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ASSESSMENT OF SOIL FERTILITY IN RELATION TO DRAGON FRUIT (*Hylocereus costaricensis*) CULTIVATION IN SOUTH-EASTERN REGION OF BANGLADESH

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Abstract

Soil, shoot and fruit samples were collected from twenty Dragon (*Hylocereus costaricensis*) orchards under different locations of Cumilla to evaluate some physico-chemical properties and nutrient status. The pH of the soil varied from medium acidic to slightly alkaline (4.8 to 7.7), organic matter content varied from 1.01 to 1.95%, EC varied from 0.11 to 0.55 mS/cm. The dominant soil textural classes were loam and silt loam. The total and available N, P, K and S in soils were found to be 0.085 to 0.203% and 24.54 to 38.70 ppm, 0.027 to 0.185% and 12.74 to 76.44 ppm, 0.021 to 0.119% and 12.40 to 42.70 ppm, 0.096 to 0.213% and 9.4 to 34.8 ppm, respectively. The total N, P, K and S concentrations in shoots of dragon were 3.08 to 4.24, 0.102 to 0.246, 0.110 to 2.870 and 0.073 to 1.122%, respectively. Nutrients such as protein, N, P, K, Ca and Mg found in fruit varied from 10.20 to 17.80, 1.632 to 2.848, 0.071 to 0.184, 0.104 to 3.548, 0.057 to 0.135% and 0.118 to 0.295%, respectively. This study reveals low to medium soil fertility under dragon fruit plantations in the Cumilla region, Bangladesh. Farmers are advised to apply soil amendments to improve soil physico-chemical properties prior to planting. Regular soil testing and tailored nutrient management are recommended to enhance fertility and productivity, promoting sustainable practices and improved economic returns.

Key words: Dragon fruit; Fertility of soils; Nutrient status; Orchard; Shoot.

INTRODUCTION

Dragon fruit (*Hylocereus* spp.) also known as pitaya, is a type of edible vine cactus that is a member of the Cactaceae family (Ghosh *et al*. 2023). Despite coming from tropical regions in North, Central and South America, its economic attractiveness and low cultivation requirements have led to its global proliferation in cultivation. Cultivation of this plant offers numerous health benefits in addition to being extremely drought-tolerant, easily adapting to diverse light intensities and high temperatures, and displaying a broad tolerance to different soil salinities (Luu *et al.* 2021). Dragon fruit is becoming more and more well-known in tropical and subtropical regions because of its remarkable nutritional value, unique appearance and growing demand. Over the past ten years, there has been a significant increase in the cultivation of dragon fruit in Bangladesh, especially in districts like Rajshahi, Natore, Naogaon, Chapainawabganj and Cumilla. In Bangladesh, dragon fruit cultivation has experienced substantial growth in recent fiscal years. According to the Bangladesh Bureau of Statistics (BBS), in the fiscal year 2020-2021, dragon fruits were cultivated on 349.69 acres. This area increased significantly to 717.53 acres in the fiscal year 2021-2022 and further expanded to 1,135.40 acres in the 2022-2023 fiscal year. Correspondingly, the total production of dragon fruit rose dramatically, with outputs of 1,138.70 metric tons in 2020-

2021, 3,153.84 metric tons in 2021-2022, and 5,959.29 metric tons in 2022-2023, highlighting the crop's growing importance in the agricultural sector. In Cumilla District dragon fruits were cultivated in 99.51 acres land producing 38.64 M. tons fruits in 2022-2023 fiscal year (BBS 2023).

Understanding soil fertility in dragon fruit cultivation is crucial, as nutrient imbalances can lead to poor fruit quality, reduced yields and lower market value. For instance, the plant's nutrient uptake is sensitive to deficiencies in key elements such as nitrogen, phosphorus, potassium, calcium, and magnesium (Patil *et al.* 2018). This study seeks to investigate the current soil fertility and nutrient status within dragon fruit gardens in the Cumilla district. By examining various parameters, including soil texture, organic matter content, pH levels, and the concentrations of essential macro and micronutrients, the research aims to offer valuable insights into the health and nutrient dynamics of the soil in these gardens. Furthermore, it will emphasize the importance of sustainable nutrient management practices that not only enhance crop yields but also contribute to the preservation of long-term soil fertility in Cumilla.

MATERIAL AND METHODS

Experimental site

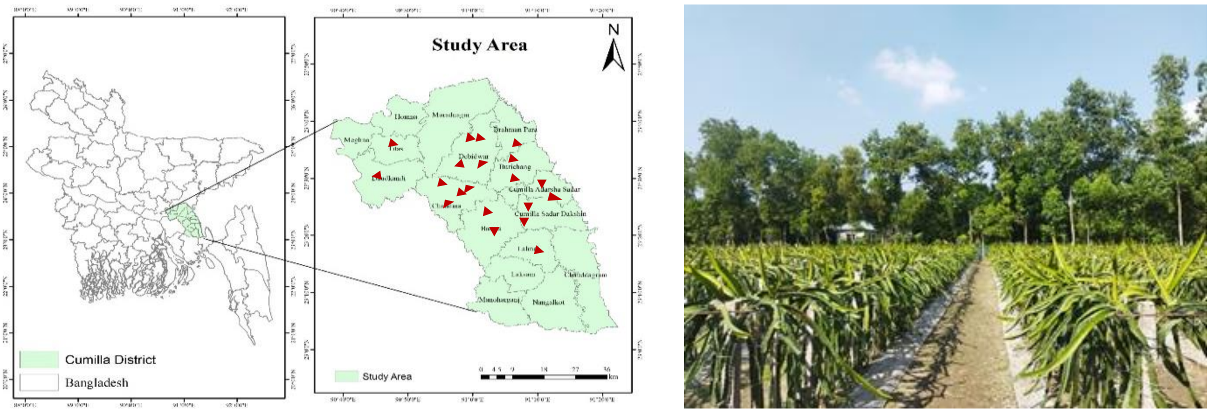
Cumilla district (Fig. 1) is located in Agro-Ecological Zone (AEZ) 19, known as the Old Meghna Estuarine Floodplain, Northern and Eastern Piedmont Plain (AEZ-22) and Northern and Eastern Hills (AEZ-29). These AEZs are characterized by medium high to medium low and low land with medium organic matter and fertility level, high to medium high and low lands with low to medium organic matter and fertility and high land with low organic matter level, respectively (Brammer 2012). The area primarily consists of non-calcareous brown floodplain soils, and the average pH ranges from 5.8 to 7.2, which is conducive to the growth of a wide variety of crops, including horticultural products like dragon fruit. The climate in Cumilla is also favorable for dragon fruit cultivation, with an average annual rainfall of approximately 2,179 mm, and temperatures ranging between 25°C and 35°C during the growing season (BBS 2023). The well-distributed rainfall and moderately fertile soil provide favorable conditions for dragon fruit to thrive.

Physical characteristics

Soil moisture content was determined using the gravimetric method as outlined by Miller and Donahue (1965). The collected soil samples were transported to the laboratory, where they were initially weighed and subsequently oven-dried at 100°C for 24 hours. Moisture content was determined, the oven-dry weight was subtracted from the initial weight, with the resulting values expressed as percentages. The particle size analysis of the soil samples was conducted using the hydrometer method. Subsequently, the textural classes were identified through Marshall's triangle coordinate curve, as described by Bouyoucos (1962).

Chemical characteristics

To determine the pH of the soil samples, a mixture of soil and distilled water was prepared in a ratio of 1:2.5. This suspension was shaken for half an hour and allowed to stand for one hour before the pH was measured with pH meter at 25°C, following the procedure outlined by Jackson (1958). Additionally, electrical conductivity (EC) in the soil samples was assessed using a digital conductivity meter (EUTECH Instruments CON 700), with a soil-to-water ratio of 1:5, in accordance with Richards (1954).



a **b**

Fig. 1. Study area: **a**. Map showing the study area in Cumilla district; and **b**. View of a dragon fruit orchard in Chepara (Debidwar) Cumilla district.

The organic carbon content of the soils was determined using the Wet Oxidation method as described by Walkley and Black (1934). The organic matter was then calculated by multiplying the percentage of organic carbon by the van Bemmelen factor of 1.72. Total nitrogen in the samples was assessed through the micro-Kjeldahl steam distillation method, which involved H_2SO_4 acid digestion followed by alkali distillation, according to Marr and Cresser (1983). Total phosphorus was determined by vanadomolybdate yellow colour method (Kitson and Mellon 1944). For total potassium (K) and sulfur (S), the soil samples were digested using a mixture of sulfuric and perchloric acids, as outlined by Jackson (1958). Total phosphorus was measured using the vanadomolybdate yellow color method, based on the procedures established by Kitson and Mellon (1944). Additionally, total potassium was quantified with a flame photometer, following the guidelines set by Klute (1986).

Available nitrogen in the samples was determined by extracting the soils with 10% NaCl, followed by distillation of the extract with 40% NaOH and Devarda's alloy using a micro distillation apparatus, the distillates were then titrated with sulfuric acid. Available phosphorus (P) was assessed using the colorimetric method, which involved developing a yellow colour via the vanadomolybdate yellow color method. For the determination of available phosphorus (P), the Bray 1 method (Bray and Kurtz 1945) was employed for acidic soils, while the Olsen method (Olsen and Sommers 1982) was applied for neutral and alkaline soils. The filtrate was subsequently analyzed for phosphorus content using the Murphy and Riley (1962) method. For available potassium, soils were extracted with neutral normal NH_4OAc, and the potassium content was measured using a flame photometer. Available sulfur was quantified calorimetrically through the colorimetric method with a spectrophotometer, following the development of turbidity with $BaCl_2$, with tween-80 used as a suspending agent. Finally, the concentrations of exchangeable calcium and magnesium were determined using an atomic absorption spectrometer (AAS: VARIAN AA240, New Jersey, USA) which was also used to measure the iron and zinc in the digest.

Nutrient analysis of shoots and fruit pulp

To analyze nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg), Iron (Fe) and Zinc (Zn) concentrations in dragon shoots and fruit pulp, 0.1 g of ground material was digested in a sand bath with 5 ml of concentrated sulfuric acid (H_2SO_4) and 2 ml of a 4% (v/v) perchloric acid solution. After cooling, the digest was diluted to 100 ml with deionized water (Cresser and Parson 1979). Nitrogen concentration was determined using the micro-Kjeldahl steam distillation method, where an excess of 40% sodium hydroxide (NaOH) was added, and ammonia was trapped in a 2% mixed boric acid solution, then titrated with sulfuric acid (H_2SO_4). Based on early determinations, the average nitrogen (N) content of protein was found to be about 16 per cent, which led to the calculation N × 6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content (Lourenco *et al.* 1998). Potassium(K), Calcium (Ca), Magnesium (Mg), Iron (Fe) and Zinc (Zn) concentrations were measured with a photometer flame named JENWAY flame photometer, while phosphorus and sulfur concentrations were assessed using an atomic absorption spectrophotometer (AAS). The nutrient content in the shoot and fruit pulp was represented as the average value for each replication.

Statistical analysis

All statistical analyses were calculated using Microsoft Excel 10.

RESULTS AND DISCUSSION

Physical properties

The moisture content of the soil samples varied between 1.70% and 6.84%, with an average value of 3.73%. The availability of soil moisture is crucial as it directly influences microbial activity, which consequently impacts the level of soil organic carbon (Liu *et al.* 2009). Irrigation, therefore, plays a critical role not only in enhancing the production of new flushes and improving fruit set and yield (Purushotham and Narasimham 1981), but also in maintaining adequate moisture conditions, particularly during periods of drought (Young 1972). Trees growing under optimal soil moisture conditions demonstrate both improved growth and higher yields (Goode and Ingram 1971, Cepicka 1987), while simultaneously accumulating greater quantities of nutrients in their leaves (Menzel *et al.* 1986). The sand content of the soil samples ranged from 20 to 62%, with an average of 35.6%, while silt content varied between 26 and 64%, averaging 44.9%. The clay content, on the other hand, ranged from 12 to 26%, with an average of 19.5%. The ratio of sand to clay ranged from 0.4 to 2.38, with an average of 0.921, whereas the silt-to-clay ratio varied from 1.38 to 5.33, with an average of 2.521 (Table 1).

In terms of texture, the majority of soil samples were classified as loam or silt loam, with the exception of sample 13 from Nimsar, which was identified as sandy loam. Soil texture plays a critical role in influencing productivity by affecting moisture availability, soil temperature, nutrient supply and the accessibility of soil organic matter for microbial decomposition (Schimel *et al.* 1996).

Table 1. Physical properties of soils from different dragon fruit orchards.

Locations	Moisture %	Sand %	Silt %	Clay %	Texture	Sand/Silt	Silt/Clay
Bhubanghar	5.55	40	38	22	Loam	1.05	1.73
Durgapur	5.43	44	36	20	Loam	1.22	1.8
Chandsar north	4.22	48	32	20	Loam	1.5	1.6
Chandsar south	6.84	46	32	22	Loam	1.44	1.45
Panipara	3.63	26	58	16	Silt loam	0.45	3.63
Vomorkandi	3.12	22	60	18	Silt loam	0.37	3.33
Aganagor	2.55	28	60	12	Silt loam	0.47	5
Ziruin	2.43	24	64	12	Silt loam	0.38	5.33
Anandapur	4.36	22	58	20	Silt loam	0.38	2.9
Lalmai	5.26	26	56	18	Silt loam	0.46	3.11
Titas	4.03	20	56	24	Silt loam	0.36	2.33
Daudkandi	4.35	20	50	30	Loam	0.4	1.67
Nimsar	5.41	52	30	18	Sandy loam	1.73	1.67
Barella	3.29	62	26	12	Loam	2.38	2.17
Rajapur	1.70	52	36	12	Loam	1.44	3
Chepara	3.95	40	46	14	Loam	0.87	3.29
Yousufpur	2.05	34	42	24	Loam	0.81	1.75
Wahedpur	1.97	34	40	26	Loam	0.85	1.54
Saitala	1.84	34	42	24	Loam	0.81	1.75
Barura	2.64	38	36	26	Loam	1.06	1.38
Range	1.70-6.84	20-62	26-64	12-26	-	0.40-2.38	1.38-5.33
Mean	3.73	35.6	44.9	19.5	-	0.92	2.52

Chemical properties

The soil samples exhibited a broad range of pH values, from strongly acidic (pH 4.8 in Barura) to slightly alkaline (pH 7.7 in Ziruin) (Table 2), with an average pH of 6.19, indicating slightly acidic conditions overall. Soil pH plays a crucial role in regulating the availability of various nutrients, toxic elements, and chemical compounds to plant roots, making it a key factor in soil fertility. As such, pH serves as a reliable indicator of potential nutrient deficiencies and toxic effects that may impact plant growth (Brady 1984, McKenzie *et al.* 2004). All soil samples ranged from non-saline to slightly saline, with electrical conductivity values varying between 0.11 mS and 5.5 mS, and an average of 0.27 mS. Organic matter content showed a range from 1.10% to 1.95%, with an average of 1.40%. Soil Organic Carbon (SOC) plays a pivotal role in determining soil quality and health, as it is closely related to crop yield and the availability of key nutrients such as nitrogen (Reyna-Bowen *et al.* 2020, Nahdia *et al.* 2021). Organic matter supports essential soil microfauna and microflora. Its decomposition and interaction with soil components play a key role in maintaining soil's physical and chemical fertility (Allison 1973, Charman and Roper 2007).

Rabelo *et al.* (2020) also reported that potassium is the most exported nutrient in dragon fruit, significantly influencing the uptake of other nutrients and simultaneously impacting both fruit yield and quality. The total sulfur content in the soil samples ranged from 0.096 to 0.212%, with an average of 0.145%. Meanwhile, the available sulfur levels varied from 9.40 to 34.8 ppm, averaging 18.31 ppm. According to the Bangladesh Agricultural Research

Council, the standard value of available sulfur for crop cultivation is 31.5 µg/g, while the critical value is 8 mg/kg (BARC 2018).

Table 2. Soil pH, electrical conductivity, organic carbon and organic matter status, as well as C/N ratios in different dragon fruit orchards.

Locations	pH	EC (mS/cm)	Organic Carbon (%)	C/N Ratio	Organic Matters (%)
Bhubanghar	5.1	0.24	0.94	7.49	1.61
Durgapur	6.9	0.28	1.00	6.10	1.72
Chandsar north	6.4	0.24	1.07	5.78	1.84
Chandsar south	6.1	0.11	0.73	6.49	1.25
Panipara	6.8	0.38	0.64	6.09	1.10
Vomorkandi	6 .1	0.25	0.88	7.24	1.52
Aganagor	7.4	0.55	0.93	6.74	1.60
Ziruin	7.7	0.45	1.13	5.58	1.95
Anandapur	6.6	0.25	0.99	6.10	1.70
Lalmai	6.1	0.24	0.60	5.16	1.02
Titas	7.2	0.28	0.59	5.34	1.01
Daudkandi	6.8	0.45	0.76	4.50	1.30
Nimsar	6.5	0.27	0.70	4.50	1.20
Barella	6	0.26	0.65	5.52	1.12
Rajapur	6.1	0.23	0.62	5.92	1.07
Chepara	5.5	0.23	0.83	7.61	1.44
Yousufpur	5.3	0.21	0.78	4.06	1.34
Wahedpur	5.2	0.20	0.76	9.57	1.30
Saitala	5.1	0.21	0.64	7.52	1.10
Barura	4.8	0.11	1.05	5.75	1.80
Range	4.8-7.7	0.11-0.55	0.59-1.13	4.50-9.57	1.01-1.95
Mean	6.19	0.274	0.81	6.15	1.40

Macro nutrients

The total nitrogen content across the soil samples ranged from 0.079 to 0.203%, with an average of 0.1375%, while available nitrogen content varied between 24.54 and 38.7 ppm, with an average of 31.07 ppm. Phosphorus concentrations showed a total phosphorus content averaging 0.079%, with values ranging from 0.027 to 0.185%. The available phosphorus content however, ranged from 13.74 to 76.44 ppm with an average of 39.92 ppm. The total potassium content of the soil samples ranged from 0.182 to 0.940% with an average of 0.540%, while the available potassium levels varied between 12.4 and 42.7 ppm with an average of 25.46 ppm (Table 3). In fruit crops, potassium plays a crucial role in enhancing both yield and key fruit quality attributes such as colour, soluble solids, acidity and mineral content. As a result, it is often referred to as the "quality element" in crop production (Saha *et al.* 2016). Established standards for soil nutrient evaluation specific to dragon fruit orchards vary by soil type, region and climate. Interpretations of soil nutrient levels were made using suggested optimum values of nitrogen (N) at 125 to 250 mg/kg (Subbiah and Asiza 1956), phosphorus (P) at 12 to 25 mg/kg (Mohr *et al.* 1965), and potassium (K) at 90 to 100 mg/kg (Du Plessis 1977).

Calcium, magnesium, iron and micronutrients

The soil nutrient analysis from dragon fruit orchards showed significant variability in nutrient concentrations. Calcium (Ca) ranged from 2.12 to 30.20 meq/100 g, with an average of 6.27 meq/100 g, while Magnesium (Mg) ranged from 1.10 to 2.84 meq/100 g, with a mean of 1.80 meq/100 g.

Table 3. Macronutrient status of the soil in dragon fruit orchards.

Locations	Nitrogen		Phosphorus		Potassium		Sulfur	
	Available (mg/kg)	Total (%)	Available (mg/kg)	Total (%)	Available (mg/kg)	Total (%)	Available (mg/kg)	Total (%)
Bhubanghar	24.54	0.125	19.01	0.038	12.4	0.033	17.8	0.147
Durgapur	31.36	0.164	12.74	0.027	18.7	0.119	26.6	0.112
Chandsar north	35.1	0.185	29.78	0.038	23.6	0.023	23.2	0.2
Chandsar south	32.6	0.112	33.84	0.058	18.6	0.027	21.7	0.213
Panipara	31.1	0.105	25.59	0.109	34.4	0.089	19.7	0.201
Vomorkandi	30.54	0.122	50.59	0.027	28.6	0.021	14.3	0.177
Aganagor	34.5	0.138	40.62	0.063	38.5	0.090	17.5	0.15
Ziruin	33.7	0.203	42.46	0.104	42.7	0.084	17.3	0.158
Anandapur	32.3	0.162	55.39	0.185	33.5	0.056	12.4	0.12
Lalmai	31.8	0.115	53.54	0.165	26.6	0.080	14.8	0.112
Titas	26.75	0.11	76.44	0.058	38.6	0.083	15.3	0.134
Daudkandi	31.4	0.168	44.31	0.073	35.2	0.093	18.4	0.166
Nimsar	28.7	0.155	76.44	0.063	32.7	0.091	11.9	0.118
Barella	24.7	0.118	40.62	0.058	24.8	0.089	9.4	0.096
Rajapur	27.7	0.105	49.46	0.058	27.7	0.084	34.8	0.11
Chepara	25.8	0.11	38.65	0.093	16.6	0.085	21.9	0.176
Yousufpur	35.5	0.192	36.15	0.083	14.2	0.077	18.5	0.136
Wahedpur	32.6	0.079	35.25	0.088	14.7	0.049	20.6	0.12
Saitala	32.1	0.085	21.69	0.093	13.2	0.054	15.8	0.109
Barura	38.7	0.182	15.85	0.099	13.9	0.045	14.4	0.147
Range	24.54-38.70	0.085-0.203	12.74-76.44	0.027-0.185	12.40-42.70	0.021-0.119	9.4-34.8	0.096-0.213
Mean	31.07	0.137	39.92	0.079	25.46	0.069	18.31	0.145

Table 4. Calcium, magnesium, iron and the status of some micronutrients in soils under dragon fruit orchards.

Locations	Calcium (meq/100 g)	Magnesium (meq/100 g)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)
Bhubanghar	5.29	2.16	1.62	149.20	62.00
Durgapur	3.72	1.72	2.24	121.00	82.70
Chandsar north	3.31	0.84	1.35	45.80	16.40
Chandsar south	7.65	2.26	0.98	40.60	60.00
Panipara	2.97	1.10	0.58	137.76	29.00
Vomorkandi	4.80	1.42	2.42	140.20	40.70
Aganagor	6.42	1.33	1.73	158.20	55.70
Ziruin	30.20	2.18	1.29	68.20	31.00
Anandapur	8.50	2.50	4.16	65.30	42.40
Lalmai	2.12	1.64	1.13	20.60	26.70
Titas	3.20	1.14	1.34	42.20	55.00
Daudkandi	4.40	1.19	1.39	160.20	18.00
Nimsar	6.32	2.84	0.98	114.20	90.00
Barella	4.48	2.59	1.08	82.70	86.00
Rajapur	6.50	1.72	2.55	189.00	34.50
Chepara	6.20	2.41	0.84	134.00	28.70
Yusufpur	3.77	1.18	1.24	127.80	24.80
Wahedpur	4.24	1.39	1.92	58.00	17.20
Saitala	7.14	2.48	1.67	55.00	70.90
Barura	4.10	1.95	0.93	128.00	21.20
Range	2.12-30.20	1.10-2.84	0.58-4.16	20.60-189.00	17.20-90.0
Mean	6.27	1.80	1.57	101.90	44.64

Copper (Cu) in the soils was between 0.58 and 4.16 mg/kg, averaging 1.57 mg/kg. Iron (Fe) levels varied from 20.60 to 189.00 mg/kg, with a mean of 101.90 mg/kg, and Manganese (Mn) ranged from 17.20 to 90.00 mg/kg, with an average of 44.64 mg/kg (Table 4). These nutrient variations can influence plant growth and fruit quality differently across the orchards.

Nutrient status in the shoot and fruit of dragon

Leaf or shoot analysis is commonly used as a primary indicator of nutrient status in orchards, whereas soil analysis provides insight into the nutrient sources available to plants (Jorgenson and Price 1978). In pitaya shoots, nitrogen levels ranged from 3.08 to 4.24%, with an average of 3.69%. Phosphorus levels varied between 0.102 and 0.246%, averaging 0.166%. Potassium and sulfur levels in the shoots ranged from 1.11 to 2.87%, with an average of 1.69%, and from 0.073 to 1.122%, with an average of 0.163%, respectively (Table 5). According to Embleton *et al*. (1973) the optimum nutrient levels in shoots are 3.0 to 5.5% for calcium (Ca), 0.26 to 0.60% for magnesium (Mg), 60 to 120 ppm for iron (Fe), 25 to 200 ppm for manganese (Mn), 5 to 16 ppm for copper (Cu), and 25 to 100 ppm for zinc (Zn).

Table 5. Nutrient concentrations in the shoots of dragon fruit plants grown in different orchards.

Locations	Nitrogen	Phosphorus	Potassium	Sulfur
Bhubanghar	3.08 ± 0.051	0.141 ± 0.009	1.75 ± 0.102	0.131 ± 0.003
Durgapur	3.74 ± 0.097	0.121 ± 0.006	2.14 ± 0.077	0.094 ± 0.001
Chandsar north	4.02 ± 0.145	0.153 ± 0.002	0.11 ± 0.008	0.094 ± 0.002
Chandsar south	3.82 ± 0.181	0.177 ± 0.005	1.26 ± 0.028	0.108 ± 0.002
Panipara	3.69 ± 0.038	0.142 ± 0.007	2.01 ± 0.039	0.132 ± 0.006
Vomorkandi	3.57 ± 0.139	0.202 ± 0.007	1.85 ± 0.084	0.107 ± 0.001
Aganagor	3.96 ± 0.059	0.171 ± 0.005	1.17 ± 0.031	0.106 ± 0.002
Ziruin	3.9 ± 0.106	0.185 ± 0.007	2.32 ± 0.135	0.119 ± 0.008
Anandapur	3.86 ± 0.081	0.183 ± 0.013	1.81 ± 0.033	0.119 ± 0.001
Lalmai	3.75 ± 0.261	0.203 ± 0.008	1.51 ± 0.098	0.127 ± 0.007
Titas	3.19 ± 0.136	0.246 ± 0.009	2.13 ± 0.035	0.102 ± 0.005
Daudkandi	3.76 ± 0.236	0.221 ± 0.011	0.71 ± 0.02	0.096 ± 0.002
Nimsar	3.49 ± 0.046	0.205 ± 0.006	2.87 ± 0.124	1.122 ± 0.028
Barella	3.31 ± 0.217	0.162 ± 0.007	1.89 ± 0.019	0.156 ± 0.007
Rajapur	3.4 ± 0.034	0.186 ± 0.007	1.53 ± 0.024	0.125 ± 0.008
Chepara	3.42 ± 0.136	0.148 ± 0.005	1.11 ± 0.023	0.091 ± 0.002
Yusufpur	4.01 ± 0.121	0.102 ± 0.006	1.19 ± 0.08	0.131 ± 0.006
Wahedpur	3.87 ± 0.202	0.126 ± 0.002	1.89 ± 0.024	0.121 ± 0.007
Saitala	3.84 ± 0.047	0.122 ± 0.003	0.28 ± 0.006	0.073 ± 0.002
Barura	4.24 ± 0.071	0.128 ± 0.004	0.28 ± 0.006	0.117 ± 0.007
Range	3.08-4.24	0.102-0.246	0.11-2.87	0.073-1.122
Mean	3.696	0.166	1.49	0.163

'±' standard deviation

In dragon fruits, nitrogen levels ranged from 1.632 to 2.848%, with an average of 1.982%. Phosphorus levels ranged between 0.071 and 0.184%, with an average of 0.122%. Potassium levels in dragon fruits ranged from 0.571 to 3.548%, averaging 2.162%. Calcium and magnesium levels in the fruit ranged from 0.057 to 0.135%, with an average of 0.0897% and from 0.118 to 0.295%, with an average of 0.195%, respectively (Table 6). From a consumer perspective, these parameters are important because nitrogen enhances protein content, phosphorus boosts freshness and quality, and potassium improves nutritional value and taste in fruits.

Table 6. Nutrient concentrations in the fruit pulp of dragon fruits from different orchards.

Locations	Nitrogen (%)	Protein (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
Bhubanghar	1.632	10.20	0.092	2.748	0.092	0.217
Durgapur	1.856	11.60	0.086	3.483	0.057	0.173
Chandsar north	2.234	13.96	0.111	0.571	0.105	0.118
Chandsar south	1.937	12.10	0.129	1.453	0.085	0.255
Panipara	1.893	11.83	0.098	3.478	0.124	0.128
Vomorkandi	1.795	11.22	0.149	2.456	0.087	0.158
Aganagor	1.949	12.18	0.127	1.370	0.080	0.148
Ziruin	2.039	12.74	0.138	3.517	0.121	0.234
Anandapur	2.024	12.65	0.143	2.520	0.062	0.263
Lalmai	2.084	13.03	0.168	1.694	0.135	0.168
Titas	2.175	13.59	0.184	3.227	0.079	0.132
Daudkandi	2.848	17.80	0.153	1.238	0.084	0.136
Nimsar	1.768	11.05	0.147	3.548	0.075	0.295
Barella	1.712	10.70	0.135	2.639	0.106	0.270
Rajapur	1.763	11.02	0.163	2.439	0.082	0.185
Chepara	1.754	10.96	0.094	1.390	0.079	0.281
Yusufpur	1.799	11.24	0.071	1.366	0.088	0.149
Wahedpur	2.153	13.46	0.085	3.048	0.096	0.147
Saitala	1.994	12.46	0.081	0.965	0.066	0.284
Barura	2.247	14.04	0.087	0.104	0.091	0.174
Range	1.632-2.848	10.20-17.80	0.071-0.184	0.104-3.548	0.057-0.135	0.118-0.295
Mean	1.982	12.39	0.122	2.162	0.0897	0.195

The study found a moderate to strong correlation between soil nitrogen (N), phosphorus (P) and potassium (K), and their respective concentrations in the fruit. Likewise, a similar correlation was observed between shoot N, P and K, and the nutrient contents in the fruit (Fig. 2).

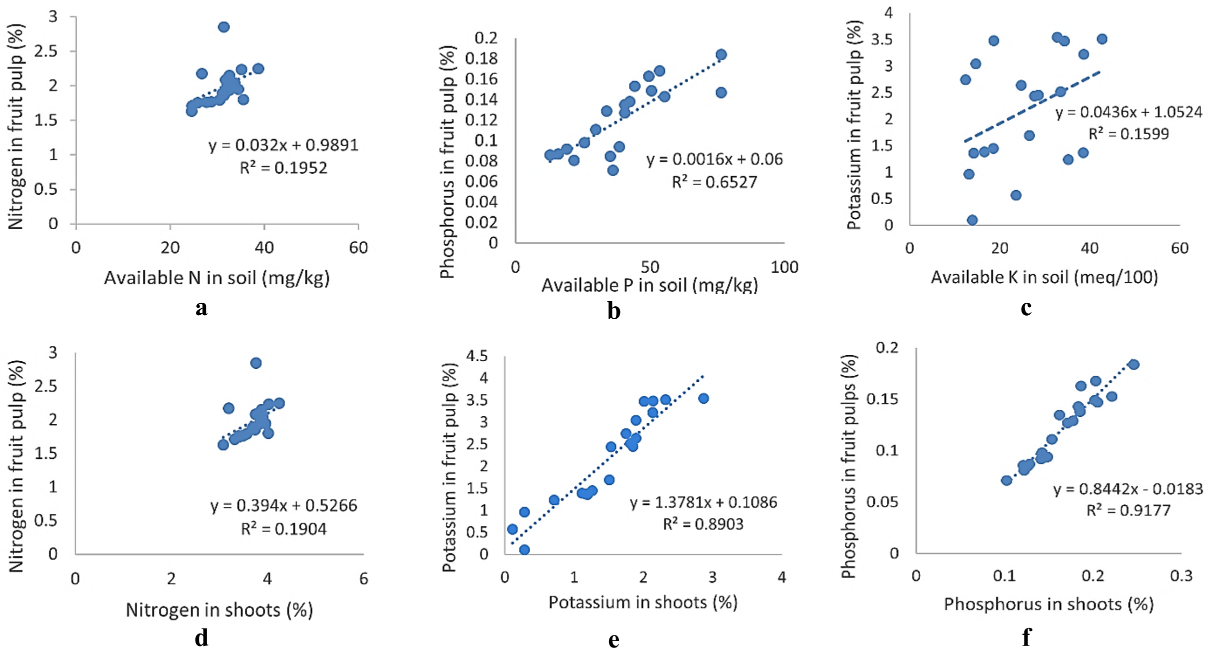


Fig. 2. Relationship between fruit nutrients and soil macronutrients, and shoot nutrients.

These results indicate that both soil and shoot nutrient levels play a crucial role in determining the N, P and K contents of dragon fruit, emphasizing the enhancement fruit quality and productivity. Continued low fertilizer input may result in reduced fruit yield and declining soil productivity. The study demonstrated a positive correlation among nutrient contents in soil, dragon shoots and fruit pulp. To sustain soil health and optimize yield, it is recommended that farmers should follow fertilizer guidelines and Soil Resource Development Institute (SRDI) recommendations. Moreover, the nutrient composition of fruit pulp offers valuable insights for future research, contributing to a deeper understanding of crop management and soil fertility.

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