+half dose of P ₂ O ₅)
T ₄	Integrated (5 t of farmyard manure per ha +Nitrogen fixer-A+half nitrogen + phosphate solubilizer+half dose of P ₂ O ₅)
T ₅	Integrated (5 t of farmyard manure per ha +nitrogen fixer-B + phosphate solubilizer+half dose of P ₂ O ₅)
T ₆	Integrated [5 tonnes of farm yard manure per ha+ Nitrogen fixer-B+half dose of nitrogen+ phosphate solubilizer+half dose of P ₂ O ₅)
T ₇	Chemical fertilizer (Recommended dose of N, P ₂ O ₅ and K ₂ O)
T ₈	Control (No fertilizer or farm yard manure)

Also organic management resulted in significantly higher soil enzyme activities (Garcia-Ruiz et al., 2008).

French bean is commercially cultivated in Himachal Pradesh, Jammu and Kashmir, hills of Uttrakhand, North-Eastern states and peninsular India, covering an area of about 0.15 m ha with annual production of 4,20,000 tonnes (Anonymous, 2007). Being a legume crop, its nutrient requirement from external sources is less as compared to cereal crops. Supply of nutrients from organic management is less and spontaneous as compared to integrated management and chemical management. So crop having low nutrient requirement may emerge as a potential crop under organic management without losing remunerative price to farmers and additional benefits to assess the impact of organic management on soil properties and crop quality. Hence the studies with the objective to assess the impact of different management practices on productivity, quality of French bean and soil properties were under taken.

MATERIALS AND METHODS

Site

The experiment with French bean (*Phaseolus vulgaris* L.) was initiated during the 2005 at Palampur (32°N, 76°E, 1260 masl) representing the wet temperate zone of the western Himalayas. The area received mean annual rainfall was 2443 mm (averaged for 2005-2008) with June to September being the wettest months. Initial analysis of experimental soil (0-0.15 m) were recorded: Acidic, with a pH of 5.7 (1:2.5 soil:water); 9.9 g kg⁻¹ organic carbon (Walkley and Black, 1934); 325, 24.2 and 212.5 kg ha⁻¹ of available N (Subbiah and Asija, 1956), P (Olsen et al., 1954) and K (Black, 1965), respectively; and 1.24 Mg m⁻³ bulk density (Singh, 1980), 16.5% available water content and 51.5% water holding capacity

(Keen's box method, Piper, 1950). The biological properties viz. 120 µg g⁻¹ microbial biomass carbon (Vance et al., 1987), 1.2 µg triphenyl formazan (TPF) g⁻¹ hr⁻¹ dehydrogenase activity (Casida et al., 1964), 2.8 µg g⁻¹ min⁻¹ urease (Tabatabai and Bremner, 1969) 5.8 µg g⁻¹ microbial respiration (Primer and Schmidt, 1964). The soil texture is silty clay loam with 29, 47 and 24% sand, silt and clay respectively, and illite is the dominant clay mineral.

Experimental design and analysis

The field experiment was conducted on French bean during the four years starting from 2005 to 2008 at the research farm of CSK HPKV; Palampur falling in mid hills wet temperate zone of Himachal Pradesh. The treatments details are presented in Table 1.

Eight treatments were evaluated in a randomized block design with three replications. The recommended dose for French bean is 50 kg nitrogen, 100 kg P₂O₅ and 60 kg K₂O on hectare basis. On an average farmyard manure contained 0.60%N, 0.15% P and 0.54% K. The N, P and K were applied as urea, single super phosphate and muriate of potash respectively. The full amount of farmyard manure, P and K; whole of N was applied at sowing time. The Rhizobium culture was applied as seed treatment and phosphorus solubilizing bacteria through farmyard manure at sowing. The seeds were sown by dropping them manually at a spacing of 60 × 15 cm in the 2nd week of April each year. Symbiotic parameters viz. nodule number and nodule weight were recorded at the flowering stage in each year. The pods were picked at 10 day intervals and yield was calculated by adding the three pickings.

RESULTS

Symbiotic parameters

Nodule number

Nodule number per plant was recorded at flowering stage

Table 2. Effect of organic, inorganic and integrated use of nutrients on symbiotic parameter, yield attributes, green pod yield and quality of green pods (Data pooled over for four years).

Treatment	Nodule number pooled over four years	Nodule weight (mg plant ⁻¹) pooled over four years	No. of pods plant ⁻¹ pooled over four years	Yield in t ha ⁻¹				Pooled yield four years (t ha ⁻¹)	Nitrogen in green pods pooled over four years	Protein in green pod (%) pooled over four years
				2005	2006	2007	2008			
T ₁	17	45.7	20	6.14	10.6	5.76	5.97	7.12	3.7	22.9
T ₂	16	43.4	22	6.09	11.1	5.55	5.68	7.10	3.8	23.3
T ₃	14	30.8	26	6.54	13.6	6.17	6.24	8.15	3.5	21.6
T ₄	12	18.7	28	6.94	14.2	6.82	7.06	8.73	3.0	18.5
T ₅	15	31.8	25	6.60	14.6	5.87	6.13	8.31	3.4	21.0
T ₆	12	22.4	29	7.14	14.8	6.58	6.94	8.92	3.0	18.4
T ₇	5	2.5	30	7.24	12.1	5.02	5.12	7.35	3.2	19.8
T ₈	9	14.3	14	3.41	7.60	3.56	3.94	4.63	2.9	17.9
CD(P0.05)	2.6	4.7	5.7	0.784	1.47	0.379	0.485	0.692	0.43	2.28

each year and pooled data for four years are presented in the Table 2. It is evident from the table that number of nodule differed significantly. The maximum nodule number was recorded in T₁ (organic) and minimum was in T₇ (chemical fertilizer). Treatment T₇ recorded lesser nodule number than the absolute control, akin to T₇, application of nitrogenous fertilizers (T₄ and T₆) recorded lesser nodule number than T₃ and T₅.

Nodule weight

Nodule weight per plant recorded at flowering time differed significantly in each treatment except T₁ and T₂, T₄ and T₆. Minimum nodule weight was recorded in T₇.

Yield attribute and yield

Number of pods

Number of pods per plant was recorded at each

harvesting time and sum up to find out the total number of pods per plant at each season and the pooled data of four seasons are presented in Table 2. It is discernible from the data that the maximum number of pods was recorded in chemical fertilizer applied treatments followed by integrated use of nutrients, organic treatments and control respectively. Application of nitrogenous fertilizer in integrated treatments T₄ and T₆ gave numerically more number of pods than T₃ and T₄ and numerically less number of pods than chemical treatments. Control treatment recorded minimum and significantly less number of pods than other treatments. Numbers of pods under organic treatments were significantly higher than control and lower than chemical and integrated treatments.

Green pod yield

From the pooled data of green pod yield, it is inferred that application of nitrogenous fertilizer in integrated treatments T₆ and T₄ was found to be

statistically and numerically superior to other treatments (Table 2). Integrated use of nutrients gave significantly higher pod yield than other treatments. The minimum and significantly lower pod yield was recorded in control than other treatments. Pod yield under organic treatments was significantly at par with the chemical treatment and statistically superior to control and statistically inferior to integrated use of nutrients. Both the organic treatments are statistically at par with each other showing the nitrogen fixer A and B are considered equally good as for as nitrogen fixation is concerned.

Quality parameters of green pods

Nitrogen

Nitrogen content in green pod was determined each year and the pooled data are presented in Table 2. It is discernible from the table that maximum nitrogen content was recorded in organic treatments, which was significantly better

Tables 3. Effect of organic, inorganic and integrated use of nutrients on soil chemical, physical and biochemical properties after four years.

Treatment	Chemical properties				Physical properties				Biological properties				
	Organic carbon (g kg ⁻¹)	Available Nitrogen (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (cmol)	exchange capacity (p+)kg ⁻¹)	Bulk density (Mg m ⁻³)	Available water content (%)	Water holding capacity (%)	Biomass carbon (µgC g ⁻¹)	Dehydrogenase activity (µgTPFg ⁻¹ h ⁻¹)	Urease activity (µgg ⁻¹ min ⁻¹)	Phosphatase activity ((µg g ⁻¹ h ⁻¹)	Microbial Respiration (µg g ⁻¹ h ⁻¹)
T ₁	12.5	350	26.4	245	12.8	1.36	18.6	55.1	176	2.4	3.4	2.2	11.6
T ₂	12.3	380	25.8	252	12.9	1.34	17.6	52.8	168	2.5	3.3	2.6	11.3
T ₃	11.5	385	27.4	258	13.2	1.28	16.5	50.8	166	2.2	5.4	1.9	10.3
T ₄	11.7	390	27.7	254	13.4	1.28	17.2	50.3	156	2.1	5.6	2.0	7.2
T ₅	11.1	425	29.6	258	13.6	1.31	16.8	49.7	137	2.6	5.5	2.1	8.9
T ₆	11.2	428	32.7	260	13.7	1.30	17.3	50.9	130	2.7	5.9	3.1	7.6
T ₇	10.9	365	26.6	195	12.5	1.27	16.2	51.2	112	2.3	4.3	1.5	7.0
T ₈	10.1	312	23.0	190	11.9	1.23	16.0	50.3	98	1.8	2.6	1.3	5.2
CD(P0.05)	0.72	20.9	3.4	14.5	0.55	0.012	NS	2.3	9.8	0.3	0.12	0.24	0.90
Initial	9.9	325	24.2	212.5	11.6	1.24	16.5	51.0	120	1.7	2.8	1.2	5.8

than rest of treatments except T₃ and T₅. Both the organic treatments were at par with each other. Control treatment gave the minimum nitrogen content which was significantly at par with treatments T₇, T₄ and T₆ and significantly lowers than treatments T₂, T₁, T₃ and T₅.

Protein content

Protein content in green pod was determined each year and the pooled data are presented in Table 2. It is discernable from the data that protein content in green pod was maximum in organic treatment and minimum in control. A numerical decrease in nitrogen content was also observed in T₄ and T₆.

Soil properties

Soil chemical, physical and biological properties

are studied after four year of experimentation and the results are presented in Table 3.

Soil chemical properties

Organic carbon: On the perusal of data, it is clear that soil organic carbon level increased from initial levels (9.9 g kg⁻¹) in all the treatments. Organic carbon level differed significantly under all the treatments over control. The maximum organic carbon was recorded in organic treatment T₁ and the minimum was recorded in control treatment. Both the organic treatments were significantly at par.

Cation exchange capacity (CEC): It varied from 11.9 cmol (p+) kg⁻¹ in T₈ to 13.7 in T₆. The highest was recorded in T₆ which was at par with T₅. The values were significantly higher in integrated treatments than organic treatments.

The organic treatments contained significantly higher values than control.

Available nitrogen: It is discernable from Table 3 that available nitrogen in soil differed significantly. The available nitrogen content was the maximum in T₆ and the minimum was recorded in control treatment. Available nitrogen content in control treatment decreased from its initial value (325 kg ha⁻¹) whereas the available nitrogen in rest of the treatments increased from its initial levels. The minimum increase was in chemical fertilizer applied treatment, followed by organic treatment and integrated treatments, respectively. Available nitrogen was more in integrated treatments as compared organic treatments.

Available phosphorus: Available phosphorus was determined by standard method and the data are presented in Table 3. It is depicted that available phosphorus in soil in different

treatments differed significantly. The available phosphorus content was the maximum in T₆ and the minimum was recorded in control treatment. Available phosphorus content in control treatment decreased from its initial value (24.2 kg ha⁻¹) whereas the available phosphorus in rest of the treatments increased from its initial levels.

Available potassium: It is discernable from data that available potassium in soil differed significantly. The available potassium content was the maximum in T₆ and the minimum was recorded in control treatment. Available potassium content in control treatment and chemical fertilizers applied treatment decreased from its initial value (212.5 kg ha⁻¹) whereas the available potassium in rest of the treatments increased from its initial levels. The minimum increase was recorded in organic treatments followed by integrated treatments, respectively. Available potassium was more in integrated treatments as compared organic treatments.

Physical properties

Bulk density: On the perusal of data from Table 3 it is evident from table that soil bulk density differed significantly in all the treatments except in integrated treatments that is, T₃ and T₄, and T₅ and T₆. The maximum bulk density was recorded in organic treatment T₁ and the minimum was recorded T₈ treatment. The bulk density in all the treatments increased from its initial value (1.24 Mg m⁻³) except control, where it decreased (1.23 Mg m⁻³) numerically, whereas, in rest of the treatments, it increased significantly.

Water holding capacity: Water holding capacity of experimental soil was determined by standard method and results are presented in Table 3. It is discernable from the table that water holding capacity did not differed significantly; however, it increased in all the treatments from its initial value (51%) except in control. In control treatment, it has decreased numerically from its initial value. The maximum water holding was recorded in organic treatment T₁ and the minimum was recorded T₈ treatment. Integrated treatment gave numerically less water holding values than the chemical fertilizers applied treatments.

Available water: On the perusal of data from Table 3, it is evident from the table that the available water content did not differed significantly. It was numerically lowest in the control and was numerically higher in the organic treatments T₁ and T₂ than rest of the treatments. The available water content in control and chemical fertilizers applied treatments decreased from its initial status (16.8%) and the rest of treatments gave numerically higher value of available water than the initial status.

Soil biological parameters

Microbial biomass: On the perusal of data from Table 3, it is evident that the contents of biomass carbon varied significantly under different treatment. The contents of biomass carbon have decreased from its initial status (120 µg Cg⁻¹) in control and chemical fertilizers applied treatments, but the decrease was more in control treatment than chemical fertilizers applied treatment. The contents of biomass carbon were the highest under organic treatment followed by integrated nutrient management. The biomass carbon content decreased from 176 in T₁ to 98 µg Cg⁻¹ in the control.

Dehydrogenase activity: The activity was significantly higher in organic and integrated treatments than the chemical one.

Phosphatase activity: The activity of phosphatase enzyme differed significantly amongst all the treatments (Table 3). The minimum phosphatase activity was recorded in control and maximum was found in integrated nutrient management treatment where each of the organic, inorganic and biofertilizers were used. Significantly highest activity was found in T₆ followed by T₅ and T₂.

Urease activity: The activity varied from 2.6 to 5.9 µg g⁻¹ min⁻¹. The value was significantly higher in the treatments where chemical fertilizer and integrated treatments were used. The values in the organic treatments were significantly lower than the integrated treatments.

Microbial respiration: Microbial respiration was measured by CO₂ evolved. It was minimum in the control and maximum in the organic treatments followed by T₃. This is also an index of higher organic carbon content of the organic treatments. Application of alone fertilizer treatment T₇ and other integrated treatments except T₃ resulted in lesser microbial respiration in comparison with organic treatments.

DISCUSSION

Nodule number

Organic treatment (T₁ and T₂) gave higher nodule number than integrated treatments indicating that application of organic enhanced the microbial activity, however integration of nutrients increased yield and other yield attributes, indicating the enhancement of nutrients availability which resulted higher yield and yield attributes. The results are in close proximity with Kundu et al. (1996) who reported that application of farm yard manure incorporation resulted in increase in N₂ fixation in soybean. Application of chemical fertilizer alone

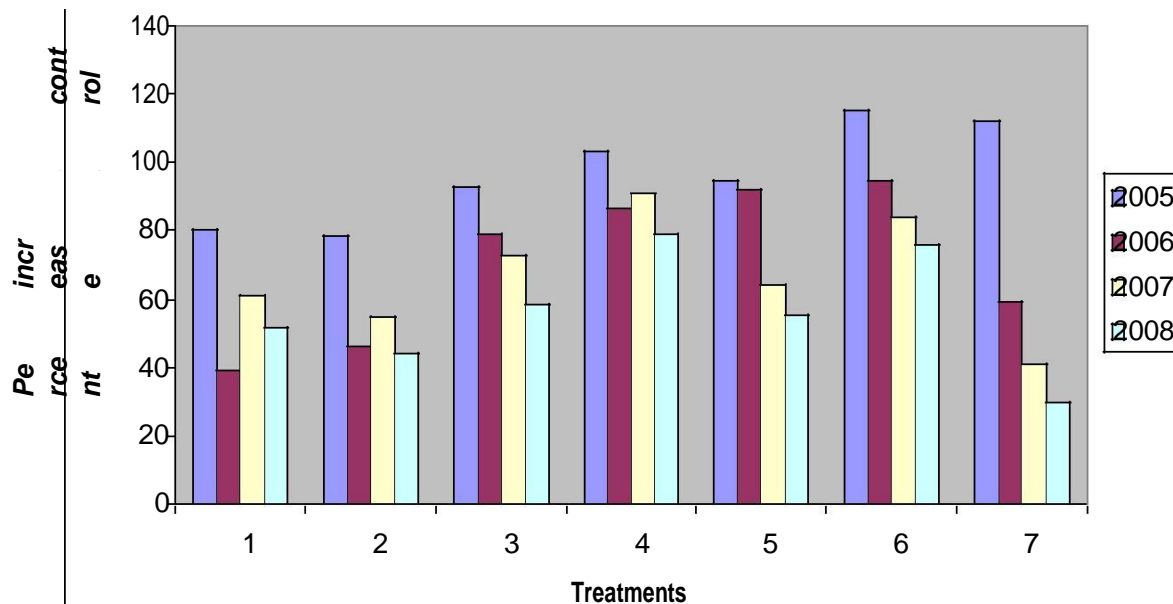


Figure 1. Percent increase in pod yield in each treatment during different years.

suppresses the microbial activity than control resulted in poor nodule number in chemical applied treatments than absolute control. Results are corroborated with the findings of Pathak et al. (1999).

Nodule weight

Minimum nodule weight was recorded in T₇, favoured our observation that application of organic enhanced microbial activity and application of nitrogenous fertilizer enhance nutrient mobility and availability and suppressed the microbial activity. Among the soil chemical factors that influence symbiotic nitrogen fixation in legume crops, mineral nitrogen concentration is the most important one. Based on several studies, nodulation and /or nitrogen fixation was reduced by approximately 50% in different legumes, when nitrogen concentration in root environment was between 20 and 90 mg kg⁻¹ in the growth medium. The suppression in symbiotic nitrogen fixation is particularly due to nitrate fraction in the root growth environment (Streeter, 1988). In the present findings application of chemical fertilizers suppressed the nodule formation owing to readymade supply of nitrogen from the soil which resulted in poor symbiosis between the plant and Rhizobia caused poor nodulation in chemical fertilizer applied treatments rather than the control.

Number of pods

It is discernible from the data that the maximum number of pods was recorded in chemical fertilizer applied

treatments followed by integrated use of nutrients, organic treatments and control respectively. Similar results were reported by Datt et al. (2003) who found that application of chemical fertilizer alone gave numerically more number of pods per plant than integrated application of chemical fertilizers and FYM in Lauhal valley in Himachal Pradesh. Application of nitrogenous fertilizer in integrated treatments T₄ and T₆ gave numerically more number of pods than T₃ and T₄ and numerically less number of pods than chemical treatments. Control treatment recorded minimum and significantly less number of pods than other treatments.

Green pod yield

Both the organic treatments are statistically at par with each other show the nitrogen fixer A and B are considered equally good as far as nitrogen fixation is concerned. It can be inferred from the data in Figure 1 that there was increase in yield in the treatments where farmyard manure was applied along with biofertilizers, that is, difference of 5 t FYM in these treatments produced yield equivalent to the yield produced by half dose of phosphorus and full dose of potassium. The results are in accordance with the findings of Singh et al. (2008) who reported that the reduction to the tune of 25% in recommended dose of N, P and K could be made with the application of farmyard manure. An increase in yield during all the years (except 2006) has been observed in treatments T₄ and T₆ when farmyard manure was added with chemical fertilizers and biofertilizers. In other words the percent increase over control decreased slowly in treatments where farmyard manure and biofertilizers

were added and there was sharp decrease in percent increase data in T₇ where FYM was not added (Figure 1). While comparing the results of 2005 and 2008 the maximum decrease was noticed in T₇, That is, from 112.3 to 29.3%. Application of half doses of nitrogen under integrated nutrient management along with biofertilizers proved to be more sustenance than organic treatments and integrated treatment without nitrogen. It might be due to fact that the application of nitrogen in presence of organic manures helps the mineralization by minimizing C/N ratio. In organic treatments the percent increase over control in third and fourth year was more as compared to chemical fertilizers treatment. Organic treatments gave consistently better increase in green pod yield during subsequent years. Integrated treatments gave better increase in yield during subsequent years. The results are corroborated the finding of Sharma et al. (2002) who reported maintenance of yields with the use of farmyard manure and NPK in a long term fertilizer experiment. The higher yield because of farmyard manure along with biofertilizers may be owing to nutrients supplied by farmyard manure and biofertilizers (Sharma et al., 1988) and improvement on physical properties which led to better soil physical health (Sharma, 1986) and improvement in physico-chemical properties (Veerabhadraiah et al., 2006). Organic fertility amendments enhanced beneficial microorganisms, increased soil organic matter, total carbon, cation exchange capacity and lowered bulk density thus improved soil quality which ultimately increased the yield of tomato during the 2nd year of study (Bulluck et al., 2002). It is revealed from data of T₁ and T₂ that biofertilizers and farmyard may prove an important input in organic farming.

Quality parameters of green pods

Nitrogen

Application of nitrogen through chemical fertilizers decreased nitrogen content in comparison to treatments where nitrogen was not applied through chemical fertilizers. It might be due to fact that the application of nitrogen through fertilizer enhances the nitrogen availability rapidly whereas, nitrogen from organic sources act slow and spontaneous may caused better nitrogen accumulation in plant parts.

Protein content

It is discernable from the data that protein content in green pod was maximum in organic treatment and minimum in control. Since protein content is a product of nitrogen concentration of green pod and yield of green pod. So it is not merely indicator of single parameter, increase in any one parameter may affect the value of it.

However, increased in yield may caused the reduction in nutrient concentration owing to dilution effect. Maximum nitrogen content was observed in T₂ which was at par with T₁. When nitrogen was added through chemical fertilizers as in case of treatments T₇, T₄ and T₆; the nitrogen content and protein content decreased in comparison to T₁ and T₂. This may be due to decrease in nodulation in chemical fertilizer treatment and secondly 80% of the fixed nitrogen comes from the symbiosis (Vance, 1998).

Soil chemical properties

Organic carbon

On the perusal of data, it is clear that soil organic carbon level increased from initial levels (9.9 g kg⁻¹) in all the treatments. Organic carbon level differed significantly under all the treatments over control. The maximum organic carbon was recorded in organic treatment T₁ and the minimum was recorded in control treatment. Both the organic treatments were significantly at par. The increase in organic carbon might be due to direct addition of organic source of nutrients and less mineralization due to wide C: N ratio material. Results are in accordance with the findings of Kanwar et al. (2002) who reported that application organic manure alone recorded higher organic carbon content than chemical fertilizers (NPK) applied treatments. Organic carbon under integrated treatment did not differed significantly with each other. In control treatment organic carbon increased from its initial status, but was significantly lower than other treatments. Chemical fertilizer applied treatment gave significantly and numerically less organic carbon than the other treatments except control. Increased doses of organic manures along with decreased doses of chemical fertilizers improved soil organic carbon in comparison to application of chemical fertilizer alone in long term experimentation as revealed from the study of Bedi and Dubey (2009).

Cation exchange capacity (CEC)

It varied from 11.9 cmol (p+) kg⁻¹ in T₈ to 13.7 in T₆. The highest was recorded in T₆ which was at par with T₅. The values were significantly higher in integrated treatments than organic treatments. The organic treatments contained significantly higher values than control. This might be due to release of cations with the decomposition of organic matter which would have increased the CEC. Yagi et al. (2003) have also reported similar findings.

Available nitrogen

The minimum increase was available N was observed in chemical fertilizer applied treatment followed by organic

treatment and integrated treatments, respectively. The results are corroborated with the findings of Workneh et al. (1993) who reported that microbial activity and nitrogen mineralization rates were higher under organic production than under conventional production practices. Available nitrogen was more in integrated treatments as compared organic treatments. It might be due to fact that integration of organic and chemical fertilizer has increased the mineralization owing to narrow C/N ratio as compared to organic treatments. In chemical fertilizers applied treatment low available nitrogen is owing high mineralization and low organic matter caused nutrients mining.

Available phosphorus

Available phosphorus content in control treatment decreased from its initial value (24.2 kg ha^{-1}) whereas the available phosphorus in rest of the treatments increased from its initial levels. The increase in the available P content due to incorporation of organic manures may be attributed to the direct addition of organic manures as well as solubilization of native P through release of various organic acids. The minimum increase was in organic treatments followed by chemical fertilizer applied treatment, respectively. Available phosphorus was more in integrated treatments as compared organic treatments. Build up of phosphorus status in acidic soils generally occurs owing to poor availability of phosphorus and complex formation with iron and aluminium, but better availability under chemical fertilizers applied treatment and integrated nutrient management might be due to more mineralization owing to addition of chemical fertilizers. Similar improvement in available P due to integrated use of manures and chemical fertilizers has been observed by Sharma et al. (2008 and 2009).

Available potassium

The minimum increase was recorded in organic treatments followed by integrated treatments, respectively. Available potassium was more in integrated treatments as compared organic treatments. The beneficial effect of integrated use of fertilizers and organic treatments on available K may be ascribed to the direct potassium addition in the potassium pool of the soil.

Physical properties

Bulk density

The bulk density in all the treatments has increased from its initial value (1.24 mg m^{-3}) except control, where it has decreased (1.23 mg m^{-3}) numerically, whereas, in rest of the treatments, it has increased significantly. The

increase in bulk density might be due to increase in organic carbon. The results are corroborated with the findings of Pathak et al. (2005). The bulk density in organic treatments was significantly superior to the rest of treatments.

Available water

The available water content in control and chemical fertilizers applied treatments decreased from its initial status (16.8%) and the rest of treatments gave numerically higher value of available water than the initial status. Increased in organic matter content which resulted in the improvement in stable soil aggregates and macro and micro pore spaces caused to increase in free movement of water within the soil might have increased the available water content of the soil. Similar results were also reported by Walia et al. (2010).

Soil biological parameters

Microbial biomass

The contents of biomass carbon were the highest under organic treatment followed by integrated nutrient management. The biomass carbon content decreased from 176 in T_1 to $98 \mu\text{g Cg}^{-1}$ in the control. The highest biomass carbon in organic treatments may be attributed firstly to the fact that the build up of organic carbon was more which might harbor more microbial population and ultimately resulted in the higher biomass carbon and secondly to the formation of root exudates, mucigel sougged off cells and addition of crop residues (Goyal et al., 1992). The content was significantly highest in T_1 but was at par with T_2 . Addition of nitrogen decreased the biomass content in T_4 and T_6 . The contents in integrated treatments were significantly higher than chemical fertilizer treatment. The contents were significantly lowest in the control.

Dehydrogenase activity

The activity was significantly higher in organic and integrated treatments than the chemical one. Addition of farmyard manure with crop residues, biofertilizers along with chemical fertilizers increased the activity of dehydrogenase enzyme as FYM and crop residues being the major carbon sources which provided energy for soil microorganisms and increased the number of pores, which are considered important in soil-water-plant relationship and maintained good soil structure accompanied by better dehydrogenase activity (Marinari et al., 2000). The results also corroborated with the findings of Verma and Mathur (2009) who reported that integrated use of FYM with chemical fertilizer increased

this activity. Further, addition of nitrogen in the farmyard manure and biofertilizers increased the dehydrogenase activity than the alone chemical fertilizer treatment might be due to more availability of substrate for dehydrogenase enzyme. Among the *Rhizobium* strains A and strain B, the strain B performed better than strain A in affecting the dehydrogenase activity. The value was significantly lowest in the control. The value increased in all treatments from the initial value.

Phosphatase activity

The minimum phosphatase activity was recorded in control and maximum was found in integrated nutrient management treatment where each of the organic, inorganic and biofertilizers were used. Significantly highest activity was found in T₆ followed by T₅ and T₂. It may be due to that fact that integrated treatment provided narrow and optimum C: P ratio which resulted in slow mineralization from the organic forms of di- and mono-esters.

Urease activity

Urease activity was significantly higher in the treatments where chemical fertilizer and integrated treatments were used. The values in the organic treatments were significantly lower than the integrated treatments. The higher urease activity in integrated use of nutrients (organic and inorganic together) might be due to maintenance of the continuity of conversion of nutrients from organic to inorganic form owing to that urease enzyme acts on C-N bonds other than the peptide bonds in a linear amides and thus belong to a group of enzymes that include glutaminase and amidase. The results are corroborated with the findings of Jaun et al. (2008). An increase in values was observed in all treatments from the initial value except in the control.

Microbial respiration

It was minimum in the control and maximum in the organic treatments followed by T₃. This is also an index of higher organic carbon content of the organic treatments. Application of alone fertilizer treatment T₇ and other integrated treatments except T₃ resulted in lesser microbial respiration in comparison to organic treatments. It was might be due to fact that in organic applied treatments, microbial population was more and resulted in more respiration. Results are corroborated with the findings of Liang et al. (2003).

Conclusion

It can be concluded from the study that the nitrogen, phosphorus can be saved to the tune of 25 kg ha⁻¹ and

20.5 kg respectively in French bean with the use of 5 t of farm yard manure and 50% of the nutrients can be supplied through the use of nitrogen and phosphate biofertilizers. Integrated treatments found better than organic ones in terms of pod yield, phosphatase and urease and available nutrient status and cation exchange capacity whereas organic treatments increased the quality parameters of French bean like nitrogen and protein; soil biomass carbon, microbial respiration, dehydrogenase activity; physical properties viz. bulk density and water holding capacity. Biofertilizers and farmyard manure has proved potential organic inputs for yield sustenance under these conditions for French bean.

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