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Evaluating The Performance Of BAU Sapota-4 Under Saline Stressed Environment Of Bangladesh

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Abstract
An experiment was conducted at the Germplasm Centre (GPC) of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and saline stressed Bagerhat district during the period from May to September, 2024 to evaluate the comparative performance of BAU Sapota-4 in terms of growth, yield, and nutrient content. The experiment was consisted of single factor with ten replications. The morphological (plant height, number of branches, leaves, and canopy volume), physiological (flowering duration, fruit setting, and yield), and biochemical parameters (vitamin C, total sugar, reducing sugar, and titratable acidity) alongside the soil factors (pH, electrical conductivity, organic matter, total nitrogen, phosphorus, and potassium levels) were measured. The results indicated that significant regional effects influenced the morphological, physiological, and biochemical traits of BAU Sapota-4. Between the regions, the BAU Sapota-4 exhibited superior growth (tallest plant, maximum leaves, maximum branches and higher canopy volume) in all the months after planting (23, 24, 25 and 26 MAP) and also noticed higher yield (maximum number of flowers and fruits, maximum harvested fruits, heaviest fruit) at the Fruit Research Center of Bangladesh Institute of Nuclear Agriculture (BINA-FRC) while saline stressed Rampal of Bagerhat district experienced faster flowering and fruit setting. Regarding quality characters, the BAU Sapota-4 showed the highest vitamin C and total sugar content at BINA-FRC while the highest reducing sugar content at Rampal, Bagerhat but neither site had a significant impact on the acidity of the fruits. Furthermore, the soil analysis revealed greater nutrient fluctuations in Rampal soil during the study period (May, June and August) than BINA-FRC soil. Moreover, the climatic condition (maximum temperature, minimum temperature, and rainfall) of Rampal fluctuated more during the study period rather than the climatic condition of BINA-FRC. This may be due to its close proximity to the Bay of Bengal which makes Rampal experiencing heavy showers and more vulnerable to cyclones and coastal flooding. Thus, it can be concluded that though the cultivar BAU Sapota-4 showed inferior development in Rampal region, it exhibited reasonable growth rates, earlier flowering and fruit setting, and resilience under challenging environment by producing economically viable fruit and maintaining its quality at acceptable level. Therefore, these findings underline the importance of saline-tolerant fruit varieties like BAU Sapota-4 in enhancing food security and livelihoods in the coastal regions of Bangladesh and also suggests strategies for improving agricultural practices, including farmer training, soil management, and promotion of saline-tolerant crop varieties.

Keywords: *BAU Sapota-4, BINA-FRC, Environment, Growth, Performance, Stress, Yield*

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I. Introduction

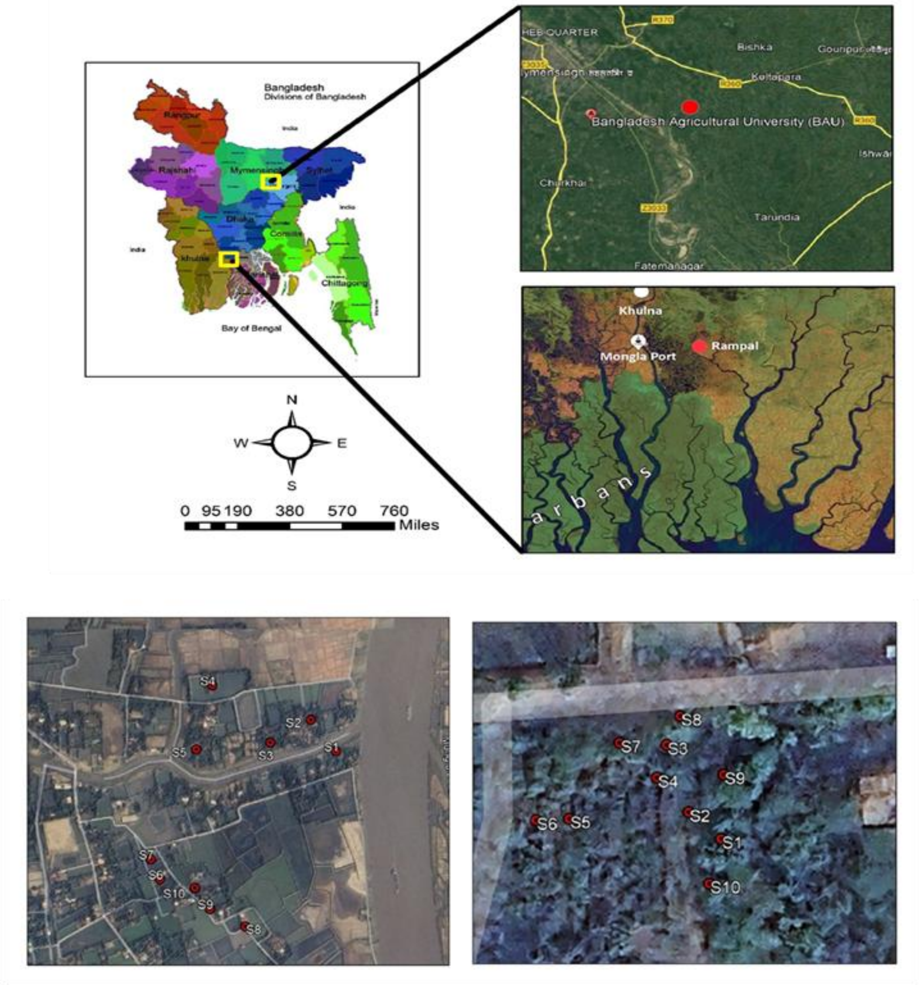
Sapota, often called sapodilla *Achras sapota* L., is an evergreen fruit tree (Rymbai, 2019) belongs to the family Sapotaceae (Armstrong *et al*., 2012) comprising about 50 genera, 1100 species and among the edible species around 70 species of sapota exists in tropical America and South East Asia (Milind and Preeti, 2015; Jayachandran *et al*., 2023). Although sapota is indigenous to Yucatan peninsula, Central America and Mexico, it has greatly spread throughout South Asia, Southeast Asia, and portions of Africa and the Caribbean due to its adaptability to different climates, high demand, and economic value (Uekane *et al*., 2017; Dola *et al*., 2019; Baskar *et al*., 2020). Sapota is known by number of names including chico, sapodilla, lamut, chicle etc. (Sudhakar, 2022). Sapota is regarded as one of the most significant small fruit crop due to its rich nutritional profile, medicinal and economic importance (Pawar *et al.*, 2011; Singh *et al*., 2020; Bangar *et al*., 2022). Nutritionally, sapota is rich in vitamins, minerals, and antioxidants (Oliveira *et al*., 2011). It is an excellent source of dietary fiber which supports digestive health and contains several phytochemical constituents belonging to categories such as alkaloids, carbohydrates, glycosides, tannins, triterpenes and flavonoids etc.

(Peter, 2008; Kamaruddin *et al*., 2021; Tewari *et al*., 2021). Economically, sapota is a high-value crop for farmers especially in regions with saline-prone soils where crop cultivation can be challenging due to the adverse effects of salinity on plant growth and productivity (Mansour, 2003; Hanin *et al*., 2016; Lal, 2016; Raghavendra *et al*., 2020). Bangladesh is one of densely inhabited countries in the world with a population of 165.16 million (BBS, 2023). The coastal area of Bangladesh covers about 20% of the whole country and over 30% of the total cultivable areas. About 40 million people of the coastal areas of Bangladesh depend on agriculture and experiencing vulnerability to salinity, sea level rise, cyclone and tidal surges (BBS, 2018). As per the report of Soil Resource Development Institute of Bangladesh, about 0.833 million are affected by varying degrees of salinity out of these coastal and offshore areas where about 0.203 million ha of land is very slightly (2-4 dSm^{-1}), 0.492 million ha is slightly (4-8 dSm^{-1}), 0.461 million ha is moderately (8-12 dSm^{-1}) and 0.490 million ha is strongly (>12 dSm^{-1}) salt affected soils in southwestern part of the coastal area of Bangladesh (SRDI, 2007 and 2020). Therefore, southwestern region of Bangladesh is highly vulnerable to soil salinity where increasing trend of salinity is from November-December to March-April, until the onset of the monsoon rains (SRDI, 2020). This increased soil salinity can limits the growth of standing crops, threatens crop yields, soil health, and water quality, and creates nutrient deficiency and micronutrients imbalances and making the soil unsuitable for many potential crops (Bazzaz and Hossain, 2015; Lu *et al*., 2016; Shirazi *et al.*, 2016). Moreover, normal crop production in this region is also hampered due to inadequate irrigation water source, unavailability of salt tolerant crop varieties, habited to cultivation local variety, increase climate change related natural disaster, insufficient locally adaptable technologies for mitigating salinity problem (Gupta and Sharma, 2010; Hasegawa, 2013; Acosta-Motos *et al*., 2017; Miah *et al*., 2020). Therefore, soil salinity not only destructs crop yield but also causes a loss of total crop production and reduces agricultural biodiversity and the economic resilience of local farmers (Hossain *et al*., 2011; Gain *et al.*, 2014; Nikam *et al*., 2016; Alam *et al.*, 2017). In this situation, it is deemed necessary to find out an alternative farming strategy in the context of changing climate that helps to reduce the sufferings. Saline tolerant crop and fruit varieties can be a good farming strategy in this aspect that replace fruits failure occurrence. Hence, keeping in view an attempt was made to identify the promising BAU sapota-4 variety's suitability in saline stressed region of Bangladesh for food and nutrition security and livelihoods. So, the main objective of this study was to assess the comparative performance of BAU Sapota-4 in terms of growth, yield, and nutrient content at BAU campus, Mymensingh, and salinity stressed Rampal Upazila of Bagerhat district.

II. Materials And Methods

The study was conducted to evaluate the comparative performance of BAU Sapota-4 in terms of growth, yield, and nutrient content at the Germplasm Centre (GPC) of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and Bagerhat district during the period from May to September, 2024. The experiment was consisted of single factor: two treatments of locations i) Fruit Research Center of BINA, BAU, Mymensingh and ii) Rampal upazila, Bagerhat. The BAU Sapota-4 was used as planting material released by BAU-GPC. One year grafted sapota fruit saplings were planted in both Rampal and BINA-FRC locations on July, 2022. In Rampal upazila, sapota saplings were collected from World Vision Bangladesh (WVB) and farmers planted them in their homestead areas. The experiment was laid out on 22 months old plants of BAU Sapota-4 in row planting with ten replications in both locations. Single plant of each BAU sapota-4 about 2 years old plant was considered as replication and therefore a total of twenty treatment combinations of the locations were considered. For assessing the performance of BAU Sapota-4, the data on morphological, physiological and biochemical parameters were collected and besides soil samples were collected to know the nutritional status of the study locations. The data on morphological parameters (plant height, leaves $plant^{-1}$, branches $plant^{-1}$ and canopy volume) were collected at 35 days interval from 23 MAP to 26 MAP (Months After Planting). The data on physiological parameters (Days to complete flowering, days to fruit setting, number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, number of harvested fruits $plant^{-1}$, individual fruit weight and yield) and the biochemical parameters (vitamin C, total sugar, reducing sugar, titratable acidity) were recorded during and after harvesting stage, respectively. The soil samples were collected three times through a V-shape method described by Islam *et al (*2021) from ten homogenous plot of both Rampal and BINA-FRC locations on monthly basis (May, June, and August of 2024). Among the biochemical parameters, the vitamin C, total sugar, reducing sugar and titratable acidity were determined with DCPIP visual titration method described by Ranganna (2001), procedure of David (1990), method of miller (1972) and AOAC (1990) method described by Jadhav *et al. (*2018), respectively in the Laboratories of the Biochemistry and Molecular Biology Department of BAU, Mymensingh. To know the soil nutritional status, the soil textures, soil pH, electrical conductivity, organic matter, total nitrogen, phosphorus, and exchangeable potassium levels were determined through a Hydrometer method (USDA), a portable EC-Conductivity meter (Model: EXTECH, EC500), Walkley and Black's wet oxidation method, Modified Olsen's Method and semi-micro Kjeldhal method, and Nessler method, respectively at the Laboratories of the Horticulture Division, BINA (Negash and Mohammed, 2014;

Huq and Alam, 2005; Sattar and Rahman, 1987; Roberts, 1971). The recorded data for morphological, physiological and bio-chemical parameters from the present experiment were tabulated and analyzed statistically to find out the variation resulting from experimental treatment using statistix 10 package program. The means for all treatments were calculated and analyses of variances of parameters under study were performed by Duncan's Multiple Range Test (DMRT) test at 5% and 1% levels of significance (Duncan, 1951). The means of the parameter were separated by least significant difference test. Additionally, the Microsoft Office Excel (MS-Excel) program was utilized to analyze the soil text data in tabular and graphical representations.



(a) (b)

Figure 1. Study Area; sampling points (a) Rampal upazila and (b) BINA-FRC, BAU

(a) (b)

Photograph 1: (a) BAU Sapota-4 in Rmpal, Bagerhat region and (b) BAU Sapota-4 in BINA-FRC

(c) (d)

Photograph 2: (c) Flowering and fruit stage and (d) Harvesting stage of BAU Sapota-4

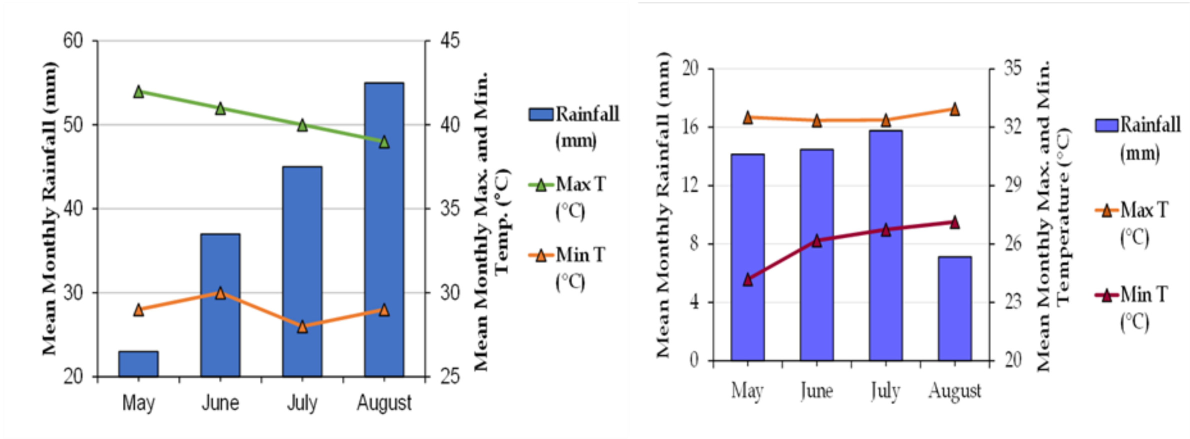
(e) (f)

Photograph 3: (e) Biochemical parameters analysis and (f) soil samples analysis in laboratory

III. Results

Climatic Variation of the Study Locations

During the study period, the climatic condition of the Rampal region experienced highest rainfall (55 mm), maximum temperature (42°C) and also showed highest value of minimum temperature (28°C) rather than BINA-FRC, BAU (figure 2). This may be due to their geographical location. The close proximity of Rampal to the Bay of Bengal makes it experiencing heavy showers and more vulnerable to cyclones and coastal flooding, whereas BAU, situated in the floodplains near the Brahmaputra River, experiences seasonal river flooding (Rahman *et al.*, 2011).



(a) **(b)**

Source:

Figure 2. Mean monthly weather condition of the study locations (a) Rampal, Bagerhat and (b) BINA-FRC, BAU

Physicochemical Properties of Soil of the Study Locations

Soil physical property

Soil textural class defines the proportion of sand, silt, and clay particles in soil. There were textural differences between saline prone zone and floodplain zone of the study where Rampal of Bagerhat had sandy loam and Fruit Research Center of BINA (BINA-FRC) had silt loam textural classes, respectively. The sand, silt and clay contents ranged from 55.64-37%, 26-55% and 18.36-8%, respectively, with high variation in the sand and silt fraction. This textural variation could be due to the stark differences in water dynamics, sediment deposition, and salinity levels. Parida and Das (2005) reported soil salinity increasing rate of sandy loam soil is approximately double than that of clay soil.

Table 1. Soil textural class of the study locations

Location	Soil Particle Size			
	Sand (%)	Silt (%)	Clay (%)	Textural Class
Rampal of Bagerhat	55.64	26	18.36	Sandy Loam
BINA-FRC	37	55	8	Silt Loam

Soil chemical properties

The soil pH, electrical conductivity, organic matter, total nitrogen, available phosphorus and exchangeable potassium of the study locations varied on a monthly basis (may, june, july and august) during the study period.

Soil pH

The soil pH of Rampal ranged from 6.945 to 8.506, while the soil pH of BINA-FRC ranged from 5.953 to 6.502. Thus, the pH results show that the soil in Rampal is neutral to highly alkaline, while the soil in BAU-FRC is somewhat acidic. This excessive alkalinity may be due to farmers' use of alkaline fertilizers, such potassium carbonate or calcium nitrate, which may raise soil pH when applied often.

Soil electrical conductivity

The electrical conductivity of BINA-FRC soil varied from a minimum of 0.504 dSm^{-1} to a high of 0.904 dSm^{-1}, whereas that of Rampal soil ranged from a minimum of 2.844 dSm^{-1} to a maximum of 5.494 dSm^{-1}. This indicated that the soil had different quality based on different locations. According to Reeder's (2020) electrical conductivity (EC) class, floodplain BINA-FRC soil suggests that salinity is not an issue for the majority of plants, whereas saline-prone Rampal soil exhibits a minor to moderate salinity level. This varying rate of EC in Rampal may be owing to the area's closeness to salty coastal regions as per Hossain *et al.* (2016).

Soil organic matter

The OM content in RB was 1.378%, 2.014%, and 2.755% in May, June, and July whereas in BINA-FRC, it was 1.954%, 1.904%, and 1.936%. As a result, although BINA-FRC maintains an equivalent level over the months, the OM content of RB soil fluctuated the greatest but both showing a medium status as per Ahmed *et al.* (2018) classification of soil organic matter. The higher OM content in Rampal soil than BINA-FRC could be attributed to close proximity of Rampal to Sundarbans where mangrove vegetation continually transported nutrient-rich sediments via rivers, tidal flows, and seasonal flooding.

Soil total nitrogen

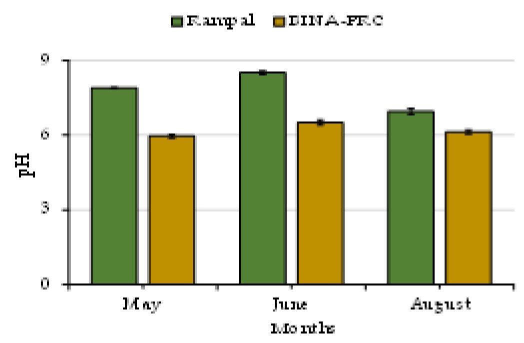
The total nitrogen levels in the soil of Rampal and BINA-FRC ranged from 0.07% to 0.14% and 0.09% to 0.11%, respectively, indicating extremely low to low status. The BINA-FRC soil maintained a nearly same level of total nitrogen content throughout the time, whereas the RB soil fluctuated most. For agricultural land, the ideal TN value is between 0.27% and 0.36% (Ahmed *et al.*, 2018). As a result, both Rampal and BINA-FRC had lower levels of total nitrogen than was ideal, which might lead to nutritional deficiencies in the soil and hence reduce yields from crops.

Soil available phosphorus

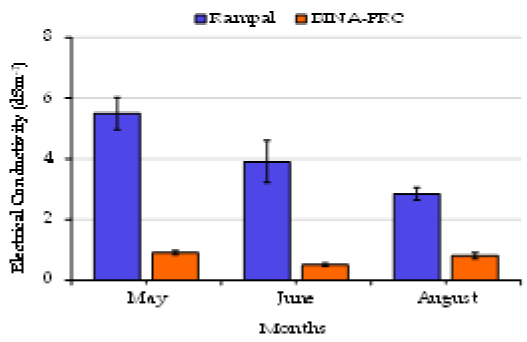
The available phosphorus in Rampal and BINA-FRC soil ranged from 39.543 ppm to 31.435 ppm, demonstrating a very high nutritional status and 14.523 ppm to 17.321 ppm, indicating a medium phosphorus nutritional condition respectively. For Bangladeshi agricultural practices, the ideal range of accessible P in soil is 18.1 ppm to 24.0 ppm (Ahmed *et al.* 2018). Rampal of Bagerhat therefore revealed extremely high soil phosphorus levels and this may be explained by the fact that salinity lowers phosphate uptake and accumulation in plants, which in turn increases phosphate absorption and buildup in soils (Grattan and Grieve 2019) impacting on plant metabolism as well as vegetative and reproductive organs.

Soil exchangeable potassium

The exchangeable potassium levels in the study region were 0.083-0.0124 meq100g^{-1} in BINA-FRC and 0.343-0.541 meq100g^{-1} in Rampal soil. According to Ahmed *et al.* (2018), the ideal amount of exchangeable K in soil is 0.226-0.300 meq100g^{-1}. Consequently, BINA-FRC had a low exchangeable K content, while RB had a very high exchangeable K status during the course of the trial. This higher status of potassium in Rampal soil can reduce the quality of fruits and vegetables by affecting sugar transport and reducing the calcium content in crops.



(a)



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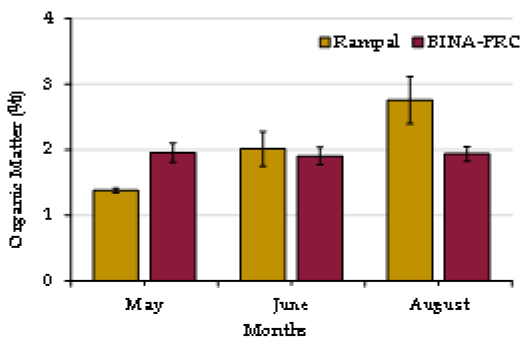

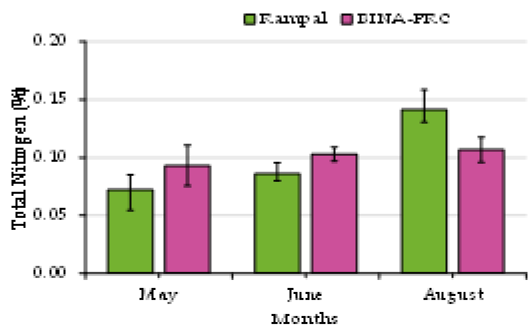

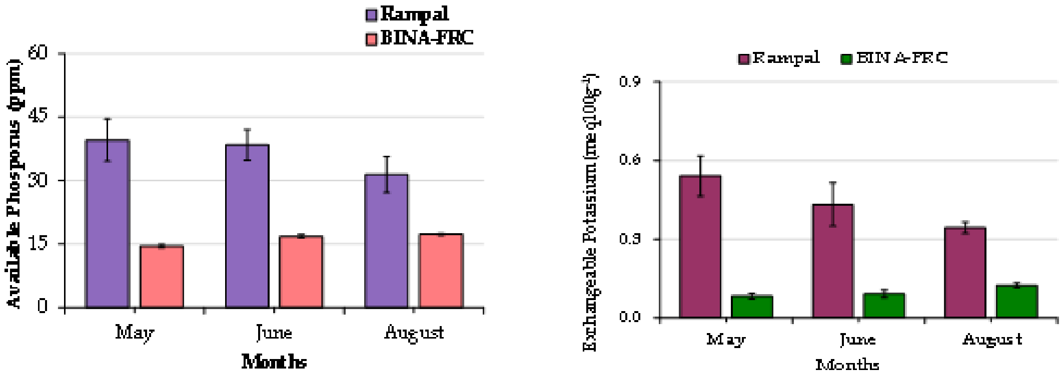

(e) (f)

Figure 3. Nutrient status of soil of the study locations (a) pH (b) Electrical Conductivity (c) Organic matter (d) Total nitrogen (e) Available phosphorus (f) Exchangeable potassium

(c) (d)

Assessment of BAU Sapota's performance

Morphological characters assessment

Morphological parameters (plant height, leaves plant^{-1}, branches plant^{-1}, and canopy volume) of BAU Sapota-4 showed highly variation due to studied areas (Rampal of Bagerhat and BINA-FRC) in the months of 23, 24, 25 and 26 after planting. At 23 MAP, highest plant height (1.67m), maximum production of leaf plant^{-1} (1958.10), maximum production of branches plant^{-1} (39.10), and maximum canopy volume (1.913 m^3) was observed at L_2 (BINA-FRC) and lowest plant height (0.91m), minimum production of leaf plant^{-1} (319.00), minimum production of branches plant^{-1} (14.70), and lower canopy volume (0.156 m^3) was observed at L_1 (table 2 and table 3). This trend continued at 24, 25 and 26 MAP. But at 25 MAP, the leaf and branches number of sapota plant in L_2 slightly decreased due to pruning activities but it still holds higher rank than leaf and branches number of BAU sapota plant at L_1. Thus, the cultivar BAU sapota-4 performed better at the BINA-FRC (L_2) in terms of morphological features than did the Rampal of Bagerhat (L_1) area. Compared to the typical floodplain zone of the Fruit Research Center of BINA, BAU, the Rampal region's soil salinity fluctuates more, which might be the cause of this inferior development.

Table 2. Effect of Locations on the plant height and number of leaves plant^{-1} of BAU Sapota- 4 at different months after planting (23, 24, 25, 26 MAP)

Treatment (Locations)	Morphological characters							
	Plant height (m)				Number of leaves plant^{-1}			
	23	24	25	26	23	24	25	26
L_1	0.91^b	1.03^b	1.11^b	1.15^b	319.00 b	525.30 b	797.10 b	888.80 b
L_2	1.67^a	1.86^a	2.02^a	2.14^a	1958.10a	3092.40a	2786.00a	3938.20a
$LSD_{0.05}$	0.11	0.14	0.07	0.10	82.13	192.66	176.32	229.64
SE(±)	0.05	0.06	0.03	0.04	36.31	85.17	77.94	101.51
Level of significant	**	**	**	**	**	**	**	**
CV (%)	8.75	9.32	4.63	6.07	7.13	10.53	9.73	9.40

Mean in column followed by dissimilar letter are significantly different whereas similar letter do not differ significantly as per DMRT.

**= Significant at 1% level of probability.

L_1: Rampal of Bagerhat L_2: BINA-FRC of Mymensingh

Table 3. Effect of locations on the number of branches plant^{-1} and canopy volume of BAU Sapota-4 at different months after planting (23, 24, 25, 26 MAP)

Treatment (Locations)	Morphological characters							
	Number of branches plant^{-1}				Canopy volume (m^3)			
	23	24	25	26	23	24	25	26
L_1	14.70 b	16.40 b	18.10 b	18.50 b	0.156b	0.477b	0.605b	0.675b
L_2	39.10a	40.30a	37.40a	38.60a	1.913a	2.802a	2.860a	3.690a
$LSD_{0.05}$	1.52	1.56	1.31	1.41	0.09	0.07	0.09	0.08
SE(±)	0.67	0.69	0.58	0.62	0.04	0.03	0.04	0.04

Level of significant	**	**	**	**	**	**	**	**
CV (%)	5.57	5.45	4.66	4.88	8.20	4.08	5.23	3.65

Mean in column followed by dissimilar letter are significantly different whereas similar letter do not differ significantly as per DMRT.
**= Significant at 1% level of probability.
L_1: Rampal of Bagerhat, L_2: BINA-FRC of Mymensingh

Physiological characters assessment

In case of physiological factors (yield contributing characters), the cultivar BAU sapota-4 had the greatest time requirements (35.50 and 35.10) for both full flowering and fruit setting in BINA-FRC and the smallest time requirements (33.10 and 34.40) in the saline-prone zone of Rampal (table 3). This lowest time may be attributed to the Abscisic acid (ABA) and ethylene concentration which cause the quickest blooming in plants under saline stress conditions (Munns and Tester, 2008). Besides, Rampal had less flowers and fruits per plant (25.20 and 5.25) than BINA-FRC, which had more (37.70 and 11) (table 3). This might be because of nutritional imbalances caused by salt stress, which limit the development of flowers even when the plant blossoms sooner (Grattan and Grieve, 2019). At the harvesting stage, the cultivar BAU sapota-4 produced the most fruits (8.80), the heaviest fruit weight (214.30g), and the highest yield plant^{-1} (1.805) in BINA-FRC. In contrast, the saline-prone Rampal produced the least amount of fruits (4.47), and the yield was 0.751 (Table 3).

Table 4. Effect of locations on fruit yield and yield contributing characters of BAU Sapota-4

Treatment (Locations)	Physiological characters						
	Days to 100% flowering	**Days to fruit setting**	**Number of flowers plant^{-1}**	**Number of fruits plant^{-1}**	**Number of harvested fruits plant^{-1}**	**Weight of individual fruit (g)**	**Fruit yield (Kg plant^{-1})**
L_1	33.10b	34.40b	25.20 b	5.25b	4.47b	199.20b	0.751b
L_2	35.50a	35.10a	37.70a	11.00a	8.80a	214.30a	1.805a
$LSD_{0.05}$	1.23	0.59	1.36	0.78	0.37	11.46	0.13
SE(±)	0.54	0.26	0.60	0.34	0.16	5.07	0.06
Level of significant	**	*	**	**	**	**	**
CV (%)	3.53	1.68	7.70	9.46	5.55	5.48	10.05

Mean in column followed by dissimilar letter are significantly different whereas similar letter do not differ significantly as per DMRT.
**= Significant at 1% level of probability,
*= Significant at 5% level of probability
L_1: Rampal of Bagerhat, L_2: BINA-FRC of Mymensingh

Bio-chemical characters assessment

BAU sapota-4's vitamin C and total sugar content were lower in Rampal (11.01 mg 100g^{-1} and 12.87%) compared to higher in BINA-FRC fruits (21.85 mg100g^{-1} and 13.70%) (Table 5). Salinity levels may be to blame for this, as they may reduce the stability of vitamin C, especially in fruit juices. Rampal, on the other hand, demonstrated a greater amount of reducing sugar content (10.63%) than BINA-FRC (8.07%), although there was no discernible difference in titratable acidity (Table 5). It is possible to attribute this variance to the fact that salty conditions raise the levels of TSS and acid in fruit juice (Pasalic, 2017).

Table 5. Effect of locations on chemical composition of BAU Sapota-4 variety

Treatment (Locations)	Bio-chemical Characters			
	Vitamin C (mg100g^{-1})	**Total sugar (%)**	**Reducing sugar (%)**	**Titratable acidity (%)**
L_1	11.01^{b}	12.87^{b}	10.63^{a}	0.600^{a}
L_2	21.85^{a}	13.70^{a}	8.07^{b}	0.607^{a}
$LSD_{0.05}$	0.60	0.63	0.75	0.009
SE(±)	0.26	0.28	0.33	0.004
Level of significant	**	**	**	NS
CV (%)	3.65	4.71	7.97	1.54

Mean in column followed by dissimilar letter are significantly different whereas similar letter do not differ significantly as per DMRT.
**= Significant at 1% level of probability, NS = Non significant
L_1: Rampal of Bagerhat, L_2: BINA-FRC of Mymensingh

IV. Discussion

Morphological parameters of plants are measurable physical traits to assess plant health, growth stages, adaptation, and performance in specific environments. The morphological features (plant height, leaves plant^{-1}, branches plant^{-1}, and canopy volume) of BAU Sapota-4 were significantly influenced by study locations. Between the locations, the saline prone Rampal of Bagerhat district (L_1) showed significantly smallest plant, minimum number of leaves plant^{-1} and branches plant^{-1}, lower canopy volume (1.15 m, 888.80, 18.50, and 0.675 m^3) than floodplain zone of BINA-FRC (L_2), BAU (2.14 m, 3938.20, 38.60, and 3.690 m^3) throughout the whole study period (23, 24, 25 and 26 MAP). This inferior development of BAU Sapota-4 in Rampal of Bagerhat district than BINA-FRC is may be due to the highly variation in climatic condition (rainfall, maximum and minimum temperatures) and nutrient fluctuations (soil pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, exchangeable potassium) in soil. The present findings are in agreement with the findings of Bhuiya (2016) where the BAU-GPC released Sapota plant in the BINA-FRC had higher plant morphology characters (plant height 1.93m , 41.23 branches plant^{-1}, 1.79 m^3) than the saline zone of Mongla in Bagerhat district (1.71m, 37.52, and 1.64 m^3). Conversely, Ma *et al.* (2019) demonstrated that plant height rose from 121 to 132 meters, indicating a 9.09% increase under <4 dSm^{-1} after a year of transplanting. However, the percentage gain progressively declined as the salt level rose. Patel (2018) conducted another study in a coastal agro climate condition and found that PKM-4 had the largest canopy area (2.67m^2) and the greatest plant height (1.746m) and number of branches (36) in CO-1.

The physiological characters (flowering duration, fruit setting, and yield) showed statistically significant differences due to the effect of different locations. The cultivar BAU sapota-4 showed maximum time requirements (35.50 and 35.10) for both full flowering and fruit setting and maximum number of fruits and flowers per plant (37.70 and 11) in BINA-FRC and the smallest time requirements (33.10 and 34.40) and less flowers and fruits per plant (25.20 and 5.25) in the saline-prone zone of Rampal. The research is supported by Roy *et al.* (2014), who experimented on BAU sapota-1 and found that the fruit set took the longest (35.40) days in BAU-GPC and the quickest (30.80) days in Gaibandha sadar. In converse, Islam *et al.* (2016) showed BAU Sapota-3 had more flowers per shoot (11.20) than Desi Sapota (22.00), and Patel (2016) found that Mohan Gootee had more blooms per shoot (18.14) in the coastal zone of Odisha. At the harvesting stage, the cultivar BAU sapota-4 produced the most fruits (8.80), the heaviest fruit weight (214.30g), and the highest yield plant^{-1} (1.805) in BINA-FRC. In contrast, the saline-prone Rampal produced the least amount of fruits (4.47), and the yield was 0.751. This is comparable to a research by Bhuiya (2016) that found the saline-prone Mongla of Bagerhat had the lowest amount of fruits gathered (5.78), while Agailjara of Barisal had the most (15.58). Similarly, García-Sánchez *et al.* (2003) showed similar findings in lemon fruit where fruit yield significantly decreased (number of fruits not the fruit size) with increasing salinity.

The Bio-chemical characters of BAU Sapota-4 showed significant variation between locations of the study area. The cultivar BAU Sapota-4 showed highest vitamin C and total sugar content (21.85 mg100g^{-1} and 13.70%) in BINA-FRC location and Rampal showed highest reducing sugar content (10.63%) but there was no significant difference in titratable acidity in both locations. This is similar with a study by Hepaksoy (2004) who discovered titratable acidity decreased from 2.38% to 1.24% and was not substantially different and also showed the TSS content was somewhat higher near the seaside fruits (11.65% to 12.36%) than inland fruits (10.06% to 11.16%). However, in saline conditions, Pasalic *et al.* (2017) found that both grafted and non-grafted tomato fruits had greater levels of sugar and total acidity. Among all treatments under salt stress, Ahmed *et al.* (2019) discovered that lettuce had a greater reducing sugar concentration.

V. Conclusion

The research comprehensively examined the performance of BAU Sapota-4 under saline-stressed conditions in Rampal of Bagerhat, compared to its performance at BINA-FRC, Mymensingh. The findings confirmed that BAU Sapota-4 is a robust, high-yielding fruit variety well-suited to saline environments. Morphological parameters such as plant height, canopy volume, and the number of leaves and branches showed significant differences across regions, with BINA-FRC consistently demonstrating superior growth metrics. In terms of physiological characteristics, BAU Sapota-4 demonstrated earlier flowering and fruit setting under saline conditions, likely due to stress-induced hormonal changes. Although yield parameters like the number of flowers and harvested fruits were somewhat lower at Rampal, the variety showed resilience by producing economically viable fruit under these challenging conditions. Nutritionally, BAU Sapota-4 excelled in producing fruits with higher vitamin C and total sugar content, particularly in less saline conditions, while maintaining resilience in harsher environments like Rampal. Despite these regional disparities, the survival rate of BAU Sapota-4 in saline conditions was remarkably high, indicating its adaptability and potential for wider adoption. Therefore, the BAU Sapota-4 emerges as a promising candidate for combating the challenges posed by soil salinity in Bangladesh's coastal regions. Its cultivation can contribute significantly to food and nutritional security while providing economic stability to farming communities. Continued research and extension efforts should focus on optimizing cultivation techniques and expanding awareness to further promote BAU Sapota-4's adoption across saline-prone areas.

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