*International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 10 (1) : 51-62, June 2024*

# Effect on vegetative growth and yield attributes of strawberry *Fragaria × ananassa*) cv. Winter Dawn in grown in nutrient film technique under shade net conditions

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*Receipt : 14.10.2023 ; Revised : 24.01.2024 ; Acceptance : 02.02.2024*

**DOI :** 10.53552/ijmfmap.10.1.2024.51-62



**ABSTRACT**

*With the view to assess the growth, production and quality of strawberry cv. Winter Dawn grown in hydroponic system under shed net condition, an experiment was conducted at the Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj during the years 2021-2022 and 2022-2023. The experiment was laid in the Complete Randomized Block Design (CRBD) with three replications and nine treatments. Based on the outcomes of the experiment, the overall best results for vegetative growth and fruiting attributes are shown under the nutrient treatment of Grow at 96 ml + Micro at 104 ml and Bloom at 102 ml feed for 12 hours i.e. at the period of 6 hrs morning and 6 hrs evening of running water. The solution of Grow, Micro and Bloom at a certain concentration and time showed significant increased in vegetative growth like plant height, number of leaves, plant spread, root length as well as fruiting attributes like number of flowers, number. of fruits and average fruit weight of strawberry plant.*

***Keywords*:** Bloom, Grow,Hydroponics, Micro, NFT system, urban farming

## INTRODUCTION

Strawberry (*Fragariax ananassa*) is a member of the Rosaceae family and Fragaria genus. Essentially, it is a little perennial herbaceous plant. In the last two decades, strawberry production and area have increased exponentially due to the fact that the majority of the crop is now grown in greenhouses (Thakur and Shylla, 2018). In India, it is cultivated on 3000 hectares with an annual output of 14,000 MT (NHB 2021), with Haryana being the largest producer (1,650 MT), followed by Mizoram (1,080 MT), Meghalaya, Maharashtra, and Himachal Pradesh (Anonymous, 2019b).The agro- climatic conditions in Uttar Pradesh are favourable for strawberry production, which has the potential to be a lucrative crop. The strawberry plants are strongly affected by the environmental parameters like temperature, photoperiod and light intensity. It requires optimum day temperature of 16ºC to 27ºC and night temperature 7ºC to 13ºC.

It is concerned that certain regions have a dearth of cultivable arable lands due to adverse topographical or geographical characteristics, and that in urban areas, soil and other rooting mix ingredients are just unavailable for crop production. The difficulty of finding suitable labour is a major issue for both traditional open-field agriculture and the pot cultivation technologies. This is an ideal environment for the introduction of soil-less culture or hydroponics. To compensate for the shortage of arable land brought on by a growing population, hydroponics provides an alternate means of cultivating food crops. Hydroponic agriculture is advantageous because it results in tidier plants, more effective use of nutrients since they are tailored to individual plants' requirements, plants that are free of weeds and pests, a greater yield per unit of land, and a higher price per unit of harvest (Puspitahat *et al.*, 2022). The Nutrient Film Technique is a popular hydroponic method for growing food crops (NFT). A thin nutritional layer is provided at the system's base, where plant roots may take up optimal conditions. Plant nutrients are continually cycled through the system for the specified number of hours. A plant's roots can develop in the nutritional solution. Application of this method must account for the potential of surplus water, which will decrease oxygen levels. Because of this, the NFT system's nutrient layer is strategically laid out, with a maximum solution height of 3 mm, to supply the necessary amounts of nutritional water and oxygen (Purbajanti*et al.*, 2017).

Several variables, including water quality, nutrient solution, EC value, nutrient solution pH, water flow rate, gutter slope, medium, and others, must be taken into account for successful hydroponic farming. Most importantly, in hydroponic technology, EC and pH value control of fertilizer solutions are essential (Binaraesa, 2017). To a large extent, the pace at which nutrients are absorbed by the roots in NFT hydroponics is determined by the gutter's slope, as this determines the velocity with which nutrient solution is distributed (Asmana *et al.*, 2017).

Production of strawberry in hydroponic culture eliminates soil borne diseases, pests, and nematodes leading to better vegetative growth parameters, number of fruits, and yield of good quality strawberry fruits. The research work on effect of different growing systems on growth, production and quality attributes of strawberry *(Fragaria x ananassa)* under shade net conditions in India is very limited. Besides, no report is available regarding growing of strawberry in hydroponic system under Prayagraj condition of Uttar Pradesh. Considering advantages of hydroponic system, an investigation was undertaken with the aim to assess the effect on growth, yield and quality analysis of strawberry (*Fragaria x ananassa*) cv. Winter Dawn in NFT (Nutrient Film Technique) system in shade net conditions.

## MATERIAL AND METHODS

The experiment was conducted at the experimental farm Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences(SHUATS), Prayagraj during the years 2021-2022 and 2022-2023 under shade net condition. Prayagraj is located in a climatic zone which experiences hot summer and fairly cold winter. During the investigation in winter months, especially December and January the temperature falls as low as 2°C- 5°C or even low whereas there may be an occasional spell of frost during the winters. However, occasional showers are uncommon during winter months. This investigation was conducted at the experimental farm of SHUATS Research Farm. 350 plants of strawberry cv. Winter Dawn were selectively brought from National Bureau of Plant Genetic Resources (ICAR) Regional Station, Bhovali, Nainital, Uttarakhand, India and planted in hydrophonic system on 14$^{th}$ November 2021. The plants were planted in a small plastic basket inside the high-quality PVC pipe as shown in Fig.1. In one configuration, four 4-foot-long PVC pipes were arranged in two tiers using iron angles, and net pot holes (20) measuring 4 inches in size were cut into the pipes. Spacing of plant to plant 12 cm. and row to row 30.48 cm the perforations were then used to accommodate the hydroponic net pots. A circulatory pump located in the nutrient reservoir tank was responsible for recalculating the nutrient solution throughout the hydroponic unit (Fig. 2 and 3).

The plants were fed with nutrient film method (NFT) as per treatments (Fig.4). The NFT (Nutrient Feeding Technique) is a constant supply of nutrients to the plant roots. Timer is not used rather a submersible water pump is used to pump the nutrient solution into the plant growing tray, the solution flows horizontally encountering the plant roots. The water is then drained out back to the water reservoir through the drain tube. An air pump is used to supply air to the air stone which supplies oxygen to the water-nutrient solution. The plants are grown in a plastic container that has holes at the bottom so that the roots can dangle into the constantly flowing water supply. 3-nutrients set were feed in the experiment. The nutrient sets were procured from Ponic Greens Agro Pvt Ltd., Plot No 511, Golf Course Road, sector 43, Gurugram 122002, India. The nutrient sets (liquid form) are Nute Grow, Nute Micro &Nute Bloom. The nutrients composition of the sets are described in the table.

| **Nute Grow (G) : NPK: 1-0-4** | **Nute Micro (M): NPK: 2-0-0** | **Nute Bloom (B): NPK: 1-3-4** |
|---|---|---|
| Total Nitrogen (N) 1% ((NH4) 1%). Water-soluble Potassium-Oxide (K2O) 4%. Derived from: magnesium nitrate, potassium nitrate. | Total Nitrogen (N) 2% ((NH4) 2%). Water-soluble Calcium (Ca) 2.4%. Water-soluble Magnesium (Mg) 0.1%. | Total Nitrogen (N) 1% ((NH4) 0.05%, (NO3) 0.4% & (NO2) 0.55%) Available Phosphate (P2O5) 3% |
| | Boron (B) 0.02%. | Water-soluble Potassium-Oxide (K2O) 4% |
| | Iron (Fe) 0.05% (chelated Iron (Fe) 0.05%). Manganese (Mn) 0.02% (chelated Manganese (Mn) 0.02%). Derived from: calcium nitrate, magnesium nitrate, iron EDTA, iron DTPA, EDDHA iron, manganese EDTA, and boric acid. | Sulfur (S) 0.2%. Derived from: mono calcium phosphate, monoammonium phosphate, potassium nitrate, potassium sulfate, and urea |

**Treatment Details**

**Factor 1 : Water flow schedule**

**[Morning (M) +Evening (E)]**

I. Total 4 hrs. of water flow i.e. 2 hrs. of morning and 2 hrs. of evening
II. Total 6 hrs. of water flow i.e. 3 hrs. of morning and 3 hrs. of evening
III. Total 12 hrs. of water flow i.e. 6 hrs. of morning and 6 hrs. of evening

**Factor 2 : Plant growth stages**

**(different stages of plant have been counted from the date of planting (14th November) in the system**

I. $S_1$ : Seedling stage (1-6 weeks)
II. $S_2$ : Vegetative growth stage (6-10 weeks)
III. $S_3$ : Transition stage (10-12 weeks)
IV. $S_4$ : Bloom and ripening stage (12-16 weeks)

The experiment was laid in the Complete Randomized Block Design (CRBD) with nine treatments and three replications in each treatment. Number of plants taken in each replication were nine. So, total number of plants in the experiment was (9x3x9)=plants are 243. The treatment combination has been presented in Table 1.

**Application of nutrients to the strawberry plants**

For preparing the nutrient solution initially two nutrient stock solutions A and B of capacity 100 liters were prepared and then diluted to 200 litres capacity tank which were connected to the drip line. The concentration (ppm) of nutrients in solution supplied through drip line as per treatments at different stages of Plant growth. In each replicated treatment a 15-litre capacity water can was used (Fig.3) and 15 litre water is fed to the plants daily in recycling system (Fig 3). The water is changed from the hydroponic system every 15-days interval. Under no circumstances should plants be allowed to suffer from water stress. Once in a week, plain water was applied to flush out the excess salts which remained in the root zone to prevent the increase in electrical conductivity (EC) in the root zone.

**Observation taken**

Plant height, plant spread and root length were taken 120 days after planting from each plant. Using a measuring scale, average height of each plant was measured from the crown to the tips of the leaves (cm). The plant spread (cm) was determined by using a measuring scale to observe the canopy of the plant in both the East-West and North-South directions. The average root length (cm) in centimetres was calculated from the root lengths of 10 randomly chosen plantlets grown in each replication. The number of flowers was calculated from each representative plant at monthly intervals after first flowering till end of the season and their average was taken. The weight of fruit was recorded with the help of weighing balance and fruit weight calculated and expressed in grams (g) as per the

**Table 1: Treatment combination applied instrawberry cv. Winter Dawn**

| Treatments | Nutrient doses ml/15Liters of water | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 hours- M (2) +E (2) | | | | 6 hours- M (3) +E (3) | | | | 12 hours-M (6) +E (6) | | | |
| | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_1$ | $S_2$ | $S_3$ | $S_4$ |
| | G M B | G M B | G M B | G M B | G M B | G M B | G M B | G M B | G M B | G M B | G M B | G M B |
| $T_1$ | 6,6,6 | 09,09,06 | 06,11,11 | 06,13,13 | 7,7,7 | 09,09,07 | 07,11,11 | 07,13,13 | 8,8,8 | 10,10,08 | 08,12,12 | 08,14,14 |
| $T_2$ | 9,9,9 | 11,11,09 | 06,13,13 | 09,15,15 | 10,10,10 | 12,12,10 | 10,14,14 | 10,16,16 | 11,11,11 | 13,13,11 | 11,15,15 | 11,17,17 |
| $T_3$ | 12,12,12 | 14,14,11 | 12,16,16 | 12,18,18 | 13,13,13 | 15,15,13 | 13,17,17 | 15,19,19 | 14,14,14 | 16,16,14 | 14,18,18 | 14,20,20 |
| $T_4$ | 15,15,15 | 17,17,15 | 15,19,19 | 15,21,21 | 16,16,16 | 18,18,16 | 18,22,22 | 16,24,24 | 17,17,17 | 19,19,17 | 17,21,21, | 17,23,23 |
| $T_5$ | 18,18,18 | 20,20,18 | 18,22,22 | 18,24,24 | 19,19,19 | 21,21,18 | 21,25,25 | 19,27,27 | 20,20,20 | 22,22,20 | 22,24,24 | 20,26,26 |
| $T_6$ | 21,21,21 | 23,23,21 | 21,25,25 | 21,27,27 | 22,22,22 | 24,24,22 | 24,26,26 | 22,28,28 | 23,23,23 | 25,25,23 | 25,27,27 | 23,29,29 |
| $T_7$ | 24,24,24 | 26,26,24 | 24,28,28 | 24,30,30 | 25,25,25 | 27,27,25 | 27,29,29 | 25,31,31 | 26,26,26 | 28,28,26 | 28,30,30 | 26,32,32 |
| $T_8$ | 27,27,27 | 29,29,27 | 27,31,31 | 27,33,33 | 28,28,28 | 30,30,28 | 30,32,32 | 28,34,34 | 29,29,29 | 31,31,29 | 31,33,33 | 29,35,35 |
| $T_9$ | 30,30,30 | 32,32,30 | 30,34,34 | 30,36,36 | 31,31,31 | 33,33,31 | 33,35,35 | 31,37,37 | 32,32,32 | 34,34,35 | 34,34,32 | 32,36,36 |

Total nutrient solution applied from 1st day of feeding to last day of feeding i.e., Date of planting (14th November) to date of final harvest (25th February)

$T_1$ – 91 (ml) Nute grow, 123 (ml) Nute micro, 117 (ml) Nute bloom

$T_2$ – 123(ml) Nute grow, 156(ml) Nute micro, 150(ml) Nute bloom

$T_3$ – 164(ml) Nute grow, 192(ml) Nute micro, 185(ml) Nute bloom

$T_4$ – 200(ml) Nute grow, 194(ml) Nute micro, 191(ml) Nute bloom

$T_5$ – 238(ml) Nute grow, 268(ml) Nute micro, 261(ml) Nute bloom

$T_6$ – 274(ml) Nute grow, 300(ml) Nute micro, 294(ml) Nute bloom

$T_7$ – 310(ml) Nute grow, 336(ml) Nute micro, 330(ml) Nute bloom

$T_8$ – 346(ml) Nute grow, 372(ml) Nute micro, 366(ml) Nute bloom

$T_9$ – 382(ml) Nute grow, 404(ml) Nute micro, 399(ml) Nute bloom

**Table 2:Plant growth of strawberry cv. Winter Dawn, as affected by Nutrient Film Technique (NFT) in shade net conditions during 2021 and 2022**

| | Plant height (cm) at 120 days after planting in NFT System | | | | | | | | | Plant Spread (cm) at 120 days after planting in NFT System | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | | | 2022 | | | Pooled | | | 2021 | | | 2022 | | | Pooled | | |
| | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs |
| $T_0$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $T_1$ | 12.02 | 14.9 | 15.57 | 12.92 | 15.8 | 16.47 | 12.47 | 15.35 | 16.02 | 23.92 | 21.33 | 23.68 | 25.56 | 20.97 | 24.64 | 24.74 | 21.15 | 24.16 |
| $T_2$ | 12.59 | 15.26 | 15.93 | 13.72 | 16.39 | 17.06 | 13.16 | 15.83 | 16.5 | 21.29 | 22.09 | 22.74 | 22.46 | 23.26 | 23.93 | 21.88 | 22.68 | 23.34 |
| $T_3$ | 12.82 | 15.44 | 16.11 | 13.98 | 16.6 | 17.27 | 13.29 | 15.93 | 16.6 | 21.25 | 22.82 | 23.49 | 22.47 | 24.04 | 24.71 | 21.86 | 23.43 | 24.10 |
| $T_4$ | 12.95 | 15.59 | 16.26 | 14.15 | 16.79 | 17.46 | 13.49 | 16.12 | 16.79 | 21.42 | 21.93 | 22.6 | 22.68 | 23.19 | 23.86 | 22.05 | 22.56 | 23.23 |
| $T_5$ | 14.09 | 16.89 | 17.56 | 14.45 | 17.25 | 17.92 | 13.7 | 16.42 | 17.09 | 22.72 | 23.21 | 23.88 | 23.14 | 23.63 | 24.3 | 22.93 | 23.42 | 24.09 |
| $T_6$ | 15.72 | 18.55 | 19.22 | 17.32 | 20.15 | 20.82 | 16.22 | 19.02 | 19.69 | 24.59 | 24.96 | 25.63 | 26.01 | 26.38 | 27.05 | 25.3 | 25.67 | 26.34 |
| $T_7$ | 15.12 | 17.88 | 18.55 | 16.48 | 19.24 | 19.91 | 15.29 | 18.07 | 18.74 | 22.86 | 23.01 | 23.68 | 24.52 | 24.67 | 25.34 | 23.69 | 23.84 | 24.51 |
| $T_8$ | 15.22 | 17.99 | 18.66 | 16.68 | 19.45 | 20.12 | 16.2 | 19 | 19.67 | 22.79 | 22.68 | 23.35 | 24.31 | 24.2 | 24.87 | 23.55 | 23.44 | 24.11 |
| $T_9$ | 15.09 | 17.84 | 18.51 | 16.89 | 19.24 | 19.51 | 16.06 | 18.62 | 19.09 | 21.75 | 22.93 | 25.6 | 24.21 | 24.39 | 26.06 | 22.98 | 23.66 | 25.83 |
| | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** |
| **Pot Media** | **0.315** | **0.651** | * | **0.313** | **0.645** | * | **0.236** | **0.488** | * | **0.288** | **0.595** | * | **0.235** | **0.485** | * | **0.229** | **0.472** | * |
| **Treat-ments** | **0.63** | **1.301** | * | **0.625** | **1.29** | * | **0.473** | **0.976** | * | **0.577** | **1.191** | * | **0.47** | **0.97** | * | **0.457** | **0.944** | * |

**Table 3:Root length and flower production in strawberry cv. Winter Dawn, as affected byNutrient Film Technique (NFT)in shade net conditions during 2021 and 2022**

| | Root Length (cm) at 120 days after planting in NFT System | | | | | | | | | Number of flowers per plant in NFT System | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | | | 2022 | | | Pooled | | | 2021 | | | 2022 | | | Pooled | | |
| | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs |
| $T_0$ | 0 | 0 | 0 | 1.02 | 1.02 | 1.02 | 0.51 | 0.51 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $T_1$ | 23.77 | 24.57 | 25.24 | 24.98 | 25.78 | 26.45 | 24.38 | 25.18 | 17.52 | 31.79 | 38.04 | 38.71 | 32.69 | 38.94 | 39.61 | 32.24 | 38.49 | 39.16 |
| $T_2$ | 23.75 | 25.32 | 25.99 | 24.99 | 26.56 | 27.23 | 24.37 | 25.94 | 16.7 | 27.22 | 31.91 | 32.58 | 28.15 | 33.04 | 33.71 | 27.69 | 32.48 | 33.15 |
| $T_3$ | 23.92 | 24.43 | 25.1 | 25.2 | 25.71 | 26.38 | 24.48 | 25.52 | 17.09 | 28.45 | 33.26 | 33.93 | 29.61 | 34.42 | 35.09 | 28.42 | 33.17 | 33.84 |
| $T_4$ | 25.22 | 25.71 | 26.38 | 25.66 | 26.15 | 26.82 | 24.79 | 25.29 | 17.04 | 30.45 | 35.54 | 36.21 | 31.65 | 36.74 | 37.41 | 30.05 | 35 | 35.67 |
| $T_5$ | 25.36 | 25.51 | 26.18 | 27.04 | 27.19 | 27.86 | 26.13 | 26.45 | 16.81 | 36.45 | 42.37 | 43.04 | 36.81 | 42.73 | 43.4 | 33.63 | 39.14 | 39.81 |
| $T_6$ | 27.09 | 27.46 | 28.13 | 28.53 | 28.9 | 29.57 | 26.91 | 27.04 | 17.97 | 39.12 | 44.93 | 45.6 | 40.48 | 46.29 | 46.96 | 38.94 | 44.64 | 45.31 |
| $T_7$ | 25.29 | 25.18 | 25.85 | 26.83 | 26.72 | 27.39 | 26.1 | 26.12 | 18.73 | 37.39 | 42.98 | 43.65 | 38.99 | 44.58 | 45.25 | 36.56 | 41.94 | 42.61 |
| $T_8$ | 24.25 | 25.43 | 28.1 | 26.73 | 26.91 | 28.58 | 26.91 | 27.19 | 18.61 | 34.12 | 39.3 | 39.97 | 35.58 | 40.76 | 41.43 | 36.02 | 41.57 | 42.24 |
| $T_9$ | 24.66 | 25.82 | 26.49 | 25.77 | 26.93 | 27.6 | 25.01 | 26.18 | 18.07 | 31.79 | 36.67 | 37.34 | 33.19 | 38.07 | 38.74 | 36.16 | 41.5 | 42.17 |
| | **SE (m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** | **SE(m)** | **C.D. at 5%** | **F-test** |
| **Pot Media** | **0.309** | **0.638** | * | **0.154** | **0.319** | * | **0.203** | **0.418** | * | **0.402** | **0.831** | * | **0.403** | **0.831** | * | **0.398** | **0.821** | * |
| **Treat-ments** | **0.618** | **1.276** | * | **0.309** | **0.638** | * | **0.405** | **0.837** | * | **0.805** | **1.661** | * | **0.805** | **1.662** | * | **0.796** | **1.642** | * |

**Table 4:** Fruit production and fruit weight (g) in strawberry cv. Winter Dawn, as affected by Nutrient Film Technique (NFT) in shade net conditions during 2021 and 2022

| | Number of fruits per plant in NFT system | | | | | | | | | Average fruit weight (g) in NFT system | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | | | 2022 | | | Pooled | | | 2021 | | | 2022 | | | Pooled | | |
| | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs | 4hrs | 6hrs | 12hrs |
| $T_0$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $T_1$ | 10.95 | 11.1 | 11.87 | 11.35 | 11.3 | 11.97 | 11.15 | 11.2 | 11.92 | 39.92 | 42.1 | 42.77 | 40.82 | 43 | 43.67 | 40.37 | 42.55 | 43.22 |
| $T_2$ | 14.95 | 15.5 | 16.17 | 15.05 | 17.1 | 17.77 | 15 | 16.3 | 16.97 | 41.92 | 44.2 | 44.87 | 43.35 | 45.33 | 46 | 42.64 | 44.77 | 45.44 |
| $T_3$ | 15.28 | 16.1 | 16.77 | 14.98 | 17.3 | 17.97 | 14.97 | 16.4 | 17.07 | 42.49 | 44.78 | 45.45 | 43.65 | 45.94 | 46.61 | 42.79 | 45.07 | 45.74 |
| $T_4$ | 15.28 | 16.1 | 16.77 | 14.14 | 16.46 | 17.13 | 14.71 | 16.28 | 16.95 | 44.91 | 47.55 | 48.22 | 46.11 | 48.75 | 49.42 | 44.3 | 46.77 | 47.44 |
| $T_5$ | 14.62 | 15.13 | 15.8 | 14.58 | 16.59 | 17.26 | 14.93 | 16.35 | 17.02 | 45.86 | 48.63 | 49.3 | 46.22 | 48.99 | 49.66 | 45.57 | 48.27 | 48.94 |
| $T_6$ | 16.62 | 17.74 | 18.41 | 16.45 | 18.87 | 19.54 | 16.04 | 17.68 | 18.35 | 47.22 | 49.99 | 50.66 | 48.58 | 50.55 | 51.32 | 46.75 | 48.97 | 49.69 |
| $T_7$ | 15.62 | 16.48 | 17.15 | 15.28 | 17.64 | 18.31 | 14.95 | 16.39 | 17.06 | 44.91 | 47.39 | 48.06 | 46.37 | 48.85 | 49.52 | 46.12 | 48.74 | 49.41 |
| $T_8$ | 14.95 | 15.5 | 16.17 | 14.81 | 16.86 | 17.53 | 15.72 | 17.3 | 17.97 | 46.7 | 49.4 | 50.07 | 48.3 | 50.2 | 50.67 | 47.76 | 50.1 | 50.67 |
| $T_9$ | 14.28 | 14.75 | 15.42 | 14.18 | 16.15 | 16.82 | 14.57 | 15.83 | 16.5 | 44.79 | 47.25 | 47.92 | 46.19 | 48.65 | 49.32 | 46.45 | 49.03 | 49.7 |
| | SE (m) | C.D. at 5% | F-test | SE(m) | C.D. at 5% | F-test | SE(m) | C.D. at 5% | F-test | SE(m) | C.D. at 5% | F-test | SE(m) | C.D. at 5% | F-test | SE(m) | C.D. at 5% | F-test |
| **Pot Media** | **0.335** | **0.691** | * | **0.434** | **0.896** | * | **0.235** | **0.485** | * | **0.306** | **0.631** | * | **0.31** | **0.64** | * | **0.305** | **0.63** | * |
| **Treat-ments** | **0.669** | **1.382** | * | **0.868** | **1.793** | * | **0.47** | **0.971** | * | **0.612** | **1.262** | * | **0.621** | **1.281** | * | **0.61** | **1.259** | * |

formula given below- Average fruit weight = Total weight of Fruits (g) / Numbers of Fruits.

The data were analysed by a statistical method known as the Complete Randomized Block Design (CRBD) "analysis of variance method" to look into the connections between the variables (Panse and Sukhatme, 1985). Each component of the combined s2 and dn1 variances may be traced back to a unique cause. F values were calculated by comparing the variance of the replication and treatment effects with the variance of the error, and P values of 0.05 were used to evaluate statistical significance. A key difference was established for mean comparisons across treatments at the 5% level of significance.

## RESULTS AND DISCUSSION

### Plant height (cm)

The data regarding the plant height (cm) of strawberry cv. Winter Dawn was found significantly affected by different treatments and timing of running water in hours as indicated by Table 2. It was found that Treatment $T_6$ (96,104,102 ml of G, M, B respectively) when applied with 12 hours of running water, it recorded the maximum plant height [19.22 (2021-22), 20.82 (2022-23) and 19.69 (Pooled)] cm over all other treatments during both the years of study as well as pooled analysis. It was followed by Treatment $T_8$ (120,128,126) with 12 hours of running water which recorded the 2$^{nd}$ best plant height [18.66 (2021-22), 20.12 (2022-23) and 19.67 (Pooled)] cm. The minimum height of plant [12.02 (2021-22), 12.92 (2022-23) and 12.47 (Pooled)] cm was recorded in treatment $T_1$ (27, 39, 36 ml of G, M, B respectively) with 4 hours of running water during both the years of study as well as pooled analysis. Higher plant height under $T_6$ and $T_8$ may be attributed to optimum availability of macronutrients and micronutrients for better plant growth. These elements affect the meristematic growth of plant and the $CO_2$ fixation is enhanced which, leads to enhanced photosynthesis(Abdullah *et al.*, 2021). The macronutrient Nitrogen, especially, when applied at optimum level has a growth promoting effect by affecting the production of cytokinin, which in turn affects the elasticity of cell wall and increases the meristematic cells (Bloom *et al.*, 2006).Similar findings have been reported by Abdullah *et al.* (2021) and Hindersah *et al.* (2021) while working

**Figure - 1**


**Figure - 2**

**Figure - 3**

**Figure - 4**

on strawberry. However, hydroponically grown plants had more height than the pot culture grown plants. This may be due to continued supply of nutrients to the roots than in the pot culture media. It was also observed by Kulkarni *et al*. (2017) that plants grown in hydroponically settings (Spinach-28.33cm and Coriander-47.21cm) had somewhat better height when compared to soil grown plants.

**Plant spread (cm)**

The data regarding the plant spread (cm) of strawberry cv. Winter Dawn was found significantly affected by different treatments and timing of running water in hours as indicated by Table 2. It was found that Treatment $T_6$ (96,104,102 ml of G, M, B respectively) when applied with 12 hours of running water, it recorded the maximum plant spread [25.63 (2021-22), 27.05 (2022-23) and 26.34 (Pooled)] cm over all other treatments during both the years of study as well as pooled analysis. It was followed by Treatment $T_9$ (132,136,135 ml of G, M, B respectively) with 12 hours of running water, which recorded the 2nd best plant spread [25.6 (2021-22), 26.06 (2022-23) and 25.83 (Pooled)] cm. It was also observed that treatment $T_9$ (132,136,135 ml) was found at par with treatment $T_6$ (96,104,102 ml) when applied with 12 hours of running water. The minimum spread of plant during 2021-22 i.e., 21.25 cm was recorded in treatment $T_3$ (50,60,57 ml) with 4 hours of running water where-as during 2022-23 the minimum spread of 22.46 cm was found under treatment $T_2$ (35,48,46 ml) with 4 hours of running water. According to pooled analysed data the minimum spread of the plant 21.86 cm was found under treatment $T_3$ (50,60,57 ml) with 4 hours of running water. The plant spread was higher because in hydroponic system, all the nutrients were sufficiently available for plants due to the controlled pH condition in the hydroponic system (Sharma *et al*., 2018). The optimum availability of both macronutrients and micronutrients through Nute grow, Nute Micro and Nute bloom led to the vigorous increase in plant spread. Another reason may be that there is very less mechanical hindrance than any other mediums of growth in hydroponics; as a result, plant grows vigorously. Similar results were reported by Chow *et al*. (2002) while working on strawberry hydroponic system.

**Root Length (cm)**

120 days after planting, the root length (cm) of strawberry cv. Winter Dawn was found significantly affected by different treatments and timing of running water in hours as indicated by Table 3. It was found that Treatment T6 (96,104,102 ml of G, M, B respectively) with 12 hours of running water recorded the maximum root length [28.13 (2021-22), & 29.57 (2022-23)] cm over all other treatments during both the years of study but pooled analysis data showed T8 (120,128,126 ml of G, M, B respectively) with 12 hours of running water was found the best with 28.36 cm root length. The minimum root length (cm) i.e., 23.75 cm was found under treatment $T_2$ (35,48,46) with 4 hours of running water during 2021-22 where-as during 2022-23, 24.98 cm of root length was found minimum under treatment $T_1$ (27,39,36) with 4 hours of running water. However, according to pooled data, 24.37 cm root length was found minimum under treatment $T_2$ (35, 48, 46) with 4 hours of running water. The highest root length may be due to optimum availability of phosphorous which help in root growth and development. Due to its limited mobility, fixation by the soil, and low diffusion coefficient, phosphorus is commonly used as a fertilizer. Similar results were also reported by Noh *et al*. (2017) and Tohidloo *et al*. (2018). It was also found that hydroponically grown plants had more root length than the pot culture grown plants. This may be because of optimum nutrient availability in hydroponics due running water containing nutrients while in pot culture media in which the nutrients were lost due to fixation. Similar results were observed by Girdthai *et al*. (2010) while working on peanut and Horibe (2017) while working on edible opuntia.

**Number of flowers per plant**

It was observed that Number of flowers per plant increased throughout the period of observation till the harvest stage during both the years (2021-22 and 2022-23) of study. The data regarding It was observed that the Number of flowers per plant of strawberry cv. Winter Dawn were significantly influenced by different treatments and timing of running water in hours as indicated by Table 3. It was found that Treatment $T_6$ (96,104,102 ml of G, M, B respectively ) with

12 hours of running water recorded the maximum number of flowers per plant[45.6 (2021-22),46.96 (2022-23)& 45.31 (Pooled)] over all other treatments during both the years of study as well as pooled data. It was followed by Treatment $T_7$ (108,116,114 ml of G, M, B respectively) with 12 hours of running water which recorded the 2nd best treatment with [43.65 (2021-22), 45.25 (2022-23 ml)& 42.61 (Pooled)]number of flowers per plant during both the years of study and pooled data. The minimum Number of flowers per plant [27.22 (2021-22), 28.15(2022-23) & 27.69 (Pooled)] was recorded in treatment $T_2$ (35, 48, 46 ml) with 4 hours of running water during both the years of study and pooled analysis data. The number of flowers increased due to availability of optimum plant nutrients through the hydroponic system. The availability of all the nutrients led to biosynthesis of growth regulators like Auxin and cytokinin (Halbert-Howard *et al*., 2021). Auxin might have been involved in the floral bud initiation of plants, while cytokinin may have been involved in nutrient mobilization to the reproductive structures (Renau-Morata *et al*., 2021). Similar reports were reported by Caruso *et al*. (2011) and Rana and Prasad (2022).The hydroponically grown strawberry had a greater number of flowers per plant than the plants grown by pot culture. This may be due to optimum nutrient availability in hydroponics where running water containing nutrients while in pot culture media in which the nutrients were lost due to volatilization by the action of microbes. Similar results were observed by Rana and Prasad (2022) while working on strawberry.

**Number of fruits per plant**

The data regarding the number of fruits per plant of strawberry cv. Winter Dawn were significantly influenced by different treatments and timing of running water in hours as indicated by Table 4. It was found that Treatment $T_6$ (96,104,102 ml of G, M, B respectively) & $T_2$ (46, 56, 54 ml of G, M, B respectively) with 12 hours of running water recorded the maximum number of fruits per plant [18.41 (2021-22), 19.54 (2022-23) & 18.35 (Pooled)] over all other treatments during both the years of study as well as pooled data. It was followed by Treatment $T_7$ (108,116,114 ml) with 12 hours of running water which recorded the 2nd best treatment with [17.15 (2021-22) &18.31 (2022-23)] number of fruits per plant during both the years of study whereas according to pooled data, treatment $T_8$ (120,128,126 ml) with 12 hours of running water was found 2nd best with 17.97number of fruits per plant. The minimum number of fruits per plant [10.95 (2021-22) & 11.35 (2022-23)] was recorded in treatment $T_1$ (27, 39, 36 ml) with 4 hours of running water during both the years of study as well as pooled analysis data.

The Treatment $T_6$ containing Nutegrow, Nute Micro and Nute bloom @ 96ml, 104ml and 102 ml respectively in 15l of water with 12 hours of running water recorded maximum number of fruits per plant. This is because nutrients are continuously available with the ideal pH, more starch, carbohydrates, and photosynthesis accumulates, leading to more blooms per plant and a greater rate of fruit set, which results in more fruits per plant. Similar results were reported by Shawer (2014) while working on cucumber and Halbert-Howard *et al*. (2021) while working on tomato. The number of fruits per plant was higher in hydroponically grown plants due to the fact that in hydroponics culture the plant roots were provided with nutrients directly which lead to profuse growth of above ground plant parts. The higher vegetative growth led to higher photosynthesis in plants leading to availability of nutrients to the reproductive sinks leading to increase in number of fruits per plant. Similar reports were also observed by Chow *et al*. (2002) and Rana and Prasad (2022).

**Average fruit weight (g)**

It was observed that the average fruit weight (g) of strawberry cv. Winter Dawn were significantly influenced by different treatments and timing of running water in hours as indicated by Table 4. It was found that Treatment $T_6$ (96,104,102 ml of G, M, B respectively) with 12 hours of running water recorded the maximum average fruit weight (g) [50.66 (2021-22) & 51.32 (2022-23)] g over all other treatments during both the years of study whereas according to pooled data, treatment $T_8$ (120,128,126 ml of G, M, B respectively) with 12 hours of running water recorded significantly best treatment with 50.67 g average fruit weight. It was also found that treatment $T_8$ (120,128,126 ml) was found at par with $T_6$ (96,104,102 ml) with 12 hours of running water during both the years of study whereas according to pooled data, $T_6$ (96,104,102), $T_7$ (108,116,114 ml) & $T_9$ (132,136,135 ml) were found at par with $T_8$ (120,128,126 ml) with 12 hours of running water. The minimum average fruit weight [39.92 (2021-22), 40.82 (2022-23) & 40.37 (Pooled)] was recorded in treatment $T_1$ (27, 39, 36 ml) with 4 hours of running water during both the years of study as well as pooled analysis data.The Treatment $T_6$ containing Nute grow, Nute Micro and Nute bloom @ 96ml, 104ml and 102 ml respectively in 15l ml of water with 12 hours of running water recorded maximum average fruit weight. With the optimal availability of nutrients to the plant's roots and the perfect pH, more starch, carbohydrates, and photosynthesis accumulate, resulting in higher fruit weight. The optimal availability of K in plants causes an increase in carbon content, which in turn influences dry matter and fruit yield (Lim *et al.*, 2015).

## CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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