Plant Archives Vol. 25, No. 2, 2025 pp. 1299-1305 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.186

INTEGRATED NUTRIENT MANAGEMENT IN BRINJAL (*SOLANUM MELONGENA* L.)

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(Date of Receiving-26-06-2025; Date of Acceptance-07-09-2025)

ABSTRACT

The effect of integrated nutrient management (INM) on brinjal growth and yield was investigated in a field experiment conducted at the Main Vegetable Research Station at Anand Agricultural University during the *Kharif–Rabi* season of 2020–2023. Five treatments totaling four replications were used in the Randomized Block Design (RBD) trial setup. Different amounts of inorganic fertilizers are combined with biofertilizer to create unique combinations. Treatment T_3, which included 80% RDN supplied through inorganic fertilizer + 80% recommended dose of fertilizer (75:40:40 N:P: kg /ha) along with a 15-minute liquid Bio NPK consortium root dip for seedlings before transplanting and a 500-liter water/one lit Bio NPK/ha soil drenching with Bio NPK at 40 and 70 DATP, demonstrated the highest growth parameters, including days to 50% flowering, plant height, number of branches, number of fruits/plants, average fruit weight, and fruit. Treatment T4, on the other hand, had the lowest growth parameters, including days to 50% flowering, plant height, number of fruits/plants, average fruit weight, and fruit. The yield attributes like number of fruits per plant (65.00), average fruit weight (48.19 g) fruit yield per plant (3063g/plant), yield per plot (70.26 kg/plot) and yield per hectare ((542q/ha) were significantly highest in treatment T_5 and were lowest in T4. Hence the combination of 80% RDN supplied through inorganic fertilizer + 80 % recommended dose of fertilizer (75:40:40 N:P: kg /ha) along with seedling root dip with liquid Bio NPK consortium (5mL/L water) for 15 minutes before transplanting and soil drenching with Bio NPK (500Lwater /1 lit Bio NPK/ha) at 40 and 70 DATP could be recommended for the farmers for higher growth and yield along with enhancing crop productivity of brinjal with enhancing soil productivity.

***Key words*: Integrated nutrient management, brinjal, fruit yield and environmental sustainability Biofertilizer**

Introduction

India is the center of origin and diversification for the eggplant, often known as the brinjal (*Solanum melongena* L.), a member of the *Solanaceae* family and one of the most widely grown vegetables in the world, after tomatoes. Except for the higher altitudes, it can be grown in practically all of India's states. It is a widely consumed fruit and vegetable that is primarily grown in tropical and subtropical regions of the world, including India. In temperate countries, however, it is mostly grown during the warm season. Typically used as a "poor man's crop," it is extremely productive. West Bengal, Orissa, Bihar, and Gujarat are the main states where brinjal is grown. Throughout ancient times, brinjal has been utilized in numerous culinary applications. In many tropical nations, it is a staple vegetable. Amino acid concentration is higher in purple fruits. The fruit and leaves of the aubergine are said to lower specific blood cholesterol levels, and its tissues and extract are used medicinally to treat cholera, diabetes, bronchitis, diarrhoea, and asthma. Numerous interrelated elements have a significant impact on brinjal's growth, productivity, and fruit quality. Conversely, the eggplant is a high-yielding, long-lasting crop that draws a lot of nutrients from the soil. A crop of egg plants that produces 60 tonnes of fruit per hectare removes 190 kg of N, 10.9 kilograms of P, and 128 kg of K from the soil. Due to its improved fruit colour, size, and flavor, consumers of vegetables are becoming more and more in demand for brinjal as a fruit vegetable. The brinjal crop's average productivity is quite poor, and there is room for improvement in India to meet all local and national needs.

Due to its affordability, good theoretical foundation, practical viability, and ability to foster sustainable agriculture, the integrated nutrient management systems approach to crop husbandry is becoming more and more popular. The integrated use of mineral fertilizers, organic manures, and microbial inoculants to sustain optimal yields to maintain and improve soil fertility is one aspect of integrated nutrient management. 1990 Abrol *et al*., 2019 Sukhlal *et al*., Mandwade V. (2021) and Payal P. *et al*., (2018). Brinda is typically grown with the help of biofertilizer such as Vesicular Arbuscular Mycorrhiza (VAM), Azotobacter, Azospirillum, and Phosphate Solubilizing Bacteria (PSB). Grows effectively in a medium devoid of nitrogen, Azatobacter is a free-living, aerobic genus of soil microorganisms. They need nitrogen from the atmosphere to synthesize cell proteins, which are then mineralized in the soil following their demise and add to the crop plants' supply of nitrogen Sherpa *et al*., (2019). It is impossible to increase or maintain soil health and sustainability of production with just one source of nutrients, such as chemical fertilizers, organic manures, and biofertilizer. Under these circumstances, comprehensive nutrition control is quite helpful. In order to get and maintain the best yield, integrated plant nutrition management involves the strategic application of the ideal blend of organic, inorganic, and biological nutrient sources within a particular crop, cropping system, and climate. Agricultural is the foundation of human nutrition and is always looking for new and creative ways to increase output without compromising the environment. Nutrient management is a key aspect that distinguishes itself among the other factors impacting crop productivity. Nutrient management is crucial for attaining maximum yields because it not only promotes plant growth. Exploring integrated strategies that combine organic and inorganic nutrition sources has become more important as sustainable agriculture practices are sought after. These strategies can maximize nutrient utilization efficiency while reducing environmental concerns. Integrated Nutrient Management (INM) aims to promote sustainable agricultural intensification, mitigate nutrient deficits, and enhance soil health by utilising the complimentary impacts of several nutrient sources. INM methods have the ability to improve growth parameters, maximize plant nutrition, and eventually increase yield potential when used to brinjal agriculture.

Material and Method

The influence of integrated nutrition management (INM) on brinjal growth and yield was investigated over the course of three years at the Main Vegetable Reaseach Station at Anand Agricultural University, during the *Kharif-Rabi* season. Randomised Block Design (RBD) was used to conduct the experiment, and the five treatments replicated four different conditions: $T_1$100% RDF (100-50-50 kg NPK/ha); T_2: 80% RDF+ seedling dip with Bio NPK at the time of transplanting; T_3: 80% RDF + seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP; T_4: 60% RDF+ + seedling dip with Bio NPK at the time of transplanting; and T_5: 60% RDF + seedling dip with BioNPK +soil drenching with Bio NPK at 40 and 70 DATP. For the purpose of growing the brinjal crop, all agronomic procedures were carried out in accordance with the standard practice packages. Different growth and yield parameters, such as plant height (cm), number of branches, average fruit weight (g), number of fruits per plant, fruit yield per plant (kg/plant), fruit yield per plot (kg/plot), and fruit yield (q/ha), were recorded at different growth stages of the brinjal crop in order to study and analyze them. Plant growth metrics, such as plant height, were measured at the harvest stage and 90 days following transplanting from five randomly chosen plants. By counting the days from

T_3: 80 % RDF +seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP

T_1: 100 % RDF (100-50-50 kg NPK/ha)

Plate 1: Field View of the Brinjal plants growing under treatment T_3 and T_1.

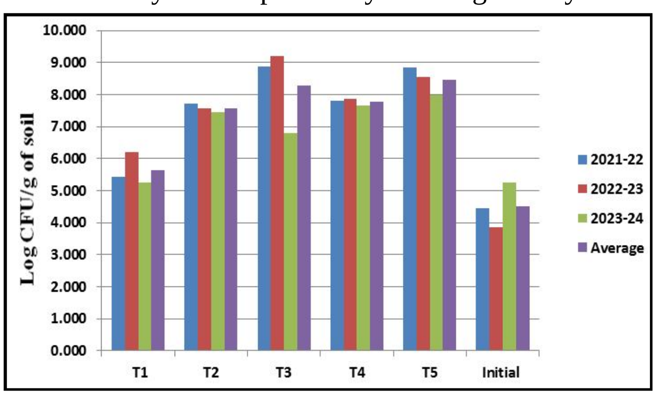

Fig. 1: Soil microbial population Initial and at harvest (2021-22, 2022-23, 2023-24 & pooled of three years).

Table 1: Days to 50% flowering and plant height as influenced by different treatments.

Treatments (T)		Days to 50% flowering				Plant height at harvest (cm)			
		21-22	22-23	23-24	Pooled	21-22	22-23	23-24	Pooled
T_1	100% RDF (100-50-50 kg NPK/ha)	49.00	49.00	46.00	48.00	100.63	101.00	94.99	98.87
T_2	80 % RDF+ seedling dip with Bio NPK at the time of transplanting	59.00	46.00	47.00	50.00	93.00	95.90	89.46	92.66
T_3	80 % RDF +seedling dip with Bio NPK+ soil drenching with Bio NPK at 40 and 70 DATP	51.00	48.00	44.00	48.00	98.03	107.70	100.28	101.59
T_4	60 % RDF+ seedling dip with Bio NPK at the time of transplanting	58.00	47.00	48.00	51.00	92.86	96.98	81.10	90.85
T_5	60 % RDF + seedling dip with Bio NPK +soil drenching with Bio NPK at 40 and 70DATP	49.00	46.00	45.00	46.00	111.91	98.75	92.83	101.17
S.Em. +	T	2.63	2.08	2.25	1.42	3.48	3.96	5.18	2.52
	Y	-	-	-	1.43	-	-	-	1.91
	Y × T	-	-	-	2.33	-	-	-	2.21
CD (P=0.05)	T	8.11	NS	NS	NS	10.71	NS	NS	6.55
	Y	-	-	-	-	-	-	-	7.18
	Y × T	-	-	-	NS	-	-	-	-
CV%		9.93	8.84	9.83	9.59	7.00	7.92	11.28	8.80

the transplanting date, the earliness characteristics, such as the number of days to 50% flowering, were recorded in each treatment. By totalling the fruits obtained from five randomly chosen tagged plants, the number of fruits per plant was counted and the average was expressed to document yield metrics. Using fruit yield per plot (kg $plot^{-1}$), fruit production per hectares (q/ha^{-1}) was computed. Baseline: FYM (10 t/ha), with four equal splits of RDF application: Biofertilizer at basal, 30, 60, and 90 DATP 5 milliliters Before transplanting, the BIO NPK biofertilizer was diluted to 1 L of water and the seedlings were plunged for 15 minutes. At 40 and 70 DATP, 1 L/ha of biofertilizer was soaked in the soil for treatments T_3 and T_5.

Results and Discussion

Table 1 shows the information gathered on growth characteristics, such as plant height at harvest. Based on the data, the highest plant height (101.59, 101.17, and 98.87 cm) at harvest was observed in treatment T_3 (80% RDF + seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP), T_5 (60 % RDF + seedling dip with BioNPK + soil drenching with Bio NPK at 40 and 70 DATP), and T_1 (100% RDF (100-50-50 kg NPK/ ha). The lowest plant height (90.85 cm) was observed under treatment T4 (60 % RDF+ + seedling dip with Bio NPK at the time of transplanting). The combined results of three years show that these data are accurate. On the

Table 2: Number of branches/plant and no. of fruits/plant as influenced by different treatments.

Treatments (T)		No. of branches/plant				No. of fruits/plant			
		21-22	22-23	23-24	Pooled	21-22	22-23	23-24	Pooled
T_1	100% RDF (100-50-50 kg NPK/ha)	4.55	3.17	3.60	3.77	60.00	65.00	67.00	64.00
T_2	80 % RDF+ seedling dip with Bio NPK at the time of transplanting	3.27	3.75	4.07	3.70	45.00	48.00	49.00	47.00
T_3	80 % RDF +seedling dip with Bio NPK+ soil drenching with Bio NPK at 40 and 70 DATP	3.20	3.65	3.65	3.50	56.00	67.00	72.00	65.00
T_4	60 % RDF+ seedling dip with Bio NPK at the time of transplanting	3.80	3.25	4.05	3.70	54.00	44.00	47.00	49.00
T_5	60 % RDF + seedling dip with Bio NPK +soil drenching with Bio NPK at 40 and 70DATP	4.30	4.35	4.45	4.37	70.00	56.00	57.00	61.00
S.Em. +	T	0.13	0.13	0.17	0.25	1.96	1.95	2.32	3.78
	Y	-	-	-	0.06	-	-	-	0.93
	Y × T	-	-	-	0.14	-	-	-	2.08
CD (P=0.05)	T	0.40	0.41	0.51	NS	6.03	6.00	7.15	12.32
	Y	-	-	-	NS	-	-	-	-
	Y × T	-	-	-	0.41		-	-	5.98
CV%		6.80	7.34	8.39	7.57	6.86	6.96	7.98	7.30

Table 3: Av. fruit wt (g) and Yield (g/plant) as influenced by different treatments.

Treatments (T)			Av. fruit wt (g.)				Yield (g/plant)			
			21-22	22-23	23-24	Pooled	21-22	22-23	23-24	Pooled
T_1	100% RDF (100-50-50 kg NPK/ha)		49.50	48.50	46.50	48.17	3041	3080	3067	3063
T_2	80 % RDF+ seedling dip with Bio NPK at the time of transplanting		49.72	45.70	48.25	47.90	2319	2177	2475	2323
T_3	80 % RDF +seedling dip with Bio NPK+ soil drenching with Bio NPK at 40 and 70 DATP		50.00	48.58	46.00	48.19	2880	3064	3149	3031
T_4	60 % RDF+ seedling dip with Bio NPK at the time of transplanting		35.64	46.00	45.25	42.33	2070	2009	1851	1979
T_5	60 % RDF + seedling dip with Bio NPK +soil drenching with Bio NPK at 40 and 70DATP		43.95	40.75	39.25	41.33	3035	2314	2370	2573
S.Em. +		T	1.93	2.94	2.13	2.00	101.00	123.00	104.00	126.00
		Y	-	-	-	1.06	-	-	-	49.00
		Y × T	-	-	-	2.37	-	-	-	110.00
CD (P=0.05)		T	5.90	NS	NS	NS	313.00	380.37	320.00	411.0
		Y	-	-	-	NS	-	-	-	NS
		Y × T	-	-	-	NS	-	-	-	318
CV%			8.44	12.79	9.47	10.41	7.60	9.76	8.05	8.49

other hand, growth-promoting chemicals secreted by biofertilizer are expected to improve root development and provide more effective delivery of water and nutrients to crop plants. Similar outcomes were noted in the research conducted by Manimegala and Gunasekaran (2020), Thakur *et al.*, (2019), Thakur *et al.*, (2019), Chumei *et al.*, (2013), Thingujam *et al.*, (2015), and Solanki *et al.*, (2010). The plant's heightened ability to absorb nutrients resulted in an increase in chlorophyll content, carbohydrate synthesis, and the activity of hormones released by Azospirillum and PSB. This led to a significant increase in plant height, primary branch count, and secondary branch count. The PSB seedling root dip treatment improved the amount of available phosphate in the soil, which in turn improved the growth of the roots and the uptake of other nutrients to a greater extent. This resulted in an increase in cell size and division, which may have contributed to the growth of the plants and the number of primary and secondary branches.

The results for the days till 50% flowering of brinjal are shown in Table 1, which shows that over a pooled three-year period, the days to 50% flowering varied from 46.00 to 51.00. Table 2 displays the findings in relation to the number of branches per plant. Treatment T_5 (60 percent RDF + seedling dip with BioNPK + soil soaking with Bio NPK at 40 and 70 DATP) and treatment T_1

Table 4: Yield as influenced by different treatments.

Treatments (T)			Yield (kg/plot)				Yield (q/ha)			
			21-22	22-23	23-24	Pooled	21-22	22-23	23-24	Pooled
T_1	100% RDF (100-50-50 kg NPK/ha)		70.95	71.50	68.21	70.23	548	552	527	542
T_2	80 % RDF+ seedling dip with Bio NPK at the time of transplanting		53.37	50.49	54.46	52.78	412	390	421	407
T_3	80 % RDF +seedling dip with Bio NPK+ soil drenching with Bio NPK at 40 and 70 DATP		66.45	73.28	71.06	70.26	513	565	549	542
T_4	60 % RDF+ seedling dip with Bio NPK at the time of transplanting		45.66	46.17	44.41	45.42	353	356	343	350
T_5	60 % RDF + seedling dip with Bio NPK +soil drenching with Bio NPK at 40 and 70DATP		73.88	55.30	56.89	62.02	570	427	439	478
S.Em. +		T	2.36	2.57	2.23	1.07	18.23	19.79	17.18	23.53
		Y	-	-	-	3.06	-	-	-	8.24
		Y × T	-	-	-	4.78	-	-	-	18.43
CD (P=0.05)		T	7.26	7.92	6.88	9.98	56.16	61.00	52.96	76.72
		Y	-	-	-	NS	-	-	-	NS
		Y × T	-	-	-	6.86	-	-	-	52.89
CV%			7.60	8.66	7.57	7.95	7.61	8.65	7.55	7.95

Table 5: Effect of integrated nutrient management on Economics.

Sr.	Treatments (T)	1	2	3	4	5	6	7	8	9
T_1	100% RDF (100-50-50 kg NPK/ha)	542	813000	124019	6816	7850	6542	145227	667773	5.60
T_2	80 % RDF+ seedling dip with Bio NPK at the time of transplanting	407	610500	124019	5794	7789	6491	144093	466407	4.24
T_3	80 % RDF +seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP	542	813000	124019	7130	7869	6557	145576	667424	5.58
T_4	60 % RDF+ seedling dip with Bio NPK at the time of transplanting	350	525000	124019	4130	7689	6407	142246	382754	3.69
T_5	60 % RDF +seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP	478	717000	124019	5466	7769	6474	143729	573271	4.99

1: Fruit yield (q/ha); **2:** Gross return(Rs/ha); **3:** Common cost (Rs/ha); **4:** Treatment cost(Rs/ha);
5: Interest of column (3+4) @ 12 % for 6 months; **6:** Interest on fixed capital @ 10 % for 6 months(Rs/ha);
7: Total cost of cultivation; **8:** Net returns(Rs/ha); **9:** BCR

(100% RDF (100-50-50 kg NPK/ha)) had the highest number of branches (4.37).

Table 2 displays the data on the number of fruits per plant. Treatment T_3 (80% RDF + seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP) and T_1 (100% RDF (100-50-50 kg NPK/ha)) recorded the highest and lowest numbers of fruits per plant, respectively, at 65.00 and 64.00. Treatment T_2 (80% RDF + seedling dip with BioNPK) had the lowest number of fruits per plant, 47.00. According to research published by Malik *et al.*, (2011), Ramkrishanan and Selvakumar (2012), and Thingujan *et al.*, (2014), the superior translocation of carbohydrates from sink to source and their faster synthesis may be the cause of the enhanced yield. Suryanto *et al.*, (2017) and these results were nearly identical. Table 3 provides the information regarding the average fruit weight. In the pooled findings of three years, the data clearly shows that the highest average fruit weight (48.19g) achieved by treatment T_3 was comparable to that of treatment T_3 (48.17g). Table 3 provides the information on the yield per plant statistics. According to the data, which is a three-year pooled set of data, the highest fruit output per plant (3063g/plant) for treatment T_1 was comparable to that of treatment T_3 (3031g/plant). Increasing the weight of the fruit while simultaneously increasing its organic and inorganic nutrient content is made possible by chemical fertilizers that balance the availability and supply of nutrients. Good vegetative growth promotes better photosynthetic activity, which in turn increases yield. Similar findings were also reported by Wasim *et al.*, (2013). The implementation of different INM procedures greatly boosted the yield per plot, according to a review of the data in Table 4. Treatment T_3 produced a significantly higher fruit yield kg/plot (70.26 kg/plot), which was comparable to treatment T_1's (70.23 kg/plot) in the three-year pooled results. Table 4 shows that, when pooling data from three years, treatment T_3 produced the highest yield (542 q/ha), matching treatment T_1's yield (542 q/ha). The enhanced availability of plant nutrients and a well-balanced supply of vital nutrients from organic, inorganic, and biofertilizer sources may be responsible for the improvement in crop growth and production in T_5. As a result, there was an increase in cell division, the expansion of cell walls, meristematic activity, photosynthetic efficiency, and the absorption of nutrients through increased root activity. Veena (2018) reported that all of these elements work together to boost the crop's growth, production, and yield characteristics. Mishra *et al.*, (2018) and Mohanty *et al.*, (2020) reported similar results. Based on the findings of Nantha Kumar *et al.*'s research experiment from 2021, it can be concluded that the most effective way to increase plant height, branch count, fruit weight, diameter, and length as well as fruit yield with maximum net realization and benefit cost ratio was to apply 75% RDF (150: 37.5: 37.5 NPK kg/ha.) through 75% RDF of N & P (75:37.5 kg/ha.) + 100% RDF of K (30 kg/ha.) + Azospirillum (2 kg/ha.) + Phosphobacteria (kg/ha.) consortium.

Graph-1 displays that, over a three-year period, treatments T_3 and T_5 exhibited the greatest microbial population, with 8.47 × 108 and 8.29 × 108 cfu/g of soil, respectively. Treatments T_1 and T_3 recorded highest net revenue of 667773/ha with 5.60 BCR, according to the economic statistics shown in Table 5. Displays the soil physiochemical data, which were measured both during the initial and harvesting stages and include pH, EC (dS/m), OC (%), soil average N, soil average P_2O_5, and soil average K_2O.

Conclusion

In summary, by highlighting the need of integrated nutrient management in attaining sustainable and high-yield brinjal agriculture, this research adds significant knowledge to the agricultural community. A viable tactic to improve soil fertility, crop productivity, and overall agricultural sustainability is the use of diverse nutrient management strategies, such as integrated systems, which combine organic and inorganic fertilizer inputs. Increases in growth and yield parameters highlighted how well the integrated nutrient management method maximized the production of brinjal. Based on the three years' worth of data, it can be said that both in individual years and in the combined findings, the effects of various treatments on brinjal production were substantial. The application of 100% RDF (100:50:50), 80% RDF + seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP, or 60% RDF + seedling dip with BioNPK+ soil drenching with Bio NPK at 40 and 70 DATP resulted in more yield.

Conflict of interest: The authors declare no conflicts of interest relevant to this article.

Author contribution statements

- Sneha, J. Mistry conceived of the presented idea and developed the treatment details regarding the field experiment.
- Mihir Pandya verified the field layouts, maintained the field and also contribute in preparation of seedlings during the three years of experiment and encouraged Sneha J. Mistry to investigate specific crop related data and supervised the findings of this work.
- V.I. Joshi has conceived and planned the experiments with Mihir Pandya for carried out the experiments. Sneha J. Mistry, Mihir Pandya and V.I. Joshi planned and carried out the whole experiment throughout three years.
- V.I. Joshi, Sneha J. Mistry and Mihir Pandya contributed to seedlings preparation and timely management of crop for disease and pest and also present in the field during biofertilizer application time to time. All the three authors contributed to the interpretation of the results. Sneha J. Mistry took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors discussed the results and contributed to the final manuscript.

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