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Influence of integrated nitrogen management on French bean (*Phaseolus vulgaris* L.) var. Contendor under temperate conditions of Kashmir Valley

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Abstract
An experiment entitled “Influence of Integrated nitrogen management (INM) on French bean (*Phaseolus vulgaris* L.) var. Contendor and its effect on physico-chemical and biological properties of soil under temperate conditions of Kashmir Valley” was carried out during kharif season 2014 at research farm of SKUAST-K, Shalimar, Srinagar under Temperate Kashmir conditions. The experiment was laid out in randomized block (RDF) design with 13 treatments and 3 replications. The combination of dalweed compost and vermicompost with bio-fertilizer (rhizobium) and reduced dose of chemical fertilizers were tested in comparision with RDF. The soil under study was clay loam in texture, medium in available nitrogen (310.10 $kgha^{-1}$), phosphorus (22.92 $kgha^{-1}$) and potassium (249.10 $kgha^{-1}$) with neutral pH (7.2). The physical, chemical and biological parameters of soil were found to be significantly improved under INM practices than organic and chemical management practices. The results revealed that application of 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed) recorded maximum NPK (374.33, 33.53 and 270.35$kgha^{-1}$ N, P and K respectively). Further the integrative use of organic and inorganic fertilizers along with bio- fertilizers improved phyisco-chemical and biological properties of soil as compared to other treatments. Thus, it may be concluded that integrated nitrogen management (INM) improved the soil fertility.

Keywords: Biofertilizer, Nitrogen, *Phaseolus vulgaris*, Soil Health, Vermicompost

Introduction
French bean is a short duration crop and one of the precious and highly relished pulse crops of the North India (Zahida *et al.*, 2016) [25]. It can be grown in all types of soils ranging from sandy loam to clay soils but can’t withstand under waterlogging conditions. Though its cultivation is mainly restricted to hilly region of north India, in Jammu & Kashmir, Himachal Pradesh, Hills of Uttrakhand and in some parts of Maharastra (Mahabaleshwar and Ratnagiri region) it is grown as a *kharif* crop. The use of chemical fertilizers boosted the agricultural production but the farming communities are not using it judiciously and hence it results in the loss of soil productivity. In spite of the importance of urgent step up, very little attention has been paid so far to nutrient management in various soils and climatic conditions.Nutrient balance is the key component to increase crop yields. Unlike other pulses, Rajmash is inefficient in symbiotic nitrogen fixation (Ali and Lal, 1992) [3] as it lacks nodulation due to absence of NOD gene regulator (Kushwaha, 1985) even with native Rhizobia and commercially produced cultures. Hence, the nitrogen requirement of Rajmash is different from other pulse crops and application of nitrogen through fertilizers is imperative for exploiting its yield potential. Inoculation of French bean seed with biofertilizers helps in increasing all growth characters by enhancing the nutrient supply to the plant (Thakur *et al.*, 1999) [21]. Besides, biofertilizers are capable for mobilizing elements from non-usable form to usable form through biological processes (Sharma, 2002) [22]. 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 sources has a direct impact on soil health and crop productivity (Sharma *et al.*, 2013) [23]. Organic sources of the plant nutrients have been reported to improve growth, yield attributes, yield and soil fertility status. In commercial agriculture, the use of chemical fertilizers cannot be ruled out completely.

However, there is a need for integrated use of alternate sources of nutrients for sustaining the crop productivity (Dar *et al*., 2014) [6]. The integration of organic and inorganic sources of plant nutrients has proved superior to individual components with respect to growth, yield and quality of pulses (Ghosh *et al.,* 2014; Datt *et al.,* 2013) [8, 5]. Keeping this in view, an experiment was carried out to improve yield and soil fertility of French bean with integrated nitrogen management under temperate conditions.

Materials and methods

The field experiment was conducted at the experimental field of Shalimar campus, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K) during *kharif* season 2014 located at 34.01ºN and 74.5ºE at an elevation of 1606 meters, to study the influence of Integrated nitrogen management (INM) on French bean (*Phaseolusvulgaris* L.) var. Contendor and its effect on physico-chemical and biological properties of soil. The soil of experimental site was clay loam in texture, medium in available nitrogen, phosphorus and potassium with neutral pH (Table-1). The experiment was laid out in a randomised complete block design (RBD) having thirteen treatments combinations (Table-1) comprising different combinations of inorganic fertilizers, organic manure and biofertilizers with three replications. The entire dose of FYM was applied as basal dose and thoroughly incorporated in the soil. The entire dose of phosphorus (P) and potassium (K) was given as basal dose. Moreover, nitrogen (N) was applied through vermicompost, Dalweed and biofertilizer (*Rhizobium)* to soil as per the treatment combinations at the time of sowing. French bean (contedor) was sown @ 80 kg/ha during second fortnight of April and harvested in the first fortnight of July. Ten randomly plants were choosen over an area of 0.5m^2 and were left undisturbed in each plot for recording observations. Soil samples (0-15 cm) were collected from each plot after harvest of the crop. These samples were analysed for pH (1:2.5 soil: water suspension), organic carbon by rapid titration method (Walkley and Black, 1936), available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956) [24], available P by Olsen's method (Olsen *et al*, 1954) [17], available K by ammonium acetate extraction method (Jackson, 1967) [9], CEC by Ammonium acetate method (Peech *et al.,* 1947) [18]. Dehydrogenase activity was determined by the method given by (Casida *et al.* 1964) [4], Urease activity was estimated by the method given by (Tabatabal and Bremmer 1969), Phosphatase activity was estimated by the method given by (Tabatabal and Bremmer 1969) and Microbial respiration was estimated by method given by (Pramer and Schmidt 1964) [19].

Statistical Analysis

The data collected on physical, chemical and biological parameters of soil was statistically analyzed using the standard procedure and the results were tested at five per cent level of significance as given by Gomez and Gomez. (1984) [7]. The critical difference was used to compare treatment means.

Results and discussion

Soil physical, chemical and biological properties were studied after the harvest of crop and the results are presented in Table 3 and Table 4. On the perusal of data from Table 4 it is evident that bulk density and particle density increased with increase in recommended dose of chemical fertilizers but the effect of different treatments was statistically non-significant. Among all the treatment combinations T_6 showed lowest bulk density (1.18 Mg m^{-3}) and particle density (2.27 Mg m^{-3}). It may be attributed that a well aggregated soil has lower bulk and particle density compared with dispersed and poorly structured soil. It could be due to that the organic matter resulted in considerable increase in polysaccharides and microbial gum synthesis in the soil. The microbial decomposition product being resistant to further decomposition and act as binding agent for soil separates. This might help in soil aggregation resulting lower bulk density of soil. Similar results have also been earlier reported by Zahida *et al.* (2016) [25]. It is clear that soil organic carbon level increased considerably in all the treatments from the initial level. Both organic carbon and soil pH did not show any significant differences among the treatments (Table 3). This might have been due to shorter duration of the crop (85 days) which might have been insufficient for the treatments to cause any significant changes in these parameters.

The data revealed that the CEC of soil increased significantly among all the treatments. From all treatment combinations (T_6) showed significantly higher CEC (14.72 Cmol$_c$ kg^{-1}) than rest of treatments. This might be due to release of cations with the decomposition of organic matter which would increase the CEC. Yagi *et al.* (2003) [27] have also reported similar findings. Inoculation with bio-fertilizers significantly increases CEC, which might be due to release of soluble inorganic phosphates and secretion of organic acids which may form chelates with the iron and Aluminium resulting solubilisation of phosphates. These results are in conformity with findings of Laxminarayana (2001) [12]. The results presented in Table 3 revealed that the highest electric conductivity (0.311 dSm^{-1}) was recorded in T_6 than the rest of treatments. The plot which received vermicompost showed highest electrical conductivity (0.287dSm^{-1}) over initial values. Application of biofertilizers also showed significantly superior results over no inoculation. This might be attributed due to increase of microbial population in philosopher zone which enhanced microbial decomposition of organic matter and thus leading to increase electrical conductivity. Similar results were earlier also reported by Babu *et al.* (2007).

Significant results were obtained in case of available N, P and K (Table 3). Maximum available N (374.33 kg/ha), available P (33.53 kg/ha) and available K (270.35 kg/ ha) were recorded in treatment T_6 and the lowest available N (320.00 kg/ha), available P (15.20 kg/ha) and available K (246.00 kg/ha) were recorded in treatment T_3. However, in case of available K, T_6 remained statistically at par with T_4. It might be due to the fact that the application of nitrogen in presence of organic manures helps mineralization by minimizing C/N ratio. These results are in agreement with Datt *et al*. (2013) [5]. Increase in N might also be due to N fixing with *Rhizobium* inoculation (Abd El-fatah and Arisha, 2000) [2], increase in the available P content is due to incorporation of organic manures which may be attributed to solubilisation of native P through release of various organic acids. The available K may be due to direct addition of K to the available K pool of the soils besides the reduction of K fixation due to interaction of organic matter with clay. Naik *et al.* (2014) [16] also reported improvement in nutrient status of soils through application of organics.

The dehydrogenase activity was significantly higher in T_6 than the rest of treatments. The lowest activity was recorded in T_1. This might be due to the integrated application of fertilizers which in turn increased the activity of dehydrogenase enzyme as vermicompost being the major carbon sources which provided energy to soil microorganisms and increased the number of pores, which maintained good soil structure accompanied by better dehydrogenase activity (Marinari *et al.*, 2000) [14]. The highest phosphatase activity was found in integrated nitrogen treatments. Significantly highest activity was found in T_6 while as minimum phosphatase activity was recorded in recommended nitrogen dose T_1. It might be due to that fact that integrated treatment provided narrow and optimum C: P ratio which resulted in slow mineralization of di- and mono-esters.Urease activity was found significantly highest in T_6. The higher urease activity in integrated use of nutrients 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 glutominase and amidase. The results are corroborated with the findings of Jaun *et al.* (2008) [10]. Microbial respiration was found maximum in the organic treatment 100% N through vermicompost T_2 followed by T_6. This is also an index of higher organic carbon content. Application of chemical and integrated fertilizer treatments resulted in lesser microbial respiration in comparison to organic treatments. It was due to fact that in organic treatments, microbial population was more and resulted in more respiration. Results are corroborated with the findings of Liang *et al.* (2003) [13].

Table 1: Details of various treatments combinations.

T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}
T_2	100% N through vermicompost @ 2.2 t ha^{-1}
T_3	100% N through Dal weed @ 6 t ha^{-1}
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})
T_6	75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed)
T_7	75% N through urea + 25% N through Dal weed + biofertilizer (Rhizobium) (22.5 kg N + 1.5 t ha^{-1} + 20 g kg^{-1} seed)
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})
T_{10}	50% N through urea + 50% N through Dal weed + biofertilizer (Rhizobium) (15 kg N + 3 t ha^{-1} + 20 g kg^{-1} seed)
T_{11}	50% N through urea + 50% N through vermicompost + biofertilizer (Rhizobium) (15 kg N + 1.1 t ha^{-1} + 20 g kg^{-1} seed)
T_{12}	75% N through urea + 12.5% N through vermicompost + 12.5% through Dal weed compost + biofertilizer (Rhizobium) (22.5 kg N + 0.27 t ha^{-1} + 0.75 t ha^{-1} + 20 g kg^{-1} seed)
T_{13}	50 % N through urea + 25% N through vermicompost + 25% N through Dal weed compost + biofertilizer (Rhizobium) (15 kg N + 0.55 t ha^{-1} + 1.50 t ha^{-1} + 20 g kg^{-1} seed)

(The per cent of nitrogen was that of recommended dose of nitrogen).

Table 2: Effect of integrated nitrogen management on availability of nutrients in soil (kg ha^{-1}).

Treatment		Availability of nutrients in soil (kg ha^{-1})		
		N	P	K
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	354.10	27.63	266.40
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	359.24	30.83	266.43
T_3	100% N through Dal weed @ 6 t ha^{-1}	320.00	16.52	245.03
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	362.40	30.67	268.47
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	325.00	17.25	247.16
T_6	75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed)	374.33	33.53	270.35
T_7	75% N through urea + 25% N through Dal weed + biofertilizer (Rhizobium) (22.5 kg N + 1.5 t ha^{-1} + 20 g kg^{-1} seed)	335.01	17.48	252.05
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	339.82	24.30	258.10
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	327.86	18.50	252.98
T_{10}	50% N through urea + 50% N through Dal weed + biofertilizer (Rhizobium) (15 kg N + 3 t ha^{-1} + 20 g kg^{-1} seed)	335.43	18.60	254.32
T_{11}	50% N through urea + 50% N through vermicompost + biofertilizer (Rhizobium) (15 kg N + 1.1 t ha^{-1} + 20 g kg^{-1} seed)	337.43	20.91	256.11
T_{12}	75% N through urea + 12.5% N through vermicompost + 12.5% through Dal weed compost + biofertilizer (Rhizobium) (22.5 kg N + 0.27 t ha^{-1} + 0.75 t ha^{-1} + 20 g kg^{-1} seed)	356.40	28.45	266.40
T_{13}	50 % N through urea + 25% N through vermicompost + 25% N through Dal weed compost + biofertilizer (Rhizobium) (15 kg N + 0.55 t ha^{-1} + 1.50 t ha^{-1} + 20 g kg^{-1}seed)	349.43	24.57	260.01
	Initial	310.10	22.92	249.10
	C.D$_{(p \leq 0.05)}$	1.82	0.27	0.187

Table 3: Effect of integrated nitrogen management on physio-chemical parameters of soil after harvest.

Treatment		Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	EC (dSm^{-1})	CEC ($cmol_c kg^{-1}$)	OC (%)	pH
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	1.32	3.08	0.261	14.36	0.71	7.32
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	1.20	2.26	0.281	14.22	0.91	6.85
T_3	100% N through Dal weed @ 6 t ha^{-1}	1.28	2.40	0.251	13.64	0.89	7.01
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	1.24	2.29	0.271	14.46	0.82	7.29
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	1.30	2.40	0.254	14.03	0.75	7.36
T_6	75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed)	1.18	2.27	0.311	14.72	0.84	7.22
T_7	75% N through urea + 25% N through Dal weed + biofertilizer (Rhizobium) (22.5 kg N + 1.5 t ha^{-1} + 20 g kg^{-1} seed)	1.29	2.39	0.259	13.89	0.76	7.41
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	1.27	2.38	0.241	14.11	0.86	7.44
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	1.25	2.34	0.231	13.88	0.79	7.42
T_{10}	50% N through urea + 50% N through Dal weed + biofertilizer (Rhizobium) (15 kg N + 3 t ha^{-1} + 20 g kg^{-1} seed)	1.23	2.30	0.237	14.03	0.80	7.47
T_{11}	50% N through urea + 50% N through vermicompost + biofertilizer(Rhizobium) (15 kg N + 1.1 t ha^{-1} + 20 g kg^{-1} seed)	1.22	2.28	0.249	14.38	0.87	7.40
T_{12}	75% N through urea + 12.5% N through vermicompost + 12.5% through Dal weed compost + biofertilizer (Rhizobium) (22.5 kg N + 0.27 t ha^{-1} + 0.75 t ha^{-1} + 20 g kg^{-1} seed)	1.21	2.36	0.275	14.54	0.83	7.34
T_{13}	50 % N through urea + 25% N through vermicompost + 25% N through Dal weed compost + biofertilizer (Rhizobium) (15 kg N + 0.55 t ha^{-1} + 1.50 t ha^{-1} + 20 g kg^{-1} seed)	1.26	2.29	0.263	14.15	0.85	7.46
	Initial	1.21	2.90	0.19	14.0	0.70	7.2
	C.D. ($p \leq 0.05$)	NS	NS	0.023	0.232	NS	NS

Table 4: Effect of integrated nitrogen management on microbial parameters (μg g^{-1}) of soil.

Treatments		Dehydrogenase activity (μg g^{-1})	Urease activity (μg g^{-1})	Phosphatase activity (μg g^{-1})	Microbial respiration (μg g^{-1})
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	2.00	3.40	1.98	5.8
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	2.70	4.49	2.53	11.6
T_3	100% N through Dal weed @ 6 t ha^{-1}	2.32	4.04	2.00	10.3
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	2.52	5.80	3.14	8.52
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	2.42	5.34	2.89	8.11
T_6	75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed)	2.65	5.91	3.23	8.92
T_7	75% N through urea + 25% N through Dal weed + biofertilizer (Rhizobium) (22.5 kg N + 1.5 t ha^{-1} + 20 g kg^{-1} seed)	2.38	5.51	2.99	8.52
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	2.39	5.17	2.84	8.23
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	2.35	5.01	2.64	8.12
T_{10}	50% N through urea + 50% N through Dal weed + biofertilizer (Rhizobium) (15 kg N + 3 t ha^{-1} + 20 g kg^{-1} seed)	2.40	5.30	2.80	8.42
T_{11}	50% N through urea + 50% N through vermicompost + biofertilizer (Rhizobium) (15 kg N + 1.1 t ha^{-1} + 20 g kg^{-1} seed)	2.50	5.72	3.10	8.71
T_{12}	75% N through urea + 12.5% N through vermicompost + 12.5% through Dal weed compost + biofertilizer (Rhizobium) (22.5 kg N + 0.27 t ha^{-1} + 0.75 t ha^{-1} + 20 g kg^{-1} seed)	2.61	5.82	3.15	9.3
T_{13}	50 % N through urea + 25% N through vermicompost + 25% N through Dal weed compost + biofertilizer (Rhizobium) (15 kg N + 0.55 t ha^{-1} + 1.50 t ha^{-1} + 20 g kg^{-1} seed)	2.47	5.67	3.01	8.6
	Initial	1.7	2.8	1.2	5.6
	C.D. ($p \leq 0.05$)	0.026	0.89	0.824	0.123

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