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Effects of various growing media, as well as jeevamrit, on the growth and production of strawberry: A review

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Abstract
Strawberry (*Fragaria* × *ananassa*), a member of the Rosaceae family. A soft fruited herbaceous perennial plant with short days, strawberry may be effectively cultivated at optimum day temperatures of 22 to 25 °C and optimal night temperatures of 7 to 13 °C. It spreads by runners, which is a natural method of propagation. The use of runners as propagation material is more efficient than the use of seed propagation. Strawberry is an aggregate fruit containing seeds on the top of a red fleshy receptacle, according to botany, which grows in soil, which makes it more susceptible to pathogens such as soil-borne disease and other diseases. When compared to other growing media such as perlite, FYM, rice husk, coco peat, bio-char, and pumice, the soil's water-holding capacity, porosity, and pH are all significantly lower than they are in the soil. These growing media have a high water-holding capacity, high porosity, a balanced pH, and are free of soil-borne pathogens, which allows for better growth, development, and productivity. The use of liquid organic manures, such as Jeevamrit, can aid in the improvement of crop growth and yield.

Keywords: *Fragaria* × *ananassa*, perlite, FYM, cocopeat, bio-char, pumice, jeevamrit

Introduction
Strawberry (*Fragaria* × *ananassa* Duch.) is a soft fruited herbaceous perennial plant that can be grown successfully at optimum day temperatures of 22 °C to 25 °C and night temperatures of 7 °C to 13 °C. It is a member of the Rosaceae family and produces soft fruited, short-day herbaceous perennial plants (De and Bhattacharjee, 2012). A octoploid hybrid of two dioecious octoploid species, *Fragaria chiloensis* Duch. and Fragaria virginiana Duch is *Fragaria x ananassa* Duch. It is a monoecious octoploid (8n) (2n=56) hybrid with a basic chromosomal number (x) of 7. According to botany, a strawberry is a sort of aggregate fruit that bears seeds on the surface of a red fleshy receptacle and is a form of aggregate fruit (Thakur, M., & Shylla, B. 2018) [12]. Strawberries have a greater concentration of phenolic components, flavonoids, and vitamins like C, than other berry fruits, making them a healthier choice (Ayesha, R. *et al*., 2011) [6]. Because of its widespread appeal among consumers, the strawberry has grown to become the most popular fruit in the category of soft berries during the previous decade. Strawberry production and area have increased dramatically over the last 20 years all over the world, with the majority of the crop being grown in greenhouses or other protected structures. Among other states and provinces, strawberry is grown commercially in India in the states of Haryana, and Delhi, Maharashtra, Punjab, as well as in sections of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, and Uttar Pradesh, among other states and provinces. As Shahzad, U *et al*., (2018) pointed out, there are a number of advantages of soilless production methods over traditional systems. These advantages include greater yields, better pest control management, and more efficient use of labour, among other things. Strawberry is one of the berries of fruits that responds very well to soilless growing technologies. According to Willer *et al*. (2009), organic strawberries are in high demand around the world, but the demand is mostly in North America and Europe. More than two-thirds of U.S. consumers buy organic goods at least periodically, with 28% purchasing organic items on a weekly basis, according to many surveys, including Shahzad, U *et al*., (2018). Organic foods are preferred by customers for a variety of reasons, including health advantages (such as fewer or no pesticide residues and higher nutritional value), flavour, and ecologically friendly agricultural techniques (such as those that support soil health). Organic strawberry farms produce higher-quality fruit, and organic strawberry farms with higher soil quality have greater microbial functional capability and resilience to stress than conventional strawberry farms, according to Lockie *et al*. (2006) and Reganold *et al*. (2010).

According to Johnson *et al.* (2010), the characteristics of substrates include the ability to hold water and nutrients, the ability to provide good aeration to the root system, the ability to be lightweight, and having the potential to be free of harmful organisms and hazardous compounds for plants. Raja, W. H *et al*., 2018) said that, when growing strawberries in the soil, there are some restrictions because there are no chemical fumigants that can be used to control phytopathogens and because it is hard to work with the plants on the bottom of the ground.
Based on their nature growing media are divided into two categories i.e. Organic growing media and Inorganic growing media.

Table 1: List of different organic and inorganic growing media

Organic growing media	Inorganic growing media
Rice husk	Perlite
Peat	Vermiculite
Sphagnum moss	Rock wool cube
Shredded bark	Calcined clay
Coco peat	Expanded clay aggregate
Sawdust	Pumice

***Source*:** Anicua-Sánchez *et al.*, 2005 [3].

Jeevamrut: Fermentation of a combination of cow dung and cow urine with jaggery, pulses flour, soil, and water produces the traditional Indian bioinsecticide and organic manure called Jeevamrut. It's not only economical, but it's also good for the plants and the soil. Fertilizer and pesticide spending by farmers can be reduced by using this incredible traditional treatment for plants. Jeevamrut is completely organic and has no negative impact on the health of the soil. The two words "Jeevan" and "Amrit" make up this phrase. There are two words: Jeevan and Amrit. Jeevan means "life," and Amrit means "medicine." This compound contributes to the stimulation of plant growth while also assisting in the supply of immunity in the plant system. Microbes can produce antimicrobial toxins that are effective against a wide range of harmful microbes in addition to beneficial metabolites such as organic acid, hydrogen peroxide, and antibiotics. Bacteria can also produce metabolites that are helpful to humans, such as organic acid and antibiotics (Solanki *et al*., 2015). Microbial counts and beneficial bacteria in soil are increased by using Jeevamrut. When jeevamrut is applied to soil, it will aid in the growth of earthworm populations in the soil. The presence of earthworms helps to enhance the porous nature of soil as well as the aeration and water holding capacity of the soil. It has the ability to absorb minerals from the soil's deeper layers (Devakumar N, *et al.*, 2014) [2].

Table 2: Ingredients

Materials	Quantity
Cow dung	10 kilograms
Cow urine	10 liters
Local jaggery	2 kilograms
Garden sand	Hand full
Water	200 liters

***Source*:** Devakumar N, *et al.*, 2014 [2].

Preparation: All the ingredients are added stepwise, which are stated in table (02) and volume was made up to 200 liters in a plastic drum. During incubation, place the drum in the shade, cover it with a moist gunny bag, and mix thoroughly 2 - 3 times a day in a circular motion. (Source: Devakumar N, *et al.*, 2014) [2].

Effect of growing media on plant growth
Thakur, M., & Shylla, B. (2018) [12] have observed better plant growth under Perlite + FYM. The greater enhancement in plant growth observed under FYM + Perlite can be contributed to improved water holding capacity and nutrient availability, which in turn promotes better vegetative growth. Hall *et al.*, (1998) observed that perlite alone has been reported to have excellent growth characters when used as a substrate in hydroponic culture. Because of its high water retention capacity and increased water efficiency, Djedidi *et al*. (1998) and Inden and Torres (2004) discovered that perlite and its combination mixture is a substrate with excellent characteristics that can improve growth and development of plants grown in soilless cultivation. Researchers such as Bartczak *et al.*, 2007 [7], and Hesami *et al*., (2012) [9] have substantiated this feature by elaborating that the use of different organic and inorganic substrates in appropriate proportion optimises water and oxygen holding capacity, allowing for better nutrient uptake required for sufficient growth and development to occur. Yavari S *et al.* (2008) [13] reported that S4 (liquorice processing wastes (50%) + mineral soil (50%) produced more floral buds, yield, root dry and fresh weights of plants than other substrates. Thakur M *et al.*, (2018) [12] reported that under perlite + FYM (T2) treatment, the maximum height of the plant (29.19 cm), the no of leaves (18.31), and area of leaf (135.08 Cm2) were observed, while the minimum height of the plant (25.28 cm), the no of leaves (14.70), and area of leaf (120.74 Cm2) were observed under soil + FYM (T6) treatment. According to Palekar (2006), and Devakumar *et al*. (2006), the beneficial effects of Jeevamrut were attributed to increased microbial load and growth hormones, which may have increased soil biomass and thus sustained the availability and uptake of applied and native soil nutrients (2008). According to Adak, N., & GÜBBÜK, H. (2015), Rockwool has a negative effect on the vegetative growth of strawberries and the development of their roots. Coconut coir, on the other hand, is ideal for use with strawberries because it is very absorbent. Thakur, M., & Shylla, B. (2018) [12] stated that a broad range of soilless media is now in use in various regions of the globe to serve as a substitute for soil in various applications. Of all of these numerous growth mediums, the soilless growing media for strawberries that are most widely used include sphagnum moss, Rockwool, Perlite, and Cocopeat. According to Rostami Z *et al.*, (2014) [11], the palm material treatment with a size of 0 - 5 mm particals resulted in largest number of leaves (34.1 leaves/plant), whereas the palm material treatment with a size of 10- 20 mm particals resulted in lowest number of leaves (27.2 leaves/plant).
Ors, S., & Anapali, O. (2010) [25] stated that maximum growth of leaf number (10.35) and leaf area (30.93 cm2) results obtained treatment T1 (100% perlite) whereas minimum growth is shown in treatment T5 (50% Soil + 50% Perlite). Jafarnia *et al.* (2010) [20] stated that hydroponic strawberries can be grown in a mixture of perlite and sphagnum. This is the most common substrates for strawberries growing in hydroponics in most of the developing countries. The perlite/sphagnum substrate led to the most leaf and flower count as well as the most number of fruits and the heaviest fruit dry weight. Wang, D *et al*., (2016) said that sphagnum

was used a lot as a growing medium. However, there have been more and more concerns about how harvesting sphagnum can damage wetlands and lose organic carbon from the soil. Thakur, M., & Shylla, B. (2018) [12] stated that using a variety of organic and inorganic substrates allows plants to better take in nutrients, grow and develop, and hold on to water and oxygen. Raja, W. H *et al*., (2018) stated that perlite and cocopeat substrates benefit the root system as a result of improved particularly cations, elemental exchange, within the substrate and sufficient moisture distribution, both of which contribute to the development of the root system and, ultimately, the height of the plant. According to Hassan *et al.*, (2011) [21], utilizing husk of coconut resulted in the maximum no of leaves and height of plant, whereas control (soil) resulted in the lowest no of leaves and plant height. According to Ors, S., & Anapali, O. (2010), an increase in the quantity of soil in the growth medium typically results in a reduction in the number of leaves on the plant. Anagnostou K and Vasilakakis MD reported that 60% perlite & 40% peat resulted in the higher plants (74.52g and 77.31g) in terms of Fern and Selv. It is mostly owing to the fact that it has the finest water and solution holding capacity. According to MM Maher *et al.*, (2020) [4], among the various growing media, the FYM (50%) + Perlite (50%) + jeevamrit treatment required a very less no of days (115.10 days) for the 1st flower to open, whereas soil + FYM treatment required the most days (122.68 days) for the 1st flower to open, according to the research.

Ayesha *et al.*, (2011) [6] stated that our experiment on flowers yielded the highest number of blooms (not per truss, but individually), 96 blossoms in total on the treatment T4 (Soil: Silt: Coconut coir Dust) which was extremely significant when compared to the control media (30 blossoms), T0 (Soil: Sand). Height of the plant, dry matter contents, area of leaf, dry and fresh weight of runners, and spread of canopy were all found to be growing with FYM and treatments of vermicompost, but length of the root was found to be greater with the leaf manure-based treatment, according to Sara Khalid *et al.*, (2013) [19]. Parameters of fruit quality such as fruit weight, fruit size, and quantity of fruits were greater in vermicomposts than in FYM. Sasan jafarnia *et al.*, (2010) [20] stated that highest number of leaves and flowers were obtained from treatment T1 (Perlite + Peat moss 100%:0%) rather them treatment T2 (80%: 20%) and T3 (60%: 40%). Sharma, V. K *et al.*, (2017) [23] stated that the maximum growth of no of leaves (10.45 and 15.42), length of petiole (9.19 and 9.18 cm), height of the plant (15.26 cm and 16.27 cm), diameter of crown (17.44 mm and 18.10 mm) obtained from treatment T2 (Perlite + Cocopeat + Vermicompost in ratio of 3:1:1) while the growth is seen in control plot was minimum (Soil). A study conducted by Singh, R., *et al.* (2008) found that vermicompost treatment (7.5 tonn/hac) improved spread of the leaf (10.7%), area of leaf (23.1%), & dry matter (20.7%) while simultaneously increasing overall fruit output (32.7 percent). When vermicompost was substituted for manure in strawberry production, the occurence of physiological disorders like albinism (16.1–4.5 percent), malformation of fruit (11.5–4.0 percent), and incidence of grey mould (10.4–2.1 percent) decreased dramatically, noticing that vermicompost played a vital role in decreasing nutrient-related disorders and diseases such as Botrytis rot, and by the end raising the marketable yield of fruit up to 58.6 percent with good quality parameters.

Effect of growing media on fruit yield:

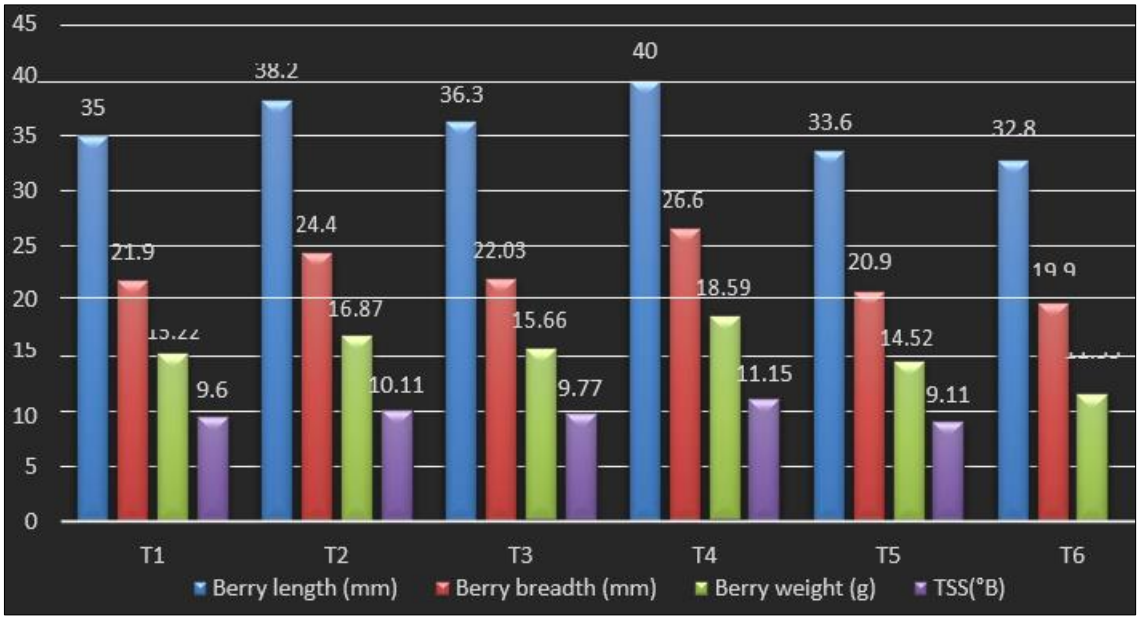
Wysocki, K *et al.*, (2017) [22] reported that fruit yield obtained from past three years of research, the highest yield is obtained from treatment (Peat + coconut crisps 50%:50%) and cultivars of Albion and Polka (2.47kg/m2, 2.43kg/m2) where as lowest yield (honeoye Cultivar 1.31kg/m2) is obtained from treatment (Peat + Coconut fibre 80%:20%). *et al.* (2007), stated that the best TSS were found in a blend of perlite medium (zeolite+ perlite) rather than perlite alone when used as a growth media in strawberry production. Jafarnia *et al.* (2010) [20] stated that higher percentage of TSS was seen when plants were cultivated in a mixtures of perlite for better growth and development. Cantliffe *et al.*, (2008) and Hochmuth (2008) stated that Sweet Charlie strawberry and Camarosa strawberry grew better when they were grown in a mixture of perlite and FYM (1:1). Yavari *et al.*, (2008) [13], Cantliffe *et al.*, (2008), Mashadi *et al.*, (2009), & Rostami *et al.*, (2014) [11] noticed that the strawberry yield gradually changed when substrates consists of various ratios of perlite, cocopeat and farm yard manure are used. Researchers Yuan and colleagues and Verdonck, O., & Demeyer, P. (2001) claimed that various combinations of media have also been observed to promote root aeration, resulting in a better root system and therefore a greater yield of the crop. (Thakur, M., & Shylla, B. 2018) [12]. Du *et al.* (2007) stated different proportions of different growing media have been noticed to enhance aeration of roots resulting in a good root system which results in greater yield.

As reported by G. Paraskevopoulou *et al.* (1995) [17], Cv. Selva produced the greatest total (315 g/plant) & marketable (259 g/plant) yields in soilless culture, although its output in soil was much greater (467g/plant and 382g/plant, total and marketable yield, respectively). Although the estimated yield in soilless culture was approximately 7571 kg per stremma total yield and 6207 kg per stremma marketable and, the estimated yield in soil culture was approximately 2332 kg/stremma total yield and 1915 kg/stremma marketable, owing to the greater plant density per stremma in soilless culture. A study conducted by Alan *et al.* (1994) found that 100 percent perlite and a mixture of 100 percent perlite produced the greatest amount of strawberry and tomato fruit weight and volume. The researchers attribute this to improved physical attributes of the growing medium, which result in greater weight of fruit and fruit volume. According to Ghazvini *et al.* (2007) [1], the use of soilless substrates such as Perlite/Zeolite 3:1 and 1:1 medium provided appropriate water storage capacity, enough aeration, minimal salt stress, and no water constraint for strawberry production in greenhouses. A study conducted by M. Maher *et al.* (2020) [4] found that the highest output of berries per plant was seen under the perlite (75%) + cocopeat (25%) + jeevamrit treatment, while the lowest yield of fruits was reported under the soil + FYM treatment (181.33 g per plant).

According to Linardakis and Manios (1991) [10], the very best higher yield of strawberry is achieved from peat (20%) + perlite (80%), whereas Wang, D *et al*., (2016) found that the very best higher yield of strawberry is obtained from coconut coir. Dinar, (2003) stated that strawberry production under protected cultivation (Greenhouse) provides the advantages of enhanced yield per unit area, early production when market prices are high, comparatively simpler pest control with less chemical usage, and highest fruit quality.

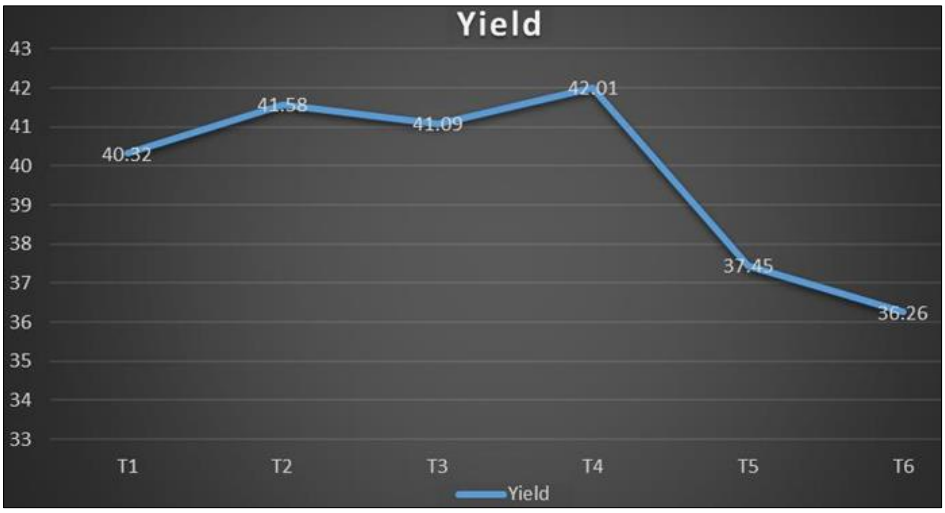
According to Puri (2012) and Kumar *et al.* (2014), the qualities of various materials employed as a soilless growing medium have both direct and indirect impacts on the production of high-quality plant material and the increase in plant productivity. According to Ayesha *et al.* (2011) [6], the treatment T3 (manure of poultry) offered greater accessible P nutrients, greater organic matter, and a higher total organic nitrogen percentage, all of which affected the weight of the fruit (10g) which was extremely significant when compared to the media of control (2g). MM Maher *et al.,* (2020) [4] stated that the largest berry size (26.55 mm and 40 mm, respectively) were obtained in plants grown under the cocopeat (25%) + perlite (75%) + jeevamrit treatment, which was statistically different from all other treatments, whereas the smallest berry size (19.95 mm and 32.75 mm, respectively) were obtained in plants grown in the control (FYM + soil) treatment. According to Bartczak M *et al.* (2007) [7], plants grown in rockwool generated the highest weight (29.2 g), whereas plants grown in a combination of brown coal and disintegrating rockwool produced the lowest weight (11.7 g). A maximum diameter of crown (1.40 cm) was attained on plants cultivated in a mixture of sand, silt, and FYM (1:1:1) at 15cm x 30cm (T1) according to Tariq and colleagues (2013) [8]. Coir (T4) at a 15cm x 30cm size provided the smallest possible crown diameter (1.06 cm).

Hesami *et al.*, (2012) [9] stated that the treatment P2D1C1 (2 parts of perlite + 1 part of date-peat + 1 part of cocopeat) had a significantly greater effect on yield of fruit (88.88g/plant) than the remaining treatments. Among the treatments, D (Date-peat) and C1D1 (1 part date-peat + 1 part cocopeat) produced the least amount of fruit (20.8 and 22.05g/plant, respectively). DK Linardakis *et al.*, (1991) [10] stated that the substrate Perlite 80% +Peat 10% has shown the greatest marketable yield of 248gr/plant, while substrate Perlite 90% + Peat 10% has shown a yield of 237gr/plant. Rostami Z *et al.*, (2014) [11] reported that the high strawberry fruit yield (186.08 g/plant) was observed in treatment of palm with a size of particle of 0-5 mm and the least strawberry yield (89.08 g/plant) resulted in treatment of palm with a size of particle of 10-20 mm. Thakhur M *et al.*, (2018) [12] revealed that the perlite + FYM (T2) treatment produced the highest berry yields per plant (203.32 g) and yield per hectare (50.83 t/ha). The FYM + soil (T6) treatment, on the other hand, produced the lowest berry production per plant (185.11 g) and yield (46.28 t/ha), respectively. According to IIgin M *et al.*, (2002) [14], when yield/plant values for cultivars and hybrids of strawberry were assessed, the maximum yield (452.05 g) was achieved from strawberry of Hybrid No. 320, while the lowest yield (41.32 g) was obtained from Hybrid No. 321. IIgin M *et al.* (2002) [14] reported that the greatest TSS content was identified in Hybrid No. 246 of strawberry at 12.5%, while the lowest value was observed in Hybrid No. 242 of strawberry at 7.25%. According to Marfa Pages *et al.*, (1984) [15] results indicated that slope aligned sacks performed significantly (1%) better than horizontal sacks for both early and total yield of strawberry plants, with a mean difference of 25.5g/plant for early yield and 130g/plant for total yield, and Peat + Perlite mixture performed significantly better than pine bark + perlite for early yield rather than for total yield. According to Ozdemir E *et al.* (1996) [16], solarized freshly produced peat + sand media yielded 838.44g/plant, followed by solarized newly prepared and re-used sand + FYM media yields of 701.28g/plant and 710.32g/plant. According to Ozekar *et al.* (1999) [18], the treatment T3 (Perlite + Pumice) yielded the most fruits (307.30 fruits/plot), whereas the treatment T1 (Perlite) produced the fewest fruits (242.90 fruits/plot). Sara Khalid *et al.*, (2013) [19] stated that the maximum number of fruits (42fruits/plant) seen in T1 (Soil + Silt + FYM in equal proportions) while minimum number of fruits 8 fruits/plant is observed in T5 (planting media + 200g/kg fertilizer). As reported by Hassan A. H. *et al.* (2011) [21], the results revealed that using coconut husks in black bags achieved the greater values for the following characteristics: no of leaves, height of plant and area of total leaves, total N, P and K, average weight of the fruit and firmness, early and total yield per plant, & TSS rather than other treatments (sand + coconut husks, peanut husks and sand + peanut husks).



***Source*:** Maher *et al.*, 2020 [4].

Fig 1: Effect of various soilless substrates and jeevamrut on berry length, berry breadth, berry weight, and Total soluble solids in strawberry cv. Chandler



***Source*:** Maher *et al.*, 2020 [4].

Fig 2: Influence of growing media on yield (tonnes per hectare) of strawberry cv. Chandler

Conclusion

After reviewing the literature based on the research done by different agricultural workers on strawberry fruit crops, it can be concluded that growing media (Organic or Inorganic like Perlite, Cocopeat) play an important role in inducing the qualitative and quantitative factors of the economic importance of the strawberry crop.

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