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Influence of different substrates combinations on reproductive growth and quality of strawberry (*Fragaria* × *Ananasa* Duch.) cv. 'Camarosa' grown under protected conditions

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Abstract
Influence of different substrate combinations on plant growth of strawberry (*Fragaria* × *ananassa* Duch.) cv. Camarosa under protected conditions were conducted during the cropping seasons of 2019-20 and 2020-21. The studies concluded that T_9 (cocopeat + perlite + vermiculite + vermicompost + FYM, 3:1:0:1:0) took minimum days to first flowering (72.00 days and 74.50 days) during both years of experiment which is followed by (cocopeat + perlite + vermiculite + vermicompost + FYM , 3:1:1:0:0) (73.75 days and 76.75 days), while maximum days to first flowering (94.00 days and 97.50 days) was observed in T_1 (control). The studies have also revealed that the maximum TSS (7.94 °B and 8.18 °B), TSS: Acid ratio (10.72 and 11.52), total sugar (5.84 % and 5.97 %) and reducing sugars (5.27 % and 5.45 %), sugars content was recorded in S_9 (cocopeat + perlite + vermiculite + vermicompost + FYM, 3:1:0:1:0), while minimum were found in control (soil) during both the years.

Keywords: 'Camarosa', *Fragaria* × *Ananasa*, strawberry, world due

Introduction
The modern cultivated strawberry (*Fragaria* × *ananassa* Duch.) is one of the most commonly spread soft fruits in the world due to its genotypic richness, exceptionally heterozygous composition and wide variety of environmental adaptations (Childers *et al.*, 1995) [2]. It can be cultivated in tropical and subtropical climates and is commercially grown in temperate climates. Strawberry is a short-day plant that thrives in temperatures between 22 and 25 degrees Celsius during the day and 7 to 13 degrees Celsius at night (De and Bhattacharjee, 2012) [3]. Around 119 hectares of land in Haryana's Hisar district have been planted with strawberries, making it Northern India's strawberry capital and the second largest producer after Mahabaleshwar, Maharashtra (Anon., 2015) [1]. Due to the availability of a market in Delhi and fast returns, strawberry production in northern India is rapidly spreading. A commercially grown strawberry, *Fragaria* × *ananassa* Duch., is a monoecious octoploid (2n=56) hybrid of two dioecious octoploid hybrids, *Fragaria* × *chiloensis* Duch. and *Fragaria* × *virginiana* Duch. (Bowling, 2000) [4], with a basic chromosome number (x) of 7. It is a member of the Rosaceae family and the genus *Fragaria* (Hancock, 1999) [5]. Strawberry is a small herbaceous perennial plant that can be cultivated commercially as either an annual or perennial crop. A crown (shortened stem) produces all of the leaves, roots, runners, and inflorescence that strawberry plants grow (Maas, 1984) [6]. The edible component of strawberry contains 89.9% water, 8.4% carbohydrates, 1.3% fiber, 0.7% protein, 0.5% fat, 0.5% ash, 21 mg calcium, 1.0 mg iron, 1.0 mg sodium, 164 mg potassium,60 I.U. vitamin A, 0.03 mg thiamin, 0.07 mg riboflavin, 0.6 mg niacin, and 59 mg ascorbic acid per 100 g (Considine, 1982) [8].

Strawberry is a common crop that is cultivated in soil all over the world. It's a delicate plant, with a variety of species assaulting almost every aspect of it, including the roots, crown, leaves, and berries. When fungi and nematodes work together, they cause diseases, lower yield capacity, and increase mortality. Artificial media are increasingly being used to eradicate plant-borne pathogens and pests, and a variety of soilless substrates/media may be used to cover the soil (De-Rijck and Schrevens, 1998) [9]. Soilless culture has the potential to be a sustainable alternative to soil-based farming (Albaho *et al*., 2008) [7] and the use of locally accessible materials as growing media with complex Physico-chemical properties (Ortega *et al.*, 1996), which have both direct and indirect effects on plant growth and production (Verdonck *et al.*, 1981) [12].

Cocopeat, India's most commonly used organic substrate, has a high water holding and cation exchange capacity, while perlite provides the necessary porosity. Since vermicompost contains readily available nutrients such as nitrogen, exchangeable phosphorus, potassium, calcium, and magnesium, it is an excellent source of these nutrients (Edwards and Burrows, 1988) [11], it was used in soilless culture to improve strawberry growth and yields (Arancon *et al.,* 2004) [10]. By specifically regulating the supply of water, nutrients, root temperature, and pH, the proper proportion of substrate in strawberry not only increases yield potential but also improves fruit consistency (Olympios,1993) [13].

Material and Methods

The present investigation was conducted at the Hi-tech greenhouse and the Post-Harvest Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar situated at 215.2 m above mean sea level with co-ordinates of 29º 10′ N latitude and 75º 46′ E longitudes. It is characterized by semi-arid climate with hot and dry summer and cold winter during the year 2019-20 and 2020-21. The plants of strawberry cultivar 'Camarosa' were selected for planting. Single uniform runner was planted in each container. The planting was done in the first week of October in both consecutive year (2019-20 and 2020-21). The transplanted plants were kept under uniform condition in high-tech greenhouse during the study period where all the management practices were carried out as per the package of practices. The experimental design consisted of completely randomized design with eleven treatments with four replications.

Treatments	Substrate used	Ratio
1.	Soil (control)	
2.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(1:0:0:0:1)
3.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(3:1:0:0:1)
4.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(1:0:0:0:0)
5.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(0:0:1:0:1)
6.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(0:1:0:0:0)
7.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(1:0:1:0:0)
8.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(3:1:0:0:0)
9.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(3:1:0:1:0)
10.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(3:0:1:0:0)
11.	Coco peat + Perlite + vermiculite + vermicompost + FYM	(3:1:1:0:0)

Number of days to flower induction, number of flowers per plant, TSS (ºB), TSS: Acid ratio (%), total sugar (%), and reducing sugars (%) were used to determine the effect of various substrate combinations. Statistical analysis of the data was performed using MS-Excel and OPSTAT, as proposed by Panse and Sukhatme (Sheoran *et al.,* 1998) [14].

Results and Discussion

In the current research, the substrate combination had a significant effect on the number of days it took to flower and the average number of flowers per plant. Plants grown in T_9 (cocopeat + perlite + vermiculite + vermicompost + FYM, 3:1:0:1:0) produced the earliest flowering (72.00 days and 74.50 days) and the highest total number of flowers (29.50 and 32.20) per plant, as seen in Table 1. Among the various combinations, the T9 may have provided the most suitable conditions for strawberry plant flowering. The better flowering results in artificial media relative to soil may be due to the improved root zone quality. In a soilless substrate, Nourizadeh (2003) [16] recorded an increase in the number of flowers in plants as a result of proper ventilation and water maintenance. Plant development and flowering are affected by the physicochemical characteristics of the increasing media (Wilkerson, 2002) [15], and the composition of the growing media is a vital consideration to remember (Ingram *et al.,* 2003) [18]. According to Arancon *et al.* (2004) [10], organic matter (vermicompost) applications improved strawberry flowers by 40%. Coconut coir and compost-based growing media, according to Ayesha *et al*. (2011) [17], would significantly increase the size of strawberry flowers, and Riaz *et al.* (2008) [19] observed similar results in zinnia.

In terms of quality parameters, S_9 (cocopeat + perlite + vermiculite + vermicompost + FYM, 3:1:0:1:0) had the highest TSS (7.94 ºB and 8.18 ºB), TSS : Acid ratio (10.72 and 11.52), total sugar (5.84 % and 5.97 %) and reducing sugars (5.27 % and 5.45 %), sugars content, while control (soil) had the lowest as shown in Table-2 and 3. Increased leaf area in soilless culture may have favoured photosynthetic rate, translocation, and accumulation of sugars and metabolites in fruits, resulting in higher TSS and sugars. Ozdemir and Kaska (1997) [21] and Ayesha *et al.* (2011) [17] reported similar results, finding that strawberries grown in soilless culture had higher TSS and better flavour than those grown in soil. Gruda and Schnitzler (2004) [20] discovered an increase in dry matter, sugars, soluble solids, vitamins, and carotenoids in soilless tomato culture. Significant variations in TSS, TSS : acid ratio, and sugars were observed in various combinations of soilless media in this experiment. This may be due to the fact that different concentrations of cocopeat, perlite, and vermicompost change the physical and chemical properties of the substrates, which has a significant impact on the quality characteristics of strawberries. The results are also in line with those of Jafarnia *et al.* (2010) [22], Inden and Torres (2004) [24], and Ameri *et al.* (2012a) [23], who looked at the impact of various substrate combinations on TSS and sugar content.

Table 1: Effect of different substrates combination on number of days to first flowering and total number of flowers in strawberry cv. Camarosa

	Treatments	Days to First Flowering			Total Number of Flowers Per Plant		
		2019-20	2020-21	Mean	2019-20	2020-21	Mean
1	**Soil (control)**	94.00	97.50	95.75	14.00	16.75	15.37
2	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:1)	83.25	84.75	84.00	19.25	23.50	21.37
3	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:1)	78.00	80.75	79.37	23.00	26.20	24.60
4	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:0)	87.75	89.00	88.37	15.25	19.25	17.25
5	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:0:1:0:1)	85.50	87.50	86.50	17.50	21.75	19.63
6	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:1:0:0:0)	90.00	94.40	92.20	14.50	17.40	15.95
7	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:1:0:0)	80.75	82.75	81.75	20.50	24.40	22.45
8	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:0)	75.75	78.23	76.99	25.25	28.60	26.92
9	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:1:0)	72.00	74.50	73.25	29.50	32.20	30.85
10	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:0:1:0:0)	79.50	82.00	80.75	22.00	26.00	24.00
11	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:1:0:0)	73.75	76.75	75.25	26.75	29.50	28.12
	Mean	81.84	84.37		20.68	24.14	
	CD (0.05)	1.63	1.78		1.31	1.53	

Table 2: Effect of different substrates combination on TSS and TSS: Acid ratio in strawberry cv. Camarosa

	Treatments	Total Soluble Solids (°B)			TSS : Acid ratio		
		2019-20	2020-21	Mean	2019-20	2020-21	Mean
1	Soil (control)	6.51	6.81	6.66	0.91	0.88	0.89
2	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:1)	6.91	7.41	7.16	0.82	0.81	0.81
3	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:1)	7.41	7.68	7.55	0.79	0.76	0.77
4	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:0)	6.61	7.36	6.98	0.87	0.84	0.85
5	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:0:1:0:1)	6.78	7.38	7.08	0.84	0.82	0.83
6	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:1:0:0:0)	6.52	7.31	6.91	0.89	0.86	0.87
7	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:1:0:0)	6.94	7.45	7.19	0.80	0.79	0.79
8	C oco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:0)	7.55	7.95	7.55	0.77	0.75	0.76
9	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:1:0)	7.94	8.18	8.06	0.74	0.71	0.73
10	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:0:1:0:0)	7.33	7.59	7.46	0.80	0.77	0.78
11	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:1:0:0)	7.79	8.01	7.90	0.76	0.73	0.74
	Mean	7.12	7.56		0.82	0.79	
	CD (0.05)	0.11	0.10		0.018	0.02	

Table 3: Effect of different substrates combination on total sugar (%) and reducing sugars (%)in strawberry cv. Camarosa**.**

	Treatments	Total Sugar (%)			Reducing Sugars (%)		
		2019-20	2020-21	Mean	2019-20	2020-21	Mean
1	Soil (control)	4.89	5.06	4.97	4.26	4.38	4.32
2	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:1)	5.26	5.37	5.31	4.62	4.77	4.69
3	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:1)	5.51	5.69	5.60	4.84	5.03	4.93
4	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:0:0:0)	5.11	5.26	5.18	4.41	4.55	4.48
5	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:0:1:0:1)	5.23	5.34	5.28	4.45	4.68	4.56
6	Coco peat + Perlite + vermiculite + vermicompost + FYM (0:1:0:0:0)	5.01	5.17	5.09	4.32	4.47	4.39
7	Coco peat + Perlite + vermiculite + vermicompost + FYM (1:0:1:0:0)	5.29	5.41	5.35	4.70	4.89	4.79
8	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:0:0)	5.67	5.77	5.72	4.95	5.16	5.05
9	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:0:1:0)	5.84	5.97	5.90	5.27	5.45	5.36
10	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:0:1:0:0)	5.38	5.52	5.45	4.81	4.94	4.87
11	Coco peat + Perlite + vermiculite + vermicompost + FYM (3:1:1:0:0)	5.73	5.91	5.82	5.09	5.39	5.24
	Mean	5.35	5.49		4.70	4.88	
	CD (0.05)	0.19	0.22		0.08	0.09	

As compared to soil, all substrate combinations improved strawberry reproductive growth and efficiency, but the substrate combination T_9 (cocopeat + perlite + vermiculite + vermicompost + FYM 3:1:0:1:0) was deemed superior.

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