INFLUENCE OF DIFFERENT GROWING MEDIA ON THE GROWTH, YIELD AND QUALITY OF STRAWBERRY UNDER PROTECTIVE CONDITIONS

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*This is to certify that thesis entitled, "INFLUENCE OF DIFFERENT GROWING MEDIA ON THE GROWTH, YIELD AND QUALITY OF STRAWBERRY UNDER PROTECTIVE CONDITIONS" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (MS) in HORTICULTURE, embodies the result of a piece of bonafide research work carried out by **ISMAIL HOSSAIN, Registration no. 14-06293** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

Experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October-2019 to February-2020, to investigate the influence of different growing media on the growth, yield and quality of strawberry under protective conditions. The experiment consisted of two factors, and followed randomized complete block design (RCBD) with 2 factors with three replications. Factor A: Different growing media (3) viz; M_1 = Cowdung, M_2 = Cocopeat and M_3 = Vermicompost and Factor B: Different protected condition (3) viz; C_1 = No shade (Open space) C_2 = Net house and C_3 = UV poly tunnel. Experimental result revealed that among different growing media, strawberry plant grown in Cocopeat based growing media exhibited the highest number of fruit plant^{-1} (14.43), individual fresh fruit weight (15.47 g), fruit yield plant^{-1} (226.5 g), titratable acidity (0.54 %), ascorbic acid content (45.57 mg/100 g), moisture content (93.39 %), reducing sugar (8.57 %) and total anthocyanin content (29.45 mg g^{-1}). In case of different protected conditions strawberry growing in net house condition recorded the highest number of fruits plant^{-1} (14.33), individual fresh fruit weight (15.54 g), fruit yield plant^{-1} (229.16 g), total soluble solids (7.33 °Brix), titratable acidity (0.50 %), ascorbic acid content (46.08 mg/100 g) and moisture content (94.19 %). In case of interaction effect strawberry growing in Cocopeat based growing under net house condition exhibited the highest number of fruits plant^{-1} **(**17.00), individual fresh fruit weight **(**18.05 g), fruit yield plant^{-1} **(**307.11 g), titratable acidity (0.62 %), and ascorbic acid content (49.00 mg/100 g). Therefore, it can be concluded that strawberry grown in Cocopeat based growing media under net house condition performed well and found to be most suitable for achieving higher growth, yield and qualities and can be successfully used for the production of good quality strawberries.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF APPENDICES

LIST OF APPENDICES (Cont'd)

LIST OF PLATES

ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agr.
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Entomology	Entomol.
Environments	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER-I

INTRODUCTION

Strawberry (*Fragaria ananassa* Duch.), belonging to the family Rosaceae, is one of the most delicious fruits of the world. It is an excellent source of antioxidant, vitamin C and manganese together with a very good source of dietary fiber, iodine, copper, potassium, biotin, phosphorus, magnesium, vitamin $B_{6,}$ omega-3 fatty acids and sugar having a delicate flavor (Saridas *et al*., 2021). The fruits are eaten fresh as it is tasty and nutritious or may be used in making ice-cream, jam and other processed products. The strawberries are native to North America and its cultivation was started in Europe in early 18^{th} century (Bhatti *et al*., 2021). It is a fruit of temperate regions but it can be grown even in tropical as well as in subtropical regions. The area of strawberry cultivation in the sub-continent is increasing rapidly (Paul *et al.*, 2017). It can be grown in a wide range of soil but sandy to sandy loam soil is most suitable with a pH range of 4.6-6.5 (Milosevic *et al*., 2009).

The main season of strawberry cultivation in Bangladesh is October to April (Ahmed and Uddin, 2012). Strawberries are usually planted in the field in October to November. But at that time, harvesting of *Aman* rice is not completed and after harvesting of rice, soil moisture remains high that makes it difficult to prepare soil for strawberry cultivation in most areas of southern Bangladesh. In this situation, soilless cultivation system may be an alternative technique for this region. Hydroponic, aeroponics, air-dynaponics, organic culture etc. are the alternatives to soil for strawberry cultivation but these systems are costlier. At present rooftop gardening is being popular in Bangladesh. Rarely it could be found a single building in any city of Bangladesh without rooftop gardening (Sheel *et al*., 2019).

Strawberry is an expensive and important fruit. People can make their won organic substances with kitchen waste and other household materials that may allow rooftop soilless organic farming of strawberry. Organic substrates significantly affect the growth, yield and other qualitative parameters of strawberry. Rather than the conventional cultivation in soil, organic substrates are the main part of the planting system of strawberry (Ayesha *et al*., 2011). The most commonly used organic substrates for strawberry cultivation are gravel, sand, peat, vermiculite, perlite, coco-peat etc.

(Sheel *et al*., 2019). Vegetative growth, yield and other qualitative parameters of strawberry can be improved with the use of organic substrates compared to soil or with addition (Marinou *et al*., 2013). Vermi-compost provides an advantageous effect on the growth and yield of strawberry (Arancon *et al*., 2004). Strawberry grown in combination of coco-peat, perlite and vermi-compost on earthen pot produces the highest shoot length (Godara and Sharma, 2016). Perlite performs best in growing container i.e. bag on gutter and bag on ground in case of growth and yield of strawberry (Cantliffe *et al*., 2007).

Effective growing medium that facilitates anchorage the root system, better root space, minerals supply, moisture holding capacity, gaseous exchange of CO_2 and O_2 for respiration, proper growth and development of plants.

Strawberry plants are very sensitive to weather condition especially during flower and fruit development. Continuous rain in a particular area would damage the developing flowers and fruits. The use of protected structure is very important in order to protect the growing and developing crops from adverse condition during heavy rains particularly vegetative and reproductive stage (Weber, 2021).

Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the vegetable species grown during their period of growth. With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged. Among these are Green house, Plastic house, Lath house, Cloth house, Net house, shade house etc. Protected crops require a controlled climatic environment to produce adequate commercial yields (Negi *et al*., 2013). Higher than normal temperatures, controlled humidity, or additional artificial induced light levels under protection encourage the crops to grow before and after their natural growing season and extend their overall lifespan, thus maximizing yields and improving quality (Rabbi *et al*., 2019). Considering the above situations, the research work was carried out with the following objectives:-

i. To evaluate the influence of different growing media on plant growth, yield and quality of strawberry.
ii. To evaluate the effect of different protective conditions on plant growth, yield and quality of strawberry.

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding to investigate the influence of different growing media on the growth, yield and quality of strawberry under protective condition, to gather knowledge helpful in conducting the present piece of work.

2.1 Effect of different growing media

Lakshmikanth *et al.* (2020) conducted a study on development of above ground plant parts of strawberry cv. 'Winter dawn', in naturally ventilated polyhouse with seven different substrate combination consisting of soil, sand, farmyard manure, cocopeat, vermicompost and vermiculite under vertical faring system and reported that the maximum yield per plant (391.24 g) was found in treatment combination comprising of soil, cocopeat, vermiculite and vermicompost in combination ratio of 1:1:1:1 on volume basis followed by the treatment combination comprising of cocopeat, vermiculite and vermicompost in combination ratio of 1:1:1.

Kilic *et al*. (2018) compared the effect of four substrates on the growth and quality of tomato in the greenhouse. The substrates used were rockwool (R), perlites + carbonized rice hulls (PCRH), Cyprus bark (CB) and coconut coir (CD). Coconut coir (CD) represented higher number of fruits per cluster, increased productivity, which were closely followed by perlites + carbonized rice hulls PCRH treatment.

Raja *et al.* (2018) studied the influence of substrates on different growth and quality of strawberry cv. Chandler under greenhouse conditions and reported that cocopeat, vermiculite with combination ratio of 25:75 showed better performance in respect of maximum petiole length (16.77 cm), diameter of crown (2.10 cm), canopy spread (42.75 cm), fresh weight of shoot (17.16 g), dry weight of shoot (4.36 g), fresh weight of root (16.53 g), dry weight (5.13 g) of root, leaf area (1542 cm^2), number of leaves (17), weight of fruit (10.76 g), diameter of fruit (27.48 mm), length of fruit (29.89 mm) whereas the treatment consisting of cocopeat, perlite, and vermiculite with combination ratio of 50:25:25 produced maximum plant height (28.36 cm), length of shoot (23.13 cm), length of root (32.40 cm), TSS (10.8 0B) and lowest titratable acidity (0.86%).

Shahzad *et al.* (2018) conducted a study on variations in growing media for the improved production of strawberry cv. Chandler and revealed that peat moss amendment reported the maximum fruit yield (531.56 g), leaf chlorophyll content (12.53) and TSS (8.45) in strawberry

Truong *et al.* (2018) reported that the plant height of tomato was maximum in the medium containing mixture of vermicompost, cocopeat and rice husk as the physico-chemical properties of media were optimal for the root growth development.

Thakur and Shylla (2018) carried out a study on impact of different growing media on growth and yield of strawberry cv. Chandler under protected conditions and reported that perlite as a growing media shows maximum number of leaves (18.32), root length (18.91 cm) and number of runners (40.25) significantly.

Mathowa *et al.* (2017) reported that the variation of plant height, leaf number, radius and branches plant^{-1} was due to use of different growing media that vary greatly in composition, particle size, pH, aeration and ability to hold water and nutrients capacity.

Rodriguez-Ortega *et al.* (2017) reported that plants grown hydroponically had the greatest vegetative growth, characterized by their high leaf and stem biomass and large total area.

Dhaker *et al.* (2016) carried out a study on the influence of growing media and various containers on papaya variety Pusa Nanha and resulted that soil, FYM, sand, cocopeat, and vermicompost with combination ratio of 1:1:1:1:1 gave better performance in respect of seedling height (12.30 cm), leaf number per seedling (10.92), area of leaves (28.65 cm), leaf fresh weight (3.88 g), dry weight of leaves (0.43 g), primary root diameter (2.45 mm), index of seedling vigor (1683.52) and root and shoot ratio (0.14).

Godara (2016) conducted an experiment on the impact of different growing systems on roots of strawberry under green house and revealed that the plants grown in treatment combination comprising of cocopeat, perlite and vermicompost (3:1:1) gave highest yield (339.43 g and 345.01 g) whereas, lowest yield (143.93 g and 171.54 g) per plant was recorded from soil (control).

Haghighi *et al.* (2016) observed that the highest fruit weight and yield per plant was obtained in tomato plants grown in substrate combination of control + vermiculite + perlite (C25:V25:PR50) as compared to control.

Dysko *et al*. (2015) carried out a study on lignite as a medium in soilless cultivation of tomato showed that, under hydroponics tomato plants produced highest early marketable and total yield when grown in lignite media and this was not significantly different from the marketable yield obtained under coir pith.

Mazahreh *et al.* (2015) revealed that Perlite + cocopeat (1:1) produced significantly highest total yield (112.9 t ha^{-1}) as compared to cocopeat (46 t ha^{-1}). The total yield (112.1 t ha^{-1}) was on par with Perlite and Perlite + cocopeat in 2:1 proportion (98.4 t ha^{-1}) in cucumber.

During various observations made on the strawberry fruit qualitative characteristics, Sharma (2015) observed that plants grown in cocopeat + perlite + vermicompost (3:1:1) produced maximum fruit length followed by cocopeat + perlite + vermicompost (2:1:1) whereas the minimum fruit length was observed in soil Further, he also reported maximum fruit breadth in cocopeat + perlite + vermicompost (2:1:1) and maximum total sugars in the fruits harvested from cocopeat + perlite + vermicompost (4:1:2) which was statistically at par with cocopeat + perlite + vermicompost (3:1:1).

Soumya (2015) evaluated tomato in soilless culture, the experiment comprised of two pot culture experiments. First experiment was to standardize the growth media for soilless culture. The experiment consisted of eight treatments, namely, Coir pith + FYM (1:1), Coir pith + FYM (1:2), Coir pith compost + FYM (1:1), Coir pith compost + FYM (2:1), Coir pith compost alone, Neopeat + FYM (1:1), Neopeat + FYM (1:2) and potting mixture (1:1:1 soil, sand and FYM), replicated thrice. Coir pith compost +FYM (2:1) was found to be the best soil less media for tomato cultivation in grow bags.

Joseph and Muthuchamy (2014) conducted the case study on productivity, quality and economics of tomato cultivation in aggregate hydroponics. The maximum yield (4.9 kg $plant^{-1}$) was observed for the treatment with trough cocopeat + gravel + silex stone followed by trough with cocopeat + prelite + silex stone (4.2 kg $plant^{-1}$) and trough with cocopeat + pebble + silex stone (3.9 kg $plant^{-1}$). The highest productivity (245.3 t ha^{-1}) was obtained from the treatment trough with cocopeat + gravel + silex stone. The treatment tray with cocopeat + pebble + silex stone yielded (2.8 kg $plant^{-1}$) least productivity (138.3 t ha^{-1}).

Kumawat *et al.* (2014) conducted an experiment on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Coorg Honey Dew. They revealed that the treatment combination of soil, compost and cocopeat with ratio of 1:1:1 with GA- 150 ppm is better for early as well as higher percentage of germination (83.33 %), pronounced shoot growth (14.27 cm) and growth of tap root (9.15 cm) in papaya seedlings.

Rostami *et al*. (2014) found that, different cultivars of strawberry grown in a hydroponic greenhouse behaved differently in different cultivation substrates. However, the results indicated that the maximum plant height (18.63 cm) was obtained under date palm culture media, which was not significantly different from cocopeat and perlite cultivation substrate.

Olle *et al.* (2014) in greenhouse tomato production concluded that organic growing media gave more yield and number of fruits than conventional growing system.

Aktas *et al.* (2013) compared influence of different growing media *viz.* cocopeat, split mushroom compost, perlite, volcanic tuff and sawdust on growth, yield and quality of brinjal. Maximum plant height (82.2 and 78.7 cm) and number of leaves (51.1 and 51.4) was obtained with cocopeat and spent mushroom compost, respectively.

Gungor and Yildirim (2013) determined the effects of peat and mixture of peat + perlite + sand (1:1:1) in some pepper cultivars grown under greenhouse conditions. The ascorbic acid content (30.80 mg $100ml^{-1}$) and total soluble solids (4.82%) of fruit were higher in peat grown plants than in substrate mixture with different cultivars.

Marinou *et al.* (2013) observed that the strawberry fruits obtained from saw- 100 substrate were more acidic compared with fruits obtained from pum-saw (50:50) and cocopum (50:50).

Tariq *et al*. (2013) reported that plants grown in coir based growing media showed significant increase in acidity of strawberry fruits.

Effect of substrates on growth characteristics in soilless culture in tomato was investigated by Ameri *et al.* (2012) in Iran. Higher leaf area (54.17 cm^2) was recorded in 50 per cent cocopeat + 50 per cent perlite, when compared to other substrates (rice hull (48.77 cm^2), sycamore pruning waste (47.90 cm^2), 15 per cent vermicompost + 40 per cent perlite + 45 per cent cocopeat (48.30 cm^2) and 25 per cent vermicompost + 35 per cent perlite + 40 per cent cocopeat (47.87 cm^2).The total biomass differed significantly between each media.

Ebrahimi *et al*. (2012) reported that Cocopeat + perlite combinations have a great effect on growth traits viz. leaf number, leaf area and root length in strawberry.

Gholamnejad *et al*. (2012) tried different proportions of cocopeat and vermicompost for better seed emergence and some qualitative and quantitative characteristics of sweet pepper transplant (cv. California wonder). The treatments included: vermicompost + cocopeat (3:1), vermicompost + cocopeat (1:3), vermicompost + cocopeat (1:1) (v/v) and normal soil and recorded maximum plant weight (fresh and dry), stem diameter, internode quantity, leaf area and height of transplant under treatment vermicompost + cocopeat (3:1).

Hesami *et al.* (2012) carried out an experiment on date-peat as an alternative in hydroponic strawberry production and suggested that the better amalgamation was took when a amalgamation of two parts of perlite, one part of date-peat and one part of cocopeat resulted in increased fruit yield (88.88g). They also reported that the application of date-peat + cocopeat (3:1) and cocopeat + date-peat (3:1) led to an increase in the total soluble solids of strawberry fruits.

Luitel *et al.* (2012) reported that there was no significant difference in the fruit length (41.8 mm) and TSS (5.4 °Brix) of tomato raised in cocopeat and rockwool (40.2 mm fruit length and 5.3 °Brix) substrates.

Roosta and Afsharipoor (2012) reported better performance of strawberry in aquaponic system when the substrate had a higher percentage of perlite but in hydroponic system the use of sole perlite or cocopeat as substrates had no significant effect in increasing the number of fruits and total yield per plant in strawberry.

Suhaimi *et al.* (2012) opined that ginger grown in 100 per cent coir dust gave the best growth performance and yield as compared to the other treatments. It produced the highest shoot height (123 ± 23 cm), shoot fresh weight (1,340 ± 235 g) and rhizome yield (5,480 ± 325 g $plant^{-1}$). The lowest rhizome yield (2,570 ± 135 g) was obtained from plants planted with 30 per cent coir dust + 70 per cent burnt paddy husks.

Ikram *et al.* (2012) used different potting media in different combinations of FYM, poultry manure, sand, leaf compost and coconut coir in equivalent ratio in tuberose.

Coconut coir + FYM contributed to the maximum values of plant height, leaf area and spike length.

Luitel *et al.* (2012) evaluated different growing media (cocopeat, rockwool and masato) along with varying bed size (20 cm, 40 cm, 60 cm, and 80 cm width) onyield and fruit quality of tomato. Number of fruits per plant were recorded highest (16) under cocopeat followed by rockwool (15.2). Maximum Fruit weight (54.7 g) and yield (571.5 g/plant) was found to be in cocopeat based substrate and minimum 14 fruit weight (50.4 g) and yield per plant (540.7 g) was in masato substrate. Total soluble solids ranged from 5.3 ºBrix (rockwool substrate) to 5.6 ºBrix (masato).

Mazur *et al.* (2012) recommended coconut fiber as a environmental friendly medium for cultivation of cherry tomatoes as the plants grown in this media recorded higher fruits number and yield compared to plants grown in mineral wool.

Villagra *et al.* (2012) reported that different cultivation systems significantly influenced the number of flowers in strawberry cv. Camarosa. Maximum number of flowers was recorded in plants grown with conventional system compared to soilless culture system while no significant differences between soil and soilless culture system were observed in the data pertaining to number of fruits per plant and fresh weight of fruits.

Ayesha *et al.* (2011) observed highest vitamin C content from the plants grown in 3:1 ratio of perlite and cocopeat treatment. A significant effect on total sugars in strawberry fruits was induced by soil + silt + coconut coir dust (1:1:1) and it also improved the ascorbic acid contents. On the other hand, application of three parts of date-peat + one part of cocopeat and also three parts of cocopeat + one part of date-peat, led to an increase in the TSS content.

Ghehsareh *et al.* (2011) revealed that TSS content of the fruit was higher in perlite (6.37 °Brix), but was on par with datepalm peat2 incubated (6.25 °Brix) substrate. However it had significant difference with datepalm peat1 without incubated substrate (5.38 °Brix).

Hassan *et al*. (2011) concluded that using peanut husk as growing media for strawberry cv. Festival produced the highest titratable acidity whereas maximum total soluble solids were recorded in fruits grown in coconut husks alone.

Radhouani *et al.* (2011) opined that there were no significant difference in EC, TSS and acidity among different substrates like perlite, sand and compost. The pH was superior in compost (6.98 ± 0.08) and was on par with sand media (6.87 ± 0.09) but differed significantly with perlite (6.66 ± 0.02).

Wahome *et al*. (2011) reported that high water holding capacity and high nutrient retention capacity induced higher vegetative growth in hydroponics culture.

Hansen *et al*. (2010) conducted an study at Ohio State University, USA proved that under hydroponics lettuce gave 23% more yield when coconut fibre was used as the substrate.

Borji *et al*. (2010), found that the substrate prepared by mixing date palm peat and coir peat gave significantly higher yield for tomatoes compared to other substrates in hydroponics, in an experiment held at the greenhouse of Islamic Azad University, Khorasgan, Iran.

KacjanMarsi and Jakse (2010) was conducted an experiment on an effect of different soilless substrate on yield of grafted and ungrafted cucumber (*Cucumis sativus* L.) and reported that the growth of cucumber showed better performance in perlite with marketable yield 7.9 kg plant $^{-1}$.

Neocleous and Polycarpou (2010) carried out an experiment carried out at Agricultural Research Institute, Cyprus showed that the use of local gravel for the hydroponic cultivation of tomato produced similar yield to those with imported perlite

According to Awang *et al.* (2009) a suitable medium should anchor or support the plant, serve as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate. The growing media's have proper physiochemical properties such as electrical conductivity, cation exchange capacity, water retention capacity and bulk density influence plant growth and development.

Ullah *et al.* (2008) also found that organic growing media improved the quality of fruit crops and concluded that leaf manure based growing media was better in producing maximum fruit size which may be due to its ability to provide essential micronutrients to the plants.

Bartczak *et al.* (2007) observed that the number of leaves depended on the type of the substrate used. The highest number of leaves (11.8) was reported in the plants rooted in rockwool, while, plants rooted in the remaining substrates had 10.4-10.5 leaves per plant.

Tehranifar *et al*. (2007) reported a higher number of leaves, runner and crown diameter in strawberry cultivars Camarosa, Gaviota and Selva when peat and cocopeat media were used as compared to media with 100 percent sand and perlite.

Vinkovic *et al*. (2007) found out the success of tomato production in coco is mainly based on the behavior of the plants growing in it. Better media results in higher yields and improved crop quality. Coconut husk has shorter fibers, adjusted to give a successful growing medium. As an alternative to peat or rock wool, it offers a high moisture and air retention capacity, which enables easy growth and well spread root system. It appears from this study that coco coir is a suitable growing medium for the production of tomatoes under greenhouse conditions.

Inden and Torres (2004) who grew tomato in a greenhouse with four growing substrates observed highest total soluble solids in fruits grown in cocopeat substrate.

Lopez-Medina *et al*. (2004) using closed soilless growing system in Huelva (Spain) led to the conclusion that coconut coir with vertical systems produced best plant growth and yield in strawberry as compared to perlite medium.

Ali *et al*. (2003) reported that improved berry set and yield of strawberry in coconut based growing medium may be due to the provision of adequate supply of nitrogen and phosphorus nutrients at the fruit setting stage that might have reduced the abortion of the female parts of flowers.

Nourizadeh (2003) concluded that, cocopeat and perlite substrates were effective in promoting root and plant growth due to better interchange of the elements especially cations inside the substrate and proper moisture distribution that improved root system and finally plant height.

Studies conducted on Camarosa strawberry in Iran by Tehranifar and Sarsaefi (2002) revealed that cocopeat (40%) + perlite (60%) medium produced the highest number of fruits and yield per plant. They concluded that, the yield in substrates with peat or cocopeat was higher than those in substrates without peat or cocopeat.

2.2 Effect of different protective condition

Choudhury and Zaman (2021) conducted a study to determine the effect of the growing environment on the growth, yield and fruit quality parameters of strawberries. The experimental treatments include net house, poly shade house, UV poly shade house, and open field (control) conditions. The results revealed that the plants produced in the net house condition had maximum plant height (18.5 cm), total chlorophyll content (62.66), fruit number (17), and yield (289.16 g/plant) of strawberries. In contrast, plants grown under UV poly shade conditions recorded higher total soluble solid (7 °Brix), titratable acidity (0.46%), ascorbic acid (39.68 mg/100g) and lower pH (3.41). Reducing sugar (7.57 mg/g) and phenol (2.44 mg/g) levels were higher in fruits grown in poly shade. Results indicated that the most suitable growing condition for yield and yield parameters of strawberries is under the net house. In contrast, UV poly and poly house conditions are favourable for producing better quality fruit.

Chien and Chang (2019) conducted experiments to evaluate the comprehensive response of commercial cultivation of the white-fleshed pitaya (*Hylocereus undatus* 'VN White') under net house in Taiwan, during the natural reproductive period (from June to Sept. 2016) with fruits grown within net houses (either 16 or 24 mesh insect-proof netting, without fruit bagging) or in an open field (the control, without netting, with fruit bagging). The effects of netting on microclimate, phenological period, flowering (floral bud emergence) of current and noncurrent cladodes (shoots) (2- to 3-year-old), fruit quality, market acceptability, pests and diseases control, and level of sunburn were investigated. Indoor solar radiation in the 16 and 24 mesh net houses were 78.12% and 75.03%, respectively, and the sunlight intensities [photosynthetic photon flux density (*PPFD*), $\mu mol \cdot m^{-2} \cdot s^{-1}$] were 76.03% and 73.00%, respectively, that of control. The maximum daily temperature for the 16 and 24 mesh net houses was greater than that of the control. However, there were no significant differences in daily average temperature, minimum temperature, or relative humidity (RH). The first flowering cycle (12 June 2016) and last flowering cycle (11 Sept. 2016) in both net houses were the same as those in the control. The accumulative flowering of current cladodes was unaffected by net covering, but that of noncurrent-year cladodes in both net houses was lower than that in the control. Although the L* and C* values of fruit color in the 16 and 24 mesh net houses were lower than those in the control, the fruits still had commercial value. The average fruit weight of the 16 mesh net house was significantly greater than that of the control. Average total soluble solid (TSS) content, TSS content at the fruit center, and titratable acidity were unaffected. In addition, the 16 mesh net house blocked some large pests without exacerbating disease or sunburn.

Beniwal *et al.* (2017) conducted an experiment for propagation of strawberry mother plant and runner production under protected conditions viz., Greenhouse, Naturally ventilated polyhouse, Shadenet house (50%) and Open field conditions. The initiation of runner was early (29.5 days) and the number of strawberry runners per plant was maximum (10.19) under Shadenet house. Diameter and height of runner crown increased significantly with time and was maximum under Naturally ventilated polyhouse. Other growth parameters like plant height, spread of the runner plant and number of leaves per runner were better under Naturally ventilated polyhouse.

Gaurav *et al.* (2016) found that the ornamental plant Dracaena fragrans grown under white and red nets exhibited maximum height as compared to green and black coloured shade nets.

Pandey *et al.* (2015) studied the influence of weather parameters on the growth and yield of the strawberry (*Fragaria x ananassa Duch*.) in the open and naturally ventilated polyhouse. They observed that fruits grown in the open field conditions had higher number of roots per plant, root weight, root volume and total chlorophyll content, leaves per plant, fruit length and weight. In the controlled conditions, plant had higher growth, crown height and plant spread. Other factors are somewhat similar in the open and controlled conditions.

Thapa *et al*. (2013) studied the assessment of producing quality sprouting broccoli (Brassica oleracea var. italica) under cover and open condition situation and reported that plants grown in polyhouse gave the highest production in all the four genotypes as compared to the plants grown in open field. Marketable curd yield of 'Early you' were highest in polyhouse condition.

Andhale (2012) studied the influence of colour shadenet and physiological parameter in capsicum and indicated that, micrometeorological parameters *viz*., absorbed photosyn thetically active radiation, rate of photosynthesis, stomatal conductance, light use efficiency and growth parameters *viz*., plant height, number of branches, number of leaves, leaf area, and dry matter per plant significantly increased under green + white coloured shadenet house than black, red and blue coloured shadenet house.

Ramana Rao *et al*. (2012) evaluated the performance of capsicum crop (Swarna variety) in open field and under covered cultivation. Under covered cultivation, black colour shade net having 50% shade factor was used in the study. Same crop cultural practices in the open field and under covered cultivation were adopted for comparison. Drip irrigation system was adopted in both the cases and irrigation system parameters such as frequency of irrigation and wetting pattern were collected. Other parameters such as soil temperature, duration of the crop, morphological parameters of the crop and yield were monitored. The study revealed that under shade net the crop yield was increased by 80 per cent over open field cultivation along with water saving of about 40 per cent in covered cultivation. Duration of the crop was also extended by 40 more days under covered cultivation. Sun scalding affect was found absent under covered cultivation whereas, majority of the fruits were damaged due to sun scalding in open field.

Nami *et al.* (2011) reported that the lower TSS (total soluble solids) and pH of Cabernet-Sauvignon grapes were in high temperature than in the low temperature. Higher total acidity and berry weight was recorded under low temperatures than in the high temperature.

Zoran *et al.* (2011) evaluated the influence of different colour shadenet (photoselective) on the plant development yield and quality of bell pepper (*Capsicum annuum* L.) grown under four different colored shadenet (pearl, red, blue and black) with different relative shading (40 and 50%). They revealed that, use of color-shade nets improve the productivity by moderating climatic extremes. The total fruit yield (t/ha) under colour shadenet were higher by 113 to 131 percent relative to the open field.

Panigrahi *et al.* (2010) conducted an experiment with green house and open field condition on capsicum annum cv. California Wonder. The germination percentage (52.47%) growth characters, like plant height, number of primary branches, number of leaves, number of fruits per plant, length of fruits and girth of fruits found significantly better under green house as compared to open field condition (37.32%). Under protected environment the yield was two times more (5.18 kg/m2) as compared to open field condition (2.46 kg/m^2).

Basu and Singh. (2009) studied hybrid seed production of brinjal under net house condition and reported that higher seed yield with better seed quality can be obtained under net house condition as compared to open field condition.

Dhatt and Kaler (2009) studied the effect of Shade net and growing media on nursery raising of cauliflower in subtropical area. Among the three shade treatments, agro Shade net (green colour 6 mesh size, 25 % reduction of sunlight), monofilament insect net (white colour 26 mesh size, 10 % reduction of sunlight) and open field, the monofilament insect net showed the best results for cauliflower germination, seedling length, number of true leaves, dry matter, field establishment of transplant, plant height, days to harvesting and yield.

Fallik *et al.* (2009) conducted an experiment and found that crops grown under various colored (photo-selective) shade nets (Chromatinets) were found to improve their fruit yield and fruit quality. The pepper grown in an arid region under red and yellow shade nets, had a significant higher yield compared with black nets of the same shading factors, without reducing fruit size. The results suggest the advantage of growing pepper under light-dispersive photo-selective shade nets, rather than the traditional black nets for improving productivity, quality and probably also, shelf-life.

Medany *et al.* (2009) conducted an experiment and reported that, black net greenhouse gave significantly the highest early yield, while white net greenhouse gave significantly the highest plant height, number of leaves per plant, leaf area index and total yield of sweet pepper compared to other greenhouse.

Gent (2007) reported that there was high total chlorophyll content in the leaves of tomato cultivated under the black and blue coloured shade nets as compared to the tomato plants cultivated in the open conditions.

Elad *et al.* (2007) tested the effect of coloured shade nets with different shade intensities and qualities of irradiation transmittance on field pepper. They reported that, yield was higher under nets than in the open, nevertheless the yield from plants grown under the 10 per cent shade black net was not higher than that of the plants under the 25 per cent black net, despite the significantly lower levels of disease at the higher shade intensity. B quality pepper field was significantly higher in the plots covered by 25 per cent shade. Thus, growing sweet pepper under shade nets results in increased yield.

Pandey *et al*. (2007) studied performance of capsicum varieties under greenhouse and open field condition. They concluded that different capsicum varieties gave higher yield under greenhouse condition as compared to open field condition.

Voca *et al.* (2007) reported that the cultivation systems can have a greater influence on the chemical composition of the fruits of the strawberry.

Jessica and James (2006) observed that the titratable acidity and pH were slightly higher in exposed treatment (control) than the shade net in the Pinot Noir vineyard, while shaded and exposed treatments had similar proportions of seed, skin, and pulp, also total soluble solid (TSS) at harvesting time.

Swagatika *et al.* (2006) observed that the cauliflower sown on september month and grown under shadenet recorded the highest values for plant height, number of leaves, girth and curd yield.

Gindaba and Wand (2005) reported that the shade nets reduced the fruit growth in 'Royal Gala' apple. In the 'Fuji' apple, increased fruit growth. Contrary to this, covering the 'Mondial Gala' apple orchard with nets, did not affect fruit size. Heavy shading during early stages of fruit growth reduced apple fruit growth rate and induced fruit drop, and it was closely related to decreases in photosynthesis.

Naik (2005) reported that, among the three growing conditions namely, medium cost polyhouse, low cost polyhouse and net house. The medium cost polyhouse observed higher yield. The favourable environmental conditions prevailing in medium cost polyhouse might have helped in better growth of roots and shoots which directly helped in better vegetative growth and finally improving the yield attributing parameters *viz*., number of fruits per plant (10.29), fruit weight per plant (1.02 kg), pericarp thickness at blossom end (1.23 cm), fruit length (8.49 cm) and fruit breadth (7.24 cm) and these finally led to highest total yield of 37.77 t per ha.

Shahak *et al.* (2004) showed that the fruit size and fruit set of apple cv. 'Red Delicious', 'Smoothee Golden Delicious' and 'Hermosa' Peach increased with all nets (blue, red, yellow, grey and pearl of 30% shading and a white 12%) especially the red/white shade net than compared with the control (no-net).

Singh *et al.* (2004) found that, out of seven capsicum hybrids, the hybrid bharat had significantly higher marketable yield (1.118 kg $plant^{-1}$) and total yield (1.176 kg $plant^{-}$

^{1}) as compared to other hybrids (0.468-0.910 kg plant^{-1}) marketable and (0.511-0.930 kg plant^{-1}) total yield under protected cultivation. Fruits were more uniform, larger in size, and mature one month earlier to conventional cultivation.

Ganesan (2003) conducted a study to compare naturally ventilated greenhouse and open field conditions for their effect on yield (2145.21g fruits/plant) and quality of fruits of tomato and they were found that greenhouse with ventilation gaps in four side walls had significantly higher total sugar, reducing sugar, protein and nitrogen content. The lycopene content and chlorophyll content was not much affected compared to open field conditions.

Takte *et al*. (2003) reported that, plastic films and shade nets were used for protection of valuable crops against excess sunlight, cold, frost, wind and insect/birds. Further, they added that ventilation played an important role in crop production under controlled conditions. Which was provided naturally or mechanically to create optimum condition for crop growth.

Spayd *et al.* (2002) concluded that the TSS (total soluble solid) and colour of *Vitis vinifera* cv. Merlot berries were higher in control than under shade but titatable acidity, pH and berry mass was higher in the net shade than in control (sunlight).

Ban *et al.* (2000) reported that the anthocyanin content in berries of Kyoho grapes were higher than in the control than shading treatment (covered with aluminum film) and no effect on the resveratrol levels in grape berry skin was observed.

Jeevansab (2000) reported that highest and significant fresh fruit yield (30.5 t/ha) was obtained under poly house followed by open condition (12 t/ha). Similarly capsicum fruits obtained from poly house had a higher ascorbic acid and total soluble solids (TSS) compared to fruits of open field.

Megharaja (2000) reported that Capsicum fruits grown under greenhouse condition were recorded significantly higher TSS and total chlorophyll content (3.24% and 17.54 mg/100 g) as compared to fruits from open condition (1.44 % and 11.36 mg / 100 g respectively).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Horticulture farm, Dhaka to investigate the influence of different growing media on the growth, yield and quality of strawberry under protective condition. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental period

The experiment was conducted during the period from October-2019 to February-2020.

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.2 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Farukh *et al.*, 2019). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-II

3.3 Experimental materials

In this experiment Festival strawberry variety was used as planting material. Whereas cowdung, cocopeat and vermicompost were used as growing media and Harvita PGR was used as plant growth regulator. The short description of this materials was given below.

3.3.1 Festival strawberry variety

Festival strawberry variety was used as planting material for this experiment. The main characteristics of this variety was : High fruit yielding variety, plant height 30 cm, average fruit/ plant 32 which average weight are 450g, medium sized fruit(14g), heart shape fruit, attractive red color, scented, sour-sweet, TSS-11% taste, edible portion of fruit 100%. The planting season of this variety is October to November and the flower initiation in mid November month. Harvesting time in December to March. Yield 10-12 t/ha and its tolerant to insect and disease.

3.3.2 Cowdung

Cow dung, which is usually a dark brown color, is often used as manure (agricultural fertilizer). This type of manure is not as rich in nitrogen as many other types; however, the high ammonia levels can burn plants when the fresh manure is directly applied. This allows us to water less frequently, as the roots of plants can use the additional water and nutrients when needed. Composted cow manure also contains beneficial bacteria, which convert nutrients into easily accessible forms so they can be slowly released without burning tender plant roots. Composting cow manure also produces about a third less greenhouse gases, making it environmentally friendly

3.3.3 Cocopeat

Cocopeat is a growing media made of coconut husk. It is a very good alternative to traditional peat moss and rock wool and having air filled porosity and high water holding capacity makes it, an ideal growing media for the plant crops. It is an eco-friendly, free from soil-borne pathogens and weeds and considered as better organic substrate in soilless cultivation. It has a pH of 5.7 – 6.5 and EC level <1 ds m^{-1} is ideal for plant growth.

3.3.4 Vermicompost

It is the compost made by microbial activity of earthworms and rich in major and minor plant nutrients and increases the microbial population of nitrogen fixing bacteria, actinomycetes, and symbiotic association of mycorrhiza on the plant root system. It also improves soil phosphorous and nitrogen availability.

3.4 Experimental treatment

There were two factors in the experiment namely different growing media and different protective condition as mentioned below:

Factor A: Different growing media denoted as M:

M_1 = Soil : Cowdung (1:1.5)
M_2 = Soil : Cocopeat (1:1.5) and
M_3 = Soil : Vermicompost (1:1.5)

Factor B: Different protected condition denoted as C:

C_1 = No shade (Open space)
C_2 = Net house and
C_3 = UV poly tunnel.

3.5 Experimental design

The experiment was laid out in randomized complete block design (RCBD) with 2 factor and three replications. Total 27 unit pots were used in for the experiment with 9 treatments.

3.6 Detail of experimental preparation

The details of various cultural operations carried out during the course of experiment are as mentioned below.

3.6.1 Selection and preparation of the pot

10 litre size of plastic pots were used for this experiment.

3.6.2 Preparation of growing media

Three different growing media cowdung, Cocopeat, and vermicompost were used to make the different treatments in different combination ratio (different growing media: sand @ 1:1.5 ratio or 40 % : 60 %) for strawberry cultivation. Cocopeat, vermicompost, and FYM were purchased from the local supplier. Three treatments made out of different combinations of growing media and sand. The media were prepared on the basis of ratios and properly mixed according to the treatment requirements.

3.6.3 Filling of pots

Before filling the pots, drainage hole were made at the bottom so that excess water can drain out. Each pot was filled with prepared growing media of different ratios and planted a single uniform seedling in each container.

3.6.4 Planting material and planting

Festival strawberry variety seedlings were parched from Jannat Nursery located at Sher-e- Bangla Nagar Agargoan. The seedlings were then planted according with par treatment requirement. The planting was done on 16th October during the year 2019.

3.6.5 Construction of protected structure

Net house

The most common types of Agriculture Shade Net Houses are created using wire rope and wooden frames. The wire rope used in such structures is usually heavy-duty and can be any colour that best blends into its surroundings. These structures are easy to install and very low cost, but they’re also less durable than other types of shade net houses. The rope must be added every five years or so to keep up with growth and prevent sagging. Heavy winds can cause serious damage as well; however, good quality construction will make wind damage much rarer. Wire rope structures tend to be used on a large scale and cover vast areas because of their low price point. This makes them an excellent choice for farmers looking to reduce costs by covering wide swaths of land with a single installation.

UV poly tunnel

Three (3) protected structures (2 m x 3 m x 5 m) were constructed with the use of Steel rod and covered with ultra violet (UV) polyethylene Film with 0.001mm thickness. A platform of 2.5 ft. high was established inside the structure where the potted seedlings of strawberry were set up on top.

3.7 Intercultural operations

3.7.1 Weeding

No weeding was done in the experiment.

3.7.2 Irrigation

Immediately after transplanting, light irrigation to the individual pot was provided to overcome water deficit. After establishment of seedlings, each pot was watered in alternate days to keep the growing media moist for normal growth and development of the plants. During pre-flowering stage, irrigation was done sincerely.

3.7.3 Plant protection management pests

Strawberries are susceptible to several common problems such as garden pests. Some of these are Aphids, Red spider mite, Vine weevil, Tarnished Plant Bug. Adult sap beetles, Spider mites.

Control: Application of malathion (0.05%) on appearance of caterpillars has been found to be effective in most cases.

Diseases: Diseases such as Anthracnose (*Colletotrichum spp*.), powdery mildew, Red core, Crown rot and gray mold may cause serious losses as well. Root Rot-Many root-rotting diseases including Verticillium wilt, Red stele, Fusarium, Rhizoctonia, and Pythium root rots affect planting of strawberries.

Control: To avoid diseases use an important cultural practice is to rotate crops.

Application of carbendazim has been found to be effective in most cases.

3.7.4 Harvesting

Harvesting of fruits was done after the fruits reached at maturity stage. Mature fruits were harvested when fruits turned to red in color with waxy layer on surface of fruits. The optimum time to harvest strawberries is the early morning when the fruits are cool. If picked later in the day, the berries will need to be cooled to remove the field heat and maintain their quality. Fruit should be uniformly coloured and be harvested complete with a stalk conjoined with the berry. Fruits were harvested from last week of January 2020 to last week of February 2020.

3.8 Data collection

The data were recorded on different growth and yield component traits and quality traits on all the plants in each treatment and each replication.

i. Plant height (cm)

The plant height was measured individually from the base of the plant to the tip of the main stem with a measuring scale and result was expressed as average height in centimetres and subjected to statistical analysis.

ii. Number of leaves plant^{-1}

The number of fully opened leaves per plant was counted and the average number of leaves per plant was calculated at each observation.

iii. Leaf chlorophyll content

Chlorophyll content in leaves of strawberry was determined by the use of chlorophyll meter SPAD-502 manufactured by KONICA MINALTA SENSING, INC. in Japan. The data were expressed as percent.

iv. Number of flowers plant^{-1}

It was determined by counting the number of flowers till it reached the final harvest and the average number of flowers per plant was worked out.

v. Number of fruits plant^{-1}

The total numbers of fruits were counted in each treatment at the time of harvesting (last week of January to the last week of February) and their average was expressed in the number of fruits per plant.

vi. Individual fresh fruit weight (g)

The fresh fruit weight of each treatment from each plant was calculated by weighing the individual fruit on an electronic balance and the average weight (g) per fruit was worked out.

vii. Fruit yield plant^{-1} (g)

Once the fruits turns fully colored were picked along with about one quarter of the stem attached. The harvesting operation was done in the early morning hours to reduce the transpiration losses. The observations on fruit weight were recorded from each treatment after harvest. The total yield per plant was calculated by dividing the recorded yield by the number of surviving plants and expressed as gram per plant.

viii. pH

For each replicate, strawberries were squeezed, about 25 ml of juice was taken in a beaker and the pH values were determined by using the digital pH meter with a standard buffer solution of pH 4.0 as described in A.O.A.C. (1995).

ix. Total soluble solids (°Brix)

The juice was extracted from the strawberry fruit with a help of hand extractor and strained through a muslin cloth. The strained juice of each sample was thoroughly stirred before recording. Hand Refractometer having a range of 0 to 30 °Brix (ERMA made) by putting a drop of juice or pulp on the screen and taking the readings. The Refractometer was calibrated with distilled water with every use and the values were expressed in degree brix soluble solids.

x. Titratable Acidity (%)

The titratable acidity was estimated in terms of citric acid by titration process against NaOH solution as per A.O.A.C. (1995). The total titratable acidity was expressed in terms of citric acid percent on a fresh fruit weight basis.

xi. Ascorbic acid (mg per 100 g of fruit)

The ascorbic acid was estimated by using the procedure given in A.O.A.C. (1990).

Reagents

Metaphosphoric acid solution (3%)

Metaphosphoric acid (HPO_3) : 15 g

Glacial acetic acid : 40 ml ; Volume : 500 ml

2, 6-Dichlorophenol Indophenol dye

2, 6-Dichlorophenol Indophenol dye : 50 mg

Sodium bicarbonate : 42 mg ; Volume : 200 ml

Preparation of standard ascorbic acid solution

50 mg of ascorbic acid was dissolved in metaphosphoric acid solution (3%) and the final volume was made to 50 ml by adding metaphosphoric acid. One ml of standard ascorbic acid solution was used to standardize the dye with the appearance of pink color as the endpoint.

Estimation:

Ascorbic acid was extracted from the fruit by macerating 5 g of sample with 3 percent metaphosphoric acid and final volume was made to 50 ml and a pinch of activated charcoal was added for the disappearance of red color. It was then filtered through rough filter paper and 2 ml aliquot was taken in conical flask from the filtrate and titrated against 2, 6 Dichlorophenol Indophenol dye. The endpoint was the appearance of pink color persisting up to one minute. The ascorbic acid content was calculated using the following formula and results were expressed in mg of ascorbic acid per 100 g of sample.

$$\text{Ascorbic acid (mg/ 100 g)} = \frac{\text{Titrate value (Y)} \times \text{Total volume made up}}{\text{Standard reading} \times \text{Vol. of aliquot} \times \text{Vol. of sample}} \times 100$$

where, Y is ml of 2, 6- Dichlorophenol indophenol dye used.

xii. Moisture content

Moisture content was determined by weight loss after drying in a vacuum oven at 60 °C for 10 hours. Each sample’s weight, approximately 15g, was recorded before and after drying (AOAC method 920.151). The samples were first chopped into small pieces and placed in aluminum canisters prior starting the drying process. The weight of canisters was also recorded for measurements that are more accurate. After removing the samples from the vacuum oven, the samples were placed in a desiccator to cool down before recording the final weight. Two pieces of strawberry for each repetition per treatment (coated samples and controls) were used for the analysis. The test was performed in 3 times and the moisture content (MC) in wet basis (w.b.) was calculated as follows:

$$MC_{(wb)} = (M_{wet} - M_{dry}) / M_{wet}$$

Where, M_{wet}(g) is the weight of the wet sample and M_{dry}(g) is the weight of the dry sample.

xiii. Reducing sugar

200 mg sample was pissed with 5 ml distill water, filtrated its and transferred into a test tube. By using pipette transferred 2 ml sample solution in another test tube, add 0.4 ml phenol and 2ml H_2SO_4 and mixed thoroughly. After sometimes put the sample solution in the spectrophotometer cube and measurement the absorbance of the sample solution at 540 nm wave length. Before doing so, taking distilled water in a cube and neutral the value. After getting the absorbance unknown concentration of the reducing sugar of the sample was measured by standard curve graph formula, y= mx + b. Where absorbance, the dependent variable, is placed on the y-axis and concentration, the independent variable is graphed on the x-axis. m is the slope of the line and b is the y-intercept. By plotting the information, we can get the reducing sugar concentration of the samples

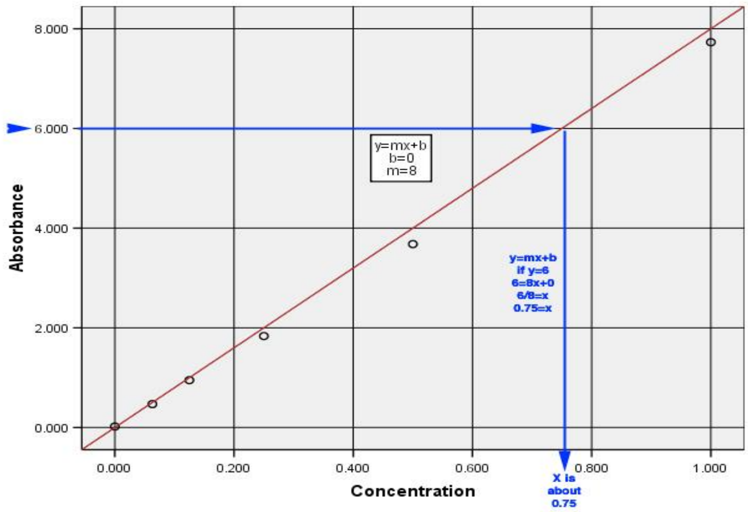


Plate 1. Reducing sugar estimation using standard curve spectrophotometer absorbance.

xiv. Total anthocyanin content

Total anthocyanin extraction was conducted by separating the exocarp and mesocarp from the endocarp (stone) with a stainless steel knife, and the resulting material, approximately 0.2 g, was macerated using a porcelain mortar and pestle. Two macerated pulp portions were weighed to 0.05 g each. One portion was mixed with 0.025 Mpotassium chloride buffer (pH 1.0), and the other portion mixed with 0.4 M sodium acetate buffer pH 4.5. Following two hours of extraction at room temperature

(25^0C), samples were filtered through Whatman No. 1 filter paper, and absorbance recorded using a Shimadzu UV-1650 PC spectrophotometer (Shimadzu Corp., Kyoto, Japan) at wavelengths of 520 and 700 nm, for solutions at pH 1.0 and pH 4.5, respectively. TAC was expressed as cyanidin-3-glucoside (% w/w) equivalents, as follows:

Total anthocyanin content (% w/w) $= \frac{A}{\varepsilon \times l} \times \mathrm{MW} \times \mathrm{DF} \times \frac{V}{W} \times 100\%$

where, A = ($A520_{nm}$ - $A700_{nm}$) pH1.0 - ($A520_{nm}$ - $A700_{nm}$)pH4.5; MW (molecular weight) = 449.2 g mol^{-1} for cyanidin-3-glucoside (cyd- 3-glu); DF = dilution factor; W = sample weight (mg); *l* = path length in cm; ε = 26,900 M extinction coefficient in L $mol^{-1}cm^{-1}$ for cyd-3-glu; and 10^3 = factor for conversion from g to mg. The total anthocyanin content (TAC) ranged from 1.5 to 82.0 mg g^{-1}.

3.9 Statistical Analysis

Data obtained for different parameters were statistically analyzed to observe the significant difference among the treatment. The data were analyzed using ANOVA technique with the help of computer package programme “Statistic 10 software” and mean difference among the treatments were adjudged with Least Significant Difference (LSD) at 0.01 levels of probability as described by Gomez and Gomez (1984). Graphs were made by using Excel software.

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the study have been presented and discussed in this chapter with a view to investigate the influence of different growing media on the growth, yield and quality of strawberry under protective condition.

4.1 Plant height

Effect of different growing media

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. Experimental result revealed that the plant height showed significant influence by different growing media harvesting stage. (Figure 1). The highest plant height (18.44 cm) was recorded under Cocopeat based growing media treatment (M_2). Whereas the lowest plant height (14.89 cm) was recorded under Vermicompost based growing media treatment (M_3). The variation of plant height may be due to use of different growing media that vary greatly in composition, particle size, pH, aeration and ability to hold water and nutrients capacity. Vinkovic *et al*. (2007) reported that cocopeat offers a high moisture and air retention capacity, which enables easy growth and well spread root system. It appears from this study that coco coir is a suitable growing medium for the production of tomatoes under greenhouse conditions.

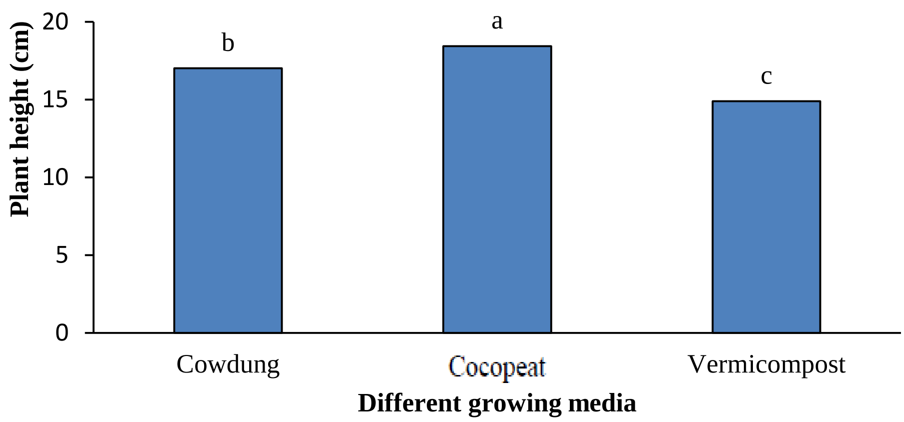


Figure 1. Effect of different growing media on plant height of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

Strawberry grown in different protected conditions had shown significant effect on plant height of strawberry at harvesting stage (Figure 2). Experimental result showed that the highest plant height (17.89 cm) was recorded in net house condition (C_2) which was statistically similar (17 cm) with no shade condition (C_1). Whereas the lowest plant height (15.45 cm) was recorded in UV poly tunnel based (C_3) protected condition. Similar result also observed by Gaurav *et al* (2016) who found that the ornamental plant *Dracaena fragrans* grown under white and red nets exhibited maximum height as compared to green and black coloured shade nets.

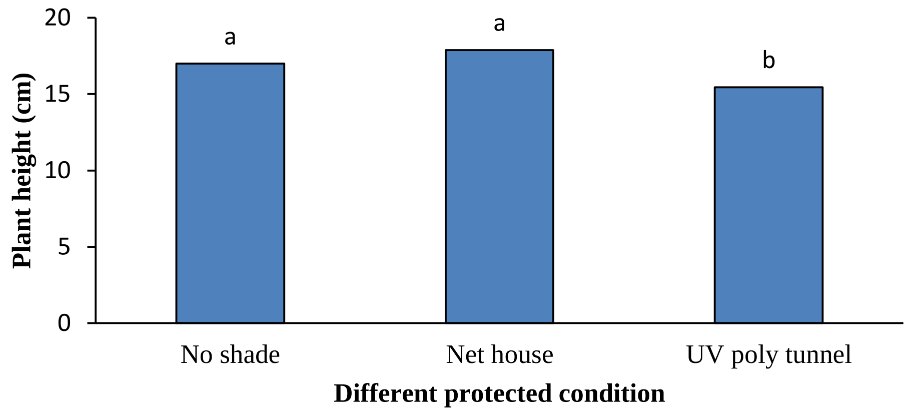


Figure 2. Effect of different protected condition on plant height of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition resulted in significant effect on plant height of strawberry at harvesting stage (Figure 3). Experimental result showed that the highest plant height (20.33 cm) was obtained in Cocopeat based growing media under net house condition (M_2C_2) which was statistically similar with M_2C_1 (19.00 cm) treatment combination. Whereas the lowest plant height 14.67 cm was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3) which was statistically similar with M_3C_1 (14.67 cm), M_3C_2 (15.33 cm), M_1C_3 (15.67 cm) and M_2C_3 (16.00 cm) treatment combination.

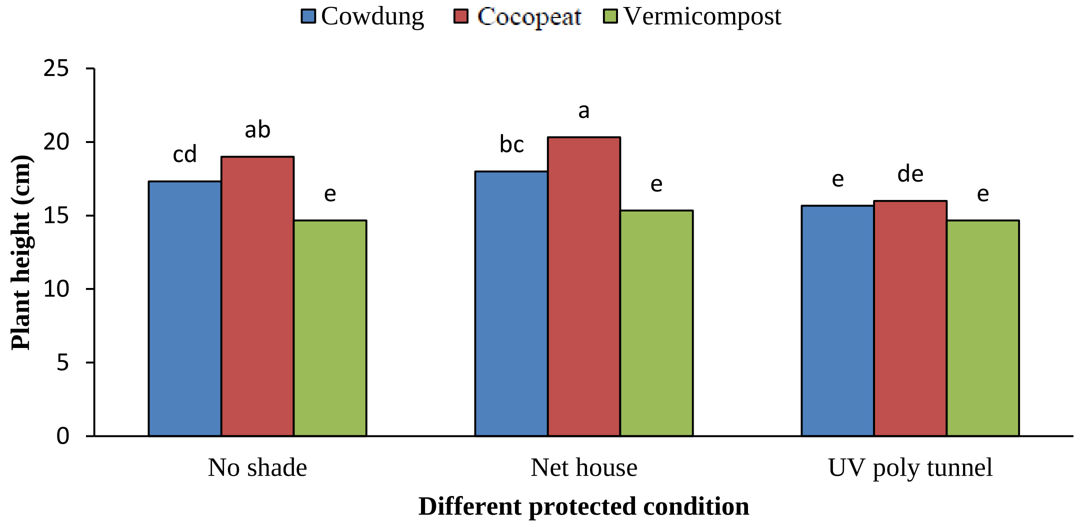


Figure 3. Interaction effect between different growing media and protected condition on plant height of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

4.2 Number of leaves plant^{-1}

Effect of different growing media

A leaf is the principal lateral appendage of the vascular plant stem, usually borne above ground and specialized for photosynthesis. Strawberry growing in different growing media significantly affect number of leaves plant^{-1} at harvesting stage (Figure 4). The highest number of leaves plant^{-1} (11.99) was recorded under Cocopeat based growing media treatment (M_2). Whereas the lowest number of leaves plant^{-1} 10.78 was recorded under Cowdung based growing media treatment (M_1) which was statistically similar with M_3 (11.00). The variation of leaf number plant^{-1} was due to the use of different growing media that vary greatly in composition, particle size, pH, aeration and water and nutrients holding capacity. The result obtained from the present study was similar with the findings of Aktas *et al.* (2013) and they reported that the maximum number of leaves was obtained with cocopeat and spent mushroom compost, respectively.

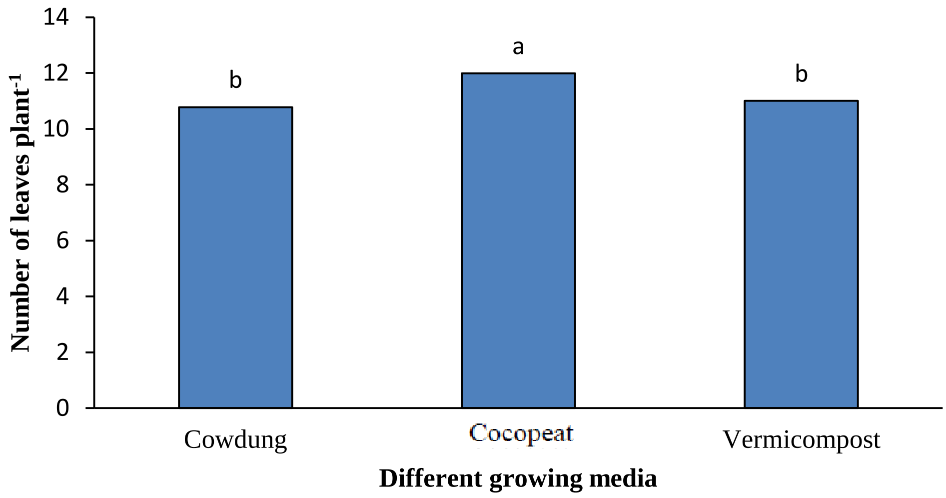


Figure 4. Effect of different growing media on number of leaves plant^{-1} of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

Number of leaves plant^{-1} varied significantly in response to the use of different protected condition for strawberry cultivation at harvesting stage (Figure 5). Experimental result revealed that the highest number of leaves plant^{-1} (12.22) was recorded in net house condition (C_2) which was statistically similar (11.78) with no shade condition (C_1). Whereas the lowest number of leaves plant^{-1} 9.78 was recorded in UV poly tunnel based (C_3) protected condition. This increase in number of leaves in the net conditions as compared to others protected conditions may be attributable to the genotypic factors. The result obtained from the present study was similar with the findings of Gaurav *et al* (2016). They recorded maximum number of leaves in *Dracaena fragrans* under the red shade net which was attributed to usually to the stem diameter (mm) spectral effect of the red shade net that influences the plant growth. Medany *et al.* (2009) also reported that, black net greenhouse gave significantly the highest early yield, while white net greenhouse gave significantly the highest plant height, number of leaves per plant, leaf area index and total yield of sweet pepper compared to other greenhouse.

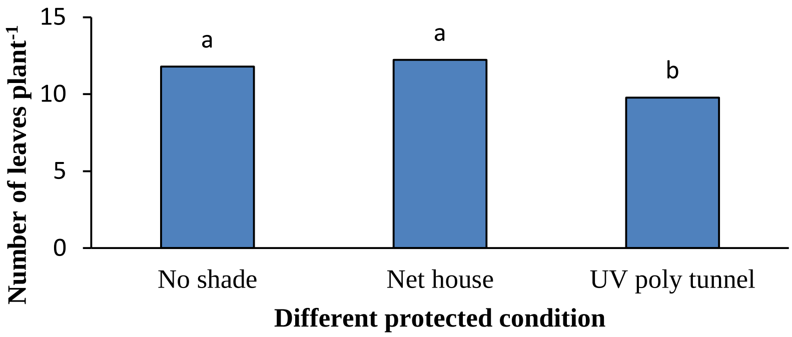


Figure 5. Effect of different protected condition on number of leaves plant^{-1} of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition resulted in significant variation in respect of leaf number plant^{-1} of strawberry at harvesting stage (Figure 6). Experimental result showed that the highest number of leaves plant^{-1} (13.33) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest number of leaves plant^{-1} (9.00) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3).

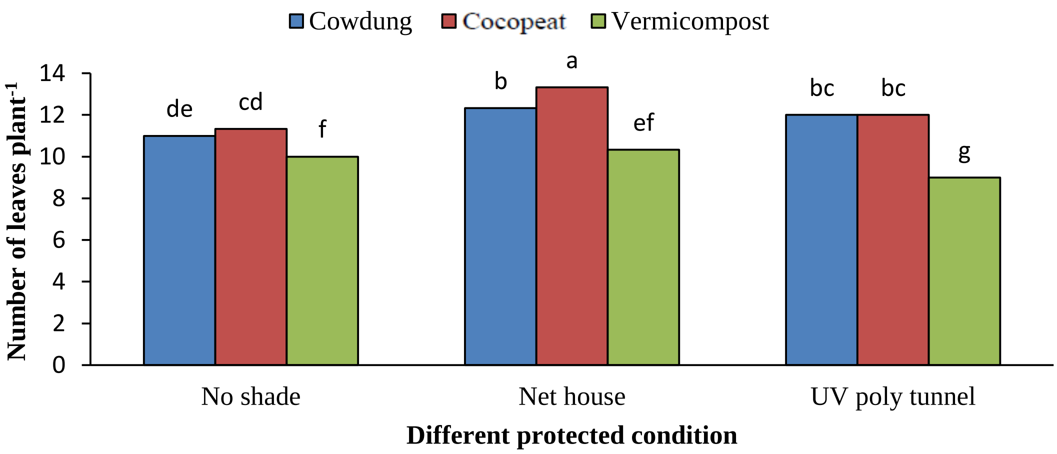


Figure 6. Interaction effect between different growing media and protected condition on number of leaves plant^{-1} of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

4.3 Leaf chlorophyll content (%)

Effect of different growing media

Chlorophyll is the natural compound present in green plants that gives them their color. It helps plants to absorb energy from the sun as they undergo the process of photosynthesis. In this experiment, different growing media had shown significant effect on leaf chlorophyll content at harvesting stage (Figure 7). Experimental result revealed that the highest leaf chlorophyll content (43.72 %) was recorded under cowdung based growing media treatment (M_1). Whereas the lowest leaf chlorophyll content (43.35 %) was recorded under Vermicompost based growing media treatment (M_3).

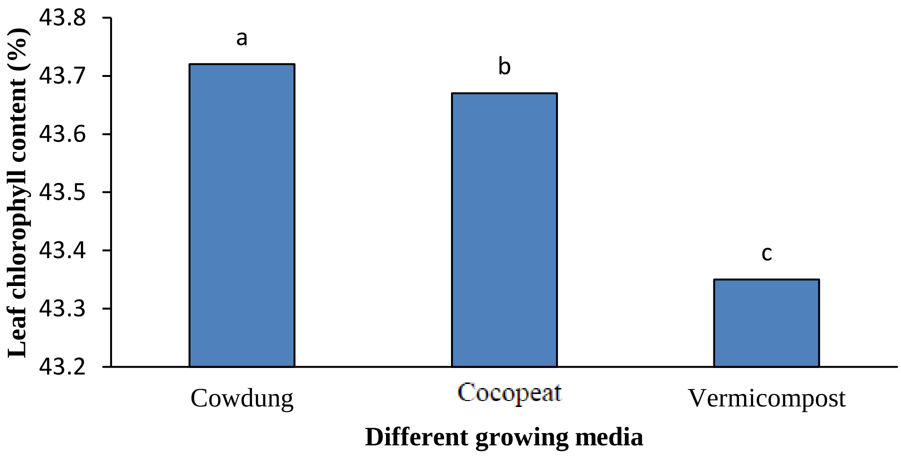


Figure 7. Effect of different growing media on leaf chlorophyll content of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

Strawberry grown in different protected condition had shown significant effect on leaf chlorophyll content at harvesting stage (Figure 8). Experimental result showed that the highest leaf chlorophyll content (45.27 %) was recorded in net house condition (C_2). Whereas the lowest leaf chlorophyll content (42.00 %) was recorded in UV poly tunnel based (C_3) protected condition. Shade net house modify the light concentration which affect the chlorophyll concentration. The leaves grown under shade net house reduced levels of light and contains more chlorophyll than leaves grown under the open conditions. The reason for the more chlorophyll in the leaves grown under shade net house could be attributed to the purpose of capture of scattered radiation which ultimately is needed for the plant growth by the production of the carbohydrates. Similarly, Gent (2007) reported that there was high total chlorophyll content in the leaves of tomato cultivated under the black and blue coloured shade nets as compared to the tomato plants cultivated in the open conditions.

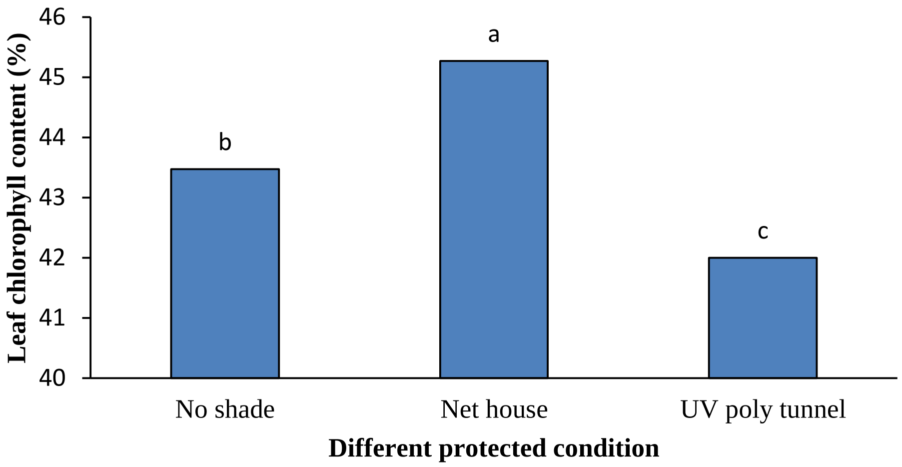


Figure 8. Effect of different protected condition on leaf chlorophyll content of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition resulted in significant variation in respect of leaf chlorophyll content of strawberry at harvesting stage (Figure 9). Experimental result showed that the highest leaf chlorophyll content (46.10 %) was obtained in cowdung based growing media under net house condition (M_1C_2). Whereas the lowest leaf chlorophyll content (41.50 %) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3) which was statistically similar with M_1C_3 (42.13 %).

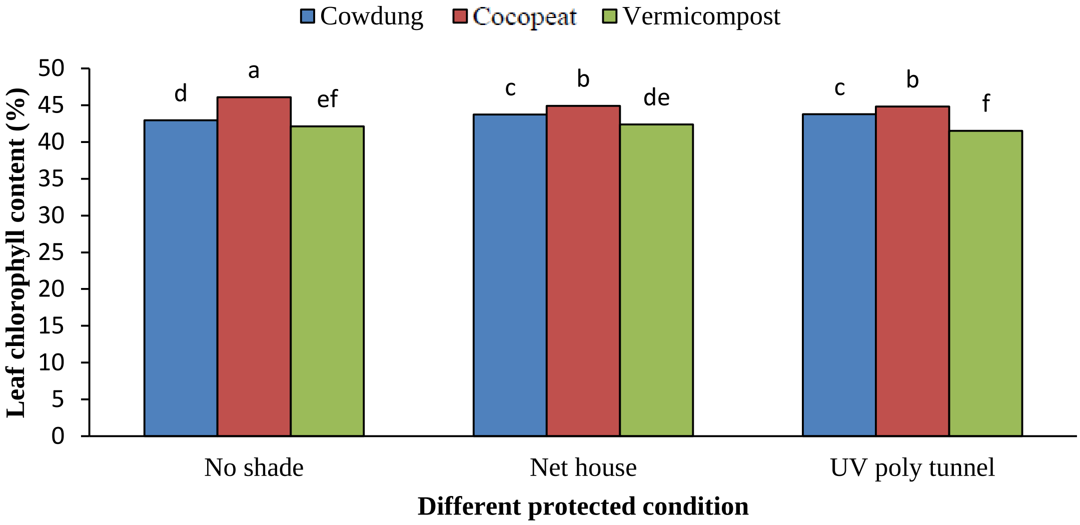


Figure 9. Interaction effect between different growing media and protected condition on leaf chlorophyll content of strawberry at harvesting stage.

Means with different letters are significantly different at the 0.01 level.

4.4 Number of flowers plant^{-1}

Effect of different growing media

Different growing media significantly influenced number of flowers plant^{-1} of strawberry (Figure 10). The highest number of flowers plant^{-1} (17.67) was recorded under Cocopeat based growing media treatment (M_2). Whereas the lowest number of flowers plant^{-1} 11.56 was recorded under Vermicompost based growing media treatment (M_3). Different growing media have different nutrient holding capacity which influences growth and development of the plant. Ali *et al*. (2003) reported that improved berry set and yield of strawberry in coconut based growing medium may be due to the provision of adequate supply of nitrogen and phosphorus nutrients at the fruit setting stage that might have reduced the abortion of the female parts of flowers.

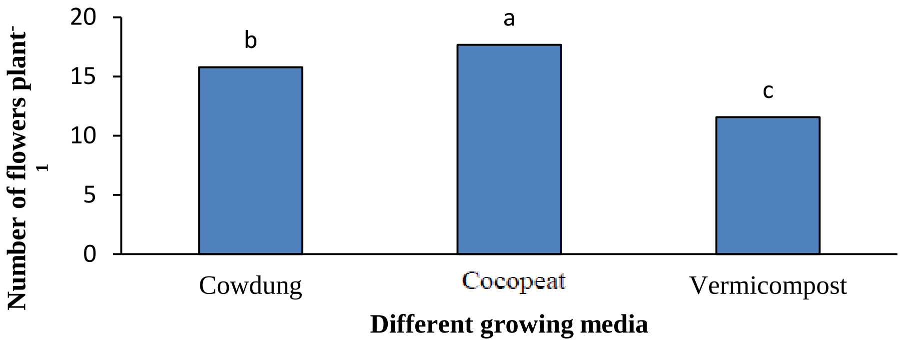


Figure 10. Effect of different growing media on number of flowers plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

Different protected condition had shown significant effect on number of flowers plant^{-1} in strawberry (Figure 11). Experimental result showed that the highest number of flowers plant^{-1} (16.78) was recorded in net house condition (C_2). Whereas the lowest number of flowers plant^{-1} (13.44) was recorded in UV poly tunnel based (C_3) protected condition. Prado *et al.* (2008) revealed that plants raised in two and three layered shading nets were least attacked by insect pest and hence had the least mortality rate than the rest of the treatments. Brocoli raised under two or three layers of Shade net, flowered and matured earlier, had more leaves with taller plants at heading and harvesting, had bigger and heavier heads and higher yield per treatment.

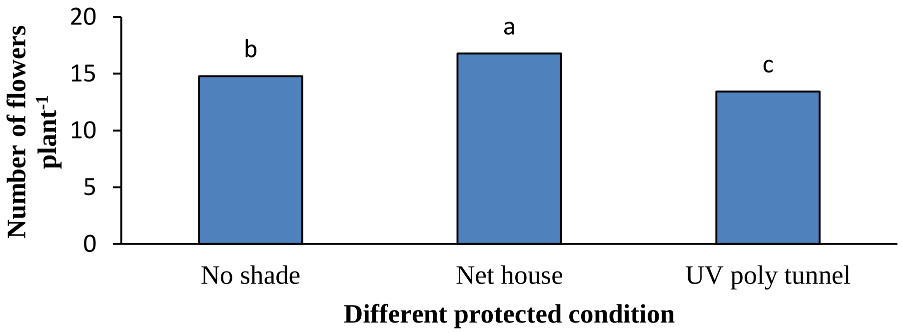


Figure 11. Effect of different protected condition on number of flowers plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition resulted in significant variation in respect of number of flowers plant^{-1} in strawberry (Figure 12). Experimental result showed that the highest number of flowers plant^{-1} **(**19.67) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest number of flowers plant^{-1} **(**11.00) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3) which was statistically similar with M_3C_1 (11.00).

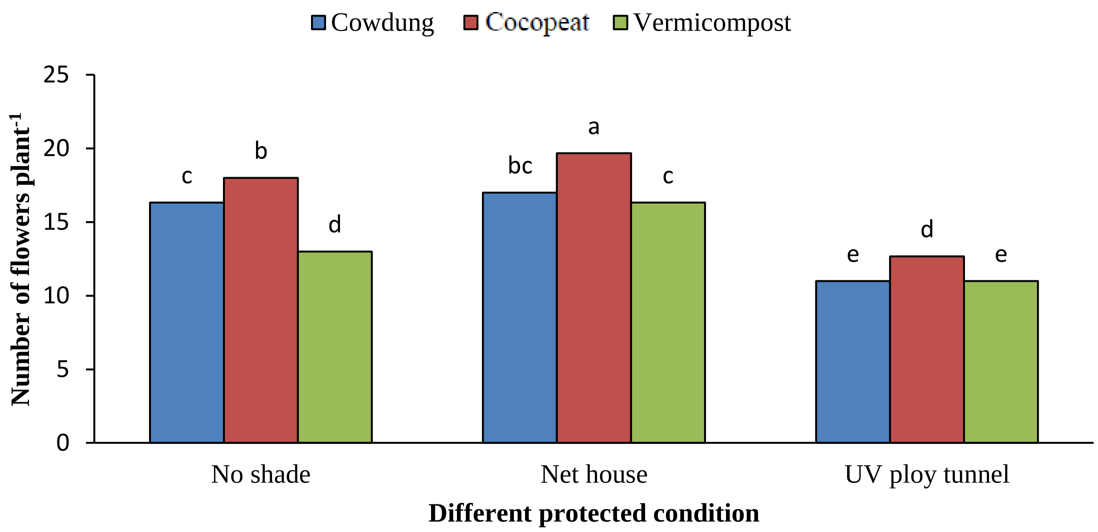


Figure 12. Interaction effect between different growing media and protected condition on number of flowers plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.5 Number of fruits plant^{-1}

Effect of different growing media

Strawberry growing in different growing media significantly influenced number of fruit plant^{-1} (Figure 13). The highest number of fruit plant^{-1} (14.43) was recorded under Cocopeat based growing media treatment (M_2). Whereas the lowest number of fruits plant^{-1} **(**9.67) was recorded under Vermicompost based growing media treatment (M_3). The variation in fruit plant^{-1} may be due to use of different growing media that varies greatly in composition, particle size, pH, aeration and ability to hold water and nutrients capacity. The result obtained from the present study was similar with the findings of

Mazur *et al.* (2012) who reported that coconut fiber as an environmental friendly medium for cultivation of cherry tomatoes as the plants grown in this media recorded higher fruits number and yield compared to plants grown in mineral wool.

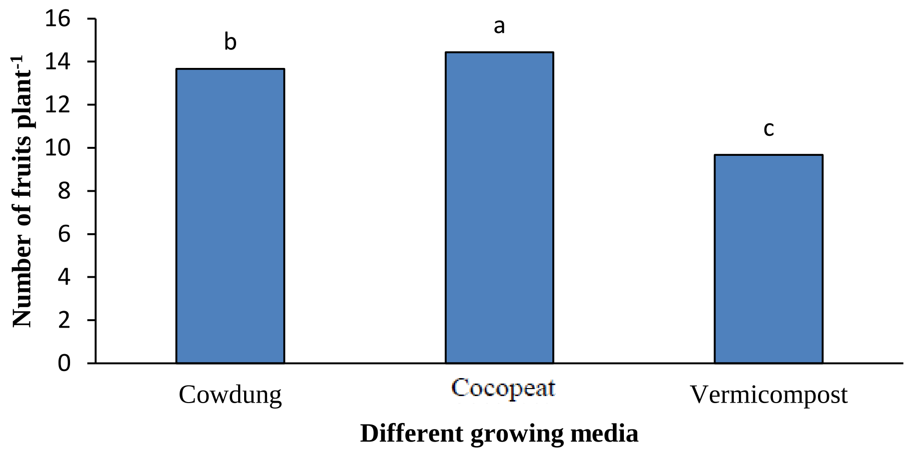


Figure 13. Effect of different growing media on number of fruits plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The number of fruit plant^{-1} of strawberry were significantly influenced by different protected condition (Figure 14). Experimental result showed that the highest number of fruits plant^{-1} (14.33) was recorded in net house condition (C_2). Whereas the lowest number of fruits plant^{-1} (11.11) was recorded in UV poly tunnel based (C_3) protected condition. The number of fruit plant^{-1} was significantly higher in insect net house which could be due to the better availability of better environmental conditions especially the higher relative humidity which might have helped in maintaining the pollen viability and avoided desiccation of pollen on stigmatic surface. Similarly, number of matured fruit per plant was also significantly better in net house. The more number of matured fruit per plant could be due to congenial environment under net house, where as high irradiation affected the maturation of fruit under open field and UV poly tunnel based protected condition. The result obtained from the present study was similar with the findings of Pandey *et al.* (2007) who reported that different capsicum varieties gave higher yield under protected condition as compared to open field condition.

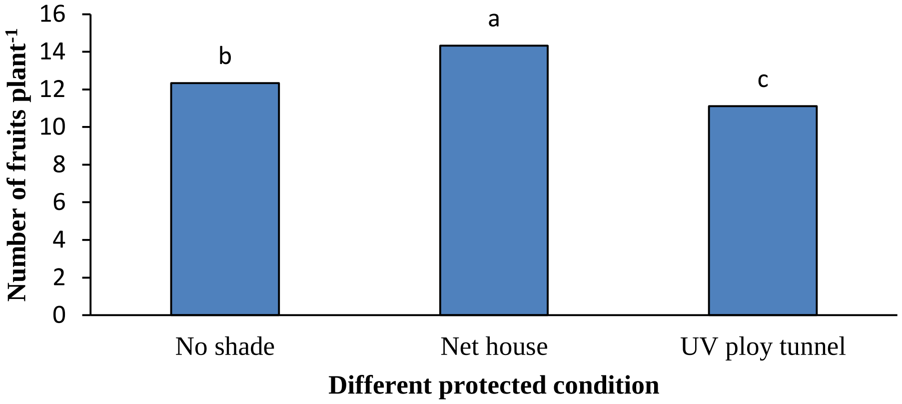


Figure 14. Effect of different protected condition on number of fruits plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction between different growing media and protected condition were found significant (Figure 15) and revealed that the highest number of fruits plant^{-1} **(**17.00) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest number of fruits plant^{-1} (8.67) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3).

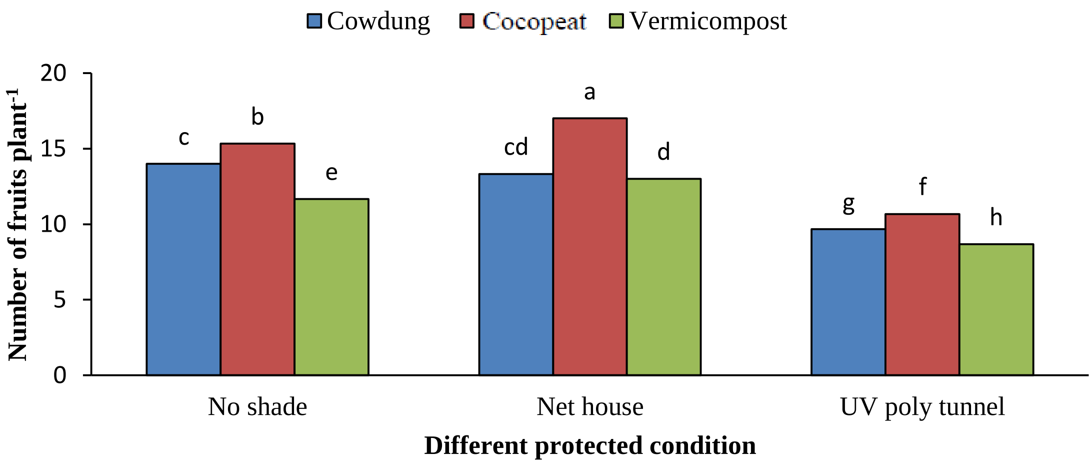


Figure 15. Interaction effect between different growing media and protected condition on number of fruits plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.6 Individual fresh fruit weight

Effect of different growing media

Different growing media significantly influenced individual fresh fruit weight (g) of strawberry (Figure 16). Experimental results revealed that the highest individual fresh fruit weight of strawberry (15.47 g) was recorded under Cocopeat based growing media treatment (M_2). While the lowest individual fresh fruit weight of strawberry (12.21 g) was recorded under Vermicompost based growing media treatment (M_3). The differences of individual fruit fresh weight of tomato may be due to variation of substrates property which influences nutrient supply and water holding capacity and impacts on growth and development of the vegetable crop. The result obtained from the present study was similar with the findings of Luitel *et al.* (2012) and reported that maximum fruit weight (54.7 g) was found to be in cocopeat based substrates due to reason that it offers a high moisture, nutrient and air retention capacity, which enables easy growth and well spread root system.

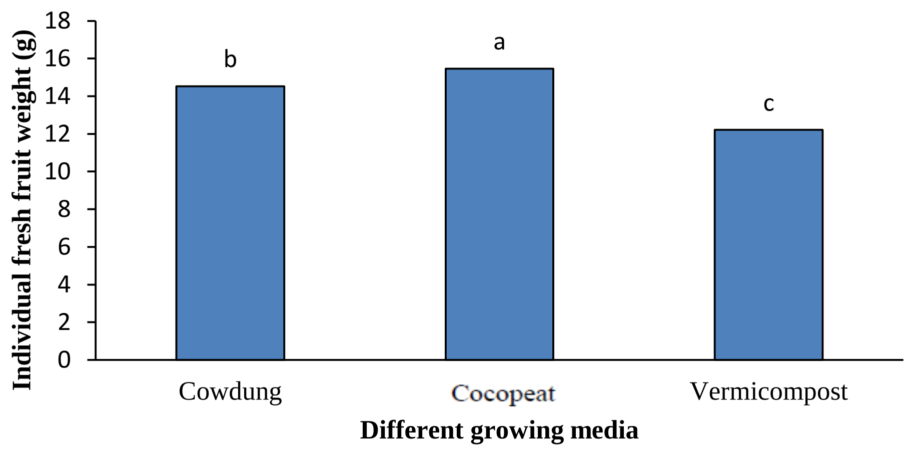


Figure 16. Effect of different growing media on individual fresh fruit weight of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The individual fresh fruit weight of strawberry was showed significant effect due to the effect of different protected condition (Figure 17). Experimental result revealed that, the highest individual fresh fruit weight of strawberry (15.54 g) was recorded in net house condition (C_2). Whereas the lowest individual fresh fruit weight of strawberry (12.65 g) was recorded in UV poly tunnel based (C_3) protected condition. Net house protects crops from natural weather disturbances such as wind, rain, hail, frost, snow, bird and insects also improved growth and yield of crops. Takte *et al*. (2003) reported that, plastic films and shade nets were used for protection of valuable crops against excess sunlight, cold, frost, wind and insect/birds. Further, they added that ventilation played an important role in crop production under controlled conditions. Which was provided naturally or mechanically to create optimum condition for crop growth.

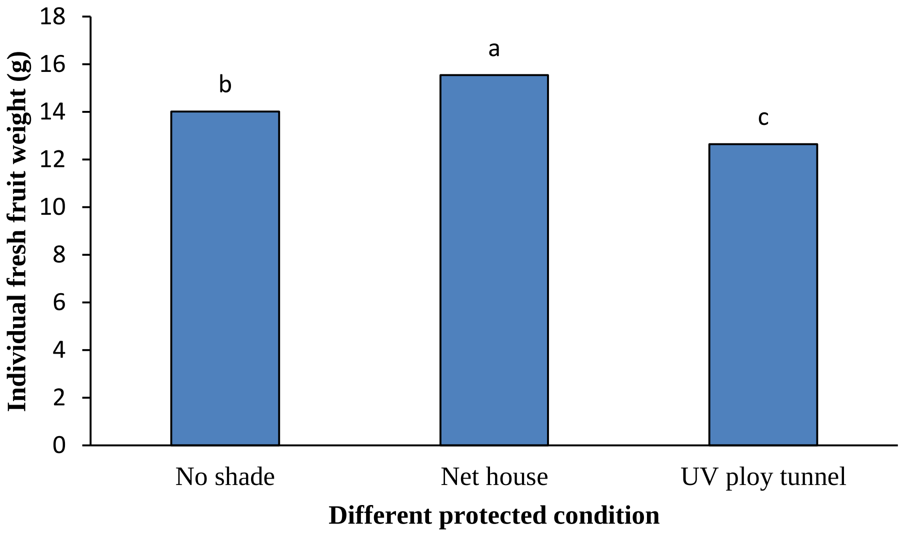


Figure 17. Effect of different protected condition on individual fresh fruit weight of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition were found significant (Figure 18) and revealed that the highest individual fresh fruit weight of strawberry **(**18.05 g) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest individual fresh fruit weight of strawberry (12.00 g) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3) which was statistically similar with M_3C_1 (12.21 g) and M_3C_2 (12.43 g).

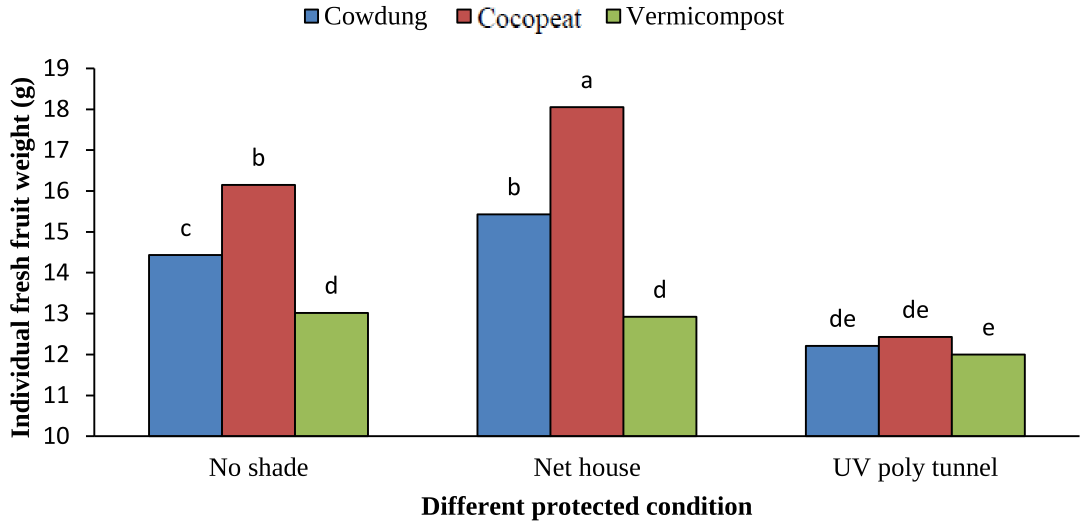


Figure 18. Interaction effect between different growing media and protected condition on individual fresh fruit weight of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.7 Fruit yield plant^{-1}

Effect of different growing media

Strawberry growing in different growing media significantly influenced fruit yield plant^{-1} (Figure 19). Experimental results revealed that the highest fruit yield plant^{-1} of strawberry (226.51 g) was recorded under Cocopeat based growing media treatment (M_2). While the lowest fruit yield plant^{-1} of strawberry (117.71 g) was recorded under Vermicompost based growing media treatment (M_3). Hansen *et al*. (2010) reported that under different growing media lettuce gave 23% more yield when coconut fibre was used as the substrates. Tehranifar and Sarsaefi (2002) revealed that cocopeat (40%) + perlite (60%) medium produced the highest number of fruits and yield per plant. They concluded that, the yield in substrates with peat or cocopeat was higher than those in substrates without peat or cocopeat.

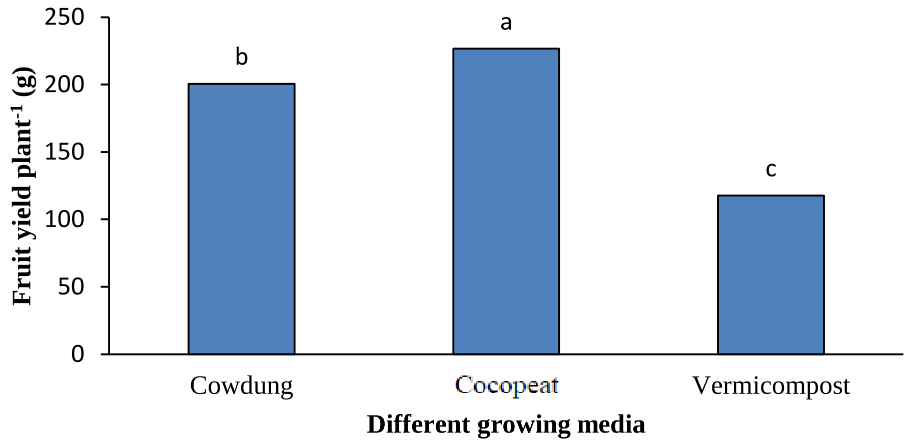


Figure 19. Effect of different growing media on fruit yield plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The fruit yield plant^{-1} of strawberry was significantly affected by different protected condition (Figure 20). Experimental results revealed that the highest fruit yield plant^{-1} of strawberry (229.16 g) was recorded in net house condition (C_2). Whereas the lowest fruit yield plant^{-1} (142.28 g) of strawberry was recorded in UV poly tunnel based (C_3) protected condition. The higher yield plant^{-1} under net house may be due to better photosynthetic efficiency of plant in comparison to other protected conditions and increased quantity of chlorophyll. Zoran *et al.* (2011) reported that, the use of color-shade nets improve the productivity by moderating climatic extremes. The total fruit yield (t/ha) under colour shadenet were higher by 113 to 131 percent relative to the open field. Panigrahi *et al.* (2010) also reported that the fruits yield and fruits found significantly better under green house as compared to open field condition (37.32%). Under protected environment the yield was two times more (5.18 kg/m2) as compared to open field condition (2.46 kg/m^2).

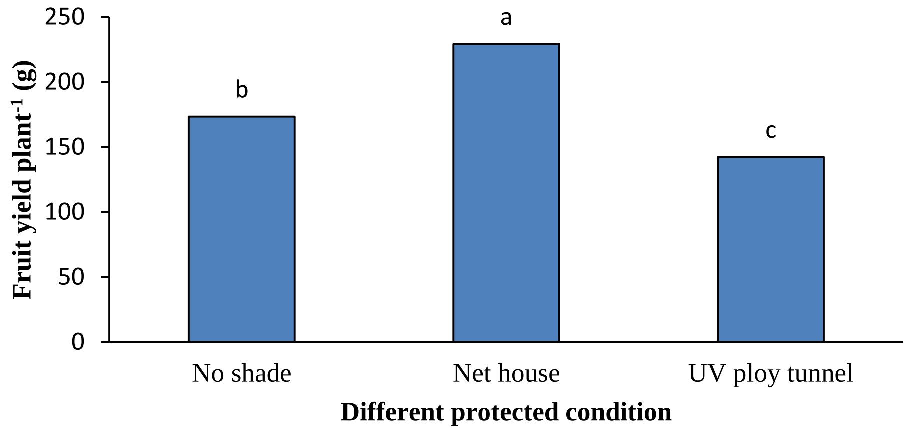


Figure 20. Effect of different protected condition on fruit yield plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition were found significant (Figure 21) and revealed that the highest fruit yield plant^{-1} of strawberry **(**307.11 g) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest fruit yield plant^{-1} of strawberry (103.00 g) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3).

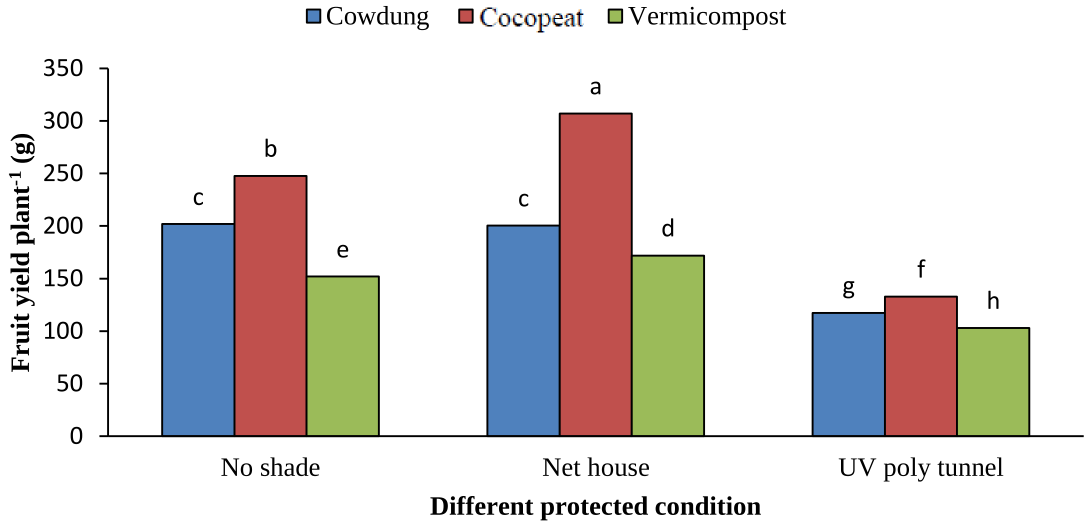


Figure 21. Interaction effect between different growing media and protected condition on fruit yield plant^{-1} of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.8 pH

Effect of different growing media

Different growing media significantly influenced pH of strawberry (Figure 22). Experimental results revealed that the highest pH of strawberry (3.58) was recorded under cowdung based growing media treatment (M_1). While the lowest pH of strawberry (3.51) was recorded under vermicompost based growing media treatment (M_3) which was statistically similar with M_2 (3.51). This is because the soilless growing media changed the physical and chemical properties, also converted higher amounts of organic acids and photosynthates into sugars during the fruit ripening stage and thereby affecting the quality characteristics especially pH in strawberry. Marinou *et al.* (2013) observed that the strawberry fruits obtained from saw- 100 substrate were more acidic compared with fruits obtained from pum-saw (50:50) and cocopum (50:50). Radhouani *et al.* (2011) opined that the pH was superior in compost (6.98 ± 0.08) and was on par with sand media (6.87 ± 0.09) but differed significantly with perlite (6.66 ± 0.02).

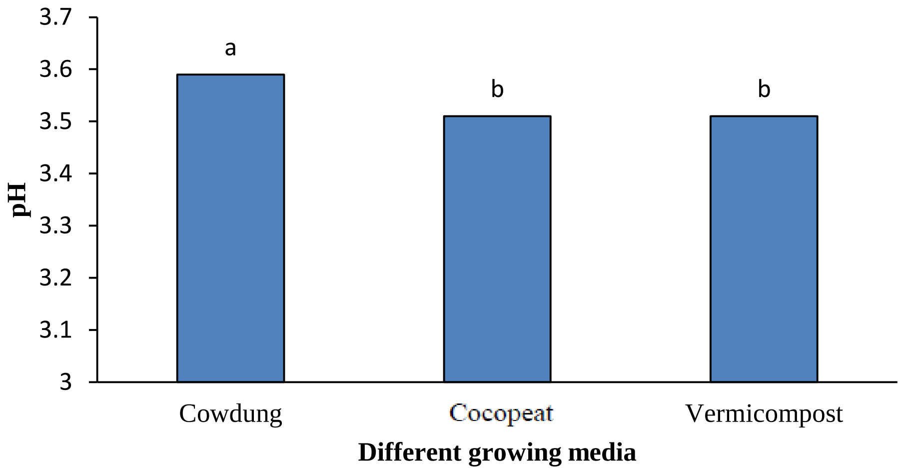


Figure 22. Effect of different growing media on pH of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The pH of strawberry was significantly affected by different protected condition (Figure 23). Experimental results revealed that the highest pH of strawberry (3.59) was recorded in UV poly tunnel based (C_3) protected condition. Whereas the lowest fruit yield plant^{-1} (3.48) of strawberry was recorded in net house condition (C_2).

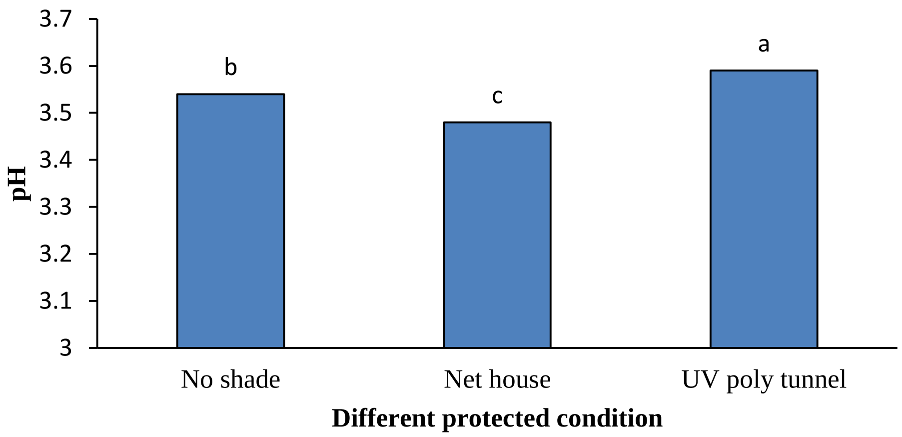


Figure 23. Effect of different protected condition on pH of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition had shown significant effect on pH of strawberry (Figure 24). Experimental result showed that, the highest pH of strawberry **(**3.69) was obtained in cowdung based growing media under UV poly tunnel condition (M_1C_3). Whereas the lowest pH of strawberry (3.45) was obtained in Cocopeat based growing media under net house protected condition (M_2C_2) which was statistically similar with M_3C_2 (3.46) treatment combination.

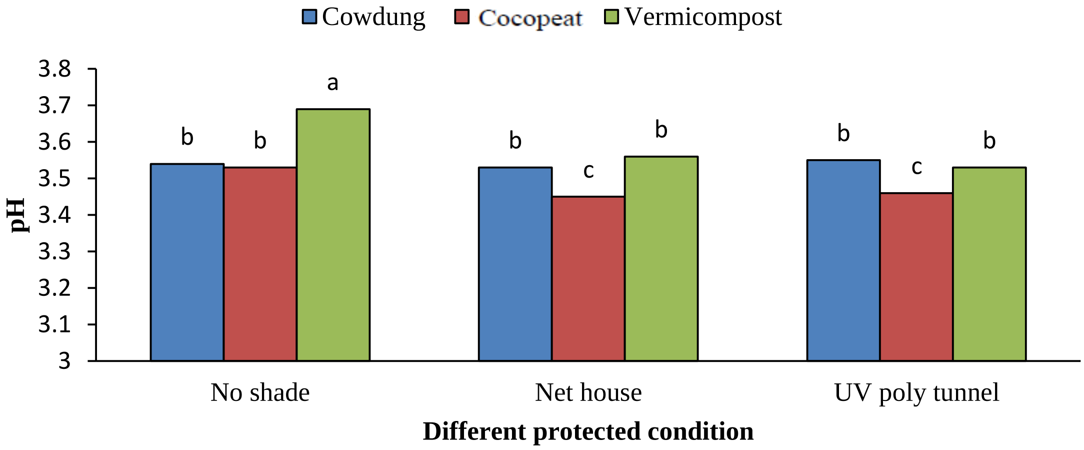


Figure 24. Interaction effect between different growing media and protected condition on pH of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.9 Total soluble solids

Effect of different growing media

Plant growing in different growing media significantly influenced total soluble solids (°Brix) of strawberry (Figure 25). Experimental results revealed that the highest total soluble solids of strawberry (7.67 °Brix) was recorded under vermicompost based growing media treatment (M_3). While the lowest total soluble solids of strawberry (6.33 %) was recorded under cowdung based growing media treatment (M_1). Optimum levels of total soluble solids of strawberry (7.0 °Brix) was recorded under Cocopeat based growing media treatment (M_2). These results might be due to the fact that cocopeat, cowdung and vermicompost enhanced TSS due to the presence of macro and micronutrients of media. The presence of K improves vegetative growth and also promotes sugar accumulation, which ultimately yields higher TSS. Shahzad *et al.* (2018) reported that variation of growing media influences TSS in strawberry.

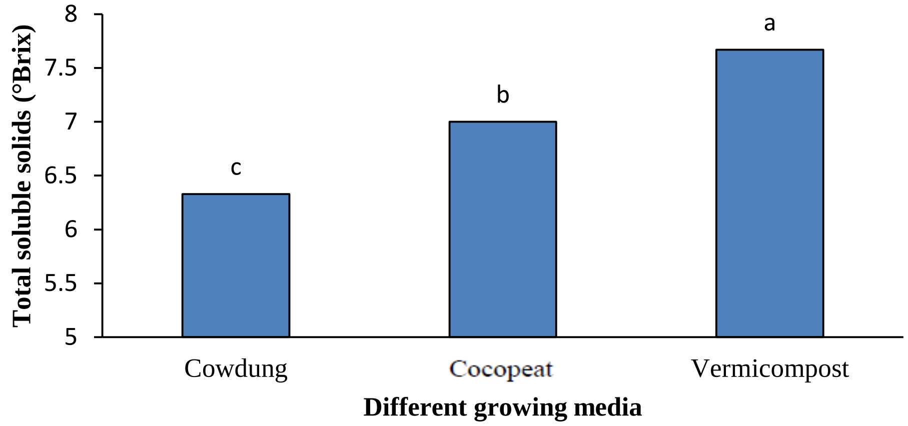


Figure 25. Effect of different growing media on total soluble solids of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The total soluble solids (°Brix) of strawberry was significantly affected by different protected condition (Figure 26). Experimental results revealed that the highest total soluble solids (°Brix) of strawberry (7.33 °Brix) was recorded in net house condition (C_2). Whereas the lowest total soluble solids (6.67 °Brix) of strawberry was recorded in UV poly tunnel based (C_3) protected condition. Voca *et al.* (2007) reported that the cultivation systems can have a greater influence on the chemical composition of the fruits of the strawberry. Jeevansab (2000) also reported that capsicum fruits obtained from protected condition had a higher ascorbic acid and total soluble solids (TSS) compared to fruits of open field.

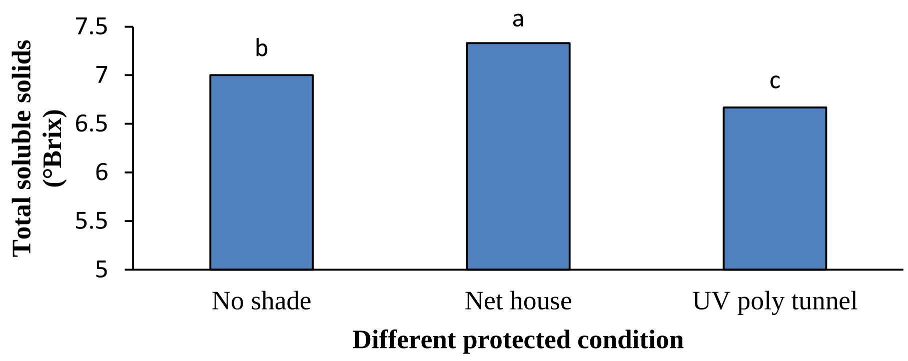


Figure 26. Effect of different protected condition on total soluble solids of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition had shown significant effect on total soluble solids (°Brix) of strawberry (Figure 27). Experimental result showed that, the highest total soluble solids of strawberry (8.0 °Brix) was obtained in vermicompost based growing media under net house condition (M_3C_2). Whereas the lowest total soluble solids of strawberry (6.0 °Brix) was obtained in cowdung based growing media under UV poly tunnel protected condition (M_1C_3).

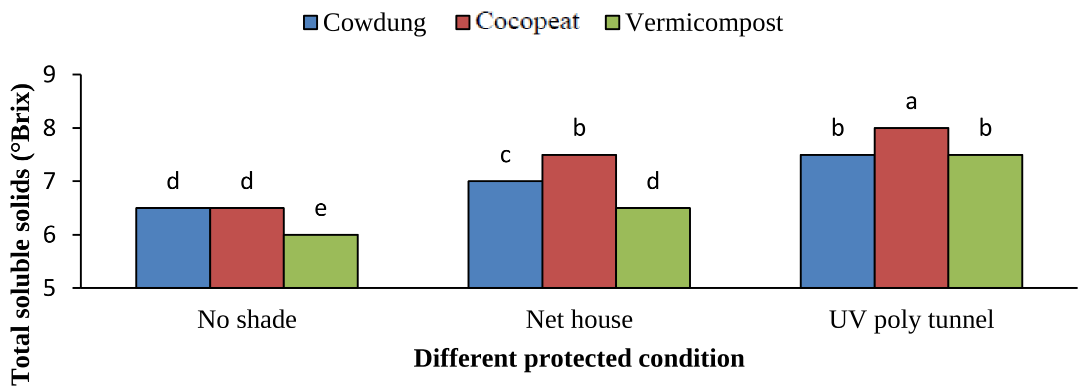


Figure 27. Interaction effect between different growing media and protected condition on total soluble solids of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.10 Titratable acidity

Effect of different growing media

Strawberry growing in different growing media significantly influenced titratable acidity (Figure 28). Experimental result revealed that the highest titratable acidity (0.54 %) was recorded recorded under Cocopeat based growing media treatment (M_2). While the lowest titratable acidity (0.40 %) was recorded under cowdung based growing media treatment (M_1). Tariq *et al*. (2013) reported that plants grown in coir based growing media showed significant increase in acidity of strawberry fruits.

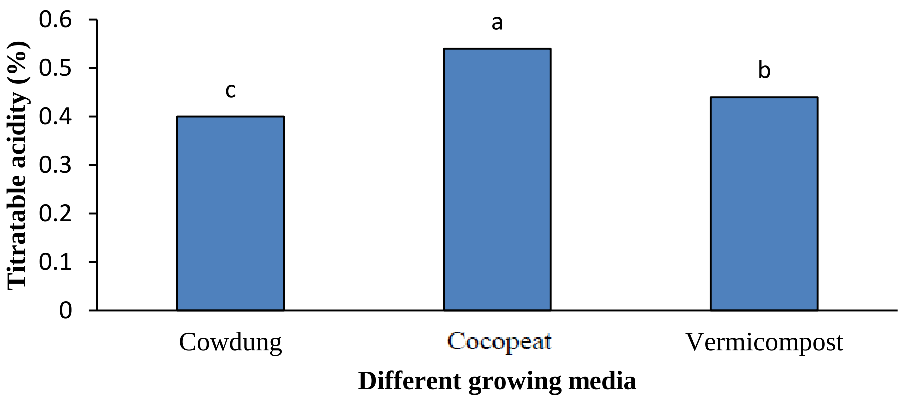


Figure 28. Effect of different growing media on titratable acidity of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The titratable acidity of strawberry was significantly affected by different protected condition (Figure 29). Experimental results revealed that the highest titratable acidity of strawberry (0.50 %) was recorded in net house condition (C_2). Whereas the lowest titratable acidity (0.43 %) of strawberry was recorded in UV poly tunnel based (C_3) protected condition. Spayd *et al.* (2002) concluded that the TSS (total soluble solid) and colour of *Vitis vinifera* cv. Merlot berries were higher in control than under shade but titatable acidity, pH and berry mass was higher in the net shade than in control (sunlight).

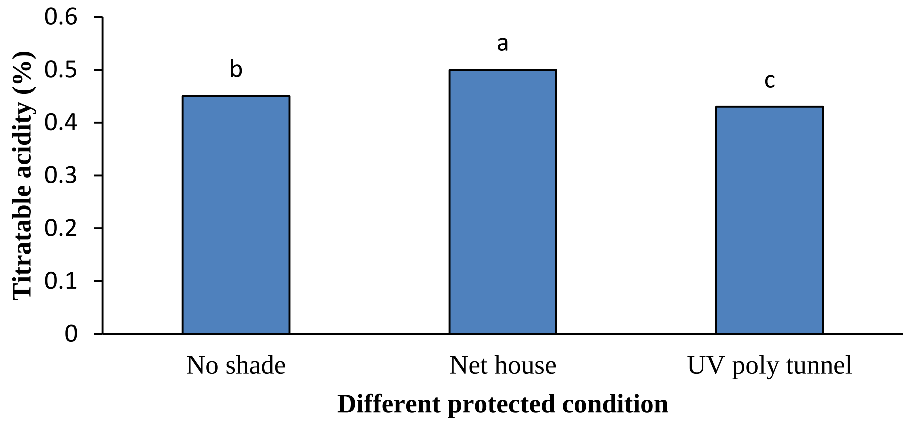


Figure 29. Effect of different protected condition on titratable acidity of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition had shown significant effect on titratable acidity of strawberry (Figure 30). Experimental result showed that, the highest titratable acidity of strawberry (0.62 %) was obtained in Cocopeat based growing media under net house condition (M_2C_2). Whereas the lowest titratable acidity of strawberry (0.37 %) was obtained in cowdung based growing media under UV poly tunnel protected condition (M_1C_3).

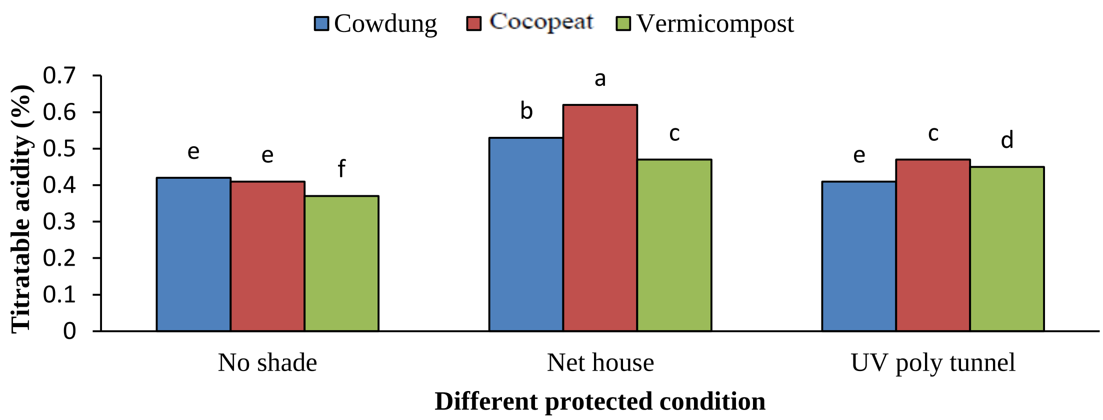


Figure 30. Interaction effect between different growing media and protected condition on titratable acidity of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.11 Ascorbic acid content

Effect of different growing media

Strawberry growing in different growing media significantly influenced ascorbic acid content (Figure 31). Experimental result revealed that the highest ascorbic acid content (45.57 mg/100 g) was recorded recorded under Cocopeat based growing media treatment (M_2). While the lowest ascorbic acid content (38.92 mg/100 g) was recorded under vermicompost based growing media treatment (M_3).

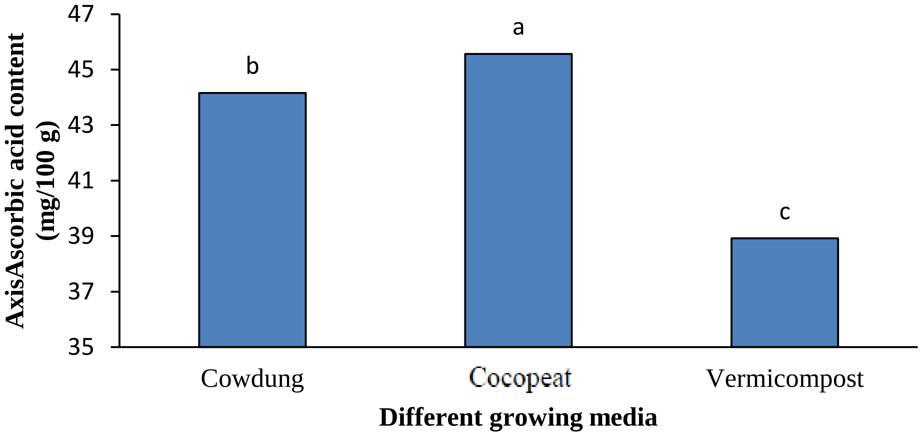


Figure 31. Effect of different growing media on ascorbic acid content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The ascorbic acid content of strawberry was significantly affected by different protected condition (Figure 32). Experimental results revealed that the highest ascorbic acid content of strawberry (46.08 mg/100 g) was recorded in net house condition (C_2). Whereas the lowest titratable ascorbic acid content (38.89 mg/100 g) of strawberry was recorded in UV poly tunnel based (C_3) protected condition.

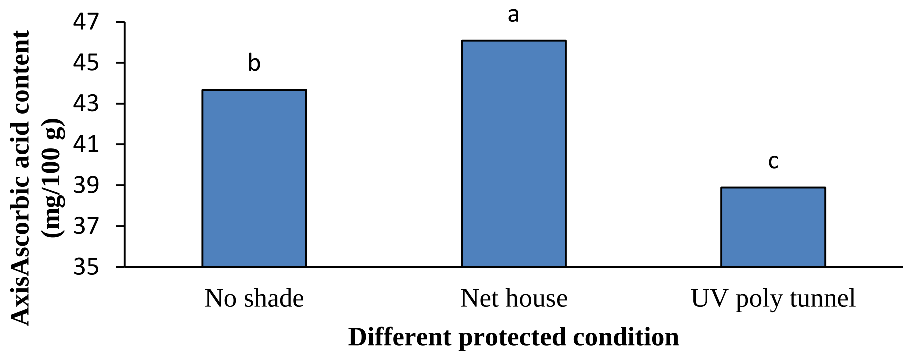


Figure 32. Effect of different protected condition on ascorbic acid content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition had shown significant effect on ascorbic acid content of strawberry (Figure 33). Experimental result showed that, the highest ascorbic acid content of strawberry (49.00 mg/100 g) was obtained in Cocopeat based growing media under net house condition (M_2C_2) which was statistically similar with M_1C_2 (48.75 mg/100 g) treatment combination. Whereas the lowest ascorbic acid content of strawberry (35.84 mg/100 g) was obtained in vermicompost based growing media under UV poly tunnel protected condition (M_3C_3).

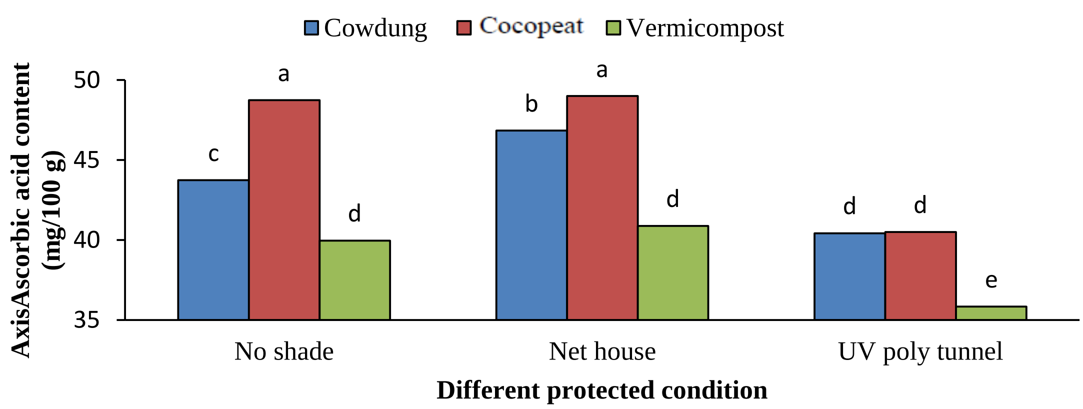


Figure 33. Interaction effect between different growing media and protected condition on ascorbic acid content of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.12 Moisture content

Effect of different growing media

Moisture content is the quantity of water contained in a food material and also a fact that helps to explain the refreshing character of the food. Moisture content of strawberry showed significant variation due to effect of different growing media (Figure 34). Experimental result revealed that the highest moisture content (93.39 %) was recorded under cowdung based growing media treatment (M_1). While the lowest moisture content content (93.21) was recorded under vermicompost based growing media treatment (M_3).

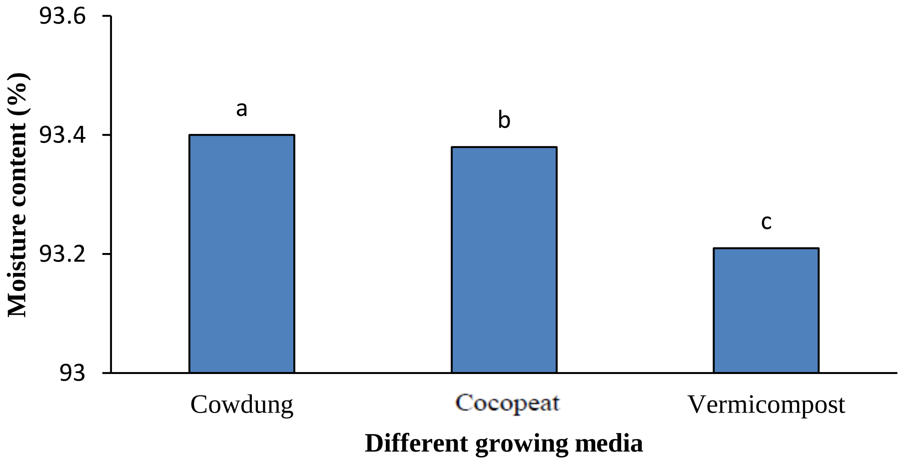


Figure 34. Effect of different growing media on moisture content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The moisture content of strawberry was significantly affected by different protected condition (Figure 35). Experimental results revealed that the highest moisture content of strawberry (94.19 %) was recorded in net house condition (C_2). Whereas the lowest moisture content (92.47 %) of strawberry was recorded in UV poly tunnel based (C_3) protected condition.

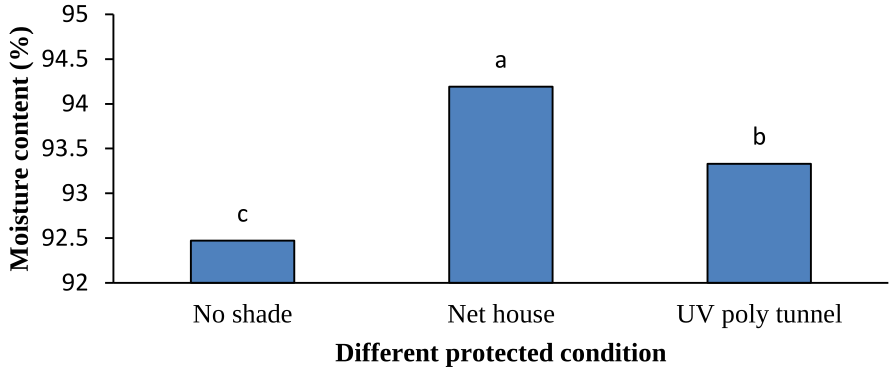


Figure 35. Effect of different protected condition on moisture content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

The interaction effect between different growing media and protected condition had shown significant effect on moisture content of strawberry (Figure 36). Experimental result showed that, the highest moisture content of strawberry (94.30 %) was obtained in cowdung based growing media under net house condition (M_1C_2) which was statistically similar with M_3C_2 (94.26 %) and M_3C_2 (94.02 %) treatment combination. Whereas the lowest moisture content of strawberry (92.11 %) was obtained in vermicompost based growing media under open condition (M_3C_1).

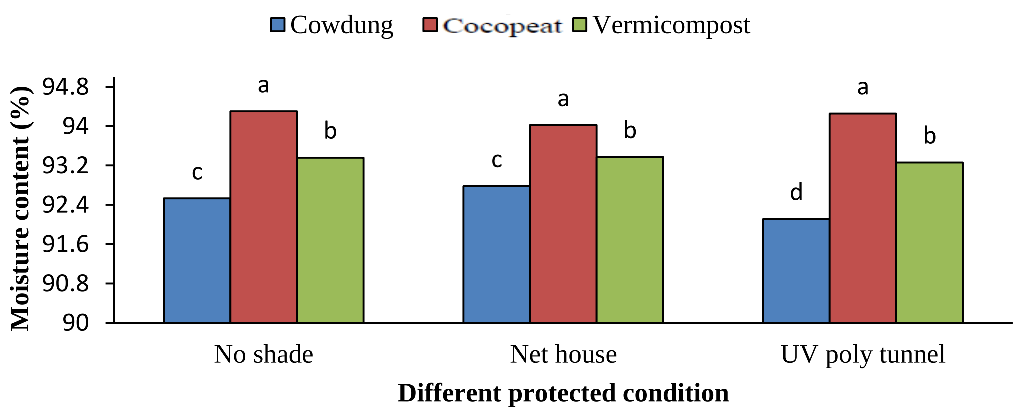


Figure 36. Interaction effect between different growing media and protected condition on moisture content of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.13 Reducing sugar

Effect of different growing media

Significant variation was observed in reducing sugar content due to different different growing media applied in strawberry cultivation (Figure 37). Experimental result revealed that the highest reducing sugar (8.57 %) was recorded under Cocopeat based growing media treatment (M_2). While the lowest reducing sugar (8.23 %) was recorded under cowdung based growing media treatment (M_1).

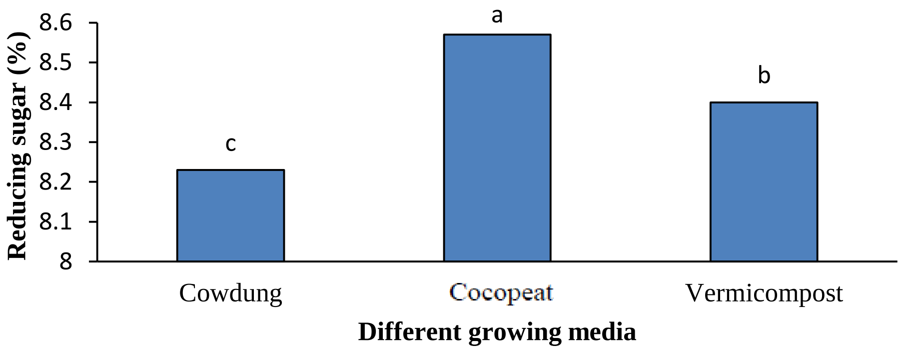


Figure 37. Effect of different growing media on reducing sugar of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The moisture content of strawberry was significantly affected by different protected condition (Figure 38). Experimental results revealed that the highest reducing sugar of strawberry (8.57 %) was recorded in UV poly tunnel condition (C_3). Whereas the lowest reducing sugar (8.25 %) of strawberry was recorded in open space (C_1) condition. The differences of reducing sugar content in the UV poly tunnel and net house comparable to pen shade condition might be attributed to its favourable weather condition.

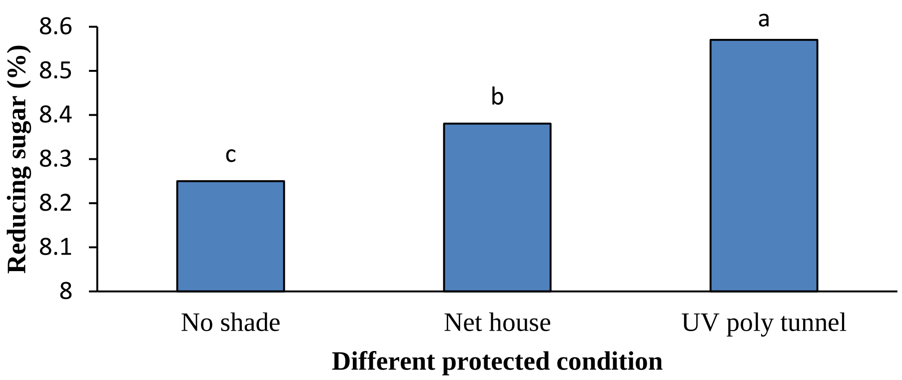


Figure 38. Effect of different protected condition on reducing sugar of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition significantly affected the reducing sugars of strawberry (Figure 39). Experimental result showed that, the highest reducing sugar of strawberry (8.75 %) was obtained in Cocopeat based growing media under UV poly tunnel condition (M_2C_3). Whereas the lowest reducing sugar of strawberry (8.10 %) was obtained in cowdung based growing media under open condition (M_1C_1).

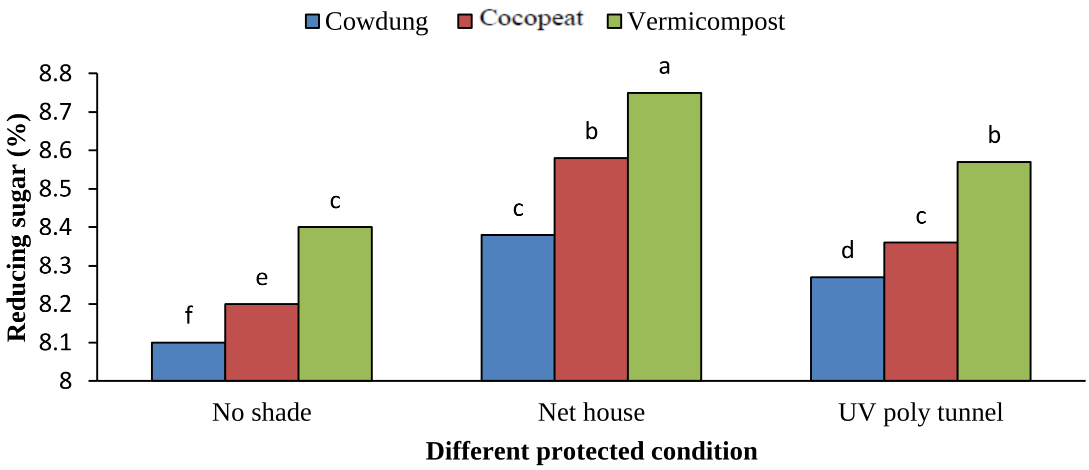


Figure 39. Interaction effect between different growing media and protected condition on reducing sugar of strawberry.

Means with different letters are significantly different at the 0.01 level.

4.14 Total anthocyanin content

Effect of different growing media

Anthocyanins are a type of pigment found in plants that are thought to offer health benefits. They belong to a class of compounds called flavonoids that have antioxidant effects. This means that they fight unstable molecules, called free radicals, that damage cells and increase the risk of certain diseases. In this experiment significant variation was observed in total anthocyanin content due to different growing media applied in strawberry cultivation (Figure 40). Experimental result revealed that the highest total anthocyanin content (29.45 mg g^{-1}) was recorded under Cocopeat based growing media treatment (M_2). While the lowest reducing sugar (28.61 mg g^{-1}) was recorded under cowdung based growing media treatment (M_1).

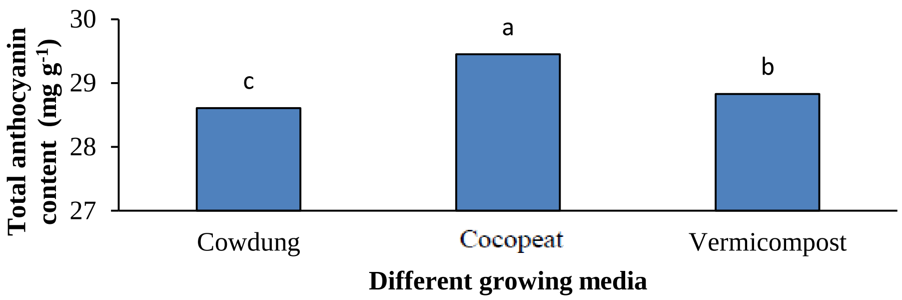


Figure 40. Effect of different growing media on total anthocyanin content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Effect of different protected condition

The total anthocyanin content of strawberry was significantly affected by different protected condition (Figure 41). Experimental results revealed that the highest total anthocyanin content of strawberry (30.13 mg g^{-1}) was recorded in UV poly tunnel condition (C_3). Whereas the lowest reducing sugar (27.88 mg g^{-1}) of strawberry was recorded in open space (C_1) condition. Ban *et al.* (2000) reported that the anthocyanin content in berries of Kyoho grapes were higher in net shading treatment (covered with aluminum film) than control treatment and no effect on the resveratrol levels in grape berry skin was observed.

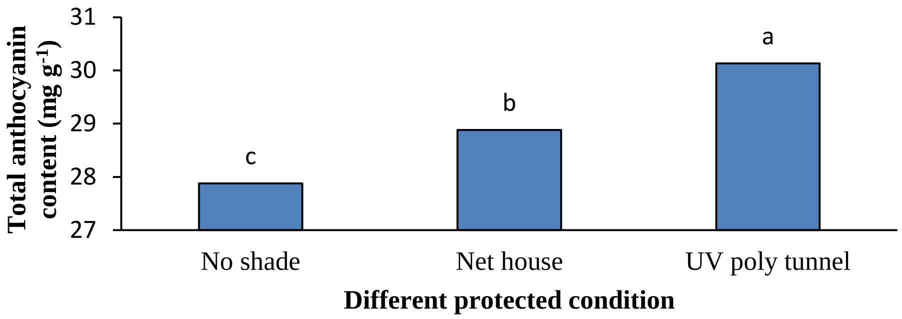


Figure 41. Effect of different protected condition on total anthocyanin content of strawberry.

Means with different letters are significantly different at the 0.01 level.

Interaction effect between different growing media and protected condition

Interaction effect between different growing media and protected condition significantly affected the total anthocyanin content of strawberry (Figure 42). Experimental result showed that, the highest total anthocyanin content of strawberry (30.80 mg g^{-1}) was obtained in Cocopeat based growing media under UV poly tunnel condition (M_2C_3). Whereas the lowest reducing sugar of strawberry (27.50 mg g^{-1}) was obtained in cowdung based growing media under open condition (M_1C_1) which was statistically similar with M_3C_1 (27.80 mg g^{-1}) treatment combination.

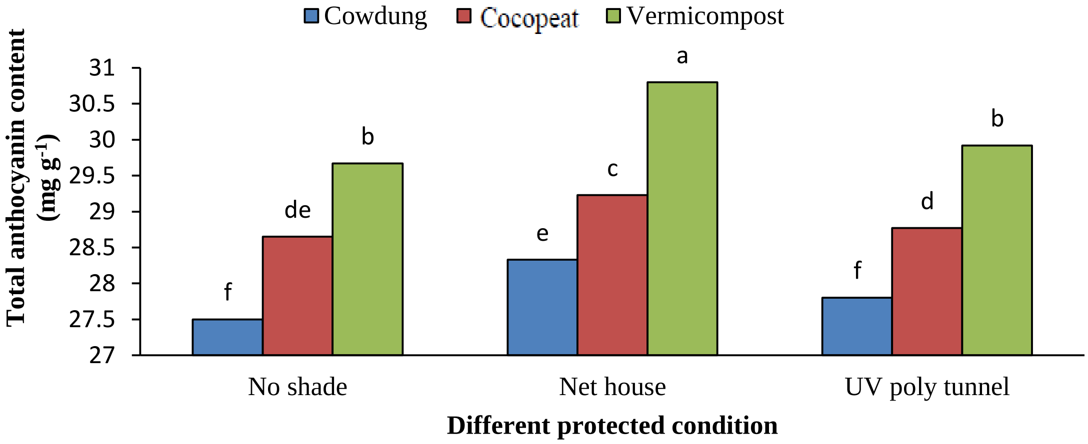


Figure 42. Interaction effect between different growing media and protected condition on total anthocyanin content of strawberry.

Means with different letters are significantly different at the 0.01 level.

CHAPTER V

SUMMARY AND CONCLUSION

The experimental results suggested that different growing media greatly influenced the the growth, yield and quality of strawberry. Among different growing media, strawberry plant growing in Cocopeat based growing media recorded the highest plant height (18.44 cm), number of leaves plant^{-1} (11.99), number of flowers plant^{-1} (17.67), number of fruit plant^{-1} (14.43), individual fresh fruit weight (15.47 g), fruit yield plant^{-1} (226.51 g), titratable acidity (0.54 %), ascorbic acid content (45.57 mg/100 g), moisture content (93.39 %), reducing sugar (8.57 %) and total anthocyanin content (29.45 mg g^{-1}). In contrast cowdung and vermicompost based growing media also performed well and among them cowdung growing media recorded the highest leaf chlorophyll content (43.72 %) and pH (3.58) whereas vermicompost based growing recorded the highest total soluble solids of strawberry (7.67 °Brix).

Strawberry growing in different protected condition also influenced the growth, yield and quality of strawberry. In this experiment strawberry growing in net house condition recorded the highest plant height (17.89 cm), number of leaves plant^{-1} (12.22), leaf chlorophyll content (45.27 %), number of flowers plant^{-1} (16.78), number of fruits plant^{-1} (14.33), individual fresh fruit weight (15.54 g), fruit yield plant^{-1} (229.16 g), total soluble solids (7.33 °Brix), titratable acidity (0.50 %), ascorbic acid content (46.08 mg/100 g) and moisture content (94.19 %). In contrast strawberry growing in UV poly tunnel based (C_3) protected condition recorded the highest pH of strawberry (3.59), reducing sugar of strawberry (8.57 %), total anthocyanin content of strawberry (30.13 mg g^{-1}.

In this experiment among interaction effect between different growing media and protected condition, strawberry growing in Cocopeat based growing under net recorded the highest plant height (20.33 cm), number of leaves plant^{-1} (13.33), number of flowers plant^{-1} **(**19.67), number of fruits plant^{-1} **(**17.00), individual fresh fruit weight **(**18.05 g), fruit yield plant^{-1} **(**307.11 g), titratable acidity (0.62 %) and ascorbic acid content (49.00 mg/100 g). In contrast strawberry growing in cowdung based growing media under net house condition recorded the highest leaf chlorophyll content (46.10 %) moisture content of strawberry (94.30 %). The highest pH of strawberry **(**3.69) was obtained in cowdung based growing media under UV poly tunnel condition (M_1C_3). The highest total soluble solids of strawberry (8.0 °Brix) was obtained in vermicompost based growing media under net house condition (M_3C_2). The highest reducing sugar of strawberry (8.75 %) and total anthocyanin content (30.80 g kg^{-1}) were obtained in Cocopeat based growing media under UV poly tunnel condition (M_2C_3).

Conclusion

On the basis of the results obtained in the present course of investigation, it can be concluded that strawberry growing in Cocopeat based growing media under net house condition performed well and found to be most suitable for achieving higher growth, yield and qualities and can be successfully used for the production of good quality strawberries.

REFERENCES

A.O.A.C. (1990). Official Methods of Analysis. 15th edition. Association of Official Analytical Chemist, Washington, D.C.

A.O.A.C. (1995). Official methods of analysis of 16th edition. Association of Official Agricultural Chemists, Washington D.C.

Ahmed, A.R. and Uddin A.S.M.M. (2012). Strawberry production in bangladesh. in: book of abstracts. Yun-tao Zhang (ed.). VII International Strawberry Symposium, ISHS, Beijing, China. p. 29.

Aktas, H., Daler, S., Ozen, O., Gencer, K., Bayındır, D., and Erdal, I. (2013). Effect of some growing substrate media on yield and fruit quality of eggplant (*Solanum melongena* L.) grown and irrigated by drip irrigation system in greenhouse. *Infrast. Eco. Rural Areas.* **3**(1): 5-11.

Ali, Y., Iqbal, M., Shah, S.Z.A. and Ahmed, M.J. (2003). Effect of different combinations of nitrogen, phosphorus and FYM on yield and quality of strawberry. *Sarhad J. Agric.* **19**: 185-188.

Ameri, A., Tehranifar, A., Shoor, M. and Davarynejad, G. H. (2012). Effect of substrate and cultivar on growth characteristic of strawberry in soilless culture system. *African J. Biotechnol.* **11**(56): 11960-11966.

Ameri, A., Tehranifar, A., Shoor, M. and Davarynejad, G.H. (2012). Effect of substrate and cultivar on growth characteristics of strawberry in soilless culture system. *African J. Biotec.* **11**: 11960-11966.

Ameri, A., Tehranifar, A., Shoor, M. and Davarynejad, G.H. (2012). Effect of substrate and cultivar on growth characteristics of strawberry in soilless culture system. *African J. Biotech.* **11**: 11960-11966.

Andhale, R.P. (2012). Effect of shadenet intensities and colour on micro meteorological parameters, growth, yield and quality of capsicum. Ph.D. Thesis submitted to M.P.K.V. Rahuri. (M.S.). pp. 1-5.

Arancon, N.Q., Edwards, C.A., Bierman, P., Welch, C. and Metzger, J.D. (2004). Influences of vermicomposts on field strawberries: effects on growth and yields. *Bio. Tech*. **92**(2): 145–153.

Awang, B., Shaharom, A.S., Mohammad, B., Selamat, A., Ayub, M., Ullah, J. and Muhammad, A. (2009). Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of Celosia cristata. *Am. J. Agric. Biol. Sci.* **4**(1): 63-71.

Ayesha, R., Fatima, N., Ruqayya, M., Faheem, H., Qureshi, K.M., Hafiz, I.A., Khan, K.S,, Ali, U. and Kamal, A. (2011). Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (*Fragaria* × *ananassa*). *J. Med. Plants Res.* **5**: 6224-6232.

Ayesha, R., Fatima, N., Ruqayya, M., Qureshi, K.M., Hafiz, I.A., Khan, K.S. and Kamal A. (2011). Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (*Fragaria ananassa*). *J. Med. Pl. Res.* **5**(26): 6224-6232.

Ban, T., Shiozaki, S., Ogata, T. and Horiuchi, S. (2000). Effects of abscisic acid and shading treatments on the levels of anthocyanin and resveratrol in skin of kyoho grape berry. *Acta Hort.* **514**(4): 83-90.

Bartczak, M., Pietrowska, M. and Knaflewski, M. (2007). Effect of substrate on vegetative quality of strawberry plants (*Fragaria* x *ananassa* Duch.) produced by a soilless method. *Folia Hort.* **19**: 39-46.

Basu, S. and Singh, B. (2009). International conference on Horticulture (ICH-2009) Horticulture for Livelihood Security and Economic Growth November 09-12, 2009, Banglore. pp. 1-5.

Beniwal, V., Godara, A.K. Prince, A. and Sourabh, M. (2017). Propagation studies in strawberry (Fragaria X Ananassa Duch.) under protected conditions. *Chem. Sci. Rev. Lett.* **6**(23): 1795-1799.

Bhatti, S.M., Panhwar, M.A., Bughio, Z.R., Sarki, M.S. Gandahi, A.W. and Wahocho. N.A. (2021). Influence of foliar application of zinc on growth, yield and zinc concentration in strawberry. *Pakistan J. Agric. Res*. **34**(2): 486-493.

Borji, H., Ghahsareh, A. M., and Jafarpour, M. (2010). Effects of the substrate on tomato in soilless culture. *Res. J. Agric. Biol. Sci.* **6**(6): 923-927.

Cantliffe, D.J., Paranjpe, A.V., Stoffella, P.J., Lamb, E.M. and Powell, C.A. (2007). Influence of soilless media, growing containers, and plug transplants on vegetative growth and yield of 'sweet charlie' strawberry grown under protected culture. *Pro. Florida State Hort. Soc.* **120**: 142-150.

Chien, Y. and Chang, J. (2019). Net houses effects on microclimate, production, and plant protection of white-fleshed pitaya. *Hort. Sci*. **54**(4): 692-700.

Choudhury, S. and Zaman, M. (2021). Effect of different growing environments on growth, yield and quality attributes of strawberry. *J. App. Hort*. **23**: 178-183.

Dhaker, S.S., Kaushik, R.A. and Sarolia, D.K. (2016). Influence of growing media and containers on germination and seedling growth of papaya (*Carica Papaya* L.) cv. Pusa nanha. *Green farm.* **7**(2): 451-454.

Dhatt, A.S. and Kaler, H.S. (2009). Effect of Shade net and growing media on nursery raising of cauliflower in sub-tropical area. *Adv. in Hort. Sci.* **23**(2) : 118-122.

Dysko, J., Kaniszewski, S. and Kowalczyk, W. (2015). Lignite as a new medium in soilless cultivation of tomato. *J. Elementology.* **20**(3): 559-569.

Ebrahimi, R., Souri, M.K., Ebrahimi, F. and Ahmadizadeh, M. (2012). Growth and yield of strawberries under different potassium concentrations of hydroponic system in three substrates. *World App. Sci. J.* **16**: 1380-1386.

Elad, Y., Messika, Y., Brand, M., David, D.R. and Sztejnber, A. (2007). Effect of coloured nets on pepper powdery mildew *J. Phyto.* **35**(3): 285-299.

Fallik, E., Alkalai-Tuvia, S., Parselan, Y., Aharon, Z., Elmann, A., Offir, Y., Matan, E., Yehezkel, H., Ratner, K., Zur, N. and Shahak, Y. (2009). Can colored shade nets maintain sweet pepper quality during storage and marketing? *Acta Hort.* **830**: 37-44.

Farukh, M. A. Islam, M. A., Akter, L. and Khatun, R. (2019). Trend and Variability Analysis of Sunshine Duration in Divisional Headquarters of Bangladesh. *J. Environ. Sci. and Natural Res.* **12**(1&2):127-133.

Ganesan, M. (2003). Comparative evaluation of Low cost Greenhouse and its effect on the yield and Quality of two varieties of Tomato (*Lycopersicon esculentum* Mill.). *Indian Agric.* **6** : 161-168.

Gaurav, A.K, Raju, D.V.S., Janakiram, T., Singh-Bhupinder, J.R. and Krishnan, S.G. (2016). Effect of coloured shade net on production of Dracaena fragrans. *Indian J. Hort.* **73**(1): 94-98.

Gent, M.P.N. (2007). Effect of shade on quality of greenhouse tomato. *Acta Hort*. **747**: 107-112.

Ghehsareh, A. M., Borji, H. and Jafarpour, M. (2011). Effect of some culture substrates (datepalm peat, cocopeat and perlite) on some growing indices and nutrient elements uptake in greenhouse tomato. *Afr. J. Microbio. Res*. **5**(12): 1437-1442.

Ghehsareh, A.M., Samadi, N. and Borji, H. (2011). Comparison of date-palm wastes and perlite as growth substrates on some tomato growing indexes. *African J. Biotech.* **10**: 4817-4878.

Gholamnejad, S., Arouiee, H., and Nemati, S.H. (2012). Effect of different ratios of cocopeat and vermicompost as a cultural media on seed emergence and some qualitative and quantitative characteristics of sweet pepper (*Capsicum annuum* L.) transplants. *J. Hort. Sci.* **25**: 369-375.

Gindaba, J. and Wand, S.J. (2005). Comparative effects of evaporative cooling, kaolin particle film and shade net on the control of sunburn and fruit quality in apples. *Hort Sci.* **40**: 592-596.

Godara, A.K. and Sharma, V.K. (2016). Influence of soilless media and containers on shoot growth of strawberry *Fragaria ananassa* Duch. cv. sweet charlie. *Int. J. Farm Sci.* **6**(1): 112-119.

Godwa, B.M. (2016). Evaluation of different genotypes for growth, yield and quality of strawberry *(Fragaria x ananasa Duch.) u*nder naturally ventilated polyhouse in hill zone of Karnataka. M.Sc. Thesis, University of Agricultural and Horticultural Sciences, Shimoga, Karnataka, India. p. 46.

Gomez, M.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research. John Wiley and sons. New York, Chichester, Brisbane, Toronto. Pp. 97–129, 207–215.

Gungor, F. and Yildirim, E. (2013). Effect of different growing media on quality, growth and yield of pepper (*Capsicum annuum* L.) under greenhouse conditions. *Pak. J. Bot.* **45**(5): 1605- 1608.

Gungor, F. and Yildirim, E. (2013). Effect of different growing media on quality, growth and yield of pepper (*Capsicum annum* L.) under greenhouse conditions. *Pakistan J. Bot.* **45**: 1605-1608.

Haghighi M, Barzegar MR, Jaime A and Silva T. (2016). The effect of municipal solid waste compost, peat, perlite and vermicompost on tomato (*Lycopersicon esculentum* L.) growth and yield in a hydroponic system. *Int. J. Rec. Org. Waste Agric.* **5**: 231-242.

Hansen, R., Balduff, J., and Keener, H. (2010). Development and operation of a hydroponic lettuce research laboratory. *Resour. Eng. Technol. Sustain World.* **17**(4): 4-7.

Hassan, A.H., Khereba, A.H., El-Kattan, M.H., Noha, G. and El- Rahman, A. (2011). Effect of various organic substrate culture and container types on productivity and fruit quality of strawberry (*Fragaria* × *ananassa*) cv. Festival. *Res. J. Agric. Bio. Sci.* **7**: 379-387.

Hesami, A., Khorami, S.S., Amini, F. and Kashkooli, A.B. (2012). Date-peat as an alternative in hydroponic strawberry production. *African J. Agric. Res.* **7**(23): 3452-3458.

Hesami, A., Khorami, S.S., Amini, F. and Kashkooli, A.B. (2012). Date-peat as an alternative in hydroponic strawberry production. *African J. Agric. Res.* **23**: 3452- 3458.

Ikram, S., Habib, U. and Khalid, N. (2012). Effect of different potting media combinations on growth and vase life of tuberose (*polianthes tuberosa* linn.). *Pak. J. Agri. Sci.* **49**(2): 121-125.

Inden, H. and Torres, A. (2004). Comparison of four substrates on the growth and quality of tomatoes. *Acta Hort.* **644**: 205-210.

Jeevansab, A. (2000). Effect of nutrient sources on growth, yield and quality of capsicum grown under different environments. M. Sc. (Agri) Thesis, University of Agricultural Sciences, Dharwad. pp. 1-5.

Jessica, M. C. and James, A.K. (2006). Effect of shading on accumulation of flavonoid compounds in (*Vitis vinifera* L.) Pinot Noir fruit and extraction in model system. *J. Agric. Food Chem.* **54**: 8510-8520.

Joseph, A. and Muthuchamy, I. (2014). Productivity, Quality and economics of tomato cultivation in aggregated hydroponics- A case study from Coimbatore region of Tamil Nadu. *Indian. J. Sci. Tech.* **7**(8): 1078-1086.

KacjanMarsic, N. and Jakse, M. (2010). Growth and yield of grafted cucumber (*Cucumis sativus* L.) on different soilless substrates. *J. Food, Agric. Environ.* **8**: 654-658.

Kilic, P., Aktas, H. and Erdal, I. (2018). Effect of different substrates on yield and fruit quality of tomato grown in soilless culture. *Pol. Aca. Sci*. **2**: 249-261.

Kumawat, R., Maji, S., Govind and Meena, D.C. (2014). Studies on seed germination and seedling growth of papaya (*Carica Papaya* L.) cv. Coorg Honey Dew as influenced by media and chemicals. *J. Crop and Weed.* **10**(2): 281-286.

Lakshmikanth, K.H., Madaiah, D., Dinesh Kumar, M. and Dhananjaya, B.C. (2020). Effect of different pot culture media on growth parameters, yield and economics of strawberry in vertical system. *Int. J. Che. Stud*. **8**(3): 2122-2125.

Lopez-Medina, J., Peralbo, A. and Flores, F. (2004). Closed soilless growing system: a sustainable solution for strawberry crop in Huelva (Spain). *Acta Hort.* pp. 213-215.

Luitel, B. P., Adhikari, P.B., Yoon, C.S., and Kang, W.H. (2012). Yield and fruit quality of tomato (*Lycopersicon esculentum* Mill.) cultivars established at different planting bed size and growing substrates. *Hort. Environ. Biotech.* **53**(2): 102-107.

Luitel, B. P., Adhikari, P.B., Yoon, C.S., and Kang, W.H. (2012). Yield and fruit quality of tomato (*Lycopersicon esculentum* Mill.) cultivars established at different planting bed size and growing substrates. *Hort. Environ. Biotech.* **53**(2): 102-107.

Marinou, E., Chrysargyris, A. and Tzortzakis, N. (2013). Use of sawdust, coco soil and pumice in hydroponically grown strawberry. *Plant, Soil and Environ.* **59**(10): 452–459.

Mathowa, T., Tshipinare, K., Mojeremane, W., Legwaila, G. M. and Oagile, O. (2017). Effect of growing media on growth and development of sweet paper (*Capsicum annum* L.) seedlings. *J. App. Hort*. **19**(3): 200-204.

Mazahreh, N, Nejatian, A. and Mousa, M. (2015). Effect of different growing Media on Cucumber Production and Water Productivity in Soilless Culture under UAE Conditions. *Merit Res. J.Agric. Sci. Soil Sci.* **3**(9): 131-138.

Mazur, K.Z., Gajewski, M., Metera, A.M., Wtulich, J.A., and Marcinkowska, M.M. (2012). Effect of growing medium and harvest term on yield and several quality traits of two cultivars of "cherry" tomatoes. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca.* **40**: 197-202.

Medany, A.M., Hassanein, M.K. and Farag, A.A. (2009). Effect of black and white nets as alternative cover in sweet pepper production under green house in Egypt. *Acta Hort.* **807**: 121-126.

Megharaja, K. M. (2000). Studies on the effect of growing conditions and growth regulators on growth and productivity of hybrid capsicum *cv.* Indira. M. Sc. (Agri) Thesis, University of Agricultural Sciences, Bangalore. pp. 1-4.

Milosevic, T., Milosevic, N. and Glisic, I. (2009). Strawberry (*Fragaria* × *ananassa* Duch.) yield as affected by the soil pH. *Anais da Academia Brasileira de Ciências.* **81**(2): 265-269.

Naik, R. K. (2005). Influence of N-aubstitution levels through organic and inorganic sources on growth, yield and post harvest quality of capsicum under protected condition. Ph. D. Thesis, *Univ. Agric. Sci*., Dharwad, Karnataka, India. pp. 1-13.

Nami Goto-Yamamoto, Kentaro, M., Mineyo, N., Kazuya, K. and Masahiko, K. (2011). Effects of temperature and water regimes on flavonoid contents and composition in the skin of red-wine grapes. *J. Int. Sci. Vigme. Vin.* **13**(29): 75-80.

Negi V.S., Maikhuri R.K., Rawat L.S. and Parshwan D. (2013). Protected cultivation as an option of livelihood in mountain region of central Himalaya, India. Int. J. Sust. Develop. World Eco. **20**(5): 416–425.

Neocleous, D. and Polycarpou, P. (2010). Gravel for soil less tomato culture in Mediterranian. *Int. J. Veg. Sci.* **16**(2): 148-159.

Nourizadeh M. (2003). The effect of different substrate cultivation on the growth, performance and to evaluate the cold acclimation and freezing quality of greenhouse cucumber in without soil cultivation system. *Iran J. Elem.* **13**: 205–210.

Olle M, Ngonajio M. and Siomos A. (2014). Vegetable quality and productivity as influenced by growing medium. *A Review: Zem. Agric.* **99**: 399-408.

Pandey, S., Singh, J., Kumar, S., and Mourya, I.B. (2015). Influence of growing environment on growth, yield and chemical composition of Strawberry (*Fragaria x ananassa*) fruits under open vs. naturally ventilated polyhouse conditions. *Indian J. Agric. Sci.* **85**(12): 1540-1545.

Pandey, V., Panth, T. and Das, S. (2007). Performance of capsicum varieties under green house and open field condition *Phal Phul*, Jan-Feb. pp. 17-22.

Panigrahi, H.K., Tiwari, S. P., Agrawal, N., Agrawal, R. and Sharma, D. (2010. Comparative study of capsicum (*capsicum annum* L.) Cv. California wonder under protected (green house) and open field condition, *Int. J. Agric. Stat. Sci.* **6** (2) : 659-662.

Paul C., Gomasta J. and Hossain, M.M. (2017). Effects of Planting Dates and Variety on Growth and Yield of Strawberry. *Int. J. Hort. Agric. Food Sci*. **1**(4): 1-12.

Prado, J.C., Raga-as, M. and Inosantos, J.N. (2008). Growth and yield of broccoli in (*Brasica oleracea* Linn) as influenced by different layers of shading nets. *Philippine J. Crop Sci.* pp. 37-38.

Rabbi, B., Chen, Z. and Sethuvenkatraman, S., 2019. Protected Cropping in Warm Climates: *A Rev. Hum. Con. Cool. Met. Ener*. **12**(14): 2737.

Radhouani, A., Bekkay, E.B. and Ferchichi, A. (2011). Effect of substrate on vegetative growth, quantitative and qualitative production of muskmelon (*Cucumis melo*) conducted in soilless culture. *African J. Agric Res.* **6**(3): 578-585.

Raja, W.H., Kumawat, K.L., Sharma, O.C., Sharma, A., Mir, J.I., Nabi, S.U., Lal, S. and Qureshi, I. (2018). Effect of different substrates on growth and quality of strawberry cv. Chandler in soilless culture. *The Pharma Inn. J.* **7**(12): 449-453.

Ramana Rao, K., Agaraval, V., Chourasia, L., Keshri, R and Patel, G. (2012). Performance evaluation of capsicum crop in open field and under covered cultivation. *Intl. Conf. on Agri. and Hort. Sci.* Organized by Hyderabad International Convention Center, India during Sept. 14-15, 2012.

Rodriguez-Ortega, W.M., Martinez, V., Nieves, M., and Camara-Zapata, J.M. (2017). Agronomic and Physiological Response of Tomato Plants Grown in Different Soilless Systems to Saline Conditions. *Peer J. Preprints.* **1**: 1 - 33.

Roosta, H.R. and Afsharipoor, S. (2012). Effects of different cultivation media on vegetative growth, eco-physiological traits and nutrients concentration in strawberry under hydroponic and aquaponic cultivation systems. *Adv. Environ. Bio.* **6**: 543-555.

Rostami, Z., Ghahsare, A.M. and Kavoosi, B. (2014). Date palm waste application as culture media for strawberry and its impact on some growth indices and yield components. *Agric. Comm.* **2**: 15-21.

Rostami, Z., Ghahsare, A.M. and Kavoosi, B. (2014). Date palm waste application as culture media for strawberry and its impact on some growth indices and yield components. *Agric. Comm.* **2**: 15-21.

Saridas, M., Simsek, O., Donmez, D., Kacar, Y. and Kargi, S. (2020). Genetic diversity and fruit characteristics of new superior hybrid strawberry (*Fragaria* × *ananassa* Duchesne ex Rozier) genotypes. *Gen. Res. Crop Evo*. **68**(2): 741-758.

Shahak, Y., Gussakovsky, E. E., Cohen, Y., Lurie, S., Stern, R., Kfir, S., Naor, A., Atzmon, I., Doron, I. and Greenblat-Avron, Y. (2004). Colour nets: A new approach for light manipulation in fruit trees. *Acta Hort*. **636**: 609-616.

Shahzad, U., Ijaz, M.I., Noor, N., Shahjahan, M., Hassan, Z., Kahn, A.A. and Calica, P. (2018). Variations in growing media and plant spacing for the improved production of strawberry (*Fragaria* × *ananassa* cv. Chandler). *Philippine J. Sci.* **147**(4): 711-719.

Sharma, V.K. (2015). Effect of soilless growing substrates on vegetative growth and roots of strawberry cv. Sweet Charlie. *The Ecoscan.* **9**: 89-91.

Sheel, M., Mamun, S.M.A. and Islam M.M. (2019). Evaluation of soilless strawberry (*fragaria ananassa* duch.) cultivation using alternative growing devices. Life Sci. **16**(1 & 2): 33-40.

Singh, D., Kaur, S., Dhillon, T.S., Singh, P., Hundai, J.S. and Singh, G.J. (2004). Protected cultivation of sweet pepper hybrids under net house in Indian conditions. *Acta Hor*t. **659**: 515-521.

Soumya, A. (2015). Performance evaluation of tomato in soilless culture. M.Sc. Thesis, College of Agriculture, Vellayani. p. 79.

Suhaimi, M.Y., Mohamad, A.M., Mahamud, S. and Khadzir, D. (2012). Effects of substrates on growth and yield of ginger cultivated using soilless culture. *J. Trop. Agric. Food Sci.* **40**(2): 159-168.

Swagatika Srichandan, Panda, S.C., Sahu, G.S., Mahapatra, P. and Mishra, R. (2006). Effect of shadenet on growth and yield of cauliflower. *Orissa J. Hort.* **34**(1): 28-31.

Takte, R. L., Ambad, S. N., Kadam, U. S. and Dhawale, B. C. (2003). Green house cladding material shade nets ventilation etc. Proceedings of All India Seminar on Potential and Prospects for Protective Cultivation, Organized by the Institute of Engineers, Ahmednagar. pp.117–119.

Takte, R.L., Ambad, S.N., Kadam, U.S. and Dhawale, B.C. (2003). Greenhouse cladding material shade nets ventilation etc. Proceeding of National. Seminar on "Potential and Prospects for Protective Cultivation" Organized by the Institute of Engineers, Ahmednagar during December 12-13. pp. 117-119.

Tariq, R., Hassan, I., Rasheed, M., Qureshi, K.M. and Qureshi, U.S. (2003). Effect of planting density and growing media on growth and yield of strawberry. *Pakistan J. Agric. Res.* **16**: 113-125.

Tehranifar, A. and Sarsaefi, M. (2002). Strawberry growing in Iran. *Acta Horti.* **567**: 547- 549.

Tehranifar, A., Poostchi, M., Arooei, H. and Nematti, H. (2007). Effects of seven substrates on qualitative and quantitative characteristics of three strawberry cultivars under soilless culture. *Acta Hort.* **761**: 485-488.

Thakur, B. and Shylla B. (2018). Influence of different growing media on plant growth and fruit yield of strawberry (*Fragaria* × *Ananassa* Duch.) Cv. Chandler grown under protected conditions. *Int. J. Cur. Micro. App. Sci.* **7**(4): 2724-2730.

Thakur, M. and Shylla, B. (2018a). Influence of different growing media on plant growth and fruit yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Chandler grown under protected conditions. *International Journal of Current Microbiology App. Sci.* **7**: 2724-2730.

Thapa, U., Rai, R., Lyngdoh, Y.A., Chattopadhyay, S.B and Prasad, P.H. (2013). Assessment of producing quality sprouting broccoli (*Brassica oleracea* var. italica) under cover and open condition. *African J. Agri. Res.* **8**(15): 1315-1318.

Truong H.D., Wang, C.H. and Kien T.T. 2018. Effect of vermicompost in media on growth, yield and fruit quality of cherry tomato (*Lycopersicon esculentum* Mill.) under net house conditions. *Compost Sci. Utiliz.* **26**(1): 52–8.

Ullah, M.S., Islam, M.S., Islam, M.A. and Haque, T. (2008). Effects of organic manures and chemical fertilizers on the yield of brinjal and soil properties. *J. Bangladesh Agric. Uni.* **6**: 271-276.

Villagra, E.L., Minervini, M.G. and Brandan, E.Z. (2012). Determination of response in strawberry (*Fragaria* × *ananassa* Duch. cv. 'Camarosa') to different nutrition's in conventional agriculture on soil and soilless in vertical sleeves. *Acta Hort.* **947**: 173-178.

Vinkovic, T., Iljkic, D. and Paradjikovic, N. (2007). Tomato Cultivation on Coconut Husks Substrate. *Acta. Agric. Ser.* **12**(23): 55-56.

Voca, S., Duralija, B., Druzic, J., Skendrovic-Babojelic, M., Dobricevic, N., and Cmelik, Z. (2007). Influence of cultivation systems on physical and chemical composition of strawberry fruits cv. Elsanta. *Agric.Con. Sci.* **71**(4): 171-174.

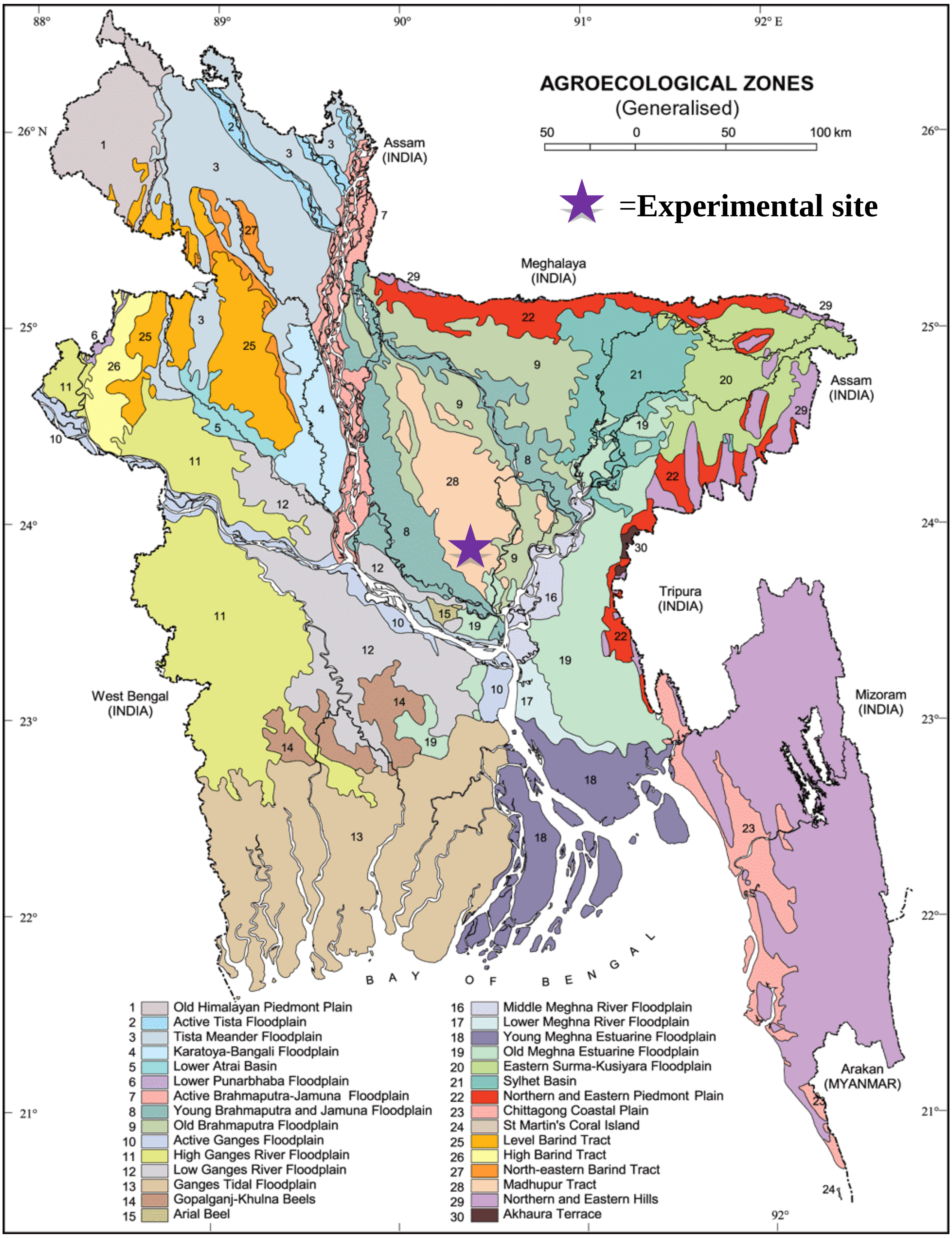
Wahome, P.K., Oseni, T.O., Masarirambi, M.T. and. Shongwe, V.D. (2011). Effects of different hydroponics systems and growing media on the vegetative growth, yield and cut flower quality of gypsophila (*Gypsophila paniculata* L). *World J. Agric. Sci.* **7**: 692-698.

Weber, C.A. (2021). Performance of strawberry varieties developed for perennial matted-row production in annual plasticulture in a cold climate region. *Agron*. **11**: 1407.

Zoran, I., Lidija M., Mihal, D. and Nikolaos, K. (2011). The effect of colour shade nets on the greenhouse climate and pepper yield. Proc. 46th Croatian and 6th *Internationall. Symposium on Agriculture Opatija, Croatia.* pp. 529-532.

APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly meteorological information during the period from October, 2019 to February 2020.

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2020	January	25.5	13.1	41	00
	February	25.9	14	34	7.7

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix III. Analysis of variance of the data of plant height of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.889	0.4444		
Growing media (M)	2	57.484	28.7422	64.67	0.0000**
Protected condition (C)	2	27.458	13.7289	30.89	0.0000**
M×C	4	11.565	2.8911	6.51	0.0026**
Error	16	7.111	0.4444		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data of number of leaves plant^{-1}of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.2358	0.1179		
Growing media (M)	2	7.5949	3.7974	34.40	0.0000**
Protected condition (C)	2	30.4993	15.2496	138.16	0.0000**
M×C	4	4.3785	1.0946	9.92	0.0003**
Error	16	1.7660	0.1104		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data of leaf chlorophyll content (%) of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.0022	0.0011		
Growing media (M)	2	0.7064	0.3532	317.88	0.0000**
Protected condition (C)	2	48.1736	24.0868	21678.12	0.0000**
M×C	4	4.9748	1.2437	1119.33	0.0000**
Error	16	0.0178	0.0011		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of number of flowers plant^{-1}of strawberry

Source	DF	SS	MS	F	P
Replication	2	1.389	0.6944		
Growing media (M)	2	176.138	88.0689	334.97	0.0000**
Protected condition (C)	2	50.773	25.3867	96.56	0.0000**
M×C	4	12.416	3.1039	11.81	0.0001**
Error	16	4.207	0.2629		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of number of fruits plant^{-1}of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.236	0.1179		
Growing media (M)	2	118.084	59.0419	534.91	0.0000**
Protected condition (C)	2	47.570	23.7852	215.49	0.0000**
M×C	4	8.601	2.1502	19.48	0.0000**
Error	16	1.766	0.1104		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of individual fresh fruit weight of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.250	0.1248		
Growing media (M)	2	50.513	25.2565	215.65	0.0000**
Protected condition (C)	2	37.789	18.8944	161.33	0.0000**
M×C	4	16.713	4.1783	35.68	0.0000**
Error	16	1.874	0.1171		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of fruit yield plant^{-1} of strawberry

Source	DF	SS	MS	F	P
Replication	2	11	5.5		
Growing media (M)	2	58103	29051.3	5345.22	0.0000**
Protected condition (C)	2	34901	17450.7	3210.81	0.0000**
M×C	4	10647	2661.8	489.76	0.0000**
Error	16				

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data of pH of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.00056	0.00028		
Growing media (M)	2	0.03227	0.01613	90.75	0.0000
Protected condition (C)	2	0.05787	0.02893	162.75	0.0000
M×C	4	0.02313	0.00578	32.53	0.0000
Error	16	0.00284	0.00018		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data of total soluble solids of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.0200	0.01000		
Growing media (M)	2	8.0000	4.00000	800.00	0.0000**
Protected condition (C)	2	2.0000	1.00000	200.00	0.0000**
M×C	4	0.5000	0.12500	25.00	0.0000**
Error	16	0.0800	0.00500		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data of titratable acidity of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.00020	0.00010		
Growing media (M)	2	0.09247	0.04623	924.67	0.0000**
Protected condition (C)	2	0.02287	0.01143	228.67	0.0000**
M×C	4	0.02113	0.00528	105.67	0.0000**
Error	16	0.00080	0.00005		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XIII. Analysis of variance of the data of ascorbic acid content of strawberry

Source	DF	SS	MS	F	P
Replication	2	2.000	1.000		
Growing media (M)	2	220.852	110.426	220.85	0.0000**
Protected condition (C)	2	240.818	120.409	240.82	0.0000**
M×C	4	24.469	6.117	12.23	0.0001**
Error	16	8.000	0.500		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XIV. Analysis of variance of the data of moisture content of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.0800	0.04000		
Growing media (M)	2	0.2001	0.10007	5.00	0.0205*
Protected condition (C)	2	13.3129	6.65647	332.82	0.0000**
M×C	4	0.6463	0.16157	8.08	0.0009**
Error	16	0.3200	0.02000		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XV. Analysis of variance of the data of reducing sugar of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.00180	0.00090		
Growing media (M)	2	0.51007	0.25503	364.33	0.0000**
Protected condition (C)	2	0.47647	0.23823	340.33	0.0000**
M×C	4	0.01153	0.00288	4.12	0.0176*
Error	16	0.01120	0.00070		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

Appendix XVI. Analysis of variance of the data of total anthocyanin content of strawberry

Source	DF	SS	MS	F	P
Replication	2	0.0800	0.0400		
Growing media (M)	2	3.4658	1.7329	86.64	0.0000**
Protected condition (C)	2	22.9352	11.4676	573.38	0.0000**
M×C	4	0.2702	0.0675	3.38	0.0348*
Error	16	0.3200	0.0200		

**: Significant at 0.01 level of probability
*: Significant at 0.05 level of probability

PLATES

Plate 2: Flowering of the strawberry plant

Plate 3: Data collection of various parameters

Plate 4: Measurement of the chlorophyll content of the leaf strawberry

Plate 5: Harvseting of the strawberry fruits