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Impact of integrated nutrient management on soil health in dragon fruit orchards

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Abstract

This study was conducted in the Jammu District of Jammu & Kashmir to evaluate the effects of organic and inorganic nutrient treatments on the growth, yield, and soil health of dragon fruit plants. The experimental design included two separate trials, each consisting of nine treatments, with three replications per treatment. The first experiment focused on varying combinations of urea, vermicompost, and farmyard manure (FYM) as nitrogen sources, while the second experiment incorporated Azotobacter along with different nutrient combinations. Soil parameters, including pH, electrical conductivity, and organic carbon content, were assessed to gauge the impact of treatments on soil health. Statistical analysis was performed to determine significant differences between treatments. Results showed that integrated nutrient management strategies, particularly those combining organic sources like vermicompost and FYM with inorganic fertilizers or Azotobacter, enhanced plant growth, yield, and soil health. The findings suggest that these nutrient strategies can contribute to more sustainable dragon fruit cultivation, improving both plant productivity further studies are needed to explore the long-term effects of these treatments on dragon fruit farming systems.

Keywords: Dragon fruit, Integrated Nutrient Management (INM)

Introduction

Medicinal qualities, high nutritional content, and distinctive look make dragon fruit (*Hylocereus* spp.)—also called pitaya—a tropical and subtropical fruit highly prized. Many health-conscious people choose it because of its high antioxidant, vitamin, and dietary fiber content. A focus for sustainable agricultural development has emerged: improving dragon fruit production techniques in response to its rising demand in both local and international markets. Soil fertility, crop yield, and environmental sustainability may all be improved by the application of biological, inorganic, and organic fertilizers in an integrated manner known as Integrated Nutrient Management (INM). Soil health and the use of chemical fertilizers may both be preserved or improved with this method, which seeks to satisfy crop nutrient needs. When it comes to managing fruit crops, INM has become more popular since it improves growth, production, and quality metrics while reducing the negative impacts of chemical fertilizer overuse. Due to its shallow root system and high fertilizer requirement throughout the blooming and fruiting periods, dragon fruit production is especially beneficial for balanced nutrient management systems. Mycorrhizae, Azotobacter, and phosphate-solubilizing bacteria (PSB) are bio fertilizers that have shown promise in enhancing nutrient availability and absorption when applied with organic manures like compost or farmyard manure. To further contribute to sustainability in the long run, these techniques boost soil fertility, microbial activity, and organic matter content. This study analyzes the effects of different integrated nutrient management (INM) treatments on dragon fruit growth, yield, and quality. Its goal is to find an optimal NMS strategy that maximizes production while preserving ecological balance, and it will provide policymakers and farmers with practical solutions to enhance dragon fruit cultivation. (Jat *et al*. 2020) [5] (Dolker *et al*. 2017) [3] (Hasan *et al*. 2023) [4] (Rakhmawati, *et al*., 2021) [9] (Biswajit Das *et al*., 2024) [2]

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Literature review

(Kumar *et al*. 2022) [7] The Aizawl District's Muthi and Durtlang villages were the 2019 PKVY Program showcase locations for a dragon fruit cluster. Thirty farmers were honored for the support they got from KVK, which consisted of 300 100 mm diameter, two meters tall concrete poles and a thousand cuts of strong, dark green, healthy trees that were free of damage and pests. Each plant received an organic input of fifteen to twenty kilograms (kg), which included bio-fertilizers, vermicompost, coir compost, and either chicken manure or well-decomposed FYM. Annually, each plant received 500 milligrams of NPK, 300 milligrams of phosphorus-solubilizing bacteria, and 100 milligrams of potassium-solubilizing bacteria. Dosing is done at three stages: just before flowering in April, throughout fruit growth in July and August, and again in December after harvest. The farmers' procedures differed considerably from the average vine length (196.26 cm), vine thickness (19.03 cm), and number of vines per plant (5.98 m). The data from both years of the demonstration demonstrated that the technology significantly altered the practices of farmers. The shown technology increased yield by 18.50 percent, reaching 8.043 metric tons per hectare, compared to 6.787 metric tons per hectare with farmer-practices. Compared to farmer practices, the depicted field had higher mean gross returns ('USD 12763.70 /ha) and mean net returns ('USD 12155.91 /ha), with an average benefit-cost ratio of 1.14. The findings demonstrated that the suggested strategy has the potential to increase broccoli production and economics. "

(Lalduhsangi, R.C. *et al*., 2021) [8] Red bodied dragon fruits were planted in 2018 and 2019 with a spacing of 4m x 2m and studied using thirteen different treatments. Purified inorganic fertilizer dose recommendation (RDF) T1; Task 2: Fertilized Yard Manure (FYM) to provide phosphorus- and potassium-soluble bacteria (KSB and PSB) in equal proportions; T3: Bacteria that are soluble in potassium and phosphorus, supplied by vermi compost (VC) in equal parts; The fourth treatment, Neem Cake (NC), will provide bacteria that are 50% soluble in potassium and 50% soluble in phosphorus. The fifth treatment, Farm Yard Manure (FYM), will do the same for potassium and phosphorus. T6: VC to supply 50% K + 50% RDF+AZ+PSB+ KSB; T7: NC to supply 50% K + 50% RDF + AZ + PSB + KSB; T8: FYM to supply 25% K + VC to supply 25% K + 50% RDF + AZ + PSB + KSB; T9: FYM to supply 25% K + NC to supply 25% K + 50% RDF + AZ + PSB + KSB; T10: VC to supply 25% K + NC to supply 25% K+ 50% RDF + AZ +PSB + KSB; T11: FYM to supply 25% K + VC to supply 25% K + NC to supply 25% K + 25% RDF; T12: FYM to supply 25% K + VC to supply 25% K + NC to supply 25% K + 25% RDF + AZ + PSB + KSB; T13: Control (no fertilizer) and four replication per treatments arranged in Randomized Block Design. Plants grown at T5 had the best harvest (4.65 kg/vine) and fruit production (14.67 kg/vine). T2 had the highest ascorbic acid concentration (21.90 mg/100g fruit weight), ahead of T11, which had the highest fruit weight (390.33g) and TSS (12.180 Brix).

(Vikalp, Arjoo, and Sharma 2022) [10] It is essential to manage nutrition in order to grow fruit of excellent quality. People who consume crops that have been damaged by irresponsible use of chemical pesticides and poor nutrient management are also negatively impacted by these issues. Several fruits suffer in quality due to the irresponsible use of inorganic agrochemicals. Consequently, quality has declined, leading to fewer options for consumers and a decline in company revenues. Pesticides, herbicides, and other synthetic fertilizers may deplete soil nutrients and reduce fruit quality and output if used in excess. On the other hand, INM (integrated natural management) aids in maintaining healthy soil. Integrated nutrient management refers to the practice of using all available fertilizer sources, including organic and inorganic, in crop production at the same time. So, the INM fixes fertility and helps plants get the nutrients they require.

(.A. Raut, C.D. *et al*., 2022) [1] An experiment entitled "utrient management studies on vegetative growth performance of dragon fruit plants" was carried out during the year2018-19 at Experimental Farm, Department of Fruit Science, Faculty of orticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with objective to study the effect of P.K. levels on vegetative growth of Dragon fruit and to find out the suitable concentration of N.P.K. for better vegetative growth of Dragon fruit under Akola condition. The experiment was laid out in Randomized Block design with ten treatments *viz*., T1 (200:50 P) g/plant, T2 (200:37.5 P) g/plant, T3 (200:50 K) g/plant, T4 (200:37.5 K) g/plant, T5 (150:50 P) g/plant, T6 (150:37.5 P) g/plant, T7 (150:50 K) g/plant, T8 (150:37.5 K) g/plant, T9 (200:50:50 PK) g/plant, T10 (150:37.5:37.5 PK) g/plant. All treatment were replicated three times. The results of present investigation indicated that, the maximum plant height, number of branches, main stem circumference, plant canopy north to south, plant canopy east to west, number of sprouting, new shoots height was recorded in treatment T9 (200:50:50:P:K g/ plant). The available nitrogen, phosphorous, potassium content in soil were maximum under treatment T9 (200:50:50:P:K g/ plant)."

(Jayshree Lakhanotra, ND Polara 2024) [6] The impact of integrated nutrition management on dragon fruit development and production was tested in an experiment. A Randomized Block Design (RBD) experiment with eleven treatments and three replicates was conducted. The results of the study on the effects of integrated nutrient management on plant growth parameters, yield, and yield attributing parameters showed that the treatment consisting of 75% NPK, 2 kg vermicomposting, 100 ml PSB, and 100 ml KSB (T10) resulted in the following: maximum incremental stem length (62.33 cm), number of cladodes (8.20), highest number of flowers per plant and per pillar (6.73 and 26.93, respectively), fruit set (91.33%), fruits per plant and per pillar (6.15 and 24.60, respectively), yield (2.25 kg/plant), yield (9.01 kg/pillar), and yield (10.41 t/ha). Maximum average fruit length (12.33 cm), breadth (8.97 cm), and weight (406.17 g).

Materials and Methods

Experimental Site and Design

The study was conducted in the Jammu District, Jammu & Kashmir, India. The region has a subtropical climate with an annual rainfall of approximately 1,200 mm, temperatures ranging between 25°C and 38°C, and relative humidity of 50–70%. The soil at the experimental site was sandy loam, with an initial pH of 6.5, electrical conductivity (EC) of 1.2 dS/m, and organic carbon content of 0.45%. The experimental layout included 9 treatments per experiment, 3 replications per treatment, and 4 plants per pole. The spacing between poles was 10 feet × 8 feet, and a total of 54 poles were used across two experiments.

Planting Material

Dragon fruit plants were used as the experimental material. Healthy and uniform plants were selected for planting to ensure consistency in the experimental outcomes.

Soil Preparation and Planting

The soil was tilled and prepared to ensure uniformity and optimum conditions for plant growth. Dragon fruit plants were planted with appropriate spacing following the experimental layout.

Treatments

Two experiments were conducted to study the effects of organic and inorganic nutrient sources on dragon fruit growth, yield, and soil health:

Experiment 1

- T1: 100% of N/plant through urea
- T2: 80% of N/plant through urea + 20% through vermicompost
- T3: 75% of N/plant through urea + 25% through vermicompost
- T4: 80% of N/plant through urea + 20% through FYM
- T5: 75% of N/plant through urea + 25% through FYM
- T6: 50% of N/plant through urea + 25% through FYM + 25% through vermicompost
- T7: 100% of N/plant through vermicompost
- T8: 100% of N/plant through FYM
- T9: Control

Experiment 2

- T1: 100% of N/plant through vermicompost
- T2: 100% of N/plant through FYM
- T3: Azotobacter @200 ml/plant
- T4: Azotobacter @200 ml/plant + 50% of N through FYM + 50% through vermicompost
- T5: Azotobacter @200 ml/plant + 75% of N through FYM + 25% through vermicompost
- T6: Azotobacter @200 ml/plant + 25% of N through FYM + 75% through vermicompost
- T7: Azotobacter @200 ml/plant + 100% of N through vermicompost
- T8: Azotobacter @200 ml/plant + 100% of N through FYM
- T9: Control

Data collection

Soil Parameters

1. **Soil pH:** Measured using a digital pH meter to assess the acidity or alkalinity of the soil.
2. **Soil Electrical Conductivity (EC):** Determined using a conductivity meter to evaluate the soil's soluble salt content.
3. **Organic Carbon (%):** Assessed using the Walkley-Black method, involving chromic acid digestion and titration for estimating soil organic carbon content.

Statistical Analysis

In this study, statistical analysis is performed using Excel to process and interpret data effectively. Various techniques such as descriptive statistics, regression analysis, and hypothesis testing are employed to identify trends, relationships, and significant differences in the data. Excel's built-in functions, such as pivot tables, charts, and data analysis tools, enable the extraction of meaningful insights, which are essential for drawing conclusions about the study and their practical implications. This approach offers a user-friendly and efficient way to handle large datasets while ensuring accurate and reliable results.

Results and Discussion

The study focuses on the impact of organic nutrient sources, such as vermicompost and farmyard manure (FYM), on soil parameters. The application of organic amendments showed a significant improvement in soil health indicators compared to control treatments. Vermicompost and FYM increased soil pH, enhanced organic carbon content, and maintained favorable electrical conductivity (EC) levels. The organic inputs contributed to better nutrient cycling and improved soil structure, which are essential for sustainable agricultural practices. These results underscore the potential of organic amendments to enhance soil fertility while reducing reliance on synthetic fertilizers, promoting environmentally friendly farming systems.

Effect of Treatments on Soil Parameter

The application of organic, inorganic, and biofertilizer treatments significantly influenced soil properties, such as pH, electrical conductivity (EC), and organic carbon. Organic amendments like vermicompost and FYM improved soil structure, enhanced microbial activity, and increased organic carbon content due to their high nutrient composition and gradual decomposition. Biofertilizers, particularly Azotobacter, enriched the soil microbiome, aiding in nitrogen fixation and improving nutrient availability. The combined application of organic and inorganic sources balanced nutrient release, optimizing soil pH and maintaining EC levels within desirable ranges. These synergistic effects contribute to better soil health and sustainable agricultural practices.

Table 1: Effect of Vermicompost, Farm Yard Manure and Urea applied individually and in combination on growth, yield and quality of Dragon fruit Effect of Treatments on Soil pH, EC, and Organic Carbon

Treatment	Soil pH			Soil EC (ds/m)			Organic Carbon (%)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T1: 100% of N/plant through urea	6.75	6.76	6.76	0.70	0.70	0.70	0.69	0.68	0.69
T2: 80% of N/plant through urea +20% through vermicompost	6.91	6.92	6.92	0.71	0.72	0.72	0.77	0.78	0.77
T3: 75% of N/plant through urea +25% through vermicompost	6.97	6.94	6.96	0.71	0.73	0.72	0.81	0.83	0.82
T4: 80% of N/plant through urea+20% through FYM	7.03	7.04	7.04	0.72	0.71	0.72	0.81	0.82	0.82
T5: 75% of N/plant through urea+25% through FYM	7.04	7.05	7.04	0.75	0.74	0.75	0.86	0.89	0.88
T6: 50% of N/plant through urea +25% through FYM+25% through vermicompost	7.00	6.99	6.99	0.71	0.73	0.72	0.83	0.85	0.84
T7: 100% of N/plant through vermicompost	6.95	6.96	6.95	0.74	0.75	0.75	0.87	0.88	0.87
T8: 100% of N/plant through FYM	7.02	6.99	7.00	0.71	0.71	0.71	0.89	0.92	0.90

T9: Control	6.99	7.03	7.01	0.72	0.74	0.73	0.72	0.71	0.72
S.Em(±)	0.05	0.05	0.06				0.01	0.01	0.01
CD (0.05%)	0.15	0.15	0.19	N.S	N.S	N.S	0.02	0.02	0.03

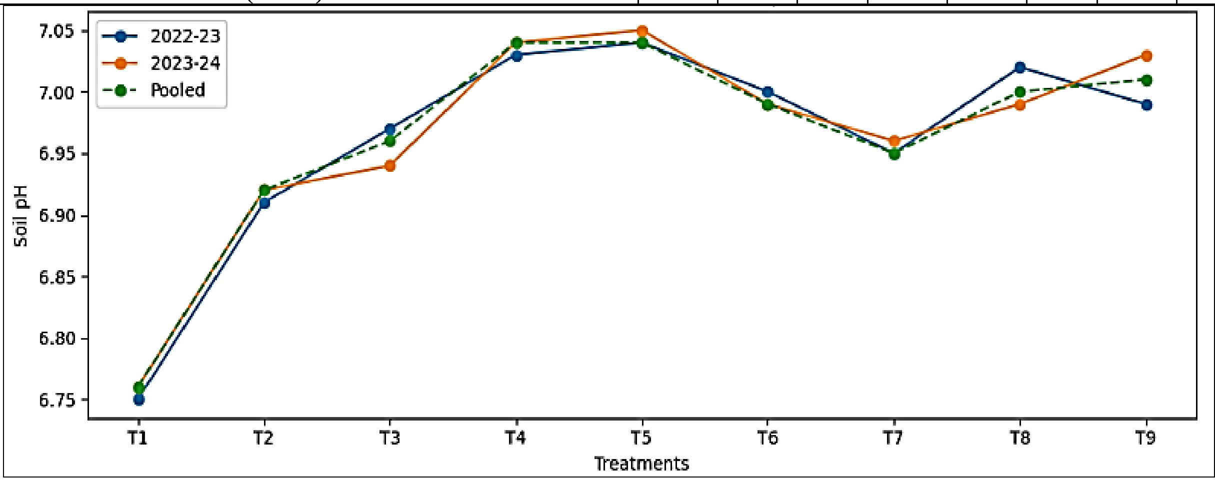

Fig 1: Effect of Treatment on Soil pH

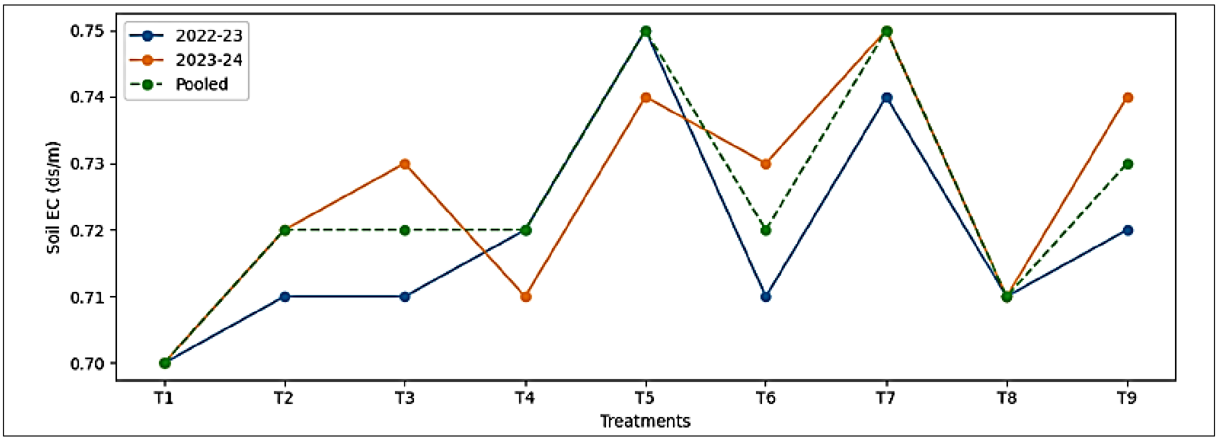

Fig 2: Effect of Treatment on Soil EC

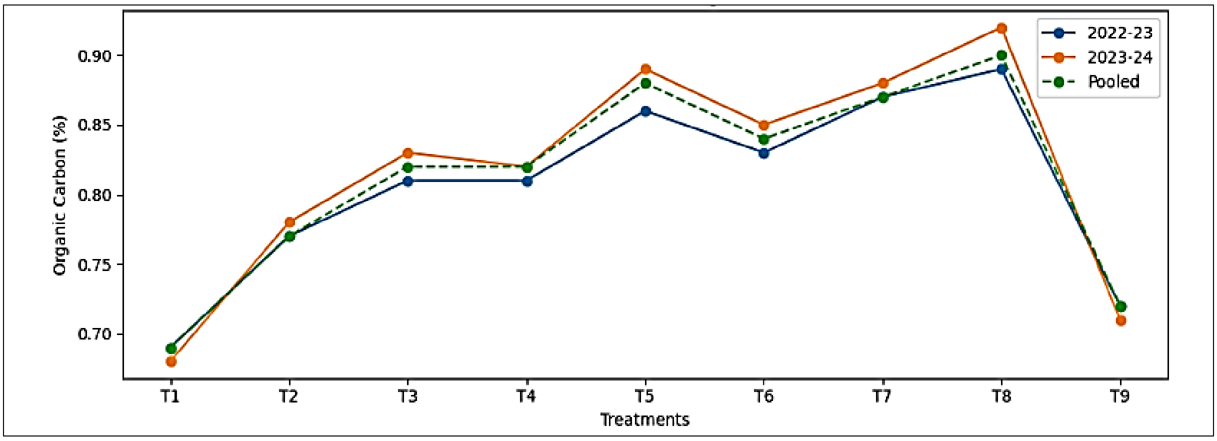

Fig 3: Effect of Treatment on Organic Carbon

The data demonstrates the influence of various treatments on soil pH, electrical conductivity (EC), and organic carbon content over two years (2022-23 and 2023-24). The soil pH values were relatively stable across the treatments, with minimal fluctuations. Treatment T1, where 100% nitrogen is supplied through urea, showed the lowest pH (6.76) while treatments with higher organic matter, such as T2 (80% urea + 20% vermicompost) and T5 (75% urea + 25% FYM), exhibited slightly higher pH values, reaching up to 7.04. These results suggest that organic amendments like vermicompost and FYM contribute to slightly alkaline soil conditions. Regarding EC, there was no significant difference observed between the treatments, indicating that the different nitrogen sources did not drastically affect soil salinity. Similarly, organic carbon content showed notable improvements with treatments that included organic matter. T5 (75% urea + 25% FYM) had the highest organic carbon (0.88%), indicating that organic amendments enhance soil fertility. Overall, while pH and EC did not exhibit significant differences (as per CD values), organic carbon increased with the inclusion of organic inputs, highlighting the importance of organic fertilizers in improving soil health.

Table 2: Effect of vermicompost, FYM, and Azotobacter applied individually or in combination on soil pH, EC, and organic carbon.Effect of Treatments on Soil pH, EC, and Organic Carbon

Treatment	Soil pH			Soil EC (ds/m)			Organic Carbon (%)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T1:100% of N/plant through vermicompost	6.77	6.75	6.76	0.70	0.71	0.71	0.85	0.88	0.86
T2:100% of N/plant through FYM	6.92	6.91	6.92	0.71	0.71	0.71	0.88	0.92	0.90
T3: Azotobacter @200ml/plant	6.99	6.97	6.98	0.71	0.71	0.71	0.80	0.80	0.80
T4: Azotobacter @200 ml/plant +50% of N throughFYM+50% through vermicompost	6.98	7.03	7.01	0.72	0.72	0.72	0.71	0.72	0.72
T5: Azotobacter @200ml/plant+75% of N through FYM+ 25% through vermicompost	7.05	7.04	7.05	0.74	0.75	0.75	0.94	0.95	0.95
T6: Azotobacter @200ml/plant+25% of N through FYM+75% through vermicompost	7.00	7.00	7.00	0.73	0.71	0.72	0.91	0.90	0.91
T7: Azotobacter@200ml/plant+100% of N/plant through vermicompost	6.94	6.95	6.95	0.76	0.74	0.75	0.90	0.91	0.90
T8: Azotobacter@200ml/plant +100% of N/plant through FYM	7.02	7.02	7.02	0.74	0.71	0.73	0.89	0.90	0.89
T9: Control	7.09	6.99	7.04	0.74	0.72	0.73	0.84	0.86	0.85
S.Em(±)	0.06	0.05	0.07				0.02	0.02	0.03
CD (0.05%)	0.17	0.15	0.21	N.S	N.S	N.S	0.05	0.06	0.08

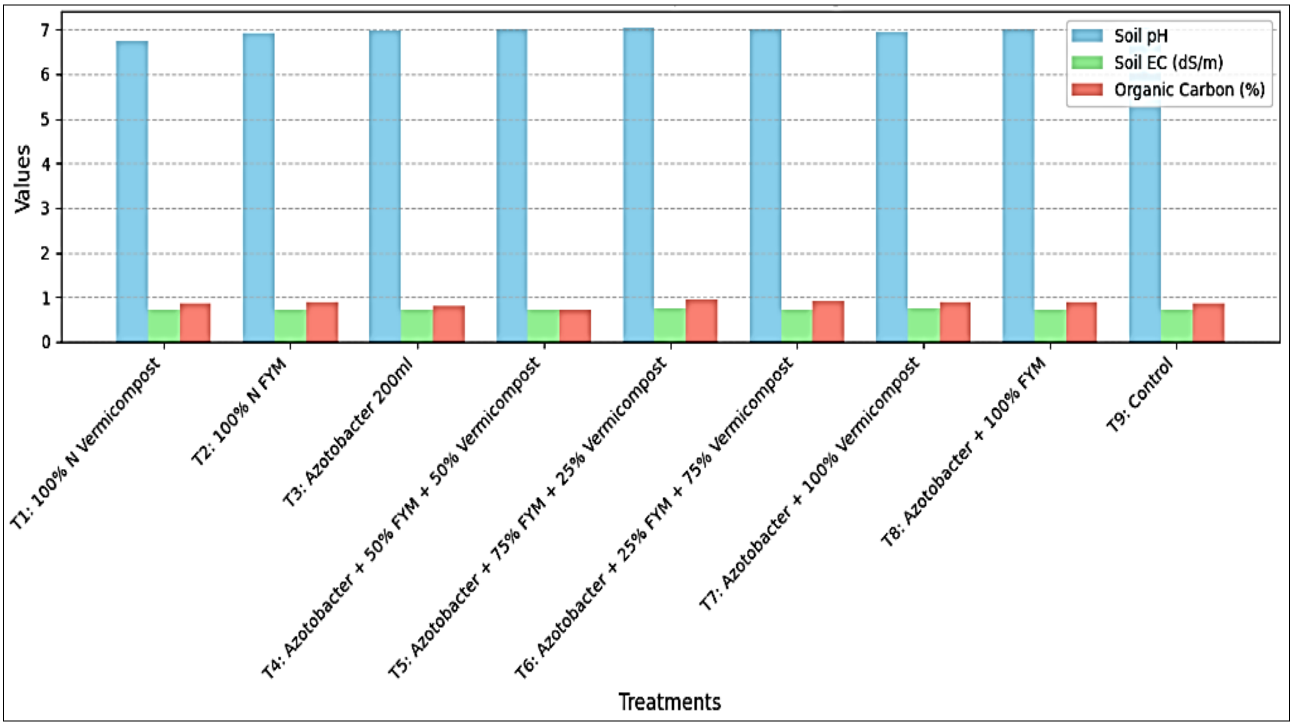

Fig 2: Effect of Treatment on Soil pH, EC and Organic Carbon

The data presented in the table highlights the effects of various treatments on soil pH, electrical conductivity (EC), and organic carbon content over two years (2022-23 and 2023-24). The pooled values show the overall trends across both years. Soil pH varied slightly across treatments, with the highest value observed for the treatment combination of Azotobacter, @200 ml/plant with 75% of N through FYM and 25% through vermicompost (T5), reaching 7.05 in the pooled data. Most treatments ranged from 6.75 to 7.05, indicating a generally neutral pH. Statistically, the differences in soil pH across treatments were significant, as evidenced by the CD (0.05%) value of 0.17 and 0.21 for the 2022-23 and 2023-24 periods, respectively. Soil electrical conductivity (EC), which indicates the soil's salinity level, showed minimal variation across treatments. Most treatments had similar EC values, with the pooled values ranging from 0.71 to 0.75 dS/m. The control treatment (T9) had EC values of 0.73, which is close to the average for most treatments, suggesting that none of the treatments led to significant changes in soil salinity. The analysis showed no significant difference (N.S) in EC, as indicated by the lack of significant CD values for both years. The organic carbon content of the soil varied across treatments, with the highest pooled value observed in T5 (0.95%), where 75% of nitrogen was provided through FYM and 25% through vermicompost. The organic carbon content in the control group (T9) was slightly lower, at 0.85%. Most treatments exhibited a positive effect on organic carbon levels, with values ranging from 0.71% to 0.95%. Statistically, the differences in organic carbon content across treatments were significant, as indicated by the CD (0.05%) values of 0.05, 0.06, and 0.08. In summary, treatments involving Azotobacter combined with organic fertilizers (FYM and vermicompost) tended to increase soil pH and organic carbon content. While there was no significant effect on soil EC, the use of organic amendments showed a beneficial impact on enhancing the soil's nutrient profile, particularly in terms of organic carbon, which is crucial for soil fertility. These results suggest that integrated treatments, particularly with higher proportions of FYM and vermicompost, can effectively improve soil health, without adversely affecting soil salinity.

Conclusion
The study conducted in Jammu District, Jammu & Kashmir, aimed to evaluate the effects of different nutrient treatments on the growth, yield, and soil health of dragon fruit plants. The results highlighted the importance of combining organic and inorganic nutrient sources for enhancing plant performance. The treatment combinations, particularly those integrating vermicompost, FYM, and Azotobacter, demonstrated positive effects on plant growth and soil health compared to the control group. Significant improvements were observed in soil parameters such as pH, electrical conductivity, and organic carbon content. The statistical analysis indicated that certain treatment combinations were more effective in optimizing nutrient utilization and promoting sustainable plant growth. These findings provide valuable insights for improving dragon fruit cultivation in subtropical regions, with potential implications for enhancing soil health and crop yield through integrated nutrient management. Future research can explore long-term effects and refine nutrient strategies for maximizing productivity and sustainability in dragon fruit farming.

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