



# Effect of Foliar Application of Micronutrients and NPK on Available Soil Nutrients in Rice Bean (*Vigna umbellata* L.)

Sharada Megur <sup>a++</sup>, Anand Naik <sup>b##</sup>, Siddaram <sup>ct</sup>,  
M.A. Bellakki <sup>b</sup> and Balanagoudar, S.R. <sup>b#</sup>

<sup>a</sup> Department of Soil Science, College of Agriculture, Raichur University of Agricultural Sciences, Raichur (Karnataka), India.

<sup>b</sup> Department of Soil Science and Agricultural Chemistry, College of Agriculture, Kalaburagi, UAS, Raichur (Karnataka), India.

<sup>c</sup> Department of Agronomy, College of Agriculture, Kalaburagi, UAS, Raichur (Karnataka), India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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<sup>++</sup> M.Sc. (Soil Science);

<sup>#</sup> Associate Professor;

<sup>†</sup> Assistant Professor;

<sup>‡</sup> Professor;

\*Corresponding author: E-mail: [anandnaik2@gmail.com](mailto:anandnaik2@gmail.com);

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## ABSTRACT

Foliar application of micronutrients is more beneficial than soil application. Since application rates are lesser as compared to soil application, the same quantity of nutrient application could be supplied easily and crop reacts to nutrient application immediately. One of the limiting factors for low yield is to be imbalance and indiscriminate use of fertilizers and emergence of micronutrients deficiencies. The present study aimed to determine the effect of macro and micro nutrients on available soil nutrients in Rice bean (*Vigna umbellata* L.). An experiment was conducted at College of Agriculture, Kalaburagi, during *Kharif* 2023. The experiment was laid out in Randomized Complete Block Design (RCBD) with eleven treatments and replicated thrice. The soil parameters such as pH, Electric Conductivity, Organic carbon content, Free calcium carbonate (%), Available Nitrogen, Available Phosphorus, Available Potassium, Available soil sulphur, Exchangeable Calcium and Magnesium were measured by Using standard protocol of APHA (1995). The experimental results revealed that 100% RDF as basal dose + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application at 25 and 50 DAS recorded significantly higher available soil nitrogen (234 kg ha<sup>-1</sup>), available phosphorus (32.06 kg ha<sup>-1</sup>), available potassium (344.71 kg ha<sup>-1</sup>) and available sulphur (22.65 kg ha<sup>-1</sup>) in rice bean crop. Further, exchangeable calcium and exchangeable magnesium is non significantly with foliar spray of 100% RDF + 0.5 % Zinc sulphate (21%)+ 0.5 % Ferrous sulphate (20.1%) foliar application however which was on par with the treatments foliar spray 75% RDF + 0.5 % Zinc sulphate (21%)+ 0.5 % Ferrous sulphate (20.1%) the treatment with foliar spray of 100% RDF + 0.5 % Zinc sulphate (21%)+ 0.5 % FeSO<sub>4</sub>. In contrast, lower values for available soil nutrients were recorded in the absolute control treatment. Application of 100% RDF and foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS was found to be at par with 75% RDF along with foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS in terms of available macro and micronutrients in soil after harvest of rice bean crop. Hence, for effective crop management to rice bean crop, application of 75% RDF and foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS was recommended.

**Keywords:** Rice bean; Zinc sulphate; Ferrous sulphate; Ex. Calcium; magnesium.

## 1. INTRODUCTION

Micronutrients can be applied through a variety of techniques, including soil application, foliar application, seed priming, and fortification; however, foliar application is thought to offer greater advantages than other approaches. Foliar application is applied to established crop stands at various stages of crop growth. When micronutrients are applied to plants, their physiological processes are improved, which leads to increased growth and the production of dry matter. The most efficient way to apply nutrients to plants is through foliar application, which removes soil barriers and leaching losses that arise from applying fertilizers through soil (Gunalan et al., 2024). Rice bean is an underutilized legume crop that comes up with many benefits *i.e.*, dried pulse, fodder and green manure, thus helping in human, animal nutrition and environmental health. In India, it is cultivated in 20,000 ha with average green fodder productivity of 15-30 t/ha (Singh et al., 2020). It is mainly grown for human consumption, though it is also used for fodder and green manure. Rice

bean foliage and dry straw are valuable livestock feed and used as green manure which improves soil fertility. Rice bean retains high nutritional value as it contains 20 per cent protein and is richer than cowpea and black gram. Dried seeds of rice bean contain 16 % protein, 3 % fat, 5 % crude fibre, 3 % ash and 61 % carbohydrates, 11 % aspartic acid, 17 % glutamic acids and sulphur-containing amino acids (Singh et al., 2020). It is an N-fixing legume that improves the N status of the soil, thus providing N to the succeeding crop. Its tap root has a beneficial effect on soil structure and when ploughed in, returns organic matter and N to the soil. The conventional recommended remedy for this is the soil application of fertilizers composed of the macro-nutrients, N, P and K, whereas crop micronutrient requirements are neglected. This leads to nutrient mining and diminished fertiliser use efficiency (Ch.Ramulu et al., 2024). Application of micronutrients along with recommended NPK fertiliser rates can prevent nutrient mining and boost rice yields. The lack of NPK effects reported in some cases on the quantity and quality of crop yield may be due to

the fact that micronutrients' ability to enhance the use efficiency of NPK fertilizers has not been harnessed (Senthilkumar et al., 2021).

One of the limiting factors for low yield is to be imbalance and indiscriminate use of fertilizers and the emergence of micronutrient deficiencies. In the absence of micronutrients, plant shows physiological disorders which eventually lead to low crop yield and fair quality. Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are used (Nasiri et al., 2010). Foliar application of micronutrients is more beneficial than soil application. Since application rates are lesser as compared to soil application, same quantity of nutrient application could be supplied easily and crop reacts to nutrient application immediately. Foliar spraying of micronutrients is very helpful when the roots cannot provide the necessary nutrients. Moreover, soil pollution would be a major problem by the soil application of micronutrients. As people are concerned about the environment and uptake of nutrients through plant leaves is better than soil application, therefore foliar spraying was advised (Bozorgi et al., 2011). Crop roots are unable to absorb important nutrients such as zinc, because of soil properties, such as high pH, lime or heavy texture, and in this situation, foliar spraying is better as compared to soil application (Kinaci and Gulmezoglu, 2007). It has been found that micronutrient foliar application is in the same level and even more influential as compared to soil application. It was suggested that micronutrients could be applied successfully to compensate shortage of those elements. Since in field situation, soil features and environmental factors which affect nutrient absorption are extremely changeable, foliar application could be an advantage for crop growth. Also, the effectiveness of three foliar spraying is higher and the cost of foliar application is lower as compared to soil application. According to the results of numerous studies, the macronutrients like nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and micronutrients like boron, chloride, iron, manganese, molybdenum, zinc have a significant impact on seed quality, which in turn affects seed yield (Patra, 2023).

## 2. MATERIALS AND METHODS

A field experiment on was conducted during *Kharif*, 2023 at College of Agriculture, Kalaburagi. Soil of the experimental site was low in available N (215 kg ha<sup>-1</sup>) and medium in

available P<sub>2</sub>O<sub>5</sub> (24 kg ha<sup>-1</sup>) and available K<sub>2</sub>O (321 kg ha<sup>-1</sup>). The experiment was conducted in a Randomized complete block design with eleven treatments and three replications along with spacing of 45 cm x 10 cm. The soil parameters such as pH, Electric Conductivity, Organic carbon content, Free calcium carbonate (%), Available Nitrogen, Available Phosphorus, Available Potassium, Available soil sulphur, Exchangeable Calcium and Magnesium were measured by Using standard protocol of APHA (1995). The treatments comprised of T<sub>1</sub>- RDF (20:40:00 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>), T<sub>2</sub> - 50% RDF + 0.5 % Zinc sulphate (21%) foliar application, T<sub>3</sub> - 50% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>4</sub> - 50% RDF + 0.5 % ZnSO<sub>4</sub> + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>5</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) foliar application, T<sub>6</sub> - 75% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>7</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>8</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) foliar application, T<sub>9</sub> - 100% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>10</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application, T<sub>11</sub> - Absolute control. The fertilizer recommendation for rice bean was followed as per package of practice (PoP) of University of Agricultural Sciences, Bengaluru (40:20:00 Kg N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O per hectare). The Variety used for sowing was KBH-1.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect on Soil pH, EC and OC Content

After rice bean harvest, there were no significant differences in the soil pH, EC and OC among the treatments. However, the pH ranged from 7.89 to 8.05. Whereas, the electrical conductivity ranged from 0.37 to 0.44 dSm<sup>-1</sup>. Further, organic carbon content in surface soil (0-15 cm) ranged from 3.40 to 6.89 g kg<sup>-1</sup> with a mean of 4.63 g kg<sup>-1</sup>

### 3.2 Free Calcium Carbonate (%)

After rice bean harvest, there were no significant differences in the free calcium carbonate content of the soil among the treatments. The free CaCO<sub>3</sub> ranged from 2.73 to 3.06. However, 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) resulted higher free CaCO<sub>3</sub> (3.06%) and the lower free CaCO<sub>3</sub> (2.73%) was in absolute control.

**Table 1. Soil chemical properties after harvest of rice bean as influenced by foliar application of zinc sulphate and ferrous sulphate**

Treatments	Soil pH	EC (dS m <sup>-1</sup> )	Organic carbon (g kg <sup>-1</sup> )	CaCO <sub>3</sub> (%)
T <sub>1</sub> - RDF (20:40:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> )	7.89	0.37	4.04	2.98
T <sub>2</sub> - 50% RDF + 0.5 % Zinc sulphate (21%) foliar application	8.02	0.43	4.05	2.79
T <sub>3</sub> - 50% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	7.97	0.42	4.02	2.82
T <sub>4</sub> - 50% RDF + 0.5 % ZnSO <sub>4</sub> + 0.5 % Ferrous sulphate (20.1%) foliar application	8.06	0.43	4.09	2.84
T <sub>5</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) foliar application	8.05	0.43	4.06	2.86
T <sub>6</sub> - 75% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	7.98	0.44	4.03	2.87
T <sub>7</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	7.91	0.43	4.07	3.04
T <sub>8</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) foliar application	8.07	0.42	4.04	3.01
T <sub>9</sub> - 100% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	7.99	0.43	4.04	3.03
T <sub>10</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	8.05	0.44	4.08	3.06
T <sub>11</sub> - Absolute control	8.04	0.42	3.80	2.73
<b>S. Em. ±</b>	<b>0.19</b>	<b>0.01</b>	<b>0.02</b>	<b>0.02</b>
<b>CD @ 5%</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>

**Table 2. Available macro nutrients status in soil after harvest of rice bean as influenced by foliar application of zinc sulphate and ferrous sulphate**

Treatments	N (kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	K <sub>2</sub> O (kg ha <sup>-1</sup> )	SO <sub>4</sub> (kg ha <sup>-1</sup> )
T <sub>1</sub> - RDF (20:40:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> )	227	27.43	328	14.48
T <sub>2</sub> - 50% RDF + 0.5 % Zinc sulphate (21%) foliar application	221	24.20	320	9.62
T <sub>3</sub> - 50% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	222	23.40	321	10.20
T <sub>4</sub> - 50% RDF + 0.5 % ZnSO <sub>4</sub> + 0.5 % Ferrous sulphate (20.1%) foliar application	223	24.00	321	11.64
T <sub>5</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) foliar application	225	25.50	325	11.98
T <sub>6</sub> - 75% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	225	26.36	327	12.31
T <sub>7</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	233	31.80	335	22.65
T <sub>8</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) foliar application	227	28.82	330	19.37
T <sub>9</sub> - 100% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	229	29.24	334	19.46
T <sub>10</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	234	32.60	345	22.70
T <sub>11</sub> - Absolute control	220	24.18	305	7.97
<b>S. Em. ±</b>	<b>1.74</b>	<b>1.07</b>	<b>3.52</b>	<b>1.05</b>
<b>CD @ 5%</b>	<b>5.11</b>	<b>3.13</b>	<b>10.56</b>	<b>3.07</b>

**Table 3. Exchangeable Calcium and magnesium content in soil after harvest of rice bean as influenced by foliar application of zinc sulphate and ferrous sulphate**

Treatments	Exchangeable Ca (mg kg <sup>-1</sup> )	Exchangeable Mg (mg kg <sup>-1</sup> )
T <sub>1</sub> - RDF (20:40:00 N: P <sub>2</sub> O <sub>5</sub> : K <sub>2</sub> O kg ha <sup>-1</sup> )	9.07	3.57
T <sub>2</sub> - 50% RDF + 0.5 % Zinc sulphate (21%) foliar application	8.50	3.11
T <sub>3</sub> - 50% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	8.61	3.19
T <sub>4</sub> - 50% RDF + 0.5 % ZnSO <sub>4</sub> + 0.5 % Ferrous sulphate (20.1%) foliar application	8.64	3.29
T <sub>5</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) foliar application	8.77	3.31
T <sub>6</sub> - 75% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	9.00	3.37
T <sub>7</sub> - 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	9.37	4.20
T <sub>8</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) foliar application	9.13	3.83
T <sub>9</sub> - 100% RDF + 0.5 % Ferrous sulphate (20.1%) foliar application	9.17	3.93
T <sub>10</sub> - 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) foliar application	9.40	4.40
T <sub>11</sub> - Absolute control	8.49	3.00
<b>S. Em. ±</b>	<b>0.37</b>	<b>0.35</b>
<b>CD @ 5%</b>	<b>NS</b>	<b>NS</b>

### 3.3 Available Nitrogen

Significant variation in available soil nitrogen was observed due to various treatments. Application of 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) recorded higher available N in soil (234 kg ha<sup>-1</sup>) and it was on par with 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) (232 kg ha<sup>-1</sup>). Whereas, the lower available N in soil (220 kg ha<sup>-1</sup>) was recorded with absolute control.

Available soil nitrogen status was significantly higher in the treatments 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%). It may be due to the available soil nitrogen status after harvest of rice bean crop. The increase in nitrogen in soil may be to the role of leguminous crop in it fixes nitrogen symbiotically in the root nodules. Similar results were recorded by Kanwal et al. (2020).

### 3.4 Available Phosphorus

Application of 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) significantly recorded higher available P<sub>2</sub>O<sub>5</sub> in soil (32.60 kg ha<sup>-1</sup>) and it was on par with 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) (31.80 kg ha<sup>-1</sup>).

However, the lower available P in soil (24.18 kg ha<sup>-1</sup>) was recorded in absolute control.

Available soil phosphorous status was significantly higher with 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%). It may be due to the declining trend in soil P<sub>2</sub>O<sub>5</sub> availability observed across crop development stages, irrespective of N levels. This trend can be attributed to the continuous uptake of phosphorus by crops as their biomass increases during each successive crop growth stage. This aligns with similar research findings on Sankalpa (2013), who also observed a decline in soil-available P<sub>2</sub>O<sub>5</sub> with crop development.

### 3.5 Available Potassium

Application of 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) recorded significantly higher available K<sub>2</sub>O in soil (345 kg ha<sup>-1</sup>) and it was on par with 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) (343 kg ha<sup>-1</sup>). Whereas, the lower available K<sub>2</sub>O in soil (305 kg ha<sup>-1</sup>) was recorded in absolute control.

N and P<sub>2</sub>O<sub>5</sub>, the drop in soil K<sub>2</sub>O level may be explained by the crop's ongoing K absorption as its growth stage progresses, which is

accompanied by an increase in biomass. Increased crop nutrient needs due to increased biomass production at higher levels of N and P could be linked to a greater loss in soil K<sub>2</sub>O content as N and P levels rise. Similar results were obtained by Santhosh (2018).

### 3.6 Available Soil Sulphur (kg ha<sup>-1</sup>)

Application of 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) significantly recorded higher available S in soil (22.70 kg ha<sup>-1</sup>) and it was on par with 75% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) (22.65 kg ha<sup>-1</sup>). However, the lower available S in soil (7.97 kg ha<sup>-1</sup>) was recorded in absolute control.

Available soil sulphur status was significantly higher in 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) treatment. It may be due to soil application of RDF with conventional fertilizer had a significant effect on available soil sulphur status after harvest of rice bean crop.

### 3.7 Exchangeable Calcium and Magnesium

Exchangeable calcium content in soil after harvest was non-significantly influenced by the foliar application of Zinc sulphate (21%) and Ferrous sulphate (20.1%) at varied concentration to rice bean. However, the treatment which received 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) recorded maximum Exchangeable calcium content (9.40 kg ha<sup>-1</sup>). Further, application of 100% RDF + 0.5 % Zinc sulphate (21%) + 0.5 % Ferrous sulphate (20.1%) at recorded maximum Exchangeable magnesium content (4.40 kg ha<sup>-1</sup>).

## 4. CONCLUSION

Application of 100% RDF (20:40:0 N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg ha<sup>-1</sup>) and foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS was found to be at par with 75% RDF along with foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS in terms of available macro and micronutrients in soil after harvest of rice bean crop. Hence, for effective crop management to rice bean crop, application of 75% RDF and foliar spray of 0.5 % Zinc sulphate (21%) and Ferrous sulphate (20.1%) at 25 and 50 DAS was recommended.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

- APHA. (1995). Chemical oxygen demand. In *Standard methods for the examination of water and wastewater* (19th ed., pp. 5.12–15.14). Washington, DC: American Public Health Association, Water Environment Federation, and American Water Works Association.
- Bozorgi, H. A., Azarpour, E., & Moradi, M. (2011). The effects of bio, mineral nitrogen fertilization and foliar zinc spraying on yield and yield components of faba bean. *World Applied Sciences Journal*, 13(6), 1409–1414.
- Gunalan, S., Elankavi, S., Sudhakar, P., & Karthikeyan, P. K. (2024). Effect on foliar nutrition of micro nutrients on growth attributes in transplanted rice (*Oryza sativa* L.). *International Journal of Research in Agronomy*, 7(3), 329–331. <https://doi.org/10.33545/2618060X.2024.v7.i3e.418>
- Kanwal, A., Khan, M. B., Hussain, M., Naeem, M., Rizwan, M. S., & Zafar-ul-Hye, M. (2020). Basal application of zinc to improve mung bean yield and zinc-grains biofortification. *Phyton. International Journal of Experimental Botany*, 89(1), 88–96.
- Kinaci, E., & Gulmezoglu, N. (2007). Grain yield and yield components of triticale upon application of different foliar fertilizers. *Interciencia*, 32(9), 624–628.
- Nasiri, Y., Zehtab-Salmasi, S., Nasrullahzadeh, S., Najafi, N., & Ghassemi-Golezani, K. (2010). Effects of foliar application of micronutrients (Fe and Zn) on flower yield and essential oil of chamomile (*Matricaria chamomilla* L.). *Journal of Medicinal Plants Research*, 4(17), 1733–1737.
- Patra, S. (2023). Review an investigation of the effects of macro and micro nutrients on the production of high quality seed.

- International Journal of Theoretical & Applied Sciences*, 15(2), 16–21.
- Ramulu, C., Shravan Kumar, R., Padmaja, G., & Uma Reddy, R. (2024). Effect of different nutrient management practices on Kharif rice yield, nutrient uptake and soil properties in Telangana. *Asian Journal of Soil Science and Plant Nutrition*, 10(4), 62–70.  
<https://doi.org/10.9734/ajsspn/2024/v10i4382>
- Sankalpa, C. P. (2013). *Effect of different levels of nitrogen on micronutrients (Zn, Fe, Mn, and Cu) availability, uptake and yield of paddy in Vertisols of TBP command* (M.Sc. (Agri.) Thesis). Univ. Agric. Sci., Raichur.
- Santhosh. (2018). *Evaluation of paddy (Oryza sativa L.) varieties for salt tolerance and their response to nitrogen application in saline vertisols of TBP command* (M.Sc. (Agri.) Thesis). Univ. Agric. Sci., Raichur.
- Senthilkumar, K., Sillo, F. S., Rodenburg, J., Dimkpa, C., Saito, K., Dieng, I., & Bindraban, P. S. (2021). Rice yield and economic response to micronutrient application in Tanzania. *Field Crops Research*, 270, 108201.
- Singh, M., Rundun, V., & Ote, S. (2020). Rice bean. *Indian Farming*, 70(6), 27–31.

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