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Evaluation of the Different Low-Tech Protective Cultivation Approaches to Improve Yield and Phytochemical Accumulation of Papaya (*Carica papaya* L.) in Bangladesh

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Abstract: The production of horticultural crops in the outdoor environment facing various environmental factors, such as cyclones, droughts, heavy rain, and hailstorms, significantly affects the papaya production in the sub-tropical regions, especially in Bangladesh. Protected cultivation of horticultural crops is a common practice in developed countries. However, it is rarely observed in the developing countries, particularly for papaya production. Therefore, this study was carried out to find a protective approach to papaya cultivation to mitigate the environmental factors to obtain a quality yield. This production system consists of three treatments, including net house, poly shed house, UV poly shed house, and open field conditions (control). The results revealed that plants grown in the net house had significantly higher leaf number (30), fruit number (68), and fruit yield (56.28 kg/plant) than the control grown plant. Papaya cultured in the net house also showed significantly higher accumulation of chlorophyll, ascorbic acid, total phenol, reducing sugar, and β-carotene than those grown in other environments. In terms of peel color, papaya grown in the net house had the highest a* value (redness), whereas that grown in the open field had the lowest. Thus, the study demonstrated that papaya can be cultivated successfully in a net house with increased yield and phytochemical content. The findings provide a fundamental production strategy for quality papaya production in Bangladesh.

Keywords: new production method; papaya growth; protective cultivation; phytochemical accumulation; yield

1. Introduction

Papaya (*Carica papaya* L.) is a highly nutritious fruit as well as vegetable grown in subtropical and tropical regions [1,2]. Papaya is a significant source of calcium, vitamins A and C, along with thiamin, riboflavin, iron, potassium, magnesium, and sodium [3].

Papaya is a light-demanding plant, and prolonged periods of low light intensity can result in significant changes in leaf anatomy and morphology [4]. Temperature is a factor that affects the chemical composition of the fruits. It interferes in the formation of sugars, due to cell division and multiplication in the fruits, the alteration in the biosynthetic enzymatic activity of carbohydrates, and the increase in the transpiration rate [5].

The climate is the most important factor in agricultural production because of its high variability, so that the atmosphere in which the crops are grown can be changed by a protected environment [6]. The conditions in which plants are produced must be measured and it must be taken into consideration that environmental factors influence the quality of the fruit [7]. Some of the environmental effects that have an important impact are temperature and relative humidity [8].

Temperature is the principal environmental factor influencing cymes, flowers, and fruit production. Growing papaya in plastic-covered greenhouses can have a negative impact on yield. Plastic covers can restrict solar radiation transmission within the greenhouse below the optimum level, especially in winter (when days are cloudier and shorter than in other seasons), but they can also produce an excessive increase in temperature during summer [9]. High temperature stress alters plant physiological and biochemical responses, lowering crop quality and yield. The temperature behavior inside the high tunnel is critical because it affects metabolic activity, water and nutrition absorption, gas exchange, carbohydrate generation and expenditure, and growth regulators [10]. Higher fruit production of papaya is possible under naturally ventilated poly houses [11]. Growing papaya in a poly house produces a higher yield since insect and disease incidence is lower than in an open field [12]. Fruit productivity and quality have been reported to increase when papaya is grown in protected structures [13]. The most practical way to achieve the goals of protected agriculture is to adapt the natural environment using solid engineering concepts to promote optimum plant growth and production with increased input utilization efficiency.

Protected agriculture has grown in popularity as a means of increasing agricultural productivity and lowering costs. In Bangladesh, very little study has been conducted on papaya cultivation in a low-tech protected setting.

To fulfill the growing demand for fruit crops, it is critical to analyze the cultivation, suitability, and quality measurement of papaya under low-tech protected culture. In terms of papaya fruit quality and yield, this experiment aimed to introduce a low-tech protected farming approach compared to open field.

2. Materials and Methods

2.1. Plant Materials and Growing Conditions

This experiment was performed at the Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from February to October 2020. Dhaka is located at 23°42′37′′ N (Latitude), 90°24′26′′ E (Longitude) and has an average elevation of 4 m (13.12 ft.) according to the National Mapping Organization of Bangladesh. The papaya cv. Red Lily was planted at 1.2 × 1.2 m spacing under four protected cultivation systems, namely open field condition (control), net house (60 mesh), poly shed house (naturally ventilated polyhouse; entire roof and half the portion of four sides covered with poly sheet, the remaining half covered with 25% shed net), and UV poly shed house (Fan pad UV polyhouse; fully covered with UV film sheet). The experiment was laid out with 4 treatments with 4 replications. During the experiment, all essential cultural practices and plant protection measures were followed uniformly for all the plots. In each replication, five plants were randomly selected for observations on fruit production, yield, and physio-chemical parameters. Three fruits from each plant and each treatment were harvested for various biochemical analyses. Temperature and relative humidity were recorded during the growing period in all environments to monitor the actual environmental conditions in which the plants were grown.

2.2. Measurement of Growth Parameters

Five plants in each treatment and each replication were used for plant height, leaves number, stem diameter, and leaf chlorophyll content at flowering, fruiting, and harvesting stages. Plant height was measured from the base of the plant to the top of the plant. The stem diameter of each plant was measured from a height of 10 cm above the ground.

2.3. SPAD Chlorophyll Meter Reading

Leaf chlorophyll content was measured using a SPAD-502 chlorophyll meter on the first fully expanded leaves (Minolta, Tokyo, Japan). In each shed house, the measurements were obtained from the center of the leaf lamina of five randomly selected plants.

2.4. Measurement of Yield Parameters

Days to flower initiation were recorded for all five plants in each treatment. The number of fruits/plants was recorded by counting the fruits that reached harvestable ripeness. The weight of fruits (g) from each selected plant was taken on each date of harvest with the help of an electronic top pan balance. The yield/plant (kg) was recorded by adding the yield of all the harvests obtained from selected plants in each treatment and each replication.

2.5. Measurement of Biochemical Parameters

2.5.1. Total Soluble Solids (TSS) Content

The TSS content of papaya was measured by a digital refractometer (MA871; Bucharest, Romania). A drop of strawberry juice was obtained with a dropper and placed on the refractometer prism. The refractometer showed a reading of total soluble solids.

2.5.2. pH Determination

The fruit juices of individual treated strawberries were filtered separately, and pH was measured using a digital pH meter (HI 2211; Bucharest, Romania).

2.5.3. Titratable Acidity (TA %)

The leaf samples (5 g) were macerated by the mortar and pestle for the determination of the TA. After maceration, samples were filtered, and water added to make 100 mL of volume.

Then, 10 mL of stock solution was taken in a conical flask and 2 drops of phenalpthelin were added. The solution was titrated three times with 1N NaOH. The titration was stopped until the pink color appeared.

2.5.4. Vitamin C Determination

The vitamin C content of papaya was calculated using the technique of Tee et al. [14]. A 5 g papaya fruit sample was blended, and the juice was sieved with filter paper (Whatman No. 1). The volume was made up to 100 mL by adding 5% oxalic acid solution. Titration was performed with dye solution 2, 6-dichlorophenol indophenol. The mean observations provided the amount of dye required to oxidize an unknown concentration of a definite amount of L-ascorbic acid solution, using L-ascorbic acid standard. A 5 mL solution was taken for titration each time, and the pink color determined the last point of titration, which remained for 10 s.

2.5.5. Phenolic Content Analysis

The content of phenolics was calculated using the method of Singleton et al. [15]. Fresh ripened fruits (250 mg) were homogenized with methanol (85%). The extract was centrifuged at 3000$\times$ g for 15 min and separated the supernatant. Folin–Ciocalteu reagent (2 mL) was added to the supernatant per 2 mL. A sodium carbonate solution was applied to each test tube (7.5%, 2 mL) and after 30–45 min the absorbance was recorded against a blank sample at a wavelength of 725 nm. To determine the total phenolic concentration, a standard curve was generated using gallic acid.

2.5.6. Reducing Sugars Content

Reducing sugars were determined based on a method using phenol-sulphuric acid proposed by Dubois et al. [16] with slight modifications. Thus, 0.2 g fresh ripened fruit was homogenized with deionized water, and the extract was filtered. Then, 2 mL of the solution was mixed with 0.4 mL of 5% phenol reagent. Subsequently, 2 mL of 98% sulphuric acid was added rapidly to the mixture. The test tubes were allowed to rest for 10 min at room temperature and placed in a water bath at 30 °C for 20 min for color development. Light absorption at 540 nm was then recorded with the spectrophotometer. A blank solution (distilled water) was prepared in the same way as above. The content of reducing sugars was expressed as mg g^{-1} FW.

2.5.7. β-Carotene Content

The amount of beta-carotene in papaya was determined using the method of [17]. One gram of pulp was mixed with 10 mL of an acetone-hexane (4:6) mixture and vortexed for 5 min. The mixture was filtered, and absorbance was measured at wave lengths of 453, 505, and 663 nm. The estimation was performed using the following equation:

$$\beta\text{-carotene (mg/100 gm)} = 0.216\ \text{A663} - 0.304\ \text{A505} + 0.452\ \text{A453}$$

2.6. Color Measurement

The papaya skin colors were measured nondestructively using a Minolta Chroma meter (Model CR400, Sakai site, Japan), which was set up with a D65 illuminant and 10° observer angle. The color values were recorded as L*, a*, b*, and C*. The reading was set to take an average of 6 random points per fruit. The instrument must be completely in contact with the fruits to avoid any light leakage from the light emitted by the colorimeter.

2.7. Statistical Analyses

The experiments used a randomized complete block design (RCBD) with four replications for each treatment and five plants in each replicate. Statistical analyses were conducted with version 9.4 of the Statistical Analysis System (SAS) (SAS Institute, Cary NC, USA). The mean value among the treatments was statistically significant when $p = 0.05$. All results were presented with the mean standard error (SE) from the replicates.

3. Results and Discussion

3.1. Temperature and Relative Humidity (RH) Conditions

Under low-tech protected conditions, temperatures can be monitored and managed, and better plant growth could be expected. Different shed houses and open field conditions influenced the temperature. The temperature for each treatment was measured at 12 p.m. daily during the experimental period. The average monthly temperature varied approximately between 23.09 and 36.40 °C, as shown in Table 1. In our experiment, it was found that air temperature in poly, UV poly shade, and open field was always more than that in net houses condition. The optimal temperatures in papaya for growth and yield range from 21 to 32 °C. High temperatures above 32 °C may cause flowers to droop, while low temperatures of less than 15 °C may prevent flowering or result in malformed fruit [18].

During the experimental period, the relative humidity for each treatment was measured at 12 p.m. daily. From February to October, the average monthly relative humidity ranges between 61.90% and 85.13% during the day (Table 1). Relative humidity was always higher in the net house during the growing season, while the relative humidity was approximately similar in both the poly shed and the open field conditions. Relative humidity was higher under the net house even though the temperature was low in the net house. The lowest percentage of relative humidity and higher temperatures were measured under the UV poly shed. In the present study, under net house, there was a reduction in temperature in the summer months to 3–6 °C compared to control. Fruit set is reduced, and early leaf drop is caused by a low humidity. Relative humidity was higher under the net house even though the temperature was low [19].

Table 1. Monthly average air temperature (°C) and relative humidity (%) at 12 h in different shed house and open field during February to October 2020.

Month	12 h							
	Open Field		UV Poly Shed		Net Poly Shed		Net House	
	Temp. (°C)	RH (%)	Temp. (°C)	RH (%)	Temp. (°C)	RH (%)	Temp. (°C)	RH (%)
February	26.48	66.17	26.21	63.93	24.96	67.72	23.09	69.01
March	31.41	62.51	32.05	61.90	30.85	62.19	27.55	68.19
April	33.8	75.70	34.52	66.07	33.84	70.27	28.61	72.87
May	32.58	82.45	34.29	76.53	33.04	83.63	29.62	84.53
June	32.33	83.23	33.30	72.60	31.61	79.20	29.78	81.53
July	33.04	78.10	36.40	70.39	35.11	77.89	32.29	76.82
August	32.13	86.13	35.76	76.67	34.51	82.97	31.61	84.97
September	32.63	82.07	34.01	76.03	31.87	81.43	30.34	83.93
October	31.90	81.94	33.27	81.26	30.94	83.35	29.27	85.13

3.2. Growth Parameters

The results for the papaya under three low-tech protected structures (UV poly house, net poly house, and net house) studied showed that plant height was increased significantly during the growing periods. Plant height was the highest under net house, from flowering (157.2 cm) to the harvesting stage (306 cm). The lowest plant height was observed in the case of control, from flowering (124 cm) to harvesting (151.4 cm) (Figure 1A). The plant height of papaya was highest in the net house. This may be due to enhanced photosynthesis and respiration due to the favourable microclimatic conditions in the net house. High temperatures reduced shoot dry mass, relative growth rate, and net assimilation rate significantly in maize, pearl millet, and sugarcane [20].

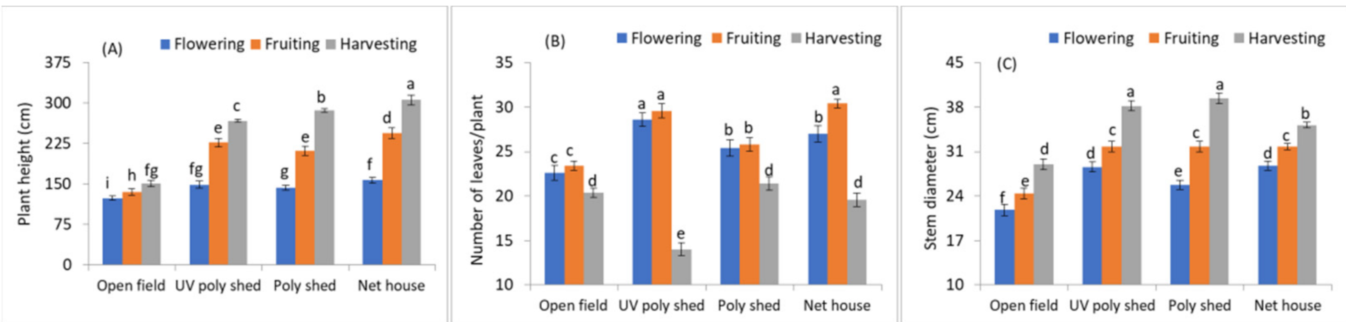

Figure 1. Average plant height (cm) (**A**), number of leaves/plant (**B**) and stem diameter (cm) (**C**), of papaya grown under different sheds and open field condition. Mean ± Standard error (S.E.) (n = 15). Means with the same lower-case letter are not significantly different at p = 0.05 by Duncan's multiple range test.

During the flowering, fruiting, and harvesting stages, the leaf number varied in different shed houses and open field conditions (Figure 1B). The result showed that the number of leaves of papaya decreased in all growing conditions during the harvesting stage, whereas the number increased in the fruiting stage in all growing conditions. The highest number of leaves was observed in the net house (30) at the time of fruiting and the lowest was found in the control condition (23). There is a significant increase in the number of green leaves and average maximum number of total leaves of mango grown under net house in comparison to open field conditions [21]. This was due to the crop's favorable environmental conditions, e.g., adequate relative humidity, lower maximum temperature, lower light irradiance, and lower evapotranspiration that usually prevailed under net house [22].

There was no significant difference in stem diameter between poly and UV poly shed during the fruiting and harvesting stages (Figure 1C). In the harvesting stage, the maximum stem diameter of papaya was observed in the poly shed (39.4 cm), followed by the UV poly shed (38.2 cm) during the harvesting stage, and the lowest was found in open field conditions (21.8 cm). This could be attributed to increased bud growth, which increased nutrient absorption and translocation from the soil, both of which play a role in a variety of plant metabolic activities under poly and UV polymer conditions [23].

3.3. Chlorophyll Content (SPAD Reading)

In this study, there were significant differences among different growing environments in leaf chlorophyll content (Figure 2). The highest chlorophyll content was found in plants during the flowering stage in all growing environments. However, the plants in the net house showed the highest chlorophyll content (54.48) and the lowest chlorophyll content was found in open field condition (47.50) at flowering stage. In our study, leaf chlorophyll content was found significantly lower in open field conditions and other shed houses than in net houses. Similar results were found by [24], who showed that total chlorophyll contents in baby spinach leaves were significantly higher under the nettings. Tomato leaves grown in the shade have a higher total chlorophyll content than leaves produced in the open field [25].

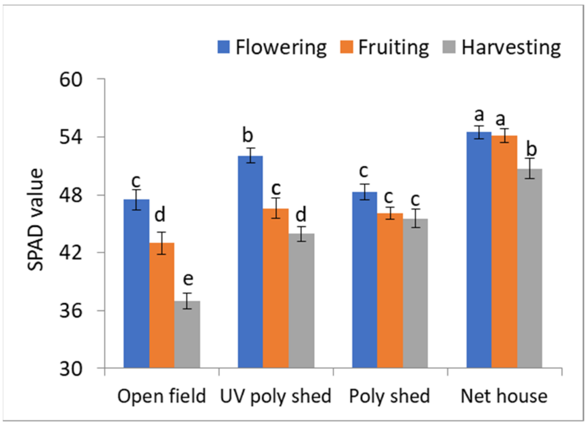

Figure 2. Average leaf chlorophyll content (SPAD reading) of papaya grown under different sheds and open field condition. Mean ± Standard error (S.E.) (n = 15). Means with the same lower case letter are not significantly different at $p = 0.05$ by Duncan's multiple range test.

3.4. Yield Parameters

Different growing conditions (Figure 3A) significantly influenced the days to flowering. It was found that the maximum number of days to flowering (67) was recorded in open field conditions, whereas the minimum number of days to flowering was recorded (58) for the plants grown under net house.

The number of fruits/plants was significant among the shed houses (Figures 3B and 4). The net house had the most fruit plants (71), while the UV poly shed had the fewest (37), followed by open field conditions (39) and the poly shed (42). In our experiment, higher temperatures might have reduced flower formation and fruit yield of the plants grown in poly and UV poly sheds. Likewise, [18] showed that high temperatures (above 32 °C) have a negative impact on fruit set in papaya, decreasing yield. Plants cultivated in favorable conditions may have a higher rate of photosynthesis, which may explain their increased growth and fruit set [26].

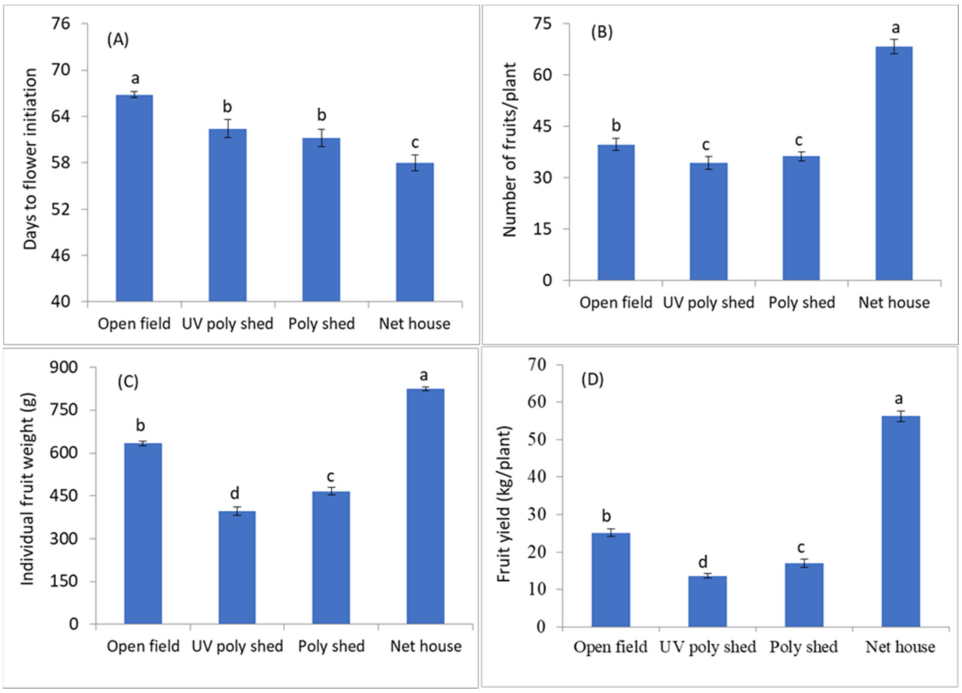

Figure 3. Average days to flower initiation (**A**), number of fruits/plant (**B**), individual fruit weight (g) (**C**) and fruit yield (kg) (**D**) of papaya grown under different sheds and open field condition. Mean ± s.e. (n = 15). Means with the same letter are not significantly different at p = 0.05 by Duncan's multiple range test.

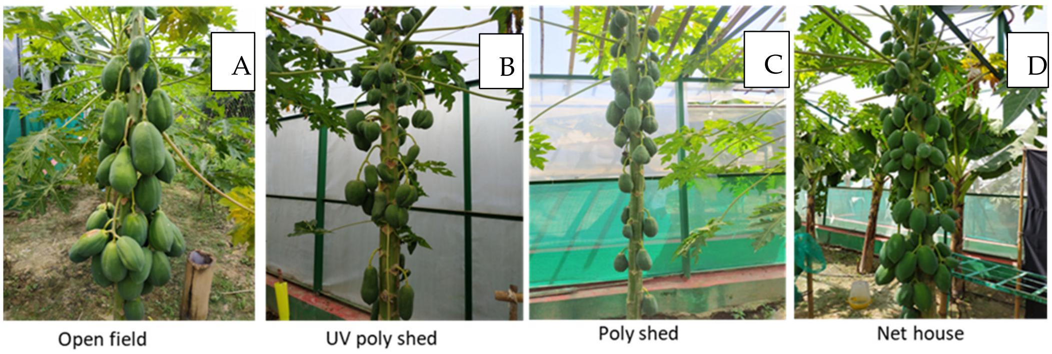

Figure 4. Papaya fruits grown under different shed houses. Open field (**A**), UV poly shed (**B**), Poly shed (**C**) and Net house (**D**).

Different growing environments showed significant variation in individual fruit weight (Figure 3C). The maximum fruit weight (824 g) was recorded in plants grown under net houses and the minimum weight was recorded in UV poly sheds (396 g). The minimum fruit yield was observed in the UV poly shed (14 kg/plant), followed by the poly shed (17 kg/plant), whereas the maximum fruit yield was found in the net house (56 kg/plant) (Figure 3D). Weight and yield could be affected by changes in environmental conditions beneath protective netting. The unfavorable environmental conditions, such as higher temperature and lower humidity, prevented the development of proper fruit size, resulting in a decrease in fruit weight. These might be due to higher temperatures during flowering and fruiting stages (Tables 1 and 2). In our result, favourable environmental conditions, such as optimum temperature and humidity, were recorded in net house (Table 1), which resulted in faster fruit growth throughout the season. Fruit weight and yield were found to be linearly related to the percentage of full sunlight received by trees [27]. Higher temperatures are likely to play an important role in limiting growth and fruit development by reducing photosynthetic activity and increasing the rate of respiration [28].

Table 2. Plants turn in different growth stages during the growing periods.

Month	Plant Growth Stage
February	Vegetative stage
March	Vegetative stage
April	Flowering stage
May	Flowering stage/Fruit setting
June	Fruit setting/Fruit development
July	Fruit development
August	Fruit development/Harvesting
September	Harvesting
October	Harvesting

3.5. Total Soluble Solid, Titratable Acidity and Juice pH

The total soluble solids content of the fruit responded significantly differently to the different shed houses (Figure 5A). The total soluble solids were maximum in the fruits obtained from the plants grown under net house conditions (13 °Brix), whereas a minimum was recorded from the plants cultivated in the UV poly shed (9.33 °Brix). Similar results were revealed by [29] as tomato cultivars had maximum TSS contents under the net house. This might be due to the congenial micro-climatic conditions maintained in net house. Greenhouse cultivation greatly increased the sucrose buildup and metabolism of bayberry fruit, probably due to changes in sucrose-phosphate synthase and acid invertase activity [30,31] reported that greater accumulation of TSS in fruit has been observed in shading conditions due to reduced sugar degradation. [32] stated that the titratable acidity also increases with shading.

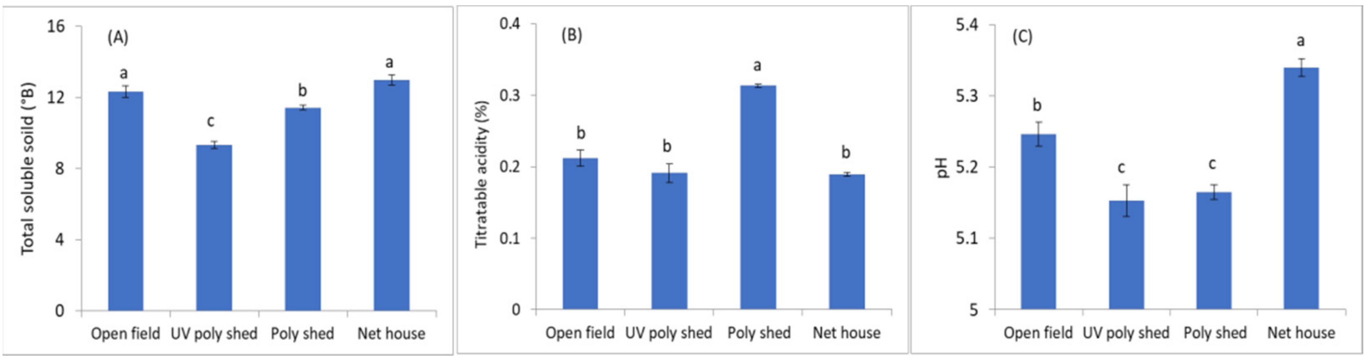

Figure 5. Average content of total soluble solid (°B) (**A**), titratable acidity (%) (**B**) and pH (**C**) of papaya fruits grown under different sheds and open field condition. Mean ± Standard error (S.E.) (n = 15). Means with the same lower case letter are not significantly different at $p = 0.05$ by Duncan's multiple range test.

According to [33], high tunnels alter microclimatic conditions, boosting early flowering and fruit ripening as well as fruit precocity production.

We found that the fruits produced in the net house are less acidic than the fruits produced in other growing environments. The higher titratable acidity (0.31%) was found in poly shed followed by the open condition (0.21%), and the lowest titratable acidity was found in the fruits grown in net house conditions (0.18%) (Figure 5B). In the present investigation, a decrease in percent titratable acidity was found during ripening, which is similar to the findings of [34]. The results of the study revealed that the minimum titratable acidity in the juice of papaya obtained from net house might be due to the high sugar content present in the fruit and the more edible portion of the fruit.

High fruit quality is associated with low juice pH [35]. The juice pH values of papaya fruits cultivated in poly shed and UV poly shed showed no significant variations. The lower juice pH was found in the UV poly shed (5.15), followed by poly shed (5.17), and the higher juice pH was found in fruits grown in net house (5.34), followed by open field condition (5.25) (Figure 5C). However, determining fruit acidity at complete maturation, when acidity decreases, is a possible explanation for the low values. The increase in wild plum fruit juice pH with increasing storage temperature was attributed to the increased level of fruit ripening [36].

3.6. Ascorbis Acid, Total Phenol, Reducing Sugar and β-Caroteen Content

The highest ascorbic acid content was found in the net house (60.13 mg/100 g), followed by open field conditions (54.19 mg/100 g), and the lowest ascorbic acid was found in the fruits grown in the UV poly shed (41.95 mg/100 g), followed by the poly shed (50.14 mg/100 g) (Figure 6A). [37] investigated quality parameters of tomato under protected conditions and found significantly higher vitamin C in the fruit produced under protected structures. In our study, the fruits grown in the UV poly shed and poly shed showed lower quality due to the maximum temperature during the fruit production stage, resulting in lower ascorbic acid contents in harvested fruits. Temperature has a significant influence on vitamin C, with low average temperatures during fruit maturation and ripening contributing to increased enzymatic activity and thus increasing vitamin C and other bioactive compounds in the fruit [38].

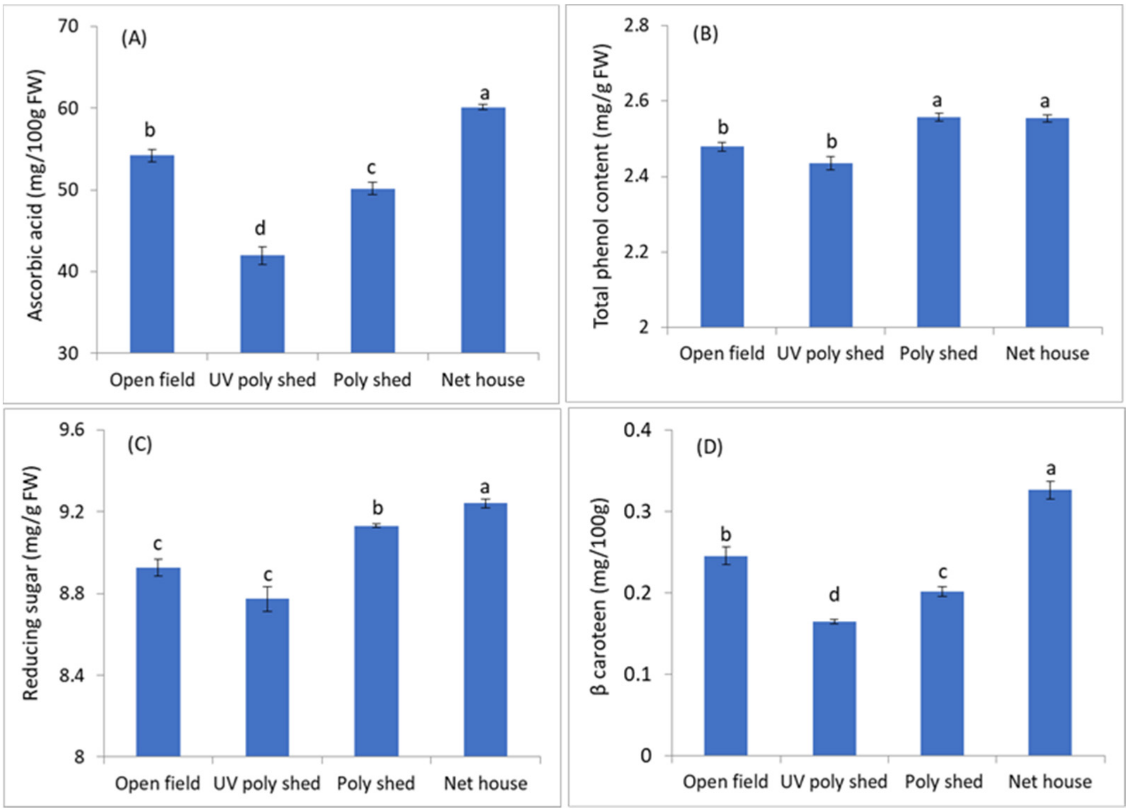

Figure 6. Average content of ascorbic acid (mg/100 g) (**A**), total phenol (mg/g FW) (**B**), reducing sugar (mg/g FW) (**C**) and β-caroteen (mg/100 g) (**D**) of papaya fruits grown under different sheds and open field condition. Mean ± Standard error (S.E.) (n = 15). Means with the same lower case letter are not significantly different at $p = 0.05$ by Duncan's multiple range test.

The total phenolic content was significantly variable depending on the shading conditions. The total phenolic content in the plants grown under the poly shed was the highest (2.56 mg/g FW) followed by the net house (2.55 mg/g FW), whereas the total phenolic content in papaya fruits in the UV poly shed was the lowest (2.44 mg/g FW), followed by the open field (2.33 mg/g FW) (Figure 6B). The phenolic compounds directly contributed to the antioxidant action. [39] investigated quality parameters of tomato under protected and open cultivation and found significantly higher antioxidant activity in the fruit produced under protected structures at full ripe stage. Polyphenols in papaya have antioxidant properties because they defend cells from free radical damage and prevent low density lipoproteins from oxidizing [40].

There were significant differences between different growing environments in reducing sugar contents (Figure 5B). The highest reducing sugar content was seen in the plants grown in net houses (9.24 mg/g FW), while the lowest sugar content was observed in UV poly sheds (8.77 mg/g FW), followed by open field papaya fruits (8.92 mg/g FW) (Figure 6C). [40] revealed that strawberry fruits grown under a tunnel had higher levels of reducing sugar than open field produced fruits. The increase in sugar could be attributed to enhanced PAR absorption [41] and improved light utilization in the apple orchard [42] which could result in more export of leaf carbohydrate [43].

There was a significant response in the carotene content of the fruit to the different shed houses (Figure 6D). The fruits obtained from the net house had the highest carotene content (0.33), while the fruits obtained from the UV poly house had the lowest carotene content (0.16). According to [39], papaya grown in a net house had a higher beta carotene content than papaya grown in the field. In our study, fruits grown in poly and UV poly sheds had the highest temperatures compared to other growing environments. Papaya exposed to direct sunshine in the field developed a poor color, owing to the low beta carotene content of fruit subjected to high temperatures. The findings show that a cooler microclimate created by a shed net generates a favorable environment in the fruit for carotene accumulation.

3.7. Color Measurement

Distinct variation was noted in the fruit color of papaya, influenced by the different shed houses (Figure 7A–D and Figure 8A–D). The higher L* value indicates the lighter color which was found in the fruits grown in the open field (55.46), which was statistically similar to the treatment of the UV poly shed (56.52) and the lower L* value found in both the poly shed and net house (approximately 48). The redness value a* was highest in the treatment of the net house (48.28), whereas the lowest a* value was found in the treatment of the open field (24.94). The higher b* value indicates yellow color and was found in the treatment of open fields (44.03) and the lower value was found in the treatment of poly sheds (36.73). The higher Chroma value was found in the treatment of net houses (52.89) and the lower value was found in the treatment of open fields (49.55).

Several factors influence fruit color development, including canopy temperature and light intensity [38]. Compared to open-field papayas, those cultivated in greenhouses had better pulp and peel color [44]. Pomegranate fruit grown in the open field has poor color development compared to trees grown under shed nets [45].

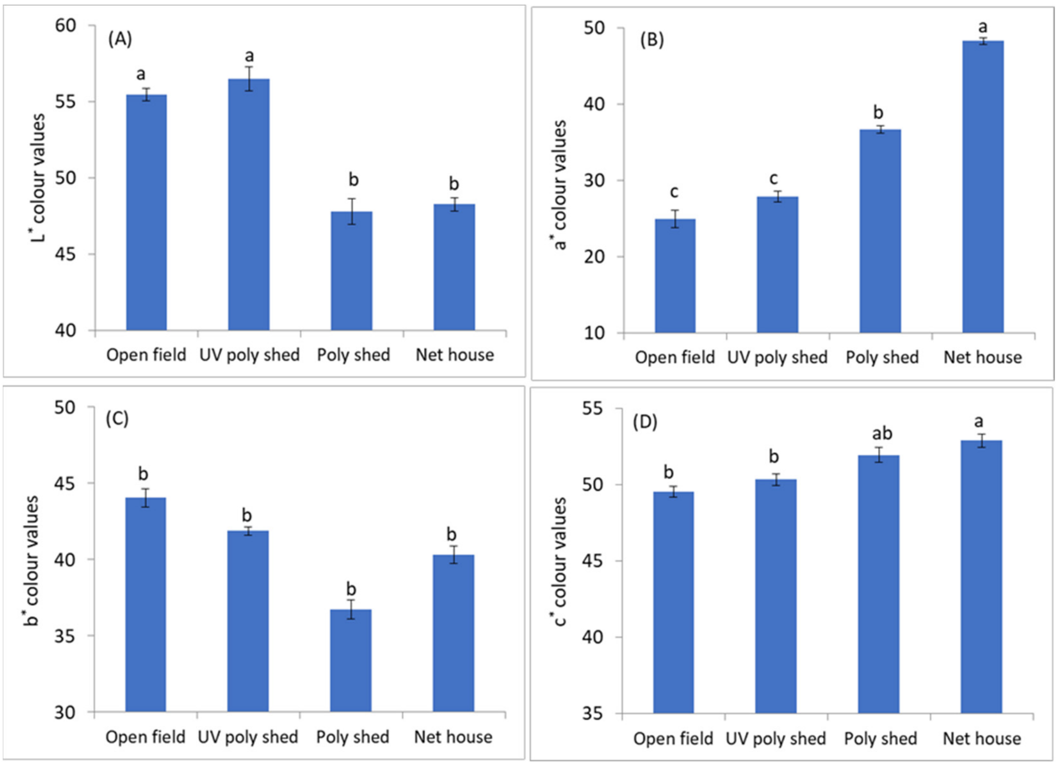

Figure 7. Average color values of L* (**A**), a* (**B**), b* (**C**), and C* (**D**) of papaya fruits at edible stage grown under different sheds and open field condition. Mean ± Standard error (S.E.) (n = 15). Means with the same lower case letter are not significantly different at $p = 0.05$ by Duncan's multiple range test.

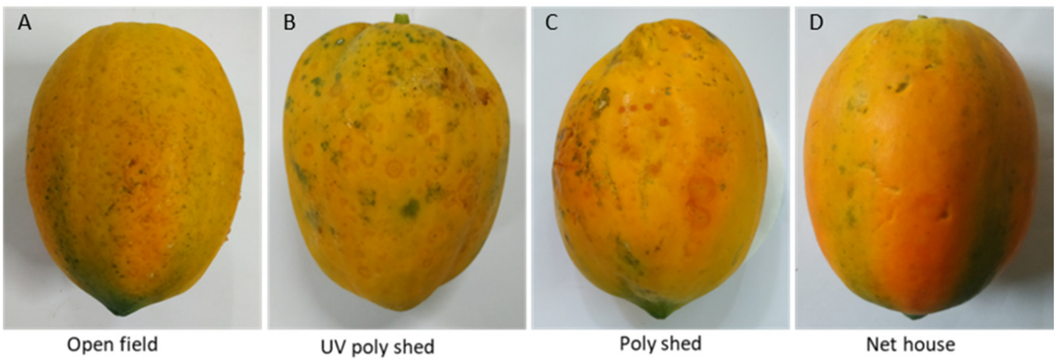

Figure 8. Skin color of papaya fruits grown under different shed houses (**A**: Open field; **B**: UV poly shed; **C**: Poly shed; **D**: Net house).

4. Conclusions

Our results revealed that shading conditions significantly influenced the growth, yield, and quality of papaya. Fruits grown under a net house had substantially more total soluble solids, ascorbic acid, reducing sugar, total phenol, and beta-carotene. Furthermore, in the net house, the fruit peel color, yield, and yield contributing parameters of the papaya were higher. Finally, it can be concluded that the findings of this research provide very basic information that could be used to increase the quality and nutrient contents of papaya in tropical and subtropical regions including Bangladesh.

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