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Growth, yield and soil fertility of brinjal (*Solanum melongena* L.) as influenced by integrated nutrient management practices

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Abstract
The study was carried out at the Research farm of Abhilashi University, Mandi (H.P) during the summer season 2024. The experiment was laid out in Randomized Block Design comprising of seven treatments with three replications. The treatments were T_1 [N: P: K (100%)], T_2 [Farm Yard Manure (100%)], T_3 [Poultry Manure (100%)], T_4 [N: P: K (50%) + Farm Yard Manure (50%)], T_5 [N: P: K (50%) + Poultry Manure (50%)], T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)] and T_7 (Absolute Control). The results showed that treatment T_5 recorded maximum plant height (98.74 cm), number of leaves (172.60), leaf length (17.66 cm), leaf width (12.17 cm), fruit weight (76.37 g), number of fruits (15.63), fruit diameter (5.01 cm), yield per plot (10.74 kg) and yield per hectare (397.70 q/ha). Similarly in terms of economics maximum gross income (₹ 4,77,808), net income (₹ 4,02,640) and (5.39) B: C ratio were recorded under treatment T_5. Therefore, T_5 appeared to be the best for achieving the higher growth, yield and economic benefit of brinjal.

Keywords: Growth, yield, fertilizers, brinjal, economics

Introduction
Brinjal or eggplant (*Solanum melongena* L.) belongs to the family solanaceae is one of the important and popular vegetable crops grown in India and other parts of the world. Various sizes, shapes, colours and forms of cultivated as well as the wild type of brinjal are found in India, white type brinjal fruits are said to be good for diabetic patients. Brinjal fruits have medicinal properties (Rajan and Markose, 2002) [15]. Brinjal is a delicate, tropical perennial often cultivated as a tender or half-hardy annual intemperate climate. India is considered its center of origin.

Some medicinal uses of eggplant tissues and extract include the treatment of diabetes, asthma, cholera, bronchitis and diarrhea, its fruit and leaves are reported to lower certain levels of blood cholesterol it is an important vegetable due to its nutritive value, consisting of minerals like iron, phosphorus, calcium and vitamins like A, B and C. It is believed to be a rich source of phenolic compounds that function as an antioxidant and helps to prevent cancer.

Apart from India, the other major brinjal growing countries are China, Egypt, Turkey, Japan, Italy, Indonesia, Iraq, Syria, Spain and Phillippines. In India, brinjal is cultivated in 669 thousand hectares of area with production of 12400 thousand MT (Anonymous, 2017a) [2], whereas in Himachal Pradesh area under brinjal is 1.22 thousand hectares with a production of 27.80 thousand MT (Anonymous, 2017b) [3]. Major brinjal producing states are Orissa, Bihar, Karnataka, West Bengal, Andhra Pradesh, Maharastra and Uttar Pradesh.

Several methods, which include integrated nutrient management, organic farming and high-quality hybrid seeds, can be used to increase brinjal productivity. Both chemical fertilizers and organic manure by their own cannot contribute to sustainable production because of the significant nutrient turnover in soil plant systems during intensive vegetable cultivation (Khan *et al.* 2008) [9]. Moreover, the application of high input technologies such as chemical fertilizers, pesticides and herbicides improve the production but there is growing concern over the adverse effects of the use of chemicals on human health, soil productivity and environmental quality

(Sharma *et al*. 2012) [18]. On the other hand, eggplant is a long duration crop with high yield which reduces large quantities of nutrients from the soil.

Materials and Methods

Experimental site

The present study was carried out at the Experimental Research farm, School of Agriculture, Abhilashi University, Mandi, (H.P.) during the *Kharif* season of 2024. The experimental site is located at 31º33'30" N latitude and 77º00'46" E longitude with the elevation of 1426 m amsl. Agro-climatically, Mandi represents the high hill temperate wet zone and the mid hill sub-humid zone of Himachal Pradesh, which are distinguished by chilly winter months and moderate summers (March to June). The region experiences high rainfall from June to September's monsoon season and medium to high rainfall with sporadic snowfall from October to February.

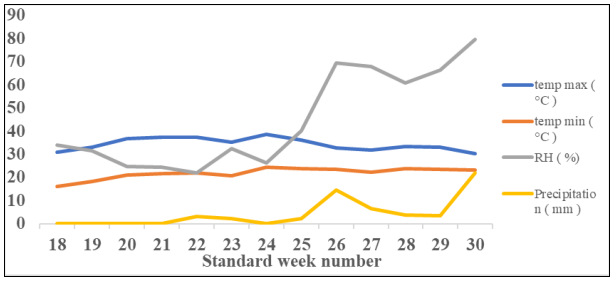

Figure 1: Meteorological data of the experimental farm recorded during May- August 2024

Table 1: Treatment details.

Treatment code	Treatments
T_1	NPK (100%)
T_2	Farm Yard Manure (100%)
T_3	Poultry Manure (100%)
T_4	NPK (50%) + Farm Yard Manure (50%)
T_5	NPK (50%) + Poultry Manure (50%)
T_6	NPK (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)
T_7	Absolute control

Design of experiment

The experiment was laid out in Randomized Block Design with three replications comprising of seven treatment combinations of organic and inorganic fertilizer. The layout plan is provided below:

Variety	Shamli (F1 hybrid)
Design	Randomized Complete Block Design (RCBD)
Replication (s)	3
Treatments	7
Plot size	1.35m ×1.8m= 2.43m^2
Spacing	45 cm × 60 cm
Date of sowing	4th April 2024
Date of transplanting	1st May 2024

Growth and yield parameters

Plant height (cm)

The plant height was recorded from the base of the plant to the highest growing tip of the plant at harvest. An average of five tagged plants was worked out from each plot and the data was expressed in centimeters**.**

Number of leaves per plant (cm)

The lateral branches arising from the main stems of five randomly selected plants were counted and average was calculated as mean.

Leaf length per plant (cm)

Ten leaves were selected from lower, middle and top part of the selected plants per plot and then length of the leaves was measured from the tip of the entire leaf down to the base of the lowest leaflets where they meet the leaf stem using ruler and average was worked out as mean length of leaves.

Leaf width per plant (cm)

Leaf width was measured at the widest point perpendicular to the longitudinal axis of the leaf. The measurements were calculated and recorded by using a measuring scale.

Fruit weight (g)

After harvesting of fruits from selected 5 plants, the individual weight of fruit using the digital balance was recorded and the average weight was calculated and expressed as fruit weight in grams.

Number of fruits per plant

The total numbers of fruits harvested from five randomly selected plants in different pickings was summed up and average value per plant was worked out.

Fruit diameter (cm)

The fruits used for recording fruit length were used to measure the fruit diameter. The diameter was taken from the center of the fruit using vernier calliper and their average value was worked out.

Fruit yield per plot (kg)

The total weight of harvested fruits of all the pickings was considered and the average yield per plant was calculated. From this value the total fruit yield per plot was worked out and values were expressed in kilograms.

Fruit yield per hectare (q ha^{-1})

Each net plot's individual yield from each of the several treatments was recorded and converted to hectares. It determined how much fruit was produced per hectare and its quantity was expressed in quintals.

Soil analysis

Soil samples from 0-15 cm depth were collected from all the plots separately and were air dried, crushed, passed through 2 mm sieve and then soil testing was done for chemical parameters like soil pH, available NPK and organic carbon concentration.

Table 2: Initial chemical parameters of the experimental soil

Sr. No.	Parameters	Values obtained	Methods used
1.	Soil pH (1:2.5 soil: water suspension)	5.62	Glass electrode method (Jackson, 1973) [8]
2.	Available Nitrogen (kg/ha)	236.42	Alkaline potassium permanganate (Subbiah and Asija, 1956) [20]
3.	Available Phosphorous(kg/ha)	17.72	Olsen's method of extraction with 0.5 1NaHCO3 at pH 8.5 (Olsen *et al*. 1954) [14]
4.	Available Potassium(kg/ha)	191.32	Neutral ammonium acetate extraction method (Merwin and Peech 1950) [13]
5.	Organic carbon (%)	0.68	Rapid titration method (Walkley and Black 1934) [25]

Economics

The cost of cultivation of each treatment was calculated per hectare on the basis of prevailing rates of labour, organic manures, irrigation and other expenditure. The total income per hectare was calculated as per the average wholesale price of broccoli in the market. The net profit per hectare was obtained by deducting the cost from treatment.

Cost of cultivation (₹/ha)

By presuming the item-wise input cost based on the local market rate, the cost of cultivation per hectare of land was worked out and were computed treatment-wise also

Gross returns (₹/ha)

From the total yield of each treatment plot, the gross monetary return was worked out based on the average selling price of the product and it was recorded accordingly in ₹/ha.

Gross return (₹/ha) = Market price × Yield/ha

Net returns (₹/ha)

The most crucial factor to consider before recommending any remedies to farmers for widespread use is their economic viability. The average treatment yield and current market rates for inputs and output were utilized to determine the therapy's economics. The cost of cultivation for each treatment was deducted from the gross return from the economic yield to determine the net return. Net returns (₹/ha) are calculated as follows:

Net return (₹/ha) = Gross returns (₹/ha) - Cost of cultivation (₹/ha)

Benefit cost ratio (B: C ratio)

Benefit cost ratio were worked out for each nutrient treatment by adopting the following formula:

$$\text{Benefit: Cost ratio} = \frac{\text{Net returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Results and Discussion

Growth and yield parameter

Growth and yield parameters *viz.* plant height (cm), number of leaves, leaf length (cm), leaf width (cm), fruit weight (g), number of fruits, fruit diameter (cm), yield per plot (kg) and yield per hectare (q/ha) were recorded and presented in Table 3 and Table 4.

Growth and yield parameters of brinjal were significantly influenced by different treatments. The results showed that maximum plant height (98.74 cm), number of leaves (172.60), leaf length (17.66 cm), leaf width (12.17 cm) fruit weight (76.37 g), number of fruits (15.63), fruit diameter (5.01 cm), yield per plot (10.74 kg) and yield per hectare (397.70 q/ha) were obtained under treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] which was statistically at par with the treatment T_4 [(N: P: K (50%) + Farm Yard Manure (50%)], While the minimum plant height (78.33 cm), number of leaves (141.53), leaf length (11.80 cm), leaf width (8.79 cm) fruit weight (57.72 g), number of fruits (9.37), fruit diameter (3.97 cm), yield per plot (4.87 kg) and yield per hectare (180.30 q/ha) were recorded in treatment T_7 (Absolute control). NPK fertilizers, with their specific ratios of nitrogen, phosphorus and potassium, promote vigorous vegetative growth, root development and overall plant health, thereby enhancing these growth parameters. Poultry manure, rich in organic matter and essential nutrients, improves soil structure and fertility, providing a balanced and slow-release nutrient supply that supports steady plant growth. When used together, NPK fertilizers and poultry manure can collectively optimize nutrient availability and uptake, resulting in increased plant height, larger leaves, timely fruit formation, fruit diameters, fruit weight, increased yield per plot and yield per hectare, when applied in appropriate amounts and at the right times. Similar results were also reported by Suvarna *et al*. (2007) [21], Kumar *et al*. (2018), [10] Chatterjee *et al*. (2014) [5], Anayat *et al*. (2021) [1], Manimegala and Gunasekaran (2020) [12], Singh *et al*. (2018) [19] and Vidhate *et al*. (2015) [24].

Soil parameters

Soil parameters *viz.* soil pH, organic carbon (%) and available NPK (kg/ha) were recorded after the experiment and results are presented in Table 5.

The pH of soil is the most important chemical properly that governs nutrient availability and microbial activity. Soil pH determines nutrient sufficiency, deficiency, toxicity and the need for liming and is one of the important soil chemical properties for optimal crop production. A perusal of the data presented in Table 5 showed that non-significant differences were observed for soil pH. The pH of the soil varied from 5.8 – 6.0.

Organic carbon is a strong determinant of soil fertility through its positive effects on soil structure and soil chemical and biological properties which in turn stimulate primary production. A measurable component of soil organic matter is soil organic carbon. A significant effect of different treatments (Table 5) was recorded for organic carbon. Highest organic carbon (0.73%) was founded in treatment T_2 [Farm Yard Manure (100%)] which was followed by treatment T_3 [Poultry Manure (100%)]. Lowest (0.58%) was recorded in T_7 (Absolute control). Similar results were obtained by Chumei *et al*. (2013) [6] and Dhiman *et al*. (2018) [7].

Available NPK content shown in Table 5 revealed that highest content of available nitrogen (287.53 kg/ha), phosphorus (27.37 kg/ha) and potassium (230.09 kg/ha) was observed in treatment T_1 [N: P: K (100%)]. whereas lower content of available nitrogen (224.81 kg/ha), phosphorus (13.42 kg/ha) and potassium (186.96 kg/ha) were recorded in treatment T_7 (Absolute control). Treatment T_1 [N: P: K (100%)] Increase in available nitrogen, phosphorus and potassium content might be due to the application of full dose of NPK, which also resulted in increased soil fertility. While decreased content of NPK in soil might be due to the absence of nutrient application in controlled

plots. Similar results were obtained by Thingujam *et al*. (2016) [23], Batabyal *et al*. (2017) [4], Raut *et al*. (2019) [16], Malavade *et al*, (2019) [11] and Raut *et al*. (2017) [17].

Economics

Economic parameters *viz.* gross returns (₹/ha), net returns (₹/ha) and Benefit-Cost ratio (B: C) were observed and presented in Table 6. The results showed that maximum gross returns ₹ 4,77,240, higher net returns ₹ 4,02,640 and maximum B: C ratio 5.39 were incurred in treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] followed by treatment T_4 [N: P: K (50%) + Farm Yard Manure (50%)]. Whereas lowest gross returns ₹ 2,16,360, net returns ₹ 1,55,534 and B: C ratio 2.55 were observed in treatment T_7 (Absolute control). Similar results were also observed by Thakur *et al*. (2019) [22].

Table 3: Effect of integrated nutrient management practices on plant height (cm), number of leaves per plant, leaf length (cm) and leaf width (cm)

Treatment code	Treatments	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf width (cm)
T_1	N: P: K (100%)	89.42	153.23	14.76	11.29
T_2	Farm Yard Manure (100%)	81.08	146.77	12.97	9.96
T_3	Poultry Manure (100%)	85.17	147.89	13.91	10.86
T_4	N: P: K (50%) + Farm Yard Manure (50%)	94.21	170.37	16.53	12.02
T_5	N: P: K (50%) + Poultry Manure (50%)	98.74	172.60	17.66	12.17
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	92.87	166.53	16.13	11.54
T_7	Absolute control	78.33	141.45	11.80	8.79
S.E(m)		1.04	2.55	0.28	0.16
$CD_{(0.05)}$		3.20	7.87	0.85	0.49

Table 4: Effect of integrated nutrient management practices on fruit weight (g), number of fruits per plant, fruit diameter (cm), yield per plot (kg) and yield per hectare (q)

Treatment code	Treatments	Fruit weight (g)	Number of fruits per plant	Fruit diameter (cm)	Yield per plot (kg)	Yield per hectare (q)
T_1	N: P: K (100%)	67.89	12.89	4.47	7.88	291.72
T_2	Farm Yard Manure (100%)	63.23	11.73	4.03	6.68	247.44
T_3	Poultry Manure (100%)	65.41	12.13	4.32	7.14	264.50
T_4	N: P: K (50%) + Farm Yard Manure (50%)	73.91	14.08	4.79	9.37	346.91
T_5	N: P: K (50%) + Poultry Manure (50%)	76.37	15.63	5.01	10.74	397.70
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	69.53	13.14	4.63	8.23	304.84
T_7	Absolute control	57.72	9.37	3.97	4.87	180.30
S.E(m)		1.23	0.76	0.05	0.23	8.70
$CD_{(0.05)}$		3.80	0.81	0.17	0.72	26.82

Table 5: Effect of integrated nutrient management practices on soil pH, organic carbon (%) and available NPK (kg/ha) of the soil after the experiment

Treatment code	Treatments	Soil pH	Organic carbon (%)	Available Nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T_1	N: P: K (100%)	5.8	0.63	287.53	27.37	230.09
T_2	Farm Yard Manure (100%)	6.0	0.73	248.65	15.97	194.81
T_3	Poultry Manure (100%)	6.0	0.68	266.13	18.09	203.78
T_4	N: P: K (50%) + Farm Yard Manure (50%)	6.0	0.67	270.43	19.89	208.65
T_5	N: P: K (50%) + Poultry Manure (50%)	6.0	0.65	281.76	25.17	218.39
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	5.9	0.63	278.39	22.97	214.49
T_7	Absolute control	6.0	0.58	224.81	13.42	186.96
S.E(m)		0.09	0.01	3.95	0.36	1.71
$CD_{(0.05)}$		NS	0.02	12.17	1.11	5.27

Table 6: Effect of integrated nutrient management practices on cost of cultivation (₹/ha), gross returns (₹/ha), net returns (₹/ha) and Benefit-Cost ratio (B: C)

Notations	Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B: C ratio
T_1	N: P: K (100%)	68,375	3,50,064	2,81,689	4.11:1
T_2	Farm Yard Manure (100%)	90,826	2,96,928	2,06,102	2.26:1
T_3	Poultry Manure (100%)	80,826	3,17,400	2,36,574	2.92:1
T_4	N: P: K (50%) + Farm Yard Manure (50%)	79,570	4,16,292	3,36,722	4.23:1
T_5	N: P: K (50%) + Poultry Manure (50%)	74,600	4,77,240	4,02,640	5.39:1
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	77,100	3,65,808	2,88,708	3.79:1
T_7	Absolute control	60,826	2,16,360	1,55,534	2.55:1

Conclusion

From the present studies it can be concluded that among all the treatments, treatment T_5 performed best for most of the growth and yield contributing traits. This treatment also resulted in maximum gross returns (₹ 4,77,240), net returns (₹ 4,02,640) with highest benefit cost ratio of (5.39). Hence, this treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] may be recommended for the commercialization after verification of results by the way of conducting the field trials across the brinjal growing areas of Himachal Pradesh.

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