International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 1371-1375

Received: 18-07-2017
Accepted: 20-08-2017

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# Influence of integrated nutrient management on various mineral nutrients uptake by chrysanthemum

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**Abstract**
The investigation entitled "influence of integrated nutrient management on various mineral nutrients uptake by chrysanthemum." was carried out at Floriculture Unit, Department of Horticulture, Dr. P.D.K.V., Akola, during the winter season of the years 2014-15 and 2015-16. The experiment was laid out in Split Plot Design with fourteen treatment combinations and was replicated for three times. The treatments comprised of two levels of biofertilizers in main plot and seven combinations of organic and inorganic fertilizers including one treatment of recommended dose of fertilizers. From this study it is observed that, the application of biofertilizers (i.e. *Azotobactor* and PSB) and 50 % RDF (150:100:100 kg $ha^{-1}$ of NPK) + 10 t $ha^{-1}$ VC (50% N through VC) resulted in significantly higher uptake of mineral nutrients by chrysanthemum plants from soil.

**Keywords:** biofertilizers, chrysanthemum, management, nutrient, uptake.

## Introduction
Various cultural practices are adopted in chrysanthemum for increasing yield and among them; INM plays an important role in influencing the growth, yield and quality of flowers. INM encourages better uptake of mineral nutrients by plants which resulted in more number of branches as well as leaf area on plant and there by more flowers yield $plant^{-1}$ (Patanwar *et al*. 2014) [9]. Requirement of a crop for a nutrient is decided by the rooting behavior and its mining ability, the native soil status, the potential yields as decided by the soil-agroclimatic situations, the targeted yields and nutrient management. Since chrysanthemum forages deeper (45 cm) into the soil and are thus, efficient in availing the native soil nutrients like P & K. Yet, universal crop response to applied-N is reported in many locations in India. Amongst secondary and micronutrients, S & Zn deficiency is on the rise. Therefore, an INMS is the most efficient and practical way to mobilize all the available, accessible and affordable plant nutrient sources in order to optimize the productivity of the crops/cropping systems and economic return to the farmers.

## Materials and Methods
This experiment was conducted in split plot design with fourteen treatment combinations which were replicated thrice at Floriculture Unit, Department of Horticulture, Dr. PDKV, Akola during the winter season of the year 2014-15 and 2015-16. The allotment of treatments to the various plots were done randomly in each replication. The treatments comprised of two levels of biofertilizers i.e. with biofertilizers (Azotobacter and PSB @ 5 kg $ha^{-1}$) and without biofertilizers in main plot and seven combination of organic and inorganic fertilizers including one treatment of recommended dose of fertilizers *viz*., 100% RDF (300:200:200 kg $ha^{-1}$), 75% RDF + 15 t $ha^{-1}$ FYM (25% N through FYM), 50% RDF + 30 t $ha^{-1}$ FYM (50% N through FYM), 75% RDF + 5 t $ha^{-1}$ VC (25% N through VC), 50% RDF + 10 t $ha^{-1}$ VC (50% N through VC), 75% RDF + 1.5 t $ha^{-1}$ NC (25% N through NC) and 50% RDF + 3 t $ha^{-1}$ NC (50% N through NC). The nutrients (major nutrients *viz*., nitrogen, phosphorus and potassium; micronutrients *viz*., zinc, copper, iron and manganese) uptake by plants were analyzed by utilizing various instruments e.g. Kjelplus apparatus as suggested by Tandon (1993) [11], spectrophotometer at 420 nm wavelength as suggested by Chopra and Kanwar (1978) [4], flame photometer as suggested by Piper (2010) [10] and atomic absorption spectrophotometer as suggested by Mclaren and Crawford (1950) [7].

The uptake of nutrients were calculated by using the formula suggested by Piper (2010) [10].

**[Nutrient uptake (kg ha$^{-1}$)** = Nutrient content (%) X Total dry matter production (kg ha$^{-1}$) / 100]

The data on various parameters during the course of investigation was statistically analysed as per the method suggested by Panse and Sukhatme (1995) [8].

## Results and discussion

### Effect of biofertilizers

The total uptake of macro and micro nutrients by plants (Table 1 and 3) were significantly influenced by application of biofertilizers (*Azotobacter* and PSB).

The treatment $M_1$ (i.e. application of biofertilizers) recorded significantly maximum total uptake of nitrogen (114.56, 108.83 and 111.69 kg ha$^{-1}$, respectively), whereas, the treatment $M_2$ recorded significantly minimum total uptake of nitrogen by plants (104.98, 97.80 and 101.39 kg ha$^{-1}$, respectively) during both the years i.e. 2014-15 and 2015-16 as well as in the pooled data. Nitrogen uptake by chrysanthemum plants was increased with the application of biofertilizers, might be due to better root system under bio inoculants treatment. This also might be due to, the fact that, atmospheric nitrogen fixed by applied *Azotobactor*, as well as the growth hormones synthesized by biofertilizers which increase the ability of absorption of nutrients. Another possible reason for that is increased cell metabolism and enzymatic activities due to applied PSB which enhances uptake of nitrogen. Similar results were also reported by Hoda and Mona (2014) [5] in petunia and Kumari *et al*. (2014) [6] in chrysanthemum.

Similarly, in case of phosphorus uptake by plants, it was observed significantly maximum (15.20, 14.67 and 14.94 kg ha$^{-1}$, respectively) with the treatment $M_1$, whereas, the treatment $M_2$ recorded significantly minimum total uptake of phosphorus by plants (13.73, 13.03 and 13.38 kg ha$^{-1}$, respectively) during the years 2014-15, 2015-16 and in pooled data. The increase in uptake of phosphorus by chrysanthemum plant under biofertilizers treatment might be due to the fact that, PSB influence the activities of a number of enzymes which lead to increased cell metabolism and enzymatic activities. The another possible reason for increase in uptake of phosphorus, with the inoculation of PSB, as PSB increases the root system of plant which in turn increases the absorption of phosphorus. These results are in accordance with the findings of Verma (2010) [12] and Airadevi (2012) [2] in chrysanthemum and Hoda and Mona (2014) [5] in petunia.

The uptake of potassium was found statistically non-significant during the year 2014-15, but during the year 2015-16 and in pooled data, the treatment $M_1$ recorded significantly maximum total uptake of potassium by plant (136.84 and 141.70 kg ha$^{-1}$, respectively), whereas, the treatment $M_2$ recorded significantly minimum total uptake of potassium by plant (122.32 and 128.28 kg ha$^{-1}$, respectively). The higher uptake of potassium by plants receiving bio-fertilizers as the high population of microbes produced considerably high quantity of organic acids (formic, citric, malic, etc.), The organic acid are the source of biotically generated $H^+$ ion which dissolved minerals and make it available for the plant absorption and uptake; signifying the role of bio-fertilizers in enhancing the nutrient supply and uptake by chrysanthemum plants. These results are similar with the results obtained by Kumar *et al*. (2006) in marigold, Abo-Baker and Mostafa (2011) [1] in hibiscus, Airadevi (2012) [2] and Airadevi (2014) [3] in chrysanthemum.

In case of micronutrients, the treatment $M_1$ (i.e. application of biofertilizers) recorded significantly maximum total uptake of zinc (769.43, 729.35 and 749.39 g ha$^{-1}$, respectively), copper (216.07, 205.12 and 210.60 g ha$^{-1}$, respectively), iron (2482.90, 2327.18 and 2405.04 g ha$^{-1}$, respectively) and manganese (3887.11, 3639.45 and 3763.28 g ha$^{-1}$, respectively) by chrysanthemum plants. Whereas, the treatment $M_2$ recorded significantly minimum total uptake of zinc (691.48, 651.20 and 671.33 g ha$^{-1}$, respectively), copper (193.88, 180.23 and 187.06 g ha$^{-1}$, respectively), iron (2229.63, 2053.11 and 2141.37 g ha$^{-1}$, respectively) and manganese (3533.71, 3206.24 and 3369.99 g ha$^{-1}$, respectively) from soil, during the years, 2014-15 and 2015-16 as well as in pooled data. The increase in micronutrients uptake due to application of *Azotobacter* and PSB might be due to fact that, better root system under bioinoculent treatment, as biofertilizers synthesized growth hormones which enhances ability of absorption of nutrients by plants.

**Table 1:** Effect of integrated nutrient management on uptake of major nutrients by chrysanthemum plants (kg ha$^{-1}$)

| Treatments | Nitrogen (kg ha$^{-1}$) | | | Phosphorus (kg ha$^{-1}$) | | | Potassium (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| Bio-fertilizers (M) | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| $M_1$ – With bio-fertilizers | 114.56 | 108.83 | 111.69 | 15.20 | 14.67 | 14.94 | 146.55 | 136.84 | 141.70 |
| $M_2$ – Without bio-fertilizers | 104.98 | 97.80 | 101.39 | 13.73 | 13.03 | 13.38 | 134.23 | 122.32 | 128.28 |
| 'F' Test | Sig | Sig | Sig | Sig | Sig | Sig | NS | Sig | Sig |
| SE (m) ± | 1.570 | 1.412 | 1.493 | 0.209 | 0.169 | 0.190 | 2.052 | 2.378 | 2.221 |
| CD at 5% | 9.554 | 8.593 | 5.863 | 1.270 | 1.031 | 0.746 | - | 14.469 | 8.721 |
| Organic and inorganic fertilizers (S) | | | | | | | | | |
| $S_1$ - 100 % RDF | 95.46 | 81.61 | 88.54 | 12.45 | 10.91 | 11.68 | 122.52 | 100.86 | 111.69 |
| $S_2$ – 75 % RDF + 15 t ha$^{-1}$ FYM | 110.50 | 103.57 | 107.04 | 14.58 | 13.89 | 14.23 | 141.25 | 130.16 | 135.71 |
| $S_3$ – 50 % RDF + 30 t ha$^{-1}$ FYM | 115.75 | 113.29 | 114.52 | 15.03 | 14.95 | 14.99 | 147.79 | 142.20 | 145.00 |
| $S_4$ – 75 % RDF + 5 t ha$^{-1}$ VC | 112.90 | 108.63 | 110.76 | 14.81 | 14.48 | 14.65 | 144.29 | 136.48 | 140.38 |
| $S_5$ – 50 % RDF + 10 t ha$^{-1}$ VC | 121.05 | 122.25 | 121.65 | 16.06 | 16.48 | 16.27 | 154.47 | 153.35 | 153.91 |
| $S_6$ – 75 % RDF + 1.5 t ha$^{-1}$ NC | 104.80 | 95.84 | 100.32 | 13.97 | 12.98 | 13.48 | 134.27 | 120.71 | 127.49 |
| $S_7$ – 50 % RDF + 3 t ha$^{-1}$ NC | 107.93 | 97.98 | 102.95 | 14.37 | 13.26 | 13.82 | 138.16 | 123.30 | 130.73 |
| 'F' Test | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig |
| SE (m) ± | 1.160 | 1.214 | 0.484 | 0.191 | 0.092 | 0.078 | 1.515 | 2.246 | 0.782 |
| CD at 5% | 3.387 | 3.542 | 1.378 | 0.558 | 0.561 | 0.223 | 4.421 | 6.556 | 2.223 |
| Interaction (M x S) | | | | | | | | | |
| 'F' Test | NS | Sig | Sig | NS | NS | NS | NS | NS | NS |
| SE (m) ± | 1.641 | 1.716 | 0.969 | 0.270 | 0.272 | 0.156 | 2.142 | 3.176 | 1.564 |
| CD at 5% | - | 5.009 | 2.756 | - | - | - | - | - | - |

**Table 3:** Effect of integrated nutrient management on uptake of micronutrients by chrysanthemum plants (g ha$^{-1}$)

| Treatments | Zinc (g ha$^{-1}$) | | | Copper (g ha$^{-1}$) | | | Iron (g ha$^{-1}$) | | | Mangnese (g ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| Bio-fertilizers (M) | | | | | | | | | | | | |
| $M_1$ – With bio-fertilizers | 769.43 | 729.35 | 749.39 | 216.07 | 205.12 | 210.60 | 2482.90 | 2327.18 | 2405.04 | 3887.11 | 3639.45 | 3763.28 |
| $M_2$ – Without bio-fertilizers | 691.48 | 651.20 | 671.33 | 193.88 | 180.23 | 187.06 | 2229.63 | 2053.11 | 2141.37 | 3533.71 | 3206.24 | 3369.99 |
| 'F' Test | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig |
| SE (m) ± | 12.369 | 4.103 | 9.215 | 3.416 | 1.962 | 2.785 | 39.095 | 30.116 | 34.895 | 53.172 | 48.281 | 50.786 |
| CD at 5% | 75.264 | 24.967 | 36.182 | 20.787 | 11.937 | 10.938 | 237.886 | 183.250 | 137.016 | 323.546 | 293.785 | 199.409 |
| Organic and inorganic fertilizers (S) | | | | | | | | | | | | |
| $S_1$ - 100 % RDF | 613.81 | 490.28 | 552.04 | 172.17 | 146.09 | 159.13 | 1973.41 | 1667.69 | 1820.55 | 3100.86 | 2698.33 | 2899.60 |
| $S_2$ – 75 % RDF + 15 t ha$^{-1}$ FYM | 738.35 | 699.80 | 719.08 | 207.17 | 193.82 | 200.50 | 2382.51 | 2177.11 | 2279.81 | 3742.58 | 3417.94 | 3580.26 |
| $S_3$ – 50 % RDF + 30 t ha$^{-1}$ FYM | 790.71 | 782.62 | 786.66 | 221.92 | 216.81 | 219.36 | 2552.03 | 2453.88 | 2502.96 | 3985.83 | 3801.08 | 3893.45 |
| $S_4$ – 75 % RDF + 5 t ha$^{-1}$ VC | 759.01 | 738.35 | 748.68 | 213.01 | 204.53 | 208.77 | 2449.62 | 2347.79 | 2398.71 | 3881.66 | 3638.75 | 3760.21 |
| $S_5$ – 50 % RDF + 10 t ha$^{-1}$ VC | 838.72 | 856.49 | 847.60 | 235.32 | 237.20 | 236.26 | 2706.14 | 2656.88 | 2681.51 | 4232.47 | 4164.17 | 4198.32 |
| $S_6$ – 75 % RDF + 1.5 t ha$^{-1}$ NC | 671.20 | 620.63 | 645.91 | 188.38 | 171.93 | 180.15 | 2166.34 | 1980.93 | 2073.63 | 3426.84 | 3053.44 | 3240.14 |
| $S_7$ – 50 % RDF + 3 t ha$^{-1}$ NC | 701.37 | 643.75 | 672.56 | 196.86 | 178.35 | 187.60 | 2263.84 | 2046.69 | 2155.26 | 3602.63 | 3186.30 | 3394.47 |
| 'F' Test | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig | Sig |
| SE (m) ± | 8.919 | 19.587 | 6.212 | 2.515 | 3.909 | 1.342 | 38.830 | 27.680 | 13.766 | 42.355 | 59.177 | 21.008 |
| CD at 5% | 26.034 | 57.170 | 17.666 | 7.341 | 11.408 | 3.815 | 113.337 | 80.791 | 39.142 | 123.626 | 172.726 | 59.735 |
| Interaction (M x S) | | | | | | | | | | | | |
| 'F' Test | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SE (m) ± | 12.614 | 27.700 | 12.426 | 3.557 | 5.527 | 2.683 | 54.914 | 39.145 | 27.532 | 59.899 | 83.689 | 42.016 |
| CD at 5% | - | - | - | - | - | - | - | - | - | - | - | - |

**Effect of organic and inorganic fertilizers**

The effect of organic and inorganic fertilizers (Table 1 & 3) on total uptake of macro and micronutrients by chrysanthemum plants was found to be significant.

During the years, 2014-15, 2015-16 and in pooled data, the treatment $S_5$ recorded significantly maximum total uptake of nitrogen (121.05, 122.25 and 121. 65 kg ha$^{-1}$, respectively) and phosphorus (16.06, 16.48 and 16.27 kg ha$^{-1}$, respectively), Whereas, significantly minimum total uptake of nitrogen (95.46 81.61 and 88.54 kg ha$^{-1}$, respectively) and phosphorus (12.45, 10.91 and 11.68 kg ha$^{-1}$) by plants were noted under the treatment $S_1$. The probable reason for increase in uptake of nitrogen and phosphorus is that, the vermicompost not only improve the physical condition of soil, but also improve the availability of major and micronutrients to the plants for its better growth, which might be expressed in higher uptake of nitrogen by chrysanthemum plants. This is in agreement with the findings of Verma (2010) [12], Airadevi (2012) [2] and Airadevi (2014)[3] in chrysanthemum.

Similarly, in case of potassium uptake by chrysanthemum plants, it was found significantly maximum with the treatment $S_5$ (154.47, 153.35 and 153.91 kg ha$^{-1}$, respectively), which was followed by the treatments $S_3$ (147.79, 142.20 and 145.00 kg ha$^{-1}$, respectively) and $S_4$ (144.29, 136.48 and 140.38 kg ha$^{-1}$, respectively). Whereas, significantly minimum total uptake of potassium by plants (122.52, 100.86 and 111.69 kg ha$^{-1}$) was noted under the treatment $S_1$, during the years, 2014-15, 2015-16 and in pooled data. The humic acid formed during decomposition of vermicompost had greater influence in stimulating the roots and speeding up the developmental process of plant which in turn resulted in better potassium uptake by chrysanthemum plants. These results are in conformity with Airadevi (2012) [2] and Airadevi (2014) [3] in chrysanthemum.

In case of micronutrients, during the years, 2014-15, 2015-16 and in pooled data, the treatment $S_5$ recorded significantly maximum total uptake of zinc (838.72, 856.49 and 847.60 g ha$^{-1}$, respectively), copper (235.32, 237.20 and 236.26 g ha$^{-1}$, respectively), iron (2706.14, 2656.88 and 2681.51 g ha$^{-1}$, respectively) and manganese (4232.47, 4164.17 and 4198.32 g ha$^{-1}$, respectively). Whereas, the treatment $S_1$ recorded significantly minimum total uptake of zinc (613.81, 490.28 and 552.04 g ha$^{-1}$, respectively), copper (172.17, 146.09 and 159.13 g ha$^{-1}$), iron (1973.41, 1667.69 and 1820.55 g ha$^{-1}$) and manganese (3100.86, 2698.33 and 2899.60 g ha$^{-1}$) by chrysanthemum plants.

**Interaction effect**

The interaction effect of application of biofertilizers and organic and inorganic fertilizers (Table 2 and 4) on uptake of macro and micronutrients studied in this investigation by chrysanthemum plants was found statistically non-significant, except in case of nitrogen which was significantly influenced by interaction effect.

During the year, 2015-16 and in pooled data significantly maximum total uptake of nitrogen (131.60 and 130.24 kg ha$^{-1}$, respectively) was recorded under the treatment combination $M_1S_5$, which was followed by the treatment combinations $M_1S_3$ (119.48 and 119.88 kg ha$^{-1}$, respectively) and $M_1S_4$ (113.00 and 115.41 kg ha$^{-1}$, respectively). Whereas, significantly minimum total uptake of nitrogen by plants (78.38 and 85.82 kg ha$^{-1}$, respectively) was noted under the treatment combination $M_2S_1$. This might be due to the combined beneficial effect of biofertilizers along with vermicompost and chemical fertilizers. These results could paint be in the same direction of Airadevi (2012) [2].

**Table 2:** Interaction effect of integrated nutrient management on uptake of major nutrients by chrysanthemum plants (kg ha$^{-1}$)

| Treatments | Nitrogen (kg ha$^{-1}$) | | | Phosphorus (kg ha$^{-1}$) | | | Potassium (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| $M_1S_1$- Biofertilizers + 100 % RDF | 97.68 | 84.85 | 91.26 | 13.03 | 11.50 | 12.27 | 125.37 | 107.06 | 116.22 |
| $M_1S_2$- Biofertilizers + 75% RDF + 15 t ha$^{-1}$ FYM | 115.31 | 109.44 | 112.37 | 15.34 | 14.79 | 15.06 | 147.49 | 137.60 | 142.54 |
| $M_1S_3$- Biofertilizers + 50% RDF + 30 t ha$^{-1}$ FYM | 120.28 | 119.48 | 119.88 | 15.84 | 15.99 | 15.92 | 153.56 | 149.96 | 151.76 |
| $M_1S_4$- Biofertilizers + 75% RDF + 5 t ha$^{-1}$ VC | 117.83 | 113.00 | 115.41 | 15.54 | 15.14 | 15.34 | 150.65 | 142.03 | 146.34 |
| $M_1S_5$- Biofertilizers + 50% RDF + 10 t ha$^{-1}$ VC | 128.89 | 131.60 | 130.24 | 17.10 | 17.74 | 17.42 | 164.55 | 165.16 | 164.86 |
| $M_1S_6$- Biofertilizers + 75% RDF + 1.5 t ha$^{-1}$ NC | 109.64 | 100.65 | 105.15 | 14.61 | 13.63 | 14.12 | 140.48 | 126.77 | 133.63 |
| $M_1S_7$- Biofertilizers + 50% RDF + 3 t ha$^{-1}$ NC | 112.31 | 102.76 | 107.54 | 14.95 | 13.90 | 14.43 | 143.77 | 129.32 | 136.54 |
| $M_2S_1$- 100 % RDF | 93.25 | 78.38 | 85.82 | 11.87 | 10.31 | 11.09 | 119.67 | 94.67 | 107.17 |
| $M_2S_2$- 75% RDF + 15 t ha$^{-1}$ FYM | 105.69 | 97.71 | 101.70 | 13.82 | 12.99 | 13.40 | 135.02 | 122.72 | 128.87 |
| $M_2S_3$- 50% RDF + 30 t ha$^{-1}$ FYM | 111.21 | 107.09 | 109.15 | 14.21 | 13.91 | 14.06 | 142.02 | 134.45 | 138.23 |
| $M_2S_4$- 75% RDF + 5 t ha$^{-1}$ VC | 107.97 | 104.26 | 106.12 | 14.08 | 13.82 | 13.95 | 137.92 | 130.94 | 134.43 |
| $M_2S_5$- 50% RDF + 10 t ha$^{-1}$ VC | 113.22 | 112.90 | 113.06 | 15.02 | 15.22 | 15.12 | 144.38 | 141.53 | 142.96 |
| $M_2S_6$- 75% RDF + 1.5 t ha$^{-1}$ NC | 99.96 | 91.03 | 95.50 | 13.33 | 12.33 | 12.83 | 128.06 | 114.66 | 121.36 |
| $M_2S_7$- 50% RDF + 3 t ha$^{-1}$ NC | 103.55 | 93.19 | 98.37 | 13.79 | 12.62 | 13.20 | 132.55 | 117.27 | 124.91 |
| 'F' Test | NS | Sig | Sig | NS | NS | NS | NS | NS | NS |
| SE (m) ± | 1.641 | 1.716 | 0.969 | 0.270 | 0.272 | 0.156 | 2.142 | 3.176 | 1.564 |
| CD at 5% | - | 5.009 | 2.756 | - | - | - | - | - | - |

**Table 4:** Interaction effect of integrated nutrient management on uptake of micronutrients by chrysanthemum plants (g ha$^{-1}$)

| Treatments | Zinc (g ha$^{-1}$) | | | Copper (g ha$^{-1}$) | | | Iron (g ha$^{-1}$) | | | Mangnese (g ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| $M_1S_1$- Biofertilizers + 100 % RDF | 642.41 | 490.45 | 566.43 | 180.42 | 156.67 | 168.54 | 2061.63 | 1772.31 | 1916.97 | 3192.66 | 2967.69 | 3080.17 |
| $M_1S_2$- Biofertilizers + 75% RDF + 15 t ha$^{-1}$ FYM | 773.46 | 742.25 | 757.86 | 217.22 | 205.76 | 211.49 | 2498.04 | 2332.84 | 2415.44 | 3929.56 | 3633.46 | 3781.51 |
| $M_1S_3$- Biofertilizers + 50% RDF + 30 t ha$^{-1}$ FYM | 831.16 | 834.73 | 832.95 | 233.43 | 231.40 | 232.41 | 2684.41 | 2599.75 | 2642.08 | 4159.69 | 4025.71 | 4092.70 |
| $M_1S_4$- Biofertilizers + 75% RDF + 5 t ha$^{-1}$ VC | 797.16 | 772.90 | 785.03 | 223.88 | 214.26 | 219.07 | 2574.58 | 2453.31 | 2513.95 | 4065.88 | 3799.00 | 3932.44 |
| $M_1S_5$- Biofertilizers + 50% RDF + 10 t ha$^{-1}$ VC | 899.87 | 929.00 | 914.44 | 252.57 | 257.38 | 254.97 | 2904.55 | 2869.07 | 2886.81 | 4506.79 | 4482.95 | 4494.87 |
| $M_1S_6$- Biofertilizers + 75% RDF + 1.5 t ha$^{-1}$ NC | 710.92 | 659.81 | 685.37 | 199.66 | 182.91 | 191.28 | 2296.06 | 2088.43 | 2192.24 | 3608.23 | 3227.12 | 3417.67 |
| $M_1S_7$- Biofertilizers + 50% RDF + 3 t ha$^{-1}$ NC | 731.04 | 676.30 | 703.67 | 205.31 | 187.48 | 196.39 | 2361.03 | 2174.51 | 2267.77 | 3746.99 | 3340.25 | 3543.62 |
| $M_2S_1$- 100 % RDF | 585.21 | 490.10 | 537.65 | 163.93 | 135.51 | 149.72 | 1885.19 | 1563.07 | 1724.13 | 3009.07 | 2428.97 | 2719.02 |
| $M_2S_2$- 75% RDF + 15 t ha$^{-1}$ FYM | 703.24 | 657.35 | 680.30 | 197.13 | 181.88 | 189.51 | 2266.97 | 2021.38 | 2144.18 | 3555.61 | 3202.42 | 3379.01 |
| $M_2S_3$- 50% RDF + 30 t ha$^{-1}$ FYM | 750.26 | 730.50 | 740.38 | 210.40 | 202.22 | 206.31 | 2419.65 | 2308.01 | 2363.83 | 3811.96 | 3576.45 | 3694.20 |
| $M_2S_4$- 75% RDF + 5 t ha$^{-1}$ VC | 720.87 | 703.80 | 712.33 | 202.14 | 194.81 | 198.48 | 2324.65 | 2242.27 | 2283.46 | 3697.44 | 3478.50 | 3587.97 |
| $M_2S_5$- 50% RDF + 10 t ha$^{-1}$ VC | 777.57 | 783.97 | 780.77 | 218.06 | 217.02 | 217.54 | 2507.73 | 2444.70 | 2476.21 | 3958.15 | 3845.38 | 3901.77 |
| $M_2S_6$- 75% RDF + 1.5 t ha$^{-1}$ NC | 631.48 | 581.44 | 606.46 | 177.10 | 160.95 | 169.03 | 2036.61 | 1873.43 | 1955.02 | 3245.46 | 2879.76 | 3062.61 |
| $M_2S_7$- 50% RDF + 3 t ha$^{-1}$ NC | 671.69 | 611.20 | 641.45 | 188.40 | 169.22 | 178.81 | 2166.64 | 1918.87 | 2042.75 | 3458.27 | 3032.36 | 3245.32 |
| 'F' Test | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SE (m) ± | 12.614 | 27.700 | 12.426 | 3.557 | 5.527 | 2.683 | 54.914 | 39.145 | 27.532 | 59.899 | 83.689 | 42.016 |
| CD at 5% | - | - | - | - | - | - | - | - | - | - | - | - |

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