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Influence of integrated nutrient management on yield, biochemical attributes, and soil fertility in dragon fruit (*Hylocereus* spp.)

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Abstract

Dragon fruit (*Hylocereus* spp.) is an emerging high-value fruit crop in India with notable nutraceutical potential, yet information on optimal nutrient management under local conditions is limited. A field experiment was conducted at the University Central Research Farm, Gayeshpur West Bengal, to assess the effect of integrated organic and inorganic NPK sources on yield, fruit quality, and soil nutrient status. Seven treatments combining chemical fertilizers with farmyard manure or vermicompost were evaluated in a randomized block design. Integrated application significantly improved crop performance compared to sole inorganic or organic treatments. The combination of 300 g urea, 250 g SSP, 160 g MOP, and 40 kg vermicompost per plant produced the highest fruit yield (15.60 kg plant⁻¹; 32.33 t ha⁻¹) with superior fruit attributes, including total soluble solids (15.74 °Brix), total sugars (15.58%), titratable acidity (0.184%), and ascorbic acid (8.30 mg 100 g⁻¹ pulp). Post-harvest soil analysis showed enhanced organic carbon and minimal depletion of available N, P, and K. These findings indicate that integrating vermicompost with inorganic fertilizers is an effective strategy for sustainable dragon fruit cultivation.

Keywords: Dragon fruit, *Hylocereus* spp., integrated nutrient management, vermicompost; fruit quality, soil fertility

Introduction

Dragon fruit or pitaya is the fruit of several tropical climbing cactus species belonging to the genus *Hylocereus* of the family Cactaceae. Native to the tropical regions of North, Central, and South America, pitaya has gained global commercial importance due to its attractive appearance, high market value, and relatively low input requirements. The crop is well adapted to arid and semi-arid environments owing to its high drought tolerance, adaptability to varying light intensities and elevated temperatures, and tolerance to a wide range of soil salinity conditions. In addition, dragon fruit is valued for its nutraceutical properties, including high antioxidant content, dietary fiber, vitamins, and bioactive compounds beneficial to human health (Nie *et al.*, 2015; Mercado-Silva, 2018) [6, 4]. Currently, dragon fruit is commercially cultivated in more than 20 tropical and subtropical countries, including Indonesia, Vietnam, Thailand, Malaysia, Israel, Mexico, Sri Lanka, southern China, Australia, Bangladesh, and the West Indies (Mercado-Silva, 2018) [4]. The fruit is particularly popular due to its striking variability in flesh and skin colour, such as red flesh with pink skin (*Hylocereus polyrhizus*), white flesh with pink skin (*Hylocereus undatus*), red-purple flesh with red skin (*Hylocereus costaricensis*), and yellow skin with white flesh [*Selenicereus megalanthus* (K. Schum. ex Vaupel) Moran] (Muniz *et al.*, 2019) [5]. Genetic studies have shown that *S. megalanthus* is tetraploid, while *Hylocereus* species are diploid, which may influence growth, fruiting behavior, and nutrient requirements. Despite its agronomic adaptability, dragon fruit is a nutrient-responsive crop, and inadequate fertilization often results in poor fruit set, reduced yield, and substantial depletion of soil nutrients. Balanced application of nitrogen, phosphorus, and potassium (NPK) plays a critical role in enhancing vegetative growth, flowering, fruit development, and quality. Continuous cultivation without proper nutrient replenishment can lead to nutrient mining and deterioration of soil health, particularly under tropical conditions. In India, dragon fruit cultivation is still in a nascent stage, although the crop is gradually gaining popularity in regions such as South Gujarat, West Bengal, and

Andhra Pradesh. Limited scientific information is available regarding its nutrient requirements and soil fertility management under Indian agro-climatic conditions, especially in the new alluvial zone of West Bengal. Understanding the combined effects of inorganic fertilizers and organic nutrient sources on crop performance and soil health is essential for the sustainable and profitable cultivation of dragon fruit. Therefore, systematic evaluation of integrated nutrient management strategies is required to optimize yield, fruit quality, and soil fertility under Indian conditions. The present investigation was undertaken with the following objective to evaluate the effect of different organic and inorganic sources of NPK on growth, yield, and yield attributes of dragon fruit.

Materials and Methods

Experimental site and location

The present investigation was conducted at the All India Coordinated Research Project on Fruits, University Central Research Farm, Gayeshpur, under Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal, India. The experimental site falls under the new alluvial zone of West Bengal, characterized by a subtropical humid climate with hot summers and mild winters. The region receives an average annual rainfall of approximately 1400-1500 mm, most of which occurs during the monsoon season. The soil of the experimental field was alluvial in nature, well-drained, and moderately fertile. Prior to the imposition of treatments, composite soil samples were collected and analyzed for physico-chemical properties, including organic carbon and available nitrogen, phosphorus, and potassium.

Experimental material and design

Uniform, healthy, and well-established dragon fruit (*Hylocereus spp.*) plants of similar age, growth, and vigour were selected for the study. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. Each treatment consisted of a combination of inorganic fertilizers and organic nutrient sources.

Treatment details

Seven levels of organic and inorganic sources of NPK were evaluated, as detailed below:

T₀: 300 g Urea + 250 g SSP + 160 g MOP (Control)

T₁: 500 g Urea + 500 g SSP + 350 g MOP + 30 kg FYM

T₂: 800 g Urea + 750 g SSP + 400 g MOP + 60 kg FYM

T₃: 150 kg FYM

T₄: 500 g Urea + 500 g SSP + 350 g MOP + 10 kg vermicompost

T₅: 800 g Urea + 750 g SSP + 400 g MOP + 20 kg vermicompost

T₆: 300 g Urea + 250 g SSP + 160 g MOP + 40 kg vermicompost

The inorganic fertilizers were applied in split doses as per standard package of practices, while FYM and vermicompost were applied as basal doses around the plant basin.

Observations recorded

Yield and yield attributes

The following yield and yield-related parameters were recorded during the harvesting period:

Fruit yield per plant (kg), Number of fruits per plant, Average fruit weight (g), Fruit yield per hectare (t ha⁻¹)

Biochemical analysis of fruits

Representative fruit samples were collected from each treatment and analyzed for biochemical quality parameters using standard analytical procedures: Total soluble solids (TSS) were measured using a hand refractometer and expressed in °Brix. Total sugars (%) were estimated using standard chemical methods. Titratable acidity (%) was determined by titration with standard alkali and expressed as percentage. Ascorbic acid content was estimated using the 2,6-dichlorophenol indophenol dye method and expressed as mg per 100 g of pulp.

Soil sampling and analysis

Soil samples were collected from the experimental field before treatment application (initial soil status) and after harvest (post-harvest soil status) from the root zone of the plants. The samples were air-dried, sieved, and analyzed for: Organic carbon (%), Available nitrogen (kg ha⁻¹), Available phosphorus (kg ha⁻¹), Available potassium (kg ha⁻¹). Standard laboratory procedures were followed for soil analysis. The percentage decline in soil nutrient status after harvest was calculated based on the difference between initial and post-harvest values.

Statistical analysis

The recorded data were statistically analyzed following analysis of variance (ANOVA) appropriate for a Randomized Block Design. The significance of treatment effects was tested at the 5% probability level ($p = 0.05$). The critical difference (CD) was calculated to compare treatment means where the F-test was found significant.

Results and Discussion

Effect of organic and inorganic sources of NPK on yield and yield attributes of dragon fruit

The application of different organic and inorganic sources of NPK significantly influenced the yield and yield attributes of dragon fruit (Table 1). Integrated nutrient management treatments produced markedly superior results compared to the control and sole organic application, indicating the importance of balanced nutrient supply for optimum crop performance.

Among the treatments, T₆ (300 g Urea + 250 g SSP + 160 g MOP + 40 kg vermicompost) recorded the highest fruit yield per plant (15.60 kg) and maximum yield (32.33 t ha⁻¹), which was statistically significant at the 5% level. This improvement was primarily attributed to a higher number of fruits per plant (25.27) and greater average fruit weight (413.62 g). Treatments T₅ and T₂ also recorded higher yields but were inferior to T₆, suggesting that moderate inorganic fertilization combined with sufficient organic input is more effective than higher chemical fertilizer doses. The results were also supported by the researcher Chakma *et al.*, (2014) [2] who observed that the total cladode length increased with the application of the higher dose of the nutrient. Tamanna Perween and Md. Abu Hasan (2019) [7] who observed the inorganic and organic manure would be optimum for the higher yield and acceptable quality of dragon fruit under the New Alluvial Zone of West Bengal.

The lowest yield was observed under the control treatment (T₀), indicating nutrient insufficiency under sole inorganic fertilizer application. FYM alone (T₃) resulted in moderate yield improvement but was unable to match integrated treatments, highlighting the limited capacity of organic manure alone to meet the nutrient requirements of dragon fruit.

Table 1: Effect of inorganic and organic sources of NPK on growth and yield attributes of Dragon fruit.

Treatment	Fruit Yield (kg plant ⁻¹)	Yield (t/ha)	Av. Fruit wt. (g.)	Number of fruits per plant
T ₀ (Control)	6.08	9.85	311.19	27.19
T ₁	8.38	13.57	361.76	28.82
T ₂	15.20	24.62	382.96	30.32
T ₃	10.96	17.76	315.76	27.1
T ₄	12.77	20.69	342.18	28.17
T ₅	14.38	23.29	390.14	31.33
T ₆	15.60	25.27	413.62	32.33
CD (p=0.05)	0.65	1.05	32.95	1.52

Effect of nutrient management on biochemical quality of fruits

Biochemical parameters of dragon fruit were significantly influenced by nutrient treatments (Table 2). Integrated nutrient application significantly enhanced total soluble solids (TSS), total sugars, titratable acidity, and ascorbic acid content compared to the control. Treatment T₆ recorded the highest TSS (15.74 °Brix) and total sugars (15.58%), followed by T₅. Enhanced sugar accumulation may be attributed to improved photosynthetic activity and efficient translocation of assimilates

due to balanced nitrogen and potassium availability. Similarly, ascorbic acid content was highest under T₆ (8.30 mg 100 g⁻¹ pulp), indicating improved nutritional quality of fruits. Titratable acidity also increased significantly under integrated nutrient treatments, which may be related to enhanced metabolic activity and organic acid synthesis facilitated by improved nutrient availability. This observation is in line with the findings of Cajazeira *et al.* (2018) [1]. Lower biochemical values under T₀ and T₃ indicate restricted nutrient availability and reduced metabolic efficiency.

Table 2: Effect of inorganic and organic sources of NPK on biochemical changes in Dragon fruit

Treatment	TSS (Brix)	Total sugar	Titrate acidity	Ascorbic acid (mg/100 g pulp)
T ₀ (Control)	11.61	11.49	0.135	8.05
T ₁	12.43	12.30	0.145	8.12
T ₂	14.61	14.46	0.170	8.17
T ₃	11.79	11.67	0.138	8.07
T ₄	13.38	13.24	0.156	8.15
T ₅	15.33	15.18	0.179	8.22
T ₆	15.74	15.58	0.184	8.30
CD (p=0.05)	1.00	0.99	0.012	0.47

Effect of integrated nutrient management on post-harvest soil nutrient status

Significant differences in soil organic carbon and available N, P, and K were observed among treatments in both initial and post-harvest soil analyses (Table 3). Treatments receiving organic amendments showed higher organic carbon content and nutrient availability compared to the control. The maximum depletion of soil nutrients was observed in the control treatment (T₀), with declines of 13.35% in nitrogen, 12.00% in phosphorus, and 12.31% in potassium, indicating intensive nutrient mining due to continuous crop uptake without organic supplementation. In contrast, T₆ recorded the lowest percentage decline in soil nutrients, with reductions of 5.08% in nitrogen, 2.27% in phosphorus, and 4.23% in potassium, along with minimal reduction in organic carbon. This demonstrates the effectiveness

of vermicompost in enhancing nutrient retention, improving soil buffering capacity, and minimizing nutrient losses. Other integrated treatments also showed reduced nutrient depletion compared to the control, confirming that combined application of inorganic fertilizers and organic manures plays a crucial role in sustaining soil fertility. Kiran Pilli *et al.*, 2018 [3] reported that INM package including use of vermicompost maintained higher status of available N, P, K, Ca, Mg and S. Highest availability of nutrients in 100% organic nitrogen may be attributed to slow and steady release of nutrients by addition of vermicompost to the soil. However, the availability decreases with incremental proportion of inorganic nitrogen. Vermicompost addition can increase the availability of nutrients because rate of release of nutrients was slow and proved nutrients for longer period in soil.

Table 3: Effect of inorganic and organic sources of NPK on physico-chemical properties of post-harvest soil nutrients status in Dragon fruit

Treatment	Initial soil nutrients status				Post harvest soil nutrients status				% decline in soil nutrients status after harvest			
	Organic carbon (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	Organic carbon (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	Organic carbon	N	P	K
T ₀ (Control)	0.37	348.2	20.27	182.44	0.36	307.2	18.1	162.44	2.78	13.35	12.00	12.31
T ₁	0.67	361.5	30.93	188.39	0.66	328.8	28.51	171.66	1.52	9.95	8.49	9.75
T ₂	0.68	448	31.60	197.21	0.67	416.4	30	181.68	1.49	7.59	5.33	8.55
T ₃	0.7	334.8	34.37	202.38	0.69	312	31.58	187.39	1.45	7.31	8.83	8.00
T ₄	0.64	418.2	29.16	186.52	0.63	386.4	26.93	172.56	1.59	8.23	8.29	8.09
T ₅	0.7	332.5	33.37	199.20	0.69	312	31.58	187.39	1.45	6.57	5.67	6.30
T ₆	0.7	372	31.52	276.29	0.69	354	30.82	265.08	1.45	5.08	2.27	4.23
CD (p=0.05)	0.06	29.1	2.74	9.88	0.06	26.4	2.45	9.15				

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