Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 2406-2412
Received: 12-07-2017
Accepted: 14-08-2017

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Effect of substrate mixtures on precocity and flower development in strawberry potted plants

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Abstract
The current study was done for evaluation the effect of substrate mixtures and pots on precocity and reproductive growth of strawberry cv. Sweet Charlie in soil and soilless culture system. Results showed that the earliest flowering (77.47 days and 79.60 days) after transplanting was observed in S_2 (cocopeat + perlite + vermicompost, 3:1:1), whereas, maximum days for first flowering was observed in S_4 (95.87 days and 98.53 days) during 2013-14 and 2014-15, respectively. The significant increase in the number of primary (8.77 and 9.73) and secondary (16.21 and 17.76) flowers were recorded from S_2 and S_1, except number of secondary flowers in 2014-15. The total number of flowers also increased (28.67 and 33.93) significantly, when plants were grown in S_2 than other treatments. The size of primary and secondary flower also increased with all soilless substrate combinations as compared to control. The maximum size of primary flower (33.73 mm and 35.86 mm) was recorded in S_2, which was statistically at par with S_1 during both the years of study, whereas, the size of secondary flowers increased (29.80 mm and 30.97) significantly in S_2 than other treatments. The plants grown in earthen pots produced earliest flowering (78.97 days and 79.53 days), maximum number of primary (7.86 and 8.70), secondary (14.53 and 15.83) and total flowers (25.46 and 28.29). In future, these experimental results will prove very useful to find out most suitable substrate combination and pot for reproductive growth of strawberry.

Keywords: flowering, precocity, primary and secondary flowers, substrate mixtures, sweet charlie

Introduction
Cultivated strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious, refreshing and soft fruit of the world. It is one of the major export crops, because of its taste, scent and high vitamin content, strawberry is well known all over the world and is a common fruit in food diets. Strawberry is generally grown in soil worldwide. It is a sensitive plant and a number of organisms affect almost all parts including roots, crown, leaves and fruits. The greenhouse production of strawberry has the advantage of increased yield per unit area, early production when market prices are high, relatively easier pest management with reduced use of chemicals, as well as better fruit quality (Cantliffe *et al.*, 2007) [7]. To eliminate the soil borne diseases and pest the use of artificial media is gaining popularity and number of soilless substrate/ media can be used to substitute the soil (De-Rijck & Schrevens, 1998) [8]. Suitable mixtures of substrate in soilless culture within greenhouse systems prolong harvesting duration of strawberry production and increase in yield (Jafarnia *et al.*, 2010) [11]. Material properties of substrate display direct and indirect effects on plant physiology and production (Cantliffe *et al.*, 2001) [6]. The use of different organic and inorganic substrates allows the plants to have better nutrient uptake, sufficient growth and development to optimize water and oxygen holding (Albaho *et al.*, 2009; Ameri *et al.*, 2012) [1,2]. Application of organic materials as substrates for hydroponic culture media was reported by Hesami *et al.*, (2012) [9]. The appropriate proportion of the substrate in strawberry not only increases the yield potential but also improves the quality of the fruits by accurate control over the supply of water, nutrients, aeration, root temperature and pH (Olympios, 1993 [18]; Jensen, 1999 [12]).
The size and type of the pot is important for the sufficient root development, which results in a significant influence on growth, canopy, yield and quality indicators in different crops (Manole *et al.*, 2008 [16]; Krezel & Kolota, 2009 [14]). A number of pots are available in the market of the different size and type for different crops. Strawberry has large number of roots but the more than 90% of the roots are confined to the 20-30 cm depth (Mann, 1930 [15]). The use of artificial media may further reduce the depth of roots as the plant can meet the requirement easily due to appropriate air water relation and nutrient holding capacity. Keeping in view the above points, an attempt was made to determine the effect of different substrate combination and pots on flowering in strawberry (*Fragaria* × *ananassa* Duch.) cv. Sweet Charlie.

Materials and Methods

Experimental site and material

The experiment was conducted at Hi-tech greenhouse of Department of Horticulture, CCS Haryana Agricultural University during 2013-14 and 2014-15 growing season. Three substrates cocopeat, perlite and vermicompost were used to create the different treatments in different proportion (by volume) for plant propagation (Table 1).

Table 1: Combination and ratio of different substrates used in experiment

S. No.	Substrate code	Substrate used	Ratio
1.	S_1	cocopeat + perlite + vermicompost	(2:1:1)
2.	S_2	cocopeat + perlite + vermicompost	(3:1:1)
3.	S_3	cocopeat + perlite + vermicompost	(4:0:1)
4.	S_4	cocopeat + perlite + vermicompost	(4:1:0)
5.	S_5	cocopeat + perlite + vermicompost	(4:1:1)
6.	S_6	cocopeat + perlite + vermicompost	(4:1:2)
7.	S_7 (control)	Soil	-

The plants of strawberry cultivar 'Sweet Charlie' were planted under natural light condition during the first week of October after treating with Carbendazim and monocrotophos. Holes were made at the bottom of each container to allow the drainage the excess water. The greenhouse with facility of controlling temperature, humidity and light with automation system for irrigation and fertigation was used. The transplanted plants were kept under uniform condition in poly-house during the study period where all the management practices were carried out as per the package of practices. The pH for this experiment maintained from 6.0 - 6.5 to facilitate the maximum uptake of elements. The Electrical Conductivity (EC) for soilless growing strawberry is maintained below 1.5 mS cm^{-1} for better growth, yield and good quality fruits. The standard and uniform fertilizer solution was used for whole course of investigation. The vegetative formulation used from plant establishment until fruit set on the first truss then a fruiting formulation introduced. The fertigation system was open drip irrigation with no circulation, using 2 liter/ hour capacity inline lateral drippers installed on each pot. The experiment was laid out in a completely randomized design with five replications and forty two combinations.

Containers: Polyethylene Bags, PVC Pots and Earthen Pots

Polyethylene Bags (C_1) : CS_1) 16 × 16 cm
: CS_2) 20 × 20 cm
PVC Pots (C_2) : CS_1) 15 × 15 cm
: CS_2) 25 × 25 cm
Earthen Pots (C_3) : CS_1) 15 × 15 cm
: CS_2) 25 × 25 cm

Methodology and observations recorded

The number of days taken to flowering from the date of planting was calculated and the mean days required to first flower was worked out (Kidmose *et al.*, 1996) [13]. Primary and secondary flowers are produced on a modified stem, which is calculated by counting the primary and secondary flowers, each treatment from each plant was recorded and average number of flowers per plant was worked out. The total number of flowers was recorded by counting the all primary, secondary and tertiary flowers in each sampling plant and their average was taken. The size of primary and secondary flowers was measured at full bloom stage (flower petals at their widest point using scale) and their average was calculated in mm.

Statistical Analysis

The data were analyzed according to the procedure for analysis of completely randomized design (CRD) as given by Panse and Sukhtme (1984) [19]. The overall significance of difference among the treatments was tested, using critical differences (C.D.) at 5% level of significance. The results were statistically analyzed with the help of a windows based computer package OPSTAT (Sheoran, 2004) [24].

Results and Discussion

Days taken to initiate first flower exhibited significant difference due to different combinations of substrates and containers. The interactions between substrate and container were found significant, whereas, the container and their size with all the three factors of the variation were non-significant (Table 2). The results showed that substrates combination two (S_2) took minimum days (77.47 days and 79.60 days) to appear first flower, which was statistically at par with S_1 (78.63 days and 82.33 days) and the first flower was late in S_4 (95.87 days and 98.53 days) followed by S_7 (91.97 days and 94.07 days) in both seasons, respectively. The plants grown in C_3 took less days to initiate first flower (78.97 days and 79.53 days) followed by C_2 (83.46 days and 88.96 days) and maximum were taken in C_1 (88.84 days and 98.64 days). The container size had non-significant effect on days to bear first flower in all three types of pots. Data suggested that the strawberry plants grown in earthen pots with S_2 took minimum days to bear first flower (72.80 days and 71.50 days) and were found earliest among all the treatment combinations, except S_1C_3 (74.20 days), S_6C_3 (74.80 days) and S_5C_3 (75.40 days) during 2013-14 and S_1C_3 (76.10 days) during 2014-15.

Significant difference in number of primary flowers per plant was observed due to combinations of substrates and containers (Table 3). The data also showed significant interactions between substrate and container, whereas, all the three factors of the variation tried were absent. The interactive effect of container and their size was non-significant during 2013-14 and significant during 2014-15. An examination of data presented in this Table (3) indicated the maximum number of primary flowers (8.77 and 9.73) was observed in substrate combination two (S_2), which was statistically at par with S_1 (8.58 and 9.39) and the minimum number of primary flowers per plant was observed from S_7 (5.52 and 5.21) in both the growing seasons, respectively. The strawberry plants grown in earthen pots produced maximum number of primary flowers (7.86 and 8.70) per plant followed by C_2 (7.47 and 7.90), while C_3 (7.03 and 7.02) induced minimum number of primary flowers per plant. Thus, it could be inferred that the strawberry plants grown in earthen pots with S_2 induced maximum number of primary flowers (9.19 and 10.39) per plant except the S_1C_3 combination (9.12 and 10.25). During 2014-15, the CS_2 of earthen pot gave highest primary flowers (9.59) per plant and found to be best among all the treatments.

The number of secondary flowers per plant differed significantly due to different combinations of substrate and containers. The two way interactions between substrate and container, container and container and container size were found significant, while three factors interaction was not present during both the years of study (Table 4). The all substrate combinations significantly increased the number of secondary flowers per plant as compared to control. A perusal of data presented in the Table 4 indicated that the maximum number of secondary flowers (16.21 and 17.76) was observed from S_2 except S_1 (15.90) in 2013-14. The minimum secondary flowers per plant were found in soil (10.21 and 9.49) followed by S_4 (12.22 and 12.11). The plants grown in earthen pots (C_3) produced highest number of secondary flowers (14.53 and 15.83) per plant followed by C_2 (13.83 and 14.38) and lowest was produced by C_1 (13.01 and 12.79). Thus, C_3 with S_1 produced maximum number of secondary flowers (16.94 and 18.94) and was best among all the treatments except C_3S_1 (16.88 and 18.65) combination in both seasons. During 2013-14, the highest number of secondary flowers (15.69 and 17.44) per plant was observed from CS_2 of C_3 than all other combinations. The trend was similar during the second year of experiment.

The difference in total number of flowers per plant due to different combinations of substrate and containers was found significant. The interactions between substrate and container and container and their size were present, whereas, the interactions all three factors of the variation were non-significant (Table 5). The data on total number of flowers produced per plant presented in Table 5 showed that among the different substrate combinations assessed, the combination S_2 produced highest total number of flowers (28.67 and 33.93) per plant followed by S_1 (27.37 and 30.57) and the lowest flowers (16.73 and 16.53) per plant were observed in S_7 (soil). Among different containers used, the C_3 produced maximum total number of flowers (25.46 and 28.29) followed by C_2 (24.46 and 26.03) and lowest (23.20 and 24.19 were recorded from polyethylene bags (C_1). It can be observed that the strawberry plant grown with S_2 in C_3 produced highest total number of flowers (30.00 and 34.70) per plant and was found to be best among all the treatments, except S_2C_2 (28.90) during 2013-14 and S_2C_2 (30.34) and S_2C_1 (32.80) during 2014-15. The CS_2 of earthen pot gave highest total number of flowers (27.51 and 30.69) per plant during 2013-14 and 2014-15, respectively.

Significant difference in size of the primary flowers due to combinations of substrate and containers were observed (Table 6). The pair-wise interactions between substrate and container were found significant, while the other two and three way interactions between the treatments were absent. The data given in Table 6 showed that among the different substrate combinations tried, the S_2 produced largest primary flower (33.73 mm and 35.86 mm), which was statistically at par with S_1 (33.07 mm and 35.56 mm) and the smallest primary flower (31.21 mm and 31.32 mm) was observed in S_7 (control) during 2013-14 and 2014-15, respectively. The plants were grown in PVC pots gave maximum size of primary flower (33.22 mm and 35.25 mm) followed by earthen pots (32.24 mm and 34.23 mm), whereas, minimum size (31.41 mm and 33.18 mm) of primary flower was observed from polyethylene bags. During 2013-14, the plants grown in PVC pots with S_2 combination produced largest primary flower (34.88 mm), which was statistically at par with S_1C_2 (34.25 mm), S_2C_3 (33.53 mm) and S_6C_2 (33.51 mm). The trend was similar during 2014-15.

The size of secondary flowers differed significantly due to combinations of substrates and the type of containers used (Table 7). The interactions between substrate combinations and container were found significant, while, other two and three factor interactions were absent during both the years of study. Amongst the different substrate combinations used, the S_2 (3:1:1, cocopeat + perlite + vermicompost) resulted maximum size (29.80 mm and 30.97 mm) of secondary flower followed by S_6 (28.70 mm and 30.14 mm) and minimum (27.03 mm and 28.30 mm) flower size was found in control. Among containers used, the PVC pots gave largest (28.81 mm and 30.07 mm) secondary flower followed by C_3 (28.06 mm and 29.41 mm) and the smallest flowers were observed in C_1 (27.40 mm and 28.92 mm). Conclusively, the strawberry plants grown in C_2 with combination of S_2 produced large sized secondary flower (30.90 mm and 31.43 mm) and was found superior amongst all the treatment combinations investigated, except S_2C_3 (29.76 mm) and S_6C_2 (29.53 mm) during 2013-14 and S_2C_3 (31.08 mm), S_6C_2 (30.53 mm) and S_2C_1 (30.41 mm) during 2014-15.

In the present studies the combinations of substrate along with control exhibited significant effect on precocity and flower development in strawberry. Among the different combinations, the S_2 has perhaps created the most appropriate condition for the flowering of the plant in strawberry. The better results for flowering in artificial media compare to the soil may have resulted due to the improvement in root zone environment. Nourizadeh (2003) [17] has also reported the increased the number of flowers in plants due to suitable conditions in soilless substrate by ventilation and water maintenance. Physiochemical properties of the growing media pose their effect on the plant growth and flowering (Wilkerson, 2002) [25], the composition of growth media is very important factor to be taken under consideration (Ingram, 2003) [10]. Arancon *et al.* (2004) [3] reported that the organic matter (vermicompost) applications increased strawberry flowers by 40%. According to Ayesha *et al.* (2011) [4] coconut coir and compost based growing media can significantly improve the flowers size of strawberry and similar results were reported by Riaz *et al.* (2008) [22] in zinnia.

In present study, earliest flowering, number of primary, secondary and total flowers were reported from earthen pots, whereas, maximum size of primary and secondary flower found in PVC pots. This might be due to the cooling effect and better gas diffusion provided by the earthen pots, resulting in better flowering than other growing containers. The results of present study are in line with the findings of Pawar *et al.* (2005) [20], who also reported better flowering in earthen pots in chrysanthemum. Similar results in hybrids of wild passion fruit were observed by Santos *et al.* (2012) [23]. The variation in reproductive growth in strawberry with respect to container size was non-significant. However, in interaction between type of container and container size was found significant for number of primary, secondary and total flowers per plant. The strawberry plants grown in earthen pots in combination of CS_2 produced maximum number of primary flowers during 2014-15 and also highest number of secondary and total flowers per plant during both the years. The similarity in the reproductive growth in different containers may be due of the flowering behavior is dependent on the environmental conditions. The results of present study are in agreement with previous studies of Phala *et al.* (2012) [21] in strawberry, who also reported non-significant difference in the number of inflorescence due to size of substrate bags. However, in interaction studies, size of container caused

significant difference in reproductive growth in present investigation. This might be due to container size, plant size and temperature condition, which can affect early flowering and ultimately yield (Bish *et al.*, 2003) [5].

Table 2: Effect of different substrate combinations, containers and their size on days to first flowering in strawberry cv. Sweet Charlie

Substrates/ media	Containers (C)									Overall mean
	2013-2014									
	Polyethylene Bags (C_1)			PVC Pots (C_2)			Earthen Pots (C_3)			
	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean	
S_1	81.60	84.20	82.90	77.60	80.00	78.80	72.40	76.00	74.20	78.63
S_2	79.20	83.60	81.40	77.40	79.00	78.20	70.80	74.80	72.80	77.47
S_3	84.20	90.60	87.40	80.60	82.40	81.50	76.80	78.80	77.80	82.23
S_4	101.20	104.60	102.90	92.00	94.80	93.40	90.80	91.80	91.30	95.87
S_5	83.80	89.40	86.60	78.80	81.20	80.00	73.80	77.00	75.40	80.67
S_6	83.60	85.00	84.30	78.20	80.40	79.30	72.80	76.80	74.80	79.47
S_7 (Control)	96.40	96.40	96.40	92.00	94.00	93.00	86.20	86.80	86.50	91.97
Mean	87.14	90.54	88.84	82.37	84.54	83.46	77.66	80.29	78.97	83.76
CD (P = 0.05)	Substrate = 2.39; Container = 1.57; Container size = N.S.; Substrate × Container = 4.14									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	84.80	91.20	88.00	81.60	84.20	82.90	71.20	81.00	76.10	82.33
S_2	82.80	88.80	85.80	80.80	82.20	81.50	70.40	72.60	71.50	79.60
S_3	99.60	106.40	103.00	89.20	95.40	92.30	76.80	84.80	80.80	92.03
S_4	106.40	114.20	110.30	93.00	98.80	95.90	88.20	90.60	89.40	98.53
S_5	99.20	100.80	100.00	86.40	90.60	88.50	75.40	81.60	78.50	89.00
S_6	94.00	100.40	97.20	86.20	89.40	87.80	75.00	81.40	78.20	87.73
S_7 (Control)	105.20	107.20	106.20	91.80	95.80	93.80	76.80	87.60	82.20	94.07
Mean	96.00	101.29	98.64	87.00	90.91	88.96	76.26	82.80	79.53	89.04
CD (P = 0.05)	Substrate = 3.05; Container = 2.00; Container size = N.S.; Substrate × Container = 5.29									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									

* S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Table 3: Effect of different substrate combinations, containers and their size on number of primary flowers per plant in strawberry cv. Sweet Charlie

Substrates/ media	Containers (C)									Overall mean
	2013-2014									
	Polyethylene Bags (C_1)			PVC Pots (C_2)			Earthen Pots (C_3)			
	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean	
S_1	7.65	8.49	8.07	7.93	9.19	8.56	8.49	9.75	9.12	8.58
S_2	8.07	8.70	8.39	8.21	9.26	8.74	8.56	9.82	9.19	8.77
S_3	6.32	7.23	6.77	6.46	7.51	6.98	6.88	7.86	7.37	7.04
S_4	5.69	6.81	6.25	6.18	7.09	6.63	6.32	7.58	6.95	6.61
S_5	6.67	7.37	7.02	7.02	8.35	7.68	7.16	8.42	7.79	7.50
S_6	7.37	8.14	7.76	7.58	8.56	8.07	7.86	9.40	8.63	8.15
S_7 (Control)	4.35	5.54	4.95	5.19	6.11	5.65	5.40	6.53	5.96	5.52
Mean	6.59	7.47	7.03	6.94	8.01	7.47	7.24	8.48	7.86	7.45
CD (P = 0.05)	Substrate = 0.32; Container = 0.21; Container size = N.S.; Substrate × Container = 0.55									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	7.38	9.72	8.55	8.58	10.14	9.36	9.43	11.06	10.25	9.39
S_2	8.23	9.72	8.97	9.15	10.50	9.82	9.43	11.35	10.39	9.73
S_3	5.17	8.09	6.63	6.74	8.58	7.66	7.66	9.15	8.41	7.57
S_4	3.97	6.95	5.46	5.74	7.73	6.74	6.67	8.87	7.77	6.66
S_5	6.03	8.37	7.20	7.09	8.87	7.98	7.87	9.58	8.73	7.97
S_6	6.74	9.01	7.87	7.73	9.36	8.55	8.65	10.07	9.36	8.59
S_7 (Control)	3.41	5.46	4.43	4.12	6.31	5.21	4.96	7.02	5.99	5.21
Mean	5.85	8.19	7.02	7.02	8.78	7.90	7.81	9.59	8.70	7.87
CD (P = 0.05)	Substrate = 0.36; Container = 0.24; Container size = N.S.; Substrate × Container = 0.62									
	Container × Container size = 0.33; Substrate × Container × Container size = N.S.									

S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Table 4: Effect of different substrate combinations, containers and their size on number of secondary flowers per plant in strawberry cv. Sweet Charlie

Substrates/ media	Containers (C)									Overall mean
	2013-2014									
	Polyethylene Bags (C_1)			PVC Pots (C_2)			Earthen Pots (C_3)			
	CS_1	CS_2	Mean	CS_1	CS_2	Mean	CS_1	CS_2	Mean	
S_1	14.15	15.84	15.00	14.67	17.01	15.84	15.71	18.05	16.88	15.90
S_2	14.93	16.10	15.52	15.19	17.14	16.16	15.71	18.18	16.94	16.21

S_3	11.68	13.37	12.53	11.94	13.89	12.92	12.72	14.54	13.63	13.03
S_4	10.51	12.59	11.55	11.42	13.11	12.27	11.68	14.02	12.85	12.22
S_5	12.33	13.63	12.98	12.99	15.45	14.22	13.24	15.58	14.41	13.87
S_6	13.63	15.06	14.35	14.02	15.84	14.93	14.54	17.40	15.97	15.08
S_7 (Control)	8.05	10.26	9.16	9.61	11.29	10.45	10.00	12.07	11.04	10.21
Mean	12.18	13.84	13.01	12.84	14.82	13.83	13.37	15.69	14.53	13.79
CD (P = 0.05)	Substrate = 0.40; Container = 0.26; Container size = N.S.; Substrate × Container = 0.68									
	Container × Container size = 0.37; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	13.42	17.68	15.55	15.62	18.46	17.04	17.17	20.14	18.65	17.08
S_2	14.97	17.93	16.45	16.65	19.10	17.88	17.23	20.65	18.94	17.76
S_3	9.43	14.71	12.07	12.26	15.62	13.94	13.94	16.65	15.29	13.77
S_4	7.23	12.65	9.94	10.46	14.07	12.26	12.13	16.13	14.13	12.11
S_5	10.97	15.23	13.10	12.91	16.13	14.52	14.33	17.42	15.88	14.50
S_6	12.26	16.39	14.33	14.07	17.04	15.55	15.75	18.33	17.04	15.64
S_7 (Control)	6.19	9.94	8.07	7.48	11.49	9.49	9.036	12.78	10.91	9.49
Mean	10.64	14.93	12.79	12.78	15.99	14.38	14.22	17.44	15.83	14.33
CD (P = 0.05)	Substrate = 0.47; Container = 0.31; Container size = N.S.; Substrate × Container = 0.82									
	Container × Container size = 0.44; Substrate × Container × Container size = N.S.									

S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Table 5: Effect of different substrate combinations, containers and their size on total number of flowers per plant in strawberry cv. Sweet Charlie

Substrates/ media	**Containers (C)**									**Overall mean**
	2013-2014									
	Polyethylene Bags (C_1)			**PVC Pots (C_2)**			**Earthen Pots (C_3)**			
	CS_1	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	
S_1	25.80	27.40	26.60	26.20	28.20	27.20	26.20	30.40	28.30	27.37
S_2	26.20	28.00	27.10	27.20	30.60	28.90	27.40	32.60	30.00	28.67
S_3	20.80	24.80	22.80	21.00	25.80	23.40	22.80	27.20	25.00	23.73
S_4	19.20	22.20	20.70	20.20	23.80	22.00	21.20	25.20	23.20	21.97
S_5	23.00	25.20	24.10	24.20	26.60	25.40	24.40	27.20	25.80	25.10
S_6	24.60	27.40	26.00	25.80	28.20	27.00	26.00	30.20	28.10	27.03
S_7 (Control)	13.60	16.60	15.10	15.00	19.60	17.30	15.80	19.80	17.80	16.73
Mean	21.89	24.51	23.20	22.80	26.11	24.46	23.40	27.51	25.46	24.37
CD (P = 0.05)	Substrate = 0.88; Container = 0.58; Container size = N.S.; Substrate × Container = 1.53									
	Container × Container size = 0.82; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	24.00	33.60	28.80	28.20	33.80	31.00	29.60	34.20	31.90	30.57
S_2	31.20	34.40	32.80	33.00	35.60	34.30	33.20	36.20	34.70	33.93
S_3	18.60	28.00	23.30	21.80	28.80	25.30	25.60	30.00	27.80	25.47
S_4	16.40	20.20	18.30	18.80	24.20	21.50	20.20	28.20	24.20	21.33
S_5	20.80	28.80	24.80	22.40	30.20	26.30	26.20	31.00	28.60	26.57
S_6	22.40	30.60	26.50	25.20	31.60	28.40	29.40	33.40	31.40	28.77
S_7 (Control)	12.40	17.20	14.80	12.80	18.00	15.40	17.00	21.80	19.40	16.53
Mean	20.83	27.54	24.19	23.17	28.89	26.03	25.89	30.69	28.29	26.17
CD (P = 0.05)	Substrate = 1.10; Container = 0.72; Container size = N.S.; Substrate × Container = 1.91									
	Container × Container size = 1.02; Substrate × Container × Container size = N.S.									

S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Table 6: Effect of different substrate combinations, containers and their size on size of primary flowers (mm) in strawberry cv. Sweet Charlie

Substrates/ media	**Containers (C)**									**Overall mean**
	2013-2014									
	Polyethylene Bags (C_1)			**PVC Pots (C_2)**			**Earthen Pots (C_3)**			
	CS_1	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	
S_1	31.14	33.10	32.12	33.84	34.66	34.25	31.56	34.12	32.84	33.07
S_2	31.86	33.70	32.78	34.36	35.40	34.88	32.56	34.50	33.53	33.73
S_3	30.42	31.42	30.92	31.80	33.90	32.85	31.22	32.54	31.88	31.88
S_4	30.32	31.36	30.84	31.74	32.48	32.11	30.76	32.22	31.49	31.48
S_5	30.50	31.64	31.07	32.00	34.28	33.14	31.26	33.02	32.14	32.12
S_6	30.88	32.44	31.66	32.46	34.56	33.51	31.32	33.58	32.45	32.54
S_7 (Control)	29.66	31.32	30.49	31.60	32.00	31.80	30.74	31.92	31.33	31.21
Mean	30.68	32.14	31.41	32.54	33.90	33.22	31.35	33.13	32.24	32.29
CD (P = 0.05)	Substrate = 0.89; Container = 0.58; Container size = N.S.; Substrate × Container = 1.54									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	34.54	35.00	34.77	35.66	36.88	36.27	34.86	36.42	35.64	35.56
S_2	34.78	35.34	35.06	36.16	37.12	36.64	34.92	36.84	35.88	35.86

S_3	30.98	34.00	32.49	34.66	36.04	35.35	32.30	35.24	33.77	33.87
S_4	30.96	33.62	32.29	33.92	35.34	34.63	31.40	34.18	32.79	33.24
S_5	32.54	34.18	33.36	35.20	36.26	35.73	33.64	36.06	34.85	34.65
S_6	33.06	35.00	34.03	35.48	36.52	36.00	33.84	36.36	35.10	35.04
S_7 (Control)	29.46	31.08	30.27	31.80	32.42	32.11	30.82	32.36	31.59	31.32
Mean	32.33	34.03	33.18	34.70	35.80	35.25	33.11	35.35	34.23	34.22
CD (P = 0.05)	Substrate = 1.25; Container = 0.82; Container size = N.S.; Substrate × Container = 2.16									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									

S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Table 7: Effect of different substrate combinations, containers and their size on size of secondary flowers (mm) in strawberry cv. Sweet Charlie

Substrates/ media	**Containers (C)**									**Overall mean**
	2013-2014									
	Polyethylene Bags (C_1)			**PVC Pots (C_2)**			**Earthen Pots (C_3)**			
	CS_1	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	**CS_1**	**CS_2**	**Mean**	
S_1	27.00	28.36	27.68	28.38	29.26	28.82	27.86	28.62	28.24	28.25
S_2	28.12	29.34	28.73	30.60	31.20	30.90	28.62	30.90	29.76	29.80
S_3	26.32	27.66	26.99	27.90	28.66	28.28	27.12	27.94	27.53	27.60
S_4	25.80	27.54	26.67	27.62	27.98	27.80	26.98	27.90	27.44	27.30
S_5	26.68	27.92	27.30	28.02	29.18	28.60	27.40	28.42	27.91	27.94
S_6	27.62	28.66	28.14	28.68	30.38	29.53	28.14	28.74	28.44	28.70
S_7 (Control)	25.66	26.88	26.27	27.48	27.98	27.73	26.40	27.80	27.10	27.03
Mean	26.74	28.05	27.40	28.38	29.23	28.81	27.50	28.62	28.06	28.09
CD (P = 0.05)	Substrate = 0.80; Container = 0.52; Container size = N.S.; Substrate × Container = 1.39									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									
2014-2015										
S_1	28.94	29.26	29.10	29.92	30.52	30.22	28.98	30.38	29.68	29.67
S_2	30.14	30.68	30.41	30.98	31.88	31.43	30.68	31.48	31.08	30.97
S_3	28.48	28.82	28.65	29.28	30.14	29.71	28.62	29.32	28.97	29.11
S_4	27.72	28.80	28.26	29.16	29.74	29.45	28.02	29.16	28.59	28.77
S_5	28.62	29.08	28.85	29.46	30.48	29.97	28.66	29.68	29.17	29.33
S_6	29.74	29.86	29.80	30.24	30.82	30.53	29.78	30.40	30.09	30.14
S_7 (Control)	26.00	28.78	27.39	29.02	29.38	29.20	27.56	29.06	28.31	28.30
Mean	28.52	29.33	28.92	29.72	30.42	30.07	28.90	29.93	29.41	29.47
CD (P = 0.05)	Substrate = 0.66; Container = 0.43; Container size = N.S.; Substrate × Container = 1.15									
	Container × Container size = N.S.; Substrate × Container × Container size = N.S.									

S - Substrate; C - Container; CS - Container size; N.S. - Non-significant

Conclusion

All combinations of soilless substrates significantly improved the reproductive growth in strawberry compared to the soil and the substrate combination S_2 (cocopeat + perlite + vermicompost, 3:1:1) was found superior among all the treatments. Container size also had significant effect on flower development in strawberry. The earliest flowering was observed from the plants grown in earthen pots. The volume of artificial media also significantly affects the flower development in strawberry and large sized container produced higher number of flowers than smaller container in all three types of pots. However, further investigation is needed to deepen the knowledge about the mechanism of action exerted by the different growing media on strawberry.

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