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PRELIMINARY STUDY ON TWO LEAFY VEGETABLES GROWN IN DIFFERENT GROWING CONDITIONS IN NFT SYSTEM (*AMARANTHUS VIRIDIS* L., AND *BASELLA RUBRA* L.)

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Abstract

Amaranth and Basella are widely used as leafy vegetables in some countries in Asia and Africa due to their nutritional value. These plants usually cultivate in temperate regions with strong sunlight, so the growth and yield might be restricted under certain conditions, such as cold and low sunlight intensity. The purpose of our study was to assess the specie of amaranth and basella grown in the NFT system at the greenhouse of the *Research Center for Quality Control of Horticultural Produce, Faculty of Horticulture, USAMV. We found that amaranth grows well in natural light conditions, and the yield was doubled compared to LED red light. And basella cultivated in the NFT system gained more productivity and growth compared to cultivation in the pot.*

Key words*: Amaranth, Basella, growing condition, NFT, LED, pot.*

INTRODUCTION

Amaranth is a pseudocereal crop belonging to the family *Amaranthaceae* and the genus *Amaranthus*, comprising 74 species, of which 55 species originated from America, and the other 19 species belong to Eurasia, South Africa, and Australia (Arendt & Zannini, 2013; Waselkov et al., 2018). The species were divided into leafy vegetables and grain types based on utilization (Iftikhar & Khan, 2019).

Amaranth crop is underutilized but it is becoming more and more popular in terms of use as a vegetable, especially in Asia and Africa. It is abundant in protein, minerals, and vitamins (Schafleitner et al., 2022). Amaranth was introduced to Spain in the sixteen centuries, then spread to European nations, and in the nineteen centuries, it extended to Asia and Africa. Since amaranth has nutritional advantages, some European countries, including Germany, Italy, Poland, Czech Republic, Austria, Slovenia, Slovak Republic, Russia, and Romania, have a strong interest in the research and its production (Beatriz Valcárcel-Yamani et al., 2012). Amaranth prefers hot and strong sunlight, especially in tropical and semiarid regions, but cultivated varieties can grow in various regions even under cold climate conditions like in China and Nepal. The ideal pH for the growth of amaranth ranges from 5.5 to 7.5, and with pH 6.4, *Amaranthus tricolor* L., produced more branches, leaves, and a bigger leaf area (Singh and Whitehead, 1992). Ribeiro & Combrink (2006) researched *Amaranthus tricolor* L. using river sand under normal climate conditions and treated with different EC. The result showed that EC 4 mS/cm and EC 8 mS/cm provided the highest yield compared to lower EC treatments. Temperature and light intensity are also significant factors in the growth and yield of Amaranth, for red amaranth, to obtain the maximized yield and betacyanin, it required a temperature between 28-29ºC and light intensity around 1240-1260 $\mu mol.m^{-2}\ S^{-1}$ (Khandaker, 2009).

Basella rubra L., a perennial vine of the *Basellaceae* family, with a high tolerance to heat. It is also referred to as vine spinach, Malabar spinach, Indian spinach, and Ceylon spinach (Rathee et al., 2010; Roy et al., 2010; Deshmukh S.A; Gaikwad D.K., 2014). Although there is no concrete proof, it has been claimed to be native to Africa and or Asia

(PIER, 2017). Basella is being used as a vegetable in many countries such as India, the Philippines, Indonesia, and some African countries due to the minerals, proteins, fats, carbohydrates, fiber, carotenes, organic acids, and vitamins contains in the leave which makes this plant is beneficial to health. It can be added directly to salads or used as a stand-alone vegetable to make things that are steamed, cooked in oil, or stewed (Singh et al., 2018; Chaurasiya et al., 2021). In hot, humid areas, Basella thrives in full sunlight, in colder climates, it grows slowly and produces limited yields. The ideal temperature for plant growth is 32°C, and when the temperature falls to 26°C, plant development slows. For seed germination, a temperature range of 18-23ºC is ideal. November through February are the short-day months when flowering is triggered. Basella thrives in sandy loam soils with a pH range of 5.5 to 8.0, rich in organic matter (Manju Singh et al., 2016). Cultivation on the NFT system has always been an interesting topic among researchers (Chan et al., 2022; Asmaa et al., 2021), seeing the importance of these plant species due to their valuable nutrients, as well as not much research had been focused on it in NFT system. For this reason, the objective of our study was to examine the growing condition of the NFT system of these species related to its growth and yield component to give some pieces of information for the hydroponic growers and research scientists.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of the Research Center for Quality Control of Horticultural Produce, Faculty of Horticulture, UASMV, Bucharest, from 15 January to 10 April 2022.

Amaranth seeds were brought from Kbal Koh Vegetable Research Station, Cambodia. The stem and petiole are white, and the leaf shape, ovate, and upper and lower side leaves are green. For basella, the seeds were from Cambodia, a vein plant, that has purple colour on the stem and leaf.

The amaranth and basella seeds were sown with perlite and substrate of the peat Plantobalt type and mixed in the plastic tray (40 x 60 cm) in a ratio of 75% to 25%. The vermiculite-covered row was where the seeds were planted. 7-10 days later, when the seed emerged cotyledon leaves, the young seedlings were moved into Jiffy pots (peat pellets), and manually watered with tap water. After the seedling had 3-4 true leaves or around 4 weeks from the date of seeding, it was moved into NFT. 15 plants of each variety were placed in the NFT system (both natural light and LED red light condition) for Amaranth, and 15 plants of basella I NFT and the pot. Five represented plants of each variety were recorded for amaranth, and four for basella. EC was kept constant at 1.2-14 mS/cm for the first week on the NFT and increased to 1.8-2.2 mS/cm till harvest. pH was 5.8 for the first week and elevated to 6.2 throughout the growing cycle.

For amaranth which is cultivated in the NFT system under both natural light and LED red light conditions. The temperature for natural light was 23-28ºC, and the temperature in nutrient solution was 21-22ºC, with light intensity ranging from 350-500 $\mu mol/m^2s^1$. In LED red light, the room temperature was 20 ± 2ºC, and the nutrient solution was 19-20ºC with 12 hr/12 hr dark/light, and light intensity was 280-300 $\mu mol/m^2s^1$. EC and pH in both conditions were maintained at the same level as mentioned above.

All the data were recorded and done only one time before the flowering stage. For amaranth Leaf width, leaf length, and petiole length of amaranth, three mature leaves were measured for each plant. dry mass was used 1 g of fresh leaves by cutting leaves into small pieces, dried at a constant temperature 105ºC for 24 hours. Chlorophyll content index (ICC) using chlorophyll meter CCM-200 plus, OPTI-SCIENCE. And for basella, all the data were done once, when it reached 75 days from sowing. Regarding the fresh weight, we harvested the whole plant and weighed the stem and leaves together.

The statistical program for analysis was STATISTICA, StatSoft software (version 10) to perform ANOVA analysis at $p \leq 0.05$, 0.01, or 0.001 levels, and Tukey HSD was used to compare the significant difference of each dependent variable at $p \leq 0.05$.

RESULTS AND DISCUSSIONS

There was a significant difference in plant height between the amaranth planted in NFT (natural light) and NFT(LED) conditions at $p \leq 0.05$, (Figure 1). The amaranth cultivated in natural light conditions had higher plant height compared to LED (37.07 and 34.50 cm). However, in both conditions, the number of leaves on the mainstem was not significant difference $p \geq 0.05$ (Figure 1). A significant difference at $p \leq 0.01$, indicated by the number of branches/plant and under the natural light regime produced more branches compared with LED (8.33 and 4.67). At the same time, the total leaves on the branches/plant were also higher under the natural light regime compared with LED light by 60.0 and 49.33 leaves at $p \leq 0.01$. For fresh weight, a highly significant difference at $p \leq 0.001$ was found between the two categories, Amaranth which grew under natural light conditions produced more weight compared with LED light conditions (78.67 and 39.33 g/plant). Our result was obtained similarly to Khandaker (2009), amaranth cultivated under higher temperatures and light intensity produced more plant height and plant biomass. As in our experiment, the temperature and light intensity were higher under natural light conditions, while in LED light were lower and also at the constant point.

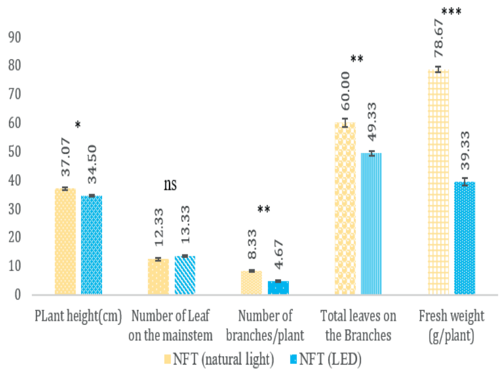

Figure 1. The mean value of plant height, number of leaves on the main stem, number of branches, total leaves number in the branch per plant, and fresh weight (stem and leaves) of Amaranth grown in the NFT system under natural light and LED red light condition. The bar on the graph indicated the standard error, ns-Not significantly different at $p \geq 0.05$. *, **, ***-Significantly different at $p \leq 0.05$, 0.01, or 0.001, respectively (n = 5)

There were no significant differences at $p \geq 0.05$ for leaf width, leaf length, and petiole length (Figure 2). Under both conditions, the leaf width ranged from 9.03-9.70 cm, the leaf length was 13.17-14.08 cm and the petiole was 4.10-4.49 cm. However, stem weight was highly significant at $p \leq 0.001$, the amaranth grown in NFT natural light provided more stem weight compared with LED light (26.0 and 11.67 g/plant). The root length and root volume were also found significant differences at $p \leq 0.01$, under natural light conditions, the root was longer compared with LED light (30.0 and 20.33 cm). This trend was also similar to root volume which plants cultivated under natural light produced more root volume than LED light (22.67 and 8.33 cm^3).

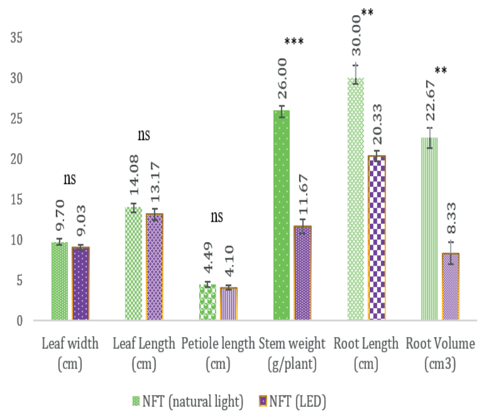

Figure 2. The mean value of leaf width, leaf length, petiole length, stem weight (g/plant), root length, and root volume of Amaranth grown in the NFT system under natural light and LED red light conditions. The bar on the graph indicated the standard error, ns-Not significantly different at $p \geq 0.05$. *, **, ***-Significantly different at $p \leq 0.05$, 0.01, or 0.001, respectively (n = 5)

There was a significant difference in CCI at $p \leq 0.01$, under natural light growing, the CCI contains in Amaranth was higher than LED (12.86 and 8.07) (Figure 3). On contrary, the brix and % of dry matter (leaf) were not different between the plant growing on natural light and LED light. The brix was from 5.87 to 6.07, while the leaf dry matter was 11.56-11.76%. However, % of dry matter of the stem was a significant difference at $p \leq 0.05$, and amaranth grew with LED light was higher in stem dry matter compared to the NFT natural light cultivation.

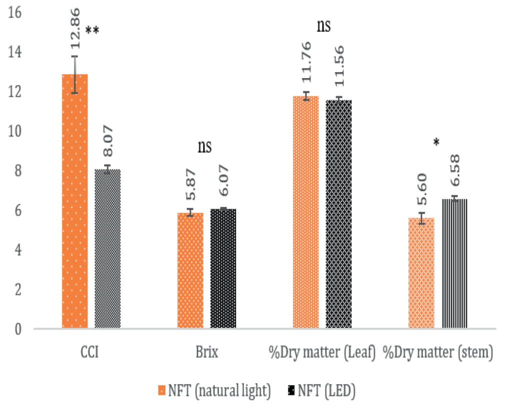

Figure 3. The mean value of CCI, Brix, % dry matter (leaf), and % dry matter (stem) of Amaranth grown in the NFT system under the natural light and LED red light conditions. The bar on the graph indicated the standard error, ns-Not significantly different at p ≥ 0.05. *, **, ***-Significantly different at p ≤ 0.05, or 0.01, respectively (n = 5, and n = 3 for dry matter)

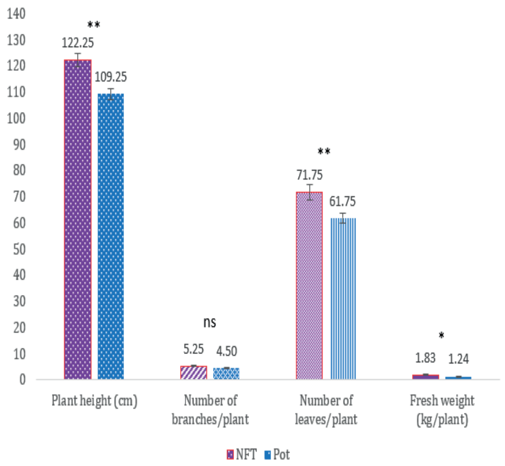

Figure 4. The mean value of plant height, number of branches per plant, number of leaves, and leaf weight of basella grown in the NFT system and in the pot. The bar on the graph indicated the standard error, ns-Not significantly different at p ≥ 0.05. *, **, -Significantly different at p ≤ 0.05, or 0.01, respectively (n = 4)

For basella, there was a significant difference in plant height at p ≤ 0.01, basella performed well with plant height under the NFT system (122.25 cm), while on the pot (109.25cm) (Figure 4). The number of branches per plant was not significantly different between these two cultures (4.50-5.25). The number of leaves per plant was significantly higher in the NFT system and lower in cultivation in the pot (71.25 and 61.65 leaves/plant) at p ≤ 0.01. A significant difference at p ≤ 0.05 presented with the leaf weight, and basella planted in NFT produced more leaves than grown in the pot (1.83 and 1.24 kg/plant).

Figure 5. Amaranth cultivated in the NFT system in both natural light and LED red light conditions

Figure 6. The appearance of Basella plants in culture in the NFT system

Figure 7. Basella cultivated in the NFT system (a) and the pot (b)

CONCLUSIONS

Based on the results of our studies on the cultivation of amaranth in the NFT system, it was indicated that the plant grown in the NFT system under natural light conditions obtained good growth and yield components including plant height, number of branched, total leaves on the branches, fresh weight and the root development. Amaranth cultivated in LED with low temperature and light intensity, the yield reduced double compared with growing under natural light environment. For the experiment of basella, we found that the best growth was the NFT system, the growth performance and yield were higher than planted in the pot culture.

Further research should be carried out to investigate the growth and yield in the summer season with similar conditions to understand more about the characteristics of two species, as these species prefer warmer weather to reach optimal growth.

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