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Influence of Integrated Nutrient Management on Root Growth, Flowering and Quality of Seed in French Bean (*Phaseolus vulgaris* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Author JB took observations, performed the statistical analysis, managed the literature searches and wrote the first draft of the manuscript. Author SSK designed the experiment, wrote the protocol and finalized the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was undertaken to evaluate the influence of integrated nutrient management on root growth, flowering and quality of seed in french bean.
Study Design: The experiment was laid out in factorial randomized design with three replications. The treatments consist of six nutrient levels viz., N_1:Vermicompost (10t/ha) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_2: Vermicompost (10 t/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_3: Vermicompost (10 t/ha) + N (25 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_4: Vermicompost(10 t/ha) + N (50 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_5: Vermicompost(10 t/ha) + N (75 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_6: Vermicompost (10 t/ha) + N (100 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha) and three varieties viz., Arka Komal (V_1), Contender (V_2), and Swarna Priya (V_3).
Place and Duration of Study: The experiment was carried out at vegetable research field Department of Vegetable Science College of Horticulture, Mandsaur campus of RVSKVV Gwalior during *rabi* season 2013-14.

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Methodology: Biofertilizer viz. *Rhizobium* and PSB (Phosphorus Solubilising Bacteria) cultures were applied as seed treatment. Well decomposed vermicompost was incorporated in soil and mixed thoroughly as basal dose. Full dose of phosphorus, potash and ½ dose of nitrogen were applied as basal dose and ½ dose of nitrogen was applied as split one month after sowing. The source of nitrogen, phosphorus and potash were urea, SSP and MOP, respectively. Sowing of healthy seed was done at a spacing of 45 cm × 15 cm. Recommended agronomic and plant protection practices were followed for raising healthy crop.

Results: The findings revealed significant effect of varieties and nutrient levels on root growth, flowering and quality of seed in French bean. Among the different varieties of french bean, Swarna Priya recorded maximum fresh {52.44, 2655.22, 5611.38 and 3447.83 g at 30, 45, 60 days after sowing (DAS) and harvest stage, respectively} and dry (27.61, 32.05, 2454.33 and 2520.22 g at 30, 45, 60 DAS and harvest stage, respectively) weight of root. Earliest first flowering (24.22 days) was commenced in Contender. Lowest number of node (4.08) of first flower appearance was observed with variety Arka Komal. Highest test weight (58.90 g), crude protein content (42.31%), germination percentage (90.27) in seed, seed vigour index I (20262) and seed vigour index II (36.09) were found with Swarn Priya. Out of six nutrient levels application of N_4 {Vermicompost(10 t/ha) + N (50 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha)} recorded highest quality attributes of seed. Though it caused delay in flowering and lesser root growth as compared to lower levels of nutrients but was better than higher levels of nutrients.

Conclusion: Among the different varieties of french bean, Swarna Priya showed superior performance for root growth attributes and seed quality. Though, it was late in first flower appearance. Among the nutrient levels N_4 resulted in the superior quality of seed in french bean. Though it had delayed flowering and lesser root growth as compared to lower levels of nutrients but was better over higher levels of nutrients.

Keywords: French bean; root; flowering; seed quality; integrated nutrient management.

1. INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is an important leguminous vegetable crop which is a valuable source of protein as well as minerals and vitamin. It is characteristically shy of nitrogen fixation and require larger amount of nitrogen. French bean being a fertilizer responsive crop, respond well to nutrition, while excess nitrogen results in poor pod yield. Like other legumes it also fixes atmospheric nitrogen and improves soil fertility [1]. There is also report that french bean is insufficient in trapping atmospheric nitrogen due to lack of nodulation in north Indian plains, therefore, requires large quantity of nitrogenous fertilizer [2]. It is well documented that higher level of nitrogen application not only seems to be uneconomic, but also endanger the basic production system. This situation warrants for a sustainable agro technology, through integrated plant nutrient supply system involving chemical, organic and biofertilizers [3].

Use of inorganic fertilizers not only increases the cost of production but also decreases over all soil fertility causing environmental pollution [4]. Organic manure not only supplies the major nutrients, micronutrients, it also improves soil health. Application of inadequate and imbalanced nutrients results into low yield as well as poor quality. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. The organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops [5]. Therefore, keeping these facts in view, present study was undertaken to evaluate the influence of integrated nutrient management on root growth, flowering and quality of seed in french bean.

2. MATERIALS AND METHODS

A field experiment was conducted at vegetable research field, Department of Vegetable Science College of Horticulture, Mandsaur campus of RVSKVV Gwalior during *rabi* season 2013-14. The soil of experimental field was light alluvial having sandy loam texture (sand: 55%, silt: 35% and clay: 10%) with 7.2 pH, 0.53 dSm^{-1} EC and uniform topography. It had low available nitrogen (215 kg/ha), medium phosphorus (8.1kg/ha) and high potassium (425 kg/ha). The experimental field was fallow during *kharif* 2013. History of

previous land use of the experimental field is given in Table 1. The experiment was laid out in factorial randomized design with 6 nutrient levels and 3 varieties replicated thrice. The treatments consist of six nutrient levels viz., N_1: Vermicompost (10 t/ha) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_2: Vermicompost (10 t/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_3: Vermicompost (10 t/ha) + N (25 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg seed) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_4: Vermicompost(10 t/ha) + N (50 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_5: Vermicompost (10 t/ha) + N (75 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha), N_6: Vermicompost (10 t/ha) + N (100 kg/ha) + *Rhizobium* (15 g/kg seed) + PSB (15 g/kg) + P_2O_5 (80 kg/ha) + K_2O (80 kg/ha) and three varieties viz., Arka Komal (V_1), Contender (V_2), and Swarna Priya (V_3). Biofertilizer viz. *Rhizobium* and PSB (Phosphorus Solubilising Bacteria) were applied as seed treatment. Well decomposed vermicompost was incorporated in soil and mixed thoroughly as basal dose. Under each treatment, full dose of phosphorus, potash and ½ dose of nitrogen (if to be given through fertilizer) were applied as basal dose and ½ dose of nitrogen was applied as split one month after sowing. The source of nitrogen, phosphorus and potash were urea, SSP and MOP respectively. All cultural operations were performed as per recommendations. Sowing of healthy seed was done with spacing of 45 cm × 15 cm. Recommended agronomic and plant protection practices were followed for raising healthy crop. Observations were recorded on fresh and dry weight of root and number of root nodules (in five randomly selected plants from each plot), days to first flower appearance, number of node of first flower appearance. Test weight of seed, crude protein content, germination percentage, vigour index I and vigour index II were calculated with the following formula:

Test weight = weight of 100 seeds expressed in grams (Randomly selected seeds under each treatment)

Crude protein content (%) = Nitrogen content × 6.25

Nitrogen content was estimated by micro-Kjeldahl method [6]

Germination test was conducted using the method as prescribed [7] and germination percentage was calculated with following formula:

Germination (%) = (No. of germinated seeds having normal seedlings/ Total number of seeds put to germination test) x 100

Vigour index were determined by using the following formula as suggested [8] and expressed in number:

Vigour Index I = Germination (%) × Seedling length (cm)

Vigour Index II = Germination (%) × Seedling dry weight (g)

Table 1. History of previous land use of the experimental field

Year	Kharif season	Rabi season	Zaid season
2011-12	Okra	Bottle gourd	Fallow
2012-13	Okra	Fallow	Muskmelon

3. RESULTS AND DISCUSSION

3.1 Root Growth Parameters

Plant root growth was studied with respect to fresh weight of root (mg), dry weight of root (mg) and number of root nodules per plant. There was significant influence of varieties and nutrient levels on fresh weight as well as dry weight of root. There was increase in fresh weight of roots with the advancement of growth upto 60DAS which showed decline at harvesting stage. The observations (Table 2) indicated that maximum fresh weight of root was found in variety Swarna Priya at all the growth stages of french bean which was significantly superior over other varieties.

Different soil nutrient rates applied significantly influenced root weight across sampling dates. Application of N_1 nutrient level recorded maximum fresh weight of root followed by N_3>N_4>N_5>N_6 at all the growth stages. Though, the difference between N_1, N_2 and N_3 nutrient levels was non significant at all the stages. Nitrogen deficiency increased root surface area, increased consumption of assimilates, reduced the amount of nitrogen transported to shoot, decreased shoot growth, and resulted in an increased root growth and R/S ratio [9].

Table 2. Effect of integrated nutrient management on root growth attributes and flowering of French bean

Treatment	Average fresh weight of root (mg)				Average dry weight of root (mg)				Days to first flowering	Number of node of first flowering
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest		
Varieties (V)										
V_1	48.94	2450.27	4855.11	3038.66	22.94	29.16	2005.00	2200.72	27.11	4.08
V_2	51.38	2513.44	5155.55	3266.00	21.72	30.5	2200.06	2328.33	24.22	4.53
V_3	52.44	2655.22	5611.38	3447.83	27.61	32.05	2454.33	2520.22	33.83	6.23
S.Em±	1.39	54.87	100.04	64.09	0.45	0.52	59.91	56.23	0.68	0.12
CD at 5%	3.87	152.10	277.29	177.65	1.27	1.45	166.05	155.85	1.88	0.38
Nutrient level (N)										
N_1	55.78	2721.89	5608.89	3628.44	27.67	34.89	2505.11	2642.67	24.67	4.44
N_2	53.33	2687.67	5583.33	3586.89	26.78	33.67	2420.56	2563.44	27.11	4.54
N_3	52.22	2634.89	5482.44	3530.11	25.00	32.56	2275.56	2431.00	27.89	4.88
N_4	49.89	2512.56	5161.44	3280.89	23.67	29.22	2136.00	2308.89	29.33	5.02
N_5	47.56	2436.44	4767.33	2844.67	21.67	27.00	2031.00	2078.67	29.78	5.30
N_6	46.78	2244.44	4640.67	2634.00	19.78	26.11	1951.67	2074.11	31.56	5.56
S.Em±	0.98	77.60	141.47	90.64	0.64	0.734	84.73	79.52	0.97	0.16
CD at 5%	2.73	215.10	392.15	251.24	1.79	2.050	234.84	220.41	2.67	0.54

Table 3. Effect of integrated nutrient management on quality of seed in French bean

Treatment	Test weight (g)	Crude protein content (%)	Germination percentage	Vigour index I	Vigour index II
Varieties					
V_1	39.61	38.70	85.83	18725.00	29.28
V_2	45.82	33.71	84.17	19019.00	32.00
V_3	58.90	42.31	90.27	20262.00	36.09
S.EM±	1.14	0.92	0.85	282.25	0.35
CD at 5%	3.18	2.56	2.36	782.36	0.99
Nutrient level					
N_1	39.92	34.92	83.33	15704.22	26.76
N_2	41.09	36.25	85.56	16135.56	27.04
N_3	45.98	38.98	86.11	18882.22	32.21
N_4	55.66	43.70	91.11	22223.33	37.27
N_5	54.85	39.41	90.00	21854.22	36.92
N_6	51.15	36.22	84.44	21213.33	34.93
S.EM±	1.62	1.30	1.20	199.58	0.49
CD at 5%	4.50	3.62	3.34	555.21	1.40

Dry weight of root showed increasing trend upto harvest stage. Variety Swarna Priya recorded highest dry weight of roots at all the stages. There was similar trend in dry weigh of roots under different nutrient levels as observed with fresh weight. These findings are corroborated with those reported by Manivannan et al. [10] and Morad et al. [11]. There was decrease in fresh and dry weight of roots with increasing level of nutrients. Application of lesser quantity of nutrients promoted more root growth for search of nutrients resulting in higher fresh and dry weight of root under lower doses of nutrient levels. Similar results were also reported by Manivannan et al. [10] and Singh et al. [12].

During the study, number of root nodules was observed. The findings revealed that there were no effective root nodules at any growth stage of the crop under any treatment. Kushwaha [2] also reported that in north Indian plains effective nodules were not formed in French bean.

3.2 Flowering

Findings pertaining to first flowering and number of node of first flower appearance are presented in Table 2. Results revealed that earliest first flowering commenced in variety Contender. It was followed by Arka Komal and Swarna Priya. Genetic constitution of variety Contender might be responsible for earliest flowering. Similar results were also reported by Singh et al. [13]. Application of nutrient levels caused significant influence on days to first flower. There was delay in appearance of first flowering with higher doses of nutrients. Maximum days for first flower were taken under N_6 nutrient level because nitrogen promotes the vegetative growth for longer period and consequently delayed the flowering in plants [13].

Lowest number of node of first flower appearance was observed in case of variety Arka Komal. It was followed by Contender and Swarna Priya. Highest number of node of first flower appearance was noted under N_6 nutrient level. Lowest number of node of flower appearance was noticed with nutrient level N_1 which was statistically at par with N_2 and N_3 nutrient level. Higher availability of nitrogen delays flowering consequently resulting in higher number of node of first flower appearance. Similar results were obtained by Singh et al. [13] and Partibhan and Thamburaj [14].

3.3 Quality Parameters

Seed quality was studied with respect to test weight, crude protein content germination percentage in seed, seed vigour index I and seed vigour index II (Table 3).

Maximum test weight was recorded with variety Swarna Priya followed by Contender and Arka Komal. Among different varieties, highest crude protein content was recorded with variety Swarna Priya followed by Arka Komal and Contender. All the varieties differed significantly with each other for both characters. Germination percentage in seed showed significant difference among the varieties. Maximum germination percentage in

seed was determined for variety Swaran Priya which was followed by Arka Komal and Contender. This could be ascribed to higher test weight and protein content in seed. Seed vigour index I and seed vigour index II indicated superiority of variety Swarna Priya followed by Arka Komal and Contender. Higher test weight, crude protein content and germination percentage consequently enhanced length and dry weight of seedlings which ultimately resulted in higher seed vigour index I and seed vigour index II. These findings are in agreement with Ramana et al. [15] and Singh and Chouhan [16].

Nutrient levels exerted significant influence on quality parameters viz., test weight, crude protein content, germination percentage in seed and seed vigour index I and seed vigour index II. Maximum test weight and protein content in seed were observed with application of N_4. Optimum availability of nitrogen under N_4 might have promoted these attributes under N_4. Highest germination percentage was found with application of N_4 probably due to better development of seed with optimum availability of nutrients as evident through higher test weight and protein content. Higher seed germination, test weight and protein content also promoted seed length and accumulation and dry weight of seedling which in turn resulted in highest seed vigour index I and II with application of N_4. Seed protein is end product of a complex series of biochemical and physiological process. Probably higher dose of fertilizers fortified with vermicompost helped in a more efficient translocation of nitrogen from vegetative parts to the developing seeds as well as synthesis of protein [3]. The more N uptake under more nitrogen applied plots might have increased protein formation [15,17,18,]. Increase in seed weight might be due to greater accumulation of plant metabolites in the seed at pod filling stage [19].

4. CONCLUSION

It is concluded from the findings of the present study that among the different varieties of French bean, Swarna Priya showed superior performance for root growth attributes and seed quality. Though, it was late in first flower appearance. Among the nutrient levels, N_4 resulted in the superior quality of seed in french bean. Though it had delayed flowering and lesser root growth as compared to lower levels of nutrients but was better over higher levels of nutrients.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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