**Differential substrate and cultivar response of strawberry under hydroponic conditions**

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**Novelty statement:**

1. First indigenously designed hydroponic system in strawberry for urban horticulture
2. Different substrates evaluated for better development of automatic future hydroponic systems.
3. Different varieties evaluated for better development of automatic future hydroponic systems

**Abstract**

Most of the strawberry cultivars available to the growers were screened and evaluated under open soil-based field conditions. Its production is challenging in terms of meagre quality/quantity, short growing season, abiotic stresses etc. Considering the role of substrates in maintaining the optimum growth/yield and the lack of respective studies, our study was undertaken to investigate the response of four strawberry cultivars (Honeoye, Camarosa, Everly and Kimberley) grown hydroponically under different proportions of growing media (Sand, Soil, Coco Peat, Perlite and Saw Dust). A hydroponic system was designed which can be used locally in homes by people living in urban areas with meagre land. All soilless substrates except sand significantly demonstrated improved growth, yield and quality. Significantly maximum vegetative characters, yield vis a vis quality attributes were observed from the plants grown on substrate M2 (coco-peat), whereas, minimum was enumerated in M1 (sand). Among different varieties tried Kimberly recorded an improved vegetative growth, floral, yield and quality characters (TSS, total sugars along with reducing and non reducing sugars, vitamin C/100 g) whereas, minimum respective attributes were recorded from cultivar V1 (Honeoye). The results contributed to endorse that the cultivar ‘Kimberly’ grown in coco peat synergistically improves growth, yield and quality characters under soilless production system of strawberry in passively ventilated greenhouse condition. As such it was recommended that the system developed can be used as a hydroponic model for strawberry cultivation for urban horticulture with coco peat as media and Kimberly as main cultivar.

**Key words:** hydroponics, strawberry, varieties, soilless media, growth, yield.

**Introduction**

Globally *Fragaria* x *ananassa* botanically a berry is grown in wide range of climates including temperate, Mediterranean, and subtropical (Hancock, 2000). The strawberry production is almost double the combined production of all other berry crops (Liston *et al*., 2014). The presence of health promoting bioactive compounds and antioxidants prompted the narrative that the strawberry is nutritiously a high value berry. The biosynthesis of these compounds depends on the variety of factors especially the growing substrate and mineral nutrition during the growing period. In India, temperate regions of Jammu & Kashmir, Himachal Pradesh and Uttarakhand have been known for strawberry cultivation. It is cultivated over 1,000 ha with a total production of 5,000 MT, where Mizoram has emerged the leading producer of strawberry, with the production of 2900 MT from an area of 150 hectares followed by Meghalaya (0.11 ha area and 0.82 Thousand Tonne production), while Jammu and Kashmir ranks 5th with a total production of 0.38 Thousand MT harvested from 0.17 Thousand ha area (Anonymous, 2017). The fruits are highly perishable and thus have limitations in long distance transport in conventional systems of fruit growing*.*

Nutrient management is one of the most important aspects of strawberry plantation because of being a very shallow rooted crop. Even though, soil is an important source of nutrients and water besides giving a physical support to the plant system but there are many delimitations to the soil cultivation of strawberries viz-a-viz to restrictions or prohibitions to the use of fumigants, notorious chemicals to control pests/ diseases (Godoi et al., 2009). Soilless growing can be a potential source to fulfil the demand for strawberry throughout the year Soilless growing system in protected environment has become an increasing trend as it has an positive influence on environment also (Jensen, 1999). Soilless farming systems comprise an artificially created environment supplied with accurate quantities of nutrients and moisture (Ameri et al., 2012). Substrates have properties such as storing water and nutrients, providing appropriate aeration to the root system, being light in weight, and being devoid of harmful organisms. Because of the contamination of agricultural land as a result of the overuse of fertilisers and insecticides, soilless farming is becoming a popular option. It also provides a great advantage with increased yield and productivity per unit area. Soilless culture gives more yields per unit area than traditional cultivation. Strawberry plants have been grown using soilless culture methods, which are often used for tomatoes and peppers. Under this system of cultivation, more no of plants are accommodated on unit area, resukting in more yield per unit area (Ozeker et al.,1999; Paranjpe et al., 2003; Paranjpe et al., 2008). Fruit quality has also improved as a result of the controlled cultivation allowed by this method. Along with the culture system, substrate selection is critical for planning soilless growing (Favaro and Marano, 2003).

The hydroponic system has various advantages, including moisture conservation, year-round production, increased yields, and reduced pesticide use (Resh and Howard, 2012). Furthermore, when compared to soil-grown food, fruits and vegetables grown under hydroponic system have been shown in the literature to have superior nutritional composition and more acceptable sensory qualities. Research on hydroponic has primarily concentrated on peppers, leafy greens, and tomato fruit (Koyama et al., 2013). However, there is a scarcity of scientific evidence on hydroponic strawberry output under protected horticulture. There has never been any work like this done in Kashmir before. Taking these facts into consideration, present investigation was carried out to identify the best cultivar and the growing media under hydroponically grown conditions.

**Materials and Methods**

The Experiment was undertaken under controlled conditions in a Polyhouse in the experimental field of Division of Fruit Science, SKUAST-K, Shalimar Campus, Srinagar during the year 2018. Different growing media were prepared using Sand, Soil, Coco Peat, Perlite and Saw Dust in different proportions. The constituents of growing media were first solar sterilized for a week. Thorough cleaning of the media constituents was done by removing the stones, pebbles and unwanted materials present in it. Vermicompost + media in the ratio of 1:3 was added uniformly to all the media. The respective media were then filled into Perforated PVC pipes of dimensions 10 feet length and 6 inches diameter placed on iron stands of height 3 feet provided with drainage holes for aeration and drainage of excess water. In addition, plants were planted in soil beds of 10 x 10 feet dimension at a distance of 18×30cm under Polyhouse conditions which served as control. The uniform runners of strawberry cultivars Honeoye, Camarosa, Everly & Kimberley, procured from farm nursery of Division of Fruit Science, SKUAST-K were selected for planting and were transplanted in each container. The transplanting was done in the first week of March 2018. Before transplanting root zone of runners were dipped in Ridomil (0.1%) solution. Uniform cultural practices were followed throughout the growing period. Fertigation was provided manually at weekly intervals by dissolving 8 grams of each urea, DAP and Potash (K2SO4) in 100 ml of water and was applied to the root zone of each plant. Furthermore, weeding-cum-hoeing and plant protection measures were carried out as and when required plant spread

The height of the plant, plant spread, and leaf area was recorded as per standard procedures. The date of flowering was recorded when first flower bud opened in each replication of each treatment at the earliest. The number of days taken to flowering from the date of planting was calculated and the mean days required to first flower was worked out (Kidmose *et al*., 1996). Average flush duration, no. of flowers per plant, total no. of berries was also recorded as per standard procedure. Yield in g/ plant was calculated by dividing the recorded yield by the number of surviving plants. Harvesting was done on alternate days, and the total yield (g/plant) was worked out by adding the yield (g/plant) from 2nd week of April to the fourth week of July.

The number of pickings was observed from the tagged plants in each replication by counting the number of time the fruits were harvested and average was drawn to record the data. The weight of the representative fruits of each treatment from each plant was recorded by weighing the individual fruits on an electronic balance and average weight (g) per berry was worked out**.**

**Results**

**Vegetative, floral and yield characters:**

Vegetative and floral parameters studied were significantly influenced by various growing media. All combinations of soilless substrates significantly increased the plant height, plant spread, number of leaves per plant, leaf area, days taken to first flower, flowering duration and number of flowers per plant as compared to M1 (sand) (Table 1). The maximum number of leaves (25.479), plant height (25.278 cm), plant spread (40.913 cm), leaf area (77.823cm2), flowering duration (6.161 days) and number of flowers (22.1837) was recorded from M2 (cocopeat), whereas, minimum number of leaves (18.854), plant height (21.351 cm), plant spread (23.022cm), leaf area (53.093cm2) flowering duration (4.901) and number of flowers (16.3315) was found in M1(sand) during the growing season, respectively (Table 1, Table 2). The maximum plant height (23.669cm), leaf area (67.346 cm2), number of leaves (24.248), number of fruits (14.051), fruit yield/weight (147.852 g) and number of pickings (2.800) was registered in V4 (Kimberly) whereas the minimum plant height (22.806 cm), number of leaves (21.285), leaf area(61.666 cm2), number of fruits (13.594), fruit yield/weight (142.598) and number of pickings (2.600) was recorded in V1 (Henoyene), however fruit length (30.405) and fruit breadth (23.975) was recorded maximum.

**Quality characteristics**

The maximum TSS (8.779%), total sugar (6.350%) and reducing sugars (3.638%) (Table 5a), non-reducing sugar (1.120%) and ascorbic acid (45.076 mg/ 100 g) content (Table 5b) was recorded in M2 (cocopeat), while minimum were found in M1 (sand). The maximum TSS (8.161%), total sugar (5.085%), reducing sugars (3.353%), and ascorbic acid (38.946%) content was recorded in V4 (Kimberly), however non reducing sugar (0.996%) was found maximum in V1 (Henoyene) respectively.

**Discussion**

**Vegetative, floral and yield characters:**

The type of cultivation system and varieties always respond differentially. Differential responses are always seen depending on the type of production system and variety. The primary reason for the differences in vegetative, floral, and yield features could be related to the qualities of different growing substrates, that may have influenced plant growth directly as well as indirectly. According to Schie (1999), coco peat is a medium ion absorbent organic substance. It also has a higher aerial porosity and water and nutrient maintenance capacity (Firoozabadi *et al*., 2009). Because of its high water absorption and higher watering efficiency, perlite is regarded as a substrate with great properties in soilless agriculture (Djedidi et al., 1999; Inden and Torres, 2004). The utilisation of a variety of organic and inorganic substrates in the right proportions maximises water and oxygen retention while also allowing for greater nutrient uptake for adequate growth and development (Bartczak et al., 2007; Albaho et al., 2009; Ayesha et al., 2011; Hesami et al., 2012). A malfunction in the plant photosynthetic system could be one of the physiological explanations for lower growth in a conventional system (soil) (Soltani, 2004). According to Nourizadeh (2003), coco peat and perlite substrates are beneficial in root due to improved element exchange, particularly cations, and adequate moisture distribution, which increases root system and ultimately plant height. Tabatabaei et al. (2006) discovered that perlite mixture treatments boosted plant height. Tehranifar et al. (2007) and Ericisli et al. (2005) found similar results in strawberry, and Tabatabaei and Razaei (2006) found similar results in cucumber. Plant vegetative characteristics like plant height, stem growth, leaf number was higher in soilless culture than in soil cultivation, according to Rumple et al. (1996). Hassan et al. (2011) discovered that coconut husk produced the most leaves and plant height, followed by control (soil cultivation). Similarly, Ericisli et al. (2005) found that soilless surfaces were efficient in promoting the growth of strawberry cultivars both above and below ground. Several previous studies have also reported the favorable effects of soilless substrates on plant growth (Tehranifar *et al*., 2007; Marinou *et al*., 2013). According to Selda and AnapM1i, 2010, perlite contains 6.9% aluminium, which may be released into the solution at low pH and significantly impair strawberry plant growth. It is evident from the investigation that substantial variation existed among the cultivars for plant height, number of leaves, plant spread, leaf area, flowering duration and number of fruits. Apparently, this variation may be due the genetic makeup and varietal differences or varied response of agro climatic conditions to different cultivars.

**Quality characteristics**

Results from the present investigation revealed that TSS, Total sugars, reducing sugars, non-reducing sugars and ascorbic acid content increased significantly under different combinations of soilless substrates. Increased leaf area may have favoured photosynthetic activity, accumulation of sugars and other metabolites in fruits during soilless culture, resulting in increased TSS and sugars in fruits. Similar results were reported by Ozdemir and Kaska (1997) and Ayesha et al. (2011), who found that strawberries produced in soilless culture had higher TSS and better taste than those grown in soil. Gruda and Schnitzler (2004) also reported increase in the dry matter, sugars, soluble solids, vitamins and carotenoids content under soilless culture in tomato. In the present study, significant difference in various combinations of soilless media also observed with respect to TSS, TSS/ acid ratio and sugars. This might be due to the different proportion of cocopeat + perlite + vermicompost change the physical and chemical properties of the substrates, which significantly influenced the quality characteristics in strawberry. The findings are consistent with those of Jafarnia et al. (2010) and Ameri et al. (2012a), who found that different substrate combinations have a beneficial effect on TSS and sugar content. But, the contrasting results were obtained by Cantliffe et al. (2008), according to them the main characteristics related to nutritional quality i.e. TSS, organic acids, soluble sugars and minerals were non-significantly differed under soil and soilless culture system.

Substantial variation also existed among the different cultivars for TSS, total sugar, reducing sugar, non-reducing sugar and ascorbic acid. The reason again may be the genetic makeup of the cultivars/varietal differences or varied response of agro climatic conditions to different cultivars.

**Conclusion**

The findings from this study suggest that the substrates used directly influenced the growth and quality of strawberry fruits grown in a soilless system. All soilless substrates greatly increased strawberry development when compared to M1 (sand), and M2 (coco peat) was found to be the best of all the treatments. Among different varieties tried maximum growth, yield and quality was observed in V4 (Kimberly). Furthermore, the maximum benefit cost ratio of 1.57:1 was recorded from treatment combination M2V4 (Coco Peat + Kimberly). 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. Futher research should examine the nutritional and biochemical composition and other marketable qualities of the strawberry fruits grown in each system, in addition to selection of best hydroponic system for strawberry cultivation. Hence it can be concluded that coco peat is best for the soilless production system of strawberry in passively ventilated greenhouse conditions. Among different substrates and varieties used Kimberly grown in coco peat and fertilised with synthetic fertilizers was found economically profitable with cost benefit ratio of 1.54. The model hydroponic system can be useful for urban horticulture with space constraints.

**References**

Albaho, M., Bhat, N., Abo-Rezq, H. and Thomas, B., 2009. Effect of three different substrates on growth and yield of two cultivars of strawberry. *European Journal of Scientific Research*, 28(2): 227-233.

Ameri, A., Tehranifar, A., Ameri, G.H., Tehranifar, A.A., Davarynejad, G.H. and Shoor, M., 2012. The effects of substrate and cultivar in quality of strawberry. *Journal of Biodiversity and Environmental Sciences,* 6(17): 181- 188.

Ameri, A., Tehranifar, A., Shoor, M. and Davarynejad, G.H., 2012 (a). Effect of substrate and cultivar on growth characteristics of strawberry in soilless culture system. *African Journal of Biotechnology*, 11(56): 11960-11966.

Anonymous. 2017. National Horticulture Board (NHB) 2017-18. www.gov.in

Ayesha, R., Fatima, N., Ruqayya, M., Faheem, H., Qureshi, K.M., Hafiz, I.A., Khan, K.S., M1i, U. and KamM1, A., 2011. Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (Fragaria × ananassa). J*ournal of Medicinal Plants Research*, 5(26): 6224-6232

Bartczak, M., Magelalena, P. and Knaflewski, M., 2007. Effect of substrate on vegetative quality of strawberry plants (Fragaria × ananassa Duch.) produced by a soilless method. Folia Horticulturae annM1s, 19(2): 39-46.

Cantliffe, D. J., Peter, J., Stoffella, B., Elizabeth, M. L., Charles,Powell and Ashwin V., and Paranjpe 2008. Relationship of plant density to fruit yield of ‘Sweet Charlie’ strawberry grown in a pine bark soilless medium in a high-roof passively ventilated greenhouse. *Scientia Horticulturae* **115:** 117–123.

Djedidi, M., Gerasopoulos, D. and Maloupa, E., 1999. The effect of different substrates on the quality of F. Carmello tomatoes *(Lycopersicon esculentum Mill.*) grown under protection in a hydroponic system*. Cahier option Mediterranneenes,* ***31****: 379-383.*

Ericisli S, Sahin U, Esitken A, Anapali O. 2005. Effects of some growing media on the growth of strawberry cvs. Camarosa and Fern. *Acta Agrobotanica*.; 58:185- 191.

Favaro JC, Marano RP (2003). Alterations in the physical and physico-chemical properties of a substrate based on composted sawdust and perlite with polycyclic tomato crops. *Spanish Journal of Agricultural Research* **1**(3):105-109.

Firoozabadi, M., Amrolahi, A. and Hokmabadi, H., 2009. Effect of different concentration of nitrogen, calcium, potassium in soilless growing strawberry (*Fragaria selva*). *Sixth Iranian Congress of Horticultural Science,* Guilan, Iran. pp: 123-124

Godoi, R. S. *et al.* Produção e qualidade do morangueiro em sistemas fechados de cultivo sem solo com emprego de substratos. Ciência Rural, v. 39, n. 4, p. 1039-1044, 2009.

Gruda, N. & Schnitzler, W.H. 2004 Suitability of wood fiber substrates for production of vegetable transplants. II: The effect of wood fiber substrates and their volume weights on the growth of tomato transplants *Scientia Horticulturea* 100:333-340.

Hancock, H. F. and Erez, A. 2000. Strawberries in Temperate fruit crops in warm climates. *Kluwer Academic Publishers, Dordreht, Netherlands*. 445-455.

Hassan, A.H., Khereba, A.H., El-Kattan, M.H., Noha, G. and El- Rahman, A., 2011. Effect of various organic substrate culture and container types on productivity and fruit quality of strawberry (Fragaria × ananassa) cv. FestivM1. *Research Journal of Agriculture and Biological Sciences*, 7(5): 379-387.

Hesami, A., Khorami, S.S., Amini, F. and Kashkooli, A.B., 2012. Date-peat as an alternative in hydroponic strawberry production. *African Journal of Agricultural Research,* **7**(23): 34523458.

Hesami, A., Khorami, S.S., Amini, F. and Kashkooli, A.B., 2012. Date-peat as an M1ternative in hydroponic strawberry production. *African Journal of Agricultural Research,* 7(23): 34523458

Inden, H. and Torres, A., 2004. Comparison of four substrate on the growth and quality of tomatoes. *Acta Hort.* **644**: 205-210.

Jafarnia, S., Khosrowshahi, S., Hatamzadeh, A. and Tehranifar, A., 2010. Effect of substrate and variety on some important quality and quantity characteristics of strawberry production in vertical hydroponics system. *Advances in Environmental Biology*, 4(3): 360-363.

Jensen, M. H. (1999). Hydroponics worldwide. *Acta Hort.* **481:** 719–729.

Kidmose, U., Andersen, H., Vang-Petersen, O., 1996. Yield and quality attributes of strawberry cultivars grown in Denmark (1990-1991). Fruit Varieties Journal, **50**: 160-167.

Koyama, M., Nakamura, C., and Kozo, N., (2013). Changes in phenols contents from buckwheat sprouts during growth stage*. Journal of Food Science and Technology*, **50**(1): 86–91.

Liston, A., Cronn, R. and Ashman, T. L.2014. [Fragaria: A genus with deep historical roots and ripe for evolutionary and ecological i](http://www.amjbot.org/content/101/10/1686.full)nsights. American Journal of Botany, **101**(10): 1686–99.

Marinou, E., Chrysargyris, A. and Tzortzakis, N., 2013. Use of sawdust, coco-soil and pumice in hydroponically grown strawberry. *Plant Soil and Environment*, 59(10): 452-459.

Nourizadeh M. 2003. 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 thesis on horticulture, Guilan University, Iran.

Özdemir, E. and Kaska, N. (1997). The production of early strawberries in new and re-used growing media in sacks under a walk-in tunnel. Acta Horticulturae. 439, 501-508
DOI: 10.17660/ActaHortic.1997.439.85

Ozeker, E., Elter, R.Z., Tuzel, Y., Gul, A., Onal, K. and Tanrisever, A., 1999. Investigation on the effect of different growing media on the yield and quality of strawberries grown in vertical black bags. *Acta Hort.* **486**: 409-413

Paranjpe A.V., Cantliffe D.J., Stoffella P.J., Lamb E.M., Powell C.A.,2008. Relation of plant density to fruit yield of ‘Sweet Charlie’ strawberry grown in a pine bark soilless medium in a high-roof passively ventilated greenhouse. Scientia Horticulturae **115**:117-123

Paranjpe A.V.,Cantliffe D.J.,Lamb E.M, Stoffella P.J.,Powell C.A.,2003., Winter strawberry production in greenhouses using soilless substrates: an alternative to methyl bromide soil fumigation. Proc Fla State Hort Soc **116**:98-105

Resh, H. M., and Howard, M., 2012. Hydroponic food production: A definitive guidebook for the advanced home gardener and the commercial hydroponic grower (7th edition). CRC Press, Santa Barbara, California (U.S.A) pp.1-560.

Rumple J, Felczynski K, Aniszewski SK, Vogel G. 1996. Results of experiments with soilless open field tomato culture in Germany and Poland. *International Society for Soilless Culture*, 373-380.

Schie, W. V., 1999. Standarization of substrates. *Acta Hort.***481**: 71-78.

Selda, O. and Anapali, O., 2010. Effect of soil addition on physical properties of perlite based media and strawberry cv. Camarosa plant growth. Scientific Research and Essays, 5(22): 3430-3433

Soltani, A., 2004. Chlorophyll fluorescence and its application. Internal Press. University of Agricultural Science and Natural Resource, Gorgan, Iran

Tabatabaei, J. and Razaei, R. M., 2006. The effect of different substrate cultivation on the growth and performance greenhouse cucumber in watery cultivation system (hydroponic). *Journal of Agricultural Sciences,* **16**(2): 35-44.

Tehranifar, A., Poostchi, M., Arooei, H. and Nematti, H., 2007. Effects of seven substrates on qualitative and quantitative charactertics of three strawberry cultivars under soilless culture. *Acta Horticulturae*, 761: 485-488.

**Table 1.** **Effect of different growing media on vegetative growth characteristics of Strawberry under hydroponic system.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **plant height** | **plant spread (cm)** | **number of leaves** | **leaf area (cm2)** |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 21.253  | 21.567  | 21.570  | 21.013  | 21.351  | 23.300  | 22.433  | 23.500  | 22.853  | 23.022  | 14.437 | 21.231 | 20.894 | 23.334 | 18.854 | 51.367  | 52.894  | 53.407  | 54.705  | 53.093  |
| M2  | 24.603  | 24.400  | 26.233  | 25.873  | **25.278**  | 40.350  | 41.760  | 40.180  | 41.363  | **40.913**  | 21.456 | 27.234 | 27.747 | 25.876 | **25.479** | 72.637  | 74.807  | 79.107  | 81.740  | **77.823**  |
| M3  | 23.383  | 24.673  | 25.167  | 24.640  | 24.466  | 36.697  | 36.799  | 34.800  | 35.718  | 36.004  | 25.520 | 25.781 | 21.913 | 26.423 | 24.404 | 72.107  | 74.777  | 75.043  | 78.473  | 74.350  |
| M4  | 21.890  | 22.643  | 22.053  | 23.833  | 22.605  | 34.553  | 35.660  | 35.807  | 34.587  | 35.152  | 23.320 | 21.234 | 26.004 | 26.327 | 23.519 | 58.533  | 59.700  | 61.854  | 64.880  | 61.242  |
| M5  | 22.900  | 24.153  | 23.067  | 22.987  | 23.277  | 28.663  | 26.611  | 27.634  | 29.847  | 28.189  | 21.693 | 21.633 | 20.840 | 20.183 | 21.388 | 53.687  | 53.957  | 55.113  | 55.930  | 54.672  |
| **Mean V** | 22.806 | 23.487 | 23.618 | **23.669** |  | 32.713 | 32.653 | 32.384 | **32.874** |  | 21.285 | 23.422 | 23.479 | **24.428** |  | 61.666 | 63.227 | 64.705 | **67.346** |  |
|  **C.D (p≤0.05)** |
| **Factor(M)**  | **0.394** | 0.148 | 1.913 | **0.360** |
| Factor(V)  | 0.352 | 0.132 | 1.672 | 0.322 |
| Factor(M x V)  | 0.787 | 0.296 | 3.125 | 0.721 |

**Table 2.** **Effect of different growing media on flowering characteristics of Strawberry under hydroponic system.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **number of days taken to first flowering** | **flower duration** | **number of flowers per plant** |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 46.180  | 45.773  | 44.693  | 45.770  | 45.604  | 4.590  | 4.693  | 6.034  | 4.286  | 4.901  | 15.655  | 16.342  | 18.654 | 14.675 | 16.331 |
| M2  | 35.030  | 35.557  | 35.157  | 33.337  | **34.770**  | 6.067  | 6.251  | 6.550  | 5.777  | **6.161**  | 21.543  | 20.324  | 21.432 | 25.436 | **22.183** |
| M3  | 39.333  | 39.783  | 39.550  | 38.483  | 39.287  | 6.113  | 6.287  | 6.118  | 5.840  | 6.089  | 19.432 | 22.432  | 18.6543 | 19.876 | 20.098 |
| M4  | 40.667  | 42.647  | 41.993  | 42.257  | 41.891  | 6.219  | 5.669  | 5.517  | 5.364  | 5.692  | 17.854 | 16.675 | 15.456 | 18.765 | 17.187 |
| M5  | 43.634  | 42.773  | 44.804  | 44.689  | 43.975  | 5.554  | 5.475  | 5.707  | 5.653  | 5.597  | 15.546 | 17.543 | 18.678 | 18.543 | 17.577 |
| **Mean V** | 40.969  | 41.307  | 41.240  | **40.907**  |  | 5.709  | 5.675  | **5.985**  | 5.384  |  | 18.006 | 18.6632 | 18.57486 | **19.459** |  |
| **Factor(M)**  | **0.325**  | **0.184**  | 0.653 |
| Factor(V)  | 0.291  | 0.164  | 0.432 |
| Factor(M x V)  | 0.651  | 0.367  | 1.234 |

**Table 3.** **Effect of different growing media on fruit yield characteristics of Strawberry under hydroponic system.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **no. of fruits**  | **fruit yield** | **number of pickings** |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 11.653  | 11.037  | 13.270  | 11.973  | 11.983  | 140.593  | 135.597  | 128.546  | 140.027  | 136.191  | 2.000  | 2.000  | 2.000  | 2.667  | 2.167  |
| M2  | 15.113  | 16.067  | 16.000  | 18.330  | **16.378**  | 156.442  | 156.693  | 154.430  | 161.447  | **157.253**  | 4.000  | 3.333  | 3.000  | 3.333  | **3.417**  |
| M3  | 14.533  | 15.580  | 15.893  | 15.737  | 15.436  | 150.670  | 159.027  | 145.503  | 157.883  | 153.271  | 3.000  | 3.333  | 3.000  | 3.333  | 3.167  |
| M4  | 14.750  | 12.863  | 11.340  | 12.087  | 12.760  | 126.137  | 140.110  | 156.433  | 140.457  | 140.784  | 2.000  | 2.667  | 3.000  | 2.000  | 2.417  |
| M5  | 11.920  | 12.677  | 12.923  | 12.127  | 12.412  | 139.150  | 139.800  | 140.174  | 139.447  | 139.643  | 2.000  | 2.333  | 2.000  | 2.667  | 2.250  |
| **Mean V** | 13.594  | 13.645  | 13.885  | **14.051**  |  | 142.598  | 146.245  | 145.017  | **147.852**  |  | 2.600  | 2.733  | 2.600  | **2.800**  |  |
| **Factor(M)**  | 0.579 | 4.886 | 0.307 |
| Factor(V)  | 0.345 | 2.987 | 0.121 |
| Factor(M x V)  | 1.158 | 8.432 | 0.614 |

**Table 4.** **Effect of different growing media on fruit physical characteristics of Strawberry under hydroponic system.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **fruit weight (g)** | **fruit length (mm)** | **fruit breadth (mm)**  | **fruit length/breadth ratio (mm)**  |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 140.593  | 135.597  | 128.546  | 140.027  | 136.191  | 27.950  | 28.177  | 28.667  | 25.690  | 27.621  | 22.140  | 20.803  | 19.270  | 20.180  | 20.598  | 51.367  | 52.894  | 53.407  | 54.705  | 53.093  |
| M2  | 156.442  | 156.693  | 154.430  | 161.447  | **157.253**  | 32.573  | 31.113  | 31.847  | 32.287  | **31.955**  | 23.227  | 25.500  | 25.857  | 26.443  | **25.257**  | 72.637  | 74.807  | 79.107  | 81.740  | **77.823**  |
| M3  | 150.670  | 159.027  | 145.503  | 157.883  | 153.271  | 30.793  | 32.457  | 32.327  | 31.787  | 31.841  | 25.737  | 25.670  | 25.390  | 23.887  | 25.171  | 72.107  | 74.777  | 75.043  | 78.473  | 74.350  |
| M4  | 126.137  | 140.110  | 156.433  | 140.457  | 140.784  | 31.633  | 30.680  | 29.423  | 30.773  | 30.627  | 25.667  | 24.173  | 25.400  | 25.173  | 25.103  | 58.533  | 59.700  | 61.854  | 64.880  | 61.242  |
| M5  | 139.150  | 139.800  | 140.174  | 139.447  | 139.643  | 28.077  | 28.527  | 29.123  | 28.227  | 28.488  | 23.107  | 21.543  | 21.840  | 21.740  | 22.058  | 53.687  | 53.957  | 55.113  | 55.930  | 54.672  |
| **Mean V** | 142.598  | 146.245  | 145.017  | **147.852**  |  | **30.405**  | 30.191  | 30.277  | 29.953  |  | **23.975**  | 23.538  | 23.551  | 23.485  |  | 61.666 | 63.227 | 64.705 | **67.346** |  |
|  **C.D (p≤0.05)** |
| **Factor(M)**  | 4.886 | 0.594 | **1.059** | **0.360** |
| Factor(V)  | 2.987 | 0.342 | 0.863 | 0.322 |
| Factor(M x V)  | 8.432 | 1.188 | 2.013 | 0.721 |

**Table 5a.** **Effect of different growing media on fruit chemical characteristics of Strawberry under hydroponic system.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Total soluble solids (%)**  | **Total sugar (%)**  | **Reducing sugars (%)**  |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 7.300  | 7.363  | 7.173  | 7.073  | 7.228  | 2.963  | 3.027  | 3.293  | 3.107  | 3.098  | 2.283  | 2.307  | 2.330  | 2.540  | 2.365  |
| M2  | 8.817  | 8.633  | 8.467  | 9.200 | **8.779**  | 5.820  | 6.787  | 6.293  | 6.500  |  **6.350**  | 3.733  | 3.727  | 3.563  | 3.527  | **3.638**  |
| M3  | 7.360  | 8.300  | 8.940  |  9.000 | 8.400  | 5.600  | 5.060  | 5.397  | 6.060  | 5.529  | 3.280  | 3.570  | 3.773  | 3.927  | 3.638  |
| M4  | 7.550  | 7.917  | 7.823  | 8.200  | 7.873  | 4.323  | 4.310  | 5.220  | 4.863  | 4.679  | 3.007  | 3.110  | 3.263  | 3.330  | 3.178  |
| M5  | 7.280  | 7.103  | 7.297  | 7.333  | 7.248  | 3.057  | 2.977  | 2.897  | 4.893  | 3.456  | 2.600  | 2.890  | 3.069  | 2.942  | 2.875  |
| **Mean V** | 7.641  | 7.863  | 7.940  | **8.161**  |  | 4.353  | 4.432  | 4.620  | **5.085**  |  | 2.981  | 3.121  | 3.200  | **3.253**  |  |
| **Factor(M)**  | 0.524 | 0.201 | 0.351 |
| Factor(V)  | 0.342 | 0.180 | 0.532 |
| Factor(M x V)  | 1.215 | 0.403 | 1.333 |

**Table 5b.** **Effect of different growing media on fruit chemical characteristics of Strawberry under hydroponic system.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Non reducing sugars (%)**  | **Vitamin C mg/100g** | **Sensory Evaluation** |
|  | **V1** | **V2** | **V3** | **V4**  | **Mean M** | V1 | V2 | V3 | V4  | Mean M  | **V1** | **V2** | **V3** | **V4**  | **Mean M**  |
| M1  | 0.613  | 0.670  | 0.750  | 0.883  | 0.729  | 29.070  | 41.930  | 28.447  | 27.210  | 31.664  | 3.160  | 3.277  | 3.146  | 3.078  | 3.165  |
| M2  | 1.077  | 1.027  | 1.160  | 1.217  | 1.120  | 40.247  | 39.050  | 41.337  | 59.670  | **45.076**  | 4.093  | 4.373  | 3.470  | 3.493  | 3.858  |
| M3  | 1.630  | 1.007  | 0.780  | 0.987  | 1.101  | 37.933  | 36.080  | 37.150  | 36.553  | 36.929  | 4.117  | 4.041  | 3.654  | 3.617  | 3.857  |
| M4  | 1.007  | 0.723  | 0.510  | 0.637  | 0.719  | 25.020  | 26.533  | 35.660  | 38.033  | 31.312  | 4.010  | 4.193  | 3.910  | 3.573  | 3.922  |
| M5  | 0.653  | 0.557  | 0.653  | 0.357  | 0.555  | 31.227  | 30.000  | 32.420  | 33.263  | 31.728  | 3.040  | 3.340  | 2.890  | 2.607  | 2.969  |
| **Mean V** | **0.996**  | 0.797  | 0.771  | 0.816  |  | 32.699  | 34.719  | 35.003  | **38.946**  |  | 3.684  | 3.845  | 3.414  | 3.274  |  |
| **Factor(M)**  | 0.196 | 0.211 | **0.136** |
| Factor(V)  | 0.107 | 0.189 | 0.122 |
| Factor(M x V)  | 0.393 | 0.422 | 0.272 |