INFLUENCE OF NUTRIENT CONCENTRATION ON GROWTH, YIELD AND QUALITY OF SPINACH (*Spinacia oleracea L.*) IN HYDROPONIC SYSTEM

ABSTRACT

The present experiment entitled **"Influence of nutrient concentration on Growth, Yield and Quality of Spinach (*Spinacia oleracea* L.) in Hydroponic system"** was carried out in Shade net, Research Field, Department of Horticulture, SHUATS, Prayagraj during March-April,2020.. The experiment was laid out in complete randomized design (CRD), with eight treatments, replicated thrice with nutrient field technique hydroponics system and variety Mulayam of Spinach, the treatments were T_1 (NPK 6.25 ml/plant), T_2 (NPK 8.33 ml/plant), T_3 (NPK 10.41 ml/plant), T_4 (NPK 12.5 ml/plant), T_5 (NPK 14.58 ml/plant), T_6 (NPK 16.66 ml/plant), T_7 (NPK 18.75 ml/plant) and T_0 (NPK 0 ml/plant). From the present experimental findings, it is found that structure with treatment T_4 was found best in terms of Growth and yield parameters of spinach in NFT hydroponic system followed by structure with T_3 and T_1 due to appropriate supply of plant nutrients and the water treated plants had the lowest values. Maximum gross return (1871.30Rs) and net return (746.30 Rs) and maximum benefit cost ratio (1.66) was also observed in treatment T_4. As seen from the experiment, it was observed that the treatment T_4 was ideal nutrient for Spinach good growth and yield. Therefore, an ideal nutrient concentration helps the plants in good growth and yield.

Keywords: Spinach, Nutrient film techniques, Hydroponic and NPK.

INTRODUCTION

Spinach (*Spinacia oleracea* L.) commonly called as Spinach (English) and Palak in India is an important leafy vegetable of which the leaves and tender shoots are consumed fresh or processed. It belongs to the family Chenopodiaceae. It is native of Central Asia, most probably of Persia (Iran).

Soil cultivation is practiced since centuries as it contains nutrients formed during natural decay. However, it may take several years of building soil

up with soil amendments to obtain the desire texture and composition. A new technique called soil-less culture commonly known as hydroponics has been developed to further improve the crop productivity in lesser space and time by controlling the supply of water and nutrients. Hydroponics comes from two Greek words *hydro*' means water and *ponos*' means labour or working with water. The word hydroponics was coined by Professor William Gericke in the early 1930s.Hydroponics is the technique of growing plants in nutrient enriched water with or without the use of an inert medium (aggregate culture) such as gravel, vermiculite, rockwool, peat moss, saw dust, coirdust, coconut fibre etc.

In this study the principle of Nutrient film technique (NFT) was applied. Nutrient film technique (NFT) is a closed hydroponic system. In this syatem plants are placed in channel tube with roots dangling in a hydroponic solution and they are constantly immersed in water or nutrient. The nutrients are mixed in a primary reservoir accordingly recirculates throughout the entire system and enters the growth through a pump without a time control **(Domingues *et al*., 2012)**.

Various experimental finding outlines that leafy greens (lettuce, spinach, parsley, celery etc) can be successfully and easily grown in hydroponic systems **Nisha *et al.* (2018)**.Therefore keeping the above facts in view the present study entitled "Production of Lettuce in Nutrient film technique (NFT) of hydroponic systems" was conducted in Department of Horticulture, SHUATS, Prayagraj.

The aim of the current research was to

evaluate the effect of different concentrations of nutrients on quantitative and qualitative traits of spinach grown in floating system.

MATERIALS AND METHODS

The present Experiment was conducted in Complete Randomized Design (CRD), with eight treatments, of NPK replicated thrice with Spinach variety (Mulayam), in the Shade net, Research field, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during March, 2020 to April, 2020. Total number of treatments were eight *viz.* T_1 (NPK 6.25 ml/Plant), T_2 (NPK 8.33 ml/Plant), T_3 (NPK 10.41 ml/Plant), T_4 (NPK 12.5 ml/Plant), T_5 (NPK 14.58 ml/Plant), T_6 (NPK 16.66 ml/Plant), T_7 (NPK 18.75 ml/Plant) and T_0 (Control (NPK 0 ml/Plant).

The data on Organoleptic evaluation was obtained by averaging the marks based on the hedonic scale.

The hedonic scale is given as follows:

1. Like extremely
2. Like very much
3. like moderately
4. like slightly
5. neither like nor
6. Dislike Slightly
7. dislike Moderately
8. Dislike Very Much
9. Dislike Extremely

Climatic condition in the experimental site:

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46^{o} C- 48^{o} C and seldom falls as low as 4^{o}C- 5^{o}C. The relative humidity ranges between 20 to 94 %. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

RESULTS AND DISCUSSION

The results of the present investigation, regarding the influence of different concentration of NPK on growth, yield and quality of Spinach in (NFT) hydroponic system, have been discussed and interpreted in the light of previous research work done in India and abroad.

The results of the experiment are summarized below:

A. Growth Parameters

In terms of Plant Height. Maximum 5, 8.81, 19.82, 26.41 and 28.59 cm at 10, 20, 30, 40 and 50 DAP was recorded in T_4 (NPK 12.5 ml/plant) followed by T_3 (NPK 10.41 ml/plant) with 4.71, 8.16, 16.76, 26.41 and 25.4 cm, minimum 4.10, 7.44, 7.76, 7.99 and 8.81cm, was recorded in Control. Significantly maximum plant height was recorded in T_4 at 10, 20, 30, 40 and 50 DAP had better growth and development due to higher levels of plant nutrient concentration provided to the plants and the water treated plants had the lowest values. This finding correlates the findings, **Oztekin *et al. (*2018)** in Spinach.

In terms of Plant spread. Maximum 4.63, 5.62, 21.1, 41.26 and 45.96 cm at 10, 20, 30, 40 and 50 DAP was recorded in T_4 (NPK 12.5 ml/plant) followed by T_3 (NPK 10.41 ml/plant) with 4.10, 5.02, 18.93, 38.76 and 42.79 cm, minimum 3.46, 4.34, 6.04, 8.04, 10 cm, was recorded in Control. Significantly maximum plant spread was recorded in T_4 at 10, 20, 30, 40 and 50 DAP, which might be due to higher levels of N, P & K, which found suitable for Spinach 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 **Oztekin *et al. (*2018)**.

In terms of Number of leaves/plant. Maximum 4.60, 6.83, 13.22, 21.55 and 23.33 leaves/plant at 10, 20, 30, 40 and 50 DAP was recorded in T_4(NPK 12.5 ml/plant) followed by T_3 (NPK 10.41 ml/plant) with 4.11, 6.02, 11.22, 19.56 and 21.44 leaves/plant and minimum 3.62, 4.44, 5.84, 6,4 and 7.44 leaves/plant was recorded in Control. Significantly maximum Number of leaves per plant was recorded in T_5 at 10, 20, 30, 40 and 50 DAP, which might be due to higher levels of N, P & K, which found suitable for Spinach in hydroponic. Differences in the number of leaves per plant could be asscociated with the increase concentration This finding correlates the findings of **Petropoulos *et al*.(2016)** in Spinach, **Sapkota *et al.* (2019)** in Lettuce and **Adams, P. (2002)** in Hydroponic production of vegetables.

In terms of Leaf length. Maximum 5.98, 10.04, 21.39, 27.20 and 29.07 cm , at 10, 20, 30, 40 and 50 DAP was recorded in T_4(NPK 12.5 ml/plant) followed by T_3(NPK 10.41 ml/plant) with 5.93, 8.86, 17.50, 24.82 and 25.50 cm, and minimum 4.63, 7.03, 7.87, 8.62 and 9.61 cm , was recorded in Control. Significantly longer Leaf length was recorded in T_4 at 10, 20, 30, 40 and 50 DAP, which could be due to better nutrient concentration. This finding correlates the findings of **Sapkota *et al.* (2019)** in Lettuce.

In terms of Leaf width. Maximum 1.13, 3.38, 7.28, 8.49 and 8.96 cm, at 10, 20, 30, 40 and 50 DAP was recorded in T_4(NPK 12.5 ml/plant) followed by T_3 (NPK 10.41 ml/plant) with 1.01, 2.91, 5.49, 8.08 and 8.37 cm, and minimum 0.87, 1.19, 1.58, 1.83 and 2.08 cm , was recorded in Control. Significantly maximum Leaf width was recorded in T_4 at 10, 20, 30, 40 and 50 DAP, which might be due to higher levels of N, P & K, which found suitable for Spinach in hydroponic system.This finding correlates the findings of **Sapkota *et al.* (2019)**

In terms of Root length. Maximum 7.58, 17.98, 32.29, 48.86 and 70.55 cm, at 10, 20, 30, 40 and 50 DAP was recorded in T_4(NPK 12.5 ml/plant) followed by T_3(NPK 10.41ml/plant) with7.19, 16.20, 27.67, 44.92 and 61.33 cm, and minimum 6.29, 13.02, 24.33, 38.86 and 54.67 cm, was recorded in Control. Significantly maximum Root length was recorded in T_4 at 10, 20, 30, 40 and 50 DAP, this may be due to large amount of nutrients directly available to the plants roots, which led in the higher water uptake of plants and ultimately growth of roots of Spinach. This finding correlates the findings of **Maneejantra *et al.* (2016**) in Spinach and **Sapkota *et al.* (2019)** in Lettuce.

In terms of Water used. Maximum 5.91, 12.21, 13.39, 17.97, and 18.46 litre, at 10, 20, 30, 40 and 50 DAP was recorded in T_4(NPK 12.5 ml/plant) followed by T_3 (NPK 10.41 ml/plant) with 5.17, 11.85, 12.17, 16.43 and 17.56 litre, and

minimum 4.07, 6.60, 7.92, 12.88 and 15.65 litre was recorded in Control.. This might be due higher dose of N, P and K in NFT hydroponic system in which plant growth, yield, and water consumption vary depending on the concentration of nutrient solution as well as the temperature during the growing season. When the temperature and nutrient concentration increased plant growth and water consumption also increased. This finding correlates the findings of **Zhang *et al.* (2016)** in water use efficiency of Tomato and **Oztekin *et al.*, (2018)** in Spinach.

B. Yield Parameters

In Average weight of plants. Maximum Average weight (62.48 g) were recorded in T_4 (NPK 12.5ml) after application of NPK, followed by T_3 (NPK 10.41ml) with (54.63 g) whereas minimum weight (3.89 g) was recorded in T_0 (Control).This might be due to N, P, and K application might be 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 **Maneejantra *et al.* (2016**) in Spinach and **Akanbi *et al.* (2007)** in pepper.

In Yield/Structure (kg). Maximum Yield/Structure (1.50 kg) were recorded in T_4 (NPK12.5 ml) after application of NPK, followed by T_3 (NPK 10.41 ml) with (1.31 kg) whereas minimum yield (0.09 kg) was recorded in T_0 (Control).This might be due to the plant growth and final yield depends on the continued 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 **Oztekin *et al.* (2018)** in Spinach and **Paradosi *et al.* (1987)** in Tomato.

C. Quality parameters

The data on Dry matter percent of Spinach of different treatment combinations of NPK in NFT hydroponics system of Spinach was recorded and are presented in table 4.12. Critical analysis of data displayed in table clearly marked out the obvious difference among the treatments with respect to Dry matter content. Significant difference was observed due to different concentration of NPK for Dry matter content. Maximum dry matter percent (35.53 %) was recorded in T_4 (NPK 12.5ml) after application of NPK, followed by T_3 (NPK 10.41ml) with (33.3 %) whereas minimum dry matter content (24.90 %) was recorded in T_0 (Control). This finding correlates the findings of **Oztekin *et al.* (2018)** in Spinach.

The data on organoleptic evaluation parameter of spinach of different treatment combinations of NPK in NFT hydroponics system of spinach was recorded and are presented in table 4.13. Critical analysis of data displayed in table clearly marked out the obvious difference among the treatments with respect to organoleptic parameters. In terms of Score for colour and appearance, maximum score was recorded in treatment T_4 (NPK 12.5 ml/Plant) with 8.60 followed by treatment T_3 (NPK 10.41 ml/Plant) with 7.12, and minimum score was observed in treatment T_0 (Control) with 2.14.In terms of Score for Texture, maximum score was recorded in treatment T_4 (NPK 12.5 ml/Plant) with 8.55 followed by treatment T_3 (NPK 10.41 ml/Plant) with 7.32, and minimum score was observed in treatment T_0 (Control) with 2.93.In terms of Score for Flavour and taste maximum score was recorded in treatment T_4(NPK 12.5 ml/Plant) with 8.71 followed by treatment T_3 (NPK 10.41 ml/Plant) with 8.04, and minimum score was observed in treatment T_0(Control) with 3.13.In terms of Score for Overall acceptability maximum score was recorded in treatment T_4 (NPK 12.5 ml/Plant) with 8.89 followed by treatment T_3(NPK 10.41 ml/Plant) with 7.77, and minimum score was observed in treatment T_0 (Control) with 2.34.

D. Economics

In terms of economics, maximum cost of cultivation (Rs. 1425.00) was observed in T_7 (NPK 18.75 ml/plant) followed by T_6 (NPK 16.66 ml/plant) (Rs. 1324.70), minimum cost of cultivation (Rs. 525.00) was observed in Control. In Gross return (Rs. 1871.30) is recorded in T_4(NPK 12.5 ml/plant) followed by T_3(NPK 10.41 ml/plant)

(Rs.1636.28), minimum Gross return (Rs. 116.45) was recorded in T_0 (NPK 0 ml/plant). In Net return (Rs.746.30) was found in T_4(NPK 12.5 ml/plant) followed by T_3(10.41 ml/plant) (Rs.611.60), minimum Net return (Rs. 87.00) was found in T_7 (NPK 18.75 ml/plant).In Benefit: Cost ratio (1.66) is observed in T_4 (12.5ml/plant) followed by T_1 (NPK 6.25 ml/plant) (1.63), minimum B:C ratio (0.22) was observed in T_0 (NPK 0 ml/plant).

Table 1. Performance of Spinach for growth parameters in NFT hydroponic system.

Treatment	Plant Height (cm)					Plant Spread (cm)					Number of Leaves/plant				
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP
T_0	4.10	7.44	7.76	7.99	8.81	3.46	4.34	6.04	8.04	10.00	3.62	4.44	5.89	6.44	7.44
T_1	4.28	7.78	13.84	17.60	22.00	3.94	5.02	17.54	27.46	30.22	4.08	5.94	10.33	16.89	18.78
T_2	4.41	7.59	13.10	14.96	16.61	3.64	4.41	13.60	21.28	23.14	4.00	5.68	8.78	13.44	15.00
T_3	4.71	8.16	16.76	22.06	25.44	4.10	5.02	18.93	38.76	42.79	4.11	6.02	11.22	19.56	21.44
T_4	5.00	8.81	19.82	26.41	28.59	4.63	5.62	21.11	41.26	45.96	4.60	6.83	13.22	21.55	23.33
T_5	4.68	7.91	12.94	16.68	20.28	4.07	4.67	14.47	25.08	30.89	3.89	5.78	8.67	14.22	15.89
T_6	4.74	7.49	15.47	17.51	21.03	4.03	4.80	14.09	22.80	25.08	3.89	5.33	8.11	13.22	14.11
T_7	4.68	7.50	14.46	17.21	19.90	3.93	4.42	13.48	19.02	21.18	3.71	5.00	7.56	11.89	14.00
F-Test	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
C.D. at 5%	0.41	0.63	1.01	1.13	0.83	0.39	0.41	0.92	1.34	1.32	0.39	0.46	0.69	0.79	0.67
SE(d)	0.19	0.30	0.47	0.53	0.39	0.18	0.19	0.43	0.63	0.62	0.18	0.22	0.33	0.37	0.31
C.V.	5.09	4.61	4.05	3.69	2.35	5.66	4.84	3.55	3.02	2.65	5.63	4.72	4.31	3.09	2.37

Table 2. Performance of Spinach for growth parameters in NFT hydroponic system.

Treatment	Leaf Length (cm)					Leaf width (cm)					Root length (cm)				
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP
T_0	4.63	7.03	7.87	8.62	9.61	0.87	1.19	1.58	1.83	2.08	6.29	13.02	24.33	38.86	54.67
T_1	5.42	8.74	16.44	18.20	21.68	0.98	2.82	5.17	7.88	8.06	4.93	12.37	20.50	31.10	45.14
T_2	5.12	8.26	13.86	17.67	21.00	0.94	2.80	4.92	7.60	7.92	7.41	17.17	29.67	46.77	64.26
T_3	5.43	8.86	17.50	24.82	25.50	1.01	2.91	5.49	8.08	8.37	7.19	16.20	27.67	44.92	61.33
T_4	5.98	10.04	21.39	27.20	29.07	1.13	3.38	7.28	8.49	8.96	8.12	20.37	35.29	52.37	76.86
T_5	5.10	8.61	14.53	18.39	21.73	0.94	2.83	4.99	7.23	7.71	7.58	17.98	32.29	48.86	70.55
T_6	5.48	8.18	15.26	17.88	20.97	0.99	2.82	4.76	5.27	5.66	7.09	14.67	27.50	42.67	59.33
T_7	4.97	8.09	13.51	15.64	17.47	0.88	2.03	4.34	4.69	4.84	6.95	14.17	26.00	41.44	57.33
F-Test	S	S	S	S	S	S	S	S	S	S	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	0.53	0.61	0.96	1.06	1.04	0.094	0.241	0.398	0.306	0.241	0.54	1.12	1.80	1.93	2.31
SE(d)	0.25	0.29	0.45	0.50	0.49	0.044	0.113	0.186	0.143	0.113	0.26	0.53	0.84	0.90	1.08
C.V.	5.72	4.11	3.65	3.28	2.86	5.561	5.311	4.736	2.748	2.060	4.49	4.08	3.68	2.54	2.16

Table 3. Performance of Spinach for water used, Weight and yield parameters in NFT hydroponic system.

Treatment Symbol	Water used (liter)					Avg. weight of plant (g)	Yield/structure (kg)
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP		
T_0	4.07	6.6	7.92	12.88	15.65	3.89	0.09
T_1	4.76	11.3	11.48	16.18	17.03	49.88	1.20
T_2	4.69	9.18	10.4	14.52	16.23	41.86	1.00
T_3	5.17	11.85	12.17	16.43	17.56	54.11	1.30
T_4	5.91	12.21	13.34	17.97	18.46	57.74	1.39
T_5	4.48	10.66	11	15.36	16.96	52.39	1.26
T_6	4.18	9.55	10.87	14.89	16.78	47.27	1.14
T_7	4.33	9.92	10.21	14.23	16.6	42.72	1.02
F-Test	S	S	S	S	S	S	S
C.D. at 5%	0.085	0.344	0.225	0.053	0.028	0.85	0.02
SE(d)	0.182	0.734	0.225	0.113	0.061	2.39	2.48
C.V.	2.215	4.141	2.526	0.421	0.206	1.82	0.05

Table 4. Performance of Spinach for Dry matter, Organoleptic evaluation (Accessed with Hedonic scale) and B: C ratio.

Treatment	Dry matter	Organoleptic Evaluation				B:C Ratio
		Score for colour and appearance	Score for texture	Score for Flavour and Taste	Score for Over all acceptability	
T_0	24.90	2.14	2.93	3.13	2.34	0.22
T_1	32.04	7.34	7.17	7.34	7.54	1.63
T_2	30.94	6.92	6.22	6.45	6.29	1.44
T_3	33.30	7.12	7.32	8.04	7.77	1.60
T_4	35.53	8.60	8.55	8.71	8.89	1.66
T_5	30.31	7.03	6.75	6.97	6.69	1.31
T_6	29.44	6.89	6.76	6.56	6.31	1.18
T_7	28.35	5.97	6.44	6.36	6.42	0.94
F-Test	S	S	S	S	S	
C.D. at 5%	0.50	0.14	0.12	0.15	0.13	
SE(d)	2.00	2.56	2.25	2.78	2.43	
C.V.	1.07	0.29	0.26	0.33	0.28	

CONCLUSION

From the present investigation it is concluded that treatment T_4 found best in terms of Growth and yield parameters of Spinach in NFT hydroponic system followed by T_3 and T_1. Minimum growth and yield was recorded in T_0. Maximum gross return and net return was recorded in T_4 and maximum cost benefit ratio 1.66 was observed in treatment T_4 minimum gross and net return recorded in T_0 and T_7 and cost benefit ratio in T_0. In hydroponics, the flow of nutrient and nutrient uptake is a vital criteria for good growth and yield. Nutrient deficit leads to stunted growth of plants and overly absorption of nutrients can lead to antagonistic consequence on plant growth. Therefore, an ideal nutrient concentration helps the plants in good growth and yield. As seen from the experiment, it was observed that the treatment T_4 was ideal nutrient for Spinach good growth and yield.

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