Original Research Article

Effect of nano mixed micronutrients on growth, quality and economics of french bean

ABSTRACT

Micronutrients are essential for the enzymatic activity of plants, which affects fruit quality and growth. The study was conducted in the Rabi season of 2021 at SHUATS, Prayagraj. The purpose of the study was to investigate how the French bean variety "Arka Komal" was affected by nano mixed micronutrients in terms of growth, quality, and economics. The experiment was set up using a FRBD one factor being application of nano mixed micronutrients and other being application of nano fertilizers. The nano mixed micronutrients given were **M_0**-control; **M_1**- 0.2ml/ L of nano mix micronutrient/L of water as foliar application; **M_2**- 0.4ml/L of nano mix micronutrient/ L of water as foliar application; **M_3** - 0.6ml/ L of nano mix micronutrient/L of water as foliar application. The nano-fertilizers treatment given were **F_0**– Control (without fertilizer); **F_1**- 100% RDF as traditional fertilizer; **F_2**-5ml/ L each of Nano NPK/ L of water as foliar application; **F_3**- 4ml/L each of Nano NPK/ L of water as foliar application; **F_4**- 3ml/L each of Nano NPK/ L of water as foliar application. 50% traditional fertilizers were applied in all treatments excluding control. From above experimental findings it was concluded that treatment **M_3** performed best for growth parameters like plant height; leaf area and pod yield per hectare studied in French bean. **M_3** performed best for quality parameters like TSS, ascorbic acid content. It also had highest BC ratio (3.07) among various treatments.

Keywords: *Phaseolus vulgaris, TSS, foliar application, BC ratio.*

1.Introduction

The French bean (*Phaseolus vulgaris* L.) holds significant importance among leguminous vegetables and is considered the most crucial legume globally. It is a multipurpose crop that can be used as a vegetable or a pulse. Due to its short growth period and nutritional advantages, it stands out among beans in that its highly nutritious dry seeds contain about 24.9% protein, 60.1% carbohydrate, and fat. **Anonymous, (1)**. The main cause of French beans' low productivity is inadequate fertilisation, which is why using chemical fertilisers has become crucial to intensive crop production in the modern era. French beans, which originated in Central and South America, are now widely used in agricultural practices around the world **Swaider *et al.* (15)**. The French bean, which belongs to the Fabaceae family and has chromosome number 2n=22, is a healthy vegetable that can be eaten in a variety of ways, such as tender pods, shelled beans, or dry beans. French beans are popular in both bush and pole varieties. This legume is widely grown in temperate, subtropical, and tropical regions, making it one of the most important legumes in the world and satisfying a significant demand for human consumption **Dhakal *et al.* (5)**. The French bean, also known as "Rajmah," is a highly valued leguminous vegetable crop that is widely grown in India for its green pods and dry seeds. In addition to being a cheap source of vegetable protein, it offers vital minerals like calcium and iron as well as vitamins like thiamine, riboflavin, and niacin. Like other vegetables, French beans are farmed for profit, and to increase yield and growth, larger nitrogen doses are applied. This is made possible by the plants' capacity to fix nitrogen from the atmosphere with the help of nearby microbes. The French bean is a highly valuable legume that is widely cultivated in temperate, sub-tropical, and tropical regions worldwide. Its production meets a substantial demand for human consumption (**Al-Juthery *et al.*, 2; Dhakal *et al.*, 5**). Zinc is an essential component of many physiological and enzymatic processes, acting as a catalyst in different parts of the plant system. It plays a major role in the transformation of protein synthesis, chlorophyll, and carbohydrates. Zinc also plays a key role in the production of auxin, the initiation of dehydrogenase enzymes, and the maintenance of ribosomal fractions. Conversely, boron is important for cell division; it is necessary for pollen grain germination and growth. It is essential to the synthesis of lignin and aids in the translocation of sugars as well as the movement of growth regulators within the plant. Because of its crucial role in reproduction, boron has an impact on all aspects of development, including the growth of pollen tubes and germination of seeds. In the future, it will be imperative to produce agricultural products that are plentiful and high in vital nutrients, especially proteins, for consumption by humans and animals. Thus, in order to meet the nutritional needs of an expanding population, there should be a concentrated effort to prioritise the production of high-quality food with the necessary levels of nutrients and proteins **Jyothi and Hebsur, (9)**. Because they give plants vital trace elements like iron, zinc, copper, manganese, and boron, micronutrient fertilisers are crucial to crop production. These micronutrients are essential for a number of biochemical reactions because they activate enzymes that are vital to the general growth of plants. These micronutrient deficiencies can reduce crop yields and degrade crop quality. These deficiencies can be addressed by applying foliar sprays or soil-applied nano-mixed micronutrient fertilisers, which boost crop vigour, enhance photosynthesis, boost disease resistance, and ultimately increase yields. An effective and sustainable crop production is facilitated by the efficient management of micronutrients, which guarantees a balanced nutrition profile for plants. This becomes especially important for agricultural sustainability and global food security (**Lobanov, 12**). One of the most important micronutrients, manganese (Mn), is vital for the development of pollen tubes and seeds. Its important function in these processes has a profound effect on the dynamics of crop reproduction and, as a result, is crucial in determining the crop's overall yield. For plants to successfully complete their reproductive stages and form seeds and pollen tubes, which are necessary components for reaching maximum crop productivity, manganese must be present and in sufficient amounts **Bashir *et al.* (3)**. The application of nano-mixed micronutrient fertiliser in French bean production has the potential to guarantee the best possible plant nutrition. Since that French beans are a crop with known high nutrient requirements, it is essential to keep a balanced supply of trace elements in order to promote healthy growth and high yields. Micronutrients like iron, zinc, and manganese are critical for improving the synthesis of chlorophyll, encouraging effective photosynthesis, and generally increasing the vitality of plants. This ultimately leads to enhanced bean production through improvements in fruit setting and flowering. The targeted strategy of applying nano mixed micronutrient fertilisers enhances the resilience and quality of the crop by addressing potential deficiencies in these trace elements. This approach becomes particularly vital for maximizing French bean yields. Consequently, the conducted research aimed to study the effects of nano mixed micronutrients on the growth, quality, and economic aspects of French beans, recognizing the importance of optimizing plant nutrition for overall crop success.

2.Materials and Methods

Examining the effects of nano mixed micronutrients on the growth, quality, and financial aspects of the french bean variety "Arka Komal" was the aim of the current study. In Prayagraj, during the Rabi season of 2021, the research was carried out at the Departmental Research Farm of the Department of Horticulture, Naini Agricultural

Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences (SHUATS). A Factorial Randomised Block Design (FRBD) was the experimental design used. One factor addressed the application of nano mixed micronutrients, and the other factor addressed the application of nano fertilisers. This design aimed to systematically assess the combined effects of these factors on the specified parameters, providing valuable insights into the potential benefits of using nano mixed micronutrients in the cultivation of french beans, particularly the "Arka Komal" variety. The **Fisher and Yates, (6)** method was used to statistically analyse the data. The software used for analysis was OPSTAT. In the study, the height of randomly chosen plants from each plot was assessed in centimetres using a meter scale. This measurement was taken from ground level to the tip of the shoot at 35 days after sowing (DAS). Additionally, the number of branches and leaves per plant, emerging from the main shoot, was counted, and the values were averaged. TSS was measured using refractometer. Ascorbic acid was measured by technique suggested by **Rangana (14).** These parameters provide comprehensive insights into the growth, development, and quality of the french bean variety "Arka Komal" under the influence of nano mixed micronutrients and nano fertilizers. The details of nano mixed micronutrients treatment given are $\mathbf{M_0}$-control (Without micronutrient); $\mathbf{M_1}$- 0.2ml/ L of nano mix micronutrient/L of water as foliar application; $\mathbf{M_2}$- 0.4ml/L of nano mix micronutrient/ L of water as foliar application; $\mathbf{M_3}$ -0.6ml/ L of nano mix micronutrient/L of water as foliar application. The details of nano-fertilizers treatment given are $\mathbf{F_0}$– Control (without fertilizer); $\mathbf{F_1}$- 100% RDF as traditional fertilizer; $\mathbf{F_2}$-5ml/ L each of Nano NPK/ L of water as foliar application; $\mathbf{F_3}$- 4ml/L each of Nano NPK/ L of water as foliar application; $\mathbf{F_4}$- 3ml/L each of Nano NPK/ L of water as foliar application. 50% traditional fertilizers were applied in all treatments excluding control.

3.Results and Discussion:

The data pertaining to plant height, number of leaves, number of branches and leaf area (Table 1) in French bean showed significant differences among treatments applied for nano mixed micronutrients studied for year 2021. In the range of treatments involving varying levels of nano mix micronutrients, $\mathbf{M_3}$ resulted in the tallest plant height (55.62) followed by $\mathbf{M_1}$ (54.59) for the years 2021. Conversely, the shortest plant height (47.12) was observed in $\mathbf{M_0}$ (Control). Within the spectrum of treatments that encompass diverse concentrations of nano mix micronutrients, $\mathbf{M_3}$ resulted in the highest number of leaves per plant (29.46) followed by $\mathbf{M_2}$ (29.19) for the years 2021. In other way round, the lowest number of leaves per plant (25.21) was observed in $\mathbf{M_0}$ (Control). The application of a foliar treatment with 0.6 ml/L of nano mixed micronutrients per litre of water demonstrated superior outcomes in terms of plant height and the number of leaves per plant in French beans compared to the 0.2 ml/L and 0.4 ml/L treatments. The higher concentration of 0.6 ml/L proved advantageous, providing an optimal and more comprehensive supply of micronutrients. This ensured that the plants had access to essential trace elements at levels conducive to robust growth. The nanoscale particles in the micronutrient mix likely played a role in enhancing nutrient absorption and translocation within the plant. This, in turn, contributed to more efficient nutrient utilization, stimulated photosynthesis, and overall improved plant health. The balanced combination of micronutrients in the 0.6 ml/L treatment effectively prevented deficiencies, promoting vigorous growth and abundant leaf production. Consequently, the plants exhibited enhanced health, productivity, greater height, and a higher number of leaves. Similar findings were also concluded by **Nahla *et al.* (13)**.

Within the spectrum of treatments that encompass diverse concentrations of nano mix micronutrients, $\mathbf{M_3}$ resulted in the maximum number of branches per plant (10.93 branches) at par with $\mathbf{M_2}$ (10.77 branches) for the years 2021, 2022, and the pooled mean, respectively. In other way round, the minimum number of branches per plant (9.39 branches) was observed in $\mathbf{M_0}$ (Control). $\mathbf{M_3}$ resulted in the maximum leaf area (158.66 cm^2) followed by $\mathbf{M_2}$ (151.86 cm^2) for the years 2021. In other way round, the minimum leaf area (114.67, cm^2) was observed in $\mathbf{M_0}$ (Control). The application of a foliar treatment with 0.6 ml/L of nano mixed micronutrients per litre of water resulted in a higher number of branches per plant in French beans compared to the 0.2 ml/L and 0.4 ml/L treatments, attributed to several factors. The elevated concentration of micronutrients in the 0.6 ml/L treatment ensured that the plants received an optimal supply of essential trace elements, thereby promoting overall plant health. The presence of nanoscale particles in the micronutrient mix likely played a crucial role in enhancing nutrient uptake and translocation within the plant. This improvement in nutrient utilization and photosynthesis contributed to increased lateral branching and the formation of secondary shoots, ultimately leading to more branches per plant. The balanced combination of micronutrients in the 0.6 ml/L treatment effectively prevented deficiencies, supporting robust vegetative growth and the development of branches. As a result, the plants exhibited a notable increase in branching under this treatment. Similar findings were also concluded by **Kumar *et al.* (11)**.

In the present investigation, TSS, protein content, fibre content and ascorbic acid (Table 2) showed significant difference within different treatments of nano mixed micronutrients applied in French bean for two successive years studied. Regarding treatments with varying levels of nano mix micronutrients, $\mathbf{M_0}$ (Control) showed the maximum TSS levels (5.33 °Brix), while $\mathbf{M_3}$ demonstrated the best for required TSS levels (5.14 °Brix) for year 2021 closely followed by $\mathbf{M_2}$ (5.17 °Brix). $\mathbf{M_3}$

displayed the maximum ascorbic acid content (14.94 mg/100g) for year 2021 at par with **M_2** (14.85 mg/100g) better than Control. **M_0** (Control) recorded the minimum ascorbic acid content (13.43 mg/100g) within the various treatments applied nano mix micronutrients. **M_3** displayed the maximum Fibre content (4.30%) for year 2021at par with **M_2** (4.28 %) better than **M_0** (Control) with minimum Fibre content (3.96 %) within the various treatments applied nano mix micronutrients. **M_3** displayed the maximum protein content (4.04%) for both the year 2021 at par with **M_2** (3.98%) better than Control **M_0** with lowest protein content (3.51%) within the various treatments applied for nano mix micronutrients. The treatment with 0.6 ml/L of nano mixed micronutrients as a foliar application exhibited superior performance in quality parameters like Total Soluble Solids (TSS), ascorbic acid, protein content, and fibre content compared to the 0.2 ml/L and 0.4 ml/L treatments. The heightened micronutrient concentration in the 0.6 ml/L treatment played a pivotal role in enhancing the synthesis of essential compounds. Nanoscale particles in the micronutrient mix likely facilitated increased nutrient uptake and translocation within the plant, leading to more efficient utilization of nutrients for enhanced biochemical processes. This, in turn, positively influenced the quality parameters, including heightened TSS levels, increased ascorbic acid content, improved protein content, and enhanced fibre content. The balanced micronutrient combination in the 0.6 ml/L treatment effectively prevented deficiencies, contributing to superior overall quality in French bean produce compared to the 0.2 ml/L and 0.4 ml/L treatments. Similar findings were also concluded by **(Kumar *et al.,* 11; Nahla *et al.,* 13; Kumar *et al.,* 10)**.

Among the treatment combination studied maximum yield per hectare and maximum cost of cultivation was found in treatment M_3 (0.6ml/ L of nano mix micronutrient/L of water as foliar application). Maximum gross return and net return was also found in M_3 (0.6ml/ L of nano mix micronutrient/L of water as foliar application). Highest BC ratio was reported in M_3. The data is shown in table 3 and 4.

Table 1 Effect of nano mixed micronutrients on growth parameters of french bean for year 2021.

Treatment Details		Plant height (cm) [50 DAS]	No of leaves per plant [50 DAS]	No of branches per plant [50 DAS]	Leaf area (cm^2) [50 DAS]
M_0	Control	47.12	25.21	9.39	114.67
M_1	0.2 ml/L of nano mix micronutrient/L of water as foliar application	54.59	27.91	10.37	136.79
M_2	0.4 ml/L of nano mix micronutrient/L of water as foliar application	55.50	29.19	10.77	151.86
M_3	0.6 ml/L of nano mix micronutrient/L of water as foliar application	55.62	29.46	10.93	158.66
'F' test		**S**	**S**	**S**	**S**
CD $_{0.05}$		**0.071**	**0.057**	**0.113**	**5.638**
SE. m (±)		**0.025**	**0.020**	**0.039**	**1.962**

Table 2 Effect of nano mixed micronutrients on quality parameters of french bean of 2021.

Treatment Details		TSS [°Brix]	Ascorbic acid content (mg)	Fibre content (%)	Protein content (%)
M_0	Control	6.10	13.43	3.96	3.51
M_1	0.2 ml/L of nano mix micronutrient/L of water as foliar application	6.03	13.85	4.12	3.81

M_2	0.4 ml/L of nano mix micronutrient/L of water as foliar application	5.92	14.85	4.28	3.98
M_3	0.6 ml/L of nano mix micronutrient/L of water as foliar application	5.89	14.94	4.30	4.04
'F' test		**S**	**S**	**S**	**S**
CD $_{0.05}$		**0.102**	**0.074**	**0.045**	**0.047**
SE. m (±)		**0.033**	**0.026**	**0.016**	**0.016**

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