Effect of different levels of nutrients on plant growth, yield and quality of Lettuce (*Lactuca sativa)* in NFT (Nutrient Film Technique) vertical system of hydroponics under shade net condition.

ABSTRACT

The present experiment was carried out under the Shade net, Research Field, Department of Horticulture, SHUATS, Prayagraj during the month of November 2021 to February 2022. Experiment was laid out in Randomized Block Design (RBD), with eight treatments, replicated thrice with nutrient field technique hydroponics system and lettuce variety Grand Rapids. The treatments were T_1 (NPK 2.8ml/Plant), T_2 (NPK 4.2ml/Plant), T_3 (NPK 5.71ml/Plant), T_4 (NPK 7.14ml/Plant), T_5 (NPK 8.57ml/Plant), T_6 (NPK 10ml/Plant), T_7 (NPK 11.43ml/Plant) and T_8 (NPK12.86ml/Plant). From the observations T_5 was found to be the best relating to growth and yield parameters followed by T_6 and T_7. In gross return, net return and B.C maximum values were also recorded in T_5.

Keywords: Lettuce, Nutrient film techniques, NPK, Growth, Yield and Quality.

INTRODUCTION

Lettuce (*Lactuca sativa L.*) is an important member of the Asteraceae family, with very successful and diverse group of plants having global distribution. It is a major fresh vegetable and its leaves are commonly found in salad mixtures and sandwiches. Lettuce is a rich source of vitamin K and vitamin A, and a moderate source of folate and iron. Growing hydroponics lettuce is one of the easiest and the best ways to start hydroponic gardening. Lettuce hydroponics will typically look after themselves and do not need a lot of nutrients as other heavy feeding plants like tomatoes. Hydroponic agriculture in urban areas is one of urban farming, an agricultural system without using soil media that uses narrow land in urban areas and is free from the use of synthetic pesticides. (**Nurlaili *et al.*, 2020**).

Lettuce being a leafy vegetable crop, needs proper nitrogenous as well as potassium fertilization schedule. **Kumar *et al.* (2021)** stated that proper nutrient management in diversified cropping system can improve the soil heath as well as crop yield in both field and protected condition. **Pramanick*et al.* (2018)**,**Dey *et al.* (2021)**, **Garai*et al.* (2019)** also showed foliar nutrition schedule is very important for crop production.

As stated, hydroponic lettuce is extremely easy to grow, once established into system. It mostly come down to providing adequate light (which varies depending on if we're growing outdoors or indoors), maintaining air temperature, and adjusting the nutrient levels to ensure the best results. In terms of autotoxin secretion reduction efficiency and yield performance of lettuce, 8R1B light regime is recommended for practical use. (**Zhou *et al.*, 2020**).

However, according to **Santos et al. (2008),** the hydroponic cultivation of lettuce has economic viability when the crop is grown with mineral solutions, but there is no formulation considered as ideal, because it involves a large number of variables and their interactions **(Rodrigues, 2002).** The solution of **Furlani (1995**) is the most used and little is known about the utilization of organomineral solutions.

MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Farm under shade net condition, Department of Horticulture, Naini Agricultural Institute, Sam Higgin bottom University of Agriculture, Technology & Sciences, Prayagraj (UP) during winter season that is from November 2021 to February 2022 in Randomized block design with 8 treatments, and three replications of Lettuce in NFT (Nutrient Film

Technique) horizontal system of hydroponics. Plants per treatment/system were 21, total number of plants 168 and distance per treatment/system 30 cm. The treatments were T_1 (NPK 2.8ml/Plant), T_2 (NPK 4.2ml/Plant), T_3 (NPK 5.71ml/Plant), T_4 (NPK 7.14ml/Plant), T_5 (NPK 8.57ml/Plant), T_6 (NPK 10ml/Plant), T_7 (NPK 11.43ml/Plant) and T_8 (NPK12.86ml/Plant). Coco peat were used for its medium.

The treatment combinations were given as per the given table 1. The nutrient solutions were changed every 15 days interval and fresh new solutions were made.

Table 1: Treatment combinations.

Treatments Symbol	Treatment combinations N, P and K ml/20 liter water			
	Initial	15 DAP	30 DAP	Total
T_1	10	20	30	60
T_2	20	30	40	90
T_3	30	40	50	120
T_4	40	50	60	150
T_5	50	60	70	180
T_6	60	70	80	210
T_7	70	80	90	240
T_8	80	90	100	270

Note: Equal amount of N, P and K was used to prepare one treatment *i. e.* (3.33 + 3.33 + 3.33ml = 10 ml)

The data recorded during the course of investigation were subjected to statistical analysis as per method of analysis of variance (ANOVA) as outlined by **Panse and Sukhatme, (1985).** The data recorded were on growth parameters (plant height, plant spread, number of leaves/plant, leaf length, leaf width, water used), quality parameters (T.S.S, vitamin C, chlorophyll content) and yield parameters (avg. weight, yield/structure, yield/29.02 m^2).

RESULTS AND DISCUSSION

A. Growth parameters

Plant height:

Maximum plant height 21.18 cm was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 20.98 cm, minimum 16.89 cm, was recorded in T_1 (NPK 2.8 ml/plant) (Table 2). Which can be due to higher levels of N, P & K, which is found suitable for lettuce in hydroponic system in cell elongation of leaves used in development of cell, rapid cell division and cell elongation in meristematic region of plant due to productionof plant growth substance, this might 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), Sundar *et al.*, (2019**).

Plant spread:

Maximum plant spread 22.02 cm was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) 21.91 cm minimum 18.36 cm was recorded in T_1 (NPK 2.8 ml/plant) (Table 2). Lettuce in hydroponic system result 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), Sundar *et al.*, (2019), Dey *et al.*, (2021)**.

Number of leaves/plant:

Maximum number of leaves/plant 11.21 was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) 11.81 leaves/plant and minimum 8.12 leaves/plant was recorded in T_1 (NPK 2.8 ml/plant) (Table 2). 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 **Ahmed *et al.*, (2021), Suyantohadi *et al.*, (2010), Frasetya *et al.*, (2019), Singh *et al.*, (2017).**

Leaf length:

Maximum leaf length 20.38 cm, was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 20.11 cm, and minimum 16.34 cm, was recorded in T_1 (NPK 2.8 ml/plant) (Table 2).

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)**.

Leaf width:

Maximum leaf width 12.58 cm, was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 12.23 cm, and minimum 10.26 cm, was recorded in T_1 (NPK 2.8 ml/plant) (Table 2). Which can be due to higher suitable levels of N, P & K, enhanced photosynthetic, 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), Sundar *et al.*, (2019) Das et al. (2021).**

Water used:

Maximum water used 12.21 liter, was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 11.92 liter, and minimum 12.34 liter, was recorded in T_1 (NPK 2.8 ml/plant) (Table 2). Water consumption depends upon the temperature, plant growth on nutrient concentration and also the temperature during the growing season as these factors contribute to the water consumption. This finding correlates the findings of **Pramanick*et al.* (2018), Laik*et al.* (2021), Oztekin *et al.*, (2018)**.

The statistically analyzed data on growth parameters of lettuce are presented in table 2. It is clear that there is significant difference.

Table 2: Growth parameters of Lettuce like plant height, plant spread, number of leaves/plant, leaf length, leaf width, water used.

Treatments	Plant height (cm)	Plant spread (cm)	Number of leaves/plant	Leaf length (cm)	Leaf width (cm)	Water used (liter)
T_1	17.4	18.82	8.51	16.83	10.61	12.34
T_2	17.69	18.85	8.58	16.92	10.88	13.35
T_3	17.99	19.18	9.81	17	11.2	14.11
T_4	18.48	19.59	9.99	17.68	11.03	14.87
T_5	20.65	21.57	10.85	19.89	12.21	15.78
T_6	20.52	21.47	10.43	19.68	11.92	15.67
T_7	20.44	21.26	10.37	19.63	11.87	15.45
T_8	19.03	20.03	10.27	18.04	11.77	15.23
T-test	S	S	S	S	S	S
SE(d)	0.44	0.44	0.36	0.43	0.35	0.22
C.D. at 5%	0.95	0.95	0.77	0.93	0.75	0.46
C.V.	2.83	2.70	4.44	2.91	3.73	1.79

B. Quality and yield parameters

T.S.S:

Maximum T.S.S content 4.59 was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 4.34 and minimum 2.91 was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). Which can 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)** and **Franquera *et al.*, (2015).**

Vitamin C:

Maximum vitamin C content 3.48 was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 3.25 and minimum 2.08 was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). Which can be due to the climatic conditions during crop growth and development which have a greater overall effect on vitamin C content. It is shown that excessive use of nitrogen decreases the vitamin C content. This finding correlates the findings of **Song *et al.*, (2020).**

Chlorophyll content:

Maximum chlorophyll content 20.05 was recorded in T_5 (NPK 10 ml/plant) followed by T_6 (NPK 8.57 ml/plant) with 18.98 and minimum 11.03 was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). Which can be due to amount of chlorophyll in leaf tissue influenced by nutrient availability and environmental stress such as salinity cold heat etc. Application of higher dosage of N also increase the chlorophyll content. This finding correlates the findings of **Coronel *et al.*, (2009)** and **Hokmalipour *et al.*, (2012).**

Average weight:

Maximum average weight (32.53 g) were recorded in T_5 (NPK 10 ml), followed by T_6 (NPK 8.57 ml) with (31.01 g) whereas minimum weight (19.36 g) was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). Which can be due to application of N, P, and K which attributed to enhanced photosynthesis, accumulation of carbohydrates and favorable effect on vegetative growth which also increase the weight and size of plants. This finding correlates the findings of **Akanbi *et al.*, (2007).**

Total yield/structure:

Maximum total yield/structure (683.13 g) was recorded in T_5 (NPK 10 ml), followed by T_6 (NPK 8.57 ml) with (651.14 g) whereas minimumyield (406.63 g) was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). 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).**

Yield Kg/29.02 m^2:

Maximum yield kg/29.02 m^2 (5.46 kg) were recorded in T_5 (NPK 10 ml) after application of NPK, followed by T_6 (NPK 8.57 ml) with (5.20 kg) whereas minimum yield (3.25 kg) was recorded in T_1 (NPK 2.8 ml/plant) (Table 3). Which can be due to plant growth and final yield depending on the continues supply of food material and water. Since N, P and K help in the absorption of water and carbohydrates metabolism, its deficiency may cause poor growth and yield of plants. This finding correlates the findings of **Akanbi *et al.*, (2007).**

The statistically analyzed data on quality and yield parameters of lettuce are presented in table 2. It is clear that there is significant difference.

Table 3: Quality parameters of Lettuce like chlorophyll content, T.S.S, vitamin C and yield parameters like average plant weight, yield per plot, yield (kg/29.02m^2).

Treatments	Chlorophyll content	T.S.S	Vitamin C	Average plant weight (g)	Yield per plot (g)	Yield (kg/29.02m^2)
T_1	11.63	3.1	2.08	19.36	406.63	13.55
T_2	11.93	3.11	2.31	21.35	448.28	14.94
T_3	13.27	3.33	2.51	22.98	482.51	16.08
T_4	15.8	3.75	2.65	27.82	584.15	19.47
T_5	19.7	4.49	3.48	32.53	683.13	22.77
T_6	18.7	4.11	3.25	31.01	651.14	21.7
T_7	18.35	3.99	2.75	30.19	634.06	21.13

T_8	16.2	3.97	2.71	29.18	612.85	20.42
T-test	S	S	S	S	S	S
SE(d)	0.68	0.17	0.10	0.53	4.72	0.10
C.D. at 5%	1.46	0.37	0.20	1.13	10.13	0.21
C.V.	5.30	5.66	4.29	2.41	3.08	0.63

CONCLUSION

From the present investigation it is concluded that treatment T_5 (NPK 8.57ml/Plant) was found best in terms of fallowing parameters of lettuce in NFT (nutrient film technique) hydroponic system, average plant height (20.65 cm), average plant spread (21.57 cm), average number of leaves/plant (10.85), average leaf length (19.89 cm), average leaf width (12.21 cm), water uptake(15.78 L), yield (22.77 kg/29.02 m^2), average T.S.S (4.49), average vitamin C (3.48) and average chlorophyll content (19.7). Maximum B:C ratio (1.75) were also obtain in treatment T_5.

References: -

1. **Andy Jacobson (2016)**. Hydroponics the essential guide 2nd edition.
2. **Awadia A . Ahamed and Ammar M. S. Abdalla (2019)** Effect of Salinity and NPK Fertilizer on the Total Soluble Solids (TSS) and N, P and K in Tomato Plants (*lycoperisiconesculentum L*). Department of Crop production, Faculty of Agricultural Sciences, Dongola University P. O.Box 47, Dongola, Sudan. Vol. 3 Issue 2, Pages: 38-42.
3. **B Frasetya, K Harisman and N A H Ramdaniah (2020).**The effect of hydroponics system on the growth of lettuce. IOP Conference Series: Materials Science and Engineering, Volume 1098.
4. **Chengbo Zhou, Chengbo Zhou, Yubin Zhang, Wenke Liu, Lingyan Zha (2020).** Light Quality Affected the Growth and Root Organic Carbon and Autotoxin Secretions of Institute Hydroponics Lettuce. Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences 2020 Plants 9(11):1542.
5. **Das, P., Pramanick, B., Goswami, S.B., Maitra, S., Ibrahim, S.M., Laing, A.M. and Hossain, A. 2021.** Innovative land arrangement in combination with irrigation methods improves the crop and water productivity of rice (*Oryza sativa* L.) grown with okra (*Abelmoschus esculentus* L.) under raised and sunken bed systems. Agronomy 11: 2087. https://doi.org/10.3390/agronomy11102087
6. **Dey, P., Mahapatra, B.S., Juyal, V.K., Pramanick, B., Negi, M.S., Paul, J. and Singh, S.P. 2021.** Flax processing waste – A low-cost, potential biosorbent for treatment of heavy metal, dye and organic matter contaminated industrial wastewater. Industrial Crops and Products 174: 114195. https://doi.org/10.1016/j.indcrop.2021.114195
7. **Dey, P., Mahapatra, B.S., Pramanick, B., Kumar, A., Negi, M.S., Paul, J., Shukla, D.K. and Singh, S.P. 2021a.** Quality optimization of flax fibre through durational management of water retting technology under sub-tropical climate. Industrial Crops and Products 162: 113277. https://doi.org/10.1016/j.indcrop.2021.113277
8. **Edmar N. Franquera (2015).** Effects of Plastic Mulch Color on the Total Soluble Solids, Total Sugars and Chlorophyll Content of Lettuce. International Journal of Research in Agriculture and Forestry Volume 2, Issue 8, August 2015, PP 18-24.
9. **G. Coronel, M. Chang and A. Rodríguez-Delfín (2009)** Nitrate Reductase Activity and Chlorophyll Content in Lettuce Plants Grown Hydroponically and organically. Acta Horticulturae 843(843):137-144.
10. **Garai, S., Brahmachari, K., Sarkar, S., Kundu, R., Pal, M. and Pramanick, B. 2019.** Crop growth and productivity of rainy maize – garden pea copping sequence as influenced by Kappaphycus and Gracilaria

saps at alluvial soil of West Bengal, India. Current Journal of Applied Science and Technology 36(2): 1–11. https://doi.org/10.9734/cjast/2019/v36i230227

11. **Kumar, M., Mitra, S., Mazumdar, S.P., Majumdar, B., Saha, A.R., Singh, S.R., Pramanick, B., Gaber, A., Alsanie, W.F. and Hossain, A. 2021.** Improvement of soil health and system productivity through crop diversification and residue incorporation under jute-based different cropping systems. Agronomy 11: 1622. https://doi.org/10.3390/agronomy11081622
12. **Laik, R., Kumara, B.H., Pramanick, B., Singh, S.K., Nidhi, Alhomrani, M., Gaber, A., and Hossain, A. 2021.** Labile soil organic matter pools are influenced by 45 years of applied farmyard manure and mineral nitrogen in the wheat—pearl millet cropping system in the sub-tropical condition. Agronomy 11: 2190. https://doi.org/10.3390/agronomy11112190
13. **Nurul Aini, Wiwin Sumiya Dwi Yamika and Bachrul Ulum. (2019)** Effect of Nutrient Concentration, PGPR and AMF on Plant Growth, Yield, and Nutrient Uptake of Hydroponic Lettuce. International Journal of Agriculture and Biology. 175-183.
14. **Oztekin, G. B., Uludag, T., and Tuzel, Y. (2018)** Growing spinach (S*pinacia oleracea* l.) in a floating system with different concentrations of nutrient solution., *Applied ecology and environmental research.*, **16**(3): 3333-3350.
15. **Pramanick, B., Brahmachari, K., Ghosh, D. and Bera, P.S. 2018.** Influence of foliar application seaweed (*Kappaphycus* and *Gracilaria*) saps in rice (*Oryza sativa*)–potato (*Solanum tuberosum*)–blackgram (*Vigna mungo*) sequence. Indian Journal of Agronomy 63(1): 7–12.
16. **Saeid Hokmalipour and Maryam Hamele Darbandi (2012)** Effects of Nitrogen Fertilizer on Chlorophyll Content and Other Leaf Indicate in Three Cultivars of Maize (*Zea mays L.).* World applied Science Journal16(6).
17. **Singh, R., Pramanick, B., Singh, A.P., Neelam, Kumar, S., Kumar, A. and Singh, G. 2017.** Bio-efficacy of Fenoxaprop-P-Ethyl for grassy weed control in onion and its residual effect on succeeding maize crop. Indian Journal of Weed Science 49 (1): 63 – 66.
18. **Suyantohadi A, Kyoren T, Hariadi M, Purnomo M H and Morimoto T (2010)** Effect of high consentrated dissolved oxygen on the plant growth in a deep hydroponic culture under a low
19. **Song, J., Huang, H., Hao, Y., Shiwei Song, Yiting Zhang, Wei Su Houcheng Liu (2020)** Nutritional quality, mineral and antioxidant content in lettuce affected by interaction of light intensity and nutrient solution concentration. *Sci Rep* 10, 2796.
20. **Tumbare, A. D. and Bhote, S. U. (2002)** Effect of solid soluble fertilizer applied through fertigation on growth and yield of chilli *(Capsicum annum).* Indian J. Agric. Sci., **72**(2): 109-111.
21. **Zienab F. R. Ahmed, Alghazal K. H. Alnuaimi , Amira Askri and Nikolaos Tzortzakis (2021)** Evaluation of Lettuce (Lactuca sativa L.) Production under Hydroponic System: Nutrient Solution Derived from Fish Waste vs. Inorganic Nutrient Solution. Horticulturae 2021, 7, 292.