**Oil yield and quality of Indian mustard (*Brassica juncea* L.) varieties as influenced by organic manures and biofertilizers**


## ABSTRACT

A field experiment was conducted at the Research Farm of Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18. The experiments consisting of two factors *viz*., 5 varieties and 10 fertilizer treatments was laid out in a randomized block design replicated thrice. The results of the study revealed that the oil yield was significantly highest with Rani variety while the oil content did not vary significantly amongst different varieties. The fatty acid composition such as palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid and arachidic acid contents did not show any significant variations amongst varieties. The biochemical characters *viz*., total chlorophyll, total soluble sugars and proline content recorded at 45 and 60 DAS were significantly higher in Rani variety. Both protein content and protein yields were also significantly highest in Rani variety. Application of 75% N through vermincompost produced significantly highest oil content and oil yield, protein content and protein yield, biochemical characters total chlorophyll, total soluble sugars and proline content recorded at 45 and 60 DAS, while palmitic acid, stearic acid and oleic acid were significantly highest with application of recommended dose of chemical fertilizers. Linoleic acid was significantly maximum with fertilizer treatment of 50% N through vermicompost + Azotobacter + Both linolenic and arachidic acid contents remained unaffected by the fertilizer treatments.



**Keywords**: *Oil yield, oil quality, biochemical, Indian mustard, protein.*


## INTRODUCTION

Oil seed groups being next to food crops hold sizeable share of the countries gross cropped area (13%). India is the 3rd largest producer of oilseeds in the world and accounts for 19% of world's area and 9% of the global production. (Sinha, 2003) The imbalanced and continuous use of chemical fertilizers in the cropping system is leading to imbalance of nutrients in soil which have an adverse effect on soil health, growth, yield and quality of crops, besides causing environmental pollution. In additions the high cost of chemical fertilizers is unaffordable for the farmers to purchase them.

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Organic agricultural practices aims to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable. Manure management is a process aiming to combine profitable agricultural production with minimum nutrient losses from manure, for the present and in the future. The manures apart from increasing yield and quality of crops improve soil health, make nutrients available to the plant and facilitate better uptake of nutrients by the crop. During recent years biofertilizers have emerged as a promising component of integrating nutrient supply system in agriculture. Certain strains of soil microbes referred to as plant growth promoting rhizo-bacteria that include species of Azotobacter and Azospirillum both of which provide direct and indirect effects on the plant growth and pest resistance.

The aim of present study was to test the effects of chemical fertilizers, organic manures and biofertilizers on the protein and oil content and yield, fatty acid composition and biochemical characters like total chlorophyll, total soluble sugars and proline content in the fresh leaves of Indian mustard (*Brassica juncea* L.) varieties.

**MATHERIALS AND METHODS**

A field experiment was conducted at the Research Farm of Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during 2016-17 and 2017-18 to study the "Oil yield and quality of Indian mustard (*Brassica juncea* L.) varieties as influenced by organic manures and biofertilizers

(*Brassica juncea* L.) The experiment consisting of two factors *viz.*, 5 varieties ($V_1$ = Rudra 99-D, $V_2$ = Shikhar, $V_3$ = Rani, $V_4$=Varuna and $V_5$ = Yellow Goldey) and 10 fertilizer levels ($T_1$ = control, $T_2$ = RDF, $T_3$ = 100% N through FYM, $T_4$ = 100% N through Vermicompost, $T_5$ = 75% N through FYM+ Azotobacter, $T_6$ = 75% N through FYM+ PSB, $T_7$ = 75% N through vermicompost + Azotobacter, $T_8$ = 75% N through Vermicompost + PSB, $T_9$ = 50% N through FYM +

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Azotobacter + PSB and $T_{10}$ = 50% N through vermicompost + Azotobacter + PSB was laid out in a randomized block design with factorial concept replicated thrice, the seed was sown in lines at 30 cm row spacing at the rate of 7.5kg $ha^{-1}$ as per treatment. The crop was thinned twice to maintain plant to plant spacing of 15 cm. The crop was harvested on 2-02-17 and 4-05-2018 during 2016-17 and 2017-18, respectively. Oil content in seed sample was determined using Soxhlet apparatus. Fatty acid analysis was done by following procedure described by AOAC (1990). Protein content was determined by the method described by Jackson (1967). The biochemical characters *viz*; total chlorophyll content, total soluble sugars and proline contents in seed were determined by the methods given by Arnon (1949), Reddy *et al.*(1950) and Bates *et al*. (1973), respectively. The data was analysed by the method described by Cochran and Cox (1963).

**Comment [UdMO5]:** I think you should briefly describe the methodologies used and not just quote the author.

**RESULTS AND DISCUSSION**

The data (table 1) revealed that Rani variety recorded significantly higher yield, while the oil content did not show any significantly variation amongst varieties. The results are in line with the findings of Panda *et al*. (2004) who did not observe any significant variation in the oil content of SEJ2 and Pusa Bold mustard varieties. The significant variation in the oil yield an amongst varieties attributed to the higher seed yield recorded by Rani variety as oil yield is the product of seed yield and respective oil content. The study also indicated that amongst fertilizer treatments, application of 75% N through vermicompost + Azotobacter recorded significantly highest oil content and oil yield. These results corroborate the findings of Singh and Singh (2006) who reported that application of 5t FYM $ha^{-1}$ along with inorganic fertilizers and biofertilizers recorded significantly highest oil content and yield in mustard. Non significant variation was noticed amongst varieties with regard to saturated and unsaturated fatty acids (Table 2 and 3). The investigation also revealed that the palmitic acid, stearic acid and oleic acid were significantly maximum with fertilizer treatment of recommended fertilizer dose, while linoleic acid was significantly highest with the

treatment 50% N through vermicompost + Azotobacter + PSB. Both linolenic and arachidic acid content remained unaffected by fertilizer treatments. There was a strong negative relationship between linoleic and oleic acid concentrations which is similar to the results obtained earlier by Seiler (2007). Earlier Steer and Seiler (1990) also reported that the biofertilizers singly or combination of two along with organic manures decreased saturated fatty acids (Palmitic and stearic acids) while significantly increased unsaturated fatty acids. Further, they also reported that oil and oleic acid content was negative due to adverse effect of nitrogen. Both protein content and yield were significantly highest in Rani variety (Table- 1) this may be attributed to genetic potential of the varieties with regard to the accumulation of nitrogen-. Earlier Sandhu *et al*. (2010) also found higher protein content and yield in RLC1 variety than other mustard varieties tested. It was also noticed that application of 75% N through vermicompost + Azotobacter recorded significantly highest protein content and yield. The high nitrate supply from the treatment might have increased amino acid synthesis in leaves which stimulated accumulation of protein in seed. Earlier Akbari *et al*. (2011) also reported similar findings.

The data (Table-4) showed that the biochemical characters *viz*., total chlorophyll content total soluble sugars and proline content recorded at 45 and 60 DAS were significantly higher in Rani variety. These results may be attributed to significant variation in the level of biosynthesis of chlorophyll and photosynthesis depending on genetic potential of mustard varieties. Further, the differential response of varieties to environmental stress and different levels of osmatic adjustment might have produced significant variation in proline content. Banerji *et al*. (2012) have also found significant variation in total chlorophyll content amongst different mustard varieties. Ali (2005) recorded variation in total soluble sugar content in leaves of Iris. Ozturk and Desmir (2002) reported significant variation in the proline content of different mustard varieties. The study also revealed that significantly highest biochemical characters were recorded by the

treatment 75% N through vermicompost + Azotobacter. The results are in agreement with those of Moria (2006) and Shetecoi and Tawfik (2007). The increase in total chlorophyll content may be attributed to increased uptake of magnesium from soil in the form of $Mg^{+2}$ under the influence of bio-fertilizer. Further, higher biosynthesis of chlorophyll and photosynthesis of mustard crop under Azotobacter treated plots might have resulted towards higher level of sugar in leaves. The higher accumulation of proline in leaves of mustard might be attributed towards the response of biofertilizer treated crop to mitigate and stimulating of draught tolerance.

## Conclusion

From the above results it is concluded that Indian mustard variety 'Rani' supplied with combination of 75% N through vermicompost and Azotobacter produced significantly highest protein and oil yields and biochemical characters *viz*., chlorophyll, total soluble sugars and proline content in fresh leaves whereas, recommended fertilizer dose of N P and K recorded significantly the highest concentration of saturated fatty acids. The oleic acid being significantly highest under 100% N dose through vermicompost.

**Table 1: Protein content/protein yield and oil content/oil yield as affected by Indian mustard varieties and organic manures /biofertilizers**

| Treatment | N content in seed (%) | | Protein content in seed (%) | | Protein yield (Kg $ha^{-1}$) | | Oil content (%) | | Oil yield (Kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| **Varieties** | | | | | | | | | | |
| $V_1$ | 2.98 | 2.97 | 18.62 | 18.56 | 216.18 | 221.23 | 37.88 | 37.75 | 440.16 | 431.26 |
| $V_2$ | 2.88 | 2.89 | 18.00 | 18.06 | 182.34 | 188.00 | 37.47 | 37.45 | 379.57 | 387.67 |
| $V_3$ | 3.01 | 3.02 | 18.81 | 18.87 | 222.15 | 228.33 | 38.07 | 37.96 | 452.27 | 459.32 |
| $V_4$ | 2.92 | 2.94 | 18.25 | 18.37 | 208.96 | 215.30 | 37.67 | 37.54 | 431.32 | 439.97 |
| $V_5$ | 2.95 | 2.96 | 18.44 | 18.50 | 212.61 | 218.30 | 37.73 | 37.63 | 434.65 | 444.03 |
| SE (m) ± | 0.039 | 0.042 | 0.207 | 0.224 | 2.956 | 2.996 | 0.429 | 0.389 | 13.238 | 14.375 |
| CD (P=0.05) | 0.11 | 0.12 | 0.58 | 0.63 | 8.30 | 8.41 | NS | NS | 37.16 | 40.35 |

| **Fertilizers/ Biofertilizers** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 2.40 | 2.41 | 15.00 | 15.06 | 135.75 | 140.81 | 36.28 | 36.18 | 328.33 | 338.28 |
| $T_2$ | 3.14 | 3.15 | 19.62 | 19.69 | 232.50 | 239.23 | 37.34 | 37.24 | 442.48 | 452.47 |
| $T_3$ | 2.71 | 2.70 | 16.93 | 16.87 | 179.12 | 183.21 | 37.72 | 37.57 | 399.08 | 409.64 |
| $T_4$ | 2.72 | 2.71 | 17.00 | 16.94 | 186.83 | 190.91 | 37.90 | 37.69 | 416.52 | 424.77 |
| $T_5$ | 3.21 | 3.22 | 20.06 | 20.12 | 241.72 | 248.08 | 38.52 | 38.40 | 465.17 | 473.47 |
| $T_6$ | 2.82 | 3.82 | 17.62 | 17.62 | 198.40 | 203.69 | 37.50 | 37.40 | 422.25 | 432.34 |
| $T_7$ | 3.24 | 3.23 | 20.25 | 20.19 | 246.24 | 251.36 | 38.66 | 38.60 | 470.10 | 480.57 |
| $T_8$ | 2.83 | 2.84 | 17.69 | 17.75 | 203.43 | 209.45 | 37.62 | 37.56 | 4732.63 | 443.21 |
| $T_9$ | 3.20 | 3.21 | 20.00 | 20.06 | 235.60 | 211.92 | 38.04 | 38.00 | 448.11 | 458.28 |
| $T_{10}$ | 3.21 | 3.22 | 20.06 | 20.12 | 237.51 | 244.05 | 38.06 | 38.02 | 450.63 | 461.18 |
| SE (m) ± | 0.053 | 0.060 | 0.292 | 0.317 | 4.68 | 4.225 | 0.605 | 0.549 | 18.668 | 20.271 |
| CD (P=0.05) | 0.15 | 0.17 | 0.82 | 0.89 | 11.70 | 11.86 | 1.70 | 1.54 | 52.4 | 56.9 |

| | | |
|---|---|---|
| $V_1$ = Rudra 99-D | $T_1$ = control | $T_2$ = RDF |
| $V_2$ = Shikhar | T3 = 100%N Through FYM | T4 = 100%N Through Vermicompost |
| $V_3$ = Rani | $T_5$ = 75%N Through FYM+ Azotobacter | $T_6$ = 75%N Through FYM+ PSB |
| $V_4$ = Varuna | $T_7$ = 75%N Through vermicompost + Azotobacter | $T_8$ = 75%N Through Vermicompost + PSB |
| $V_5$ = Yellow Goldy | $T_9$ = 50% N through FYM + Azotobacter+ PSB | $T_{10}$ = 50% N through vermicompost + Azotobacter + PSB |

**Table 2: Saturated and unsaturated fatty acids as affected by varieties and organic manurers /biofertilizers**

| Treatment | Palmitic (%) | | Stearic acid (%) | | Oleic acid (%) | | Linoleic acid (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| $V_1$ | 5.64 | 5.67 | 3.59 | 3.65 | 36.79 | 36.80 | 45.90 | 45.94 |
| $V_2$ | 5.34 | 5.38 | 3.49 | 3.56 | 36.38 | 36.45 | 45.30 | 45.36 |
| $V_3$ | 5.70 | 5.70 | 3.69 | 3.71 | 36.99 | 37.01 | 46.10 | 46.15 |
| $V_4$ | 5.42 | 5.45 | 3.49 | 3.54 | 36.48 | 36.54 | 45.60 | 45.64 |
| $V_5$ | 5.60 | 5.64 | 3.59 | 3.62 | 36.58 | 36.62 | 45.81 | 45.81 |
| SE (m) ± | 0.139 | 0.135 | 0.096 | 0.085 | 0.328 | 0.339 | 0.399 | 0.409 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |
| $T_1$ | 4.34 | 4.36 | 3.05 | 3.08 | 34.20 | 34.22 | 42.60 | 42.63 |
| $T_2$ | 6.83 | 6.87 | 4.46 | 4.52 | 37.10 | 37.16 | 45.87 | 45.92 |
| $T_3$ | 5.28 | 5.32 | 3.27 | 3.29 | 38.60 | 38.62 | 44.74 | 44.77 |
| $T_4$ | 5.32 | 5.36 | 3.26 | 3.19 | 38.62 | 38.68 | 44.64 | 44.69 |
| $T_5$ | 5.70 | 5.71 | 3.61 | 3.72 | 36.85 | 36.89 | 45.25 | 45.30 |
| $T_6$ | 5.66 | 5.69 | 3.59 | 3.61 | 36.70 | 36.74 | 45.10 | 45.15 |
| $T_7$ | 5.72 | 5.73 | 3.73 | 3.74 | 36.90 | 36.92 | 45.32 | 45.36 |
| $T_8$ | 5.65 | 5.69 | 3.68 | 3.70 | 36.75 | 36.81 | 45.15 | 45.19 |
| $T_9$ | 5.40 | 5.43 | 3.50 | 3.54 | 35.80 | 35.35 | 49.33 | 49.36 |
| $T_{10}$ | 5.51 | 5.54 | 3.58 | 3.59 | 35.40 | 35.43 | 49.42 | 49.44 |
| SE (m) ± | 0.196 | 0.189 | 0.135 | 0.121 | 0.463 | 0.748 | 0.563 | 0.577 |
| CD (P=0.05) | 0.55 | 0.53 | 0.38 | 0.34 | 1.30 | 1.33 | 1.58 | 1.62 |

| | | |
|---|---|---|
| $V_1$ = Rudra 99-D | $T_1$ = control | $T_2$ = RDF |
| $V_2$ = Shikhar | T3 = 100%N Through FYM | T4 = 100%N Through Vermicompost |
| $V_3$ = Rani | $T_5$ = 75%N Through FYM+ Azotobacter | $T_6$ = 75%N Through FYM+ PSB |
| $V_4$ = Varuna | $T_7$ = 75%N Through vermicompost + Azotobacter | $T_8$ = 75%N Through Vermicompost + PSB |
| $V_5$ = Yellow Goldy | $T_9$ = 50% N through FYM + Azotobacter+ PSB | $T_{10}$ = 50% N through vermicompost + Azotobacter + PSB |

**Table 3: Linonic acid and oleic acid concentrations in mustard oil (fatty acid) as affected by varieties, inorganic and organic fertilizers and biofertilizers**

| Treatment | Oleic acid (%) | | Linoleic acid (%) | |
|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| **Varieties** | | | | |
| $V_1$ | 0.32 | 0.33 | 0.92 | 0.94 |
| $V_2$ | 0.31 | 0.31 | 0.91 | 0.92 |
| $V_3$ | 0.32 | 0.33 | 0.92 | 0.94 |
| $V_4$ | 0.31 | 0.32 | 0.91 | 0.92 |
| $V_5$ | 0.31 | 0.32 | 0.91 | 0.93 |
| SE (m) ± | 0.007 | 0.007 | 0.012 | 0.012 |
| CD (P=0.05) | NS | NS | NS | NS |
| **Fertilizers/ Biofertilizers** | | | | |
| $T_1$ | 0.30 | 0.31 | 0.89 | 0.92 |
| $T_2$ | 0.32 | 0.32 | 0.90 | 0.93 |
| $T_3$ | 0.31 | 0.31 | 0.92 | 0.92 |
| $T_4$ | 0.31 | 0.31 | 0.92 | 0.92 |
| $T_5$ | 0.32 | 0.32 | 0.91 | 0.93 |
| $T_6$ | 0.30 | 0.32 | 0.90 | 0.92 |
| $T_7$ | 0.33 | 0.34 | 0.93 | 0.94 |
| $T_8$ | 0.31 | 0.32 | 0.90 | 0.92 |
| $T_9$ | 0.31 | 0.32 | 0.90 | 0.93 |
| $T_{10}$ | 0.31 | 0.32 | 0.90 | 0.93 |
| SE (m) ± | 0.011 | 0.011 | 0.017 | 0.017 |
| CD (P=0.05) | NS | NS | NS | NS |

| | | |
|---|---|---|
| $V_1$ = Rudra 99-D | $T_1$ = control | $T_2$ = RDF |
| $V_2$ = Shikhar | T3 = 100%N Through FYM | T4 = 100%N Through Vermicompost |
| $V_3$ = Rani | $T_5$ = 75%N Through FYM+ Azotobacter | $T_6$ = 75%N Through FYM+ PSB |
| $V_4$ = Varuna | $T_7$ = 75%N Through vermicompost + Azotobacter | $T_8$ = 75%N Through Vermicompost + PSB |
| $V_5$ = Yellow Goldy | $T_9$ = 50% N through FYM + Azotobacter+ PSB | $T_{10}$ = 50% N through vermicompost + Azotobacter + PSB |

**Table 4: Biochemical characters as affected by varieties and organic manures/biofertilizers**

| Treatment | Total chlorophyll (mg $g^{-1}$ fresh weight of leaves) | | | | Total soluble sugars (mg $g^{-1}$ leaf fresh weight) | | | | Proline content (mg $g^{-1}$ fresh leaf weight) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 | 2016-17 | 2017-18 |
| | 45 DAS | 60 DAS | 45 DAS | 60 DAS | 45 DAS | 60 DAS | 45 DAS | 60 DAS | 45 DAS | 60 DAS | 45 DAS | 60 DAS |
| **Varieties** | | | | | | | | | | | | |
| $V_1$ | 2.10 | 1.39 | 2.13 | 1.41 | 8.92 | 9.80 | 8.98 | 9.84 | 10.22 | 10.23 | 10.28 | 10.31 |
| $V_2$ | 1.59 | 1.18 | 1.62 | 1.23 | 8.46 | 9.53 | 8.55 | 9.54 | 9.27 | 9.24 | 9.14 | 9.15 |
| $V_3$ | 2.22 | 1.45 | 2.23 | 1.46 | 9.27 | 10.29 | 9.30 | 10.33 | 10.46 | 10.47 | 10.46 | 10.46 |
| $V_4$ | 1.83 | 1.24 | 1.85 | 1.28 | 8.60 | 9.64 | 8.63 | 9.66 | 9.75 | 9.75 | 9.56 | 9.59 |
| $V_5$ | 1.96 | 1.33 | 1.97 | 1.35 | 8.65 | 9.74 | 8.68 | 9.75 | 9.94 | 9.94 | 9.76 | 9.76 |
| **SE (m) ±** | 1.62 | 1.04 | 1.82 | 1.01 | 1.22 | 1.25 | 1.24 | 1.58 | 1.24 | 1.23 | 1.25 | 1.22 |
| CD (P=0.05) | 0.44 | 0.26 | 0.45 | 0.25 | 0.33 | 0.37 | 0.36 | 0.40 | 0.36 | 0.35 | 0.37 | 0.34 |
| **Fertilizers/ Biofertilizers** | | | | | | | | | | | | |
| $T_1$ | 1.04 | 0.85 | 1.06 | 0.88 | 6.71 | 7.80 | 6.74 | 7.84 | 8.01 | 8015 | 8.00 | 8.12 |
| $T_2$ | 2.49 | 1.64 | 2.53 | 1.67 | 7.43 | 8.44 | 7.47 | 8.46 | 8.60 | 8.73 | 8.43 | 8.54 |
| $T_3$ | 1.43 | 1.03 | 1.44 | 1.08 | 7.52 | 8.53 | 7.56 | 8.54 | 9.49 | 9.59 | 9.40 | 9.28 |
| $T_4$ | 1.49 | 1.06 | 1.53 | 1.10 | 7.56 | 8.58 | 7.59 | 8.59 | 9.60 | 9.50 | 9.62 | 9.73 |
| $T_5$ | 2.89 | 1.85 | 2.93 | 1.86 | 11.74 | 12.75 | 11.77 | 12.77 | 10.70 | 10.60 | 10.45 | 10.25 |
| $T_6$ | 1.64 | 1.13 | 1.65 | 1.15 | 9.35 | 10.36 | 9.37 | 10.38 | 10.25 | 10.50 | 10.20 | 10.05 |
| $T_7$ | 3.09 | 1.91 | 3.10 | 1.94 | 11.92 | 12.93 | 11.95 | 12.94 | 11.40 | 11.21 | 11.25 | 11.40 |
| $T_8$ | 1.72 | 1.14 | 1.74 | 1.17 | 9.41 | 10.41 | 9.42 | 10.44 | 10.55 | 10.38 | 10.46 | 10.58 |
| $T_9$ | 1.75 | 1.22 | 1.76 | 1.24 | 7.83 | 8.86 | 7.87 | 8.86 | 10.20 | 10.32 | 10.22 | 10.16 |
| $T_{10}$ | 1.84 | 1.35 | 1.85 | 1.38 | 8.34 | 9.34 | 8.37 | 9.37 | 10.40 | 10.28 | 10.40 | 10.49 |
| **SE (m) ±** | 1.98 | 1.24 | 2.21 | 1.22 | 1.56 | 2.10 | 2.05 | 2.24 | 2.05 | 1.62 | 2.00 | 1.58 |
| CD (P=0.05) | 0.52 | 0.37 | 0.64 | 0.36 | 0.47 | 0.53 | 0.51 | 0.57 | 0.51 | 0.49 | 0.52 | 0.48 |

| | | |
|---|---|---|
| $V_1$ = Rudra 99-D | $T_1$ = control | $T_2$ = RDF |
| $V_2$ = Shikhar | T3 = 100%N Through FYM | T4 = 100%N Through Vermicompost |
| $V_3$ = Rani | $T_5$ = 75%N Through FYM+ Azotobacter | $T_6$ = 75%N Through FYM+ PSB |
| $V_4$ = Varuna | $T_7$ = 75%N Through vermicompost + Azotobacter | $T_8$ = 75%N Through Vermicompost + PSB |
| $V_5$ = Yellow Goldy | $T_9$ = 50% N through FYM + Azotobacter+ PSB | $T_{10}$ = 50% N through vermicompost + Azotobacter + PSB |

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