The Effects of Different Nitrogen and Potassium Ratios and Indole-3-Butyric Acid Applications on Growth and Appearance Values of Impatiens Plant (Impatiens Walleriana) Grown in Hydroponic Medium

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***Abstract*— In this study, the effects of Indole-3 butyric acid (IBA) applications to Impatiens cuttings and nitrogen and potassium applied at different rates in hydroponic nutrient solution on plant development, appearance and quality values were investigated. Plant fresh weight value, branch number, branch length values, flowering time, floral longevity and generally plant appearance value score increased with increasing K rates at constant N level, while they decreased with decreasing N rates at constant potassium level. N and K contents of the plant were compatible with N and K concentrations in the nutrient solution, but showed differences at different N/K ratios in the nutrient solution. The findings showed that N/K ratios in the nutrient solution have a significant effect on N and K nutrition of Impatiens plants and the most effective N/K ratio in terms of plant growth and quality values was determined as 0.75/1. According to these ratios, the optimum N and K feeding concentration of the nutrient solution is evaluated as 10.5 mmol L-1 for N and 14 mmol L-1 for K.**

***Keywords*— Impatiens, Nitrogen, Potassium, Hydroponic medium.**

I. Introduction

Seaweeds include macroscopic, multicellular marine algae Impatiens has an important commercial value worldwide as an ornamental plant. Impatiens has an important economic value in the landscape sector, ornamental plant trade and seedling production. Impatiens is often preferred in landscaping arrangements because it is one of the rare flowers that can grow especially in shade areas, fast growth, ease of maintenance, long duration and abundant flowering [1].

Impatiens is an ornamental plant that can be successfully grown in hydroponic systems. Hydroponic cultivation is based on providing the nutrients needed by the plant with water-based solutions, and substrates such as perlite, cocopeat, rockwool, hydrotone are used to support the roots instead of soil. Impatiens plant can be easily grown in hydroponic systems, grows fast and shows intense flowering. Especially in indoor areas, greenhouses or commercial production, healthy Impatiens plants are grown throughout the year using hydroponic systems.

Plant nutrition management, including fertilization practices, is an important factor determining the ornamental value and marketability of potted plants [2]. In the nutrition of ornamental plants, nutrient form and application rate time according to the phenological developmental periods of the plant are of great importance. While the quality and marketing value of the product obtained with the appropriate fertilization program increases, negative effects such as plant toxicity, crop losses and environmental pollution are minimized. In ornamental plant production, it is known that parameters such as plant biomass, number and length of branches, total leaf area, number of leaves and number of flowers, which determine the marketing value of the plant according to plant species, are directly related to fertilization [3]. The Impatiens plant requires high nutrient levels to grow and build its total biomass. Leaves, branches and flowers are ornamental organs in the Impatiens plant and essential plant nutrient applications are needed to delay senescence of the whole plant and ensure flowering.

Nitrogen and potassium nutrients are among the essential nutrients absolutely necessary for plant nutrition. In soilless cultivation systems, the nitrogen (N)/potassium (K) ratio is a critical factor influencing plant growth, development, and overall health [4]. Balancing these macronutrients appropriately ensures optimal physiological functions and maximizes crop yields. Excessive nitrogen can lead to lush vegetative growth at the expense of flowering, while insufficient potassium may reduce flower quality and plant vigor. Therefore, a balanced fertilization approach, considering the specific growth stage and environmental conditions, is recommended. The presence of these two essential nutrients in appropriate ratios in soilless medium is important for plant nutrition and quality [5].

Hormone applications to promote rooting in plants can directly and indirectly affect mineral nutrition. Different plant hormones can increase or decrease plant access to nutrients by regulating mineral uptake, transport and utilisation. In this respect, it is important to consider hormone effects in mineral nutrition of ornamental plants grown in nutrient solution.

In this study, the effects of nitrogen and potassium applied to Impatiens plants grown in hydroponic medium at different ratios in nutrient solution on growth and yield parameters and nutrient contents were investigated with and without IBA treatments.

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II. Material and Methods

The experiment was carried out in a glass greenhouse with controlled temperature, humidity and lighting. A 1:1 by volume mixture of washed peat and perlite sieved through a 2 mm sieve was used as growing medium in pots.The physical and chemical analytical characteristics of the potting media were within the range of acceptable values for ornamental plants (Table 1).

TABLE I:
SEAWEED PRODUCTION WORLDWIDE [4].

Country	2022 Production (wet weight, tonnes)	Rate (%)
China	~19.8 million tonnes	~56%
Indonesia	~10.2 million tonnes	~29%
Korea (South)	~1.8 million tonnes	~5%
Philippines	~1.5 million tonnes	~4%
Japan	~600 thousand tonnes	~2%
Chile	~400 thousand tonnes	~1%

Before the experiment, equal sized cuttings were taken from healthy growing Impatiens plant (*Impatiens Walleriana*) samples to be used in the experiment. Some of these cuttings were subjected to commercial rooting hormone (Indole-3 butryic acid) treatment according to the experimental plan. Commercial Indole-3 butyric acid (IBA) solution was diluted and prepared according to the manufacturer's recommendations and applied to the basal end of the cuttings by mass immersion for 1 and 4 minutes, respectively. All cuttings with and without IBA treatment were allowed to root in pure perlite medium.

Impatiens plants rooted in perlite medium were transferred to pots at the developmental stage of 6 leaves .and fertilised with a nutrient solution containing different N and K ratios created by modifying the nutrient solution for ornamental plants [6].

TABLE II. Content of Nutrient Solutions Containing Different N/K Ratios in The Experiment (mmol 1^{-1})

Tretaments	N/K Rates	NO_3^-	$H_2PO_4^-$	SO_4^-	NH_4^+	K^+	Ca^{++}	Mg^{++}	Na^+
1	1/0.25	13	1.25	5.37	1	3.5	4	1	10.5
2	1/0.50	13	1.25	5.37	1	7,0	4	1	7
3	1/0.75	13	1.25	5.37	1	10.5	4	1	3.5
4	1/1	13	1.25	5.37	1	14	4	1	-
5	0.75/1	9.69	1.25	7.03	0.81	14	4	1	0.19
6	0.50/1	6.40	1.25	8.64	0.54	14	4	1	0.46
7	0.25/1	3.25	1.25	10.25	0.25	14	4	1	0.75
Reference [6]		13	1.25	1.25	1	7.5	3.125	1	-

The pH value of the nutrient solutions used in the experiment was adjusted to 6 and the EC value to 2 $ms.cm^{-1}$ (25 C°). Impatiens plants were fertigated at the rate of 50-200 ml/day with nutrient solutions prepared according to the procedures given above, based on their water consumption and practical leaching of the solution from the pots during the growth period. In order to prevent excessive salt accumulation in the pots, 500 ml of pure water was applied to all pots 1 day a week and then immediately its own solution was applied to drain the accumulated salts. Greenhouse temperature, humidity and illumination were kept at an appropriate level during the rooting and growth stages of the plants.

Four months after all plants were cut from the surface of the pots and their fresh weight, branch numbers and branch lengths were determined and prepared for analysis after standard washing, drying and grinding procedures for plant nutrient analysis.

The flowering time of Impatiens plants was determined based on the time from the transfer of the seedlings to the pots until flowering. The flowering time was determined by labeling the flowers formed on the Impatiens plants immediately after bud opening by using adhesive paper tapes with the date of flowering written on it in 1x1 cm dimensions and the time until the flower shriveled. The total number of flowers was determined based on the number of labels used in each pot. All these procedures were carried out by keeping separate notes for each pot and making regular daily phenological observations.

The appearance score of Impatiens plants was determined at the harvest stage by taking into consideration the attractiveness criteria such as the rate of filling the pot with leaves, branches and flowers, the brightness of the leaves and flowers, and the average of the scores given between 1 and 10 for each pot by a group of 5 researchers experienced in ornamental plants.

Total nitrogen was determined by Kjeldahl method in dried and ground plant samples and P and K elements were determined by ICP-MS in plant samples wet ashed with HNO_3+$HClO_4$ acid mixture in accordance with the analytical procedure.

The analysis of variance of the findings obtained in the greenhouse experiment carried out according to the random blocks experimental design with 5 replicates was analysed using SPSS software (23.0).

III. Results

The effects of IBA applications on the examined parameters were found to be significant in flowering time. Although IBA applications generally caused a positive change on all parameters examined, the fact that it was not statistically significant in other parameters is probably due to the interaction of different N/K ratios (Table 3).

Both in non-treated and treated IBA treatments, N and K treatments applied at different rates to the nutrient solution had statistically significant effects on fresh weight (biomass), number of branchs, branch length, flowering time, flowering days, total number of flowers, appearance score, N, P and K contents of Impatiens plants (Table 4, Table, 5).

TABLE III. SOME ORNAMENTAL PLANT QUALITY VALUES OF IMPATIENS IN NON-IBA AND IBA TREATMENTS

IBA Tretaments	Fresh weight (g)	Branch number	Branch length, cm	Flowering time (day)	Floral longevity (day)	Flower number	Appearance Score	N, %	P, %	K, %
Non-Treated	37,6	16,8	13,9	27,6	6,0	32,6	5,4	2,86	0,587	2,78
Treated	39,3	18,3	14,6	24,8	6,5	46,8	5,5	2,83	0,593	2,66
St. Dev.	19,6	9,0	4,0	9,6	1,6	20,5	2,2	0,86	0,144	0,74
Anova	NS	NS	NS	*	NS	NS	NS	NS	NS	NS

*:P<0,05; NS: No significancy

Plant fresh weight, branch number and branch length, flower number values increased with increasing K ratios at constant N level, while they decreased with decreasing N ratios at constant potassium level. The highest biomass and branch length and flower number values were obtained at 1/1 N/K ratio. Flowering time were decreased with increasing K ratios at constant N level, while there was no significant change with increasing N ratios at constant potassium level. The lowest flowering time was obtained at 0,25/1 N/K ratio. Flower longevity increased with increasing K rates at constant N level, and increased with decreasing N rates at constant potassium level. The highest flowering day number was obtained at 0.25/1 N/K ratio. The number of flowers of Impatiens increased with decreasing K ratios at constant N level, while it showed differences with decreasing N ratios at constant potassium level. The highest flower number was obtained at 0,5/1 N/K ratio.

As in the previous parameters, the appearance score of Impatiens plants increased with increasing K ratios at constant N level and decreased with decreasing N ratios at constant potassium level, but the highest values were obtained at 1/0.75 and 0.75/1 N/K ratios.

Nitrogen nutrient had a positive effect on vegetative growth of Impatiens plants by increasing fresh weight, branch number, branch length and number of flowers, while there was no significant change in N content at decreasing rates of potassium nutrient. However, it was observed that N content decreased significantly in relation to decreasing N at constant K rates. Nitrogen nutrient had a significant effect on the plant's attractiveness, especially on the number of flowers. Potassium nutrient has a positive effect on plant quality value by increasing flowering time and flower number at constant N levels.

No significant change was observed in the P content of Impatiens plants grown at different N/K ratios, but the highest P content was obtained at 0.5/1 N/K ratio.

While the K content of Impatiens increased with increasing K ratios at constant N level, it did not show a significant change at constant potassium level, but the highest K content was obtained at 0.25/1 N/K ratio. The N and K contents of the plant were consistent with the N and K concentrations of the nutrient solution.

TABLE V. SOME ORNAMENTAL PLANT QUALITY VALUES OF NON-IBA TREATED IMPATIENS AT DIFFERENT N AND K APPLICATION RATES

Tretaments	Fresh weight (g)	Branch number	Branch length, cm	Flowering time (day)	Floral longevity	lower number	Appearance score	N, %	P, %	K, %
1/0.25	20,7	9,0	11,1	34,3	4,5	12,3	2,5	3,78	0,620	2,20
1/0.50	43,2	23,3	15,3	29,0	4,3	30,5	4,8	3,51	0,634	2,74
1/0.75	55,0	23,5	17,2	29,5	5,0	22,3	7,3	3,24	0,620	2,70
1/1	52,7	25,8	15,2	29,0	6,3	54,0	7,0	3,34	0,602	3,39
0.75/1	47,5	22,0	17,8	20,8	7,0	46,0	7,5	3,10	0,619	2,88
0.50/1	42,5	15,3	15,3	22,8	8,0	48,0	7,5	2,69	0,677	3,37
0.25/1	33,0	11,3	13,15	16,5	7,5	40,50	5,5	1,79	0,639	3,74
St. Dev.	19,6	9,0	4,0	9,6	1,6	20,5	2,5	0,81	0,129	0,83
Anova	**	**	**	*	**	**	**	**	**	**

**:P<0,01; *:P<0,05

TABLE V. SOME ORNAMENTAL PLANT QUALITY VALUES OF IBA TREATED IMPATIENS AT DIFFERENT N AND K APPLICATION RATES

Tretaments	Fresh weight (g)	Branch number	Branch length, cm	Flowering time (day)	Floral longevity	lower number	Appearance score	N, %	P, %	K, %
1/0.25	28,2	9,8	12,4	30,3	6,0	34,3	4,5	3,41	0,622	2,28
1/0.50	36,2	11,3	16,4	27,5	6,8	31,0	7,0	3,46	0,643	3,10
1/0.75	46,3	19,0	16,5	26,0	7,3	55,8	5,5	3,26	0,630	3,12
1/1	57,6	28,5	17,6	21,0	5,8	74,8	6,3	3,75	0,654	3,12
0.75/1	53,4	26,5	17,6	23,8	6,8	43,5	7,8	3,34	0,633	2,71
0.50/1	55,4	26,3	16,6	20,0	7,3	83,0	6,3	2,53	0,716	2,97
0.25/1	31,4	21,3	13,1	17,8	7,8	44,0	4,3	1,79	0,634	2,66
St. Dev.	20,2	10,1	4,0	7,0	1,4	29,0	1,8	0,92	0,159	0,65
Anova	**	**	**	*	*	**	**	**	**	**

**:P<0,01; *:P<0,05

Abundant leaves, branches and flowers of Impatiens, flowering in a short time and floral longevity are the desired targets in ornamental plant cultivation. In the hydroponic cultivation method, the nutrient solution is an important factor that clearly affects the yield and quality of plants [7]. The data obtained showed that different N/K ratios in the nutrient solution in hydroponic cultivation were effective on these desired properties. IBA applications to the plant cuttings were also found to have a significant effect on the parameters examined, probably due to their effects on root development, but it is evaluated that the factorial application made significant changes in real terms. According to these ratios, it is evaluated that the optimum N/K application ratio of the nutrient solution is 0.75/1, and the optimum concentration in the nutrient solution is 10.5 mmol L-1 for N and 14.5 mmol L-1 for K

IV. Conclusion

Leaves, branches and flowers are the main attractive ornamental organs of Impatiens. In addition, early flowering and the floral longevity during the vegetation period are among the most important parameters that increase the marketing value of the plant. An optimum N/K nutrition ratio is necessary for Impatiens plants to obtain the high appearance quality values sought in hydroponic cultivation. IBA application was also found to be important for early flowering of Impatiens plants. The results show that the optimum N/K ratios in the nutrient solution have a significant effect on the nutrition and quality parameters of Impatiens plants in hydroponic cultivation, and the most effective N/K ratio in terms of plant growth and quality values is generally 0.75/1.

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