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Effect of coco-dust growing media on the yield and quality of strawberry in soilless culture

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ABSTRACT

Strawberry plants were cultured in three different growing media to compare their influence under glasshouse condition at hydroponic facility of Olericulture division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during winter season of 2014-15. The experimental design was completely randomized block design with 20 replicated plant/pots. There were three types of soilless culture substrates such as solution culture in the tray, coco-dust substrate and coco-dust + sand substrate (60:40) in 12 L plastic container. The concentration of nutrient solution was 1.5 dS/m and pH was maintained at 6.5. Considering dry matter production, leaves dry matter was not affected but root dry matter was much greater (178% and 83% compared to coco-dust and coco-dust + sand, respectively) in solution culture. Fruit weight per plant was higher in solution culture (178% and 137% greater than coco-dust and coco-dust + sand culture, respectively) compared to either of the coco-dust based substrates. The yield was consistently contributed by number of fruits/plant and average fruit weight. The qualities of strawberry fruits except total soluble solids were not differed significantly in all growing condition. In general plant grown in solution culture performed better than plants grown in coco-dust and coco-dust +sand substrate. This study indicates that sole coco-dust or its mixture with sand would not be comparable with solution culture in producing strawberry under soilless hydroponics.

Introduction

Strawberry (*Fragaria × anannasa* Duch.) is the most popular fruits in the world. It is a good natural source of bioactive compounds, such as vitamin C, folate, and phenolic acids (Proteggente et al., 2002; Scalzo et al., 2005). Strawberry seeds contain high amount of unsaturated essential fatty acids providing health benefits. Beside mineral nutrients strawberry reported to contain a variety of non-nutritive compounds such as polyphenolic phytochemicals (Francesca et al., 2012). Moreover, strawberry has economical and commercial importance in processing products, such as jams, juices, and jellies. Because of its good taste, scent and high vitamin content, strawberry is well known throughout the world and is common fruit in diets (Tabatabaei et al., 2006). Therefore, development of improved culture technique is of great importance to the strawberry growers.

Soil culture of strawberry is limited to the infestation of soil borne insect pests. Successful production of strawberry in soil medium requires heavy use of methyl bromide, excessive application of chemical fertilizers, and insecticides resulting higher cost of production. Moreover, in soil culture delicate strawberry fruit easily get damage/ rotten in contact of soil, which is absent in soilless culture. It is one of the major crops grown in hydroponic culture. In temperate regions such as North and Central Europe, Korea, Japan and some areas of China strawberry mainly cultivated under hydroponic culture in greenhouse (Cantliffe et al., 2007). Protected cultures under greenhouse condition reported to results in higher production through effective plant protection and thus reduce the usages of chemicals which could be a benefit for fruit quality (Dinar, 2003).

Soilless cultivation provides ideal condition of root growing environment through the supply of adequate moisture, mineral nutrients, and proper aeration. The use of different organic and inorganic substrates allows the plant better nutrient uptake, sufficient growth and development for water and oxygen holding optimization (Verdonck et al., 1982; Albaho et al., 2009). In strawberry better growth has been reported in coir than that in perlite substrate (Lopez-Madina et al., 2008). In another study, the influence of different substrates on the growth of strawberry was reported as peat, finpeat or finpeat + perlite in Camaros and Fern cultivars (Ercisli et al., 2005). Jafarnia et al. (2010) reported total soluble solid were influenced by substrate and cultivars and other fruit qualities such as vitamin C and titratable acidity were highest in rice husk substrate. Caso et al. (2009) used rice husks and pumice with different ratios in column system for the production of strawberry and they recommended that 100% rice husks substrate influence majority of measured traits. From research results it is evident that soilless culture substrate affect the quality of strawberry and desirable fruit production is greatly depends on suitable choice of substrate and cultivars (Ameri et al., 2012). They found that highest total anthocyanin content and titratable acidity in Camarosa cultivar in vermiculite + perlite + coco-peat; the highest antioxidant in Camarosa and Mrak cultivars in substrate of Sycamore pruning waste and coco-peat + perlite; and the highest total soluble solids in Selva cultivar in vermiculite + perlite + coco-peat substrate. 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. It has been reported similar (Chellemi & Rosskopf, 2004) or even higher (Curuk et al., 2004) yield for organic corps than conventional soil cultivation. 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).

In Bangladesh, coco-dust is considered as most easily available, cheap, and indigenous soilless substrate for growing several crops. The coconut industries in the southern districts produce coco-dust as byproduct. Therefore, use of these unutilized coconut substrate in the soilless culture would be highly beneficial for maintaining environmental balance, and in turn use for plant cultivation. On the other hand, sand is sterile inorganic material also has the potentiality of use in soilless cultivation. It is possibly most abundant substrate could be investigated for growing crops in hydroponics. Therefore, the present study was under taken to find out the influence of nutrient solution, coco-dust, and coco-dust + sand culture on the growth, yield and fruit quality of strawberry in hydroponics.

Materials and Methods

Plant materials

Strawberry (*Fragaria × annasa* cv. BARI Strawberry 1) was used for this experiment. The plantlets were collected from Pomology division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. Strawberry plantlets with five to seven leaves stage were collected, washed several times with tap water and transplanted to the hydroponic culture tray and plastic pots filled with coco-dust and its sand mixture substrate.

Nutrient solution preparation

Coopers solution was used as nutrient solution for strawberry plant cultivation (Table 1, Cooper, 1988). At first calcium nitrate and EDTA iron was dissolved in 10 liters of water and was labeled them as Nutrient Solution- A and the rest of the nutrient in another 10 liters of water was labeled as Nutrient Solution- B. These are called stock solutions. When feeding this solution to the plants, solution A and B was diluted 100 times in equal volumes. First, solution A was added in tank and stirred well and next solution B was added. The exact volume to be added will depend on the final volume of nutrient solution required for the hydroponics system. The pH of all nutrient solution was adjusted to 6.5 and the EC was maintained at 1.5 mS/m throughout the growing period of strawberry.

Cultivation procedure

The experiment was carried out at the glasshouse of hydroponic section of Olericulture division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during winter season of 2014-15. The experimental design was completely randomized block design with 20 replicated plant/pots. There were three types of soilless culture substrates such as solution culture in the tray, coco-dust substrate and coco-dust + sand substrate in 12 L plastic container. Healthy, disease free and cleaned plantlets were planted in cork sheet solution culture using urethane foam block as support. The concentration of nutrient solution in the tray was 1.5 dS/m with a pH of 6.5. On the other hand, for coco-dust and coco-dust:sand (60%:40%) plantlets were directly planted in the substrate making little hole on it. Before planting the substrates were washed several times with tap water. Fresh stock solution was added to the tray nutrient solution culture by examining EC value through EC meter. While plant grown in coco-dust based substrate cultures were supplied daily with 500 ml of nutrient solution to throughout the growing period.

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 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 and added 2 drops of phenolphthalein then adjusted the pH to 8.2 using 0.1 N (w/v) NaOH. The quantity of NaOH (ml), 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).

Statistical analysis

Data collected on growth characteristics, fruit yield measurement and fruit qualities were subjected to analysis of variance, and treatment means were compared by Duncan's Multiple Range Test at P = 0.05. All the data analysis was performed using the MSTAT-C program (ver. 7, Michigan State University, East Lansing, MI; Gomez & Gomez, 1984).

Table 1. Amount of chemicals required for preparation of 1000 liters of nutrient solution

Nutrient/ chemicals	Chemical formula	Amount (g)
Potassium hydrogen phosphate	KH_2PO_4	270
Potassium nitrate	KNO_3	580
Calcium nitrate	$Ca(NO_3)_2.\ 4H_2O$	1000
Magnesium sulphate	$MgSO_4.\ 7H_2O$	510
EDTA iron	EDTA-Fe	80
Manganese sulphate	$MnSO_4.\ 4H_2O$	6.10
Boric acid	H_3BO_3	1.80
Copper sulphate	$CuSO_4.\ 5H_2O$	0.40
Ammonium molybdate	$(NH_4)_6Mo_7O_{24}.\ 4H_2O$	0.38
Zinc sulphate	$ZnSO_4.\ 7H_2O$	0.44

Results and Discussion

Effect of growing substrate on the growth of strawberry plants

Strawberry plant grown in three different substrates showed significant influence on several growth characters (Table 2). Plants grown in solution culture produces maximum number of leaves compared to substrate culture, although the variation is not significant to plants grown in coco-dust. Leaf size was also varied in plants grown in three growing conditions. Maximum leaf length was found higher in coco-dust based substrate culture compared to solution culture while leaf width was not varied significantly. Plant root length also not differed among the growing media. Considering dry matter production, leaves dry matter was not affected but root dry matter was much greater (178% and 83% compared to coco-dust and coco-dust + sand, respectively) in solution culture. The large volume of root biomass production was due to the luxurious absorption of mineral nutrient by strawberry plant in solution culture. While similar trend in crown dry matter production was evident. Crown diameter was not varied in plants grown in the test substrates/solution.

Table 2. Effect of growing substrates on the growth parameters of strawberry plants grown under soilless culture

Growing media	No. of leaves	Max. leaf length (cm)	Max. leaf width (cm)	Root length (cm)	Leaves DM (g)	Root DM (g)	Crown DM (g)	Crown dia. (mm)
Solution	18.5 a^z	18.3 b	12.9 a	18.9 a	7.30 a	3.67 a	2.20 a	20.7 a
Coco-dust	12.7 ab	20.7 ab	11.7 a	22.7 a	5.03 a	1.32 b	0.93 b	20.3 a
Coco-dust + Sand	11.2 b	21.7 a	13.5 a	22.0 a	7.13 a	1.99 b	1.28 b	22.3 a
Sig. level	**	**	NS	NS	NS	**	**	NS

^{z}Means within column followed by same letters are non-significant according to the Tukey's multiple range test at $P < 0.05$, ns: non-significant, **Significant at $P < 0.001$.

Effect of growing substrate on the yield attributes and yields of strawberry

Anthesis and fruit yield of strawberry plant significantly affected by the growing substrate under soilless culture (Table 3). Plants grown in solution culture produce flowers about 30 days earlier than plants grown in coco-dust and coco-dust + sand culture. Fruit weight per plant was much greater in solution culture (178% and 137% greater than coco-dust and coco-dust + sand culture, respectively) compared to either of the coco-dust based substrates. The yield was consistently contributed by number of fruits/ plant and average fruit weight. Number of strawberry fruits was higher in solution culture than coco-dust culture however, not differed significantly than that of coco-dust + sand culture. Larger fruit was also harvested from solution culture than substrate culture (about 5.0-5.5 g greater).

Effect of growing substrate on the fruit qualities of strawberry

The qualities of strawberry fruits except total soluble solids were not differed significantly in all growing media (Table 4). The soluble solid content slightly higher in fruits harvested from solution culture compared to coco-dust + sand substrate culture which was followed by coco-dust culture plants. Other qualities like titratable acidity and ascorbic acid content was found unaffected by the growing substrates for strawberry.

Table 3. Effect of growing substrates on the yield of strawberry plants under soilless culture

Growing media	Anthesis	No. fruits/ plant	Average fruit weight (g)	Fruit weight/ plant (g)
Solution	50.1 b^z	7.4 a	14.3 a	99.01 a
Coco-dust	79.5 a	4.2 b	8.7 b	35.62 b
Coco-dust + Sand	78.7 a	4.9 ab	9.4 b	41.81 b
Sig. level	**	**	**	**

^{z}Means within column followed by same letters are non-significant according to the Tukey's multiple range test at $P < 0.05$, ns: non-significant, **Significant at $P < 0.001$.

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

Growing media	Total soluble solids (%)	Citric acidity (%)	Ascorbic acid (ppm)
Solution	5.7 a[z]	0. 44 a	725.0 a
Coco-dust	4.9 ab	0. 44 a	741.3 a
Coco-dust + Sand	4.0 b	0. 43 a	603.8 a
Sig. level	**	ns	ns

[z]Means within column followed by same letters are non-significant according to the Tukey's multiple range test at P < 0.05, ns: non-significant, **Significant at P <0.001.

Conclusion

Soil culture of strawberry has limited by the heavy use of methyl bromide to control soil borne pathogens. Thus soilless cultures have been introduced as an alternative cultivation system to traditional to avoid soil related problems such as soil exhaustion, soil-borne diseases, secondary salinity development and to improve plant growth condition such as temperature and aeration of root zone and optimal distribution of water and nutrients. Thus we cultured strawberry in an easily available, inexpensive coco-dust substrate and compared its performance over plants gown in solution culture. The major finding reveal that growth, yield and yield attributes and also fruit qualities were significantly higher in plants grown in solution culture compared to coco-dust substrate culture. Therefore, sole coco-dust or its mixture with sand would not be comparable with solution culture in producing strawberry under soilless hydroponics. Research effort will be given to find out suitable organic and inorganic substrates and their mixtures ratios for producing higher yield and quality of strawberry.

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