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Impact of soil mixtures on vegetative and reproductive growth of dragon fruits

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Abstract
The Southern Sundarban region, known for its ecological diversity and agricultural challenges exacerbated by frequent cyclones, has been exploring resilient alternatives to conventional crops in the aftermath of cyclones like Amphan (2020) and Yaas (2021) (Das, B., 2020) [4]. This study investigates the impact of soil mix variations on dragon fruit (*Hylocereus* spp.) production, considering crucial morphological parameters. Employing rigorous methods, including ANOVA for statistical analysis, the research examines the effects of eight distinct soil mixtures with varying organic matter and mineral proportions on dragon fruit growth and productivity. Dragon fruit, valued for its economic and nutritional significance, is influenced by various factors, with soil composition playing a pivotal role. Morphological parameters such as plant height, stem diameter, number of branches, flower and fruit production, and overall plant health were evaluated over the cultivation period. The objective is to offer insights into selecting optimal soil mixes to maximize dragon fruit yield and quality, aiding growers in making informed decisions to enhance production in the Southern Sundarban region.

Keywords: Dragon fruits, Sundarban, Soil -mixtures.

Introduction
The Southern Sundarban region, located in the deltaic region of the Bay of Bengal, is renowned for its unparalleled ecological diversity and its struggle with agricultural adversities. The region's farmers have been grappling with the challenges posed by recurrent cyclones, which bring destruction to embankments and inundate farmlands with saline water. Among the several factors affecting dragon fruit cultivation, soil composition plays a critical role in determining plant growth, nutrient uptake, and overall productivity (Perween, 2017)[1]. Different soil mixtures can influence the morphological parameters of dragon fruit plants, thereby impacting fruit yield and quality. Understanding the relationship between soil composition and morphological parameters is essential for optimizing dragon fruit production. (Anon, 20170[2] These studies employed rigorous methods, including statistical analysis using ANOVA, to investigate the impact of various soil mixtures on dragon fruit growth and production. It is a tropical fruit belongs to the Cactaceae family (Britton N.L., Rose J.N., 1920) [3] (Mizrahi, Y., & Nerd, A., 1999) [5]. and believed to have originated in Central America, primarily in Mexico and parts of Central and South America. Hylocereus spp., is known not only for its striking appearance and sweet, refreshing taste but also for its rich phytochemical components like Polyphenols, Vitamin C, Flavonoids, Fiber, Phytosterols, Fatty acids and Betacyanin's, which contributes to its potential health benefits. (Weiss J *et al*., 1994) [9]

Methodology/Experimental Design
The experiment was carried out in the experimental garden at Dkashin Barasat (22.23 N, 88.44S). The soil sample collected from southern Sundarban region. Eight soil mixtures were used in this study, which include soil mixture A, soil mixture B, soil mixture C, soil mixture D, soil mixture E, soil mixture F, soil mixture G and soil mixture H. The soil mixtures were prepared in earthen pots of 25 cm diameter and 30 cm height. Each pot was filled with 10 kg of soil mixture, and one dragon fruit cutting was planted in each pot. There were three sets prepared for each soil mixture set. The pots were kept under a green shade net for one week and after that they were kept in the experimental garden.

Soil Mixtures:

- **Soil mixture A**: A well-draining mixture of experimental field soil without adding any compost, minerals and chemical fertilizer.
- **Soil mixture B:** A mixture composed of 80% field soil, 20% soil mixed with chemical fertilizer.
- **Soil mixture C:** A mixture composed of 50% field soil, 50% vermicompost.
- **Soil mixture D:** A mixture composed of 50% field soil, 50% cocopeat.
- **Soil mixture E:** A mixture composed of 50% field soil, 50% cow dung.
- **Soil mixture F:** A mixture composed of 50% field soil and 10%cow dung, 10%vermicompost, 10% cocopeat, 10% bone dust, 10% neem cake.
- **Soil mixture G:** A mixture composed of 50% field soil, 50% neem cake.
- **Soil mixture H:** A mixture composed of 50% field soil, 50% local garden soil.

Table 1: Experimental pot soil analysis

SL. No.	pH	E.C.	O.C.	N	P_2O_5	K_2O
		dsm^{-1}	(%)	Kg/ha	Kg/ha	Kg/ha
A	6.33	0.85	0.80	486.00	33.59	400.51
B	5.51	2.20	0.74	446.40	113.02	1010.69
C	6.90	1.01	0.83	510.70	145.19	1201.54
D	7.17	0.28	0.82	509.80	80.28	1190.78
E	6.83	1.03	0.84	537.20	180.21	776.83
F	6.85	1.60	0.84	534.20	43.27	1368.19
G	7.07	0.87	0.82	510.50	110.18	2455.49
H	7.83	0.25	0.83	512.60	120.71	596.74

Morphological parameters such as no of vegetative bud initiation, length and width of cladode, arch height, distance between areolas, spine no, length of spine, fruit length, equatorial diameter, no of fruiting cycle and fruit weight were recorded at different growth stages. All plants received consistent care, including irrigation, fertilization, and pest management, to minimize confounding factors. The first measurement was taken 90 days after planting (DAP), (Rahim *et al*., 2009) [7] and subsequent measurements were taken at every 90 days interval after plantation. Data were analyzed using one-way ANOVA and Tukey's HSD test.

Statistical Analysis: Collected data were subjected to analysis of variance (ANOVA) and post-hoc tests to identify significant differences among the soil mixtures.

Results and discussion

The results of the study indicated significant variations in dragon fruit production based on the different soil mixtures used. Soil mixture F showed superior performance in terms of vegetative growth, flower characters and fruit production, while Treatment E exhibited the better result than other soil mixtures.

Vegetative growth parameters

Table 2: Showing the effect of different soil mixtures on vegetative growth of dragon fruits.

Veg growth data	A	B	C	D	E	F	G	H
NVB	1	0	2	1	2	3	1	1
SCL	70.1	78.1	81.1	65.1	80.4	89.5	77.6	74.3
SCD	3.2	3.2	3.5	3.1	3.4	4.8	3.2	3.4
ARCH	2.56	2.8	2.7	2.6	2.7	2.8	2.6	2.55
DIST	2.5	3.2	2.71	2.5	2.5	2.51	2.5	2.61
SNUM	3	3	4	4	4	4	4	4
SLEN	3.64	3.71	3.6	4.1	4.2	4.5	4.1	

Fig 1: showing different vegetative structure.

NVB-No of Veg Bud Initiation, SCL- Length of Secondary Cladode(cm), SCD- Cladode Width(cm), ARCH-Arch Height, DIST- Distance between Aerolas (cm), SNUM-Spine number, SLEN- Length of Spine (mm)

1. Number of Vegetative Bud Initiation (NVB)

- **Null Hypothesis (H_0):** There is no significant difference in the means of NVB among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of NVB among soil mixtures.
- **ANOVA Result:** F-statistic = 17.11, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than the significance level (0.05), the null hypothesis is rejected. There is a significant difference in the means of NVB among the soil mixtures.

2. Length of Secondary Cladode (SCL)

- **Null Hypothesis (H_0):** There is no significant difference in the means of SCL among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of SCL among soil mixtures.
- **ANOVA Result:** F-statistic = 10.74, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of SCL among the soil mixtures.

3. Cladode Width (SCD)

- **Null Hypothesis (H_0):** There is no significant difference in the means of SCD among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of SCD among soil mixtures.
- **ANOVA Result:** F-statistic = 15.58, p-value = 0.0001
- **Conclusion:** Since the p-value (0.0001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of SCD among the soil mixtures.

4.Arch height (ARCH)

- **Null Hypothesis (H0):** There is no significant difference in the means of ARCH among soil mixtures.
- **Alternative Hypothesis (Ha):** There is a significant difference in the means of ARCH among soil mixtures. ANOVA
- **Result:** F-statistic = 6.66, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, we reject the null hypothesis. There is a significant difference in the means of ARCH among the soil mixtures.

5. Distance between areolas (DIST)

- **Null Hypothesis (H0):** There is no significant difference in the means of DIST among soil mixtures. Alternative Hypothesis
- **(Ha):** There is a significant difference in the means of DIST among soil mixtures. ANOVA
- **Result:** F-statistic = 1.81, p-value = 0.120
- **Conclusion:** Since the p-value (0.120) is greater than 0.05, we fail to reject the null hypothesis. There is no significant difference in the means of DIST among the soil mixtures.

6. Spine number (SNUM)

- **Null Hypothesis (H0):** There is no significant difference in the means of SNUM among soil mixtures.
- **Alternative Hypothesis (Ha):** There is a significant difference in the means of SNUM among soil mixtures. ANOVA
- **Result:** F-statistic = 17.10, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, we reject the null hypothesis. There is a significant difference in the means of SNUM among the soil mixtures.

7. Length of spine (SLEN)

- **Null Hypothesis (H0):** There is no significant difference in the means of SLEN among soil mixtures.
- **Alternative Hypothesis (Ha):** There is a significant difference in the means of SLEN among soil mixtures. **ANOVA Result:** F-statistic = 17.03, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, we reject the null hypothesis. There is a significant difference in the means of SLEN among the soil mixtures.

These results indicate that for each of the measured cladode characteristics, there is a significant difference in the means among the different soil mixtures. This suggests that the choice of soil mixture can have a significant impact on cladode characteristics in dragon fruit plants.

Fig 2: Showing different flower characters and pollination technique.

Flower Parameters

Table 3: Showing the effect of different soil mixtures on flower characters of dragon fruits

	A	B	C	D	E	F	G	H
NFB	2	2.66	3	2	4	6	3	2
ALF	19.93	22.06	23	20.93	24.13	27.16	22.2	20.1
ADF	11.73	14.13	14.66	14.1	15.53	17.76	14.53	12.1
DTA	22.33	20.33	19.66	21.33	19.33	17	21.03	23.1
LOS	12.43	13.5	17.03	13	16.73	18.3	11.63	13.13

NFB- No of Flower Buds, ALF- Average Length of Flower(cm), ADF - Average Diameter of the Flower (cm), DTA - Day to Anthesis, LOS- Length of Style (cm)

1. Number of Flower Buds (NFB)

- **Null Hypothesis (H_0):** There is no significant difference in the means of NFB among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of NFB among soil mixtures.
- **ANOVA Result:** F-statistic = 8.89, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of NFB among the soil mixtures.

2. Average Length of Flower (ALF)

- **Null Hypothesis (H_0):** There is no significant difference in the means of ALF among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of ALF among soil mixtures.
- **ANOVA Result:** F-statistic = 9.43, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of ALF among the soil mixtures.

3. Average Diameter of the Flower (ADF)

- **Null Hypothesis (H_0):** There is no significant difference in the means of ADF among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of ADF among soil mixtures.
- **ANOVA Result:** F-statistic = 6.96, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of ADF among the soil mixtures.

4. Days to Anthesis (DTA)

- **Null Hypothesis (H_0):** There is no significant difference in the means of DTA among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of DTA among soil mixtures.
- **ANOVA Result:** F-statistic = 6.11, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of DTA among the soil mixtures.

5. Length of Style (LOS)

- **Null Hypothesis (H_0):** There is no significant difference in the means of LOS among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of LOS among soil mixtures.
- **ANOVA Result:** F-statistic = 3.35, p-value = 0.006
- **Conclusion:** Since the p-value (0.006) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of LOS among the soil mixtures.
- **Overall Interpretation:** These results indicate that for each of the measured flower characteristics, there is a significant difference in the means among the different soil mixtures. This suggests that the choice of soil mixture can have a significant impact on flower characteristics in dragon fruit plants.

Fig 3: Showing fruit characteristics and brix value of harvested fruits.

Fruit Parameters

Table 4: Showing the effect of different soil mixtures on fruit characters of dragon fruits

	A	B	C	D	E	F	G	H
ALF	7.33	8.03	10.26	8.03	9.23	15.06	10.26	9
FED	6.22	6.88	7.82	6.49	7.65	11.75	6.77	6.36
NOB	13.33	15	16	17	17	22	17	16
LAB	3.23	3.73	3.16	3.1	4.13	5.2	3.46	3.8
WBB	2.3	2.5	2.36	2.1	2.53	2.66	2.2	2.1
DAM	32.66	32	30	34	30.66	26	32	30
NFC	2	3	3	2	3	3	2	2
AFY	4	10.66	9.66	5	13	14	8	6
AFW	126	147.66	165	134.66	192.66	255.33	145	135

- ALF - Average Length of Fruit
- FED - Fruit Equatorial Diameter
- NOB - Number of Bracts
- LAB - Length of Apical Bract
- WBB - Width of Base of the Bract
- DAM - Days from Anthesis to Maturity
- NFC - Number of Fruiting Cycles
- AFY - Average Fruit Yield
- AFW - Average Fruit Weight

1. Average Length of Fruit (ALF)
- **Null Hypothesis (H_0):** There is no significant difference in the means of ALF among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of ALF among soil mixtures.
- **ANOVA Result:** F-statistic = 17.48, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of ALF among the soil mixtures.

2. Fruit Equatorial Diameter (FED)
- **Null Hypothesis (H_0):** There is no significant difference in the means of FED among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of FED among soil mixtures.
- **ANOVA Result:** F-statistic = 6.63, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of FED among the soil mixtures.

3. Number of Bracts (NOB)
- **Null Hypothesis (H_0):** There is no significant difference in the means of NOB among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of NOB among soil mixtures.
- **ANOVA Result:** F-statistic = 20.03, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of NOB among the soil mixtures.

4. Length of Apical Bract (LAB)
- **Null Hypothesis (H_0):** There is no significant difference in the means of LAB among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of LAB among soil mixtures.
- **ANOVA Result:** F-statistic = 8.16, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of LAB among the soil mixtures.

5. Width of Base of the Bract (WBB)
- **Null Hypothesis (H_0):** There is no significant difference in the means of WBB among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of WBB among soil mixtures.
- **ANOVA Result:** F-statistic = 5.68, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of WBB among the soil mixtures.

6. Days from Anthesis to Maturity (DAM)
- **Null Hypothesis (H_0):** There is no significant difference in the means of DAM among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of DAM among soil mixtures.
- **ANOVA Result:** F-statistic = 5.90, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of DAM among the soil mixtures.

7. Number of Fruiting Cycles (NFC)

- **Null Hypothesis (H_0):** There is no significant difference in the means of NFC among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of NFC among soil mixtures.
- **ANOVA Result:** F-statistic = 10.90, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of NFC among the soil mixtures.

8. Average Fruit Yield (AFY)

- **Null Hypothesis (H_0):** There is no significant difference in the means of AFY among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of AFY among soil mixtures.
- **ANOVA Result:** F-statistic = 16.56, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of AFY among the soil mixtures.

9. Average Fruit Weight (AFW)

- **Null Hypothesis (H_0):** There is no significant difference in the means of AFW among soil mixtures.
- **Alternative Hypothesis (H_a):** There is a significant difference in the means of AFW among soil mixtures.
- **ANOVA Result:** F-statistic = 16.68, p-value = 0.001
- **Conclusion:** Since the p-value (0.001) is less than 0.05, the null hypothesis is rejected. There is a significant difference in the means of AFW among the soil mixtures.

These results indicate that for each of the measured fruit characteristics, there is a significant difference in the means among the different soil mixtures. This suggests that the choice of soil mixture can have a significant impact on fruit characteristics in dragon fruit plants.

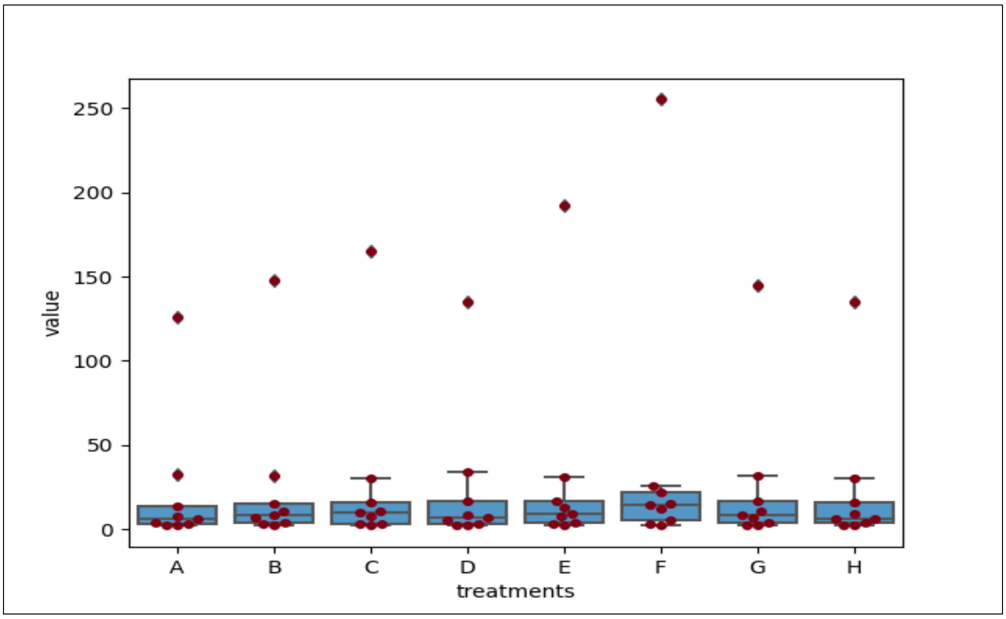

Fig 4: Box plot showing the best soil mixture for optimum fruit production.

The findings of these studies have been highly encouraging. Dragon fruit has demonstrated remarkable adaptability to the local environment, thriving even in saline soil conditions. The experiments revealed that specific soil mixtures and cultivation practices can significantly enhance dragon fruit yield. This adaptability and potential for improved yield make dragon fruit a promising alternative to traditional crops. Moreover, dragon fruit cultivation is well-suited for smallholder farmers in the Southern Sundarban. It requires minimal land and resources (Nangare DD *et al*., 2020) [6] making it an accessible option for those with limited agricultural holdings. The economic benefits of dragon fruit production are also noteworthy. The crop fetches a competitive market price and can substantially increase farmers' income, reducing their vulnerability to the impact of cyclones on traditional crops.

Conclusion

The results of this study emphasize the importance of soil composition in dragon fruit cultivation. The soil mixture with well-balanced drainage and nutrient-holding capacity (soil mixture F) exhibited the most desirable outcomes in terms of plant height, stem diameter, and fruit production. Growers should consider soil characteristics, such as texture, drainage, and organic matter content, when selecting an appropriate soil mix for dragon fruit cultivation to optimize plant growth and yield. In conclusion, dragon fruit has emerged as a compelling alternative crop for the cyclone-prone Southern Sundarban region. Its ability to thrive in challenging environmental conditions, coupled with its economic and nutritional benefits, positions it as a promising choice for sustainable agriculture and livelihoods in this unique area. To fully realize the potential of dragon fruit, future efforts should focus on practical applications, including farmer training, infrastructure development, and market access. Harnessing the full potential of dragon fruit can contribute to resilience against recurrent cyclonic events and provide economic stability to the local population, ultimately transforming agriculture in the Southern Sundarban region. (Wakchaure *et al*., 2020) [8]

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