

Research Article

Enhancement of productivity and profitability of grafted brinjal under Integrated nutrient management practices

Satyabrath Rout

Institute of Agricultural Sciences, Siksha 'O' Anusandhan, Bhubaneswar (Odisha), India

Aiswarya Saho

Institute of Agricultural Sciences, Siksha O Anusandhan, Bhubaneswar (Odisha), India

Samanyita Mohanty*

Institute of Agricultural Sciences, Siksha 'O' Anusandhan, Bhubaneswar (Odisha), India

Gour Hari Santra

Institute of Agricultural Sciences, Siksha 'O' Anusandhan, Bhubaneswar (Odisha), India

*Corresponding author. E-mail: samanuyitamohanty@soa.ac.in

Article Info<https://doi.org/10.31018/jans.v17i2.6048>

Received: August 07, 2024

Revised: May 13, 2025

Accepted: May 26, 2025

How to CiteRout, S. *et al.* (2025). Enhancement of productivity and profitability of grafted brinjal under Integrated nutrient management practices. *Journal of Applied and Natural Science*, 17(2), 702 - 712. <https://doi.org/10.31018/jans.v17i2.6048>**Abstract**

Integration of grafting technique and tailored nutrient management strategies provides a sustainable solution to address the production challenges and stress management in the cultivation of short-duration fruits and vegetables. The present study aimed to assess the productivity, nutrient uptake efficiency, plant resilience and economic viability of brinjal farming by evaluating the synergistic effect between grafted brinjal and integrated nutrient management (INM) practices. A pot experiment was conducted at the Central Horticultural Experiment Station (ICAR-CHES), Aiginia, Bhubaneswar, Odisha, from 2022-2023. The experiment was laid out in randomized block design (RBD) with ten treatments and replicated thrice. The yield performance of grafted brinjal improved with the application of 75% RDF through chemical fertilization and substitution of 25% N by FYM and vermicompost (37.8 and 35.6 t ha⁻¹, respectively). Supplementation of 25% N through vermicompost and FYM proved to be the best treatment with respect to available nutrient content in soil. The results depicted highest apparent N recovery (55 kg ha⁻¹), agronomic use efficiency (156 kg fruit kg⁻¹ of nutrient applied) and relative agronomic efficiency (1.24) with the utilization of chemical fertilizers and FYM in a 3:1 ratio. The integrated application of chemical fertilizers and organic amendments significantly enhanced the productivity and profitability of grafted brinjal. This strategy addressed both the agronomic and environmental sustainability approach, making it a viable and effective solution for the farmers of the Odisha region.

Keywords: Agronomic use efficiency, Apparent N recovery, Grafted brinjal, Integrated nutrient management, Relative agronomic efficiency

INTRODUCTION

Brinjal (*Solanum melongena* L.) is a widely cultivated vegetable worldwide (Ghosh, 2022). Approximately 54.1 million tons of brinjal are produced per annum globally, with a productivity of 29.1 tons per ha (Food and Agriculture Organization Corporate Statistical Database, 2018). It contains significant concentrations of carbohydrates (6.4 per cent), protein (1.3 per cent), fats (0.3 per cent), calcium (0.02 per cent), phosphorus (0.02 per cent), iron (0.0013 per cent) and other mineral elements. In addition, it also contains 34 mg carotene, 0.9 mg ascorbic acid, 0.5 mg niacin, 0.05 mg riboflavin and 0.05 mg thiamine per 100 g of fruit (Solanki *et al.*, 2017). It is a long-duration crop with high yield poten-

tial, thereby consuming significant amounts of nutrients in a single growth cycle, resulting in rapid nutrient depletion from the soil. However, several biotic constraints have affected the successful cultivation of brinjal, particularly bacteria, fungi, nematodes and insects. Soil-borne pathogens cause up to 78 per cent yield losses (Zhang *et al.*, 2018). The diseases include damping off in the nursery stage, Phomopsis blight, fusarium wilt, bacterial wilt and little leaf caused by Mycoplasma-like organisms (MLOs) and fungal fruit rot in the field (Singh and Thakur, 2023; Pagoch *et al.*, 2015; Nahar *et al.*, 2019). Among the diseases, bacterial wilt is the most harmful disease, causing abrupt and unrepairable wilting of the fruit and eventually leading to the death of the plant. It is mostly widespread in hot and

humid tropical areas with acidic soils, causing yield losses varying from 10 to 90 percent (Nishat *et al.*, 2015; Nahar *et al.*, 2019).

Therefore, to overcome these biotic problems, the only short-term practical solution is grafting susceptible brinjal cultivars with rootstocks having resistance to both biotic and abiotic stress (Manickam *et al.*, 2021). Grafting is quite successful in mitigating crop losses caused due to unfavourable environmental conditions (Kumar *et al.*, 2018). Integrating grafting techniques and sustainable farming practices can be the best strategy for managing biotic stress (Nadoda *et al.*, 2024; Nordey *et al.*, 2020). Grafting brinjal cultivars increases the yield and availability period of the fruits, while better crop stand can be achieved with proper management of cultural methods, irrigation, and nutrition under diversified soil and climatic conditions (Musa *et al.*, 2020).

The quest for sustainable agricultural practices has led to exploring integrated approaches that synergize organic and inorganic nutrient sources, optimizing nutrient utilization efficiency and mitigating environmental risks. The concept of integrated nutrient management (INM) embodies a holistic strategy that integrates organic, inorganic, and biofertilizer inputs to address nutrient deficiencies, improve soil health, and foster sustainable agricultural intensification. In the context of brinjal cultivation, the adoption of INM practices holds promise for optimizing plant nutrition, enhancing growth parameters, and ultimately augmenting yield potential. INM significantly improves the growth and development of grafted brinjal by improving nutrient absorption in the rootstock, fostering vigorous growth and stress resistance (Kumar and Singh, 2020). Additionally, it reduces dependence on chemical fertilizers, decreasing environmental impact and production costs. Overall, INM supports sustainable agriculture by enhancing yield and quality while maintaining ecological balance in grafted brinjal cultivation.

Understanding the intricate interactions between different nutrient sources and their cumulative impact on brinjal performance is imperative for devising tailored nutrient management strategies that align with both agronomic and environmental objectives. The present research aimed to evaluate the influence of INM practices on productivity and nutrient use efficiency of grafted brinjal having variety Cari-1 (as root stalk) × Arka Nilachala Shyama (as scion).

MATERIALS AND METHODS

Experimental details

The present study was conducted during 2022-23 in the Central Horticultural Experiment Station (ICAR-CHES), Aiginia, Bhubaneswar, Odisha. It lies at 85°78'11"E Latitude and 20° 25'09" N Longitude with an elevation of 25.9 meter above mean sea level. The average an-

nual rainfall of Bhubaneswar is 1552 mm. The average temperature varies from 14 °C in winter, 40°C in summer and 30°C in the rainy season. Relative humidity varies between 49% and 90%. The soil texture is sandy loam. The pH of the initial soil was strongly acidic (pH – 5.1) in reaction with sand, silt and clay values of 76.5%, 11% and 12.5%, respectively. The soil organic carbon available in N, P, K, and S of soil were 3.4 g kg⁻¹, 291 kg ha⁻¹, 24.7 kg ha⁻¹, 67.2 kg ha⁻¹, and 19.2 kg ha⁻¹, respectively. Ten different INM treatments were imposed on grafted brinjal in a Randomized block design (RBD), and each treatment was replicated thrice. Each polybag was packed with 3.5 kg of soil.

Nursery raising and grafting

Two self-grafted Brinjal Scion (Arka Neelachal Shyama) and CARI- I rootstock were sown in portray. Grafting was performed in moist chambers between scion and rootstock at 2-3 leaf stage (20-25 days) and the 3-4 leaf stage (35 days), respectively. Scion and rootstock of identical thickness were cut, united, and secured using plastic tapes. The grafted seedlings were transferred into the humified chamber (relative humidity of 85-95 percent) for a week to enable the graft union to heal. Thereafter, the seedlings were relocated to the nursery where the healing process was continued for next two weeks before they were finally ready for transplantation.

Treatment details

The experimental study was laid in Randomized block design (RBD) comprising of ten treatments, i.e., T₁ (100% RDF through NPK fertilizers), T₂ (25% RDF through NPK fertilizers + 75% N substituted through vermicompost), T₃ (50% RDF through NPK fertilizers + 50% N substituted through vermicompost), T₄ (75% RDF through NPK fertilizers + 25% N substituted through vermicompost), T₅ (100% N through VC), T₆ (25% RDF through NPK fertilizers + 75% N substituted through FYM), T₇ (50% RDF through NPK fertilizers + 50% N substituted through FYM), T₈ (75% RDF through NPK fertilizers + 25% N substituted through FYM), T₉ (100% N through FYM) and T₁₀ (Control with no NPK). Half the dose of nitrogen and a full dose of P₂O₅ and K₂O was supplemented as basal, while the remaining half dose of nitrogen was supplemented as top dressing at 35 days after transplanting. N, P & K sources were applied to all the treatments except control. The N, P and K contents of FYM (1.6%, 0.55% and 0.8%, respectively) and vermicompost (1.4%, 0.45% and 0.9%, respectively) were used in this study.

Collection and processing of soil and plant samples

Initial soil samples (before filling the poly bags) and post-harvest soil samples were collected for soil analysis. The collected soil samples were shade-dried,

ground and sieved through 2 mm sieve. They were stored in polythene bags with proper labels for further analysis. The soil texture was determined by the Bouyoucos Hydrometer method, as proposed by Piper (1950). Soil pH (1:2.5 soil: water suspension) was determined by pH meter as outlined by Jackson (1973). The organic carbon content of soil was determined by Walkley and Black wet digestion method as described by Page *et al.* (1982). Available nitrogen in the soil was estimated by Kjeldahl method using the Alkaline KMnO_4 method followed by titration with H_2SO_4 (Subbiah and Asija, 1956). Soil available phosphorous was estimated by Bray's 1 method (Bray and Kurtz, 1945) as described by Page *et al.* (1982). Soil available potassium was estimated by a Flame photometer (Page *et al.*, 1982). Available sulphur was determined calorimetrically by the Turbidimetric method using BaCl_2 (Chesnin and Yien, 1951). Exchangeable calcium and magnesium were determined using EDTA (Versenate) complexometric titration as outlined by Hesse (1971).

Fruit samples were collected during the harvest stage to estimate different nutrient content. Five plants from each treatment were selected randomly for sample collection. After thorough washing with distilled water, the samples were oven-dried at 75°C till a constant weight was obtained. Nitrogen in the processed fruit sample was determined by the Kjeldahl digestion method. The fruit samples were pre-digested in a diacid mixture [HNO_3 : HClO_4 (3:2)] and dissolved in dilute HCl. The P content in the extract was estimated with the help of UV-Visible spectrophotometer by using a Vanadomolybdophosphoric acid yellow colour method, while K content of the extract was determined directly by flame photometer (Jackson, 1973). The Ca and Mg were determined using EDTA (Versenate) complexometric titration using Calcon and Eriochrome black-T (EBT) indicators, respectively, as proposed by Hesse (1971). The S content in fruit was analysed from the extract with the help of a UV-Visible spectrophotometer (Systronics 118; Systronics India Ltd., Ahmedabad, India) by turbidimetric method (Jackson, 1973).

Empirical formulae

Apparent nitrogen recovery (ANR)

It is also known as recovery fraction and indicates the percentage of nitrogen absorbed from externally applied nutrients (chemical fertilizers, FYM and vermicompost). It is expressed in kg ha^{-1} . It is computed as per the formula given by Pillai and Vamadevan (1978). $\text{ANR (\%)} = \frac{\text{Uptake of N in treated pot} - \text{Uptake of N in control pot}}{\text{Amount of Nutrient applied}} \times 100$ Eq. 1

Relative agronomic efficiency (RAE)

In nutrient management, RAE is a new method of fertilizer management. It is a comparative measure of grain

yield gain due to applying different fertilizer or fertilizer management (Engelstad *et al.*, 1974).

$$\text{RAE} = \frac{\text{Yield of fertilized plots (kg ha}^{-1}) - \text{Yield of control plot (kg ha}^{-1})}{\text{Yield of standard fertilized plots (kg ha}^{-1}) - \text{Yield of control plots (kg ha}^{-1})} \text{ Eq. 2}$$

Agronomic use Efficiency (AUE)

The AUE is expressed in kg of fruit kg^{-1} of the nutrient applied (Yoshida, 1981).

$$\text{AUE} = \frac{\text{Fruit yield of fertilized plots (kg ha}^{-1}) - \text{Fruit yield of control plots (kg ha}^{-1})}{\text{Quantity of fertilizer nutrient applied (kg ha}^{-1})} \text{ Eq. 3}$$

Economics of grafted brinjal

Cost of cultivation (expenditure on pot preparation, seed materials, sowing/transplanting, intercultural operations, plant protection, irrigation, harvesting, etc.) under different treatments was considered. The variable costs included the cost of fertilizers and organic amendments (FYM and vermicompost) depending upon the particulars of the treatments. Thus, the total cost consisted of the cost of cultivation plus the cost of organic amendments and/or fertilizers. Gross return was estimated by adding the return from the harvested fruit. The benefit-cost ratio was calculated by dividing the gross returns by the total cost of cultivation.

$$\text{B: C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}} \text{ Eq. 4}$$

Statistical analysis

The experimental data pertaining to fruit yield, nutrient uptake and soil fertility parameters were recorded, compiled and analyzed statistically in SPSS (Statistical Package for Social Sciences) software as per the randomized block design (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Fruit yield

The fruit yield of grafted brinjal varied significantly under the influence of nutrient management practices, with the highest yield (37.8 t ha^{-1}) being observed in treatment T_8 (75% RDF through chemical fertilizers + 25% N substituted through FYM) (Fig. 1). However, the minimum yield (14.4 t ha^{-1}) was recorded in the treatment T_{10} (Control). The integrated treatments produced significantly higher yields than control pots. These results are in accordance with Paswan *et al.* (2022), who observed that the application of nutrients as an inorganic-organic combination produced the highest fruit yield per hectare in brinjal compared to the lone application of either RDF or organic amendments. Similar observations were also exhibited by Mohit *et al.* (2019), where the highest yield per hectare in tomato was obtained (40 t ha^{-1}) with the combined application of 75% inorganic and 25% organic sources through FYM.

Soil fertility status

Soil reaction (pH)

The change in soil reaction after harvesting of grafted brinjal varied significantly with the application of integrated nutrient management practices (Table 1). At the time of harvest, the soil was acidic, with pH varying between 4.93 to 5.24. The highest pH value (5.24) was attained in treatment T_8 (75% RDF through chemical fertilizers + 25% N substituted through FYM), whereas the lowest value (4.93) was observed in the treatment T_{10} (Control). Higher pH values in treatment T_8 can be attributed to the liming effect of FYM.

Soil electrical conductivity (EC)

The highest value of soil EC (0.32 dS m^{-1}) was recorded in treatment T_8 (75% RDF through NPK fertilizers + FYM to substitute 25% N), whereas the lowest EC value (0.12 dS m^{-1}) was observed in treatment T_6 (25% RDF through chemical fertilizers + 75% N substituted through FYM) (Table 1). Compared to the initial soil EC value (0.12 dS m^{-1}), the soil EC values increased in all the nutrient management pots. The soil EC showed variation with the applied treatments due to the variation in the absorption of ions, which have been made available by certain nutrients when absorbed by plants (Kim and Park, 2024).

Soil organic carbon (SOC)

Data indicated that SOC value was higher (8.5 g kg^{-1}) with the application of chemical fertilizers and FYM in a 3:1 ratio (T_8) followed by the treatments T_4 and T_7

where 25% and 50% of N was supplied through vermicompost and FYM, respectively (8.3 g kg^{-1}) (Table 1). In all the treatments applied pots, the SOC value increased compared to the initial value except for the treatment T_{10} (Control), which displayed a SOC value of 3.2 g kg^{-1} soil. Irrespective of the integrated nutrient management practices, SOC after harvesting brinjal crop showed an increasing trend, which may be attributed to the positive interaction between organic and inorganic amendments applied to the soil. Similar observations were also previously displayed by Singh et al. (2018), where they obtained a higher value of SOC (0.62%) with conjoint use of inorganic and organic nutrient sources at 1:1 ratio in the rice-wheat system.

Available nitrogen

Soil available nitrogen at the harvest stage of grafted brinjal showed significant variations with the application of different nutrient management practices (Table 2). The data revealed that all the treatments showed a significant increase in soil available nitrogen over absolute control at the harvest stage of crop growth. The highest available nitrogen (531 kg ha^{-1}) was recorded in treatment T_8 (75% RDF through chemical fertilizers + 25% N substituted through FYM), which was significantly superior over all other treatments. The increased nitrogen availability in treatment T_8 might be due to the higher nitrogen content in FYM and the added advantage of improved soil properties. The lowest available N in soil (301.1 kg ha^{-1}) was displayed in the treatment T_{10} (Control). Treatments T_1 (100% RDF; 472.5 kg ha^{-1}), T_4

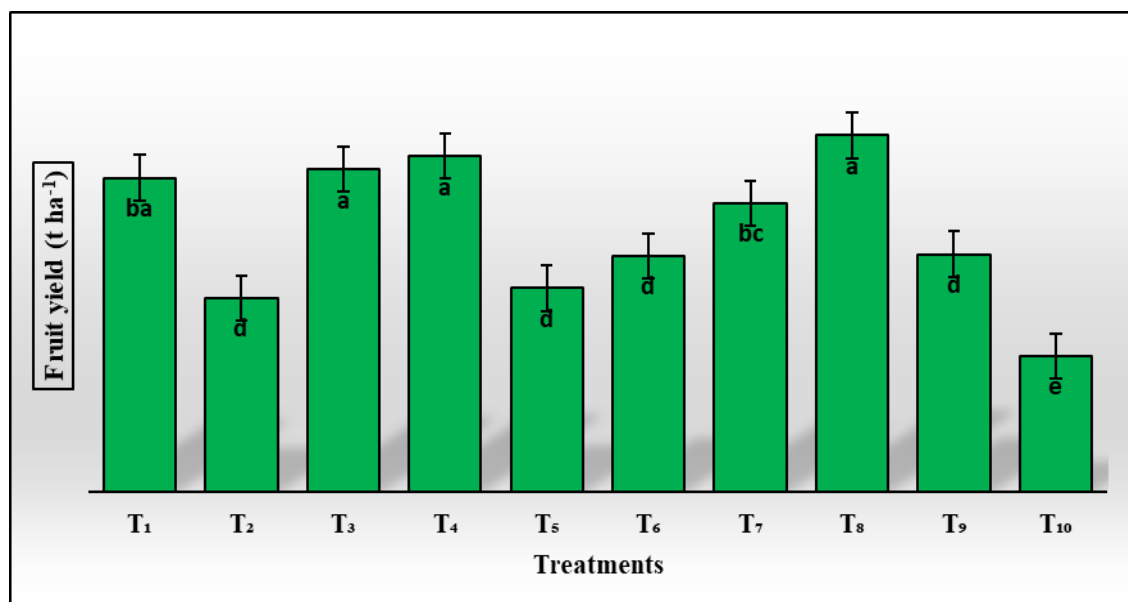


Fig. 1. Effect of integrated nutrient management on fruit yield of grafted brinjal (T_1 (100% RDF through NPK fertilizers), T_2 (25% RDF through NPK fertilizers + 75% N substituted through vermicompost), T_3 (50% RDF through NPK fertilizers + 50% N substituted through vermicompost), T_4 (75% RDF through NPK fertilizers + 25% N substituted through vermicompost), T_5 (100% N through VC), T_6 (25% RDF through NPK fertilizers + 75% N substituted through FYM), T_7 (50% RDF through NPK fertilizers + 50% N substituted through FYM), T_8 (75% RDF through NPK fertilizers + 25% N substituted through FYM), T_9 (100% N through FYM) and T_{10} (Control with no NPK).)

Table 1. Influence of integrated nutrient management on soil pH, electrical conductivity and soil organic carbon after harvest of grafted brinjal

Treatments	Soil pH	Soil EC (dS m ⁻¹)	SOC (g kg ⁻¹)
T ₁ : 100% RDF through NPK fertilizers	5.20	0.18	6.3
T ₂ : 25% RDF through NPK fertilizers + 75% N substituted through vermicompost	5.00	0.20	7.4
T ₃ : 50% RDF through NPK fertilizers + 50% N substituted through vermicompost	5.10	0.24	7.9
T ₄ : 75% RDF through NPK fertilizers + 25% N substituted through vermicompost	5.13	0.21	8.3
T ₅ : 100% N through VC	4.95	0.25	7.1
T ₆ : 25% RDF through NPK fertilizers + 75% N substituted through FYM	5.08	0.12	8.1
T ₇ : 50% RDF through NPK fertilizers + 50% N substituted through FYM	5.15	0.22	8.3
T ₈ : 75% RDF through NPK fertilizers + 25% N substituted through FYM	5.24	0.32	8.5
T ₉ : 100% N through FYM	5.00	0.21	7.4
T ₁₀ : Control (- NPK)	4.93	0.15	3.2
SE(m)	0.06	0.04	0.57
LSD	0.19	0.09	NA

EC: Electrical conductivity; SOC: Soil organic carbon

(75% RDF through chemical fertilizers + 25% N substituted through vermicompost; 485 kg ha⁻¹) and T₈ (75% RDF through chemical fertilizers + 25% N substituted through FYM; 531 kg ha⁻¹) revealed that substituting N through FYM and VC up to 25% along with RDF resulted in better availability of soil nitrogen. However, the application of only organic amendments i.e., treatment T₅ (100% N through VC) and T₉ (100% N through FYM), resulted in poor mineralization and availability of soil N as compared to treatment T₁ (100% RDF through NPK fertilizers). Previous studies have also suggested that employing INM resulted in a considerable increase in available N compared to using organic manure or fertilizers alone in pearl millet-wheat system (Sheoran *et al.*, 2024). Utilization of chemical fertilizers, either alone or in combination with organic amendments, produced significantly higher soil available N compared to the use of organic manures alone (Prakash *et al.*, 2017; Basak and Biswas, 2014).

Available phosphorus

Data pertaining to available phosphorus content in soil showed a significant increase in available phosphorus status of soil over absolute control at the harvest stage (Table 2). The highest available phosphorus (53.2 kg ha⁻¹) was recorded with conjoint use of NPK fertilizers and FYM in the ratio 3:1, which was statistically superior over all other treatments, while the lowest available phosphorus (27.1 kg ha⁻¹) was obtained with sole use of vermicompost (T₅). The increased availability of soil phosphorus in treatment T₈ might be higher due to the additive effect of FYM and SSP application. Application

of only organic amendments to soil i.e., treatment T₅ (100% N through VC; 27.1 kg ha⁻¹) and T₉ (100% N through FYM; 36.3 kg ha⁻¹), resulted in lesser availability of soil P. These results are in agreement with Sheoran *et al.* (2024). Combined application of FYM and NPK fertilizers influences the release of organically bound P and solubilization of soil P through release of organic acids during the breakdown of organic matter. The long-term application of FYM also resulted in a decrease in the activity of polyvalent cations such as calcium (Ca), iron (Fe), and aluminum (Al) due to chelation leading to a reduction in P fixation (Prashanth *et al.*, 2019).

Available potassium

Significant difference in soil-available potassium was observed due to application of different combination of nutrient management approaches (Table 2). All the treatments showed a significant increase in soil's available potassium status over absolute control at harvest stage. The highest available potassium (180.3 kg ha⁻¹) was exhibited in the treatment T₁ (100% RDF through chemical fertilizers), while the minimum value of soil available K (78.5 kg ha⁻¹) was recorded in treatment T₁₀ (Control). Results further indicated that substituting chemical fertilizers by FYM and VC to provide 25% N recorded better soil potassium availability. However, application of only organic amendments, i.e., treatment T₅ (100% N through VC) and T₉ (100% N through FYM), resulted in poor availability of soil K (100.8 kg ha⁻¹ and 123.1 kg ha⁻¹, respectively) as compared to treatment T₁ (100% RDF through chemical fertilizers; 180.3

kg ha⁻¹). Muthumanickam *et al.* (2023) also recorded higher available K in soil with combined application of 75% RDF through chemical fertilizers and FYM. Our results are in also in confirmation with the results recorded by Ahmad *et al.* (2022) who they observed that the application of 50% N through chemical fertilizers + 50% N through vermicompost displayed higher values of soil available potassium rather than the application of only inorganic fertilizers or organic nutrient sources. This may be attributed to the production of organic acid during decomposition of organic manures that resulted in the reduction of K-fixation in soil (Nayak *et al.*, 2020).

Available sulphur

Variations in nutrient management practices imposed significant differences in soil available sulphur at the harvest stage (Table 2). The data exhibited that all treatments showed a significant increase in the available S status of soil over absolute control. The highest available S (80.6 kg ha⁻¹) was noted in the treatment T₉ (100% FYM), and it was found to be statistically similar to the treatments T₅ (100% N through VC; 69.4 kg ha⁻¹), and T₆ (25% RDF through chemical fertilizers + 75% N substituted through FYM; 68.9 kg ha⁻¹). However, the minimum value of soil available S (16.3 kg ha⁻¹) was observed in treatment T₁₀ (Control). Compared to applying 100% RDF through chemical fertilizers, the use of only organic nutrient sources displayed a higher availability of soil available S.

Exchangeable calcium (Ca) and magnesium (Mg)

Exchangeable calcium and magnesium concentration of soil showed significant differences due to variations in nutrient management practices (Table 2). All the treatments showed a significant increase in soil exchangeable Ca and Mg status over absolute control at harvesting stage. Higher soil available Ca (3.28 kg ha⁻¹) was recorded in the treatment T₄ (75% RDF through chemical fertilizers + 25% N substituted through vermicompost), followed by T₅ (100% N through VC; 2.93 kg ha⁻¹) and they were statistically similar to each other. While, the lowest value of exchangeable Ca (1.73 kg ha⁻¹) was recorded in T₁₀ (control). The highest value of exchangeable Mg (3.20 kg ha⁻¹) was recorded in the treatment T₉ (100% FYM) followed by the treatment T₄ (75% RDF through chemical fertilizers + 25% N substituted through vermicompost; 2.4 kg ha⁻¹) and T₂ (25% RDF through chemical fertilizers + 75% N substituted through vermicompost; 2.4 kg ha⁻¹) and they were at par to each other, while the lowest exchangeable Mg (1.40 kg ha⁻¹) was recorded in the treatment T₃ (50% RDF through chemical fertilizers + 50% N substituted through vermicompost; 1.4 kg ha⁻¹). The higher availability of calcium and magnesium in treatment T₅ (100% N through VC) and T₉ (100% N through FYM) both receiving 100% organic amendments, might be higher due to the higher content of exchangeable calcium and magnesium in nutrient sources i.e., vermicompost and FYM.

Table 2. Influence of Integrated nutrient management (INM) practices on the available nutrient content of soil

Treatments	Avail-N	Avail-P	Avail-K	Avail-S	Exch. Ca	Exch. Mg
	(kg ha ⁻¹)					
T ₁ : 100% RDF through NPK fertilizers	472.5	39.0	180.3	41.5	2.13	2.53
T ₂ : 25% RDF through NPK fertilizers + 75% N substituted through vermicompost	455.7	39.4	123.8	64.9	2.80	2.40
T ₃ : 50% RDF through NPK fertilizers + 50% N substituted through vermicompost	464.1	40.3	125.8	52.1	2.40	1.40
T ₄ : 75% RDF through NPK fertilizers + 25% N substituted through vermicompost	485.0	38.0	169.4	41.1	3.28	2.40
T ₅ : 100% N through VC	359.6	27.1	100.8	69.4	2.93	1.67
T ₆ : 25% RDF through NPK fertilizers + 75% N substituted through FYM	439.0	32.1	125.1	68.9	2.80	1.93
T ₇ : 50% RDF through NPK fertilizers + 50% N substituted through FYM	510.1	38.9	157.9	55.6	2.93	1.67
T ₈ : 75% RDF through NPK fertilizers + 25% N substituted through FYM	531.0	53.2	175.8	46.0	2.20	2.00
T ₉ : 100% N through FYM	459.9	36.3	123.1	80.6	2.67	3.20
T ₁₀ : Control (- NPK)	301.1	31.3	78.5	16.3	1.73	1.93
SE(m)	16.94	1.25	1.57	3.89	0.15	0.29
LSD	50.72	3.75	4.71	11.6	0.44	0.87

Table 3. Influence of INM practices on nutrient (N, P, K, S, Ca and Mg) uptake of grafted brinjal

Treatments	Uptake (kg ha ⁻¹)					
	N	P	K	S	Ca	Mg
T ₁ : 100% RDF through NPK fertilizers	122.2	108.2	374.1	27.3	41.0	30.4
T ₂ : 25% RDF through NPK fertilizers + 75% N substituted through vermicompost	87.5	64.3	213.3	35.6	43.5	29.7
T ₃ : 50% RDF through NPK fertilizers + 50% N substituted through vermicompost	133.4	51.5	390.7	20.5	70.0	61.3
T ₄ : 75% RDF through NPK fertilizers + 25% N substituted through vermicompost	172.7	60.6	321.4	41.9	77.8	64.6
T ₅ : 100% N through VC	81.0	41.4	219.7	24.6	40.1	36.7
T ₆ : 25% RDF through NPK fertilizers + 75% N substituted through FYM	103.3	47.0	274.0	37.1	46.4	33.2
T ₇ : 50% RDF through NPK fertilizers + 50% N substituted through FYM	126.5	38.7	237.3	27.6	50.7	37.7
T ₈ : 75% RDF through NPK fertilizers + 25% N substituted through FYM	186.4	71.9	418.0	54.5	49.5	45.4
T ₉ : 100% N through FYM	120.5	84.1	354.2	51.7	34.6	34.5
T ₁₀ : Control (- NPK)	44.8	34.2	167.6	20.8	15.4	13.8
SE(m)	6.4	0.16	0.37	0.12	2.8	3.98
LSD	14.4	0.49	0.89	0.36	8.4	11.9

Nutrient uptake by grafted brinjal**Nitrogen uptake**

The highest nitrogen uptake (186.4 kg ha⁻¹) in brinjal fruit was observed with application of 75% RDF through NPK fertilizers + 25% N substituted through FYM (T₈) which was found to be statistically similar to the treatment T₄ (75% RDF through chemical fertilizers + 25% N through vermicompost; 172.7 kg ha⁻¹), while the lowest N uptake (44.8 kg ha⁻¹) was observed in the treatment T₁₀ (Control). Comparing treatments T₈ (75% RDF through chemical fertilizers + 25% N substituted through FYM) with the treatments receiving only organic nutrient sources i.e., treatment T₅ (100% N through VC) and T₉ (100% N through FYM) displayed that T₁ (100% RDF through chemical fertilizers) had significantly higher N uptake in comparison to the other treatments (Table 3). Higher uptake of N in integrated nutrient management treatments may be ascribed to the higher fruit yield obtained in the respective pots. The application of integrated organic and inorganic nutrient sources exhibited better responses due to a steady and incessant supply of nutrients throughout the crop growth stages (Ghimire *et al.*, 2023).

Phosphorus uptake

Application of 100% RDF through chemical fertilizers resulted in highest uptake of P (108.2 kg ha⁻¹) by grafted brinjal (Table 3). The treatment T₁ (100% RDF through NPK fertilizers) was found to be superiorly significant over all the other treatments. Higher uptake of P in integrated nutrient management treatments as compared to lone use of organic nutrient sources

(vermicompost/FYM) may be attributed to the higher fruit yield obtained in the respective pots. Application of organic sources in combination with inorganic fertilizers exhibited better response due to a steady supply of nutrients throughout the crop growing stages (Iqbal *et al.*, 2019).

Potassium uptake

The highest potassium uptake by fruit (418 kg ha⁻¹) was recorded in treatment T₈ (75% RDF + vermicompost to substitute 25% N), while the lowest K uptake (167.6 kg ha⁻¹) was observed in treatment T₁₀ (Control) (Table 3). Comparing treatments T₈ (75% RDF through chemical fertilizers + 25% N substituted through FYM, 418 kg ha⁻¹) with the treatments receiving only organic nutrient sources i.e., treatment T₅ (100% N through VC, 219 kg ha⁻¹) and T₉ (100% N through FYM, 354.2 kg ha⁻¹) displayed that conjoint application of organic and inorganic nutrients resulted in significantly higher potassium uptake rather than application of only RDF and organic amendments.

Sulphur uptake

The highest Sulphur uptake (54.5 kg ha⁻¹) was recorded with supplementation of 75% RDF through chemical fertilizers and 25% N substituted through FYM. It was significantly higher than all the other treatments (Table 3). Meanwhile, the lowest S uptake (20.87 kg ha⁻¹) was observed with no nutrient supplementation. Higher sulphur uptake by grafted plants was recorded with the combined application of inorganic and organic nutrient sources. Similar results were previously concluded by

Table 4. Influence of INM practices on Apparent nitrogen recovery (ANR), Agronomic use efficiency (AUE) and Relative agronomic efficiency (RAE) of grafted brinjal

Treatment	ANR (kg ha ⁻¹)	AUE (kg kg ⁻¹)	RAE
T ₁ : 100% RDF through NPK fertilizers	36.8	126	1.00
T ₂ : 25% RDF through NPK fertilizers + 75% N substituted through vermicompost	12.7	41	0.33
T ₃ : 50% RDF through NPK fertilizers + 50% N substituted through vermicompost	20.6	132	1.05
T ₄ : 75% RDF through NPK fertilizers + 25% N substituted through vermicompost	42.1	141	1.12
T ₅ : 100% N through VC	8.10	48	0.38
T ₆ : 25% RDF through NPK fertilizers + 75% N substituted through FYM	9.20	71	0.56
T ₇ : 50% RDF through NPK fertilizers + 50% N substituted through FYM	16.0	108	0.85
T ₈ : 75% RDF through NPK fertilizers + 25% N substituted through FYM	55.0	156	1.24
T ₉ : 100% N through FYM	30.3	72	0.57
T ₁₀ : Control (- NPK)	-	-	-

the studies conducted by Pilli *et al.* (2019), in which the conjoint application of organic manures and chemical fertilizers improved S concentration and uptake in tomato. The enhancement in uptake can be attributed to the enrichment of soil by nutrient supplementation as well as their efficient translocation into the plant. The better nutritional status of plants due to the supplementation of organic amendments has also been reported previously by Liu *et al.* (2024).

Calcium uptake

Supplementation of inorganic fertilizers and vermicompost in 3:1 and 1:1 ratios resulted in higher calcium uptake (77.8 and 70 kg ha⁻¹, respectively) and these values were at par with each other while minimum uptake (8.4 kg ha⁻¹) was recorded in T₁₀ (Control) (Table 3). Integrated inorganic and organic nutrient supplementation recorded higher Ca uptake than lone use of organic/inorganic sources. These results were supported by the findings of Pilli *et al.* (2019), who observed higher calcium uptake with integrated application of chemical fertilizers and organic nutrient sources in 3:1 ratio. Adding organic nutrient supplementation like FYM or VC may have resulted in higher microbial activities with enriched nutrients and enhanced root activities, which ultimately resulted in better nutrient absorption. Moreover, utilization of organic sources contributes both macro and micro-nutrients to the plants that would convert unavailable nutrients to available form and thus uptake is higher than inorganic fertilizers (Brempong and Addo-Danso, 2022).

Magnesium (Mg) uptake

The highest magnesium uptake was recorded (64.6 kg ha⁻¹) in the treatment T₄ (75% RDF through chemical fertilizers + 25% N substituted through vermicompost)

and it was significantly superior than other treatments, while the lowest (13.8 kg ha⁻¹) was observed in T₁₀ (Control) (Table 3). Similar results were obtained by Pilli *et al.* (2019) where they recorded greater magnesium uptake by grafted plants (brinjal and tomato) with integrated usage of inorganic fertilizers and organic nutrient sources as compared to lone use of synthetic fertilizers and organics.

Apparent nitrogen recovery (ANR)

ANR deviated significantly with the supplementation of diversified nutrient management practices (Table 4). Conjunctive application of synthetic fertilizers and organic sources in 3:1 ratio produced superior results than application of other treatments. The highest nutrient recovery (55 kg ha⁻¹) was recorded in the treatment (T₈), while the lowest value (8.1 kg ha⁻¹) was observed with sole application of vermicompost. Application of only organic amendments, i.e., treatment T₅ (100% N through VC; 8.1 kg ha⁻¹) and T₉ (100% N through FYM; 30.3 kg ha⁻¹) displayed lower ANR in contrast to lone use of NPK fertilizers. Equivalent results were obtained by Kakraliya *et al.* (2017), who observed higher ANR values when integrated organic and inorganic nutrient sources were applied.

Agronomic use efficiency

Significant variations were recorded for AUE with supplementation of different nutrient management options (Table 4). The highest AUE (156 kg ha⁻¹) was displayed by the treatment T₈ (75% RDF through chemical fertilizers+ 25% N substituted through FYM), whereas lowest nutrient use efficiency was observed with treatment T₂ (25% RDF through chemical fertilizers + 75% N substituted through vermicompost; 41 kg ha⁻¹). Similar results were obtained by Pilli *et al.* (2019), who observed high-

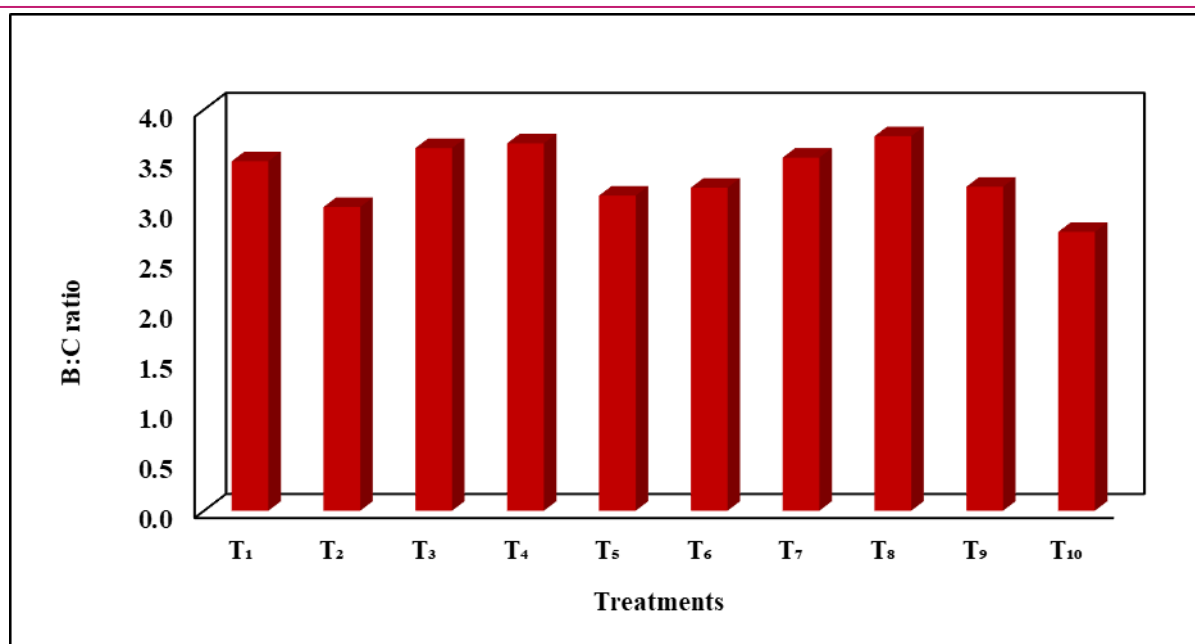


Fig. 2. Benefit cost ratio as influenced by application of INM (T₁ (100% RDF through NPK fertilizers), T₂ (25% RDF through NPK fertilizers + 75% N substituted through vermicompost), T₃ (50% RDF through NPK fertilizers + 50% N substituted through vermicompost), T₄ (75% RDF through NPK fertilizers + 25% N substituted through vermicompost), T₅ (100% N through VC), T₆ (25% RDF through NPK fertilizers + 75% N substituted through FYM), T₇ (50% RDF through NPK fertilizers + 50% N substituted through FYM), T₈ (75% RDF through NPK fertilizers + 25% N substituted through FYM), T₉ (100% N through FYM) and T₁₀ (Control with no NPK).

er AUE values when supplementing integrated organic and inorganic nutrient sources.

Relative agronomic efficiency (RAE)

RAE varied significantly with the application of different nutrient management treatments (Table 4). The highest agronomic efficiency (1.24) was recorded with the application of NPK fertilizers and FYM in the ratio 3:1 (T₈) followed by the treatment T₄ (75% RDF through chemical fertilizers + 25% N through VC; 1.12) while the lowest RAE (0.33) was observed in the treatment T₂ (25% RDF through chemical fertilizers + 75% N substituted through vermicompost). Application of only organic amendments i.e., treatment T₅ (100% N through VC; 0.38) and T₉ (100% N through FYM; 0.57 per cent) displayed lower RAE than sole application of chemical fertilizers. Combined application of chemical fertilizers and organic sources in 3:1 ratio produced superior results than the application of other treatments. Similar results were obtained by Pilli *et al.* (2019), where they observed higher RAE values with the application of integrated organic and inorganic nutrient sources.

Effect of Integrated nutrient management practices on benefit-cost ratio (B:C) of grafted brinjal

Diversified nutrient management practices imposed significant variation in B:C ratio of grafted brinjal (Fig. 2). The highest B:C ratio of 3.7 was observed with application of treatment T₈ (75% RDF through chemical fertilizers + 25% N substituted through FYM) whereas,

least B:C ratio (2.78) was observed with no application of any external nutrient sources (T₁₀). Combined application of chemical fertilizers and organic sources in 3:1 ratio produced superior results than application any other treatments. Similar results were attained by Samsangheile *et al.* (2014), they observed that the application of 50% RDF through chemical fertilizers + FYM to substitute 50% N + Biofertilizers produced the highest net return along with cost benefit ratio 1:1.92 in chilly crop. These results suggested that reducing the cost of production by 50% by substituting chemical fertilizers can produce optimum yield without compromising on the quality aspects of brinjal.

Conclusion

A higher yield of grafted brinjal was produced when 25% N was supplemented through FYM along with chemical fertilizers. Integrated application of chemical fertilizers and organic amendments resulted in higher nutrient uptake than the lone application of chemical fertilizers. Available N, P, K, S, exchangeable calcium and magnesium content in post-harvest soil were higher with the application of the recommended dose of fertilizers and FYM in a 3:1 ratio. Different productivity indices, i.e., ANR, AUE, RAE and benefit-cost ratio were superior with the combined application of inorganic and organic nutrient sources, indicating the relevance of INM in improving the production and profitability of grafted brinjal.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

- Ahmad, M., & Tripathi, S. K. (2022). Effect of integrated use of vermicompost, FYM and chemical fertilizers on soil properties and productivity of wheat (*Triticum aestivum* L.) in Alluvial soil. *The Journal of Phytopharmacology*, 11(2), 101-106.
- Basak, B. B., & Biswas, D. R. (2014). Carbon and nitrogen mineralization in soil amended with value-added manures and fertilizers under varying temperature and soil moisture regimes. *Journal of the Indian Society of Soil Science*, 62(1), 18-28.
- Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil science*, 59(1), 39-46.
- Brempong, M. B., & Addo-Danso, A. (2022). Improving soil fertility with organic fertilizers. *New Generation of Organic Fertilizers*, 1.
- Chesnin, L., & Yien, C. H. (1951). Turbidimetric determination of available sulfates.
- Engelstad, O. P., Jugsujinda, A., & De Datta, S. K. (1974). Response by flooded rice to phosphate rocks varying in citrate solubility. *Soil Science Society of America Journal*, 38(3), 524-529.
- FAOSTAT: Agriculture production data 2018. Available online: <http://www.fao.org/> (Accessed on 13 August 2024)
- Ghimire, S., Chhetri, B. P., & Shrestha, J. (2023). Efficacy of different organic and inorganic nutrient sources on the growth and yield of bitter melon (*Momordica charantia* L.). *Heliyon*, 9(11).
- Ghosh, S. K. (2022). Eggplant (*Solanum melongena* L.) and climate resilient agricultural practices.
- Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John Wiley & sons.
- Hesse, P. R., & Hesse, P. R. (1971). A textbook of soil chemical analysis, Murray, London
- Iqbal, A., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., ... & Jiang, L. (2019). Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. *Agronomy*, 9(10), 651.
- Jackson, M. L. (1973). Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India, 498, 151-154.
- Kakraliya, S. K., Jat, R. D., Kumar, S., Choudhary, K. K., Prakash, J., & Singh, L. K. (2017). Integrated nutrient management for improving, fertilizer use efficiency, soil biodiversity and productivity of wheat in irrigated rice wheat cropping system in Indo-Gangatic plains of India. *International Journal of Current Microbiology and Applied Sciences*, 6(3), 152-163.
- Kim, H. N., & Park, J. H. (2024). Monitoring of soil EC for the prediction of soil nutrient regime under different soil water and organic matter contents. *Applied Biological Chemistry*, 67(1), 1.
- Kumar, A., & Singh, R. (2020). Role of Integrated Nutrient Management in Enhancing Growth and Yield of Grafted Vegetables. *Journal of Sustainable Agriculture Practices*, 12(3), 45-58.
- Kumar, S., Bharti, N., & Saravaiya, S. N. (2018). Vegetable Grafting: A Surgical Approach to combat biotic and abiotic stresses-A review. *Agricultural Reviews*, 39(1), 1-11.
- Liu, Y., Lan, X., Hou, H., Ji, J., Liu, X., & Lv, Z. (2024). Multifaceted Ability of Organic Fertilizers to Improve Crop Productivity and Abiotic Stress Tolerance: Review and Perspectives. *Agronomy*, 14(6), 1141.
- Manickam, R., Chen, J. R., Sotelo-Cardona, P., Kenyon, L., & Srinivasan, R. (2021). Evaluation of different bacterial wilt resistant eggplant rootstocks for grafting tomato. *Plants*, 10(1), 75.
- Mohit, M. K., Singh, M. K., Singh, S. P., & Naresh, R. K. (2019). Effect of integrated use of organic and inorganic sources of nutrients on growth, yield quality and profitability of tomato (*Lycopersicon esculentum* mill.) Var. *Pusa rohini*. *International Journal of Agricultural and Statistical Sciences*, 15(1), 57-66.
- Musa, I., Rafii, M. Y., Ahmad, K., Ramlee, S. I., Md Hatta, M. A., Magaji, U., ... & Mat Sulaiman, N. N. (2021). Influence of wild relative rootstocks on eggplant growth, yield and fruit physicochemical properties under open field conditions. *Agriculture*, 11(10), 943.
- Muthumanickam, K., Chaudhary, S. K., Singh, S. P., Kumar, R., & Naik, B. M. (2023). Combined application of chemical fertilizers, organics and foliar spray of zinc and iron on yield, quality and water productivity of aerobically grown rice (*Oryza sativa*) in calcareous soil. *Journal of Plant Nutrition*, 46(13), 2990-3001.
- Nadoda, N. A., Barot, D. C., Baria, V. K., & Chaudhari, V. M. (2024). Exploitation of Grafting for Abiotic and Biotic Stress Management in Vegetable Crops: A Review. *Advances in Research*, 25(4), 125-131.
- Nahar, N., Islam, M. R., Uddin, M. M., de Jong, P., Struik, P. C., & Stomph, T. J. (2019). Disease management in eggplant (*Solanum melongena* L.) nurseries also reduces wilt and fruit rot in subsequent plantings: A participatory testing in Bangladesh. *Crop Protection*, 120, 113-124.
- Nayak, B., Rath, B. S., Shahid, M., Jena, S. N., Bagchi, T. B., & Roy, P. S. (2020). Organic nutrient management in aromatic rice-rice sequence: A critical review. *International Journal of Chemical Studies*, 8, 1435-1444.
- Nordey, T., Schwarz, D., Kenyon, L., Manickam, R., & Huat, J. (2020). Tapping the potential of grafting to improve the performance of vegetable cropping systems in sub-Saharan Africa. A review. *Agronomy for Sustainable Development*, 40(4), 23.
- Page, A. L., Miller, R. H., & Keeney, D. R. (1982). Methods of soil analysis. Part 2. Chemical and microbial properties. *American Society of Agronomy, Madison, Wisconsin, USA*.
- Pagoch, K., Srivastava, J. N., & Singh, A. K. (2015). Damping-off disease of seedlings in Solanaceous vegetables: current status and disease management. *Recent advances in the diagnosis and management of plant diseases*, 35-46.
- Paswan, A., Choudhary, A. S., Raj, S., Sonloi, P., & Sonwani, A. (2022). Effect of integrated nutrient management on yield of Brinjal. *International Journal of Agriculture and Food Science*, 4(1), 12-6.
- Pillai, K. G., & Vamadevan, V. K. (1978). Studies on an

- integrated nutrient supply system for rice. *Fertiliser news*.
31. Pilli, K., Samant, P. K., Naresh, P., & Acharya, G. C. (2019). Effect of integrated nutrient management on nutrient recovery, nutrient use efficiency and relative agronomic efficiency of grafted tomato. *Journal of Pharmacognosy and Phytochemistry*, 8(3), 506-510
32. Piper, C. S. (1950). Soil and Plant Analysis (The University of Adelaide.). *Inter. Sci. Pub., New York, USA*.
33. Prakash, D., Benbi, D. K., & Saroa, G. S. (2017). Impacts of rate and source of phosphorus application on properties of Typic Haplustept under rice-wheat system. *Indian Journal of Fertilisers*, 13(3), 36-42.
34. Prashanth, D. V., Krishnamurthy, R., & Naveen, D. V. (2019). Long-term effect of integrated nutrient management on soil nutrient status, content and uptake by finger millet crop in a typic kandiuistalf of eastern dry zone of Karnataka. *Communications in Soil Science and Plant Analysis*, 51(2), 161-174.
35. Samsangheile, K. S. (2014). Integrated nutrient management for quality production of chilli on acid alfisol. *Annals of Plant and Soil Research*, 16(2), 164-167.
36. Nishat, S., Islam Hamim, I. H., Khalil, M. I., Ali, M. A., Hossain, M. A., Meah, M. B., & Islam, M. R. (2015). Genetic diversity of the bacterial wilt pathogen *Ralstonia solanacearum* using a RAPD marker.
37. Sheoran, S., Prakash, D., Yadav, P. K., Gupta, R. K., Al-Ansari, N., El-Hendawy, S., & Mattar, M. A. (2024). Long-term application of FYM and fertilizer N improve soil fertility and enzyme activity in 51st wheat cycle under pearl millet-wheat. *Scientific Reports*, 14(1), 21695.
38. Singh, I., & Thakur, P. (2023). Impact of fungi on the world economy and its sustainability: current status and potentials. In: *Fungal resources for sustainable economy: current status and future perspectives* (pp. 3-37). Singapore: Springer Nature Singapore.
39. Singh, S. K., Kumar, M., Singh, R. P., Bohra, J. S., Srivastava, J. P., Singh, S. P., & Singh, Y. V. (2018). Conjoint application of organic and inorganic sources of nutrients on yield, nutrient uptake and soil fertility under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system. *Journal of the Indian Society of Soil Science*, 66(3), 287-294.
40. Solanki, M. M., Solanki, M. S., Gajanan Thakare, G. T., Jogi, P. D., & Sapkal, D. R. (2017). Effect of zinc and boron on growth of brinjal (*Solanum melongena* L.).
41. Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils.
42. Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, 37(1), 29-38.
43. Yoshida, S. (1981). Fundamentals of rice crop science. *International Rice Research Institute*, 269.
44. Zhang, W. (2018). Global pesticide use: Profile, trend, cost/benefit and more. *Proceedings of the International Academy of Ecology and Environmental Sciences*, 8(1), 1.