The Pharma Innovation Journal 2018; 7(12): 449-453

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(12): 449-453

www.thepharmajournal.com
Received: 26-10-2018
Accepted: 27-11-2018

Wasim H Raja
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

KL Kumawat
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

OC Sharma
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

Anil Sharma
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

JI Mir
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

Sajad UN Nabi
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

Shiv lal
ICAR-National Research Centre for seed spices- Beawar Road, Ajmer, Rajasthan, India

Iqra Qureshi
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

Correspondence
Wasim H Raja
ICAR- Central institute of temperate horticulture, Old Air Field Rengreth, Srinagar Jammu and Kashmir, India

Effect of different substrates on growth and quality of Strawberry cv. chandler in soilless culture

Wasim H Raja, KL Kumawat, OC Sharma, Anil Sharma, JI Mir, Sajad UN Nabi, Shiv Lal and Iqra Qureshi

Abstract
Strawberry (*Fragaria* × *ananassa* Duch) is one of the most important widely consumed small fruit in the world. The cultivated fruit is popular for its bright color, aroma and texture, which contain a number of nutrients for good health. The future of soilless culture will depend on the development of new production systems and substrates that are competitive in costs and returns in comparison to conventional agriculture. In present study the individual/combination of three different substrates, viz., coco peat, vermiculite and perlite were employed while sand as control. Fifteen treatments singly/combinations with different concentrations (v/v) were studied for different growth and quality related parameters of strawberry cultivar (Chandler) under passively ventilated green house condition. The results revealed that the S_7 (coco peat + vermiculite 25:75) produced the maximum petiole length (16.77cm), canopy spread (42.75cm), crown diameter (2.10cm), shoot fresh wt. (17.16g), shoot dry weight (4.36g), root fresh weight (16.53g), root fry wt. (5.13g), number of leaves (17), total leaf area (1542cm^2), fruit wt.(10.76gm), fruit dia (27.48mm), fruit length (29.89mm) whereas the treatment S_{15} (Coco peat + Perlite + Vermiculite, 50:25:25) produced maximum plant height (28.36), shoot length (23.13), root length (32.40cm) and TSS (10.8 B°) and lowest acidity (0.86%) while as minimum plant height (15.10cm), no. of leaves (8) canopy spread (21.17cm), crown dia (1.50cm), root length (9.43cm), shoot fresh wt (5.60g), shoot dry wt (1.20g), root fresh wt (7.70g), root dry wt.(1.63g), leaf area (479.0cm') were recorded in control (sand). Hence form current study it is confirmed that coco peat in combination with vermiculite (25:75) and in combination with Perlite and vermiculite (50: 25:25) and produced maximum growth as well as good quality fruit in strawberry cv. Chandler.

Keywords: strawberry, Chandler, substrate, soilless, growth, quality

Introduction
Strawberry (*Fragaria* × *ananassa* Duch) is one of the most popular soft fruits cultivated in plains as well as in the hills up to an elevation of 3000 m in humid or dry regions **(**Singh *et al.*, 2008). In India it is being widely cultivated in Maharashtra, Punjab, Haryana, Himachal Pradesh, Jammu and Kashmir and hills of west Bengal with Maharashtra as the leading state in its production. Being bestowed with a wide range of agro climatic conditions, Jammu and Kashmir offers immense potentiality for growing strawberry. There are limitations when cultivating strawberries in the soil related to the prohibition of chemical fumigants for the control of phyto pathogens and to the ergonomic difficulties of cultivating the plants on the ground. (Godoi *et al.*, 2009) [11].

Strawberry being a shallow rooted plant needs effective nutrient management. The soil acts as a reservoir to retain nutrients and water, and also provides physical support for the root system. The increased demand for strawberries throughout the year can be met through soilless cultivation. Soilless culture is an artificial means of providing plants with support and a reservoir for nutrients and water. Characteristics of substrates include holding water and nutrient, providing good aeration to root system, light weight, free of pathogenic organisms and substances that are toxic to plants (Johnson *et al.*, 2010) [15]. The use of different organic and inorganic substrates allows the plants better nutrient uptake, sufficient growth and development to optimize water and oxygen holding (Verdonck *et al.*, 1982; Albaho *et al.*, 2009) [29, 1]. In temperate regions such as northern and central Europe, Korea, Japan, and some areas of China, strawberries are grown in greenhouses under soilless cultivation. In Holland, strawberries are grown in glasshouses, with climate and irrigation control, and CO_2 supply. In other countries, strawberries are grown in polyethylene-covered greenhouses, including micro or macro tunnels, using a variety of growing containers and soilless media.

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 (Dinar, 2003) [6].

When cultivation is carried out on raised platforms, the job is easier and labour efficient, the use of fumigant soil products is eliminated and there is a reduction in the occurrence of leaf diseases and consequently in the application of pesticides. Furthermore, there is an improvement in fruit quality, both sensory and from the point of view of chemical and microbiological contaminants (Empresa brasileira de pesquisa agropecuária, 2005). Hydroponic systems can be closed, when the nutrient solution that passes through the roots returns to the reservoir, or open where the applied solution does not return to the reservoir (Fernandes-Júnior *et al*., 2002) [10]. Currently the predominant systems are open systems with drainage-loss of the nutrient solution, and cultivation in pots or polybags using different substrates. However, due to economic and environmental issues, the trend is toward cultivation using a substrate in a closed system, with recirculation of the nutrient solution (Lieten *et al*., 2004) [17]. Coir is widely used as a substrate in the soilless cultivation of vegetables and flowers because of its physical and chemical characteristics, such as excellent porosity, lack of reaction to the nutrients from fertilization, long durability without alterations in its physical characteristics, the possibility of sterilisation and being an abundant and renewable raw material of low cost (Carrijo; Liz; Makishima, 2002) [5]. At present, alternative soilless cultivation production systems under protected conditions is an intense cultivation method that can provide more efficient use of water and fertilizers. In this system maximum yields are possible and this makes the system economically with farmer holdings small land holdings and expensive land areas. Using combination of different growing media is one of the mostly used substrate for production of hydroponic strawberries in developing countries Soilless culture under greenhouse conditions attracts scientific interest and increased in portions of the world where it has not been common practice. Soilless media has more advantage than free of weed seeds, have a lower risk of incidence of root pathogens, and facilitate optimal nutrition management of the crop. Further soilless production system plant production has been practiced for several millennia and it permits crops to be grown where no suitable soil exists or where the soil is contaminated in some manner. Keeping in view all these benefits the present work was carried to find out the to find out the most suitable substrate/combination for soilless strawberry production.

Materials and Methods

The present investigation was carried out in a passively ventilated greenhouse at the, Central Institute of Temperate Horticulture (CITH), Srinagar, Jammu and Kashmir (India). during 2016-17. The aim of this experiment was to determine the effects of substrates/combination on growth, and fruit quality of strawberry cv. Chandler. Chandler is a short day variety a very good Commercial cultivar, particularly in plasticulture. Three substrates cocopeat, perlite and vermiculite were used to create the different treatments in different proportion (by volume) for propagation (Table-1) while the sand was used as control**.** One year old healthy runners of selected variety chandler were collected from strawberry germplasm block of CITH, Srinagar and planted in poly bags during the Second week of October. Before planting were treated with Carbendazim (0.02%). The polybags of 1kg size and were kept on raised platforms. 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 during the entire experiment were maintained from 6.0 - 6.5 to facilitate the maximum uptake of nutrients. The Electrical Conductivity (EC) for soilless growing strawberry was maintained below 1.5 mS cm^{-1} for better growth, and better 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 and afterwards fruiting formulation were introduced. The fertigation system was open drip irrigation with no circulation, using 1 liter/ hour capacity inline lateral drippers installed on each polybags.

Methodology and observations recorded

Plant and leaf characteristics like plant height, petiole length, number of leaves and Total leaf area, crown diameter, shoot length, shoot and root fresh and dry weights were recorded at 200 days after planting. The height of the plant was measured individually with a measuring scale from the crown level to the apex of primary leaves and result expressed as average height in centimeters.

Petiole length of three randomly selected leaves per plant was measured with the help of scale and the average of which was expressed as average petiole length in centimeters. The plant spread was calculated by measuring the canopy of plant in East- West (E-W) and North- South (N-S) direction with the scale and the average of both was expressed as plant spread in centimetres. The diameter of crown of plant was measured with the help of Vernier Callipers and expressed in centimetres. The dry weights were recorded after drying the samples properly in oven at 80ºC.

The weight of the fruit, were measured by using Sartorius balance with accuracy of 0.001 g. The length and diameter of each quince genotype was measured by digital Vernier caliper. The fruit total soluble solids (TSS) were determined by using hand refractometer. Titratable acidity was determined by macerating 10 g of fruit sample in distilled water. The pulp was filtered through muslin cloth and made up to 10 ml with distilled water and 5 ml of filtrate was titrated against standard NaOH using phenolphthalein indicator. The value was expressed in terms of malic acid as per cent Titratable acidity (measured by a method as reported by The Association of Official Analytical Chemists (AOAC. 2012) [2].

Statistical analysis

The treatments were laid out in a Completely Randomized Design (CRD) with three replications and five plants per replicate. 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].

Table 1: Combination and ratio of different substrates.

Notation	Substrate	Proportion of substrate(Ratio) V/V
S_0	Sand	100
S_1	Coco peat	100
S_2	Perlite	100
S_3	Vermiculite	100
S_4	Coco peat : Perlite	25 :75
S_5	Coco peat : Perlite	50 :50
S_6	Coco peat :Perlite	75: 25
S_7	Coco peat : Vermiculite	25: 75
S_8	Coco peat : Vermiculite	50 :50
S_9	Coco peat : Vermiculite	75: 25
S_{10}	Perlite : Vermiculite	25 :75
S_{11}	Perlite : Vermiculite	50: 50
S_{12}	Perlite : Vermiculite	75: 25
S_{13}	Coco peat : Perlite: Vermiculite	25: 25:50
S_{14}	Coco peat : Perlite: Vermiculite	25: 50:25
S_{15}	Coco peat : Perlite: Vermiculite	50 : 25:25

Results and Discussion

The substrate combination S_{15} resulted maximum plant height ((28.36 cm), followed by S_{13} (27.90cm) and the lowest plant height (15.10 cm) were noted in control. Difference in the height of established plants because of substrate combinations and container were significant (Table 2). The number of leaves per plant differed significantly due to different substrate combinations, (Table 2). The number of leaves per plant increased significantly with the use of all media combinations compared to the sand. The maximum number of leaves were recorded in S_{15}(16), followed by S_7 (15), and minimum (8) were recorded in S_0 (control). Petiole length in strawberry plants was affected significantly due to the combinations of substrates. A perusal data given in Table-2 suggested that, the treatment S_7 shows maximum petiole length followed by S_{15} (15.84 cm) and the minimum petiole length ((9.57 cm) was observed in S_4. The maximum crown diameter was recorded in S_{13} (2.26 cm), followed by S_7 (2.10) and minimum was recorded in S_6 (1.20cm).

All substrates significantly increased the plant spread compared to the sand. The substrate combination S_7 gave highest canopy spread (42.75cm) followed by S_{11} (37.85cm) and the minimum (21.70cm) was observed in sand. The maximum total leaf area was recorded in S_8 (1542 cm^2), followed by S_7 (952 cm^2) and minimum was recorded in S_{11} (315 cm^2) the maximum shoot length was recorded in S_{13} (24.30 cm), followed by S_{14} (23.73cm) and minimum was recorded in S_5 (13.73 cm).

The maximum shoot fresh weight and dry weight was recorded in S_7 (17.16 g and 4.36 g), and minimum was recorded in S_0 (5.6 g and 1.20 g) respectively. Among the evaluated substrates the maximum root fresh weight and root dry weight was recorded in S_7 (16.53 g and 5.13g), followed by S_8 (15.13 g and 4.86) and minimum was recorded in S_0 (7.70 g and 1.63g) respectively.

From the data it can be concluded that, the maximum fruit weight was recorded in S_7 (10.76 g), followed by S_{15} (10.51 g) and minimum was recorded in S_3 (4.08 g) (Table-3). The maximum pedicle length (44.9 mm), of fruit was recorded in S_3 followed by S_{15} (40.4 mm) and minimum (15.5 mm) was recorded in S_0. The maximum fruit length (31.05 mm) and fruit dia (27.25mm) were recorded in S_{15} and minimum were recorded in S_2 (20.28mm) and S_{13} (18.50 mm) respectively. The maximum TSS was recorded in S_{15} (10.54 °B), followed by S_8 (10.05 ° B) and minimum was recorded in S_3 (5.60 °B). The maximum Acidity was recorded in S_3 (1.73 %), followed by S_{10} (1.56%) and minimum was recorded in S_8 (0.98 %).

Table 2: Effect of different substrates on growth of strawberry by different substrate/ combinations

Treatment	Plant Height (cm)	No. of Leaves	Petiole Length (cm)	Canopy Spread (cm)	Crown Dia (cm)	Shoot Length (cm)	Root Length (cm)	Shoot Fresh Weight (g)	Shoot Dry weight (g)	Root fresh Weight(g)	Root Dry Weight(g)	Leaf Area $(cm)^2$
S_0	15.10	8.33	11.43	21.17	1.50	13.80	9.43	5.60	1.20	7.70	1.63	479.0
S_1	21.33	13.33	12.60	29.73	1.80	17.44	12.40	9.30	1.90	8.53	2.80	612.0
S_2	18.06	12.00	10.40	25.33	1.83	17.06	10.96	7.40	1.53	13.26	4.86	569.0
S_3	22.50	10.3	13.17	28.23	1.83	21.10	24.76	15.16	3.90	13.63	3.13	568.0
S_4	17.50	9.00	9.57	28.53	1.73	16.00	12.96	8.16	1.80	10.46	2.16	469.0
S_5	16.00	9.33	8.80	19.50	1.70	13.73	18.93	8.46	1.71	13.16	2.86	468.0
S_6	20.16	11.33	12.24	29.40	1.20	18.33	20.83	8.56	1.75	12.43	3.00	540.0
S_7	26.33	15.00	16.77	42.75	2.10	20.16	25.70	17.16	4.36	16.53	5.13	952.0
S_8	25.06	17.33	15.60	37.37	1.56	20.63	31.26	14.56	3.83	15.13	3.16	1542.0
S_9	25.60	10.00	14.67	37.45	1.86	22.73	21.40	15.43	3.82	9.73	2.96	760.0
S_{10}	23.36	10.32	14.03	35.02	1.46	21.36	23.86	14.43	4.03	9.16	2.10	640.0
S_{11}	23.56	8.66	13.84	37.85	1.46	21.60	24.36	7.76	1.90	8.33	2.36	315.0
S_{12}	20.80	9.66	12.90	32.00	1.83	20.26	21.76	11.60	2.96	9.46	2.53	676.0
S_{13}	27.90	13.33	15.80	34.72	2.26	24.30	31.90	14.13	3.70	10.03	2.93	702.0
S_{14}	27.70	12.00	15.17	34.98	2.03	23.73	29.10	14.53	3.60	10.53	3.26	807.0
S_{15}	28.36	15.66	15.84	35.48	1.80	23.13	32.40	14.03	3.20	12.90	3.10	935.0
CD at 5%	3.518	2.890	8.714	6.147	0.412	4.479	7.468	5.839	1.449	6.029	2.36	258.0

Table 3: Effect of different substrates/ combinations on fruit characteristics

Treatment	Fruit Weight (g)	Pedicle Length(mm)	Fruit Length(mm)	Fruit Dia. (mm)	TSS	Acidity
S_0	6.41	15.5	23.07	22.67	6.70	1.40
S_1	6.74	18.9	27.77	25.34	8.52	1.13
S_2	6.64	17.4	20.28	19.55	7.55	1.33
S_3	4.08	44.9	24.67	21.15	5.60	1.73
S_4	6.32	22.7	25.66	21.38	7.90	1.53
S_5	6.84	23.6	27.17	24.51	6.33	1.30
S_6	8.85	31.3	29.08	25.70	7.70	1.20
S_7	10.76	33.0	29.89	26.48	8.26	1.13
S_8	8.83	33.5	27.71	26.52	10.05	0.98
S_9	6.02	28.4	27.85	21.30	7.41	1.36
S_{10}	6.94	26.0	29.00	25.11	7.01	1.56
S_{11}	7.87	24.5	27.69	24.55	6.20	1.30
S_{12}	6.13	23.9	22.72	23.64	6.30	1.40
S_{13}	7.06	24.8	24.04	18.50	6092	1.16
S_{14}	8.58	39.4	26.11	23.21	7.60	1.12
S_{15}	10.51	40.4	31.05	27.25	10.54	1.08
CD at 5%	1.843	9.52	3.772	3.007	1.315	0.48

Discussion

The present studies indicated that the all vegetative growth parameters were significantly influenced by various growing media treatments. All combinations of soilless substrates significantly increased the strawberry growth as compared to control (sand).Water capacity, proper density and porosity of the substrate play a decisive role for its usability for cultivation (Ameri *et al*., 2012). The properties of different materials used as soilless growing media exhibit direct and indirect effects on raising quality plant material (Kumar *et al*., 2014), growth and productivity (Puri, 2012). The plant culture using substrates also allows a better control of the root environment (Abad *et al*., 2001). The variation in the vegetative growth might be due to the properties of different materials used as growing substrates exhibit direct and indirect effects on plant growth. The present results are in line with earlier findings of Verdonck *et al.,* (1981). Schie, (1999) [22] reported that the cocopeat is an organic material with medium ion absorption capacity. It also has aerial porosity and better capacity of water and nutrient maintenance (Por-Hossein *et al.,* 2009) [19]. Perlite is considered as a substrate with excellent features in soilless cultivation since it has high water absorption, increases watering efficiency (Inden and Torres, 2004) [14]. The use of different organic and inorganic substrates in appropriate proportion optimize water and oxygen holding and allows the plants better nutrient uptake for sufficient growth and development (Ayesha *et al.,* 2011; Hesami *et al.,* 2012) [3, 13]. Nourizadeh (2003) [18] reported cocopeat and perlite substrates to be effective in root due to better interchange of the elements especially cations inside the substrate and proper moisture distribution that improves root system and finally plant height. Tabatabaei *et al.,* (2006) [27] concluded that treatments which were mixture of perlite increased plant height. Rumple *et al.,* (1996) [21] found that plant growth of tomato as indicated by plant height, stem diameter, number of leaves was higher in soilless culture than in the soil cultivation. Hassan *et al.,* (2011) [12] observed using coconut husk gave the highest number of leaves and plant height and control (soil cultivation) gave the lowest. The number of leaves decreased as the soil amount increased in the media (Selda and Anapali, 2010) [23]. Similarly Ericisli *et al.,* (2005) [8] also reported soilless substrates were effective on growth of strawberry cultivars in terms of above and underground parts of plants. Such increase in the number of leaves, plant spread and crown diameter might be due to the volume of media resulting in availability of more water and nutrients besides aeration hence plant growth. Ercisli *et al.* (2005) [8] reported that higher root fresh weight was produced higher root dry weight as compared to lower root fresh weight produced lower root dry weight in cv. FERN. Similar observations were reported by Al-Raisy *et al*. (2010) in cv. Camarosa with respect to shoot fresh and dry weights.

Total soluble solid (TSS) content differed among the substrate affected by the nature of the growing substrate (Table-2). The studies by, (Tzortzakis and Economakis, 2008), reported significantly different TSS values when comparing tomato fruits grown under different substrates. Generally, TSS and TTA values were comparable with those reported by others on the same or similar cultivars at optimum maturity (Correia *et al*., 2011; Giné Bordonaba and Terry, 2009). Fruit from cultivar 'Candonga' had the greatest TSS values (8.16 %;) followed by lower values in the rest of cultivars ('Camarosa'and 'Festival'; 7.7%). High TSS content in strawberry fruits was strongly related to the leaf: fruit ratio (Carlen *et al*., 3).

Conclusion

The findings of the study of the study enable us to conclude that the applied substrates directly influenced growth and quality of strawberry fruits cultivated in the soilless system. All combinations of soilless substrates significantly improved the growth in strawberry compared to the sand and the substrate combination S_7 (coco peat + Perlite, 25:75) and S_{15} (Cocopeat + Perlite + Vermiculite, 50:25:25) was found superior among all the treatments. Further investigation is needed to standardize the other factors like other varieties and different cost effective systems to obtain the maximum benefits from this system. Hence form current study it is confirmed that coco peat in combination with vermiculite (25:75) and in (Cocopeat + Perlite + Vermiculite, 50:25:25) and are recommended for the soilless production system of strawberry in passively ventilated green house condition.

Acknowledgements

The authors are highly thankful to ICAR-Central institute of Temperate Horticulture for the financial assistance during the course of investigation.

References

1. Albaho M, Bhat N, Abo H, Tomas B. Effect of three substrates on growth and yield of two cultivars of capcicum Annum. Europ. J Scient. Res. 2009; 28:233-227.
2. AOAC. Official Methods of Analysis. Association of Official and Analytical Chemists, 17th ed.; Gaithersburg, Md, USA, 2012.
3. Ayesha R, Fatima N, Ruqayya M, Faheem H, Qureshi KM, Hafiz IA *et al*. Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (*Fragaria* × *ananassa*). Journal of Medicinal Plants Research. 2011; 5(26):6224-6232.
4. Cantliffe DJ, Paranjpe AV, Stoffella PJ, Lamb EM, Powell CA. Influence of soil media, growing containers and plug transplants on vegetative growth and fruit yield of 'Sweet Charlie' strawberry grown under protected culture. Proceedings of the Florida State Horticultural Society. 2007; 120:142-150.
5. Carrijo OA, Liz RS, Makishima N. Fibra da casca do coco verde como substrato agrícola. Horticultura Brasileira. 2002; 20(4):533-535.
6. Dinar M. Strawberry production in greenhouse. (In) Vallarta, Jalisco, Mexico Empresa Brasileira De Pesquisa Agropecuária, 2003.
7. Sistema De Produção Do Morango. cultivo protegido. Sistemas de Produção, 2005, 5. Disponível em:< http:// sistemasdeproducao.cnptia.embrapa.br/FontesHTML/ Morango/SistemaProducaoMorango/index.htm>. Acesso em: 12 ago. 2013.
8. Ericisli S, Sahin U, Esitken A, Anapali O. Effects of some growing media on the growth of strawberry cvs. Camarosa and Fern. Acta Agrobotanica. 2005; 58:185-191.
9. Fernandes C, Eduardo-Cora J. Bulk density and relationship air/water of horticultural substrate. Scientia Agricola. 2004; 61(4):446-450.
10. Fernandes-JR F, Furlani PR, Ribeiro IJA, Carvalho CRL. Produção de frutos e estolhos do morangueiro em diferentes sistemas de cultivo em ambiente protegido. Bragantia. 2002; 61:25-34.
11. Godoi RS *et al*. Produção e qualidade do morangueiro em sistemas fechados de cultivo sem solo com emprego de substratos. Ciência Rural. 2009; 39(4):1039-1044.
12. Hassan AH, Khereba AH, El-Kattan MH, Noha G, El-Rahman A. Effect of various organic substrate culture and container types on productivity and fruit quality of strawberry (*Fragaria* × *ananassa*) cv. Festival. Research Journal of Agriculture and Biological Sciences. 2011; 7(5):379-387.
13. Hesami A, Khorami SS, Kashkooli AB. Date-peat as an alternative in hydroponic strawberry production. African Journal of Agricultural Research. 2012; 7(23):3452-3458.
14. Inden H, Torres A. Comparison of four substrate on the growth and quality of tomatoes. Acta Horticulturae. 2004; 644:205-210.
15. Johnson Jr. H, Hochmuth GJ, Maynard DN. Soilless Culture of Greenhouse Vegetables. Institute of Food and Agricultural Sciences. University of Florida. 2010; 218:19-22.
16. Karol W, Jan K, Anna B, Justyna B. The effect of substrates on yield and quality of strawberry fruits cultivated in a heated foil tunnel, Zemdirbyste-Agriculture. 2017; 104(3):283-286.
17. Lieten F, Longuesserre J, Baruzzi G, Lopezmedina J, Navatel JC, krueger E *et al*. Recent situation of strawberry substrate culture in Europe. ISHS Acta Horticulturae. 2004; 649:193-196.
18. Nourizadeh M. The effect of different substrate cultivation on the growth, performance and to evaluate the cold acclimation and freezing quality of greenhouse cucumber in without soil cultivation system. M.Sc theses on horticulture, Guilan University, Iran, 2003.
19. Por-Hossein L, Ebadi A, Mostufi Y. Effect of nutrient solutions EC levels and type of media on strawberry growth and yield in hydroponic system. *Abstract in Sixth Iranian* Congress of Horticultural Science, Guilan, Iran, 2009.
20. Proceedings on International Congress. Greenhouse, Puerto.
21. Rumple J, Felczynski K, Aniszewski SK, Vogel G. Results of experiments with soilless open field tomato culture in Germany and Poland. International Society for Soilless Culture, 1996, 373-380.
22. Schie WV. Standarization of substrstes. Acta Horticulturae. 1999; 481:71-78.
23. Selda O, Anapali O. Effect of soil addition on physical properties of perlite based media and strawberry cv. Camarosa plant growth. Scientific Research and Essays. 2010; 5(22):3430-3433.
24. Sheoran OP. Statistical package for Agricultural Research workers, CCS HAU, Hisar, 2004. http://hau.ernet.in
25. Singh R, Sharma RR, Kumar S, Gupta RK, Patil RT. Vermicompost substitution influences the physiological disorders, fruit yield and quality of strawberry (Fragaria × ananassa Duch). J Biore. Tech. 2008; 99: 8507-8511.
26. Soltani A. Chlorophyll fluorescence and its application. Internal Press. University of Agricultural Science and Natural Resource, Gorgan, Iran, 2004.
27. Tabatabaei SJ, Fatemi LS, Fallahi E. Effect of ammonium, nitrate ratio on yield, calcium concentration and photosynthesis rate in strawberry. Journal of Plant Nutrition. 2006; 29:1273-1285.
28. Takeda F, Hokanson SC. Strawberry fruit and plug plant production in the greenhouse. Acta Horticulturae. 2003; 626:283-285.
29. Verdonck O, De Vleeschauwer D, De Boodt M. The influence of the substrate to plant growth. Acta. Hortic. 1982; 126:251-258.
30. Vikas Kumar Sharma, Anil Kumar Godara. Response in Strawberry (*Fragaria* × *ananassa* Duch. 'Sweet Charlie') Growth to Different Substrates and Containers under Greenhouse. Int. J Curr. Microbiol. App. Sci. 2017; 6(11):2556-2568.