E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; SP-8(9): 18-22
Received: 13-06-2025
Accepted: 17-07-2025

Yashwini Bhashkar Amrutkar
M.Sc. (Agri.) Student, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Gajbhiye BR
Associate Professor & PI, All India Network Project on Soil Biodiversity-Biofertilizers, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Khandare RN
Associate Professor, AICRP on LTFE, Department of Soil Science, College of Agriculture, Parbhani VNMKV, Parbhani, Maharashtra, India

Shelke VR
M.Sc. (Agri.) Student, Department of Agronomy, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Yashwini Bhashkar Amrutkar
M.Sc. (Agri.) Student, Department of Soil Science, College of Agriculture, VNMKV, Parbhani, Maharashtra, India

Studies on evaluation of different micronutrient grades on growth, yield and quality of French bean (*Phaseolus vulgaris* L.)

Yashwini Bhashkar Amrutkar, Gajbhiye BR, Khandare RN and Shelke VR

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9Sa.3709

Abstract
A field experiment was conducted at research farm of Department of Soil Science, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra during *Rabi* season of 2024-2025 to optimize nutrient-management practices through foliar feeding in 'Phule Vijaya' variety of french bean (*Phaseolus vulgaris* L.) The experiment was laid out in a randomized block design with ten treatments *viz*, T_1- absolute control, T_2- RDF (As per crop), T_3- RDF+ Grade-1(a) @ 25kg ha^{-1} (Gypsum based), T_4- RDF+ Grade-1(b) @ 25kg ha^{-1} (Bentonite based), T_5- RDF+ Govt. notified Grade 1(c) @ 25kg ha^{-1}(Gypsum based), T_6- RDF+Grade-II (a) @ 0.5 and 1% (Chelation with EDTA), T_7- RDF+ Grade-II (b) @ 0.5 and 1% (Chelation with glycine), T_8- RDF+ Grade-II (c) 0.5 and 1% (Chelation with EDTA), T_9- RDF+ Grade-II (d) 0.5 and 1% (Chelation with citric acid) and T_{10}- RDF+ Govt. notified Grade-II (e) @ 0.5 and 1% (Chelation with EDTA). It is revealed that application of RDF+ Grade-1(a) @ 25kg ha^{-1} (Gypsum based) resulted in maximum grain yield (1105.41 kg/ha) and straw yield (387.58 kg/ha). Maximum plant height (31.19 cm), number of pods/plant (9.23), chlorophyll content (48.62 SPAD value) and quality parameter *viz.*, protein content (22.73%), test weight (16.79 gm) were obtained from the same treatment.

Keywords: French bean, micronutrient grades, grain yield, straw yield, protein content

1. Introduction

French bean is a minor pulse crop cultivated throughout the world having 34.80 million hectares of area contributing to 27.54 million tonnes of production. India ranks first in area 13 million hectares and production 5.46 million tonnes followed by Myanmar having area 3.34 million hectares and production 3.05 million tonnes and Brazil with area 2.68 million hectares and production 3.03 million tonnes. (Anonymous, 2020) [3].

Beans are mostly utilized as pulses and green vegetables in India. It is prized for its seeds, which are high in protein (23%). Iron, phosphate and calcium are also abundant in seeds. Vegetables are made from the fresh pods. Each 100 g of edible pods contains 50 mg of calcium, 28 mg of phosphorus, 1.7 mg of iron, 132 mg of carotene, 0.08 mg of thiamine, 0.06 mg of riboflavin and 24.0 mg of vitamin C, making it a nutrient-dense vegetable (Chadha, 2001) [9].

Both macro and micronutrients are necessary for the plant's regular growth and development. In contrast to other leguminous crops, french beans have a relatively low capacity to fix atmospheric nitrogen in their root zone (Habbish and Ishaq, 1974) [15]. The most essential nutrient is nitrogen, which is absorbed by plants more than any other element. The dose of nitrogen was found to enhance french bean yield and vegetative growth (Chandra *et al.*, 1987) [11]. Since phosphorus is essential for energy storage and transfer for metabolic activities, it is one of the most significant components that enhances plant growth and biological yield (Srivastava *et al.*, 1998; Nassar and Ismail, 1999) [25, 20]. French beans like cereals, react favourably to phosphorus. It has a noticeably greater P need than other pulse crops. The third important nutrient in commercial fertilizers is potassium. It plays a crucial role in raising crop output and quality overall and fortifies plants resistance to disease. French beans flowering, seed maturity and yield are all considerably impacted by potassium (Arya *et al.*, 1999) [4].

2. Materials and Methods

A field experiment was conducted at research farm of Department of Soil Science, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra. The experimental soil was clayey in texture, calcareous in nature, moderately alkaline reaction, low in organic carbon (3.27 g kg^{-1}), available nitrogen (131.98 kg ha^{-1}), available phosphorous (11.86 kg ha^{-1}), high in available potassium (711.78 kg ha^{-1}), sufficient in available sulphur (10.12 kg ha^{-1}), deficient in DTPA zinc (0.68 mg kg^{-1}), DTPA iron (4.75 mg kg^{-1}), DTPA copper (1.33 mg kg^{-1}), DTPA manganese (2.58 mg kg^{-1}) and available boron (0.33 mg kg^{-1}). The experiment was laid out in a randomized block design with ten treatments *viz,* T_1-absolute control, T_2-RDF (As per crop), T_3- RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based), T_4- RDF+ Grade-I (b) @ 25kg ha^{-1} (Bentonite based), T_5- RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1}(Gypsum based), T_6- RDF+Grade-II (a) @ 0.5 and 1% (Chelation with EDTA), T_7- RDF+ Grade-II (b) @ 0.5 and 1% (Chelation with glycine), T8- RDF+ Grade-II (c) 0.5 and 1% (Chelation with EDTA), T_9- RDF+ Grade-II (d) 0.5 and 1% (Chelation with citric acid) and T_{10}- RDF+ Govt. notified Grade-II (e) @ 0.5 and 1% (Chelation with EDTA). The recommended dose of fertilizer is 120:60:60 NPK kg ha^{-1} was applied. The half dose of N along with full dose of P and K was applied as basal and remaining half dose of N is applied as top dressing on 30 days after sowing.

Preparation of soil and foliar micronutrient formulation grades

In the present investigation different micronutrient formulations were prepared as per the nutrient standards mentioned in the table 1. The soil micronutrient formulations Grade-I (a) gypsum and Grade-I (b) bentonite based contains, Zn: 6%, Fe: 5%, Mn: 1%, B: 1% and Cu: 0.5%. The micronutrient formulation Govt. notified Grade-I (c) gypsum based was prepared as per Maharashtra State Department of Agriculture recommendations *i.e.* Zn: 5%, Fe: 2%, Mn: 1%, B: 1.0% and Cu: 0.5%. The foliar micronutrient formulation chelation's were made *viz.*, Grade-II (a) with EDTA, Grade-II (b) with glycine, Grade-II (c) with EDTA and Grade-II (d) with citric acid was prepared as Zn: 4%, Fe: 3%, Mn: 1%, B: 0.5%, Cu: 0.2% and Mo: 0.1% and Grade-II (e) with EDTA was prepared which contains Zn: 4.5%, Fe:3.5%, Mn: 1%, B: 0.5%, Cu: 0.2% and Mo: 0.1%. These mixtures were prepared in the laboratory by using laboratory chemicals *viz.*, ferrous sulphate, zinc sulphate, manganese sulphate, copper sulphate, boric acid, sodium tetraborate and ammonium molybdate.

Table 1: Content of soil and foliar micronutrient grades

Grade	Zn (%)	Fe (%)	Mn (%)	B (%)	Cu (%)	Mo (%)
Soil application						
Grade-I (a) and (b)	6	5	1	1	0.5	-
Govt. notified Grade-I (c)	5	2	1	1	0.5	-
Foliar application						
Grade-II (a) to (d)	4.5	3.5	1	0.5	0.2	0.1
Govt. notified Grade-II (e)	3	2.5	1	0.5	1	0.1

Sources: Soil application (**Grade-I** which were prepared in 1 kg pack)

Formulation-I		
Grade-I (a)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O$ (Gypsum based)
Grade-I (b)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O$ (Bentonite based)
Govt. notified Grade-I (c)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O$ (Gypsum based)

Foliar application (Grade-II which were prepared in 1 liter capacity**)**

Formulation-II		
Grade-II (a)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + Na_2B_4O_7.10H_2O$ (Borax) + $MnSO_4.H_2O + CuSO_4.5H_2O + (NH_4)_2MoO_4$ (Chelation with EDTA)
Grade-II (b)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O + (NH_4)_2MoO_4$ (Chelation with glycine)
Grade-II (c)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3$ (Boric acid) + $MnSO_4.H_2O + CuSO_4.5H_2O + (NH_4)_2MoO_4$ (Chelation with EDTA)
Grade-II (d)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O + (NH_4)_2MoO_4$ (Chelation with citric acid)
Govt.notified Grade-II (e)	:	$ZnSO_4.7H_2O + FeSO_4.7H_2O + H_3BO_3 + MnSO_4.H_2O + CuSO_4.5H_2O + (NH_4)_2MoO_4$ (Chelation with EDTA

Table 2: Sources used for soil and foliar micronutrient formulation

Sr. No.	Nutrient	Source	Nutrient content (%)
1	Fe	$FeSO_4.7H_2O$	20.10
2.	Mn	$MnSO_4.H_2O$	32.51
3.	Zn	$ZnSO_4.7H_2O$	22.75
4.	Cu	$CuSO_4.5H_2O$	25.47
5.	B	H_3BO_3	17.49
6.	B	$Na_2B_4O_7.10H_2O$	11.34
7.	Mo	$(NH_4)_2MoO_4$	54.35

3. Results and Discussion

Effect of different micronutrient grades on growth of french bean

Plant height (cm)

Results showed that application of micronutrient formulation basal dose had a substantial impact on plant height. Application of treatment RDF+Grade-I (a) @ 25kg ha^{-1} (Gypsum based) recorded significantly taller plant (31.19) over rest of the treatments. Whereas, the dwarf plant was observed with treatment T_1: control (26.56 cm). Treatment RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) recorded 30.77cm plant height of french bean which was found to be at par with treatment RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based). It is also followed by treatment RDF+ Grade-I (b) @ 25kg ha^{-1} (Bentonite based) with plant height 30.06 cm. Increase in plant height might be due to micronutrients involvement in various physiological processes such as; enzyme activation, chlorophyll formation, electron transport and stomata regulation. Application of Zn enhanced the plant height due to increase in distance of internodes. Similar findings were reported by Addow *et al.* (2020) [2], Abhilash *et al.* (2023) [1], Maurya *et al.* (2024) [19] and Shubhashree *et al.* (2011) [26].

Number of pods per plant

The data indicated that significant difference in the number of pods per plant were recorded with values at maturity extent from 5.33 to 9.23. The highest pods count per plant (9.23) was found with treatment RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based), which was closely at par with treatment RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) *i.e.* 8.20. The remaining all treatments showed significantly maximum number of pods plant^{-1} over treatment T_1: Absolute control which noted minimum number of pods plant^{-1} (5.33). The increase in number of pods per plant due to balanced supply of nutrients at all the stages of crop growth and plant nutrient supplied through foliage might have been better used more efficiently by the plant. Similar findings were also observed by Band *et al.* (2007) [6], Shubhashree *et al.* (2011) [26] and Rajkumar *et al.* (2023) [21].

Chlorophyll content

The chlorophyll content of French bean leaves varied from 39.54 to 48.62 during flowering stage. The maximum chlorophyll content (48.62) was observed at treatment T_3 involves RDF + Grade-I (a) @ 25kg ha^{-1} (Gypsum based) which was found to be statistically at par with treatment T_5- RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) with value 47.65. However, the minimum chlorophyll content (39.54) was recorded with absolute control (39.54) at flowering stage of french bean. The increased in total chlorophyll content in leaves could be attributed to the functional role of iron and zinc in setting up some chlorophyll biosynthesis pathway enzymes and some antioxidants enzymes such as ascorbate peroxidase and glutatheon reductase have a fundamental role and prevent the chlorophyll degradation by reactive oxidation process. Similar observations were noted by Bhamare *et al.* (2018) [7], Kumar *et al.* (2021) [17], Baddour and Attia (2021) [5] and Durgude *et al.* (2021) [14].

Table 3: Effect of different micronutrient grades on growth of French bean

Tr. No.	Treatment details	Plant height (cm)	Pods plant^{-1}	Chlorophyll content (SPAD value)
T_1	Absolute control	26.56	5.33	39.54
T_2	RDF (As per crop)	26.82	5.40	42.03
T_3	RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based)	31.19	9.23	48.62
T_4	RDF+ Grade-I(b) @ 25kg ha^{-1} (Bentonite based)	30.06	8.00	45.35
T_5	RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based)	30.77	8.20	47.65
T_6	RDF+ Grade-II (a) @ 0.5&1% (Chelation with EDTA)	27.62	6.27	41.50
T_7	RDF+ Grade-II (b) @ 0.5&1% (Chelation with glycine)	27.88	6.60	43.67
T_8	RDF+ Grade-II (c) 0.5&1% (Chelation with EDTA)	29.15	7.87	45.32
T_9	RDF+ Grade-II (d) 0.5&1% (Chelation with citric acid)	28.06	6.67	44.72
T_{10}	RDF+ Govt. notified Grade-II (e) @0.5&1% (Chelation with EDTA)	28.30	6.93	45.00
	SE ±	0.65	0.39	1.09
	CD at 5%	1.94	1.17	3.24

Effect of different micronutrient grades on yield of French bean

Grain yield

Application of RDF along with different micronutrient grades on grain yield of French bean was extent from 571.00 to 1105.41 kg ha^{-1}. The highest grain yield was recorded with application of treatment T_3, which receiving RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based) resulting in 1105.41 kg ha^{-1} and found to be superior over rest of the treatments. It was found statistically at par with treatment T_5 receiving RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) with value 1081.37. However, the lowest grain yield was recorded at the absolute control treatment (T_1) *i.e.* 753.10 kg ha^{-1} and the remaining all treatments shown significantly maximum grain yield of French bean over absolute control. Further, the results clearly indicated that the use of different micronutrient grades on plants leads to improved grain yield due to elevated growth hormone levels, enhanced metabolic processes, and improved photosynthetic activities. An increase in grain yield is the direct result of improvement in yield components. Grain size, number of grains per pod and test weight had a positive correlation with grain yield and might be the direct effect of improvement in grain yield. This finding corroborates the finding of Kalita *et al.* (2016) [16], Zahida *et al.* (2016) [29], Rajkumar *et al.* (2023) [21] and Chandar *et.al.* (2023) [10].

Straw yield

Straw yield extent from 258.83 to 429.65 kg ha^{-1} with application of recommended dose of fertilizer and different micronutrient grades. The highest straw yield (429.65 kg ha^{-1}) was recorded with treatment T_3-RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based) over rest of treatments. It was statistically found to be at par with treatment T_5: RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) i.e. 425.32 kg ha^{-1}. Whereas, lowest straw yield (258.83 kg ha^{-1}) was recorded in the absolute control treatment (T_1). Increase of straw yield with RDF and micronutrient grades might be due to the role of zinc in the production of biomass and that iron is necessary for chlorophyll synthesis and has many essential roles in plant growth and development. The involvement of nutrients in a variety of physiological and biochemical processes, culminating in more dry matter production. Comparable findings were reported by Zahida *et al.* (2016) [29], Chaudhary *et al.* (2018) [12] and Abhilash *et al.* (2023) [1].

Table 4: Effect of different micronutrient grades on yield grain and straw yield of french bean

Treatment details	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1: Absolute control	571.00	258.83
T_2: RDF (As per crop)	735.11	316.11
T_3: RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based)	1105.41	429.65
T_4: RDF+ Grade-I(b) @ 25kg ha^{-1} (Bentonite based)	1013.60	387.58
T_5: RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based)	1081.37	425.32
T_6: RDF+ Grade-II (a) @ 0.5&1% (Chelation with EDTA)	761.47	325.48
T_7: RDF+ Grade-II (b) @ 0.5&1% (Chelation with glycine)	905.02	329.42
T_8: RDF+ Grade-II (c) 0.5&1% (Chelation with EDTA)	1003.54	382.11
T_9: RDF+ Grade-II (d) 0.5&1% (Chelation with citric acid)	961.15	335.48
T_{10}:RDF+ Govt. notified Grade-II (e) @0.5&1% with EDTA)	981.38	371.88
SE±	23.46	9.23
CD at 5%	69.70	27.43

Effect of different micronutrient grade on quality of French bean

Protein content

French bean protein content was extent from 19.75 to 22.73%. The highest protein content was recorded at treatment T_3 which involving RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based), resulting in 22.73%. The treatment T_3 was found to be at par with the treatment T_5-RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based), resulting in 22.67% and T_4, which includes RDF+ Grade-I(b) @ 25kg ha^{-1} (Bentonite based), with a protein content of 22.63%. Whereas, the lowest protein content was recorded in the absolute control treatment (T_1) with value 19.75%. The increase in protein content might be due to iron and zinc are two important elements in enzyme structure involved in amino acid biosynthesis and because amino acids are base of protein synthesis and thereby protein content increases in case of these micronutrients, Also, the nitrogen fertilizer in a plant is mainly in its presence in the nucleic acid protein structure. In addition, nitrogen is also found in the chlorophyll molecule. Chlorophyll enables a plant to transfer energy from sunlight by photosynthesis to assimilate. The current findings are consistent with Zahida *et al*. (2016) [29], Borang and Sharma (2020) [8], Bhamare *et al*. (2018) [7] and Mahadule *et al*. (2020) [18].

Test weight

The good impact of RDF and different micronutrient grades on test weight of french bean was observed which extent from 14.62 to 16.79 g. The highest test weight of french bean seeds was recorded in treatment T_3 receiving RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based) with value 16.79 g. The treatment T_3 was followed by treatment T_5: RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based) with test weight of 16.58 g and T_4, which included RDF+ Grade-I (b) @ 25 kg ha^{-1} (Bentonite based), with test weight of 16.25 g. Whereas, the lowest test weight was recorded in the absolute control treatment (T_1) with value 14.62 g. Further, results showed that the increase in test weight in study of french bean due to utilisation of micronutrient grades fertilizers and RDF in crop. The improvement in test weight of french bean seeds may be due to boron, which affects cell division, carbohydrate metabolism, sugar and starch formation, which increase the size and weight of the seeds. The present results have been corroborated with findings of Zahida *et al.* (2016) [29], Reddy *et.al.* (2023) [22], Senapati *et al*. (2022) [24] and Shubhashree *et al.* (2011) [26].

Table 5: Effect of different micronutrient grades on protein content and test weight of French bean seeds

Treatment details	Protein content (%)	Test weight (gm)
T_1: Absolute control	19.75	14.62
T_2: RDF (As per crop)	19.94	14.79
T_3: RDF+ Grade-I (a) @ 25kg ha^{-1} (Gypsum based)	22.73	16.79
T_4: RDF+ Grade-I(b) @ 25kg ha^{-1} (Bentonite based)	22.63	16.25
T_5: RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based)	22.67	16.58
T_6: RDF+ Grade-II (a) @ 0.5&1% (Chelation with EDTA)	20.06	15.15
T_7: RDF+ Grade-II (b) @ 0.5&1% (Chelation with glycine)	20.15	15.16
T_8: RDF+ Grade-II (c) 0.5&1% (Chelation with EDTA)	20.35	15.48
T_9: RDF+ Grade-II (d) 0.5&1% (Chelation with citric acid)	20.10	15.38
T_{10}: RDF+ Govt. notified Grade-II (e) @0.5&1% (Chelation with EDTA)	20.29	15.50
SE ±	0.57	0.37
CD at 5%	1.70	1.10

4. Conclusion

Considering the above results it may be concluded that, soil application of RDF along with micronutrient grade-I (a) @ 25kg ha^{-1} (Gypsum based) was produced the taller plants, highest number of pods $plant^{-1}$, chlorophyll content. Quality parameters *i.e*. protein content and test weight were, grain and straw yield significantly enhanced by the application of same treatment. Application of treatment T_3 [RDF+ Grade-1(a) @ 25kg ha^{-1} (Gypsum based)] resulted in the maximum seed and straw yields of french bean, closely followed by treatment T_5 [RDF+ Govt. notified Grade-I (c) @ 25kg ha^{-1} (Gypsum based)] than the other treatments.

References

1. Abhilash S, Singh S, Nawhal A. Influence of Nitrogen and Boron on Growth and Yield of French Bean. International Journal of Environment and Climate Change. 2023;13(09):2485-2489.
2. Addow MA, Hassan AA, Adde MSN, Noor AA, Kabir MA. Effect of nitrogen and potassium on the growth, yield and yield contributing traits of French Bean. Journal of Agriculture and Veterinary Science. 2020;13(04):1-12.
3. Anonymous. Horticulture Statistics at a glance. Ministry of Agriculture and Farmers' Welfare; 2018. https://agricoop.nic.in/Documents/Horticulture%20Statistics%20at%203%20Glance-2018.pdf. Accessed June 4, 2023.
4. Arya PS, Sagar V, Singh SR. Effect of NPK on seed yield of French bean (*Phaseolus vulgaris* L.) var. Contender. Haryana Journal of Horticultural Sciences. 1999;6:137-139.
5. Baddour AG, Attia RH. Effect of foliar application with nano micronutrients and organic fertilization on snap bean under sandy soil condition. Journal of Soil Sciences and Agricultural Engineering. 2021;12(2):25-32.
6. Band AM, Mendhe SN, Kolte HS, *et al*. Nutrient management studies in French bean (*Phaseolus vulgaris* L.). Journal of Soil and Crops. 2007;17(2):367-372.
7. Bhamare RS, Sawale DD, Jagtap PB, Tamboli BD, Kadam M. Effect of iron and zinc on growth and yield of French Bean in iron and zinc deficient Inceptisol soil. International Journal of Chemical Studies. 2018;6(3):3397-3399.
8. Borang B, Sharma YK. Soil Properties and French Bean (*Phaseolus vulgaris* L.) Response to Phosphorus and Sulphur under Aluminium Stress Soil Condition. International Journal of Current Microbiology and Applied Sciences. 2020;22(3):315-319.
9. Chadha KL. Handbook of Horticulture. Department of Agriculture, Govt. of India; 2001. p. 399-402.
10. Chandar DA, Manuel IR, Jeyasingh AIR, *et al*. Influence of Soil and Foliar Application of Nutrients on Growth and Yield of Black Gram (*Vigna mungo* L.). International Journal of Environment and Climate Change. 2023;13(11):4466-4471.

11. Chandra R, Rajput CBS, Singh KP, Singh SJ. A role on the effect of nitrogen, phosphorus and Rhizobium culture on the growth and yield of French bean (*Phaseolus vulgaris* L.) cv. Contender. Haryana Journal of Horticultural Sciences. 1987;16(8):146-147.
12. Chaudhary M, Singh S, Babu S, Prasad M. Effect of integrated nutrient management on productivity, nutrient acquisition and economics of black gram (*Phaseolus mungo* L.) in an Inceptisol of eastern Uttar Pradesh. Legume Research. 2018;41(5):759-762.
13. Duke JA. Hand Book of Legumes of World Economic Importance. 2nd ed. Plenum Press; 1983. p. 341.
14. Durgude AG, Kadam SR, Pharande. Response of Hybrid maize to soil and foliar application of iron and zinc on Entisols. An Asian Journal of Soil Science. 2021;9(1):36-40.
15. Habbish HA, Ishaq HM. Nodulation of legume in Sudan. III. Response of haricot bean to inoculation. Indian Journal of Agricultural Sciences. 1974;58(9):707-708.
16. Kalita H, Chakrabarty R, Zaman ASN, Deka N, Guha B. Effect of nitrogen, zinc sulphate and vermicompost on grain yield and economics of rajmash (*Phaseolus vulgaris* L.) and soil microbial population. Journal of Crop and Weed. 2016;12(2):37-40.
17. Kumar A, Singh SN, Tripathi DK, Rawat DK, Maurya N. To study the effect of growth and metabolic parameters of french bean (*Phaseolus vulgaris* L.) as influence by sulphur and iron application. Indian journal of pure and applied biosciences. 2021;9(1):336-343.
18. Mahadule PA, Jagdhani AD, Sawale DD, Jagtap PB, Tamboli BD. Effect of foliar sprays of boron on quality and nutrient uptake of french bean (*Phaseolus vulgaris* L.) in Entisol. South Asian research journal of natural products. 2020;3(3):131-135.
19. Maurya PK, Bahadur V, Shukla PK, Topno SE, Thakur G. Effect of nano-multi micronutrients on growth, quality and economics of French bean. Indian Journal of Horticulture. 2024;81(2):191-195.
20. Nassar KE, Ismail KM. Effect of ascorbic acid and phosphorus application on lupin yield (*Lupinus termis* L.) grown on sandy soil. Egypt Journal of Applied Science. 1999;14(10):357-368.
21. Rajkumar C, Suryavanshi VP, Dudde PS, Sharma P, Jadhav AT. Effect of different levels and mode of application of micronutrient grades on growth, yield and economics of Kharif French bean (*Phaseolus vulgaris* L.). The Pharma Innovation Journal. 2023;12(12):2507-2509.
22. Reddy YR, Biswarup M, Mallela NR. Influence of zinc and boron application on growth and yield of French bean (*Phaseolus vulgaris* L.). International Journal of Environment and Climate Change. 2022;13(10):859-864.
23. Salunkhe DK, Desai BB, Bhat NR. Leguminous vegetables (Peas and Beans). In: Vegetable and Flower Seed Production. Agricole Publishing Academy; 1987. p. 265-302.
24. Senapati B, Sahu GS, Tripathy P, *et al*. Effect of Nitrogen, Phosphorous and Boron on Seed Yield, Seed quality and Economics of Dolichos Bean (*Lablab purpureus* L.) var. Arka Amogh. An International Journal. 2022;14(4):1115-111.
25. Srivastava TK, Ahlawat 1PS, Panwar JDS. Effect of phosphorus, molybdenum and bio-fertilizers on productivity of pea (*Pisum sativum* L.). Indian Journal of Plant Physiology. 1998;3(3):237.
26. Shubhashree KS, Alagundagi SC, Hiremath SM, *et al*. Effect of nitrogen, phosphorus and potassium levels on growth, yield and economics of rajmash (*Phaseolus vulgaris* L.). Karnataka Journal of Agricultural Sciences. 2011;24(3):283-285.
27. Swiader JM, Ware GW, McCollum JP. Producing vegetables crops. 4th ed. Interstate Printers and Publishers Inc; 1992. p. 626.
28. Tindall HD. Vegetables in the tropics. McMillan Education Ltd; 1988. p. 527.
29. Zahida R, Dar SB, Mudasir R, Inamullah S. Productivity and quality of French bean (*Phaseolus vulgaris* L.) as influenced by integrating various sources of nutrients under temperate conditions of Kashmir. International Journal of Food, Agricultural and Veterinary Sciences. 2016;6(1):15-20.