Original Research Article

Nutrient Management For Growth, Yield and Quality Of Strawberry (Fragariax Ananassa) In Vertical Hydroponics System

Abstract

The present investigation was carried out to find out nutrient management for growth, yield attributes, yield and quality attributes of strawberry (Fragaria ananassa) under vertical hydroponics tower system in Prayagraj. The experiment was conducted in a Complete Randomized Design (CRD) with nine treatments and three replications during November-March (2022-23) at Experimental Farm of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. The data were recorded from four randomly selected plants from each replication of the treatments for 14 characters. The 9 treatments comprising of different doses in combination of macro nutrients N:P:K , micro nutrients Zn: B: Fe and organic fertilizer sea weed extract were given in three different stages of the crop i.e., seedling stage, vegetative growth stage and reproductive stage . Naphthalene Acetic Acid (NAA) as plant growth regulator (PGR) was applied in reproductive stage of the crop at the time of flowering for better fruit set. Aqueous solution of nutrients applied at seedling stage followed by vegetative growth stage and reproductive stage , treatment T7 comprising of N- 7.5, 8.5 and 9.5 g/10 litres of water at all three stages, respectively, P- 4.0, 5.0 and 6.0 g/10 litres of water at all three stages, respectively, K- 2.5, 3.5 and 4.5 g/10 litres of water, at all three stages, respectively, Zn- 0.25,0.35 and 0.45g/10 l of water at all three stages, respectively , B – 0.35, 0.45 and 0.55g/10 litres of water at all three stages, respectively, Fe- 0.65,0.75 and 0.85 mg/10 litres of water at all three stages, respectively and organic fertilizer (see weed extract) @ 8 and 10 ml/ 10 litres of water at seedling and vegetative stages and NAA @ 300 ppm was applied at reproductive stage for fruit settings was the best and recorded maximum plant height (18.42cm),plant spread area (18.58cm2), number of leaves per plant (8.21), root length (16.03cm), leaf area (47.75cm2), number of flowers per plant (14.47), number of fruits per plant (14), yield per treatment (1.451kg) with B: C ratio (1:2.72) and quality of the strawberry as TSS (9.330brix), titratable acidity (1.33%) and ascorbic acid (60.45 mg/100g) followed by T6 and T5 .

Keywords: Strawberry, Vertical Hydroponics System**, Vegetative growth, Yield, Quality**

1. INTRODUCTION:

Strawberry Fragaria x ananassa is a temperate fruit crop belonging to the family Rosaseae having 2n=56 octoploid chromosome. It is well-liked for its lovely heart-shaped, vivid crimson fruits that are studded with dried seeds resemble achenes on the fruit's outer peel. According to Sharma and Godra [1], the fruit is a great source of vitamin A (60 IU/100g), vitamin C (30–120 mg/100g), minerals, and pectin (0.55%), which is present in the form of calcium pectate can be a fantastic addition when producing jelly. Anthocyanin, which makes it rich in antioxidants [2], and ellagic acid, which inhibits cancer and the development of heart disorders, have made it an even more useful fruit in addition to its high vitamin and mineral content. It is planted on 1,000 hectares of land in India, producing 5000 MT annually, with Haryana being the top producer (1650 MT) and Mizoram coming in second (1080 MT) followed by Meghalaya, Maharashtra and Himachal Pradesh . In India, area under strawberry cultivation is very less might be fact that soil is used as a growing medium for strawberries, which frequently results in issues with soil-borne pests, diseases, nematodes, and other soil-restraining elements.

Strawberry is short duration crop that can be harvested in as little as six months when it is produced under protective conditions. In the last ten years, strawberries have become the dominant fruit in the soft berry category. Since most of the crop is now planted under protected structures, the acreage and production of strawberries have increased logarithmically worldwide over the past 20 years [3]. With a fruit production of over 3.7 million MT, China leads the world in strawberry production, followed by the United States of America with a production of about 1.45 million MT.

Since soilless growing media are typically free from soil-borne diseases, pests, and nematodes [4] [3], their use is crucial for eradicating soil- borne diseases and pests and is growing in popularity [5]. This leads to better vegetative growth parameters, a higher number of fruits, and a higher yield of high-quality strawberry fruits.

In hydroponics, plants are grown without soil with the roots submerged in nutrient solution. Terrestrial plants can be raised either with their roots entirely in the mineral nutrient solution (minerals in the raw water and nutrients provided with fertilizers) or in an inert medium like perlite, gravel, or mineral wool. Growing plants in nutrient solutions without soil is the focus of the developing horticulture discipline known as hydroponics. Hydroponics is a subset of horticulture that involves delivering mineral nutrient solutions in an aqueous solvent in order to grow crops without the use of soil media [6].This method has been used for thousands of years and is credited to the hanging gardens of Babylon and the floating gardens of China. The fertilizer, dosage, and concentration in the hydroponic nutrient solution are significantly influenced by the quality of the raw water to be used [6],[7]. This technology helps address issues with climate change, production system management for efficient use of natural resources, and the elimination of malnutrition.

Bradley discovered that hydroponic technology reduced the amount of agricultural area needed by at least 75% while also preserving 90% of the water [8]. Additionally, numerous hydroponics researchers have shown great financial success and food that is microbe-free [9].

Since strawberries are a high-value crop, contemporary agriculture is increasingly utilizing new technology including polyhouses, low tunnels, plastic films, shade screens, and plastic mulch to increase productivity and fruit quality. Because strawberry plants are small and greenhouse structures have significant beginning costs, it is necessary to change the plant geometry to maximize productivity in the vertical area of the greenhouse [10].

Growing fruits and vegetables hydroponically in greenhouses, which may be a positive step towards sustainable food sources. Regardless of soil quality, climate, or available area, growing fresh produce in soilless systems may be a potential answer to food poverty problems [6]. Other environmental advantages of soilless growing systems include reduced water consumption, higher product yields, and reduced pesticide use. These benefits enable soilless systems to provide sustainable systems in food deserts, arid areas, or urban areas, addressing a number of environmental challenges.

Increased demand for the production of off-season variety with high quality, greenhouse production is growing rapidly. A soilless medium are popularly used in greenhouse crop production aids in removing soil-borne diseases, reduces the amount of labour required on the farm and yields more crops per year. Nutrient solution and its management is the cornerstone of a successful hydroponic system and are the most important determinant of crop production and quality, which is largely dependent on the extent to which plant nutrients are acquired from the nutrient solution. The results will be important both for consumers who want to buy the best quality fruit, and for producers who want to develop sustainable production methods that increase the competitiveness of strawberry cultivation. Thus, the present investigation will be important for future aspect of strawberry with soilless culture in Prayagraj (UP) conditions as well as other parts of the country.

Keeping in views the above facts, present investigation was aimed with following objectives:

To find out suitable concentration of nutrients and its effect on growth, yield and quality of strawberry grown under vertical hydroponics system.

To determine the economics of strawberry in vertical hydroponics system.

2. MATERIALS AND METHODS:

This study was carried out for partial fulfillment of M.Sc.(Agriculture) in Horticulture (Fruit Science) degree, Department of Horticulture, Sam Higginbottom University of Agriculture , Technology and Sciences during 2022-2023. Experimental design was Completely Randomized Design (CRD) with 9 treatments and 3 replications as performed by Setyowati [11]. The variety which was used in this experiment was Nabila. Treatment means were compared using critical difference (CD) at 5% level of significance. Data were subjected to analysis of variance (ANOVA) using Online Statistical package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hisar 125004, Haryana, India).

In this study vertical hydroponics system was used, which was carried out in a structure made with fine and strong PVC pipes. Nine PVC pipes were used for this study. The height of hydroponic system was 6 feet or approximately 182.88 cm. There were 21 holes available for planting of strawberry plants per pipe. The vertical difference between each hole was 17.57 cm. This means that centre of each hole was positioned 17.57 cm higher or lower than the adjacent hole. The horizontal difference between each hole was 10 cm. This means that centre of each hole was positioned 10 cm to the left or right of the adjacent hole. Clay balls were used as the growing media in this hydroponics system. Clay balls provide support to the plants and help with water retention and aeration. Net pots were used to holds the plants and growing media within the holes of hydroponics tower. These pots provide support to the plants and allow their roots to access the nutrient- rich water. A 20-litre bucket was used to hold the nutrients solution in this vertical hydroponics system. This bucket served as a reservoir for the nutrient solution that was circulated to the plants. The bucket was placed at the base of the hydroponics system, and the nutrient solution was pumped or circulated through the system to provide the necessary nutrients to the strawberry plants. The experiment was conducted with the following objectives:

- To find out suitable concentration of NPK and duration of water flow, its effect on growth and yield of strawberry grown under vertical hydroponics system.
- To determine the economics of strawberry in vertical hydroponics system.

2.1 Source of Nutrient:

The nutrient solution contains a balance mixture of essential nutrients required for strawberry plant growth was provided as N, P, K (macro nutrients), Zn, B, Fe (micro nutrients), sea weed extract as organic fertilizer, these all were supplied at seedling, vegetative and reproductive stages of the crop and Naphthalene Acetic Acid (NAA) as plant growth regulator at reproductive stage of the crop.

Nutrient solution was prepared and applied as per treatment given in Table 2 at three stages of strawberry crop viz; seedling, vegetative growth and reproductive stages.

Table 1: Nutrients and its different sources

Sl.No.	Nutrient	Source
01	Nitrogen (N)	Urea (N=46%)
02	Phosphorus(P)	SSP (P=16%)
03	Potash (K)	MoP (K=60%)
04	Zinc (Zn)	ZnSo4 (Zn= 21%)
05	Boron (B)	Borax (B=10.5%)
06	Iron (Fe)	FeSo4 (Fe= 19%)
07	Organic liquid fertilizer- Sea weed extract	Sea Secret, IFFCO
08	NAA	Planofix, Bayer Crop Science

Observations were recorded on vegetative parameters, reproductive parameters, yield parameters and quality parameters of strawberry at different stages of the crop. For vegetative parameters, plant height was measured in centimeter (cm) from the base of the root, plant spread area was measured in centimeter square (cm2) by measuring in all four directions spread of the plant, number of leaves/plant were counted, root length was measured in centimeter (cm) and leaf area was measured with the help of leaf area meter in centimeter square (cm2). These all observations were recorded in randomly selected 4 plants in each replication of treatment at 40, 80 and 120 days of transplanting and finally averaged it.

For recording data on reproductive parameters, the period between date of transplanting to flower bloom of representative plant was recorded for calculating the days taken to flower bloom. Average number of flowers/plant and days taken to maturity of fruits were also recorded.
For yield data, average number of fruits/plant, average yield/plant (g) and average yield/treatment (kilogram) were recorded at the time of each harvest.
To determine quality parameters of strawberry following observations were undertaken in the laboratory of the department.

2.1 Total soluble solids (°brix)
Total soluble solids was determined by using the method followed by Kusumiyati *et al.*[12]. ERMA hand refractometer by placing a drop of the filtered juice on the prism of the refractometer and observing the coincidence of shadow of the sample with the reading on the scale and was expressed as °Brix.
2.2 Titratable acidity (%)
Titrable acidity was determined by using the method followed by Tyl and Sadler [13]. To determine titratable acidity, 0.5 g of fresh fruit pulp was thoroughly crushed in an electric blender and a volume of 50 ml was made with distilled water. A 5 ml aliquot was taken for further analysis. The sample solution was titrated against 0.1 N NaOH solutions using the phenolphthalein indicator. The titration continued until the final product was light pink in colour. The titratable acidity was calculated in terms of malic acid using the AOAC's formula (1980)[11], which was based on 1 ml of 0.1 N NaOH being equivalent to 0.0067 g of anhydrous malic acid.

$$\text{Titrtatable acidity \%} = \frac{Titre\ reading\ x\ normality\ of\ NaOH\ x\ Volume\ made\ up\ x\ equivalent\ weight}{Volume\ of\ sample\ taken\ x\ weight\ of\ sample\ x\ 100}\ x\ 100$$

$$\text{Titrtatable acidity \%} = \frac{\text{Titre reading x normality of NaOH x Volume made up x equivalent weight}}{\text{Volume of sample taken x weight of sample x 100}}\ \text{x 100}$$

2.3 Ascorbic acid
Ascorbic acid was determined by using the method followed by Abdullah *et al.* [16] in which 2, 6 dichlorophenol-indophenol through visual titration method. 10 gram of fresh pulp was taken as sample, crushed and volume was made up to 100 ml with 3 % metaphosphoric acid and filtered with filter paper. 10 ml of this aliquot extract of the sample was titrated with the standard dye to the pink end point which persisted for 15 seconds. Ascorbic acid was calculated as per the formula given below and expressed as mg/100g.

$$\text{Ascorbic acid \%} = \frac{\frac{1}{T}\ \text{x}\ \frac{V_1}{V_2}}{\text{W x v}}\ \text{x 100}$$

Where,
v = ml of dye indicator used in titration
V1 = Volume to which the juice was diluted
T = Titre value of dye with standard solution of vitamin C
V2 = Volume of the filtrate taken for titration
W = Volume of the juice initially taken for the determination

The data so obtained in the present study were subjected to statistical analysis. Experimental design was Completely Randomized Design (CRD) with 9 treatments and 3 replications.

3. RESULTS AND DISCUSSION:

Data depicted in table 3 clearly indicated that among all the treatments, the maximum average plant height was recorded from treatment T7 :18.42 cm followed by T6 : 17.33 cm, and T5: 16.17 cm . Treatment T7 and treatment T6 and treatment T6 and treatment T5 were statistically at par to each other while lowest plant height was recorded from treatment T9 (control) : 7.02 cm, followed by treatment T1 : 7.46 cm. Similar results were also seen in the experiment conducted by Chen et al. on Maize and Sorghum [17].

Maximum plant spread area was recorded from treatment T7 : 18.58 cm2 followed by treatment T6 : 17.8 cm2 and treatment T5: 17.77 cm2 numerically at par to each other while lowest plant spread area was recorded from treatment T9 (control): 10.54 cm2 followed by treatment T1 : 12.43 cm2. Similar findings were observed by Lola-Luz [18].

Maximum number of leaves/plant was recorded from treatment T7 : 8.21 followed by treatment T6: 7.91 and treatment T5: 7.33 statistically at par to each other while lowest number of leaves/plant was recorded from treatment T9 (control) : 3.42 followed by treatment T1: 3.67 leaves/plant. It was quite obvious from the table 3, among all the treatments the maximum root length was recorded from treatment T7: 16.03 cm followed by treatment T6: 15.92 cm while minimum root length was recorded from treatment T9 (control): 6.88 cm followed by treatment T1: 7.52cm. Similar findings were also done by kumar [20]. Maximum leaf area was recorded from treatment T7 : 47.75 cm2 followed by treatment T6 : 45.00 cm2. and both treatments were found statistically at par to each other, while lowest leaf area was recorded from treatment T9 (control): 18.63 cm2 followed by treatment T1: 20.63 cm2. Similar results were also found by Adak, N. and Gubbuk, H. [2015]5] when they conducted an experiment on effect of planting systems and different growing media on vegetative growth, yield and quality of strawberry

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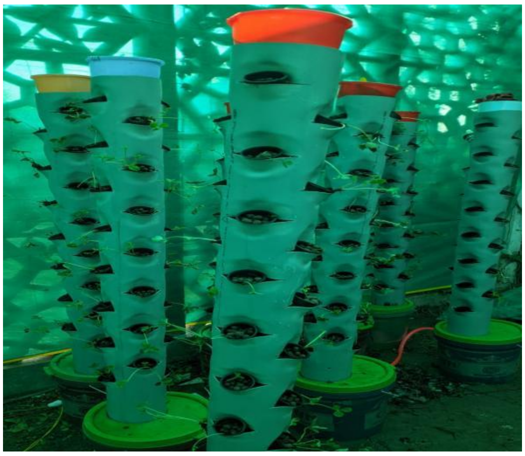

Figure 1: Hydroponics system

Figure 2: Vegetative stage

Figure 3: Flowering stage

Figure 4: Fruiting stage

cultivation under soilless culture. Berezin et.al. (2012)[12] also found the same results by using the hydroponic growth system to study the different concentration of macro and micro nutrients on vegetative growth of Arabidopsis thaliana.

It was quite obvious from the table 4 that days taken to flower initiation of strawberry in vertical hydroponics system ranged from 43.83 days to 54.83 days. Among all treatments the maximum days taken to initiate flowering was from treatment T7: 54.83 days followed by treatment T6 : 52.75 days, treatment T8: 51.75 days, treatment T5: 51 .25 days, treatment T4: 50.83 days and T3: 50.08 days. While a minimum day taken to initiate flowering was recorded from treatment T9 (control): 43.83 days followed by treatment T1: 47.92 days.

In present investigation number of flowers were recorded from each representative plant at 20 days interval after first flowering till end of the season and finally placed in table 4. Among all the treatments the maximum number of flowers was recorded from treatment T7 : 14.47 flowers/plant followed by T6 : 14 flowers/plant, T5: 12.83 flowers/plant and T8: 11.70 flowers/plant statistically at par to each other. While minimum number of flowers was recorded from treatment T9 (control): 6 flowers/plant followed by treatment T1 : 7 flowers/plant. In present investigation days taken to fruit maturity was recorded which was influenced by different level of nutrient media after anthesis. It was observed that there were no significant differences between treatments pertaining to days taken to fruit maturity but the minimum days taken to fruit maturity was recorded from treatment T7 : 34 days followed by treatment T6 : 35.75 days while maximum days taken to fruit maturity was recorded from treatment T9 (control): 38.95 days followed by T3 : 38.25 days.. Among all the treatments the significant highest number of fruits was recorded from treatment T7:14 fruits/plant followed by treatment T_6 : 13 fruits/plant while lowest number of fruits was recorded from treatment T9 (control : 5.40 fruits/plant followed by treatment T1 : 6.5 fruits /plant. Results of Thakur and Shylla (2018)3] were also in accordance with the present investigation in which they shown the influence of different growing media on plant growth and fruit yield of strawberry (Fragaria× ananassa Duch.) cv. Chandler grown under protected conditions.

A total soluble solids (T.S.S.) states the amounts of soluble solids in liquid. T.S.S. value affects the taste of strawberry fruits, because it indicates the level of sweetness of the fruits. So it is very important criteria for good quality crop. In this present investigation (table 5), T.S.S. was recorded which was influenced by different nutrient media. Among all the treatments the highest T.S.S. was recorded from treatment T7 : 9.33 0Brix followed by treatment T6 : 7.97 0Brix and T5: 7.95 0Brix and these were statistically at par to each other while lowest 0Brix was recorded from treatment T9 (control): 4.97 0Brix followed by T1 : 5.19 ^{0}Brix.

Highest acidity was recorded from treatment T7: 1.38 per cent followed by treatment T6: 1.06 per cent while lowest acidity was recorded from treatment T9 (control): 0.64 per cent followed by treatment T1: 0.65 per cent. Among all the treatments the highest ascorbic acid was recorded from treatment T7: 60.45mg/100g followed by treatment T6: 53mg/100g while lowest ascorbic acid was recorded from T9 (control): 27.05mg/100g followed by T1: 28.46mg/100g. Joshi (2003)[13] investigated the influence of growing media and nutrients on biochemical properties of strawberry and found higher TSS (9.82 0B), total sugar (7.47%) and ascorbic acid content (49.87 mg/100g) whereas, low acidity (0.78%) in hydroponics system. Treftz and Omaye (2015)**[14]** reported that ascorbic acid (74%) was significantly higher in soilless grown strawberries as compared to soil grown strawberries. [15, 22]

In this present investigation cost of cultivation for vertical hydroponics system was studied which was influenced by different nutrient media and its setup (table 6). Among all the treatments the lowest cost was recorded in treatment T9 (control): ₹347 /treatment when there was no use of nutrients followed by T1 : ₹399.80/treatment while highest cost of cultivation was recorded from treatment T8 : ₹516.20/treatment followed by treatment T7 : ₹ 499.10 /treatment .

Cost: benefit ratio is very important for recording the cost-effective crop management in any crop. Data presented

Table 2: Different nutrients solution as per treatment supplied to vertical hydroponics system.

TREATMENT	TREATMENT DETAILS																				
	STAGES OF THE CROP																				
	SEEDLING STAGE										VEGETATIVE GROWTH STAGE				REPRODUCTIVE STAGE						
	MACRO NUTRIENT gm/10 L			MICRO NUTRIENT gm/10 L			Organic Fertilizer ml/10 L	MACRO NUTRIENT gm/10 L			MICRO NUTRIENT gm/10 L			Organic Fertilizer ml/10 L	MACRO NUTRIENT gm/10 L			MICRO NUTRIENT gm/10 L			PGR (ppm)
	N	P	K	Zn	B	Fe	Sea weed extract	N	P	K	Zn	B	Fe	Sea weed	N	P	K	Zn	B	Fe	NAA
T1	3.5	1	0.4	0.04	0.05	0.02	2	4.5	2	0.8	0.08	0.15	0.04	4	6.5	3	1.5	0.15	0.25	0.055	300
T2	4	1.5	0.6	0.06	0.1	0.03	3	5	2.5	1	0.1	0.2	0.05	5	7	3.5	2	0.2	0.3	0.06	300
T3	4.5	2	0.8	0.08	0.15	0.04	4	6.5	3	1.5	0.15	0.25	0.055	6	7.5	4	2.5	0.25	0.35	0.065	300
T4	5	2.5	1	0.1	0.2	0.05	5	7	3.5	2	0.2	0.3	0.06	7	8	4.5	3	0.3	0.4	0.07	300
T5	6.5	3	1.5	0.15	0.25	0.055	6	7.5	4	2.5	0.25	0.35	0.065	8	8.5	5	3.5	0.35	0.45	0.75	300
T6	7	3.5	2	0.2	0.3	0.06	7	8	4.5	3	0.3	0.4	0.07	9	9	5.5	4	0.4	0.5	0.08	300
T7	7.5	4	2.5	0.25	0.35	0.065	8	8.5	5	3.5	0.35	0.45	0.75	10	9.5	6	4.5	0.45	0.55	0.085	300
T8	8	4.5	3	0.3	0.4	0.07	9	9	5.5	4	0.4	0.5	0.08	11	10	6.5	5	0.5	0.6	0.09	300
T9 (Control)					Water							Water							Water		

Table 3: Effect of different doses of nutrients on plant height, plant spread area, number of leaves/plant, root length and leaf area of strawberry in hydroponics system

Treatment	Plant height (cm)	Plant spread area (cm2)	No. of leaves/ plant	Root length (cm)	Leaf area (cm2)
T1	7.46	12.43	3.67	7.52	20.63
T2	9.25	13.13	4.11	7.63	22.55
T3	9.79	13.40	4.27	7.95	23.85
T4	11.97	14.21	5.20	8.71	26.13
T5	16.17	17.77	7.33	15.00	38.50
T6	17.33	17.79	7.91	15.92	45.00
T7	18.42	18.58	8.21	16.03	47.75
T8	11.00	12.46	6.03	9.08	27.25
T9 (control)	7.02	10.54	3.42	6.88	18.63
SEm	0.64	0.68	0.29	0.66	2.17
CD at 5%	1.93	2.02	0.88	1.98	6.49
CV	9.25	8.08	9.42	10.90	9.39

Table 4: Effect of different doses of nutrients on reproductive parameters of strawberry in hydroponics system

Treatment	Days taken to initiation of flowering	Av. number of flowers/plant	Days taken to fruit maturity	Number of fruits/plant
T1	47.92	7.00	36.33	6.50
T2	47.92	8.84	37.25	8.66
T3	50.08	9.63	38.25	9.00
T4	50.83	10.18	37.83	10.00
T5	51.25	12.83	36.42	12.80
T6	52.75	14.00	35.75	13.00
T7	54.83	14.47	34.00	14.00
T8	51.75	11.70	37.67	10.33
T9 (control)	43.83	6.00	38.95	5.40
SEm	1.96	0.80	1.66	0.18
CD at 5%	5.87	2.41	4.97	0.55
CV	6.77	8.70	8.52	13.36

Table 5: Effect of different doses of nutrients on total soluble solids (TSS), acidity and ascorbic acid of fruits of strawberry in vertical hydroponics system

Treatment	TSS(0Brix)	Acidity (%)	Ascorbic acid (mg/100ml)
T1	5.19	0.65	28.46
T2	6.40	0.67	29.17
T3	6.63	0.68	29.33
T4	6.65	0.69	30.25
T5	7.95	0.88	39.75
T6	7.97	1.06	53.00
T7	9.33	1.38	60.45
T8	7.10	0.90	43.33
T9 (control)	4.97	0.64	27.05
SEm	0.42	0.08	3.89
CD at 5%	1.25	0.23	11.65
CV	11.49	6.35	9.68

Table 6: Cost of Cultivation for different nutrient doses (₹/treatment) in vertical hydroponics system

Treatment	Cost of Nutrient (₹)	Cost of Runner (₹)	Labour charges (₹)	Hydroponics (₹)	Electricity (₹)	Cost of Cultivation (₹)
T1	52.80	105.00	40.00	110.00	12.00	399.80

T2	73.00	105.00	40.00	110.00	12.00	420.00
T3	88.65	105.00	40.00	110.00	12.00	435.65
T4	103.15	105.00	40.00	110.00	12.00	450.15
T5	120.80	105.00	40.00	110.00	12.00	467.80
T6	135.95	105.00	40.00	110.00	12.00	482.95
T7	152.10	105.00	40.00	110.00	12.00	499.10
T8	169.20	105.00	40.00	110.00	12.00	516.20
T9(Control)	00.00	105.00	40.00	110.00	12.00	347.00

Table 7: Cost: Benefit ratio of Strawberry cultivation in vertical hydroponics system

Treatment	**No.** of fruits per plant	**No.** of fruits per treatment	**Av.** fruit **wt.** per treatment (g)	Yield / treatment (kg)	Gross return (₹)	Cost of cultivation (₹)	Net return (₹)	B:C ratio
T1	6.50	136.5	9.21	1.257	402.24	399.80	2.44	1:1.006
T2	8.66	181.86	10.50	1.909	610.88	420.00	190.88	1:1.454
T3	9.00	189.00	10.89	2.058	658.56	435.65	222.91	1:1.511
T4	10.00	210.00	11.00	2.310	739.20	450.15	289.05	1:1.642
T5	12.80	268.80	13.56	3.644	1166.08	467.80	698.28	1:2.492
T6	13.00	273.00	13.70	3.740	1196.80	482.95	713.85	1:2.472
T7	14.00	294.00	14.46	4.251	1360.32	499.10	861.22	1:2.725
T8	10.33	216.93	10.71	2.323	743.36	516.20	227.16	1:1.440
T9 (Control)	5.40	113.40	8.75	0.992	317.44	347.00	-29.56	1:0.914

in table 7 showed that maximum net return (₹861.22/treatment) was received in treatment T7 followed by treatment T6 (₹713.85/treatment) and treatment T5 (₹698.25/treatment) whereas, cost: benefit ratio was recorded maximum (1:2.725) in treatment T7 followed by treatment T5 (1:2.492) and treatment T6 (1:2.472) while minimum net return (₹-29.56/treatment) and minimum cost: benefit ratio (1:0.914) were recorded from treatment T9 (control) followed by treatment T1 : (₹2.44/treatment) as net return and cost: benefit ratio was 1:1.006.

4. CONCLUSION

From the present investigation it was concluded that all treatments comprising of different doses of fertilizers applied at seedling, vegetative growth and reproductive stages of strawberry crop under vertical hydroponics system, treatment T7 having N doses- 7.5: 8.5:9.5, P doses- 4:5:6, K doses- 2.5:3.5:4.5 g/ 10 liter of water along with micro nutrients Zn- 0.25:0.35:0.65 , B – 0.35:0.45:0.75, Fe- 0.65:0.75:0.08 g/ 10 liter of water, sea weed extract at seedling and vegetative growth stages @ 8 and 10 ml/10 liter of water at respective stages and at reproductive stage application of NAA @ 300 ppm was found best for yield, yield attributing characters and quality of the fruits of strawberry.

It was also concluded that yield attributing characters at vegetative growth stage such as plant height, plant spread area, number of leaves, root length, leaf area etc. and at reproductive stage such as days taken to initiation of flowers, number of flowers, number of fruits and days taken to maturity of fruits ultimately resulted in maximum yield of the crop from treatment T7 followed by T6 and T5.

As far as quality of fruits was concerned, a very good and significant amount of Total Soluble Solids (TSS), Titratable Acidity and Ascorbic Acid was found in treatment T7.

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