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Influence of different soilless substrates and jeevamrit on flowering and fruiting behaviour of strawberry (*Fragaria X ananassa* Duch.) cv. Chandler

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Abstract
Strawberry cultivation in Himachal Pradesh is based mainly on outdoor planting using soil as a growing media which invariably leads to many problems related to soil borne pests, diseases, nematodes and other soil limiting factors resulting in poor yield and poor quality fruits. As such, in an effort to make the crop remunerative, a polyhouse experiment was carried out to investigate the response of strawberry (*Fragaria x ananassa* Duch.) to different soilless substrates along with jeevamrit. The experiment comprised of six treatments viz. cocopeat (50%) + FYM (50%) + jeevamrit, perlite (50%) + FYM (50%) + jeevamrit, cocopeat (50%) + perlite (50%) + jeevamrit, perlite (75%) + cocopeat 25%)+ jeevamrit, soil (50%) + FYM (50%)+ jeevamrit and soil + FYM as control with four replications. The results revealed that perlite (75%) + cocopeat (25%) + jeevamrit resulted in the maximum number of flowers, berry set, berry yield, berry size, berry weight and total soluble solids as compared to control. The number of days to first flowers was minimum while duration of flowers was maximum under perlite (50%) + FYM (50%) + jeevamrit. Based on the results obtained, it can be concluded that perlite (75%) + cocopeat (25%) + jeevamrit can be successfully used for better production of good quality strawberry under polyhouse.

Keywords: Strawberry, soilless substrates, Jeevamrit, berry quality, berry yield

Introduction
Strawberry (*Fragaria* x *ananassa* Duch) is widely appreciated for its attractive heart shaped-bright red fruits that are dotted with hardened seed-like achenes on the outer skin of the fruits. It has a characteristic refreshing aroma, juicy texture and sweetness which makes it a favourite fruit among many consumers especially the children. The cultivated strawberry has an immense market potential either as a fresh fruit, a value-added fruit, a processed product in the form of jam, jelly, preserve, pies, ice cream, milk shakes, wine and soft drinks or as flavours and aromas in candies, chocolates, bakery items, hand sanitizers, perfumes, cosmetics and many others. The fruit is an excellent source of vitamin A (60 IU/100g), vitamin C (30-120 mg/100g), minerals (Sharma, 2015) [26] and pectin (0.55%) (Mitra, 1991) [22]. Further, the presence of ellagic acid which prevents cancer and occurrence of heart diseases (Nazir *et al*. 2012) [23] as well as anthocyanin which makes it rich in antioxidants (Sun *et al*. 2002) [28] have made it an even more valuable fruit. Being a short duration crop, ready for harvest within six months or even less than three months when grown under protected conditions, it is highly remunerative and very popular among the growers in the vicinity of towns and cities.
The last decade has witnessed the emergence of strawberry as the leading fruit in the category of soft berries. The area and production under strawberry in the world has increased logarithmically during the last two decades and most of it being grown under protected structures (Thakur and Shylla 2018a) [29]. In Himachal Pradesh, the agro-climatic conditions are congenial for strawberry production which is why, people prefer to grow it in open conditions using natural soil as a growing media. But this has led to various soil related problems such as soil borne pests, diseases, nematodes and other soil limiting factors leading to the production of poor quality planting material and hence poor quality fruits. In order to eliminate soil borne diseases and pests, the most viable option is to use soilless growing media since they are mostly free from soil borne diseases, pests and nematodes (Shylla *et al.* 2018) [27] which can result in better vegetative growth parameters, number of fruits and yield of good quality strawberry fruits (Adak and Gubbuk, 2015) [2].

Further, the use of conventional farm based products like jeevamrit, beejamrut, panchagavya, etc. apart from enriching the soil with indigenous microorganisms can also decrease the incidence of diseases (Amareswari and Sujathamma, 2014) [5]. However, not much work has been done on the use of such artificial growing media and farm based products particularly in strawberry. Keeping this in view, it was thought worthwhile to conduct the investigation with the objective to study the effect of soilless substrate combinations and jeevamrit on flowering, yield and fruit quality of strawberry under protected conditions.

Materials and Methods

The present Experiment was conducted in a polyhouse having side and top ventilation and equipped with sprinkler and drip irrigation system at Horticultural Research & Training Station and Krishi Vigyan Kendra (HRTS & KVK) Kandaghat, Solan (H.P.) during the cropping seasons of 2018-19. Uniform runners of strawberry cv. Chandler were selected and planted in October 2018 within the polyhouse at a distance of 20 cm x 20 cm in 1m x1m beds filled with six different growing media combinations viz. cocopeat (50%) + FYM (50%) + jeevamrit; perlite (50%) + FYM (50%) + jeevamrit; cocopeat (50%) + perlite (50%) + jeevamrit; perlite (75%) + cocopeat 25%)+ jeevamrit; soil (50%) + FYM (50%)+ jeevamrit and soil + FYM as control with four replications. The media were filled in beds of twelve inches depth lined with perforated black polythene sheet. The plants were irrigated at 1-2 days' interval through micro sprinkler irrigation during the initial stages and through drip irrigation during fruiting stages, while recommended dose of fertilizers were applied through fertigation using soluble fertilizers. Jeevamrit prepared as per procedure suggested by Devakumar *et al.* (2014) [9] was applied at the rate of 5 per cent (5 L per 100 L of water) as foliar spray, at 30 days' interval (Acharya D, 2017) [1]. All plants were given uniform cultural practices during the course of investigations.

Results and Discussion

A perusal of data presented in Table 1 reveals that soilless substrates and jeevamrit had a significant influence on the days taken to initiate first flower, duration of flowering, number of flowers per plant and per cent berry set. Among the different growing media, perlite (50%) + FYM (50%) + jeevamrit treatment took the least number of days (115.10 days) for first flower to open, while the maximum days (122.68 days) required for first flower to open was observed under soil + FYM treatment. Maximum duration of flowering (63.38 days) was observed under perlite (50%) + FYM (50%) + jeevamrit treatment. However, this treatment was also found to be statistically at par with perlite (75%) +cocopeat (25%) + jeevamrit treatment whereas, minimum duration of flowering (57.59 days) was observed under soil + FYM treatment. The highest number of flowers (20.12) was recorded in plants grown under perlite (75%) + cocopeat (25%) + jeevamrit treatment though it was found to be statistically at par with perlite (50%) + FYM (50%) + jeevamrit treatment (18.95). The lowest number of flowers (15.95) was recorded in plants grown in soil + FYM. Similarly, the highest berry set of 79.73 per cent was also recorded in plants grown under perlite (75%) + cocopeat (25%) + jeevamrit treatment, which was however found to be statistically at par with perlite (50%)+ FYM (50%) + jeevamrit treatment. The lowest fruit set of (70.58 per cent) was recorded under soil + FYM treatment.

In the present studies, soilless substrates comprising of perlite combinations exhibited significant effect on flowering and berry set parameters. These results are in congruence with the findings of Anagnostou *et al*. (1995) [6], who obtained early flower production in strawberry cv. Fern and Selva when plants were grown in perlite medium under greenhouse condition. Better flowering and berry set in artificial media compared to the soil may have resulted due to the improvement in root zone environment. These observations are supported by the findings of Nourizadeh (2003) [24] as well as Thakur and Shylla (2018b) [30] who reported the increased number of flowers in plants due to suitable conditions in soilless substrate by way of better aeration and better water availability. However, these results are in contrast to the findings of Joshi (2003) [20] who obtained non-significant effect of soilless media on number of days to first flower and duration of flowering.

It is apparent from data presented in Table 1, that the differences among the various soilless substrates and jeevamrit were found to be significant in respect of berry yield and quality during the course of investigation. The maximum berry yield of 210.09 g per plant and 42.01 t/ha were obtained when plants were grown in perlite (75%) + cocopeat (25%) + jeevamrit treatment, followed by perlite (50%)+ FYM (50%) + jeevamrit. However, minimum berry yield per plant (181.33 g) and yield per hectare (36.26 t/ha) were recorded under soil + FYM treatment. The positive influence of perlite and its mixtures on root environment may have improved aeration thus forming greater root system which may have promoted shoot nutrient uptake leading to increased berry yield. Similar results of increased yield in perlite and its mixtures have been reported in Sweet Charlie strawberry (Cantliffe *et al*. 2008); Camarosa strawberry (Hochmuth, 2008) [8, 18] and Chandler strawberry (Shylla *et al.* 2018) [27]. Various workers (Yuan *et al*. 1996; Verdonck and Demeyer, 2004; Ghazvani *et al.* 2007; Jafarnia *et al.* 2010; Hassan *et al*. 2011) [34, 32, 12, 19, 17] have reported an improved aeration under soilless media combinations resulting in the formation of better root system, thereby resulting in higher yield (Du *et al*. 2007; Albaho *et al*. 2009) [10, 4]. These findings are in line with those of Gracia and Deverde (1994) [15] who worked on tomato using soilless culture and found a quicker root development consequently resulting in better yield. Anagnostou *et al*. (1995) [6] also obtained maximum berry yield in Selva cultivar of strawberry when grown in Perlite + Peat media. Similarly, Linardakis and Manios (1991) [21] obtained maximum yield when strawberry was grown in a media containing 80 per cent Perlite and 20 per cent Peat. In the present study it was also observed that, apart from an increase in the yield of strawberries grown in perlite combinations, the plants were also healthier with superior horticultural traits. Application of liquid organic manures i.e. jeevamrit may have also helped in improving growth and yield (Gore, 2009). Similar observations were recorded by Shylla *et al*. (2018) [27] who observed that perlite and perlite + FYM was the best media for strawberry cultivation resulting in heal their plants with higher fruit yield and better runner production. Jeevamrit which acts as a tonic may have also helped in improving soil health (Vasanth Kumar, 2006) [31].

Table 1: Influence of different soilless substrates and jeevamrit on days taken to first flower, duration of flowering, number of flowers, per cent berry set, yield per plant and yield per hectare in strawberry cv. Chandler

Treatments	Days taken to first flower	Duration of flowering (days)	Number of flowers	Per cent berry set (%)	Yield/plant (g)
T_1	117.17	60.60	16.80	76.56 (61.03)	201.62
T_2	115.10	63.38	18.95	78.98 (62.69)	207.92
T_3	116.9	61.44	18.12	76.82 (61.19)	205.39
T_4	115.68	62.22	20.12	79.73 (63.22)	210.09
T_5	121.27	58.96	16.45	75.22 (60.13)	187.26
T_6	122.68	57.59	15.95	70.58 (57.13)	181.33
$CD_{0.05}$	2.22	1.90	1.22	1.92	2.85

*The figures in the parentheses are arc sine transformed values

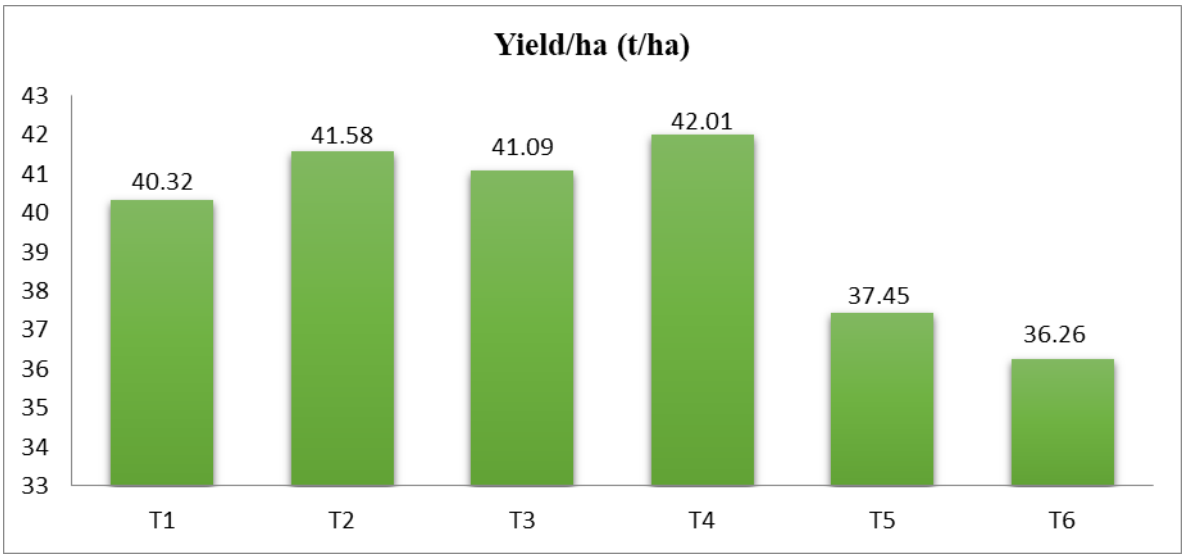

Fig 1: Influence of growing media on yield (tonnes per hectare) of strawberry cv. Chandler

T_1	Cocopeat (50%) + FYM (50%) + Jeevamrit
T_2	Perlite (50%) + FYM (50%) + Jeevamrit
T_3	Cocopeat (50%) + Perlite (50%) + Jeevamrit
T_4	Perlite (75%) + Cocopeat (25%) + Jeevamrit
T_5	Soil (50%) + FYM (50%) + Jeevamrit
T_6	Soil + FYM (Control)

It is evident from the Table 2 that all the treatments of soilless substrates and jeevamrit had a significant effect on berry size, weight and TSS. The data reveals that the berry size in terms of berry length and breadth was highest (40 mm and 26.55 mm respectively) in plants grown under perlite (75%) + cocopeat (25%) + jeevamrit treatment which was statistically different from all other treatments. Whereas, the lowest berry length and breadth (32.75 mm and 19.95 mm respectively) was obtained under soil + FYM treatment.

The present results revealed that berry size was greatly influenced by growing media particularly perlite and its combination with FYM and also cocopeat. The good physical conditions, moisture holding capacity and aeration properties of perlite as a medium may have improved the growth and vigour of the plants which possibly increased photosynthesis and translocation of assimilates in the berries (Younis *et al.* 2015; Shylla *et al.*, 2018) [33, 27]. These results are in accordance with the findings of Fornes *et al.* (2003) [11] and Ayesha *et al.* (2011) [7], who reported that perlite with manure based medium increased the berry size in strawberry, which they had attributed to the ability of this medium to provide essential micro nutrients to the plants.

The data pertaining to berry weight exhibited significant differences among different treatments. A perusal of the data reveals that the heaviest berry weight (18.59g) was recorded under perlite (75%) + cocopeat (25%) + jeevamrit treatment, which was statistically different from all other treatments. These results are in congruence with the findings of Linardakis and Manios (1991) [21] who reported the highest yield and fruit weight when plants were grown in peat + perlite medium. Similar results were also reported by Paraskevopoulou *et al.* (1995) [25] who obtained maximum yield and berry weight in Selva cultivar of strawberry when grown in soilless mixture as compared to normal soil solution. The present findings are also in agreement with that of Haghighi *et al.* (2016) [16] who recorded that the highest fruit weight and fruit volume in tomato plants when grown in perlite substrate and its mixtures. Similar results were also reported by Alan *et al.* (1994) [3] who recorded maximum tomato fruit weight and fruit volume in 100 per cent perlite and mixture of perlite and it was attributed to better physical characteristics of the growing medium resulting in a higher fruit weight and volume.

The data pertaining to the effect of different soilless substrates and jeevamrit on total soluble solids in strawberry reveals that there were significant differences with respect to total soluble solids among different treatments. The highest (11.15°B) total soluble solids of the berries in the present studies were recorded under perlite (75%) + cocopeat (25%) + jeevamrit treatment which was statistically different from all other treatments. The lowest total soluble solid contents of (8.66°B) was recorded in the berries of the plants grown in soil + FYM. The positive effect of perlite (75%) + cocopeat (25%) + jeevamrit treatment on total soluble solids could be attributed

to improved nutrient availability due to better features of the growing media. These findings in the present studies are in congruence with that of Ghazvani *et al*. (2007) [12] who recorded the highest total soluble solids in mixture of perlite medium than perlite alone. Similarly, Jafarnia *et al.* (2010) [19] reported significantly higher percentage of total soluble solids when plants were grown in mixture of perlite.

Table 2: Effect of different soilless substrates and jeevamrit on berry length, berry breadth, berry weight and total soluble solids in strawberry cv. Chandler.

Treatments	Berry length (mm)	Berry breadth (mm)	Berry weight (g)	Total soluble solids (°B)
T_1	35.10	21.87	15.22	9. 60
T_2	38.19	24.34	16.87	10.13
T_3	36.25	22.03	15.66	9.77
T_4	40.00	26.55	18.59	11.15
T_5	33.58	20.84	14.52	9.11
T_6	32.75	19.95	11.55	8.66
$CD_{0.05}$	1.42	2.17	1.40	0.63

Conclusion

On the basis of the results obtained in the present course of investigation, it can be concluded that perlite (75%) + cocopeat (25%) + jeevamrit@ 5 per cent can be successfully used for the production of good quality strawberry under polyhouse conditions.

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