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Full Length Research Paper

Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (*Fragaria ananassa*)

Riffat Ayesha[1], Noreen Fatima[2], Misbah Ruqayya[3], Khalid Mahmood Qureshi[1], Ishfaq Ahmad Hafiz[1], Khalid Saifullah Khan[1], and Atif Kamal[4,5]*

[1]Department of Horticulture, Faculty of Food and Crop Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.
[2]Department of Biology, Faculty of Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.
[3]Faculty of Food and Crop Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.
[4]Department of Biochemistry, Faculty of Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.
[5]Deartmetnt of Environmental Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan.

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Organic food is getting much preference worldwide because they are free of diseases pure and possess good physiochemical features. Taking the beneficial impact of organic production, into account, this study was conducted under a poly tunnel system using five organic media mixtures including. T_0: (Control) Soil + Sand (1: 1), T_1 Soil + Silt + Farm Yard Manure (1: 1: 1), T_2: Soil + Silt + Leaf Manure (1: 1: 1), T_3: Soil + Silt + Poultry Manure (1: 1: 1) and T_4: Soil + Silt + Coconut Coir Dust (1: 1: 1). Effects of these growing media on the reproductive growth parameters and subsequently on the quality of parameter of its fruit strawberry (*Fragaria annanasa* Duch.) cv. "Chandler" were recorded by using randomized complete block design (RCBD) with three replicates. Result showed that different reproductive growth parameters of the strawberry plant were also affected by the different growing media. It was observed that coconut coir dust based medium (T_4) proved to be the best medium in many aspects. Treatment T_4 produced favorable effects on other relevant growth stages. Its influence was also positive on the average number of trusses with (4.33), average number of flowers per truss (6.33), average number of flowers (96), flower size (1.90 cm), average number of fruit set (16.00), average number of fruits (72.96) and fruit size (3.01 cm). Improvement in the fruit weight was observed on T_3 (10.0 g). Effect of T_4 growing medium was also prominent on fruits color with maximum value of luminance, L* (32.67), redness, a* (29.00), chromaticity, C* (26.00) with low value of b* (7.500) and hue angle, h° (14.00) due to which fruits were more bright and reddish in color. Moreover it also improved the ascorbic acid contents (68.00 mg 100^{-1} ml) in fruits. The growing medium, T_1 improved the total soluble solids (6.26%) of the fruits with an additional improvement in total sugars (15.92%). A significant effect on total sugars was also induced by T_4 (15.22%) in strawberry fruits.

Key words: Strawberry (*Fragaria ananassa*), growing media, total soluble solids, ascorbic acid, total sugar, trussess, farm yard manure, coconut coir dust, leaf manure, poultry manure, growing media.

INTRODUCTION

Strawberry (*Fragaria ananassa* Duch.) is the most refreshing and delicious fruit crop which belong to the family "Rosaceae". It is a rich source of vitamins and minerals with delicate flavors (Sharma, 2002). Because of its known flavor and vitamin contents, it is used as a regular diet by many people in the world (Hancock, 1999). It also contains a higher percentage of other components including phenolics and flavonoids (Hakkinen and Torronen, 2000). Strawberry can be cultivated in almost all regions e.g. from arctic to tropic regions (Hancock, 1999). And has a wide range of climates from tropics to the near of Arctic Circle (Barney, 1999). Being a non-climacteric, it matures only on plant (Cordenunsi et al., 2003) and is grouped under three categories, that is, June bearing, ever-bearing and

*Corresponding author. E-mail: Dr.AtifKamal@yahoo.com.

day-neutral strawberries because it is a perennial herb (Finn and Strik, 2008). The cultivated strawberries are native to North America and originated in Europe in early 18th century. U.S.A. is the biggest strawberries producer (Food and Agriculture Organization of United Nations, 2009). In Pakistan the work on the strawberry culture was started in 1986 in NARC, Islamabad. Only 274 tons of strawberry was produced in Pakistan on 78 hectares land during 2008 to 2009 (GOP, 2009). Although, it is not being cultivating as a major or minor crop, still production of this fruit has increased manifold in Pakistan during recent years. It can grow in a wide range of soils but the suitable range is; sandy to sandy loam. It requires ample organic matter to retain soil moisture which helps to maintain its physiochemical features. Different types of organic growing media are the main part of most the production systems in professional and ornamental sectors of horticulture just because of the fact that they provide better root space to the plants, hold moisture, provides anchorage to the plant and facilitates the gaseous exchange of carbon dioxide and oxygen for respiration.

They also act as a reservoir of minerals and are the source to produce more yields from a given limited space. Among their constituents, organic substances like peat, coir, composted materials and mineral constituents like perlite are very important (EPAGMA, 2007). Properties of the growing media are very important determinants of the plant growth. Their effects may be direct or indirect on the productivity of plant. The most commonly used media included gravel, sand, peat, vermiculite pertile, etc. (Celikel, 1999). To make the Plants growth successful in the container the requirement of special media is very important step because their growth is largely depended on the physiochemical properties of the media used (Riaz et al., 2008; Robbins and Evans, 2001). Physiochemical properties of the growing media pose their effect on the plant growth, (Wilkerson, 2002); therefore the composition of the growth media is very important factor to be taken under consideration (Ingram et al., 2003). Among the properties of growing media, its air spaces pore space, water holding capacity, bulk density, air, pH, soluble salts and distribution of the particles size are important physical and chemical properties. Considering the importance of organic cultivation system current study was designed to evaluate the influence of different organic growing media on the reproductive growth and the quality features of strawberry cv. “Chandler” that could be helpful in future for improvement of quality and yield of its fruit.

MATERIALS AND METHODS

Tunnel setup

A poly tunnel setup at the Research Farm, Department of Horticulture, Pir Mehr Ali Shah, Arid Agriculture University, Rawalpindi, was used for experimentation. The runner plants of strawberry were collected from Swat, Khyber Pakhtunkhwa and planted in 3 L plastic bags filled with different types of growing media mixtures. Plants were irrigated on regular basis under the controlled environment, prevented from all kinds of insect invasion (by using proper insecticides spray per requirement). The growing media used for the comparison in this research trial are shown in Table 1. The data were recorded weekly from randomly selected five plants per treatment per replication on following parameters:

Number of days required for the opening first flower

Total number of days required for the blooming of first flower, in each treatment, average counted of flowers and trusses from randomly selected five plants per treatment per replication were also recorded on weekly basis to get average values. Similarly, average number and size of flowers (flower petals at their widest point using scale) were also counted from randomly selected five plants per treatment per replication from 1st flower opening to the full bloom.

Fruit parameters

Average number of ‘fruit set’ and number of fruits collected by counting fruit numbers and set on randomly selected five plants per treatment per replication from the 1st picking to the last one to see the effect of each treatment on fruits production. Fruit size was also measured by taking average length and width of ten randomly selected fruits from each treatment per replication with the help of standard vernier caliper at full maturity. Fruit weight (g) of pre-selected ten fruits from each treatment per replication was determined by using weighing balance (Setra BL - 410 S). The color developments of fruits (color space L*, a*, b*, C* and hº) were measured by using chromameter CR-400 (Konica Minolta Sensing, Inc., Japan).

Quality characteristics

Total soluble solids (%)

The total soluble solids (TSS) of harvested fruits from each treatment were measured using hand_refractometer at room temperature according to method described by AOAC (1990). Briefly a drop of squeezed juice was placed on the clean and dry prism of the instrument and the reading was measured in % unit.

Total sugars (%)

Total sugars of the sample juice were determined according to method adopted from Hortwitz (1960), briefly 25 ml of prepared aliquot was taken in a 100 ml volumetric flask in which 20 ml distilled water and 5 ml of concentrated (HCl) was added and solution was kept overnight to convert the non-reducing sugars into reducing sugars. Then it was neutralized with 50% concentrated 1N NaOH solution and using phenolphthalein as an indicator and volume was made 100 ml with distilled water. This solution was taken in burette and titrated against 10 ml Fehling’s solution by slow boiling up to brick red color appearance then again 2 to 3 drops of methyl blue was added and again the procedure was repeated up to brick red color appearance. Total sugars were calculated by the following formula:

$$\text{Total sugars (\%)} = 25 \times (X/Z)$$

Table 1. Physiochemical features of different treatments (growing media) at the stage of sowing

Treatment, growth media and ratios	Textural class	pH	E.C (dSm^{-1})	Organic matter (%)	Total No. (%)	Available (mg kg^{-1})	Available K (mg kg^{-1})
T_0: (Control) Soil + Sand (1: 1)	Sandy loam	7.0	0.40	0.70	0.03	29	79
T_1: Soil + Silt + Farm Yard Manure (1: 1:)	Sandy loam	6.5	0.30	2.50	0.11	90	196
T_2: Soil + Silt + Leaf Manure (1: 1: 1)	Loam	6.3	0.35	2.20	0.10	86	152
T_3: Soil + Silt + Poultry Manure (1: 1: 1)	Sandy loam	6.5	0.25	2.60	0.13	94	198
T_4: Soil + Silt + Coconut Coir Dust (1: 1: 1)	Loam	6.0	0.30	2.30	0.12	33.2	136

Where, X= ml of standard sugar solution used against 10 ml Fehling's solution, Z = ml of sample aliquot used against 10 ml Fehling's solution.

Ascorbic acid (mg 100^{-1} ml juice)

Ascorbic acid contents of fruits for each treatment were determined according to the method described by (Hans, 1992). Strawberry pulp (5 g) was blended with 5 ml, 1% hydrochloric acid (w/v) and the homogenate was centrifuged at 10,000 rpm for 10 minutes. The supernatant fluid was collected as vitamin C extract. The absorbance of extract was measured at 243 nm by means of spectrophotometer (OPTIMA, SP-3000-plus).

Reproductive growing characteristics

Total numbers of days were counted from transplanting day to first flower opening date to measure the number of days required to open first flower. Calculations was done visually for the prediction of average number of trusses, average number of flowers per truss and average number of flowers while the average number of fruit set and average number of fruits were recorded by counting from first picking to last harvest. Flower size was recorded with scale at their widest points while fruit size was obtained through vernier calipers and fruit weight through (Setra BL - 410 S) weighing balance.

Quality characteristics

At the last picking, the randomly selected ten fruits per treatment per replication were used to determine the relevant quality features. The color indicators such as L* (luminance), a* (redness), b* (bluish to yellowish), C* (chroma) and h° (hue angle) were recorded through chromameter CR-400 (Konica Minolta Sensing, Inc., Japan). Total soluble solids of the same fruits were measured by hand refractometer according to method described previously (AOAC, 1990). Total sugars of the fruits were analyzed by the method used by (Hortwitz, 1960) while the ascorbic acid contents were measured according to the method described by (Hans, 1992).

Statistical analysis

The treatments were laid out in a randomized complete block design (RCBD) with three replications and ten plants per replicate. Data were analyzed using ANOVA and paired sample t-test, using SPSS software version 12. An alpha level $P < 0.05$ was considered statistically significance level.

RESULTS AND DISCUSSION

This study was conducted to analyze the effect of physiochemical characteristics of five types of growing media (Table 1) on the reproductive and fruit quality parameters of strawberry fruit. Main objective was to find suitable composition of such media which could be helpful in future to minimize fruiting time and to enhance the quality attributes of strawberry fruits. It was observed that best growing media were those which had maximum percentage of organic matter, total nitrogen, available phosphorus and potassium etc. Plants grown on control media, that is, (control) Soil + Sand (1: 1) showed least quality attributes. The intermediate nutritional status was observed in T_4 medium and electrical conductivity was appropriate with pH below neutral range on all growing media except on the control. It was observed that different reproductive growth features of strawberry were significantly affected by the different growing media.

Reproductive growth characteristics as affected by different types of growth media in strawberry

Number of days required to open first flower

In our experiment minimum number of days for the opening of the flower were required on growing medium T_2 (leaf manure based growing media), with (82.67 days) in strawberry plants, as compared to growing medium T_0 after 96 days of plantation. Hence T_2 caused the early onset of reproductive growth than any other growing. Conversely strawberry plants grown on growing medium, T_3 (poultry manure) took 101 days to open first flower in, which is maximum in our study, even larger than control growing medium (96 days). The other growing media T_1 and T_4 showed the time duration of flower opening with 89 and 86.67 days respectively. It is more probable that the nutritional status of growing media (Table 1) specifically that of medium T_2 provided such a range of nutrients which induced the early flowering in strawberry. It may also be concluded that under the influence of such nutrition medium, vegetative growth of strawberry gets completed earlier which leads towards early reproduction. While in the growing medium, T_3 nutrition was high than any other treatment which might have prolonged the vegetative growth period and also caused the delayed reproduction. Some of these findings were also observed by Ahmed et al. (2004) in his studies on the dahlia

Table 2. Effect of different growing media on reproductive and fruit quality parameters of strawberry (*Fragaria annanasa* Duch.)

Treatment	T_0 (Control)	T_1	T_2	T_3	T_4
Reproductive growth parameter					
Aver. No. of flowers/ truss	1.9±0.5 ^{B}	3.4±1.4 ^{AB}	3.6±0.1 ^{AB}	4.3±0.3* ^{A}	6.3±0.3* ^{A}
days for open first of flower	96±1.5 ^{A}	89±1.7 ^{B}	82.7±1.2* ^{C}	101±2.5 ^{A}	86.7±0.3* ^{BC}
Aver. No. of trusses	1.0±0.5 ^{C}	2.33±0.9 ^{BC}	3.33±0.3* ^{AB}	3.66±0.3* ^{AB}	4.33±0.3* ^{A}
Aver. No. of flowers	30±1.0 ^{D}	50±0.5* ^{C}	54±0.5* ^{C}	70±8.1* ^{B}	96±4.5** ^{A}
Aver. No. of fruit set	6±3.3 ^{C}	12±6.1* ^{AB}	9±1 ^{BC}	14±2* ^{AB}	16±0.01* ^{A}
Aver. No. of fruits	20.0±0.6 ^{D}	32.8±1.6 ^{C}	35±1.7* ^{C}	57.7±2.7** ^{B}	72.9±0.9** ^{A}
Flower size	1.12±0.1 ^{C}	1.4±0.1 ^{BC}	1.2±0.1 ^{C}	1.7*±0.1* ^{AB}	1.9±0.1* A
Fruit size	1.8±0.1 ^{C}	2.4±0.2 ^{B}	2.8±0.2* ^{AB}	2.9±0.3 ^{A}	3.01±0.1 ^{A}
Fruit weight per berry (g)	2±0.577 ^{D}	5.9±0.39 ^{BC}	4.9±0.7* ^{C}	10±1.0* ^{A}	7±0.12** ^{B}
No. of runners / treatment	7±1.2 ^{D}	15.7±1.5* ^{BC}	12±2.6 ^{C}	22±1.2* ^{A}	19±1.0* ^{AB}
Quality parameter					
Ascorbic acid (mg 100^{-1} ml juice)	20±1.2 ^{E}	34±2.6 ^{D}	45±2.0* ^{C}	56±1.7* ^{B}	68±3.5** ^{A}
Total sugars (%)	9.7±1 ^{B}	14.9±0.1* ^{A}	12.6±2.0 ^{AB}	11.7±0.5 ^{AB}	14.2±1.3 ^{A}
TSS	4.5±0.4 ^{B}	6.3±0.6 ^{A}	4.6±0.1 ^{B}	4.5±0.1 ^{B}	4.9±0.1 ^{B}

Significantly difference at * P<0.05, ** P< 0.01 as compared to control T_0

flowers.

Average number of trusses

We found that although growing medium, T_4 (coconut coir based medium) had produced (4.33) number of trusses ($P < 0.05$ as compared to control) but it did not show any large difference as compared growing media T_2 and T_3 which produced (3.33) and (3.66) number of trusses respectively. The growing medium, T_1 with (2.33) number of trusses were also not very different from T_2 and T_3, although the control produced minimum number of trusses (that is, 1.0). Our results also showed that in the presence optimum nutrients (as in case of coconut coir dust growing medium T_4), the number of trusses were increased. Contrary, the leaf and other manures had shown positive effects on the number of flower in trusses. These results are line with that of Maksoud (2000) in which such effects ere observed on the inflorescence number of olive tree. These plants were provided with organic cultivation system through the supply of essential nutrients and organic matter to them.

Average number of flowers (ANF) per truss

Average number of flowers per truss remained higher on T_4 coconut coir dust based growing medium (6.33, $P < 0.05$ vs. control T_0) as shown in (Table 2). Other growing media, T_1 (farm yard manure) and T_2 (leaf manure) showed difference in ANF but difference remained non-significant with each other that is, (3.41) and (3.61) respectively. Minimum ANF was recorded in the control per truss (1.94). The ANF thus increased with T_4 and on T_3 (poultry manure based growing medium) hence both of these growing media proved to be suitable for reproductive growth. Hegazi et al. (2007) recorded that poultry manure application increased the number of flowers per inflorescence in olive trees. But in or study, we identified two such media which may be useful in strawberry plants (T_3, and T_4) out of which T_4 was more effective. It is more probable that the different optimum nutrients level in the growing media (T_4) proved to be more suitable for the soft fruits like strawberry than T_3. It thus increased the ANF and it may be because that the availability of nutrients increased the photosynthesis process in plants that not only promoted the vegetative growth but also reproductive growth (Maksoud, 2000).

Average number of flowers

Growing medium; T_4 (coconut coir) produced maximum number of flowers (not per truss but separately), our experiment on flowers that is 96 flowers overall which was highly significant as compared to T_0 control ($P<0.01$). Other better yield of flowers was observed under the influence of growing medium T_3 (poultry manure) that is 70 ($P<0.05$ vs. control that is, 30). It may be because the plant growth and its yield are highly dependent upon the crown size. Generally large crown produce maximum number of flower buds (Bartczak et al., 2007). In our investigation coconut coir dust growing medium (T_4) had positive effect on the crown size hence may be held responsible for the increase in the number of flowers on the same growing medium. Riaz et al. (2008) also

observed the increased number of *zinnia* flowers on coconut compost medium. Similar finding were recorded by Awang and Ismail (1997) under the influence of coconut coir mixtures which produced more flowers in zinnia and marigold plants. Our results remained in agreement with these findings but we made such observation in strawberry flower, which showed effectiveness of such medium in other plant species as well. Although, our poultry manure based on growing medium proved to be better than other growing media, and the results is in agreement with the findings of Ahmed et al. (2004). The lower number of flower production might be due to the reduced availability of nutrients in control growing medium suggesting that strawberries needed a specific range of nutrients to increase the number of the flowers.

Flower size (cm)

Growing medium, T_4 and T_3 ($P < 0.05$ in both cases vs. control) caused much improvement in the flower size (that is, about 1.90 cm and 1.66 cm respectively). The control (1.12 cm), T_1 (1.43 cm) and T_2 (1.18 cm) showed minimum increase in flowers size. In the case of control, flowers were having much reduced size (Table 2). The coir dust based growing medium hence increased the size of the strawberry flowers and according to Riaz et al. (2008) coconut compost and coconut compost based different growing media can significantly improved the flowers size in zinnia plant, and we observed almost similar observation in our strawberry plants. It is thus clear that coconut residues based growing media can also increase the flower size in strawberries (Figure 1a).

Average number of fruit set

The growing medium, T_4 in our study also increased the number of fruit set of strawberry which was highest among all treatments with 16.0 fruit sets on average. Minimum number of fruit sets were observed in control, that is, 6.0 sets on average. Thus again the maximum average number of fruit set were produced under the influence of coconut coir dust based growing medium (T_4). This may be due to the provision of the adequate supply of nitrogen (N) and phosphorus (P) nutrients at the fruit setting stage that might have reduced the abortion of the female parts of flower. Similar finding have been reported by Ali et al. (2003) on strawberry. Poor results of other growing media may be attributed to the shortage of nutrients availability which is oblivious in the case of control growing medium.

Average number of fruits

In our study T_4 increased the average number of strawberry fruits with a value of 72.96 ($P < 0.01$ vs. control T_0). In a previous study low fruit yield in poultry manure based growing medium was also investigated by Mahadeen, (2009) in strawberries. But the number of fruits observed on growing medium, T_3 with 57.74 (were also significantly with $P < 0.01$ as compared to control that is 20). It is because the adequacy of the nutrients in coconut coir dust based growing medium T_4 and poultry manure T_3 have good physiochemical properties that can enhance the total number of fruits in strawberries. Our results also show that there was an improvement in fruit yield attributable to leaf manure based growing medium over farm yard manure based growing medium, showing that leaf manure can also prove better medium for the strawberry fruits production. Fruit size was also increased by T_4 growing medium. It showed 3.01 cm increase in fruit size. Other medium did not pose much effect on the fruit size. In this study T_4 showed significant effects on strawberry fruit size than other growing media. It is previously known that poultry manure significantly increase the fruit size in tomatoes (Ljoyah, 2007). Our result of leaf manure based medium also proved better for increasing the fruit size, which may be due to its ability to provide essential micro nutrients to the plants. These findings are in line with Ullah et al. (2008). Effect of growing media and control on fruit size is shown in (Table 2, Figure 1b).

Fruit weight per berry (g)

Avarage weight of the strawberry fruits was increased by 10, 7, 5.87 and 4.94 g under growing medium, T_3, T_4, T_1 and T_2, respectively. While control remained the lowest with 2g of weight on average, the organic matter and other soil nutrients specially N and P in available forms are considerable factors that influence the plant growth and yield (Marchel et al., 1982). In our opinion the treatment, T_3 (poultry manure) provided more available phosphorus nutrient, high organic matter and total organic N percentage that affected the fruit weight. N was also in higher percentage in case of T_4. Manures contains a favorable amounts of macro and micro nutrients hence they can enhance the weight of the strawberry fruit by enhancing the synthesis of carbohydrates contents. The results of this study are also in agreement with that of Ayeni et al. (2009), who observed more fruit weight in tomato crop when poultry manure based growing media was used. According to Maegowa and Minegishi (1991) the suitable level of N in applied nutrients medium can pose a favorable effect on the fruit weight.

Quality parameters as affected by different types of growth media in strawberry

Total soluble solids (TSS %)

The total soluble solids represent the acids, sugars,

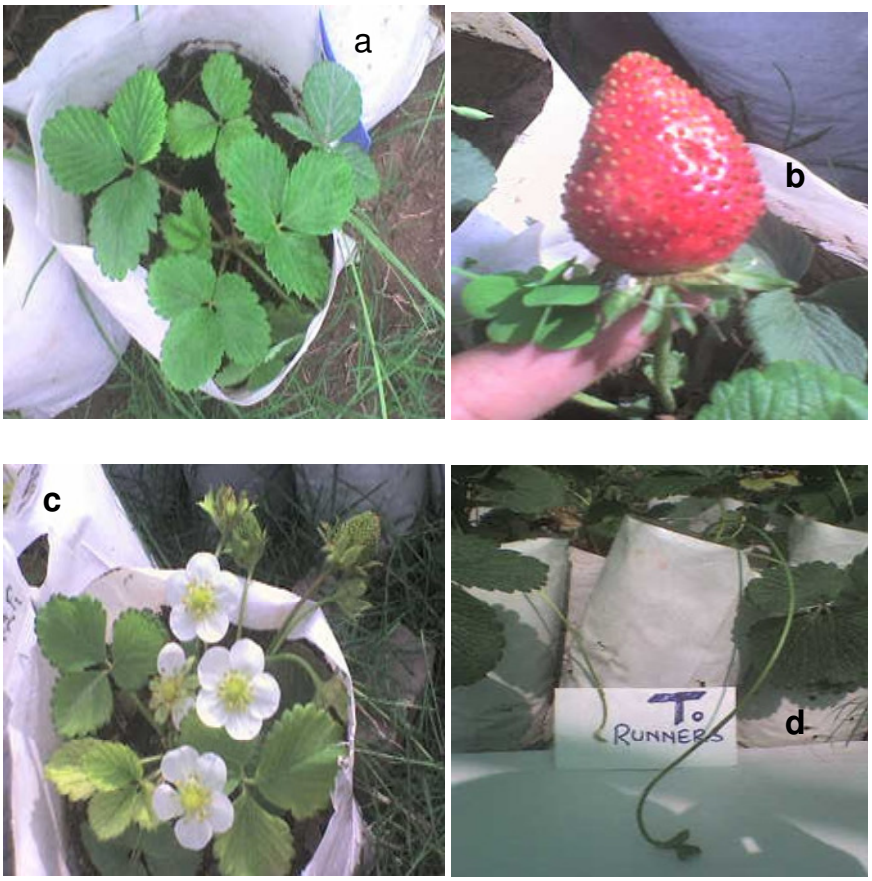

Figure 1. Plant width (a) Fruit size (b) Flower size (c) Runners production (d) Size of the fruits recorded during different experimental stages.

soluble salts, proteins and other dissolved substances of the cell sap (Wills et al., 1998). In our study we found that total soluble solids (TSS) of strawberry were maximum when grown on the T_1 (6.26 %) as compared to the other media including control. These results showed that growing medium consisted of farm yard manure can improve the TSS of strawberry fruits. Ali et al. (2003) has reported that farm yard manure based growing medium caused an increase in TSS percentage. A non-significant difference among other treatment showed that these growing media can induce no change in TSS contents of strawberry fruits, and remains in line with some previous findings also (Mahadeen, 2009; Tuzel, 2003, in the strawberry and tomatoes studies respectively) with the common conclusion that there was no any effect of organic or inorganic cultivation system was observed on TSS contents of these crops (Table 2).

Total sugars (%)

The sugars and acids contents are considerable taste attributes of strawberry fruits (Wozniak et al., 1997) which attracts the consumers. In fresh strawberries sucrose, glucose and fructose comprise 99% of the total sugars (Maniken and Soderling, 1980). The consumers and food processing industries prefer the organic food items, because they also ensure health safety. According to Cayuela et al. (1997) organically produced strawberries contain more sugars than conventionally produced fruits. Our results of total sugar contents in snobbery fruits showed that among different growing media, only T_1 and T_4 growing media sugar contents were in higher level with average values of (14.92) and (14.22%), respectively. The growing media, T_2 (12.58) and T_3 (11.70 %) showed non-significant results. In our results the lowest values of total sugars were observed only in control (9.69%) as compared to other growing media, and this difference was significant ($P < 0.005$) Table 2. Our study clearly showed that although farm yard manure and coconut coir dust based growing media showed improvement in total sugars of strawberry fruits but all growing media did not showed very high variations in the results among each other. But still the value of total sugar was higher on all growing media. Some of such findings are reported by Leskinen et al. (2002) in strawberries that produced

Table 3. Effect of different growing media the fruit color attributes of the strawberry (*Fragaria annanasa* Duch.)

Treatments	T_0: (Control)	T_1	T_2	T_3	T_4
Fruit color spaces					
L* (Lightness or darkness)	33.3±1.2 ^{A}	32±1.5 ^{A}	32.7±1.5 ^{A}	31.3±2.4 ^{A}	30±0.9 ^{A}
a* (Greenish to redness)	26.4±0.5 ^{A}	27.5±1.4 ^{A}	27±0.6 ^{A}	28.2±0.7 ^{A}	29±0.7 ^{A}
b* (Bluish to yellowness)	8.4±0.3 ^{A}	8.5±0.3 ^{A}	8.5±0.2 ^{A}	8.7±0.3 ^{A}	9.3±0.8* ^{A}
C* (Chroma)	24.3±0.3 ^{A}	24.7±0.3 ^{A}	25.4±0.3 ^{A}	26±0 ^{A}	26.2±1.7 ^{A}
h^o (Hue angle)	23.7±0.6 ^{A}	22.3±0.7 A	23.3±1.5 ^{A}	23.3±1.8 ^{A}	23±0.3 ^{A}

Significantly difference at * P<0.05, ** P< 0.01 as compared to control (T_0).

through organic cultivation system contained more sugars. Wang and Lin (2002) also observed increase in total sugars of strawberries when grown on compost based growing medium. It is likely that positive effect on total sugars may be due to organic cultivation system, which may improve the soil structure and soil fertility, by slowing down the release of nutrients as suggested by Amodio et al. (2007).

Ascorbic acid (mg 100^{-1} ml juice)

Strawberries are very rich source of ascorbic acid contents, (Food and Nutrition Board, 1989) and contain more vitamin C as compared to oranges (Ayub et al*.,* 2010). It is known that organic cultivation improve the ascorbic acid contents of the fruits. We observed with our growing media a significant influence on ascorbic acid contents in our strawberry plants. However, the growing medium, T_4 showed more significant effects on ascorbic acid contents of fruits (68 mg 100^{-1} ml juice, P<0.01 vs. control T_0). The results of other growing media that is T_3 (56 mg 100^{-1} ml juice), T_2 (45 mg 100^{-1} ml juice), T_1 (34 mg 100^{-1} ml juice) showed minimum effects as compare to control (20 mg 100^{-1} ml juice) (Table 2). As the physical properties of coconut coir dust based media (T_4) are more hydrophilic in nature and absorbs more moisture contents against their per unit volume and used to improve the soil structure. These attributes may be helpful in improving the ascorbic acid contents in vegetables (Nilsson, 1979). Thus our coir dust based growing medium produced the strawberries with high ascorbic acid contents and remained in agreement with Wang and Lin (2002) worked on compost, and also the study of Mahadeen (2009) who used poultry based organic medium and both noted that organic fertilizers significantly increased the ascorbic acid contents of strawberry fruits. Likewise different levels of farm yard manure have also been reported to enhance the ascorbic acid contents in strawberries (Bhat, 1999). Moreover strawberries that were produced under sustainable production system had produced 20% more ascorbic acid as compared to conventional growing system (Asami et al., 2003) and our results remained in agreement with them and have shown that the organic cultivation have positive effects on the ascorbic acid contents of strawberries which may be due to improvement in soil structure.

Fruit color

Among the different physical quality parameters of the fruits, color is a special character which appeals the customer and is also one of the important maturity indices of fruits and vegetables. In the case of strawberries, anthocyanins that is, natural color pigments such as pelargonidin 3-glucoside (PG) and cyanidin 3-glucoside (CG) are predominant pigments (Sondheimer and Kertesz, 1948) responsible for the color development (Kalt et al., 1993; Gil et al., 1997). This imparts the red color into many fruits (Lopes da Silva et al., 2007). In strawberry fruits, we measured the change in the skin color of strawberry fruits in terms of color space L*, a*, b*, C* and h° where L* (lightness coefficient) which are used for the measurement of brightness or darkness, and Hunter a* and b* used to determine a change from green to red and from bluish to yellowness respectively. Moreover C* (chroma) was used to measure the color intensity and h^o (hue angle) which showed highest red color at its low value (Hunter and Harold, 1987). Results of the strawberry fruits skin colors grown on different growing media are shown in (Table 3). All the growing media did much improved the fruits color. Still the fruits obtained on different growing media were dark red (lower L* and h^o value) (Table 3 as compared to control). This is in agreement with the reporting of Reganold et al. (2010) in his study different strawberry cultivars were grown under organic cultivation system. It is known that degradation of the chlorophyll contents in unripe fruits becomes active as b* value increase which indicates the ripening of the fruits. According to our findings, this parameter was improved on all types of growing media including control, but the fruits grown on different growing media showed maximum ripening as compared to control (Table 3). Ripening in strawberries causes an increase in the anthocyanin pigments specifically in the epidermis and cortex of the fruits (Nunes et al., 2005). Anthocyanins

represented red color in strawberry fruits measured as color space a*, (Table 3) indicated that all the growing media including control showed non-significant effect on red color. As the value of color space L* and h^o decreased, the value of color space a* was increased showing dark red color. Intensity of the red color was measured by color space C*. It was observed that color intensity was non-significant for the fruits obtained on all types of growing media but in comparison with control, other growing media produced fruits with more intense red color (maximum C* value). According to Laleh et al. (2006), the degradation of anthocyanin molecule takes place at high pH, temperature and light exposure. Other studies show that the synthesis of anthocyanin pigments gets stimulated under light (both ultraviolet and visible), low temperature and under nitrogen and phosphorous deficiency (Hopkins, 1995). This shows that the nutritional status of growing media in our study proved to be better than control although we could not find differentiation between control and other growing media for the color improvement in strawberry fruits which suggests that the organic cultivation have non-significant influence on such quality attributes. Moreover, our result also remained contrary to that reported by Amodio et al. (2007) in which kiwi fruits showed high L*, lower hue angle and chromaticity value as compared to organically produced fruits.

Conclusion

Utilization of suitable manure is a very good practice in improving physiochemical properties of the soil; it is also a good source of essential nutrients. Or results clearly showed that coconut coir dust based growing medium proved to be a dominant growing medium and it influenced reproductive and quality relevant parameters of strawberry plant efficiently. We observed that T_3 and T_4 medium influenced almost all the observed parameters, but in the case of T_4, some results were highly significant ($P < 0.01$) e.g. number of flower, fruits, fruit weight, per berry, and the ascorbic acid contents were increase significantly as compared to the control T_0. Although sugar contents were increased in all other treatments but result of higher increase in sugar contents were only significant in the case of T_1 growing medium ($P < 0.05$). Our results clearly showed that T_3 and T_4 treatments were the most beneficial in improving the reproductive growth and fruit quality parameters of strawberry plants but T_4 (coconut coir based medium) proved to be the best medium. These result may be attributed to the good physical condition; moisture holding and aeration properties of this medium (Fornes et al., 2003). It is also known for the slower provision of the nutrients for long time which helps to enhance the plant growth (Evans et al., 1996; Prasad, 1997). Optimum nutritional status of this growing medium affected the development of many above and below ground plant parts and also many of quality related parameters. In the light of this research outcomes it a separate study is recommended to analyze effects of mixed media T_3, T_4 and T_1, which may be helpful in devising more influential growing media to improve vegetative, reproductive growth and fruit quality in strawberry plant and subsequently helpful in improving the overall yield of the plant. In this way it would be possible to get attributes of all the above discuss growing media in a single composition of the growing medium.

Abbreviations: TSS, Total soluble solids; **E.C,** electric conductivity; **RCBD,** randomized complete block design; **L*,** luminance; **a*,** redness; **b*,** bluish to yellowish; **C*;** chroma; **h^o,** hue angle; **ANF,** average number of flowers.

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