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Influence of Organic, Inorganic and Biofertilizer Inputs on Morphological, Yield and Fruit Quality Traits of Guava (*Psidium guajava* L.) cv. L-49 in Malwa Region of Punjab

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Abstract

The present investigation was conducted from May, 2024 to February, 2025 at Arayanwala Khurd, Faridkot, Punjab with an aim to evaluate the effect of integrated nutrient management on growth, yield and soil health of guava. The experiment was laid out in a Randomized Block Design with 16 treatments and four replications on nine-year-old trees planted at 6×6 m^2 spacing. Treatments included combinations of recommended dose of fertilizers (RDF: 600:300:300 g NPK $tree^{-1}$), vermicompost, *Azotobacter*, phosphate-solubilizing bacteria (PSB) and mustard oil cake (MOC). The results revealed that integration of organic manures and biofertilizers with reduced chemical fertilizers significantly improved vegetative growth, flowering, yield and soil properties compared to control and sole inorganic fertilizer application. Among all treatments, T_{14} (75% RDF+10 kg vermicompost+50 g *Azotobacter*+50 g PSB+5 kg MOC) recorded the highest increase in tree height (17.73%), stem girth (11.87%), crown spread (17.57%), number of branches (17.85%), leaves $shoot^{-1}$ (63.79%), shoot length (46.77%) and shoot diameter (14.87%). It also produced maximum flowers (212.50 $tree^{-1}$), fruit weight (188.60 g), fruit yield (25.90 kg $tree^{-1}$) and yield (7.17 t ha^{-1}), significantly higher than control. Soil properties were also improved, with higher organic carbon (0.59%), available nitrogen (322.50 kg ha^{-1}), phosphorus (39.75 kg ha^{-1}), potassium (318.50 kg ha^{-1}) and reduced electrical conductivity (0.34 dS m^{-1}).

Keywords: Integrated nutrient management, PSB, yield, soil health

1. Introduction

Guava (*Psidium guajava* L.), a member of the family Myrtaceae, is one of the most widely cultivated tropical fruit crops and is popularly referred to as the “apple of the tropics” due to its high nutritive value, pleasant flavour, and year-round availability. The fruit is an excellent source of vitamin C, dietary fibre, minerals, and antioxidants, making it an important component of nutritional security in tropical and subtropical regions (Dutta et al., 2009). Guava originated in tropical America, particularly Mexico and Central America, and was introduced into India during the seventeenth century. Since then, it has emerged as a major commercial fruit crop in the country (Yahia, 2011). At present, India ranks first in global guava production, contributing nearly 45% of the world’s output, with Punjab being one of the important guava-growing states due to its favourable agro-climatic conditions (Anonymous, 2023). Punjab’s alluvial soils, ranging from sandy loam to clay loam with near-neutral pH, provide an ideal edaphic environment for guava cultivation. In addition, the region’s climatic conditions, including hot summers and cool winters, support better flowering and fruit development. However, intensive orchard management practices and continuous dependence on chemical fertilizers have resulted in several challenges such as soil degradation, nutrient imbalance, declining organic matter, and deterioration in fruit quality. There is a growing need to adopt environmentally sustainable and economically viable nutrient management practices.Integrated nutrient management (INM), which involves the judicious combination of organic, inorganic, and biological sources of nutrients, has been widely recognized as an effective strategy to maintain soil fertility and enhance crop productivity (Das et al., 2017; Ram and Kumar, 2019; Nodal et al., 2025). Among the various guava cultivars, L-49

(Allahabad Safeda) is highly popular due to its high yield potential, superior fruit quality, and adaptability to diverse agro-climatic conditions. The application of organic manures such as vermicompost plays a crucial role in improving soil structure, water-holding capacity, microbial activity, and nutrient availability. Vermicompost is rich in essential macro- and micronutrients, enzymes, vitamins, and plant growth regulators, which enhance root growth and overall plant performance (García-Santiago et al., 2024; Bhatia et al., 2025). *Azotobacter* fixes atmospheric nitrogen, while PSB solubilizes insoluble phosphorus, thereby increasing nutrient availability to plants and improving vegetative growth, flowering, and fruit set (Jnawali et al., 2015; Dey et al., 2005; Ghimirey et al., 2024). Mustard oil cake, another important organic input, is a nutrient-rich by-product that supplies nitrogen, phosphorus, potassium, and organic matter to the soil, while also improving soil microbial activity and fertility status (Paramesh et al., 2023). The combined use of these inputs creates a synergistic effect that enhances plant growth and soil health.Although inorganic fertilizers such as urea are essential for meeting immediate nutrient requirements and promoting rapid vegetative growth, their excessive and prolonged use has been associated with negative effects on soil health, including reduced microbial activity and nutrient imbalance. Therefore, integrating chemical fertilizers with organic and biological inputs is considered a sustainable approach for improving productivity, fruit quality, and soil fertility in perennial fruit crops (Paramesh et al., 2023; Sharma et al., 2013). Despite increasing awareness about integrated nutrient management, systematic studies evaluating the combined effects of organic, inorganic, and biofertilizer inputs under Punjab conditions are limited, particularly in guava cv. L-49. In view of the increasing demand for high-quality fruits and the need to maintain soil health, the present investigation entitled "Influence of organic, inorganic and biofertilizer inputs on morphological, yield and fruit quality traits of guava (*Psidium guajava* L.) cv. L-49 in the Malwa region of Punjab" was undertaken to assess the integrated effects of these nutrient sources on growth, yield, fruit quality, and soil fertility parameters under local agro-climatic conditions.

2. Materials and Methods

2.1. *Experimental site and plant material*

The present investigation entitled "Influence of organic, inorganic and biofertilizer inputs on morphological, yield and fruit quality traits of guava (*Psidium guajava* L.) cv. L-49" was conducted during May, 2024 to February, 2025 at a farmer's field (Satinder Singh) located atArayanwala Khurd, Faridkot, Punjab, India (30.7922° N, 74.5542° E), under the supervision of the Department of Agriculture and Life Sciences, Desh Bhagat University, Mandi Gobindgarh, Punjab. Nine-year-old, healthy and uniform guava plants cv. L-49, planted at6×6 m^2 spacingunder a square system, were selected for the experiment. A total of64 plantswere used.

2.2. *Climate and soil characteristics*

The experimental region falls under the semi-arid subtropical climate of north-western India, characterized by hot summers, monsoon rainfall during July–September, and cool winters. During the crop growth period (February, 2024–March, 2025), maximum temperatures ranged from 20–42°C, minimum temperatures from 8–31°C, relative humidity from 18–55%, and rainfall was mainly concentrated during the monsoon months (KVK Faridkot).

2.3. *Initial soil status and uniformity of experimental site*

The physical and chemical properties of the soil prior to the initiation of the experiment were presented in Table 1. The soil of the experimental site was classified as clay loam in texture, containing 23.6% sand, 37.1% silt and 38.2% clay, which was considered suitable for guava cultivation due to its good water holding capacity and nutrient retention ability. The soil reaction was slightly alkaline with a pH of 7.29 and low electrical conductivity (0.54 dS m^{-1}), indicating non-saline conditions. Organic carbon content was low (0.37%), while available nitrogen (311.50 kg ha^{-1}), phosphorus (28.50 kg ha^{-1}) and potassium (304.50 kg ha^{-1}) were in the medium range, suggesting moderate inherent fertility of the soil. These baseline soil characteristics provided a uniform and reliable foundation to evaluate the effect of organic, inorganic and biofertilizer inputs on guava performance. Similar soil conditions have been reported as favorable for guava orchards in the Indo-Gangetic plains (Sharma et al., 2022).

Table1: Physical and chemical properties of soil before the start of experiment

Parameter	Value
Sand (%)	23.6
Silt (%)	37.1
Clay (%)	38.2
Organic carbon (%)	0.37
Available nitrogen (kg ha^{-1})	311.50
Available phosphorus (P_2O_5 kg ha^{-1})	28.50
Available potassium (K_2O kg ha^{-1})	304.50
EC (dS m^{-1} at 25°c)	0.54
pH (1:2:Soil:Water suspension)	7.29

2.4. *Experimental design and treatments*

The experiment was laid out in a Randomized Block Design (RBD) with 16 treatments and four replications. Treatments comprised different combinations of recommended dose of fertilizers (RDF: 600 g N, 300 g P_2O_5 and 300 g K_2O $tree^{-1}$), vermicompost, Azotobacter, phosphate-solubilizing bacteria (PSB) and mustard oil cake (MOC), along with a control. Treatments were applied in the last week of June, 2024 after recording initial plant growth and soil parameters. Organic manures and biofertilizers procured from Krishi Vigyan Kendra, Faridkot were uniformly applied within the canopy area of each plant and incorporated into the soil up to 10 cm depth, followed by irrigation.

2.5. *Observations recorded*

Observations on vegetative growth parameters were recorded at 30, 60 and 90 days after treatment (DAT), while yield and soil parameters were recorded at harvest and at the end of the experiment, respectively. Growth parameters recorded were tree height, stem girth, canopy spread (east–west and north–south), number of branches, number of leaves shoot^{-1}, shoot length, shoot diameter and number of flowers tree^{-1}. Yield parameters recorded were number of fruits tree^{-1}, fruit weight, fruit yield tree^{-1} and fruit yield ha^{-1}. Soil parameters recorded were pH, electrical conductivity (EC), organic carbon, and available N, P and K before treatment application and after completion of the experiment.

2.6. Measurement procedures

Tree height was measured from ground level to the terminal shoot using a measuring tape. Stem girth was recorded at 10 cm above ground level. Canopy spread was measured in east–west and north–south directions. Leaves and branches were counted manually on selected shoots. Shoot length and diameter were measured from five randomly selected shoots plant^{-1} and averaged. Flowers were counted on selected shoots and extrapolated to flowers tree^{-1}. Fruit weight was determined from ten randomly selected fruits using a digital balance. Fruit yield per tree was calculated by summing yields from all harvests, while yield ha^{-1} was computed based on plant population ha^{-1}.

2.7. *Initial growth parameters of guava trees*

The initial vegetative growth parameters of guava cv. L-49 recorded before the imposition of treatments was presented in Table 2. The data clearly indicated non-significant differences among treatments with respect to tree height, stem girth, crown spread, number of branches, number of leaves shoot^{-1}, shoot length and shoot diameter. Tree height ranged from 3.75 to 3.95 m, stem girth from 37.75 to 43.96 cm, and crown spread from 3.75 to 3.93 m. Likewise, the number of branches (5.50–7.00), leaves shoot^{-1} (12.00–15.00), shoot length (27.75–31.00 cm) and shoot diameter (1.10–1.21 cm) showed narrow variations across treatments. The absence of marked variation confirmed the uniformity of plant material and ensured that subsequent changes observed during the experiment were primarily due to nutrient treatments rather than inherent plant variability. Similar experimental uniformity has been emphasized as essential for nutrient management studies in perennial fruit crops (Sharma et al., 2022; Bura et al., 2026).

Table 2: Initial growth parameters of guava (*Psidium guajava* L.) cv. L-49 before the start of experiment

Treatment		Tree height (m)	Stem-girth (cm)	Crown spread (m)	No. of branches	Number of leaves shoot^{-1}	Length of shoot (cm)	Diameter of shoot (cm)
T_0	Control	3.90	38.55	3.88	5.50	12.00	28.50	1.10
T_1	100% RDF (NPK:600:300:300 g)+10 kg VC	3.83	37.75	3.81	5.75	12.75	29.25	1.12
T_2	75% RDF+10 kg Vermicompost	3.75	43.00	3.77	6.50	15.00	29.75	1.18
T_3	50% RDF+10 kg Vermicompost	3.80	42.50	3.82	6.25	12.50	29.25	1.12
T_4	100% RDF+50 g Azotobacter	3.91	43.96	3.93	6.25	12.75	28.50	1.12
T_5	75% RDF+50 g Azotobacter	3.95	39.31	3.88	6.00	12.00	27.75	1.12
T_6	50% RDF+50 g Azotobacter	3.90	418	3.90	5.75	12.00	28.75	1.11
T_7	100% RDF+50 g PSB	3.87	434	3.84	6.25	12.25	29.00	1.12
T_8	75% RDF+50 g PSB	3.85	42.39	3.79	6.50	12.50	28.25	1.12
T_9	50% RDF+50g PSB	3.80	43.07	3.87	6.50	12.50	29.25	1.16
T_{10}	100% RDF+5 kg MOC	3.80	427	3.84	6.00	15.00	29.75	1.14
T_{11}	75% RDF+5 kg MOC	3.80	42.60	3.75	6.75	12.75	30.75	1.18
T_{12}	50%RDF+5 kg MOC	3.75	42.50	3.80	6.50	12.00	27.75	1.16
T_{13}	100% RDF+10 kg VC+50 g AZB+50 g PSB+5kg MOC	3.85	42.25	3.84	6.50	14.25	29.25	1.18
T_{14}	75% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	3.75	425	3.87	7	14.50	31.00	1.21
T_{15}	50% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	3.80	42.50	3.85	6.50	14.00	29.00	1.21

2.8. *Statistical analysis*

The recorded data were statistically analyzed using analysis of variance (ANOVA) appropriate for RBD. Treatment means were compared using critical difference (CD) at *p*=0.05 probability level to assess significance of treatment effects.

3. Results and Discussion

3.1. *Effect of organic, inorganic and biofertilizers on vegetative growth*

The influence of different nutrient management treatments on vegetative growth parameters at 90 days after treatment application was summarized in Table 3. All growth parameters responded positively to integrated nutrient management compared to control and sole application of inorganic fertilizers. Among treatments, T_{14} (75% RDF+10 kg vermicompost+50 g Azotobacter+50 g PSB+5 kg mustard oil cake) recorded the highest percentage increase in tree height (17.73%), stem girth (11.87%) and crown spread (17.57%), while the control (T_0) recorded the lowest increases (7.43%, 5.05% and 7.47%), respectively).

Table 3: Influence of organic, inorganic and biofertilizer on per cent increasein growth parameters of guava (*Psidium guajava* L.)cv. L-49 at 90 days after treatment

Treatment		Tree height (m)	Stem-girth (cm)	Crown spread (m)	No. of branches	Number of leaves shoot^{-1}	Length of shoot (cm)	Diameter of shoot (cm)	No. of flowers tree^{-1}
T_0	Control	7.43 (4.19)	5.05 (40.50)	7.47 (4.17)	9.09 (6.00)	25.00 (16.25)	21.92 (34.75)	5.45 (1.16)	170.75
T_1	100% RDF (NPK:600:300:300 g)+10 kg VC	12.27 (4.29)	7.94 (40.75)	12.91 (4.34)	12.04 (6.50)	34.54 (18.50)	29.05 (37.75)	8.92 (1.22)	193.75
T_2	75% RDF+10 kg Vermicompost	16.00 (4.35)	10.47 (47.50)	14.85 (4.33)	11.53 (7.25)	50.00 (22.50)	40.33 (41.75)	11.86 (1.32)	198.75
T_3	50% RDF+10 kg Vermicompost	12.15 (4.28)	10.00 (46.75)	12.82 (4.31)	12.00 (7.00)	44.00 (18.00)	35.89 (39.75)	7.07 (1.21)	194.00
T_4	100% RDF+50 g Azotobacter	8.43 (4.24)	5.77 (46.50)	8.39 (4.26)	12.00 (7.00)	37.25 (17.50)	28.94 (36.75)	6.25 (1.19)	175.75
T_5	75% RDF+50 g Azotobacter	8.10 (4.27)	8.11 (42.50)	10.30 (4.28)	12.50 (6.75)	39.58 (16.75)	36.03 (37.75)	6.19 (1.20)	185.25
T_6	50% RDF+50 g Azotobacter	9.48 (4.27)	6.53 (46.00)	9.74 (4.28)	12.04 (6.50)	39.58 (16.75)	22.60 (35.25)	7.20 (1.19)	180.00
T_7	100% RDF+50 g PSB	9.04 (4.22)	5.12 (45.56)	10.15 (4.23)	12.00 (7.00)	40.81 (17.25)	26.72 (36.75)	7.07 (1.21)	184.00
T_8	75% RDF+50 g PSB	10.90 (4.27)	7.92 (45.75)	12.92 (4.28)	11.53 (7.25)	37.03 (18.50)	30.08 (36.75)	9.73 (1.24)	190.50
T_9	50% RDF+50 g PSB	11.84 (4.25)	5.64 (45.50)	9.81 (4.25)	11.53 (7.25)	25.92 (17.00)	23.07 (36.00)	6.89 (1.24)	180.00
T_{10}	100% RDF+5 kg MOC	14.40 (4.29)	6.88 (46.25)	11.97 (4.30)	12.50 (6.75)	28.33 (19.25)	26.89 (37.75)	9.64 (1.25)	190.75
T_{11}	75% RDF+5 kg MOC	14.47 (4.35)	9.74 (46.75)	16.80 (4.38)	14.81 (7.75)	54.54 (21.25)	30.89 (40.25)	5.93 (1.25)	200.00
T_{12}	50%RDF+5 kg MOC	14.12 (4.28)	10.00 (46.75)	15.00 (4.37)	11.53 (7.25)	46.15 (19.00)	36.03 (37.75)	6.89 (1.24)	195.00
T_{13}	100% RDF+10 kg VC+50 g AZB+50 g PSB+5kg MOC	15.06 (4.43)	9.46 (46.25)	17.44 (4.51)	15.38 (7.50)	47.36 (21.00)	43.58 (42.00)	12.55 (1.34)	205.00
T_{14}	75% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	17.73 (4.46)	11.87 (49.25)	17.57 (4.55)	17.85 (8.25)	63.79 (23.75)	46.77 (45.50)	14.87 (1.39)	212.50
T_{15}	50% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	16.84 (4.44)	9.41 (46.50)	18.44 (4.56)	15.38 (7.50)	58.92 (22.25)	45.68 (42.25)	14.04 (1.38)	209.50
SEm±		1.67	1.57	1.41	1.25	1.52	2.12	1.12	1.93
CD (*p*=0.05)		4.75	4.46	4.03	3.57	4.33	6.03	20	5.49

The superior vegetative growth under integrated treatments could be attributed to the combined effects of readily available nutrients from chemical fertilizers and the sustained nutrient release from organic sources. Vermicompost improved soil structure, aeration and microbial activity, while biofertilizers enhanced nutrient availability through biological nitrogen fixation and phosphorus solubilization, resulting in improved nutrient uptake efficiency and enhanced cell division and elongation (Jnawali et al., 2015; Ghimirey et al., 2024). Similar improvements in vegetative growth of guava under integrated nutrient management have been reported by Singh et al. (2025).

The number of branches and leaves shoot^{-1} also increased significantly under integrated treatments. Treatment T_{14} recorded the maximum increase in number of branches (17.85%) and leaves per shoot (63.79%), followed closely by T_{15} and T_{13}. Increased branching and leaf production enhance the photosynthetic surface area, thereby improving assimilate production and translocation. The enhanced leaf proliferation under organic and biofertilizer treatments might be attributed to increased availability of nitrogen, phytohormones and enzymes present in vermicompost and microbial inoculants (Kumar et al., 2022; Oyege and Bhaskar, 2023).

Shoot growth parameters followed a similar trend. Maximum increase in shoot length (46.77%) and shoot diameter (14.87%) was recorded under T_{14}, whereas the lowest increments were observed in control. Improved shoot growth reflected better physiological activity, nutrient assimilation and hormonal balance under integrated nutrient management. Earlier studies in guava and other fruit crops have also reported significant enhancement in shoot growth with the combined application of organic manures, biofertilizers and reduced chemical fertilizers (Singh et al., 2025; Bura et al., 2026).

3.2. *Effect on flowering and yield attributes*

The number of flowers tree^{-1} varied significantly among treatments (Table 4). The maximum number of flowers tree^{-1} was recorded under T_{14} (212.50), followed by T_{15} and T_{13}, while the minimum was observed in control (170.75). Enhanced flowering under integrated nutrient management might be attributed to improved carbohydrate accumulation, balanced C:N ratio and better nutrient availability during floral initiation. Biofertilizers also enhanced rhizosphere activity, which positively influenced flowering behavior. Similar findings have been reported in guava by Singh et al. (2025) and Oyege and Bhaskar, (2023).

Yield parameters such as number of fruits tree^{-1}, fruit weight, fruit yield tree^{-1} and yield ha^{-1} were significantly influenced by nutrient treatments (Table 4). The highest number of fruits

Table 4: Effect of organic manures, inorganic fertilizers and bio fertilizers on yield parameters of guava (*Psidium guajava* L.) cv. L-49

Treatment		Number of fruits tree^{-1}	Fruit weight (g)	Fruit yield tree^{-1} (kg)	Fruit yield t ha^{-1}
T_0	Control	97.00	149.25	14.48	4.01
T_1	100% RDF (NPK:600:300:300 g)+10 kg VC	119.25	174.25	20.79	5.76
T_2	75% RDF+10 kg vermicompost	124.75	178.50	22.28	6.17
T_3	50% RDF+10 kg vermicompost	120.00	174.89	20.99	5.81
T_4	100% RDF+50 g azotobacter	96.50	154.03	14.90	4.12
T_5	75% RDF+50 g azotobacter	1025	158.78	16.45	4.56
T_6	50% RDF+50 g azotobacter	100.00	157.17	15.72	4.35
T_7	100% RDF+50 g PSB	106.00	164.72	17.49	4.84
T_8	75% RDF+50 g PSB	114.75	168.76	19.38	5.37
T_9	50% RDF+50 g PSB	97.50	167.55	16.33	4.52
T_{10}	100% RDF+5 kg MOC	117.25	173.00	20.30	5.62
T_{11}	75% RDF+5 kg MOC	128.00	177.50	22.73	6.30
T_{12}	50% RDF+5 kg MOC	118.00	174.78	20.66	5.72
T_{13}	100% RDF+10 kg VC+50 g AZB+50 g PSB+5kg MOC	121.75	185.02	24.40	6.76
T_{14}	75% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	127.25	188.60	25.90	7.17
T_{15}	50% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	126.25	186.12	25.38	7.03
SEm±		1.57	2.56	0.41	0.11
CD (p=0.05)		4.47	7.29	1.17	0.32

*Fruits were harvested at horticultural maturity in December, 2025 tree^{-1} was recorded under T_{11} (128.00), followed by T_{14} (127.25) and T_{15} (126.25), while the control recorded the lowest (97.00). Fruit weight was maximum under T_{14} (188.60 g), followed by T_{15} (186.12 g), compared to 149.25 g in control. The increase in fruit weight under integrated treatments might be attributed to improved nutrient uptake, enhanced photosynthate production and better translocation of assimilates towards developing fruits (Bura et al., 2026).

Fruit yield tree^{-1} and yield ha^{-1} followed similar trends. Treatment T_{14} recorded the highest fruit yield (25.90 kg tree^{-1} and 7.17 t ha^{-1}), followed by T_{15} and T_{13}, while the lowest yield was recorded under control (14.48 kg tree^{-1} and 4.01 t ha^{-1}). The superior yield under integrated nutrient management highlighted the synergistic effect of organic, inorganic and biofertilizer inputs in improving fruit retention, reducing fruit drop and enhancing sink strength. These results were in close agreement with earlier findings reported in guava and other perennial fruit crops (Singh et al., 2025; Bura et al., 2026; Kumar et al., 2022).

3.3. Effect on soil physico-chemical properties

The post-harvest soil analysis revealed significant improvement in soil physico-chemical properties under integrated nutrient management treatments (Table 5). Soil pH remained within a neutral to slightly alkaline range (7.25–7.68), indicating that the applied treatments did not adversely affect soil reaction. A slight increase in pH under integrated treatments might be attributed to the buffering action of organic matter and the release of basic cations during decomposition of organic inputs (Singh et al., 2025).

Electrical conductivity decreased under treatments receiving organic manures and biofertilizers, with the lowest EC recorded under T_{14} (0.34 dS m^{-1}). Reduced EC under integrated treatments suggested improved soil aggregation and reduced salt accumulation, which was beneficial for long-term soil health. Similar reductions in soil EC with organic amendments have been reported by Chawla and Sadawarti, 2020.

Soil organic carbon content increased substantially under integrated treatments, reaching a maximum of 0.59% under T_{14} compared to 0.35% in control. The increase in organic carbon reflected continuous addition and mineralization of organic inputs, leading to improved soil structure, microbial biomass and nutrient cycling. Available nitrogen, phosphorus and potassium also increased significantly under integrated treatments, with maximum values recorded under T_{14} and T_{15}.

Table 5: Influence of organic, inorganic and biofertilizer on soil physical and chemical properties of guava (*Psidium guajava* L.) cv. L-49 after experiment

Treatment		Soil pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
	Initial	7.29	0.55	0.38	310.50	29.50	305.50
T_0	Control	7.25	0.57	309.25	28.75	304.75	0.35
T_1	100% RDF (NPK:600:300:300 g)+10 kg VC	7.32	0.38	317.00	35.50	312.25	0.51
T_2	75% RDF+10 kg vermicompost	7.33	0.37	319.00	36.75	314.00	0.55
T_3	50% RDF+10 kg vermicompost	7.34	0.40	315.50	35.63	311.25	0.53
T_4	100% RDF+50 g azotobacter	7.36	0.54	311.50	30.00	306.75	0.43
T_5	75% RDF+50 g azotobacter	7.38	0.53	312.00	31.25	308.25	0.42
T_6	50% RDF+50 g azotobacter	7.38	0.52	312.75	30.50	307.75	0.45
T_7	100% RDF+50 g PSB	7.43	0.49	312.25	34.00	307.00	0.48
T_8	75% RDF+50 g PSB	7.43	0.47	314.75	35.25	309.38	0.46
T_9	50% RDF+50g PSB	7.36	0.49	312.25	34.25	308.50	0.48
T_{10}	100% RDF+5 kg MOC	7.50	0.44	315.00	34.50	314.75	0.50
T_{11}	75% RDF+5 kg MOC	7.53	0.39	317.75	36.75	315.25	0.53
T_{12}	50% RDF+5 kg MOC	7.52	0.42	315.00	36.00	312.50	0.55
T_{13}	100% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	7.59	0.37	321.00	37.00	316.25	0.57
T_{14}	75% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	7.68	0.34	322.50	39.75	318.50	0.59
T_{15}	50% RDF+10 kg VC+50 g AZB+50 g PSB+5 kg MOC	7.66	0.36	320.75	38.75	317.75	0.58
SEm±		0.08	0.02	1.03	1.19	1.36	0.02
CD (p=0.05)		0.23	0.05	2.94	38	3.86	0.05

*Initial value of soil health parameterswere recorded at the time of initiation of experiment (June)

Enhanced nutrient availability could be attributed to biological nitrogen fixation by *Azotobacter*, phosphorus solubilization by PSB and gradual nutrient release from vermicompost and mustard oil cake (Jnawali et al., 2015; Ghimirey et al., 2024).

Overall, the results clearly demonstrated that integrated nutrient management, particularly the application of 75% RDF in combination with vermicompost, Azotobacter, PSB and mustard oil cake (T_{14}), significantly improved vegetative growth, flowering, yield attributes and soil health of guava cv. L-49. The study strongly supported the adoption of integrated nutrient management as a sustainable and environmentally sound strategy for guava cultivation under the agro-climatic conditions of Punjab.

4. Conclusion

Integrated nutrient management significantly improved growth, flowering, yield, and soil fertility in guava cv. L-49 under Malwa conditions. The treatment T_{14} (75% RDF+vermicompost, *Azotobacter*, PSB, and mustard oil cake) proved most effective, enhancing plant growth, fruit yield, and soil health. It increased organic carbon and nutrient availability while reducing electrical conductivity. Results indicate that 25% chemical fertilizers can be reduced when combined with organic and biofertilizers, ensuring higher productivity and sustainable guava cultivation.

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