



## Effect of integrated nutrient management in brinjal (*Solanum melongena* L.) on micronutrient uptake and physical properties of soil

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### ABSTRACT

A field experiment was conducted at the experimental site of Department of Soil Science and Water Management, College of Horticulture and Forestry, Neri, Hamirpur (Himachal Pradesh). The experiment consisted of eleven treatments which were carried out in randomized block design with three replications. Observations for micronutrient uptake and soil physical properties were recorded and it was found that the lowest bulk density of the soil was achieved with treatment T<sub>6</sub> (100 per cent RDN through vermicompost) and T<sub>11</sub> (100 per cent RDN through vermicompost + *Azotobacter*). Particle density, porosity and water holding capacity were also slightly improved with the application of different treatments, however the differences were not significant. Further, application of chemical fertilizer or organic manure or both with or without biofertilizer positively influenced the micronutrient uptake (Zn, Cu, Fe and Mn) and the maximum uptake was recorded in treatment T<sub>11</sub> (100 per cent RDN through vermicompost + *Azotobacter*), while minimum was observed under treatment T<sub>1</sub> (control).

### Introduction

India is regarded as a horticultural paradise owing to extensive commercial production of a wide variety of vegetable crops (Saravaiya and Patel, 2005). Brinjal is the second most important vegetable crop next to the tomato. It is also known as eggplant and originates originally from India (Kiran *et al.*, 2010). It is a crop that is quite productive and is frequently referred to as "poor man's crop." The treatment of diabetes, asthma, cholera, pneumonia, and diarrhoea may be among egg plant's medical uses. Its fruit and leaves are also reported to lower specific blood cholesterol levels. As productivity has either stagnated or decreased, there is currently growing

worry about sustainability. In order to ensure sustainability in the quantity and quality of produce, it is crucial to use nutrient sources properly. These sources should be freely accessible, contain an acceptable level of nutrients, maintain soil fertility, and create an environment that is conducive to a higher yield. Application of high input technology like chemical pesticides, herbicides, and fertilizers boosts production, but there is rising worry about the negative impacts of chemical use on soil quality, human health, and the environment (Sharma *et al.*, 2012). Therefore, it is the need of the hour to use different biocontrol agents (Kumar *et al.*, 2009) not

only for sustainable plant disease management but also judicious use of biofertilizers for sustainable development of crops (Srivastava *et al.*, 2009). Exploiting organic sources has become necessary due to the decline in soil health brought on by the indiscriminate application of chemical fertilizers and the rising cost of chemical fertilizers. The presence of organic carbon and growth-promoting elements like enzymes and hormones makes organic amendments a preferential choice for improving soil fertility and productivity further ensuring high level of crop productivity and also protecting the soil from deterioration, thereby ensuring sustainable crop production. Organic amendments contain major nutrients in small quantities compared to chemical fertilizers. In addition to having a high yield, it also takes a lot of nutrients out of the soil. In order to improve soil health, crop production, and crop quality over the long term, it is now essential to establish an adequate nutrient management package that includes the use of inorganic, organic, and biofertilizer additions (Srivastava *et al.*, 2009). Therefore, an effort has been made to research how integrated nutrient management affects soil physical characteristics and micronutrient uptake in brinjal (*Solanum melongena* L.).

### Material and Methods

The field experiment was conducted at the Department of Soil Science and Water Management's Experimental Farm at Neri, Hamirpur (Himachal Pradesh). With eleven treatments and three replications of each, a Randomized Block Design (RBD) was set up. The treatments comprised of control [T<sub>1</sub>], 100 % RDF [T<sub>2</sub>], 75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost) [T<sub>3</sub>], 50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost) [T<sub>4</sub>], 25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost) [T<sub>5</sub>], 100 % RDN (Vermicompost) [T<sub>6</sub>], 100 % RDF + *Azotobacter* [T<sub>7</sub>], 75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost) + *Azotobacter* [T<sub>8</sub>], 50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost) + *Azotobacter* [T<sub>9</sub>], 25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost) + *Azotobacter* [T<sub>10</sub>] and 100 % RDN (Vermicompost) + *Azotobacter* [T<sub>11</sub>]. As a source of nitrogen, phosphorus, and potassium, respectively, recommended dose of fertilizer (RDF) was

administered in the form of urea, single super phosphate and muriate of potash. Vermicompost was used for substituting RDN through inorganic sources and the amount applied was calculated based on its nitrogen content. No manure or fertilizer of any type was applied to control plots. All of the treatments subjected to standard cultural practices advised for brinjal. The initial soil properties of the experimental site are presented in table 1.

### Calculation for nutrient uptake

Nutrient uptake on dry weight basis by brinjal plant was determined by multiplying the respective nutrient content in per cent with the obtained dry matter yield of fruit and stover (q/ha). The uptake of nutrients by stover and fruit was added up to obtain the total amount of nutrients removed by brinjal.

$$\text{Nutrient uptake (kg/ha)} = \text{Nutrient content (\%)} \times \text{Yield (q/ha)}$$

$$\text{Total uptake} = \text{Uptake by fruit} + \text{Uptake by stover}$$

**Table 1: Initial soil properties of experimental site (0-15 cm)**

SN	Soil property	Value
1	Bulk density (Mg/m <sup>3</sup> )	1.41
2	Particle density (Mg/m <sup>3</sup> )	2.53
3	Porosity (%)	44.33
4	Water holding capacity (%)	33.87
5	Texture	Sandy loam

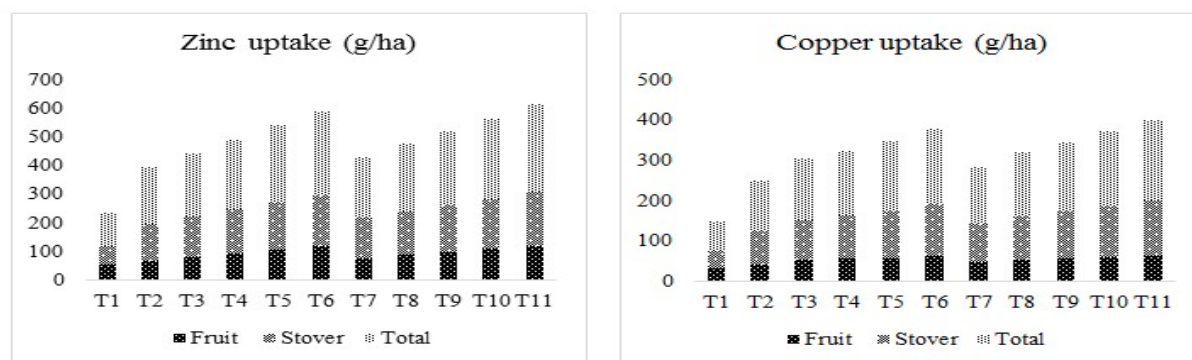
### Results and Discussion

#### Zinc uptake

The total zinc uptake in the brinjal crop ranged from 116.69 g/ha in treatment receiving no fertilizer, manure or biofertilizer (T<sub>1</sub>) to 306.27 g/ha in treatment receiving 100 per cent RDN through vermicompost + *Azotobacter* (T<sub>11</sub>). The increase in total uptake was more when 100 per cent RDF along with *Azotobacter* (T<sub>7</sub>) was applied in comparison to application with 100 per cent RDF alone (T<sub>2</sub>). It was further noticed from the data that the treatments where *Azotobacter* was applied additionally (T<sub>7</sub>-T<sub>11</sub>) increased the total zinc uptake and maximum total zinc uptake was obtained with the application of 100 per cent RDN through vermicompost + *Azotobacter* (T<sub>11</sub>) followed by 25 per cent RDN through inorganic fertilizer + 75 per cent RDN through vermicompost + *Azotobacter* (T<sub>10</sub>) while minimum

was obtained with the application of 100 per cent RDF along with *Azotobacter* (T<sub>7</sub>). Treatments where RDN was substituted by vermicompost but *Azotobacter* was not applied (T<sub>3</sub>-T<sub>6</sub>) also showed increase in total zinc uptake over 100 per cent RDF and uptake of 219.87, 245.10, 270.19 and 293.21 g/ha was obtained with the use of 75 per cent RDN

through inorganic fertilizer + 25 per cent RDN through vermicompost (T<sub>3</sub>), 50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost (T<sub>4</sub>), 25 per cent RDN through inorganic fertilizer + 75 per cent RDN through vermicompost (T<sub>5</sub>) and 100 per cent RDN through vermicompost (T<sub>6</sub>), respectively (Figure 1).



**Figure 1: Effect of integrated nutrient management practices on zinc and copper uptake.**

Poor biomass production in control lead to lower uptake of zinc by plant. Application of RDF helps in direct supply of nutrients to the plants leading to better root development and therefore resulting in increased uptake of nutrients by the plant. The application of organic manures has solubilizing effect on plant nutrients and chelating effect on metal ions resulting in their increased availability and thus improve its uptake. Organic manures also increase the availability of nutrients for longer period as the nutrients are slowly released into the soil. The increase in uptake with biofertilizers might be due to its synergistic effect with other fertilizers in making availability of plant nutrients more readily and by solubilizing the nutrients in the soil. These results of the study are corroborated with previous reports of Chavan (2003), Rashid *et al.* (2008), Dhiman (2012) and Hemalatha *et al.* (2018).

#### Copper uptake

The total copper uptake in the brinjal crop ranged from 73.64 g/ha in treatment T<sub>1</sub> (control) to 199.83 g/ha in treatment T<sub>11</sub> (100 per cent RDN through vermicompost + *Azotobacter*). Conjunctive use of vermicompost and *Azotobacter* resulted in increased uptake. Application of 75 per cent RDN through inorganic fertilizer + 25 per cent RDN through

vermicompost + *Azotobacter* (T<sub>8</sub>), 50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost + *Azotobacter* (T<sub>9</sub>), 25 per cent RDN through inorganic fertilizer + 75 per cent RDN through vermicompost + *Azotobacter* (T<sub>10</sub>) and 100 per cent RDN through vermicompost + *Azotobacter* (T<sub>11</sub>) recorded uptake of 159.41, 171.90, 185.40 and 199.83 g/ha, respectively. However, treatments T<sub>10</sub> and T<sub>11</sub> were found to be at par with each other. Application of RDN by using vermicompost as a substitute (T<sub>3</sub>-T<sub>6</sub>) was observed to increase total copper uptake over 100 per cent RDF (T<sub>2</sub>) and among these treatments, maximum uptake was obtained with the application of 100 per cent RDN through vermicompost (T<sub>6</sub>) whereas minimum was observed with 75 per cent RDN through inorganic fertilizer + 25 per cent RDN through vermicompost (T<sub>3</sub>) (Figure 1).

Low copper uptake in control might be due to lower yield in control plots ascribed to the lower nutrient content in the soil causing starvation of plants for nutrients. The increased uptake with application of RDF might be due to the better proliferous root system developed that resulted in better absorption of water and nutrients by the plants thus increasing the copper uptake. Organic compounds in the soil solutions are capable of chelating solution Cu<sup>2+</sup>,

which increases the concentration of  $\text{Cu}^{2+}$  in soil solution (Raut, 2017). Vermicompost release the nutrient slowly and steadily into the soil system and enables the plant to absorb nutrients for a longer period of time thereby enhancing the yield and uptake by the plants. This might be the reason for the increase in copper uptake by the plants upon substitution of RDN with vermicompost. The increase in copper uptake with the additional application of *Azotobacter* might be due to better root development resulting in increased uptake of water and nutrient by the plant. The results are in authentication with the conclusions of Chavan (2003), Rashid *et al.* (2008) and Dhiman (2012).

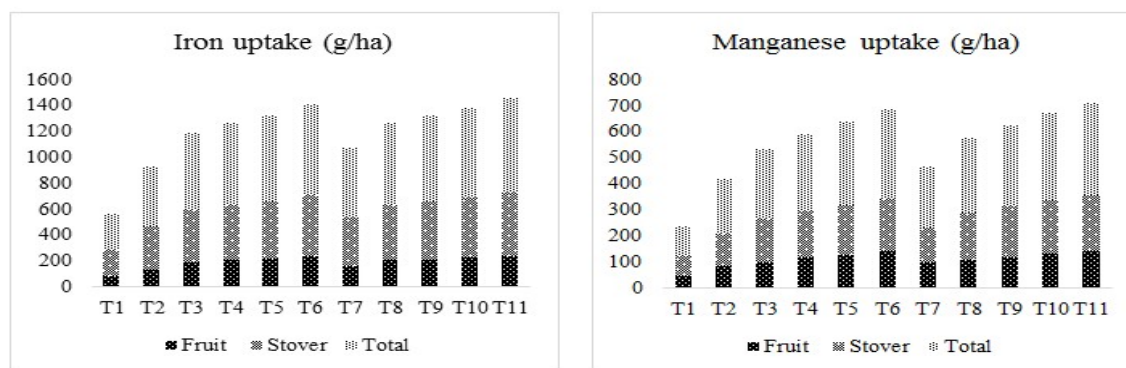
#### Iron uptake

The total iron uptake in the brinjal crop varied from 279.61 to 727.94 g/ha. The lowest values obtained from control ( $T_1$ ) and highest values from 100 per cent RDN through vermicompost + *Azotobacter* ( $T_{11}$ ). Application of RDF alone ( $T_2$ ) or in conjunction with *Azotobacter* ( $T_7$ ) was found to be superior over control. Substitution of RDN by vermicompost alone ( $T_6$ ) or with the additional application of *Azotobacter* ( $T_{11}$ ) increase the total iron uptake over 100 per cent RDF by 51.15 and 56.69 per cent, respectively. Further, it was observed that among all the treatments comprising application of RDN by vermicompost ( $T_3$ - $T_6$ ), the highest uptake was obtained with the use of 100 per cent RDN through vermicompost ( $T_6$ ) followed by 25 per cent RDN through inorganic fertilizer + 75 per cent RDN through vermicompost ( $T_5$ ), 50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost ( $T_4$ ) and 75 per cent RDN through inorganic fertilizer + 25 per cent RDN through vermicompost ( $T_3$ ). Similar trend was followed by the treatments where *Azotobacter* was applied along with recommended doses of nitrogen by vermicompost as by hundred per cent substitution of recommended doses of nitrogen by vermicompost ( $T_6$ ) registered higher total uptake compared to no substitution of recommended doses of nitrogen ( $T_2$ ) (Figure 2). Lower uptake in control treatment is attributed to lower yield in these plots due to poor nutritional status. The increase in uptake due to addition by vermicompost might be probably due to release of iron during its decomposition and by preventing loss of iron through chelation, thereby increasing its uptake by the plant. Inorganic fertilizer

helps in direct availability of nutrients to the plants thereby increasing their uptake. Application of RDN by organic manure in combination with RDN by chemical fertilizers showed positive effect on iron uptake. Higher uptake in treatments with the application of biofertilizer might be attributed due to the synergistic effect of biofertilizer with organic manure and chemical fertilizer. The results are in testimony with the findings of Chavan (2003), Dhiman (2012) and Hemalatha *et al.* (2018).

#### Manganese uptake

Application of 100 per cent RDN through vermicompost + *Azotobacter* ( $T_{11}$ ) was found to be superior in terms of total manganese uptake by brinjal crop over other treatments. The increase in total uptake was more when applied with 100 per cent RDF + *Azotobacter* ( $T_7$ ) in comparison to application with 100 per cent RDF alone ( $T_2$ ). Similar, trend was also followed when substitution of 100 per cent RDN by vermicompost was done. It was further obvious from the data that treatments applied with *Azotobacter* ( $T_7$ - $T_{11}$ ) increased the total manganese uptake by the plant and maximum total manganese uptake was achieved with the application of 100 per cent RDN through vermicompost + *Azotobacter* ( $T_{11}$ ) while, minimum was obtained with application 100 per cent RDF + *Azotobacter* ( $T_7$ ). Treatments where RDN was substituted by vermicompost but *Azotobacter* was not additionally applied ( $T_3$ - $T_6$ ) also showed a significant increase in total manganese uptake over 100 per cent RDF and uptake of 266.58, 295.19, 317.60 and 343.13 g/ha was obtained with the use of 75 per cent RDN through 85 inorganic fertilizer + 25 per cent RDN through vermicompost ( $T_3$ ), 50 per cent RDN through inorganic fertilizer + 50 per cent RDN through vermicompost ( $T_4$ ), 25 per cent RDN through inorganic fertilizer + 75 per cent RDN through vermicompost ( $T_5$ ) and 100 per cent RDN through vermicompost ( $T_6$ ), respectively (Figure 2). The increased uptake due to treatment combinations of inorganic, organic and biofertilizers over the control might be attributed to the increased yield of crop with their addition which may be explained on the basis that synergistic effect of these combinations improved the physical conditions of the soil and supported better aeration to plant root, sustained availability of nutrients and there by the uptake of manganese by the plants. Substitution of



**Figure 2: Effect of integrated nutrient management practices on iron and manganese uptake.**

RDN by vermicompost increased the uptake over 100 per cent RDF due to the release of manganese during its decomposition thereby increasing its availability and uptake. No fertilizer or manure or biofertilizer application in control might be the reason for its low uptake. Increase in uptake with the application of biofertilizer may be ascertained due to better root development, better transportation of water uptake and deposition of nutrients. These results are in line with those of Chavan (2003), Rashid *et al.* (2008), Dhiman (2012) and Sharma *et al.* (2020).

#### **Bulk density**

The data presented in the table 2 revealed that the bulk density of the soil varied from 1.41 to 1.36 Mg/m<sup>3</sup> after the harvest of brinjal crop. The bulk density of the soil was observed to decrease with the increase in substitution rate of RDN by vermicompost and lowest bulk density (1.36 Mg/m<sup>3</sup>) was achieved with the application of 100 per cent RDN through vermicompost alone (T<sub>6</sub>) or with the addition of *Azotobacter* (T<sub>11</sub>). The bulk density of the plots receiving no fertilizer, manure or biofertilizer did not undergo any change from the initial value which might be due to no application of organic manure and compaction of soil in those treatments. Higher bulk density in control might be due to no application of organic manure in those treatments. Treatment receiving vermicompost recorded decrease in the bulk density of soil as compared to control treatment which might be attributed to the fact that the application of organics might have caused better aggregation thereby increasing soil aeration. Decrease in bulk density with the application of biofertilizer might be

ascertained to synergistic effect of organic manure and bio-fertilizers in improving the soil physical conditions. The results are also in authentication with the conclusions of Salvi *et al.* (2015), Batabyal *et al.* (2017) and Lakra *et al.* (2017). Comparing a well-aggregated soil to a dispersed and poorly organised soil, the former has a lower bulk density. It might be because the soil's microbial production of gum and polysaccharides increased significantly as a result of the addition of organic materials. Due to its resistance to further deterioration, the microbial breakdown product serves as a binding substance. This could aid in soil aggregation, resulting in a decrease in soil bulk density.

#### **Particle density**

An inquisition of data presented in table 2 showed that the effect different nutrient management practices on the particle density of soil was found to be non-significant. The initial value of the particle density did not change as compared to control (T<sub>1</sub>). The plots receiving substituted doses of RDN by vermicompost with or without *Azotobacter* marginally declined the particle density over initial value. The slight change in soil particle density might be attributed to the increase in organic carbon content in soil with the application of organic manure. Understanding and determining other physical parameters, such as bulk density and porosity, depend heavily on particle density. Application of nutrient management practices affects both bulk density and porosity, but it has no effect on particle density. Because nutrient management and other short-term modifications do not influence the overall quantity or the chemical makeup of the soil mineral particles and the particle

**Table 2: Effect of integrated nutrient management practices on soil bulk density and particle density**

Treatment		Bulk density (Mg/m <sup>3</sup> )	Particle density (Mg/m <sup>3</sup> )
T <sub>1</sub>	Control	1.41	2.53
T <sub>2</sub>	100 % RDF	1.40	2.52
T <sub>3</sub>	75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost)	1.39	2.52
T <sub>4</sub>	50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost)	1.38	2.52
T <sub>5</sub>	25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost)	1.37	2.52
T <sub>6</sub>	100 % RDN (Vermicompost)	1.36	2.52
T <sub>7</sub>	100 % RDF + <i>Azotobacter</i>	1.40	2.52
T <sub>8</sub>	75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost) + <i>Azotobacter</i>	1.39	2.52
T <sub>9</sub>	50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost) + <i>Azotobacter</i>	1.38	2.52
T <sub>10</sub>	25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost) + <i>Azotobacter</i>	1.37	2.52
T <sub>11</sub>	100 % RDN (Vermicompost) + <i>Azotobacter</i>	1.36	2.52
CD (P=0.05)		NS	NS

density does not change. The results recorded are in testimony with the work done by Salvi *et al.* (2015) and Lakra *et al.* (2017).

### Porosity

The data on effect of integrated nutrient management on porosity is furnished in table 3 and it revealed that maximum (46.23%) value of porosity was observed with the application of 100 per cent RDN through vermicompost + *Azotobacter* (T<sub>11</sub>) whereas minimum (44.04%) was obtained under control (T<sub>1</sub>), however the differences were found to be non significant. Application of 100 per cent RDF with and without the use of *Azotobacter* (T<sub>7</sub> and T<sub>2</sub>, respectively) showed slight increase in porosity of the soil compared to initial value. Substitution of RDN by vermicompost showed minor increase in the porosity of the soil compared to initial soil value. The slight decrease in bulk density of soil with the increase in substitution of RDN by vermicompost with and without the use of *Azotobacter* showed a favourable change in porosity of the soil which might be attributed to the rise in soil polysaccharide and microbial gum production. These microbial breakdown products may also have worked as soil particle binding agents, assisting in soil aggregation and enhancing porosity. In addition, the inclusion of organic matter improved aggregate stability and by reducing the bulk density, the addition of organic matter increases the volume of pore space and hence

increases the soil's porosity. Bio inoculants are also found to be useful as it increases soil porosity. These results are in accordance with those obtained by Kumari (2017) and Lakra *et al.* (2017).

### Water holding capacity

An examination of data presented in table 3 depicts that water holding capacity of the soil varied from 33.94 per cent in control (T<sub>1</sub>) to 35.69 per cent where application of 100 per cent RDN through vermicompost + *Azotobacter* (T<sub>11</sub>) was done. However, it was found to be non significant. Application of RDF alone (T<sub>2</sub>) or in addition with *Azotobacter* (T<sub>7</sub>) showed increase in water holding capacity of the soil over control and initial value. Substitution of RDN by vermicompost showed marginal increase in the water holding capacity of the soil over 100 per cent RDF alone. Similarly, when *Azotobacter* was applied along with the substituted RDN by vermicompost also increased the water holding capacity. The increase in water holding capacity of the soil with the increase in the substitution rate of RDN by vermicompost might be due to the addition of organic matter which promote aggregation, improve the quantity of pores, their distribution in size and the specific surface area of soils and hence soil structure which positively affect the water holding capacity. Moreover, the use of bio inoculants is useful as it improves water holding capacity of the soil. Also, soils with more organic

matter have a larger capacity to hold water than soils with a similar texture but less organic matter. This might also be the reason for the increase in water holding capacity of the soil with the application of *Azotobacter*. The findings are in conformity with those of Salvi *et al.* (2015) and Dhiman *et al.* (2018).

**Table 3: Effect of integrated nutrient management practices on soil porosity and water holding capacity**

Treatment		Porosity (%)	Water holding capacity (%)
T <sub>1</sub>	Control	44.04	33.94
T <sub>2</sub>	100 % RDF	44.35	34.02
T <sub>3</sub>	75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost)	44.94	34.33
T <sub>4</sub>	50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost)	45.23	34.64
T <sub>5</sub>	25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost)	45.47	34.86
T <sub>6</sub>	100 % RDN (Vermicompost)	46.09	35.37
T <sub>7</sub>	100 % RDF + <i>Azotobacter</i>	44.55	34.21
T <sub>8</sub>	75 % RDN (Inorganic fertilizer) + 25 % RDN (Vermicompost) + <i>Azotobacter</i>	45.01	34.49
T <sub>9</sub>	50 % RDN (Inorganic fertilizer) + 50 % RDN (Vermicompost) + <i>Azotobacter</i>	45.31	34.79
T <sub>10</sub>	25 % RDN (Inorganic fertilizer) + 75 % RDN (Vermicompost) + <i>Azotobacter</i>	45.61	35.08
T <sub>11</sub>	100 % RDN (Vermicompost) + <i>Azotobacter</i>	46.23	35.69
CD (P=0.05)		NS	NS

## Conclusion

Application of inorganic fertilizer or organic fertilizer or both with or without biofertilizer positively influenced micronutrient uptake *viz.*, Zn, Cu, Fe and Mn. Maximum nutrient uptake was observed in treatment T<sub>11</sub> (100 per cent RDN through vermicompost + *Azotobacter*), while minimum was observed under treatment T<sub>1</sub> (control). Treatments where *Azotobacter* was used in addition with the dose of RDN supplied through

inorganic fertilizer or vermicompost or both showed increased uptake against the respective treatments where it was not used. Physical properties of soil were also slightly improved with the application of different treatments, however the differences were not significant.

## Conflict of interest

The authors declare that they have no conflict of interest.

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