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Effect of different growing media on growth and yield of strawberry (*Fragaria X anannasa*) cv. winter dawn under shade net condition

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Abstract
The present experiment entitled "Effect of different growing media on plant growth and yield of Strawberry (*Fragaria* × *ananassa*) Cv. Winter Dawn Grown under shade net condition" was conducted at Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the session 2023-2025. The experiment was laid out in Randomized Block Design (RBD), and the study consists of 9 treatments with three replications including control. From the present investigation, it was concluded that the treatment T_8 (Bio plus compost + Vermiculite + FYM + Perlite 1:1:1:1) was found to be best in the term of growth, flowering, fruiting and yield parameters of strawberry.

Keywords: Strawberry, growing media, growth, fruiting, flowering

Introduction
The cultivated strawberry (*Fragaria* × *ananassa*) is a herbaceous perennial plant belonging to the Rosaceae family and the *Fragaria* genus. It is a monoecious, octoploid hybrid (2n = 56), originating from the natural cross between two dioecious octoploid species, *Fragaria chiloensis* and *Fragaria virginiana*, which are considered the progenitors of modern strawberry cultivars (Islam *et al.*, 2023) [7]. Strawberries are widely appreciated for their nutritional value, being rich in vitamin A (60 IU/100 g) and vitamin C (30-120 mg/100 g), dietary fiber, and a variety of phytochemicals such as anthocyanins, flavanols, and phenolic compounds that exhibit antioxidant, anti-inflammatory, and anti-carcinogenic properties (Miao *et al.*, 2017) [10].

Originally confined to temperate climates, strawberries have demonstrated adaptability to subtropical and tropical high-altitude regions. They thrive best under day temperatures of 22-25 °C and night temperatures of 7-13 °C (De and Bhattacharjee, 2012) [4]. The expansion of cultivation into diverse climatic zones has been aided by the introduction of hardy cultivars such as 'Chandler' and 'Douglas Fern'. Today, strawberries are cultivated from Arctic to tropical regions due to their climatic flexibility, and they are typically propagated through one-year-old runners (Sharma *et al.*, 2022) [12].

Strawberries are considered a functional food, largely due to their high content of phenolic compounds, anthocyanins, and flavanols. These bioactive compounds contribute to various health benefits, including the prevention of cardiovascular diseases, slowing of aging, and reduction of cancer risk (Miao *et al.*, 2017) [10]. Moreover, strawberries are composed of approximately 90% water and contain a mix of organic acids, primarily malic, citric, and succinic acids, which contribute to their unique flavor and organoleptic properties (Dolker *et al.*, 2017) [5].

In India, strawberries are cultivated over approximately 1,000 hectares with an annual production of 5,000 MT, with Maharashtra being the leading producer. Other key states include Himachal Pradesh, Uttarakhand, Jammu & Kashmir, and parts of Uttar Pradesh and Punjab. Initially introduced by the National Bureau of Plant Genetic Resources at Shimla and the Kashmir valley, cultivation spread to other regions due to the successful performance of Floridian cultivars.

Proper nutrient management plays a vital role in the yield and quality of strawberries, given the plant's sensitivity to nutrient imbalance. A balanced supply of both macro-(NPK) and micronutrients is critical, as deficiencies can directly impact fruit set and overall plant health. In the past, micronutrients were naturally abundant in soils; however, intensive farming practices have necessitated their external application. Additionally, environmental factors such as temperature and relative humidity significantly influence growth, flowering, and fruiting. The use of shade nets can help modify the microclimate, thereby improving crop yield and quality (Rivera *et al.*, 2017) [13].

Materials and Methods

The present investigation entitled "Effect of different growing media on plant growth and yield of Strawberry (*Fragaria* × *ananassa*) Cv. Winter Dawn Grown under shade net condition" was carried out under Prayagraj Agro-climatic conditions at the experimental field (Shade net II), Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and sciences, Prayagraj U.P during 2024-2025. The experimental site is located at a latitude of 25.41 ° North and longitude of 81.84 ° East, with an altitude of 98 meters above the mean sea level (MSL). Area of Prayagraj district comes under subtropical belt in the south east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 °C TO 48 °C. The relative humidity ranges between 20 to 94 percent. The average rainfalls in this area are around 1013.4 nm annually.

Treatment Combinations

Under this experiment, over all 9 + 1 treatment was taken which were replicated thrice in RBD. T_0 No treatment (only 100% soil), T_1 Soil + Sand + FYM (1:1:1), T_2 FYM + Cocopeat (1:1), T_3 Perlite + Saw dust (1:1), T_4 Bio plus compost + Rice husk (1:1), T_5 FYM + Cocopeat + Vermiculite (1:1:1), T_6 Bio plus compost + Perlite + Vermi compost (1:1:1), T_7 FYM + Rice husk + Saw dust (1:1:1), T_8 Bio plus compost + Vermiculite + FYM + Perlite (1:1:1:1), T_9 Cocopeat + Vermi compost + Saw dust + Perlite (1:1:1:1).

The research was carried out with the objectives of studying the effect of different growing media on growth, yield and fruit quality of strawberry (*Fragaria x anannasa*) cv. Winter dawn under shade net condition.

Results and Discussion

A. Growth Parameters

1. Plant Height (cm)

Plant height varied significantly among different treatment combinations at all growth stages. At 30 DAP, the highest plant height (7.30 cm) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_9 (7.13 cm), while the minimum (5.05 cm) was observed in T_0 (control). At 60 DAP, T_8 again showed the highest height (8.24 cm), followed by T_9 (7.93 cm), with T_0 showing the lowest (5.65 cm). At 90 DAP, T_8 (9.78 cm) recorded the maximum height, closely followed by T_4 (9.73 cm), and T_0 remained the lowest (6.87 cm). At 120 DAP, the tallest plants were found in T_8 (11.84 cm), followed by T_1 (11.72 cm), while T_0 had the minimum (8.62 cm). Overall, T_8 consistently resulted in the maximum plant height across all stages, whereas T_0 (control) recorded the minimum.

The inclusion of perlite in the growing medium plays a crucial role in ensuring proper aeration and drainage. Perlite's lightweight and porous nature allows for better oxygen availability to the roots and prevents waterlogging, which can hinder root respiration and growth. This is consistent with the findings of (Kumar *et al.*, 2021) [9], who highlighted the importance of adequate aeration and drainage in promoting healthy root systems and improving plant growth.

2. Plant Spread (cm)

Plant spread significantly varied among the different treatment combinations at all stages of observation. At 30 DAP, the highest spread (11.32 cm) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_9 (10.54 cm), while T_0 (control) had the lowest (7.38 cm). At 60 DAP, T_8 again showed the maximum spread (18.06 cm), followed by T_9 (16.62 cm), and T_0 recorded the minimum (10.83 cm). At 90 DAP, T_8 (26.02 cm) showed the highest spread, followed by T_9 (23.04 cm), with T_0 at the lowest (13.91 cm). At 120 DAP, the highest plant spread was observed in T_8 (27.25 cm), followed closely by T_4 (27.24 cm), while the minimum was in T_0 (17.38 cm). Overall, T_8 consistently recorded the maximum plant spread across all intervals, and T0 the minimum. These findings align with Singh (2021) [9], who reported enhanced plant spread with growing media enriched with compost and vermiculite.

3. Number of leaves per plant

The number of leaves per plant varied significantly among different treatment combinations at all growth stages. At 30 DAP, the highest leaf count (6.33) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_9 (6.00), while T_0 (control) had the lowest (3.53). At 60 DAP, T_8 again recorded the maximum number of leaves (7.60), followed by T_6 (6.93), with the minimum in T_0 (3.66). At 90 DAP, the highest leaf count was observed in T_8 (11.46), followed by T_3 (9.53), and the lowest in T_0 (5.33). At 120 DAP, T_8 showed the maximum number of leaves (14.40), followed by T_6 (13.00), while T_0 recorded the minimum (7.93). Overall, T_8 consistently resulted in the highest number of leaves per plant across all intervals, whereas T_0 showed the least.

Number of leaves per plant was increased significantly with the utilization of vermicompost and various treatment combination, the expansion in vegetative growth parameter may be because of generation of more chlorophyll content with inoculation of nitrogen fixers. Vermicompost is considered as a rich source of available plant nutrients and enzymes (Arancon *et al.*, 2004) [2] in strawberry.

4. Leaf Area (cm^2)

Leaf area varied significantly among the different treatment combinations at all growth stages. At 30 DAP, the highest leaf area (6.77 cm^2) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_7 (6.05 cm^2), while the lowest (4.39 cm^2) was observed in T_0 (control). At 60 DAP, T_8 again showed the maximum leaf area (10.17 cm^2), followed by T_9 (9.92 cm^2), with the minimum in T_0 (7.43 cm^2). At 90 DAP, the maximum leaf area was observed in T_8 (13.93 cm^2), followed by T_9 (13.05 cm^2), while T_0 had the least (9.27 cm^2). At 120 DAP, T_8 continued to show the highest leaf area (18.14 cm^2), followed by T_9 (17.53 cm²), with T_0 recording the minimum (11.60 cm²). Overall, T_8 consistently resulted in the maximum leaf area, whereas T_0 (control) showed the minimum across all intervals. These findings are supported by Jain *et al.* (2016), who also reported enhanced leaf area with the use of organic growing media.

B. Flowering and Fruiting Parameters

1. Days taken for first flowering initiation

The minimum number of days to first flowering (41.93) was recorded in treatment T_8 (Bio plus compost + vermiculite + FYM + perlite 1:1:1:1), followed by T_1 (soil + sand + FYM 1:1:1) with 46.76 days, while the maximum (53.06 days) was observed in T_6 (Bio plus compost + perlite + vermicompost 1:1:1).

The earliest flowering in T_8 (41.93 days) suggests that the balanced combination of organic and inert components (Bio plus compost + vermiculite + FYM + perlite) provided optimal physical and nutritional conditions for plant development. In contrast, the delayed flowering in T_6 (53.06 days) may be due to suboptimal aeration and nutrient imbalance, highlighting the importance of media composition in influencing flowering time.

2. Number of flowers per plant

The highest number of flowers (12.73) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite 1:1:1:1), followed by T_5 (FYM + cocopeat + vermiculite 1:1:1) with 11.00 flowers, while the lowest (4.53) was observed in T_0 (control).

The highest flower count in T_8 (12.73) indicates that the balanced mix of organic and inert components significantly enhanced floral development, likely due to improved nutrient availability and aeration. The lowest flower count in the control (T_0) highlights the importance of enriched growing media for optimal flowering under shade net conditions.

3. Days taken to first fruit

The minimum number of days to first fruiting (50.06) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_2 (FYM + cocopeat 1:1) with 64.00 days, while the maximum (73.86 days) was observed in T_0 (control).

The earliest fruiting in T_8 (50.06 days) suggests that the well-balanced growing medium promoted faster plant development and reproductive transition. In contrast, delayed fruiting in the control (T_0) indicates that lack of soil amendments limited nutrient availability and overall plant vigour under shade net conditions.

4. Number of fruits per plant

The maximum number of fruits per plant (12.86) was recorded in T_8 (Bio plus compost + vermiculite + FYM + perlite in 1:1:1:1), followed by T_5 (FYM + cocopeat + vermiculite 1:1:1) with 11.00 fruits, while the minimum (5.00) was observed in T_0 (control).

The highest fruit yield in T_8 (12.86 fruits) indicates that the balanced combination of organic and inert media components created optimal conditions for fruit set and development. The significantly lower fruit count in the control (T_0) highlights the crucial role of enriched growing media in enhancing fruit productivity under shade net conditions.

5. Average yield per plant (g)

The maximum yield per plant was recorded (315.62 g) with T_8 (Bio plus compost + vermiculite + FYM + perlite 1:1:1:1). Closely followed by T_6 (Bio plus compost + perlite + vermicompost 1:1:1) (244.21). Minimum number of flowers per plant was (82.25) recorded in T_0 (control).

The highest yield per plant in T_8 (315.62 g) reflects the synergistic effect of a well-balanced growing medium that enhanced nutrient uptake, plant vigour, and fruit development. In contrast, the lowest yield in T_0 (82.25 g) underscores the limitations of unamended soil in supporting optimal crop performance under shade net conditions.

Table 1: Effect of different growing media on growth parameters of strawberry cv. Winter dawn

Notation	Treatment combinations	Plant height (cm)	Plant spread (cm)	Number of leaves per plant	Leaf Area (cm²)
T_0	Control (Soil)	8.62	17.38	7.93	12.04
T_1	Soil + Sand + FYM (1:1:1)	11.72	25.80	12.46	15.27
T_2	FYM + Cocopeat (1:1)	11.48	25.48	11.86	15.39
T_3	Perlite + Saw dust (1:1)	11.20	26.54	12.06	15.41
T_4	Bio plus compost + Rice husk (1:1)	10.71	27.24	12.26	11.60
T_5	FYM + Cocopeat + Vermiculite (1:1:1)	11.26	25.66	13.00	15.42
T_6	Bio plus compost + Perlite + Vermi compost (1:1:1)	10.46	25.81	12.60	15.31
T_7	FYM + Rice husk + Saw dust (1:1:1)	11.00	25.54	12.86	15.24
T_8	Bio plus compost + Vermiculite + FYM + Perlite (1:1:1:1)	11.84	27.25	14.40	18.14
T_9	Cocopeat + Vermi compost + Saw dust + Perlite (1:1:1:1)	11.33	25.67	12.66	17.53
F test		S	S	S	S
SEm±		0.380	0.626	0.340	0.238
CD at 5%		1.138	1.876	1.019	0.713
CV (%)		6.001	4.299	4.827	2.724

Table 2: Effect of different growing media on flowering and fruiting parameters of strawberry cv. Winter dawn

Notation	Treatment combinations	Days taken for first flowering	Number of flowers per plant	Days taken for first fruiting	Number of fruits per plant	Average yield (g)
T_0	Control (Soil)	48.13	4.53	73.86	5.00	83.52
T_1	Soil + Sand + FYM (1:1:1)	45.26	7.40	69.26	7.86	112.67
T_2	FYM + Cocopeat (1:1)	47.06	7.93	64.00	8.20	122.52
T_3	Perlite + Saw dust (1:1)	45.46	8.46	66.00	8.66	110.08
T_4	Bio plus compost + Rice husk (1:1)	52.46	8.46	64.73	8.66	92.63
T_5	FYM + Cocopeat + Vermiculite (1:1:1)	48.93	11.00	68.00	11.00	222.43
T_6	Bio plus compost + Perlite + Vermi compost (1:1:1)	53.06	10.00	67.73	10.20	244.21
T_7	FYM + Rice husk + Saw dust (1:1:1)	47.26	9.33	66.53	9.60	220.80
T_8	Bio plus compost + Vermiculite + FYM + Perlite (1:1:1:1)	41.93	12.73	50.06	12.86	315.62
T_9	Cocopeat + Vermi compost + Saw dust + Perlite (1:1:1:1)	48.73	8.80	68.86	9.26	229.78
F test		S	S	S	S	S
SEm±		1.600	0.471	1.500	0.453	1.306
CD at 5%		4.790	1.411	4.491	1.357	3.911
CV (%)		5.793	9.208	3.942	8.594	1.290

Conclusion

Based on our experiment findings, it is concluded that treatment T8 (Bio plus compost + vermiculite + FYM + perlite 1:1:1:1) was found be best in terms of growth parameters and flowering, fruiting yield and quality of strawberry. Treatment T8 (Bio plus compost + vermiculite + FYM + perlite 1:1:1:1) was found be best in terms of chemical parameters of strawberry. The benefit cost ratio was also highest in the same treatment with 2.27. The combination of Bioplus compost + vermiculite + FYM + perlite (1:1:1:1) provided optimal aeration, moisture retention, and nutrient availability, leading to enhanced growth and yield of strawberries. This mix proved to be the most effective medium under poly bag and shade net conditions. This mix demonstrated superior performance in terms of plant growth, fruit yield and overall plant health. The synergetic effect of Bioplus compost enhanced microbial activity and nutrient availability, while vermiculite and perlite improved aeration and water retention. FYM contributed organic matter and sustained nutrient release. Collectively, this combination created an optimal root zone environment, promoting vigorous plant development and maximizing strawberry production. Therefore, it can be recommended as the most efficient substrate mix for protected strawberry cultivation systems.

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