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Influence of different levels of pH of nutrient solution & TDS of micronutrients mixture on vegetative growth, flowering and fruit setting of strawberry (*Fragaria x ananassa* L.) grown in Aeroponics system

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Abstract
In 2023-24, a study was conducted at the Department of Horticulture, NAI, SHUATS, Prayagraj (U.P.). For the experiment, seven treatments were utilized to examine the impact of varying pH levels of cooper's solution and TDS of micronutrient mixture on strawberry plants (*Fragaria x ananassa* L.) in a Completely Randomised Design. The treatments were replicated three times to ensure precise and reliable results. The aim of the experiment was to determine the effect of different levels of pH of cooper’s solution and TDS of micronutrient mixture on the growth, yield and quality of strawberry (*Fragaria x ananassa* L.) in aeroponics. According to the findings of this study, treatment T_3: [Cooper’s Nutrient solution with pH 6.0] was found best with vegetative attributes like [10.02 (30 DAT), 15.91 (60 DAT), 17.02 (90 DAT), 19.12 (120 DAT)] cm plant height, [17.04 (30 DAT), 23.01 (60 DAT), 23.98 (90 DAT), 24.97 (120 DAT)] cm plant spread, [10.58 (30 DAT), 18.01 (60 DAT), 24.21 (90 DAT), 25.37 (120 DAT)] number of leaves per plant, [4.12 (30 DAT), 7.42 (60 DAT), 90 DAT), 12.84 (120 DAT)] cm2 leaf area and 27.98 cm root length; flowering attributes like 44.22 total number of flowers per plant, 60.44 days taken to first flowering and 85.45 days taken to first fruit set; yield attributes like 18.85 number of fruits per plant, 53.49 g average fruit weight and 4.3 kg yield per setup and quality attributes like 74.84 mg/100 g of pulp ascorbic acid, 14.45 moisture and dry weight ratio, 9.01 °brix TSS and 1.52% titrable acidity.

Keywords: Cooper’s solution, flowering, *Fragaria x ananassa*, growth, Micronutrient mixture, pH, quality, strawberry, TDS, yield

Introduction
Strawberries have gained a reputation for being widely distributed as soft fruits all over the world. This is due to their genetic diversity, their ability to thrive in different environments, and their highly heterozygous nature (Childers *et al.*, 1995) [15]. This plant belongs to the Rosaceae family and Fragaria genus. This plant is a compact herbaceous perennial. The strawberry is a result of crossbreeding between two species, *Fragaria chiloensis* Duch. and *Fragaria virginiana* Duch. It has a chromosome number of 56 (2n) and a basic chromosome number of 7 (x) (Bowling, 2000) [4]. According to Darnell (2003) [10], this fruit falls under the category of aggregate fruits, characterized by the presence of achenes on the surface of a red fleshy receptacle.
According to Zhang *et al.* (2014) [39], China is the top producer of strawberries, with an estimated yield of 2.99 million MT. The USA follows with 1.36 million MT, while Mexico, Turkey, and Spain produce 0.37 million MT, 0.37 million MT, and 0.31 million MT respectively. According to a study conducted by Bhat and Hussain (2023) [3], the strawberry cultivation area in India spans around 1000 hectares, yielding a production of 5000 metric tons. It is primarily grown in the mountainous areas of India. Strawberry production in Maharashtra surpasses that of all other states. Pradesh, Mahabaleshwar in Maharashtra, Jammu and Kashmir, Bangalore, and Kalimpong in West Bengal are notable regions known for their cultivation. Strawberry cultivation has seen significant success in the flat regions of the country in recent years.

The fruit is renowned for its exquisite flavor and captivating scent. This ingredient is frequently utilized in the preparation of delectable ice cream, sorbets, pies, jams, fruit juices, and milkshakes owing to its potent fragrance. According to Considine (1982) [7], strawberries contain a variety of components such as water, carbohydrates, fiber, protein, ash, fat, potassium, calcium, sodium, iron, vitamin A, vitamin C, thiamin, riboflavin, and niacin. According to a study conducted by Sun *et al.* (2002) [37], the product has a significant amount of anthocyanins and shows impressive antioxidant properties.

Soils possess specific constraints that can impede the growth and progress of plants. These include undesirable soil compaction, unsuitable soil pH levels, inadequate drainage, erosion, disease- causing organisms, and nematodes (Fussy and Papenbrock, 2022) [15]. In urban areas, the availability of soil for crop cultivation is restricted due to the dense population. Certain regions face challenges with limited availability of fertile arable lands, primarily due to unfavorable topographical or geographical conditions (Sengupta and Banerjee, 2012) [33]. Considering the decline in available arable land, it is of utmost importance to explore alternative solutions in order to address the needs of a rapidly expanding population. Therefore, Aeroponics offers an alternative approach to crop production.

Aeroponics is a state-of-the-art technique for protected cultivation, allowing plants to flourish throughout the year in a closed, dark chamber that is filled with a nutrient solution aerosol. In this case, the surplus nutrient solution that is not absorbed by the roots is usually either recycled or discarded (Christie and Nichols, 2003) [6].

Plants are cultivated in a controlled environment where their roots and lower stem are sprayed with a water solution containing essential nutrients. This method, known as aeroponic growing, allows for suspended growth. The foliage and upper part, referred to as the canopy, extend vertically. The plant roots are separated by the structure that provides support to the plant. Typically, closed-cell foam is compressed and inserted into an opening in the aeroponic chamber to minimize labor and expenses (Nichols, 2021) [27].

The efficient functioning of various plant processes, such as the development of the plant cell wall, photosynthesis, respiration activities, formation of chlorophyll, activity of enzymes, synthesis of hormones, fixation of nitrogen, and reduction activities, is influenced by the uptake and metabolism of macronutrients. On the other hand, micronutrients play a crucial role in improving the overall quality, yield, and post-harvest longevity of horticultural produce, as stated by Rajatha *et al.* (2019) [28]. Monitoring the pH levels is essential for ensuring optimal nutrient absorption by plants in an aeroponic system that recycles water and nutrients.

Using a spray system to nourish roots in aeroponic systems can greatly reduce the amount of liquid required, making it easier to control nutrient concentration and maintain pH stability. It is important to maintain proper TDS levels in order to avoid nutrient imbalances and promote effective nutrient absorption. This is crucial for promoting healthy vegetative growth, flower development, and fruit production (Sangeetha and Periyathambi, 2024) [31].

Keeping in view the above facts this experiment titled "Influence of different levels of pH of nutrient solution & TDS of micronutrients mixture on vegetative growth, flowering and fruit setting of strawberry (*Fragaria x ananassa* L.) grown in aeroponic system" was designed and carried out.

Materials and Methods

The experiment was conducted at the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Science (SHUATS), Prayagraj, in the year 2023-24. The experimental site is located on the left side of the Allahabad-Rewa Road, in close proximity to the Yamuna River, at a distance of approximately 8 kilometers from Allahabad city. The experiment is located at a latitude of 25.57°N and a longitude of 81.51°E. During the winter months, specifically in December and January, the temperature can reach as low as 2 °C- 5 °C or even lower. On the other hand, in the summer months (May-June), temperatures can soar to a scorching 49 °C. Summers often bring intense heat waves, while winters can experience sporadic frost. Annual precipitation usually falls between 850 to 1100 mm, with the majority occurring from July to September.

The treatments of the experiment consisted of: T_1: Cooper's Nutrient solution with pH 5.0, T_2: Cooper's Nutrient solution with pH 5.5, T_3: Cooper's Nutrient solution with pH 6.0, T_4: Cooper's Nutrient solution with pH 6.5, T_5: Micronutrients mixture with 500ppm, T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

The aeroponics enclosures are constructed with PVC boxes that have dimensions of 350 mm X 320 mm X 200 mm. Each box is equipped with motors, two misters, and one timer to effectively control the spray rate. The recommended spacing between plants in aeroponics cultivation is commonly set at 15 cm, as suggested by Hasan *et al.* (2018) [19] study. Based on the measurements of 35.56 cm x 32 cm x 20.32 cm, a plastic tote box was chosen to house 4 plants per box for cultivation purposes. The plants were carefully placed in net pots filled with clay balls, which allows for optimal root growth without any restrictions.

Applying fertilizers to crops in the correct ratio involves the process of feeding them with nutrients through water. When discussing nutrient feeding, it is important to apply fertilizers with the appropriate combination, concentration, EC, and pH for each fertigation cycle. Hollow cone and flat fan nozzles are commonly used in aeroponics. The spray angle range of the flat fan nozzle is from 65º to 110º, while the hollow cone nozzle has a range of 45º to 90º. The nozzle achieved a uniform coverage of 50 cm in height. The sprayers operated from 9 am to 6 pm, running for 20 seconds every 4 minutes, and from 6 pm to 9 am, running for 20 minutes every 8 minutes, all for the purpose of irrigation. For the purpose of fertigation, the sprayers operated from 10 am to 11 am, spraying for 20 seconds at 4-minute intervals. The strawberry cultivar (Winter Dawn) plantlets were obtained from the tissue culture laboratory of the Department of Biotechnology, Shuats, and then transferred to the aeroponics culture system. The plants received a nutrient solution based on Cooper's (1979) [8] recommendations. The nutrient concentrations in the Cooper solution were carefully measured and consisted of specific amounts of N, P, K, Ca, Mg, S, Fe, Cu, Zn, Mn, B, and Mo. These concentrations were determined to be 200, 60, 300, 170, 50, 68, 1, 0.1, 0.1, 2, 0.3, and 0.2 mg L-l, respectively (Asao, 2012) [2]. In addition to these nutrients, micronutrients were provided through a product called Combi-2. This product contained six essential micronutrients, namely Zn, Fe, Mn, Cu, B, and Mo, at concentrations of 4%, 2%, 0.5%, 0.3%, 0.54%, and 0.1% (w/w).

The experiment utilized a Completely Randomised Design with three replications for each of the seven treatment combinations (Fisher and Yates, 1953) [14]. Vegetative attributes like Plant height (cm), Plant spread (cm), Number of leaves, Leaf Area (cm2) at 30, 60, 90 and 120 DAP and Root length (cm); Flowering attributes like

Total number of flowers per plant, Days taken to first flowering and Days taken to first fruit initiation; Yield parameters like Number of fruits per plant, Average fruit weight (g) and Average yield or Yield per setup (kg) and Quality attributes like Ascorbic acid (mg/100g), Moisture and dry weight (ratio), Total Soluble Solids (º Brix) and Titrable acidity (%) were successfully recorded.

Results and Discussion

A statistical analysis was performed to examine the growth, yield, and quality characteristics of strawberry (*Fragaria x ananassa* L.). According to the findings, the incorporation of various treatments resulted in a notable enhancement in all the characteristics. From the data analysis, it can be inferred that the variances exhibited statistical significance, as the calculated F value surpassed the tabulated F value.

Growth attributes

Plant height (cm): According to data (Table 1; Fig 1), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum plant height (cm) i.e., [10.02 (30 DAT), 15.91 (60 DAT), 17.02 (90 DAT), 19.12 (120 DAT)] cm whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest plant height (cm) i.e., [6.44 (30 DAT), 11.42 (60 DAT), 13.91 (90 DAT), 15.89 (120 DAT)] cm.

Plant spread (cm): Data depicting the plant spread (cm) is shown in Table 1; Fig 1, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum plant spread (cm) i.e., [17.04 (30 DAT), 23.01 (60 DAT), 23.98 (90 DAT), 24.97 (120 DAT)] cm whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest plant spread (cm) i.e., [12.22 (30 DAT), 20.1 (60 DAT), 21.14 (90 DAT), 23.02 (120 DAT)] cm.

Number of leaves per plant: The data pertaining to number of leaves per plant (Table 2; Fig 2) shows treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum number of leaves per plant i.e., [10.58 (30 DAT), 18.01 (60 DAT), 24.21 (90 DAT), 25.37 (120 DAT)] whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest number of leaves per plant i.e., [6.58 (30 DAT), 12.89 (60 DAT), 16.89 (90 DAT), 19.05 (120 DAT)].

Leaf area (cm2): According to data (Table 1; Fig 1), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum Leaf area (cm2) i.e., [4.12 (30 DAT), 7.42 (60 DAT), 11.12 (90 DAT), 12.84 (120 DAT)] cm2 whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest Leaf area (cm2) i.e., [2.61 (30 DAT), 5.99 (60 DAT), 9.38 (90 DAT), 11.01 (120 DAT)] cm2.

Root length (cm): According to data (Table 3; Fig 3), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum root length (cm) i.e., 27.98 cm whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest root length (cm) i.e., 24.34 cm.

Flowering attributes

Total number of flowers per plant: The data regarding total number of flowers per plant is shown in Table 3; Fig 3, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum total number of flowers per plant i.e., 44.22 whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with total number of flowers per plant i.e., 32.89.

Days taken to first flowering: The data pertaining to days taken to first flowering (Table 3; Fig 3) shows treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the minimum days taken to first flowering i.e., 60.44 days whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with highest days taken to first flowering i.e., 79.91 days.

Days taken to first fruit set: Data depicting the days taken to first fruit set is shown in Table 3; Fig 3, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the minimum days taken to first fruit set i.e., 85.45 days whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with highest days taken to first fruit set i.e., 116.16 days.

Yield Attributes

Number of fruits per plant: According to data (Table 4; Fig 4), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum number of fruits per plant i.e., 18.85 whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest number of fruits per plant i.e., 10.74.

Average fruit weight (g): The data regarding average fruit weight (g) is shown in Table 4; Fig 4, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum average fruit weight (g) i.e., 53.49 g whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest average fruit weight (g) i.e., 42.78 g.

Yield per setup (kg): Data depicting yield per setup (kg) is shown in Table 4; Fig 4, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum Yield per setup (kg) i.e., 4.03 kg whereas effect of treatment T_7: [Micronutrients mixture with

700ppm] was found significantly the least effective with lowest yield per setup (kg) i.e., 1.84 kg.

Quality Attributes

Ascorbic acid (mg/100g of pulp): According to data (Table 5; Fig 5), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum ascorbic acid (mg/100g of pulp) i.e., 74.84 mg/100 g of pulp whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest ascorbic acid (mg/100g of pulp) i.e., 39.85 mg/100 g of pulp.

Moisture and dry weight (ratio): The data regarding moisture and dry weight (ratio) is shown in Table 5; Fig 5, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly minimum moisture and dry weight (ratio) i.e., 14.45 whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with highest moisture and dry weight (ratio) i.e., 19.21.

TSS (°Brix): Data depicting TSS (°Brix) is shown in Table 5; Fig 5, where it was found that treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly the maximum TSS (°Brix) i.e., 9.01 °Brix whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest TSS (°Brix) i.e., 6.41 °Brix.

Titrable acidity (%): According to data (Table 5; Fig 5), it was observed that the treatment T_3: [Cooper's Nutrient solution with pH 6.0] recorded significantly maximum Titrable acidity (%) i.e., 1.52% whereas effect of treatment T_7: [Micronutrients mixture with 700ppm] was found significantly the least effective with lowest Titrable acidity (%) i.e., 1.26%.

Discussion

The application of different treatments had a significant impact on the growth, flowering, yield and quality attributes of strawberry (*Fragaria x ananassa* L.). Most plants prefer a slightly acidic pH range of 6.0 to 7.0. Fluctuations in pH levels can have negative effects on plants, potentially leading to toxicities or nutrient deficiencies that hinder their growth and development (Gillespie *et al.*, 2020) [17]. The utilization of treatment T_3, specifically Cooper's Nutrient solution with a pH of 6.0, resulted in an enhanced nitrogen uptake by the plant. This, in turn, facilitated a more rapid absorption of nitrogen through the stomata located on the plant's leaves. According to Loudari *et al.* (2022) [23], these factors could potentially result in a boost in chlorophyll production, an acceleration in photosynthesis, an increase in dry matter production, and ultimately, a positive impact on the plant's height and spread. A study conducted by Fimbres-Acedo *et al.* (2023) [12] documented similar findings during their research on leafy vegetables.

Modifying the pH of the nutrient solution in aquaponics can have an impact on the leaf count of strawberry plants. Strawberries have a preference for slightly acidic conditions, as mentioned by Natsheh *et al.* (2015) [26]. However, it is important to note that excessively low pH levels can have negative effects on nutrient uptake, resulting in stunted growth and reduced leaf production and leaf area, as discussed by Long *et al.* (2017) [22]. Treatment T_3 involved the application of a nutrient solution with a pH of 6.0, which effectively provided the plant roots with all the essential nutrients they needed. Nitrogen plays a vital role in the growth of plants. When plants were provided with nitrogen through cooper's solution at a pH level below 6.0, they exhibited a higher number of leaves per plant. It is likely that in this scenario, the plants' enhanced ability to utilize potassium has also resulted in the growth of more leaves with a greater leaf area (Silva Filho *et al.*, 2022) [36]. Rajatha *et al.* (2019) [28] also documented similar reports regarding tomatoes.

The lowest pH level recorded in the study was 5.0, and it was observed that this level of acidity had a negative impact on root length. This suggests that low pH levels directly hinder root growth, likely due to the high concentration of hydrogen ions (H+) present in the nutrient solution at low pH, which restricts the elongation of roots (Rorison 1980) [29]. The restricted release of net H+ by H + -ATPase and the inability to regulate the cytoplasmic pH of root cells can lead to limited root growth. This, in turn, can result in impaired plant growth and reduced biomass production when the soil/nutrient solution pH is low (Rosas *et al.*, 2007; Schubert *et al.*, 1990) [30, 32]. Similar findings were also documented by Zhao *et al.* (2017) [40] in their study on tomato and Li *et al.* (2018) [21] in their research on lettuce.

The observed improvements in flower production and early fruit development can be attributed to the optimal nitrogen availability provided by treatment T_3: [Cooper's Nutrient solution with pH 6.0]. In a study conducted by Dalvi *et al.* (2008) [9], it was found that a higher nitrogen content had a direct impact on the vegetative growth and storage of food reserves in plants. This, in turn, led to an increase in early flower bud differentiation and ultimately resulted in a higher number of flowers per plant during the early stage. Phosphorous plays a crucial role in various biological components such as nucleic acid, protoplasm, and amino acids. It is also involved in the creation of phyto-hormones like auxins, gibberellins, and cytokines. These hormones contribute to the development of more flowers per plant and early fruit set (Thompson, 2011) [38]. Cooper's solution may have also contributed to optimizing the Boron levels in a similar manner. Research has shown that boron plays a crucial role in various plant processes, such as hormone movement, pollen germination, carbohydrate and nitrogen metabolism, respiration, water metabolism, and water relation. These functions have been found to contribute to an increase in the number of flowers per plant, as well as earlier flowering and fruitset (Shireen *et al*, 2018) [35]. Similar results were also found by Anugoolprasert *et al.* (2012) [1] and Findenegg (1987) [1].

Based on the research conducted by Msimbira and Smith (2020) [25], the most optimal results in terms of fruit production per plant, fruit weight, and overall yield were achieved when utilizing Cooper's Nutrient solution with a pH level of 6. The pH range mentioned here is crucial for optimal nutrient absorption by plants, leading to robust foliage growth, abundant flowering, and successful fruit formation. As per Meselmani (2021) [24], the precise utilization of NPK and micronutrients through the use of cooper's solution has demonstrated a positive impact on both the quantity and weight of fruits produced per plant. The process has enhanced the synthesis and deposition of photo-assimilates, leading to the generation of plant growth regulators and their effective transportation to the plant's reproductive organs. Findings from a study conducted by Halbert-Howard *et al.* (2021) [18] on tomatoes and another study by Sharma *et al.* (2021) [34] on Indian gooseberries revealed similar results.

Significant changes were observed in the titrable acidity, TSS, and ascorbic acid levels when treatment T_3 (Cooper's Nutrient solution with pH 6.0) was applied using the aeroponics approach. This could be attributed to the enhanced availability of macronutrients and micronutrients provided through Cooper's solution at regular intervals, all within controlled conditions. It is possible that the ratio of source to sink mobility has increased due to the plant's taller height, higher Leaf Area Index, and more robust root development. As a result, there has been an increase in the Total Suspended Solids (TSS) levels. In their research, El-Behairy *et al.* (2002) [11] arrived at similar conclusions.

Influence on the relationship between moisture and dry weight ratio in plants can be observed due to several factors such as nutrient availability, pH of the nutrient solution, and plant physiology (Gentili *et al.*, 2018) [16]. Alterations in pH can have an effect on the enlargement of cells and the pressure exerted by the cell contents in plant cells. According to Lager *et al.* (2010) [20], maintaining higher pH levels can enhance enzyme activity and metabolic processes that contribute to cell expansion. This can result in larger, more hydrated cells and increased moisture content in plant tissues. One possible explanation for the decrease in moisture content and dry weight ratio in treatment T_3 could be: The pH of Cooper's Nutrient solution is 6.

Table 1: Effect of pH of nutrient solution & TDS of micronutrients mixture on plant height (cm) & Plant spread (cm) of strawberry (*Fragaria x ananassa* L.)

Treatment Symbol	Plant Height (cm)				Plant Spread (cm)			
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP
T_1	8.24	13.46	15.71	17.45	14.32	21.61	22.74	24.09
T_2	9.59	15.32	16.54	18.34	16.45	22.72	23.4	24.52
T_3	10.02	15.91	17.02	19.12	17.04	23.01	23.98	24.97
T_4	9.87	15.69	16.89	18.73	16.82	22.81	23.69	24.75
T_5	7.12	12.44	15.01	16.66	13.15	20.64	22.17	23.71
T_6	6.89	11.98	14.64	16.27	12.81	20.37	21.88	23.48
T_7	6.44	11.42	13.91	15.89	12.22	20.1	21.14	23.02
F-test	S	S	S	S	S	S	S	S
S.E. (m) (±)	0.18	0.21	0.15	0.16	0.22	0.12	0.13	0.09
C.D. @ 5%	0.56	0.63	0.46	0.49	0.67	0.37	0.39	0.28
CV	3.85	2.62	1.66	1.6	2.59	0.97	0.97	0.66

T_1: Cooper's Nutrient solution with pH 5.0; T_2: Cooper's Nutrient solution with pH 5.5; T_3: Cooper's Nutrient solution with pH 6.0; T_4: Cooper's Nutrient solution with pH 6.5; T_5: Micronutrients mixture with 500ppm; T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

Table 2: Effect of pH of nutrient solution & TDS of micronutrients mixture on number of leaves per plant & Leaf area (cm2) of strawberry (*Fragaria x ananassa* L.)

Treatment Symbol	Number of leaves per plant				Leaf area (cm2)			
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP
T_1	8.54	15.44	21.01	22.38	3.35	6.72	10.31	12.19
T_2	10.09	16.33	22.38	23.51	3.97	7.26	10.8	12.64
T_3	10.58	18.01	24.21	25.37	4.12	7.42	11.12	12.84
T_4	10.35	17.32	23.29	24.44	4.02	7.32	10.96	12.74
T_5	7.49	14.51	19.32	21.25	2.89	6.28	9.87	11.59
T_6	7.04	13.82	18.27	20.33	2.74	6.14	9.78	11.42
T_7	6.58	12.89	16.89	19.05	2.61	5.99	9.38	11.01
F-test	S	S	S	S	S	S	S	S
S.E. (m) (±)	0.18	0.25	0.38	0.32	0.08	0.08	0.09	0.07
C.D. @ 5%	0.54	0.77	1.14	0.98	0.23	0.25	0.26	0.21
CV	3.58	2.84	3.13	2.51	3.84	2.08	1.45	0.99

T_1: Cooper's Nutrient solution with pH 5.0; T_2: Cooper's Nutrient solution with pH 5.5; T_3: Cooper's Nutrient solution with pH 6.0; T_4: Cooper's Nutrient solution with pH 6.5; T_5: Micronutrients mixture with 500ppm; T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

Table 3: Effect of pH of nutrient solution & TDS of micronutrients mixture on root length (cm), total number of flowers per plant, days taken to first flowering & days taken to first fruit set of strawberry (*Fragaria x ananassa* L.)

Treatment Symbol	Root length (cm)	Total number of flowers per plant	Days taken to first flowering	Days taken to first fruit set
T_1	26.51	38.85	69.69	101.17
T_2	26.9	40.52	64.52	93.61
T_3	27.98	44.22	60.44	85.45
T_4	27.59	42.52	62.48	89.53
T_5	25.78	36.79	74.57	106.69
T_6	25.37	35.09	76.41	110.24
T_7	24.34	32.89	79.91	116.16

F-test	S	S	S	S
S.E. (m) (±)	0.16	0.59	0.7	1.4
C.D. @ 5%	0.49	1.79	2.14	4.24
CV	1.06	2.64	1.75	2.41

T_1: Cooper's Nutrient solution with pH 5.0; T_2: Cooper's Nutrient solution with pH 5.5; T_3: Cooper's Nutrient solution with pH 6.0; T_4: Cooper's Nutrient solution with pH 6.5; T_5: Micronutrients mixture with 500ppm; T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

Table 4: Effect of pH of nutrient solution & TDS of micronutrients mixture on number of fruits per plant, average fruit weight (g) & yield per setup (kg) of strawberry (*Fragaria x ananassa* L.)

Treatment Symbol	Number of fruits per plant	Average fruit weight (g)	Yield per setup (kg)
T_1	14.73	47.97	2.83
T_2	16.99	50.93	3.46
T_3	18.85	53.49	4.03
T_4	17.92	52.21	3.74
T_5	12.98	46.12	2.4
T_6	11.95	44.98	2.15
T_7	10.74	42.78	1.84
F-test	S	S	S
S.E. (m) (±)	0.38	0.48	0.08
C.D. @ 5%	1.14	1.45	0.24
CV	4.37	1.72	7.56

T_1: Cooper's Nutrient solution with pH 5.0; T_2: Cooper's Nutrient solution with pH 5.5; T_3: Cooper's Nutrient solution with pH 6.0; T_4: Cooper's Nutrient solution with pH 6.5; T_5: Micronutrients mixture with 500ppm; T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

Table 5: Effect of pH of nutrient solution & TDS of micronutrients mixture on Ascorbic acid (mg/100g of pulp), Moisture and dry weight (ratio), TSS (°Brix) & Titrable acidity (%) of strawberry (*Fragaria x ananassa* L.)

Treatment Symbol	Ascorbic acid (mg/100g of pulp)	Moisture and dry weight (ratio)	TSS (°Brix)	Titrable acidity (%)
T_1	57.6	16.61	7.79	1.4
T_2	65.92	15.56	8.45	1.48
T_3	74.84	14.45	9.01	1.52
T_4	70.38	15.01	8.73	1.5
T_5	51.12	17.42	7.24	1.34
T_6	44.85	18.01	6.96	1.32
T_7	39.85	19.21	6.41	1.26
F-test	S	S	S	S
S.E. (m) (±)	1.52	0.21	0.13	0.01
C.D. @ 5%	4.62	0.61	0.38	0.03
CV	4.57	3.4	4.5	1.79

T_1: Cooper's Nutrient solution with pH 5.0; T_2: Cooper's Nutrient solution with pH 5.5; T_3: Cooper's Nutrient solution with pH 6.0; T_4: Cooper's Nutrient solution with pH 6.5; T_5: Micronutrients mixture with 500ppm; T_6: Micronutrients mixture with 600ppm and T_7: Micronutrients mixture with 700ppm.

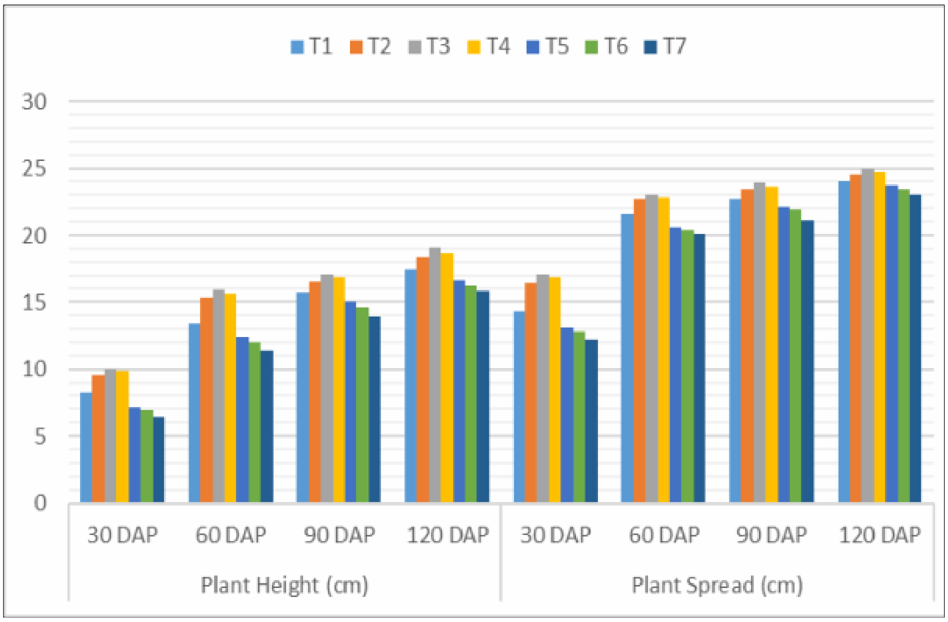

Fig 1: Effect of pH of nutrient solution & TDS of micronutrients mixture on plant height (cm) & Plant spread (cm) of strawberry (*Fragaria x ananassa* L.)

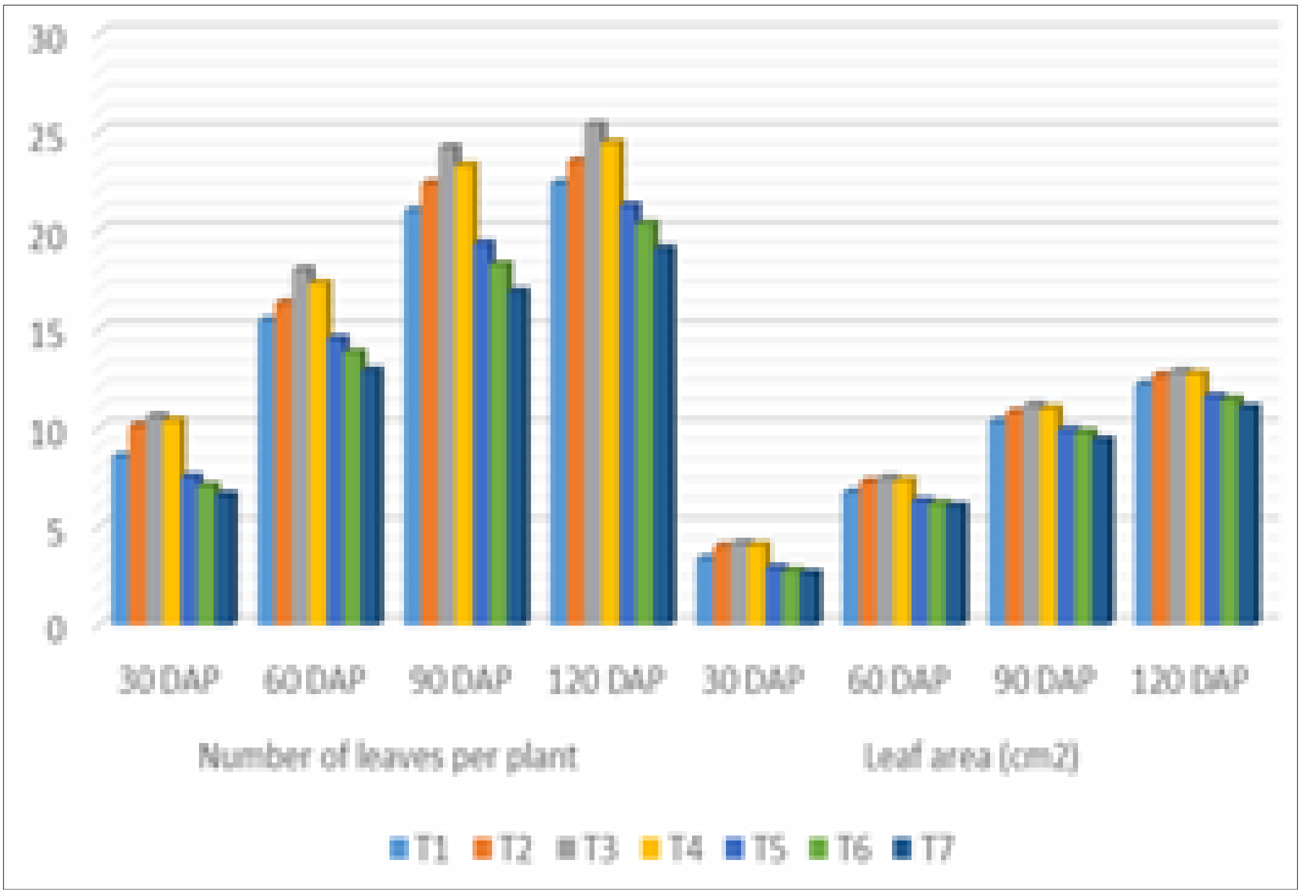

Fig 2: Effect of pH of nutrient solution & TDS of micronutrients mixture on number of leaves per plant & Leaf area (cm2) of strawberry (*Fragaria x ananassa* L.)

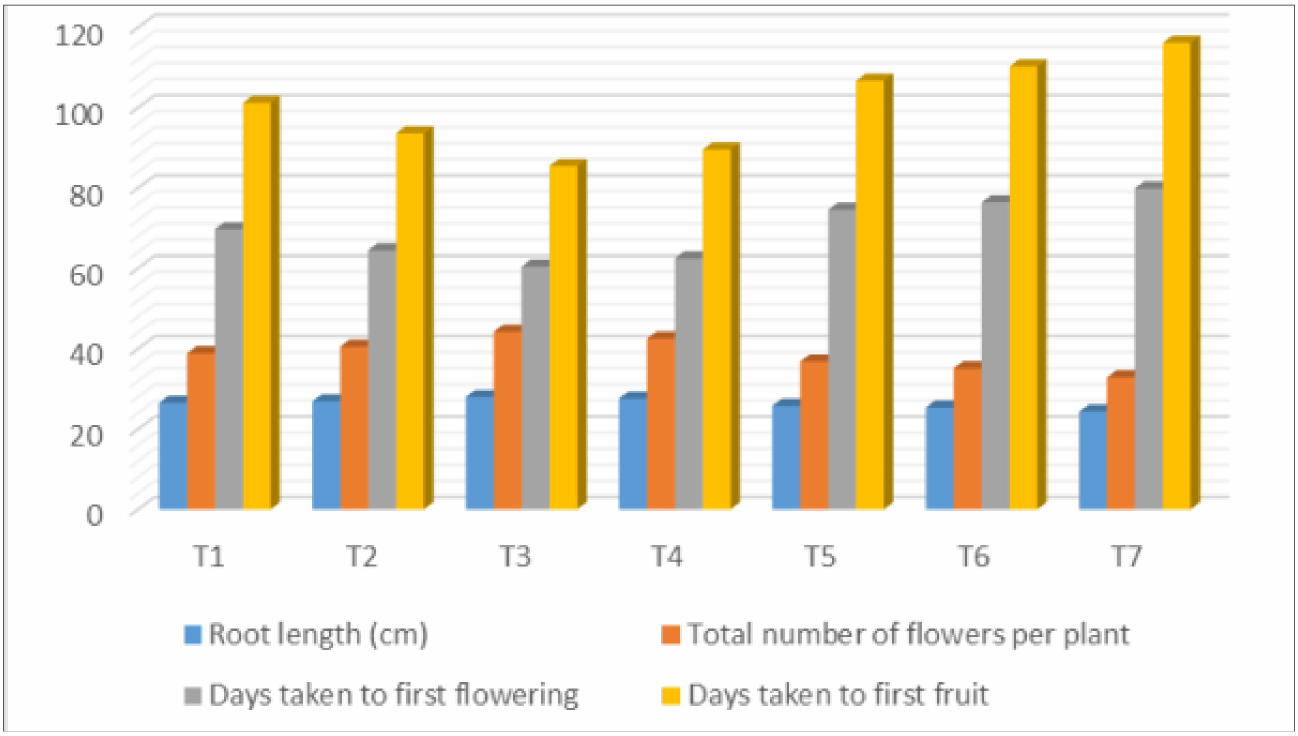

Fig 3: Effect of pH of nutrient solution & TDS of micronutrients mixture on root length (cm), total number of flowers per plant, days taken to first flowering & days taken to first fruit set of strawberry (*Fragaria x ananassa* L.)

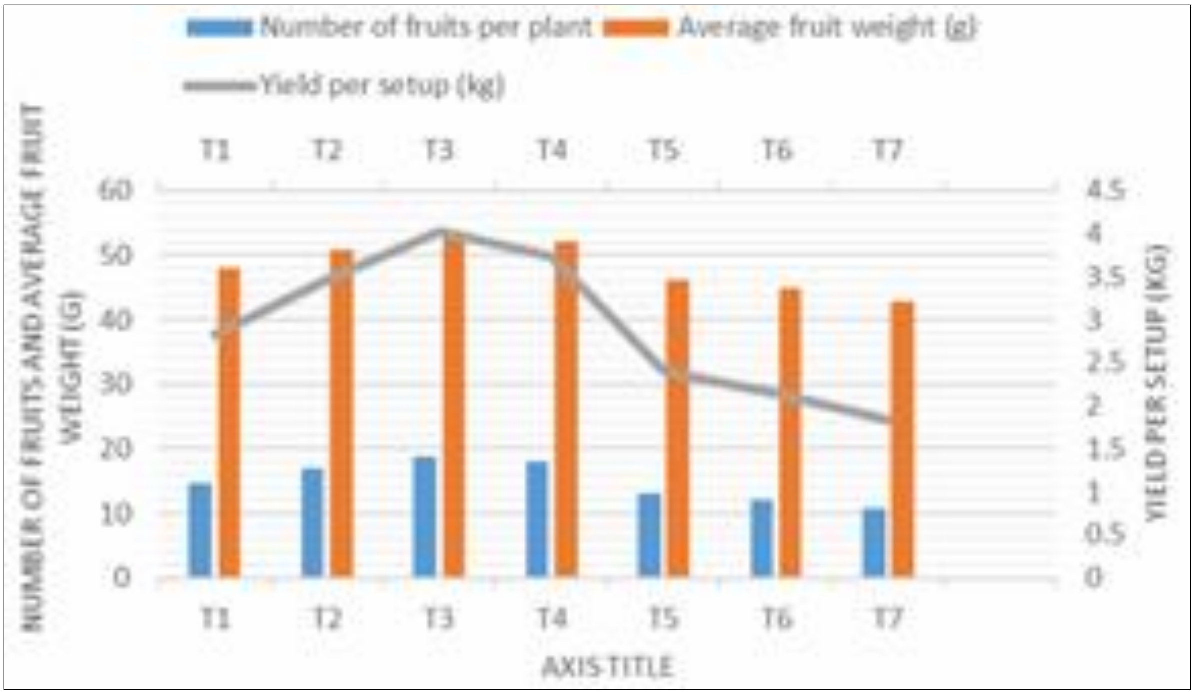

Fig 4: Effect of pH of nutrient solution & TDS of micronutrients mixture on number of fruits per plant, average fruit weight (g) & yield per setup (kg) of strawberry (*Fragaria x ananassa* L.)

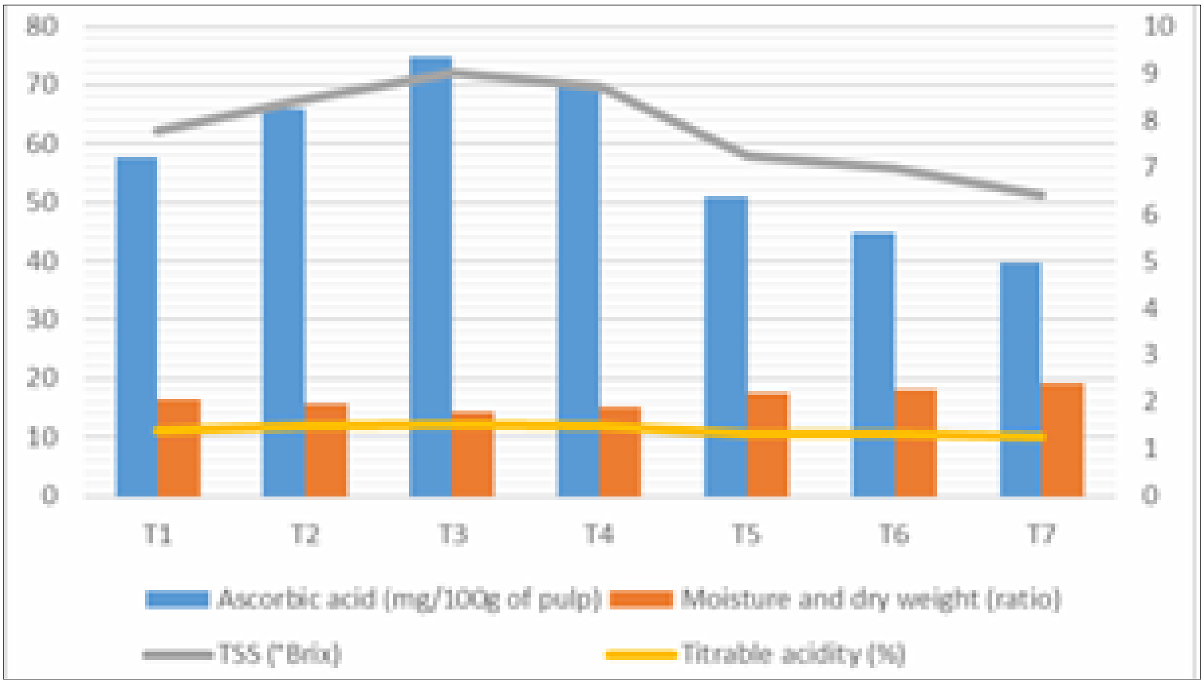

Fig 5: Effect of pH of nutrient solution & TDS of micronutrients mixture on Ascorbic acid (mg/100g of pulp), Moisture and dry weight (ratio), TSS (°Brix) & Titrable acidity (%) of strawberry (*Fragaria x ananassa* L.)

Conclusion

On the basis of results obtained during the present investigation it is concluded that T_3: [Cooper's Nutrient solution with pH 6.0] was found best in terms of Vegetative attributes like Plant height (cm), Plant spread (cm), Number of leaves, Leaf Area (cm2) at 30, 60, 90 and 120 DAP and Root length (cm); Flowering attributes like Total number of flowers per plant, Days taken to first flowering and Days taken to first fruit initiation; Yield parameters like Number of fruits per plant, Average fruit weight (g) and Average yield or Yield per setup (kg) and Quality attributes like Ascorbic acid (mg/100g), Moisture and dry weight (ratio), Total Soluble Solids (° Brix) and Titrable acidity (%).

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