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EFFECT OF COCO-DUST AND GRAVEL SUBSTRATE ON THE GROWTH AND YIELD OF STRAWBERRY

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Abstract

Strawberry plants were grown in five different mixtures of coco-dust and gravel to compare their influences under glasshouse condition at hydroponics and controlled environment agriculture research facilities of Olericulture division, HRC, BARI, Gazipur during winter season. The experimental design was completely randomized block design with 10 replicated plants/pots. The plants were supplied with 25% 'Enshi-shoo' nutrient solution in every alternative day. Strawberry plants were grown in five different mixtures of coco-dust and gravel substrates as T_1 (100:0), T_2 (75:25), T_3 (50:50), T_4 (25:75) and T_5 (0:100). Results showed that coco-dust and gravel substrate had significant influence on number of leaves, root length and root dry weight. Root length was found to be hampered greatly in plants grown with sole gravel substrate because of its poor moisture holding capacity. Fruit yield per plant was higher in T_3 (50:50 of coco-dust and gravel) compared to other substrate mixtures. The present study revealed that the growth, yield and fruit qualities were significantly higher in plants grown in 50:50 of coco-dust and gravel compared to their other mixture substrates.

Keywords: *Fragaria* × *ananassa* Duch., Coconut coir, Soilless culture, Strawberry fruit quality.

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most popular fruits in the world. It is a good source of vitamin C, folate, and phenolic acids (Proteggente *et al.*, 2002; Scalzo *et al.*, 2005). This delicious fruit is well known throughout the world and common fruit in diets because of its good taste, scent and high vitamin content (Tabatabaei *et al.*, 2006). Soil culture of strawberry is limited to the infestation of soil borne insect pests. On the other hand, soilless cultivation in protective structure provides ideal condition of root growth through the supply of adequate moisture, mineral nutrients, and proper aeration (Verdonck *et al.*, 1982; Albaho *et al.*, 2009). This type of protected cultivation techniques ensures higher yield and quality in strawberry through effective plant protection measures and use of balanced plant nutrition (Dinar, 2003).

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In Bangladesh, coco-dust is considered as most easily available and cheap soilless substrate for plant growth. Use of these unutilized coconut substrate in the soilless culture would be highly beneficial for maintaining environmental balance, and in turn use for crop cultivation. On the other hand, gravel has potential use in soilless cultivation of fruits and vegetables. Finding appropriate substrates providing proper growth of root would be helpful for producing quality strawberry under Bangladesh condition. Therefore, the present study was under taken to find out the influence of coco-dust and gravel mixtures substrates on the growth, yield and fruit quality of strawberry in soilless culture.

Materials and methods

Experimental site

The study was conduct in the greenhouse of Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, 23°59'38.2" N 90°24'39.7" E at an elevation of 8.40 m above mean sea level (Anonymous, 1995), from October 2015 to March 2016.

Plant materials

BARI Strawberry-1 was used as planting material in this experiment. The planting materials were collected from Pomology division, Horticulture Research Centre, BARI, Gazipur, Bangladesh. Five to seven leaved plantlets were collected, washed several times and transplanted in plastic buckets filled with mixture of coco-dust and gravel substrate.

Coco-dust and gravel mixtures

The coco-dust was collected from the local market. The collected coco-dust were soaked in tap water overnight, and then cleaned and air dried before use. Gravels were collected from Shitalakshya River near to Gazipur district used for this study. After thoroughly washed, gravels were sieved (10 mesh) for obtaining about 2.0 mm size. The experimental treatments consist of five different ratios of coco-dust and gravel viz., T_1 (100:0), T_2 (75:25), T_3 (50:50), T_4 (25:75) and T_5 (0:100).

Nutrient solution used

Strawberry plants were grown in 25% standard 'Enshi-shoo' nutrient solution (Table 1). The pH and EC of the nutrient solutions were 7.2 and 0.85 dS m^{-1}, respectively whereas these values of the tap water used to make the nutrient solution were 7.5 and 0.25 dS m^{-1}, respectively.

Table 1. Mineral nutrient concentrations in full strength 'Enshi-shoo' nutrient solution (Hori, 1966)

Chemicals	Concentration (µM/L)
$Ca(NO_3)_2$, $4H_2O$	4.03
KNO_3	8.02
$MgSO_4$, $7H_2O$	2.03
$NH_4H_2PO_4$	1.35
H_3BO_3	0.05
$ZnSO_4$, $7H_2O$	7.64×10^{-4}
$MnSO_4$, $5H_2O$	8.30×10^{-3}
$CuSO_4$, $5H_2O$	2.00×10^{-4}
Na_2MoO_4	9.71×10^{-5}
NaFe-EDTA	0.06

Cultivation procedure

The plants were supplied with one liter 25% 'Enshi-shoo' nutrient solution in every alternative day throughout the growing period. No disease infection and insect pest infestation observed in the strawberry plant during the cultivation. After anthesis, flowers were pollinated by soft camel hair brush. The lower older leaves were removed in order to provide proper sanitation and to avoid parasitism.

Data collection

At maturity, strawberry fruits (about 80% red color development) were harvested and data on fruit characteristics such as number of fruit, and individual fruit weight were recorded. Deformed and undersized fruits (< 5 g) were considered unmarketable and excluded from the yield calculation. Fruit yield per plant were calculated by compiling fruits of each harvest. After final harvest of fruit, data on plant growth parameters such as number of leaves, maximum leaf length and width, root length, and dry weight of shoot and root were recorded.

Fruit quality analysis

Strawberry fruits were composited after each harvest and were frozen at -30 ˚C for subsequent analysis of soluble solids, titratable acidity and ascorbic acid content. Fruit samples were kept out of freezer before analysis to obtain juice for determining above qualities of strawberry fruits. The soluble solids content of the fruits juice was determined using a hand refractometer (ATAGO, Japan). Titratable acid contents were determined by diluting each 2 ml aliquot of strawberry juice to 10 ml with 8 ml distilled water. Two drops of phenolphthalein

was added in the solution and its pH was adjusted to 8.2 using 0.1 N (w/v) NaOH. The quantity of NaOH (ml) was determined through titration, and the amount of appropriate acidity was converted in to citric acidity (%). Ascorbic acid was determined following 2,6-Dichlorophenol-Indophenol visual titration method (Johnson, 1948).

Experimental design and statistical analysis

A random experimental design of three randomized complete block was performed and each block was composed of ten plants per treatment. Data collected on growth characteristics, fruit yield measurement and fruit qualities were subjected to analysis of variance, and treatment means were compared by LSD test at P = 0.05. All the data analyses were performed using the MSTAT-C program (ver. 7, Michigan State University, East Lansing, MI; Gomez and Gomez, 1984).

Results and Discussion

Effect of growing substrate on the growth and yield of strawberry plants

Plants grown in coco-dust and gravel mixtures produces greater number of leaves compared to sole coco-dust (Table 2, Figure 1). Number of leaves per plant was not varied significantly in different mixtures of coco-dust and gravel substrate. Leaf size was not influenced in all the substrate mixtures. Root length was statistically similar in coco-dust and its mixture with gravel however, it was greater in plants grown with T_3 (50:50; coco-dust: gravel) followed by T_4 (25:75; coco-dust: gravel). It was found that root growth was hampered in plants grown in sole gravel substrate compared to other substrates. This might be due to its less moisture holding capacity leading to unfavorable environment for root growth. The use of different organic and inorganic substrates allows the plant better nutrient uptake, sufficient growth and development for water and oxygen holding optimization (Albaho *et al.*, 2009). Shoot weight was not affected by the substrate mixtures used for strawberry. However, root dry weight production differed among the substrates used. It was found that significantly higher root dry weight was produced in T_3 (50:50; coco-dust: gravel) compared to other substrates. Previously, it was found that strawberry plants grown in coco-dust or coco-dust + river sand showed reduced performance in growth and yield compared to plants grown in hydroponic nutrient solution but fruit quality was not varied significantly (Mollik *et al.*, 2015). In another research growth of strawberry plants found to be improved in coconut coir based substrate mixture with perlite, peat and finpeat (Lopez-Madina *et al.*, 2008; Ercisli *et al.*, 2005). In strawberry, better growth has been reported in coir than that in perlite substrate (Lopez-Madina *et al.*, 2008). Therefore, study on varieties of substrates for

growing strawberry in soilless culture would be beneficial for the growers. In this regard, the present study provides useful recommendation for strawberry cultivation.

Table 2. Effect of coco-dust and gravel substrates mixture on the growth of strawberry plant

Coco-dust: Gravel	No. of leaves/ plant	Max. leaf length (cm)	Max. leaf width (cm)	Max. root length (cm)	Shoot DW (g)	Root DW (g)
100:0	7.40 b[z]	19.96	12.26	24.08 b	9.65	1.74 b
75:25	11.21 ab	16.59	10.90	24.21 b	7.90	2.32 b
50:50	11.64 ab	18.32	12.53	32.53 a	5.12	3.20 a
25:75	16.40 a	16.96	10.78	30.68 a	6.52	2.24 b
0:100	11.40 ab	17.90	10.81	13.01 c	5.14	1.94 b
Sig. level	*	ns	ns	*	ns	**

[z]Means within column followed by different letters are significant according to the LSD test at $P < 0.05$.

** = significant at 1% level of probability; * = significant at 5% level of probability; ns = not significant; DW = dry weight; DAT = Days after transplanting

Results revealed that there was no significant difference in days to anthesis in plants grown in the coco-dust and gravel mixture substrates. However, comparatively fewer days were required in case of plants grown in T3 (50:50; coco-dust: gravel) substrate to initiate flowering. It is evident that fruit yield and yield contributing parameters were varied significantly by the growing substrates (Table 3). Greater number of fruits per plant was harvested from T_3 substrate compared to other substrates used. While similar number of fruits per plants was produced in substrate mixture ratio other than T_3. In case of individual fruit weight, the heavier fruit was found in plants grown with substrate in T_4 (25:75; coco-dust: gravel) compared to all other substrates that produced significantly similar weight fruits. Considerably higher fruit yield per plant was recorded in plants grown in T_3 (50:50; coco-dust: gravel) substrates (59% and 64% greater than sole coco-dust and sole gravel substrate, respectively) followed by T_4 (25:75; coco-dust: gravel) mixtures. Significantly lower fruit yield per plant was recorded in other three mixtures and there were no significant difference among them. It was reported that 100% rice husk substrate have significant influence on majority of traits of strawberry among rice husks and pumice with different ratios used in column hydroponic system (Caso *et al.*, 2009).

Table 3. Effect of coco-dust and gravel substrates mixture on the yield of strawberry

Coco-dust: Gravel	Days to 1st anthesis (days/ DAT)	No. of fruits/ plant	Individual fruit weight (g)	Fruit yield/ plant (g)
100:0	66.60	11.02 b	15.12 b	156.30 c
75:25	75.20	10.00 b	14.96 b	147.30 c
50:50	61.40	21.97 a	13.89 b	248.70 a
25:75	68.20	9.01 b	18.20 a	178.70 b
0:100	71.80	10.04 b	16.01 b	151.70 c
Sig. level	ns	**	**	**

[z]Means within column followed by different letters are significant according to the LSD test at $P < 0.05$.

** = significant at 1% level of probability; ns = not significant

Figure 1. Vegetative growth of strawberry plants at different stages of culture. (a) Initial growth during transplanting, (b) Growth during anthesis stage, (c) Whole plant showing root condition during fruiting stage.

Effect of growing substrate on the fruit qualities of strawberry

Fruit qualities measured were not differed significantly except ascorbic acid (Table 4). The ascorbic acid content was found higher in fruits harvested from plants grown in T_3 (50:50; coco-dust: gravel). Other fruit qualities such as total soluble solids and citric acidity were found to be unaffected by all the growing substrates used for strawberry. It was reported that fruit quality such as soluble solids, vitamin C and titiratable acidity were greater in rice husk substrate (Jafarnia *et al.,* 2010). Strawberries grown in greenhouses with different soilless growing media also showed their impact on phytochemical and nutritional composition (Tulipani *et al.,* 2008). Thus, agricultural cropping systems greatly influence the productivity and yield of crops. Minerals such as calcium and magnesium concentrations were observed higher in organic and low input soil system but soilless growing system produced fruits with higher firmness in the green stage which is related to higher flesh thickness of fruits (Flores *et al.,* 2009). Research results also showed that choice of soilless culture substrate affect the quality of strawberry and desirable fruit production (Ameri *et al.,* 2012).

Table 4. Effect of growing substrates on the fruit quality of strawberry under soilless culture

Coco-dust: Gravel	Total soluble solids (%)	Citric acidity (%)	Ascorbic acid (ppm)
100:0	5.31	0.22	23.41 bc[z]
75:25	5.04	0.28	20.65 c
50:50	5.62	0.21	39.60 a
25:75	5.49	0.21	30.60 b
0:100	5.32	0.23	27.92 b
Sig. level	ns	ns	*

[z]Means within column followed by different letters are significant according to the LSD test at $P < 0.05$.

* = significant at 5% level of significance; ns = not significant

Conclusion

The present results revealed that the growth, yield and fruit qualities of strawberry were significantly higher in plants grown in T3 (50:50 of coco-dust and gravel substrate). Therefore, use of coco-dust with its 50% mixture with gravel had significant influence on the production strawberry in soilless culture. Further research is recommended in finding suitable coco-dust based soilless substrates for growing strawberry in Bangladesh.

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