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Nutrient management for growth, yield and quality of lettuce (*Lactuca sativa*) in hydroponics tower system

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Abstract
The present experiment was carried out under the Shade net, Research Field, Department of Horticulture, SHUATS, Prayagraj during the month of November 2023 to February 2024. Experiment was laid out in Randomized Block Design (RBD), with nine treatments, replicated thrice with nutrient field technique hydroponics system and lettuce variety Grand Rapids. The treatments were T_0 (Control), T_1 (NPK 1.4 ml/Plant), T_2 (NPK 2.14 ml/Plant), T_3 (NPK 2.8 ml/Plant), T_4 (NPK 3.57 ml/Plant), T_5 (NPK 4.28 ml/Plant), T_6 (NPK 5.00 ml/Plant), T_7 (NPK 5.71 ml/Plant) and T_8 (NPK 6.42 ml/Plant). From the observations T_7 was found to be the best relating to growth and yield parameters followed by T_8 and T_6. In gross return, net return and B.C maximum values were also recorded in T_7.

Keywords: Lettuce, hydroponics system, NPK, growth, yield and quality

Introduction
Lettuce (*Lactuca sativa*) is an annual plant of the daisy family, Asteraceae. It is most often grown as a leaf vegetable, but sometimes for its stem and seeds. Lettuce is most often used for salads, although it is also seen in other kinds of food, such as soups, sandwiches and wraps it can also be grilled. In addition to its main use as a leafy green, it has also gathered religious and medicinal significance over centuries of human consumption.

Lettuce is the most popular according to the highest consumption rate and economic importance through the world. It has not as yet been cultivated in large scale, but its importance is gradually increasing. It produces a cluster of leaves varying considerably in shape, character and colour in different varieties. It is popular for its delicate, crispy, texture and slightly bitter taste with milky juice as fresh condition. The leaf of lettuce contains moisture 94%, protein 1.8%, carbohydrate 2.9%, vitamin-A 300- 1500 I.U, thiamine 0.09 mg, riboflavin 0.12 mg, minerals 10 mg nutrients.

Lettuce is most popular amongst the salad vegetable crops and in demand or need by the local markets throughout the year. Raw leaf lettuce has concentrations of vitamins, *viz*, vitamins C and A. It has also contained calcium, potassium, iron, protein and fiber. It is good source of vitamins and a popular food for weight conscious consumers because of its low kilo joule content. Leaf lettuce is cultivated mainly in our country in open fields as well as under greenhouse conditions. It has been found that simple hydroponics techniques such as the floating culture were successful in growing leafy vegetables. This is assured by adequate fertilizing, steady supply of water and cool temperature. By considering the above literatures, the present study was aimed to find out effect of different growing substrates on growth and yield of hydroponic lettuce.

Hydroponics is basically a contemporary method of horticulture or basically growing plants using farm produce, and the thing is without using soil. The method of hydroponics is nearly easy but it takes time to understand the method. In the method, crops are planted and grown on water. These crops are also found to be very efficient and filled with benefiting nutrients. According tothe scientist's plants in hydroponics method have direct connection to the roots in form of 'aqueous solvent' instead of the soil. Universally, Hydroponics is walking ahead but India encompasses a part of catching up to do. The reason behind this far reaching is profoundly useful in today's state of the world, where it may play a crucial part in being the back bone of the environment. The worldwide flexibility is the large number of benefits. For occasion, the strategy requires less work, and the yields are much higher as plants develop

quicker as compared with the regular ranches. Hydroponics employments comparatively less water that's 20% of the water utilized within the ordinary editing strategies. There's indeed a huge number of benefits for the agriculturists who can develop crops out of the season with their claim imaginative combinations, and give more prominent nourishment and nourishment choice to the clients.

Growing in popularity are fruits and vegetables cultivated hydroponically in greenhouses, which may be a positive step towards sustainable food sources. Regardless of soil quality and climate. Available area, growing fresh produce in soilless systems may be a potential answer to food poverty problems. 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 urbanareas, addressing a number of environmental challenges.

Increased demand for more products with high quality and off-season, greenhouse productions are increasing. Soilless media are popularly used in greenhouse crop production because they are relatively lightweight, free from diseases, readily available and more uniform and more suitable for containerization than minerals soil. The results will be important both for consumers who want to buy the best quality vegetable, and for producers who want to develop sustainable production methods that increase the competitiveness of lettuce cultivation. Thus, the present investigation will be important for future aspect of lettuce with soilless culture in Prayagraj (Allahabad) conditions.

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

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

Materials and Methods

This study was carried out for partial fulfillment of M.Sc.(Agriculture) in Horticulture (Vegetable Science) degree, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences during 2023-2024. Experimental design was Randomized Block Design (RBD) with 9 treatments and 3 replications as performed by Setyowati [11]. The variety which was used in this experiment was Grand Rapids. 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 lettuce plants.

Source of Nutrient

The nutrient solution contains a balance mixture of essential nutrients required for Lettuce plant growth was provided as N, P, K (both micro and macro nutrient) these all were supplied after transplanting. Observations were recorded on 15, 30 and 45 days after transplanting vegetative parameters, yield parameters and quality parameters of lettuce 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 (cm^2) by measuring in all four directions spread of the plant, number of leaves/plant were counted, 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 15, 30 and 45 days of transplanting and finally averaged it.

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.

Ascorbic Acid

Ascorbic acid was determined by using the method followed by Abdullah *et al*. 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/100 g.

Ascorbic acid % = x x 100 W x v

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 Randomized Block Design (RBD) with 9 treatments and 3 replications.

Results and Discussion

Plant height

Plant height of lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients.

The plant height increased in increasing days until maturity. At 15 DAP, the maximum plant height (15.20 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (14.5 cm) and minimum (7.5 cm) was recorded in T_0 (Control)

Plant height 30 DAP

Maximum plant height (19.5 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (18.5 cm) and minimum (11.5 cm) was recorded in T_0 (Control).

Plant height 45 DAP

Maximum plant height (24.7 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (23.7 cm) and minimum (16.4 cm) was recorded in T_0 (Control).

Maximum plant height were recorded in T_7 at 15, 30 and 45 DAP which might be due to higher levels of N. P & K, which found suitable for lettuce in hydroponic system helpful in cell elongation of leaves use to development of cell and rapid cell division and cell elongation in meristematic region of plant due to production of plant growth substance and this may be due to abundant supply of plant nutrients and water which led in the growth of lettuce. This finding correlates the findings of Tumbare *et al*., (2002) [13] in Chilli, Sundar, *et al*., (2019) [14] in Lettuce

Table 1: Effect of different concentrations of N. P and K on plant height of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Plant height (cm)		
		15 DAT	30 DAT	45 DAT
T_0	control	7.47	11.54	16.41
T_1	NPK 1.4 ml/plant	8.43	12.31	17.40
T_2	NPK 2.14 ml/plant	9.21	13.62	18.41
T_3	NPK 2.8 ml/plant	10.53	14.71	19.53
T_4	NPK 3.57 ml/plant	11.43	15.40	20.65
T_5	NPK 4.28 ml/plant	12.60	16.53	21.61
T_6	NPK 5.00 ml/plant	13.60	17.32	22.40
T_7	NPK 5.71 ml/plant	15.23	19.52	24.70
T_8	NPK 6.42 ml/plant	14.53	18.51	23.72
F Test		S	S	S
SE (d)		0.19	0.24	0.22
CD at 5%		0.42	0.51	0.47
C V %		2.12	1.91	1.13

Plant Spread

Plant spread of lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients. The plant spread increased in increasing days until maturity. At 15 DAP, Maximum plant spread (9.12 cm) recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK6.42/Plant) (9.03 cm) and minimum (6.01 cm) was recorded in T_0 (control). At 30 DAP the maximum plant spread (12.99 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK6.42 ml/Plant) (12.85 cm) and minimum (9.47 cm) was recorded in T_0 (control). At 45 DAP maximum plant spread (19.93 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42/Plant) (19.71 cm) and minimum (15.24 cm) was recorded in T_0 (control).

Maximum plant spread were recorded in T_7 at 15, 30 and 45 DAP which might be due to higher levels of N, P & K, which found suitable for lettuce in hydroponic system resulted enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation. This finding correlates the findings of Tumbare *et al*., (2002) [13] in Chilli, Sundar *et al*., (2019) [14] in Lettuce.

Table 2: Effect of different concentrations of N. P and K on plant spread of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Plant Spread		
		15 DAT	30 DAT	45 DAT
T_0	control	6.01	9.47	15.24
T_1	NPK 1.4 ml/plant	6.19	10.35	15.66
T_2	NPK 2.14 ml/plant	6.89	10.93	16.39
T_3	NPK 2.8 ml/plant	7.45	11.75	17.04
T_4	NPK 3.57 ml/plant	7.69	11.96	17.60
T_5	NPK 4.28 ml/plant	8.44	12.30	18.40
T_6	NPK 5.00 ml/plant	8.80	12.67	19.03
T_7	NPK 5.71 ml/plant	9.12	12.99	19.93
T_8	NPK 6.42 ml/plant	9.03	12.85	19.71
F Test		S	S	S
SE (d)		0.22	0.24	0.24
CD at 5%		0.47	0.52	0.51
C V %		3.51	2.58	1.67

Number of leaves/plant

Number of leaves/plant of lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients. The plant spread increased in increasing days until maturity. At 15 DAP, Maximum number of leaves/plant (7.32) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (7.00) and minimum (4.72) was recorded in T_0 (control). At 30 DAP maximum number of leaves/plant (8.72) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (8.31) and minimum (6.00) was recorded in T_0 (control). At 45 DAP maximum number of leaves/plant (11.72) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (11.35) and minimum (8.74) was recorded in T_0 (control). Maximum number of leaves/plant were recorded in T_7 at 15, 30 and 45 DAP. Poorly balanced nutrient solution composition led to improper growth and hence less number of leaves also components of water, nutrients and dissolved oxygen must be available proportionally. This finding correlates the findings of Suyantohadi *et al*., (2010) [12].

Table 3: Effect of different concentrations of N. P and K on Number of leaves of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Number of leaves		
		15 DAT	30 DAT	45 DAT
T_0	control	4.72	6.00	8.74
T_1	NPK 1.4 ml/plant	5.07	6.32	9.00
T_2	NPK 2.14 ml/plant	5.35	6.71	9.32
T_3	NPK 2.8 ml/plant	5.73	7.09	9.70
T_4	NPK 3.57 ml/plant	6.05	7.35	10.05
T_5	NPK 4.28 ml/plant	6.31	7.72	10.34
T_6	NPK 5.00 ml/plant	6.71	8.03	10.70
T_7	NPK 5.71 ml/plant	7.32	8.72	11.72
T_8	NPK 6.42 ml/plant	7.00	8.32	11.35
F Test		S	S	S
SE (d)		0.62	0.50	0.83
CD at 5%		1.33	1.06	1.79
C V %		12.72	8.35	10.17

Leaf length

Leaf length of lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients. The leaf length

increased in increasing days until maturity. At 15 DAP, Leaf length 15 DAP maximum leaf length (10.80 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (10.07cm) and minimum (5.93cm) was recorded in T_0 (control). At 30 DAP Maximum Leaf length (13.77cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (13.37 cm) and minimum (9.20 cm) was recorded in T_0 (control). At 45 DAP: Maximum leaf length (19.37 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (19.10 cm) and minimum (13.93 cm) was recorded in T_0 (control).
Maximum leaf length were recorded in T_7 at 15, 30 and 45 DAP. Components of water, nutrients and dissolved oxygen must be available proportionally which increases the plant growth leading to increase in leaf length. This finding correlates the findings of Suyantohadi *et al*., (2010) [12].

Table 4: Effect of different concentrations of N. P and K on Leaf length of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Leaf length (cm)		
		15 DAT	30 DAT	45 DAT
T_0	control	5.93	9.20	13.93
T_1	NPK 1.4 ml/plant	7.37	10.23	16.13
T_2	NPK 2.14 ml/plant	8.13	10.63	16.30
T_3	NPK 2.8 ml/plant	8.53	11.10	16.40
T_4	NPK 3.57 ml/plant	9.07	11.53	17.13
T_5	NPK 4.28 ml/plant	9.47	12.07	17.63
T_6	NPK 5.00 ml/plant	6.67	12.40	18.47
T_7	NPK 5.71 ml/plant	10.80	13.77	19.37
T_8	NPK 6.42 ml/plant	10.07	13.37	19.10
F Test		S	S	S
SE (d)		0.51	0.58	1.46
CD at 5%		1.09	1.25	3.12
C V %		7.12	6.19	10.44

Leaf width

Leaf width of lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients. The leaf width increased in increasing days until maturity. At 15 DAP Maximum leaf width (6.03 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (5.97 cm) and minimum (3.73 cm) was recorded in T_0 (control). At 30 DAP maximum leaf width (8.70 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (8.30 cm) and minimum (6.11cm) was recorded in T_0 (control). At 45 DAP maximum leaf width (12.51 cm) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (12.37 cm) and minimum (8.93 cm) was recorded in T_0 (control). Maximum leaf width were recorded in T_7 at 15, 30 and 45 DAP which might be due to higher levels of N, P & K, which found suitable for lettuce in hydroponic system and enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation. This finding correlates the findings of Tumbare *et al*., (2002) [13] in Chilli, Sundar *et al*., (2019) [14] in Lettuce.

Table 5: Effect of different concentrations of N. P and K on Leaf width of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Leaf width (cm)		
		15 DAT	30 DAT	45 DAT
T_0	control	3.73	6.11	8.93
T_1	NPK 1.4 ml/plant	4.03	6.49	9.64
T_2	NPK 2.14 ml/plant	4.33	6.62	10.22
T_3	NPK 2.8 ml/plant	4.67	7.08	10.81
T_4	NPK 3.57 ml/plant	5.10	7.29	11.32
T_5	NPK 4.28 ml/plant	5.40	7.70	11.41
T_6	NPK 5.00 ml/plant	5.70	7.93	12.17
T_7	NPK 5.71 ml/plant	6.03	8.70	12.51
T_8	NPK 6.42 ml/plant	5.97	8.30	12.37
F Test		S	S	S
SE (d)		0.42	0.39	0.32
CD at 5%		0.90	0.84	0.68
C V %		10.32	6.57	3.56

Water used (liter)/21 plants

Water used in lettuce was significantly differed at 15, 30, 45 DAP due to different amount of nutrients. The leaf width increased in increasing days until maturity. At 15 DAP Water used 15 DAP maximum water used (11.35 liter/21 plants) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (11.19 liter/21 plants) and minimum (7.27 liter/21 plants) was recorded in T_0 (control). At 30 DAP maximum water used (13.44 liter/21 plants) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (13.23 liter/21 plants) and minimum (10.02 liter/21 plants) was recorded in T_0 (control). At 45 DAP maximum water used (15.94 liter/21 plants) was recorded in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (15.81 liter/21 plants) and minimum (12.87 liter/21 plants) was recorded in T_0 (control). Maximum water use were recorded in T_7 at 15, 30 and 45 DAP which might be because water consumption depends upon the temperature, plant growth on nutrient concentration and also the temperature during the growing season as this factors contribute to the water consumption. This finding correlates the findings of Oztekin *et al*., (2018) [15] in Spinach.

Table 6: Effect of different concentrations of N. P and K on Water used of lettuce at 15, 30, 45 days in hydroponics system.

Treatment symbol	Treatment combination	Water used (litre)		
		15 DAT	30 DAT	45 DAT
T_0	control	7.27	10.02	12.87
T_1	NPK 1.4 ml/plant	8.04	10.51	13.09
T_2	NPK 2.14 ml/plant	8.37	10.60	13.26
T_3	NPK 2.8 ml/plant	9.27	11.03	13.92
T_4	NPK 3.57 ml/plant	9.78	11.50	14.42
T_5	NPK 4.28 ml/plant	10.45	11.91	15.01
T_6	NPK 5.00 ml/plant	10.91	12.48	15.53
T_7	NPK 5.71 ml/plant	11.35	13.44	15.94
T_8	NPK 6.42 ml/plant	11.19	13.23	15.81
F Test		S	S	S
SE (d)		0.21	0.30	0.26
CD at 5%		0.46	0.65	0.56
C V %		2.74	3.22	2.23

TSS

Due to different concentrations of NPK significant difference were observed for T.S.S. Maximum TSS (4.79) was observed in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (4.63) and minimum (3.10) was recorded in T_0 (NPK 2.8 ml/Plant). Maximum T.S.S were recorded in T_7 which might be due to increasing the rate of NPK application resulting in the percentage of T.S.S content and significantly reduced with increasing salt concentration. This finding correlates the findings of Ahamed *et al*., (2019) [5] in tomato and Franquera *et al*., (2015) [16] in Lettuce.

Ascorbic acid

Due to different concentration of NPK significant difference were observed for ascorbic acid. Maximum Ascorbic acid (3.56) was observed in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (3.40) and minimum (2.09) was recorded in T_0 (control). Maximum ascorbic acid was observed in T_7 which might be due to the climatic conditions during crop growth and development which have a greater overall effect on ascorbic acid content. It is shown that excessive use of nitrogen decreases the ascorbic acid content. This finding correlates the findings of Song *et al*., (2020) [10] in lettuce.

Table 7: Effect of different concentrations of N. P and K on TSS and Ascorbic acid in hydroponics system.

Treatment symbol	Treatment combination	TSS (^{0}brix)	Ascorbic acid
T_0	control	3.10	2.09
T_1	NPK 1.4 ml/plant	3.29	2.23
T_2	NPK 2.14 ml/plant	3.41	2.38
T_3	NPK 2.8 ml/plant	3.67	2.55
T_4	NPK 3.57 ml/plant	3.99	2.78
T_5	NPK 4.28 ml/plant	4.20	2.94
T_6	NPK 5.00 ml/plant	4.56	3.21
T_7	NPK 5.71 ml/plant	4.79	3.56
T_8	NPK 6.42 ml/plant	4.63	3.40
F Test		S	S
SE (d)		0.253	0.05
CD at 5%		0.541	0.12
C V %		7.831	2.45

Average weight

The data related to effect of different concentrations of N. P and K on average weight of lettuce in hydroponics tower system were recorded and present in table 8. Shows significant differences. Due to different concentrations of NPK significant difference were observed for average weight. Maximum Average weight (32.72 g) was observed in T_7 (NPK 5.71 ml/Plant) followed (NPK 6.42 ml/Plant) (31.10) and minimum (19.22) was recorded in T_0 (control). Maximum Average weight were recorded in T_7 which might be due to N, P, and K application attributed to enhanced photosynthesis, accumulation of carbohydrates and favourable effect on vegetative growth which also increase the weight and size of plants. This finding correlates the findings of Akanbi *et al*., (2007) [17] in pepper.

Total yield/structure

The data related to effect of different concentrations of N, P and K on total yield/structure of Lettuce in hydroponics tower system were recorded and present in table 8 Shows significant differences. Due to different concentrations of NPK significant difference were observed for total yield/plot. Maximum total yield/structure (687.18 g) was observed in T_7 (NPK 5.71 ml/Plant) followed by T_8 (NPK 6.42 ml/Plant) (653.14 g) and minimum (403.62 g) was recorded in T_0 (control). Maximum Total yield/structure were recorded in T_7 Which can be due to availability of water, oxygen and optimum nutrients sufficient to increase plant vegetative growth which leads to weight and size of plant. This finding correlates the findings of Frasetya *et al*., (2020) and Akanbi *et al*., (2007) [17].

Table 8: Effect of different concentrations of N. P and K on Average weight and Total structure/yield in hydroponics system.

Treatment symbol	Treatment combination	Average weight	Total yield/structure
T_0	control	19.22	403.62
T_1	NPK 1.4 ml/plant	19.87	418.30
T_2	NPK 2.14 ml/plant	20.52	431.04
T_3	NPK 2.8 ml/plant	21.78	457.39
T_4	NPK 3.57 ml/plant	23.54	494.52
T_5	NPK 4.28 ml/plant	27.73	582.41
T_6	NPK 5.00 ml/plant	30.09	632.07
T_7	NPK 5.71 ml/plant	32.72	687.18
T_8	NPK 6.42 ml/plant	31.10	653.14
F Test		S	S
SE (d)		0.010	0.727
CD at 5%		0.022	1.555
C V %		0.050	0.168

Conclusion

From the present investigation it was concluded that all treatments comprising of different doses of Nutrient applied to lettuce crop under vertical hydroponics system, treatment T_7 having NPK (5.71 ml/plant) was found best for the growth, yield and quality of lettuce. It was also concluded that yield attributing characters such as plant height, plant spread area, number of leaves, water uptake etc. ultimately resulted in maximum yield of the crop from treatment T_7 followed by T_8 and T_6.

As far as quality of lettuce was concerned, a very good and significant amount of Total Soluble Solids (TSS), Titratable Acidity and Ascorbic Acid was found in treatment T_7.

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Competing Interests

Authors have declared that no competing interests exist.

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