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Effect of Integrated Nitrogen Management on Growth Performance of French Bean (*Phaseolus vulgaris* L.) Var. Contendor under Temperate Conditions of Kashmir Valley

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Authors' contributions

This work was carried out in collaboration among all authors. Author RJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author TA guided during the whole study. Authors SAB and NM managed the *literature searches of the study. Authors BBN and KF managed the analyses of the study. All authors read and approved the final manuscript.*

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ABSTRACT

The present study aims to evaluate the effect of integrated nitrogen management on growth performance characteristics of French bean (*Phaseolus vulgaris* L.) var. contendor under temperate conditions of Kashmir valley during kharif season of 2014 at the research farm of SKUAST-K, Shalimar, Srinagar. The experiment was laid out in a randomized block (RDF) design with 13

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treatments and 3 replications. The combination of dalweed compost and vermicompost with bio-fertilizer (Rhizobium) and reduced dose of chemical fertilizers were tested in comparison with RDF [1]. 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. It was observed that the integrated application of nutrient levels had a significant influence on growth, yield and yield parameters in French bean. 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 growth plant height (29.13 cm), plant spread (29.17 cm), maximum number of branches per plant (5.70) and maximum plant biomass (25.70 q ha^{-1}).and yield characters like Maximum seeds per pod (5.50), Maximum 100-seed weight (40.02 g), Maximum seed yield (23.96 q ha^{-1}) and stover yield (29.20 q ha^{-1}). Thus, it may be concluded that integrated nitrogen management (INM) improved the growth and yield of French bean.

Keywords: Nitrogen; french bean; vermincompost; growth; yield.

1. INTRODUCTION

French bean (*Phaseolus vulgaris*) is a short duration, non-traditional legume and one of the precious and highly relished pulse crop of North India with a high yield potential of 18-20 q/ha [2]. It is commonly known by various names viz., rajmash, rajma, haricot bean, field bean, kidney bean, snap bean, pole bean etc. It is a cheap source of vegetable protein, vitamins and minerals like calcium and iron. With population explosion, the demand for the crop has increased significantly, leading to the extensive use of chemical fertilizers without any consideration for soil health and quality, which is a critical factor for realizing sustainable yield. Besides, the residual effects of chemical fertilizers on the environment, underground water, soil microbes and crop products is a matter of concern. Inadequate use of the organic manures has also rendered Indian soils deficient in macro and micronutrients [3]. 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 varioussoils and climatic conditions. Unlike other pulses, Rajmash is inefficient in symbiotic nitrogen fixation as it lacks modulation due to the absence of NOD gene regulator [4] 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 [5]. Besides, biofertilizers are capable of mobilizing elements from non-usable form to usable form through biological processes [6,7]. Thus, for increasing the growth and yield of French bean, besides other factors, an adequate quantity of nutrients from organic and inorganic sources is prerequisite. Keeping this in view, the present investigation was planned to study the effect of integrated nitrogen management on growth and yield of French bean.

2. 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 growth and yield parameters of French bean (*Phaseolus vulgaris* L.). 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

Table 1. 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)

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 chosen over an area of 0.5 m^2 and were left undisturbed in each plot for recording observations viz plant height, plant spread, nodule number, yield and yield attributes The data collected were statistically analyzed using the standard procedure and the results were tested at five per cent level of significance [8].The critical difference was used to compare treatment means. Plant height was measured from the lower cotledonary node to the growing tip during the vegetative period and the mean of 10 plants was taken and expressed in centimetres. Spread of plants was recorded in north-south direction, with the help of metre scale of randomly selected ten plants per plot and their average was calculated. Ten plants from each treatment were randomly uprooted at flowering and the soil adhered to the roots was removed by washing under tap water. Then the healthy nodules which were pinkish in colour (effective nodules) were counted and average number of nodules plant^{-1} was determined. Also ten plants were uprooted from each treatment and dried in an oven at 60-65ºC for 48 hours and the weight of randomly selected plants was recorded in grams and finally converted to quintals per hectare. Number of seeded pods from 10 random plants were counted to work out the average number of seeded pods plant^{-1}. The number of seeds in randomly selected 10 pods from each treatment was counted and their average was worked out. A random sample of 100 seeds from each treatment was taken and weighed to work out. Seed yield was taken from 10 undisturbed plants (0.5 m^2 area) of each plot and was converted into seed yield plot^{-1} (Kg) and finally expressed as q ha^{-1}. Stover yield was also taken from the undisturbed plants (0.5 m^2 area) after harvesting the crop which was then converted into quintals per hectare.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The data on plant height is presented in Table-2. It indicated that the plant height increased irrespective of treatment effects. Plant height was significantly influenced by the application of organic, inorganic and biofertilizer at all growth stages.

At harvesting, maximum plant height (32.46 cm) was recorded with 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) while minimum plant height (29.13 cm) was recorded with 100% N through Dal weed (T_3). The increase in plant height might be due to more and quick supply of nitrogen, phosphorus and potassium than other treatments. Nitrogen is an essential constituent of chlorophyll, enzymes and proteins, whereas phosphorus is essential for phospo-lipids, phospho-proteins, ATP and ADP formation and potassium plays an important role in the promotion of enzymatic activity and enhances the translocation of assimilates and protein synthesis. The increase in plant height is in harmony with the findings of several authors [9,10,11,12,13]. Good response to applied nitrogen in the present study may be attributed to medium initial soil nitrogen status and lack of nodule forming ability of the crop.

3.2 Plant Spread

Among all treatment combinations, 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) recorded the maximum plant spread of 33.17 cm followed by 75% N through urea + 25% N through vermicompost (T_4) (Table-2). The minimum plant spread of 29.17 cm was recorded in 100% N through Dal weed (T_3). The increase in plant spread is due to complementary effect of availability of NPK and its role in increasing cell division which ultimately leads to an increase in plant spread. Similar was also reported by Veeresh [12] and EL-Awadi et al. [14].

3.3 Nodule Number

Nodule number per plant was recorded at flowering stage presented in Table-3. It is evident

Table 2. Effect of integrated nitrogen management on plant growth parameters of French bean (*Phaseolus vulgaris* L.)

Treatments		Plant height (cm)	Plant spread (cm)	Nodule No. plant^{-1}
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	32.10	30.14	9.33
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	30.01	29.17	16.06
T_3	100% N through Dal weed @ 6 t ha^{-1}	29.13	28.75	15.00
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	32.46	32.17	11.00
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	31.04	30.14	10.33
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)	34.26	33.17	11.56
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)	30.54	30.00	11.10
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	30.92	30.09	13.00
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	30.11	29.51	11.66
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)	30.87	30.01	11.60
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)	32.33	31.17	14.35
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)	31.04	32.57	12.01
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)	31.96	30.10	12.25
	C.D$_{(p \leq 0.05)}$	0.956	0.029	2.046

Table 3. Physio-chemical properties of soil of the experimental field before sowing

Particulars	Value	Method employed
Mechanical Characteristics		
Coarse sand (%)	1.50	International Pipette Method (Piper, 1966)
Fine sand (%)	18.30	-do-
Clay (%)	37.90	-do-
Silt (%)	42.40	-do-
pH	7.2	1:2.5 soil water suspension with Beckman's Glass Electrode pH Meter (Jackson, 1967)
EC (dSm^{-1})	0.19	Solubridge Conductivity Meter (Chopra, 1976)
Organic carbon (%)	0.70	Walkley and Black Rapid Titration Method (Jackson, 1973)
Available N (kg ha^{-1})	310.10	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	22.92	Extraction with 0.5 M $NaHCO_3$ (Olsen *et al.* 1956)
Available K (kg ha^{-1})	249.10	Extraction with Neutral Normal Ammonium Acetate (Jackson, 1967)
CEC ($cmol_c$ kg^{-1})	14.0	Ammonium acetate method Peech *et al.* (1947)

from the data that the number of nodules varied significantly. The maximum nodule number (16.06) as recorded in 100% N through vermicompost (T_2) and minimum (9.33) was in recommended nitrogen dose (T_1).The data on nodule number indicated that treatment100% N through vermicompost (T_2) gave higher nodule number than other integrated treatments indicating that application of organic fertilizers enhanced the microbial activity, however, the integration of nutrients increased yield and other yield attributes, resulting the enhancement of nutrients availability which influenced the yield and yield attributes. The results are in close proximity with the findings of Kundu et al. [15] who reported that application of farmyard manure incorporation resulted in an increase in nitrogen fixation in soyabean. Application of chemical fertilizers alone suppresses the microbial activity that resulted in poor nodule number [16].

3.4 Yield and Yield Attributes

Yield of a crop is the result of its yield attributes. Yield attributes viz. number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod, 100 seed weight were markedly influenced by the application of organic and inorganic source of nitrogen fertilizers. The data on primary branches and secondary branches per plant is presented in Table-4. It revealed from the data that the number of primary and secondary branches per plant increased in all the treatments and differed significantly at all growth stages. The maximum number of branches per plant (5.70) was recorded with 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) while minimum number of branches per plant (3.07) was recorded with 100% N through Dal weed (T_3).

The data revealed a significantly higher seed yield with 75% N through urea+ 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) than all other treatments. The increase in seed yield might have been due to significantly higher yield attributes viz, number of pods per plant, seeds per pod and 100 seed weight. These results are in line with the findings of Veeresh [12] and Dhanjal et al. [17]. The increase in seed yield might also have been due to an increase in photosynthetic rate and translocation of photosynthates to sink (seed) resulting in better development of yield attributes and produced higher seed yield.

The Stover yield significantly increased with the application of 75% N through urea+ 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) than all other treatments. This might be due to significantly higher total dry matter production and more vegetative growth. These results are in agreement with Dhanjal et al. [17] and Kundu et al. [15]. Further, higher seed and stover yield by application of inorganic fertilizers in combination with organic manures may be due to its greater availability and uptake of macro and micro nutrients resulting in higher photosynthesis, tissue differentiation and translocation of assimilates etc. leading to higher seed and stover yield [18].

The pods per plant showed a significantly higher number of pods per plant with treatment 75% N

Table 4. Effect of integrated nitrogen management on yield attributes and dry plant biomass of French bean

Treatments		Primary branches	Secondary branches	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Dry plant biomass (q/ha)
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	4.60	4.50	11.60	7.50	36.35	19.03
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	3.80	3.70	9.60	4.50	32.00	16.18
T_3	100% N through Dal weed @ 6 t ha^{-1}	3.07	3.05	8.50	3.50	26.30	16.10
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	5.00	4.80	12.60	8.40	37.60	23.05
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	4.40	4.10	10.50	6.55	35.50	18.36
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)	5.70	5.20	12.95	8.75	40.02	25.40
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)	4.00	4.00	11.30	7.30	34.60	17.89
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	4.20	4.07	10.00	6.31	35.00	18.10
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	3.85	3.80	11.10	7.00	34.30	16.63
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)	4.07	4.05	11.50	7.41	34.80	17.89
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)	4.80	4.60	12.10	7.77	37.00	22.68
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)	5.20	5.00	12.40	8.00	38.90	25.70
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)	4.50	4.40	10.70	6.75	36.20	18.38
	C.D. $_{(p \leq 0.05)}$	0.44	0.28	1.30	0.95	3.85	2.75

Table 5. Influence of integrated nitrogen management on seed and stover yield (q ha^{-1}) of French bean (*Phaseolus vulgaris* L.)

Treatment		Yield	
		Seed	Stover
T_1	Recommended nitrogen dose (30 kg N ha^{-1} through inorganic source + 20 tonnes FYM ha^{-1}	22.50	39.28
T_2	100% N though vermicompost @ 2.2 t ha^{-1}	19.40	35.57
T_3	100% N through Dal weed @ 6 t ha^{-1}	18.51	29.20
T_4	75% N through urea + 25% N through vermicompost (22.5 kg N + 0.55 t ha^{-1})	23.70	37.37
T_5	75% N through urea + 25% N through Dal weed (22.5 kg N + 1.5 t ha^{-1})	21.54	35.86
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)	23.96	39.77
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)	20.75	33.44
T_8	50% N through urea + 50% N through vermicompost (15 kg N + 1.1 t ha^{-1})	21.04	35.24
T_9	50% N through urea + 50% N through Dal weed (15 kg N + 3 t ha^{-1})	20.00	32.88
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)	20.90	30.88
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)	22.70	35.70
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)	23.30	37.48
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)	21.60	35.69
	$C.D_{(p \leq 0.05)}$	0.278	0.274

through urea+ 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) followed by 75% Nthrough urea+ 25% N through vermicompost (T_4). Similar results were also reported by Datt et al. [19] 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 of Himachal Pradesh.

The data on seeds per pod and 100-seed weight also indicated significantly higher values with 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (T_6) than all other treatments. The increase in seeds per pod, 100-seed weight might be due to significantly increase in growth parameters. These results are in line with the findings of Dhanjal et al. [17].

4. CONCLUSION

From the study it is concluded that in context of sustainable agriculture, growth and yield may be improved by integrated use of organic and inorganic sources of nutrient under temperate conditions of Kashmir, and the nutrient management of French bean may involve substitution 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) Further, integrated nutrient management is required for sustaining the desired crop productivity by optimizing the benefits from all the sources of plant nutrients in an integrated manner.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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