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Influence of integrated nutrient management (INM) on growth, yield and quality of brinjal (*Solanum melongena* L.)

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Abstract
An experiment was carried out in the field of vegetable science experimental block at college of horticulture, Bagalkot, India during the year 2022-23 to study the influence of integrated nutrient management (INM) on growth, yield and quality of brinjal (*Solanum melongena* L.). Ten treatments of integrated nutrient management *viz*., T_1- 100% RDF [125(N) : 100(P_2O_5) : 50(K_2O)], T_2- 100% RDF + Azotobacter + AM + PSB, T_3- 75% RDN supplied through inorganic fertilizer + 25% RDN through FYM, T_4- 75% RDN supplied through inorganic fertilizer + 25% RDN through vermicompost, T_5- 75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB, T_6- 50% RDN supplied through inorganic fertilizer + 50% RDN through FYM, T_7- 50% RDN supplied through inorganic fertilizer + 50% RDN through vermicompost, T_8- 50% RDN supplied through inorganic fertilizer + 50% RDN through FYM and vermicompost + azotobacter + AM + PSB, T_9- 75% RDN supplied through inorganic fertilizer + micro nutrients Fe, Mn, Cu & Zn, T_{10}- 50% RDN supplied through inorganic fertilizer + micro nutrients Fe, Mn, Cu & Zn were evaluated in Randomized Completely Block Design with three replications with plot sizes of 4.0 m × 3.6 m with the spacing of 120 cm X 60 cm. Significantly higher values of growth parameters like plant height, number of primary branches, stem girth and plant spread and yield attributes like fruit length, fruit diameter, fruit volume, average fruit weight, number of fruits per plant, fruit yield/plant, fruit yield/plot and fruit yield/ha were observed under treatment T_5 (75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB). However, significantly minimum values of growth and yield attributes were observed under treatment T_{10} (50% RDN supplied through inorganic fertilizer + micro nutrients Fe, Mn, Cu & Zn).

Keywords: Brinjal, vermicompost, azotobacter, FYM, AM, PSB

Introduction
Brinjal or eggplant (*Solanum melongena* L.) of the Solanaceae family with diploid chromosome number 2n = 24 is one of the most important and popular vegetable crops grown in India and other parts of the tropical and subtropical world, but it is grown mainly in the warm season in temperate regions (Rai, 1995) [8]. The term eggplant is derived from the shape of the fruit of some types, which are white in color and resembling chicken eggs in shape. Brinjal is a popular warm-weather vegetable that is grown extensively in India, Bangladesh, Pakistan, China, and Philippines. It is also well-liked in France, Italy, and United States. In India, it is eaten as a cooked vegetable in a variety of ways.

Brinjal can be grown in a range of soils; however, deep, fertile, and well-drained soils are preferred. Brinjal grows well in slightly acidic soils with pH levels ranging from 5.5 to 6.5, and even up to pH 7.5. Maharashtra, Gujarat, Uttar Pradesh, Karnataka, Tamil Nadu, Punjab, Bihar and Madhya Pradesh are the primary brinjal-growing states in India. In Karnataka, it is grown over areas of 11,294 hectare with an annual production of 3,00,521 M. tones and the productivity is 26.61 M. t per ha (Anon, 2020-21) [2].

Brinjal appears in a variety of sizes, shapes and colors, both cultivated and wild varieties can be found in India. Brinjal has been a staple vegetable in our diet since ancient times. It has a high nutritious value. It is made up of 92% water, 1.4% proteins, 4.0% carbohydrates, 0.3% minerals, and 1.3% fibers.

Diabetes, asthama, cholera, pneumonia, and diarrhea have all been treated using eggplant fruits, leaves, tissues and extracts of plants and also have been reported to reduce the certain levels of blood cholesterol. Purple fruits have a higher amino acid content, while white brinjal is mostly beneficial to diabetic people. It has also been indicated as an effective treatment for liver problems (Shukla and Naik, 1993) [10].

No single source of plant nutrients, such as chemical fertilizers, organic manures or biofertilizers can sustain production and soil health. As a result, their combined use is essential for encouraging crop productivity, crop quality, and soil health. Integrated nutrient management (INM) is the technique of applying adequate and balanced amounts of organic manures, inorganic fertilizers and biofertilizers to maintain soil productivity, soil fertility and soil health. It helps in the constant supply of nutrients to the plant in order to obtain the highest degree of yield and so maximize profit while minimizing environmental damage. Many studies have demonstrated that combining organic, inorganic, and biological fertilizer sources increases nutrient availability and synchronizes nutrient release and uptake by crops, as well as having a good effect on soil qualities. As a result, the importance of INM for efficient nutrient resource utilization and long-term soil fertility maintenance has been recognized. For enhancing brinjal productivity and sustaining soil health, integrated nutrient management may be a better option than sole use of eighter organic or inorganic fertilizer.

Materials and Methods

The experiment was carried out in the field of vegetable science experimental block at college of horticulture, Bagalkot, India during the year 2022-23. The geographical location of the state is 16.15 N latitude, 75.61 E longitude, and 563 m above mean sea level. The climate is warm and dry all year. With an annual rainfall of 552 mm, this region is typically semi-arid and sub-tropical, benefiting from both the South-West and North-East monsoons and the soil of the experimental site is red sandy loam. The experiment was carried out in statistical Randomized Complete Block Design (RCBD) with ten treatments and three replications. Variety used Mahyco Super 10 with a spacing of 120 cm X 60 cm and RDF followed 125:100:50 (kg ha^{-1}) of NPK (UHSB).

Table 1: Description of various treatments used for the cultivation of brinjal (*S. melongena*)

T_1	100% RDF [125(N) : 100(P_2O_5) : 50(K_2O)]
T_2	100% RDF + Azotobacter + AM + PSB
T_3	75% RDN supplied through inorganic fertilizer + 25% RDN through FYM
T_4	75% RDN supplied through inorganic fertilizer + 25% RDN through vermicompost
T_5	75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB
T_6	50% RDN supplied through inorganic fertilizer + 50% RDN through FYM
T_7	50% RDN supplied through inorganic fertilizer + 50% RDN through vermicompost
T_8	50% RDN supplied through inorganic fertilizer + 50% RDN through FYM and vermicompost + azotobacter + AM + PSB
T_9	75% RDN supplied through inorganic fertilizer + micro nutrients Fe, Mn, Cu & Zn
T_{10}	50% 50% RDN supplied through inorganic fertilizer + micro nutrients Fe, Mn, Cu & Zn

Half dose of nitrogen and recommended dose of phosphorus and potassium was applied at the time of transplanting and half dose of nitrogen was applied at 30 days after transplanting and organic manures like FYM, Vermicompost and biofertilizers like Azotobacter, PSB and AM were applied. Observation on growth parameters like plant height (cm), no. of primary branches, stem girth (cm) were recorded at 45 and 90 DAT interval. Yield attributes like number of fruits per plant, fruit yield per plant (kg/plant), fruit yield per plot (kg/plot) and fruit yield per hectare (t/ha) were recorded from five selected plants in the plot area at each picking time and average was workout. Fruits were harvested at fruit maturity and yield obtained after each harvesting.

Results and Discussion

Data on various growth and yield characters of Brinjal crop as influenced by the different levels of nitrogen and their combinations are presented in Tables 1. A field experiment was conducted at the College of Horticulture, Bagalkot, during rabi season 2022-2023, to study the Influence of integrated nutrient management (INM) on growth, yield and quality of Brinjal (*Solanum Melongena* L.). The plant height at 45 and 90 DAT showed a significant difference between the treatments. At 45 DAT, among different treatments, T_5 (75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (58.43 cm) plant height and it was on par with T_8 (55.29 cm). Minimum (33.87 cm) plant height was observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). At 90 DAT treatment, T_5 (75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (76.69 cm) plant height and it was on par with T_8 (75.53 cm), T_3 (69.41 cm), T_4 (72.5 cm) and T_7 (71.33 cm) and Minimum (59.24 cm) plant height was observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). The number of primary branches at 40 and 90 DAT showed a significant difference between the treatments. At 45 DAT treatment, T_5 (75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (7.73) number of primary branches and it was at par with T_8 (7.57), T_7 (7.09), T_3 (7.33). Minimum (4.63) number of primary branches was observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). At 90 DAT treatment, T_5 (75% RDN supplied through inorganic fertilizer + 25% N through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (9.92) number of primary branches and it was at par with T_8 (9.57) and T_4 (9.35). Minimum (7.45) number of primary branches was observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). The stem girth at 45 DAT showed a significant difference between the treatments. At 45 DAT treatment, T_5 (75% RDN supplied through inorganic fertilizer + 25% N through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (1.71 cm) stem girth and it was on par with T_3 (1.57 cm), T_4 (1.63 cm), T_6 (1.55 cm), T_7 (1.59 cm), T_8 (1.67 cm) and minimum (1.35 cm) stem girth was observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). The stem girth at 90 DAT showed no significant difference between the treatments. At 90 DAT, T_5 (75% RDN supplied through inorganic fertilizer + 25% N through FYM and vermicompost + azotobacter + AM + PSB) showed maximum (2.35 cm) stem girth and minimum (1.91 cm) stem girth was observed in treatment T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). This might be due to the concurrent application of inorganic fertilizers, organic manures, and biofertilizers contributes to the elevated plant growth parameters. This is primarily due to the quick release of nutrients, enhanced nutrient absorption by plants, and improved utilization. Additionally, vermicompost and farmyard manure serve as valuable sources of plant nutrients while also acting as chelating agents to regulate nutrient availability, ultimately fostering plant growth. Biofertilizers, on their part, secrete growth-promoting substances that likely lead to enhanced root development and more efficient water and nutrient transportation to crop plants. Similar results was observed in Solanki *et al*. (2010) [11], Chumei *et al.* (2013) [3], Thingujam *et al*. (2015) [13], Thakur *et al*. (2019) [12], Raj *et al*. (2019) [9], Manimegala and Gunasekaran (2020) [5].

The number of fruits per plant, fruit yield per plant, fruit yield per plot and fruit yield per hectare showed a significant difference between the treatments. Among different treatments, T_5 (75% RDN supplied through inorganic fertilizer + 25% N through FYM and vermicompost + azotobacter + AM + PSB) showed maximum number of fruits per plant, fruit yield per plant, fruit yield per plot and fruit yield per hectare (63.91, 3.88 kg/plant, 77.53 kg/plot and 53.92 t/ha) and it was on par with T_8 (61.12, 3.65 kg/plant, 73.18 kg/plot and 50.67 t/ha) and minimum (50.59, 2.73 kg/plant, 54.68 kg/plot and 37.90 t/ha) number of fruits per plant, fruit yield per plant, fruit yield per plot and fruit yield per hectare were observed in treatment, T_{10} (50% RDN supplied through inorganic fertilizer + micronutrients). This might be due to increasing in the availability of plant nutrients and a well-balanced supply of essential nutrients from organic, inorganic, and biofertilizer sources. Consequently, this led to heightened cell division, expanded cell walls, increased meristematic activity, improved photosynthetic efficiency and enhanced nutrient absorption through increased root activity. All of these factors collectively contribute to the improved growth, yield and yield attributes of the crop as reported by Veena (2018) [14]. Similar finding was reported by Solanki *et al.* (2010) [11], Mishra *et al.* (2018) [6], Jaishwal *et al.* (2019) [4], Mohanty *et al.* (2020) [7].

Table 2: Effect of integrated nutrient management on plant growth and yield parameters of brinjal

Treatments	Plant height (cm)		Number of primary branches		Stem girth (cm)		Number of fruits per plant	Fruit yield per plant (kg/plant)	Fruit yield per plot (kg/plot)	Fruit yield (t/ha)
	45 DAT	90 DAT	45 DAT	90 DAT	45 DAT	90 DAT				
T_1	37.50^{ef}	61.29^{de}	5.15^{ef}	7.63^{e}	1.45^{cd}	1.95	53.79^{ef}	2.90^{ef}	58.06^{ef}	40.36^{ef}
T_2	41.21^{cde}	65.61^{bcde}	5.97^{cd}	7.82^{de}	1.49^{bcd}	2.07	54.43^{def}	3.05^{def}	61.12d^{ef}	42.35^{ef}
T_3	43.59^{bcd}	69.41^{abcd}	6.75^{bc}	8.63^{bcd}	1.57^{abc}	2.15	55.28^{cde}	3.19^{cde}	63.95^{cde}	44.33^{cde}
T_4	49.09^{b}	72.5^{ab}	7.33^{ab}	9.35^{ab}	1.63^{abc}	2.23	59.69^{bc}	3.51^{bc}	70.26^{bc}	48.90^{bc}
T_5	58.43^{a}	76.69^{a}	7.73^{a}	9.92^{a}	1.71^{a}	2.35	63.91^{a}	3.88^{a}	77.53^{a}	53.92^{a}
T_6	41.27^{cde}	66.61^{bcde}	6.65^{bc}	8.11^{cde}	1.55^{abc}	2.11	53.29^{def}	3.06^{def}	61.19^{def}	42.54^{def}
T_7	46.47^{bc}	71.33^{abc}	7.09^{ab}	8.95^{bc}	1.59^{abc}	2.19	57.29^{bcd}	3.37^{bcd}	67.43^{bcd}	46.85^{bcd}
T_8	55.29^{a}	75.53^{a}	7.57^{a}	9.57^{ab}	1.67^{ab}	2.27	61.12^{ab}	3.65^{ab}	73.18^{ab}	50.67^{ab}
T_9	37.77^{dfe}	64.05^{cde}	5.59^{def}	7.77^{de}	1.47^{cd}	2.03	51.47^{ef}	2.86^{ef}	57.08^{ef}	39.63^{ef}
T_{10}	33.87^{f}	59.24^{e}	4.63^{f}	7.45^{e}	1.35^{d}	1.91	50.59^{f}	2.73^{f}	54.68^{f}	37.90^{f}
S. Em±	1.98	2.82	0.27	0.32	0.06	0.08	2.00	0.12	2.25	1.65
CD (5%)	5.88	8.37	0.79	0.96	0.19	NS	5.95	0.35	6.68	4.89

T_1- 100% RDF [125 (N) : 100 (P_2O_5) : 50 (K_2O)], T_2- 100% RDF + Azotobacter + AM + PSB, T_3- 75% RDN supplied through inorganic fertilizer + 25% RDN through FYM, T_4- 75% RDN supplied through inorganic fertilizer + 25% RDN through Vermicompost, T_5- 75% RDN supplied through inorganic fertilizer + 25% RDN through FYM and Vermicompost + Azotobacter + AM + PSB, T_6- 50% RDN supplied through inorganic fertilizer + 50% RDN through FYM, T_7- 50% RDN supplied through inorganic fertilizer + 50% RDN through Vermicompost, T_8- 50% RDN supplied through inorganic fertilizer + 50% RDN through FYM and Vermicompost + Azotobacter + AM + PSB, T_9- 75% RDN supplied through inorganic fertilizer + Micro nutrients Fe, Mn, Cu & Zn, T_{10}- 50% N supplied through inorganic fertilizer + Micro nutrients Fe, Mn, Cu & Zn. AM- Arbuscular Mycorrhiza, PSB- Phosphate solubilizing bacteria, FYM- Farm yard manure.

Conclusion

Application of 50 to 25 per cent of RDN through vermicompost and FYM along with biofertilizers and inorganic fertilizers improved the crop performance. In the present experiment, it was found that the treatments T_5 (75% of RDN was supplemented through inorganic fertilizer + 25% RDN through FYM and vermicompost + azotobacter + VAM + PSB) and T_8 (50% of RDN was supplemented through inorganic fertilizer + 50% RDN through FYM and vermicompost + azotobacter + VAM + PSB) were at on par with respect to all growth and yield parameters. Significant differences in yield and yield-contributing characteristics were noticed when various combinations of organic materials were used in conjunction with inorganic fertilizers to provide nutrients. Thus, it can be concluded that, an integrated approach with 75 per cent of RDN was supplemented through inorganic fertilizer + 25 per cent RDN through FYM and vermicompost + azotobacter + VAM + PSB is sustainable approach for improving growth, yield and quality of brinjal and also the soil chemical properties. Furthermore, from an economic perspective, the same approach (T_5) also resulted in the highest (5,68,810 Rs/ha and 2.37) net monetary returns and benefit to cost (B:C) ratio.

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