UNIVERSITY OF AGRONOMIC SCIENCES AND VETERINARY MEDICINE OF BUCHAREST

DOCTORAL SCHOOL OF ENGINEERING AND MANAGEMENT OF VEGETAL AND ANIMAL RESOURCES

Domain: Horticulture

DOCTORAL THESIS

STUDY ON THE INFLUENCE OF VARIOUS FACTORS ON THE GROWTH AND DEVELOPMENT OF SOME VEGETABLE SPECIES IN NUTRIENT FILM TECHNIQUE SYSTEM

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Bucharest
2024

SUMMARY

of the doctoral thesis entitled:

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KEYWORDS: lettuce, brassica, amaranth, NFT system

This doctoral thesis, titled "*Study on the influence of various factors on the growth and development of some vegetable species in Nutrient Film Technique system*," presents significant scientific findings derived from research conducted at the Faculty of Horticulture of USAMV, Bucharest, Romania. Several research findings have been published in scientific journals and are accessible online through various volumes of international conferences.

The thesis addresses a major innovative topic related to cultivation technology factors within the NFT system, focusing on leafy vegetable species such as lettuce, *Brassica*, and *Amaranth*. These species are considered crucial crops due to their nutritional value, consumption, and economic aspects for the relevant stakeholders involved in their supply chain.

Recently, vegetable cultivation in a protected structure with a hydroponic NFT system has become an attractive scenario and is being prioritized by many farmers and researchers. This trend is attributed to the numerous advantages and conveniences offered by the system, including labor savings, nutrient efficiency, environmental friendliness, reduced risk of pest incidents, high productivity, rapid growth rates, and year-round supply capabilities.

The objectives of the thesis were to assess various factors, including the influence of fertilizers on lettuce seedlings, the optimal culture conditions for lettuce species in the NFT system, and the production of Brassica and Amaranth species using the NFT system. These objectives aimed to deepen our understanding of, improve, and disseminate cultivation technologies associated with these crops.

The thesis consists of a summary, an introduction, seven chapters, a bibliography, annexes, and a list of published papers by the author.

The paper has 181 pages and includes tables, figures, 144 references from various international sources, and 6 annexes.

The present thesis has two parts: part I (bibliography study: one chapter) and part II (own research: six chapters).

In Chapter I, the origin and historical background of the species are discussed, along with detailed descriptions of the genus, family, and systematic classification. The chapter also covers morphological characteristics, cultivation techniques, and the significance and production of the species.

Lactuca sativa L., commonly known as lettuce, is categorized under the order Asterales and belongs to the family Asteraceae. It is thought to have started around 2500 B.C in Egypt. Lettuce is widely utilized as a vegetable due to its phytochemical benefits to human health. Cultivating this species requires specific environmental conditions: daytime temperatures of 17 to 28°C and nighttime temperatures of 3 to 12°C; luminosity of 350 to 500 μmol m^{-2} s^{-1}; relative humidity maintained between 50% and 70%; pH levels ranging from 5.6 to 6.2; and electrical conductivity levels of 0.8 to 2.0 mS/cm.

Brassica species such as mustard greens (*Brassica juncea* L.), choy sum (*Brassica rap*a L.), and Chinese kale (*Brassica oleracea* L.) belong to the *Brassicaceae* family, formerly known as *Cruciferae*, within the Brassicales order. This family has a significant evolutionary history, with wild ancestors dating back 24 million years in Africa and the Arabian Peninsula. These crops have been utilized as vegetables, spices, and pharmaceuticals due to their rich content of vitamins, minerals, volatile compounds, dietary fiber, and other beneficial components. The ideal temperature range for their cultivation is 16–28°C, and 400–600 μmol $m^{-2}s^{-1}$ of light intensity is needed, pH levels ranging from 5.8–7.0, and EC levels of 1.2–2.4 mS/cm for mustard and choy sum, and 1.8–3.0 mS/cm for Chinese kale.

Amaranth viridis L. is part of the *Caryophyllales* order and the Amaranthaceae family. This ancient crop, dating back 5,000-7,000 years, was once a staple in the diet of the ancient Aztecs in Mexico. Amaranth is renowned for its rich content of proteins, vitamins, and minerals, and for its abundance of phytochemical compounds that contribute to human health. Due to its nutritional and medicinal properties, this versatile crop is used in the food, cosmetic, and pharmaceutical industries. The ideal temperature range for its growth is 20-30°C, with a light intensity of 1240–1260 μmol $m^{-2}s^{-1}$. The optimal pH range for growth is 5.5-7.5, while a higher electrical conductivity (EC) level of 4-8 mS/cm is recommended to achieve maximum yield.

Chapter II of the paper outlines the research materials and methods, results, and conclusions regarding the fertilizer testing on lettuce seedlings. The experiment included seven lettuce cultivars: 'Fast Fall' lettuce from Nam Viet Company, 'KKL' from Kbal Koh vegetable research station, 'Lollo Bioda' and 'Lollo Rosa' from Amia Seed, 'Lugano' and 'Carmesi' from Rijk Zwaan, and 'Chinese Purple' from Yingre Seeds Company. The fertilizers used were Formulex (2.3N-0.9P-3.4K), Universol (18N-11P-18K+2.5MgO), Bio-Grow (4N-3P-6K), and a control treatment using only water.

First, a total of 100 seeds of each variety were sown on a 40 x 60 cm plastic tray filled with a substrate consisting of 75% coco-peat and 25% perlite. The seedlings were placed in jiffy peat as soon as the cotyledon leaves appeared. Fertilizers were applied at a rate of 2 ml/L of water and administered daily from sowing until the seedlings reached the four true leaf stage. Twenty plants of each variety were treated with different fertilizers. On day 28 after sowing, five representative plants from each variety were selected and assessed for various parameters, including plant height, leaf number, growth rates, and the total number of days required to form the true leaves. We conclude that fertilizers can have varying effects on lettuce seedlings, either positive or negative. The application of Universol yielded the most favorable outcomes in terms of leaf count, with the fourth leaf of lettuces forming two days earlier compared to the control treatment and five days earlier than those treated with Bio-Grow. Seedlings treated with Formulex exhibited similar effects to those of the control treatment such as plant height, leaf count, growth rates, and the leaf formation. In contrast, seedlings treated with Bio-Grow displayed poor growth characteristics, including reduced plant height, slow growth rates, and a delay of three days in the formation of the fourth leaf.

Chapter III: We conducted experiments on seven lettuce varieties within the Nutrient Film Technique (NFT) system, testing them under two different lighting conditions during the years 2022 and 2023. One group was exposed to natural light conditions, while the other group was subjected to LED lighting. These were the same lettuce varieties tested in Chapter II.

The experiment was designed using a Randomized Complete Block Design (RCBD) with three replications, totaling 15 plants per variety, with five plants per replication. EC and pH levels were

maintained at specific levels throughout the experiment. Additionally, temperature, humidity, and CO_2 levels were automatically regulated. Under the LED lighting conditions in the NFT system, the light intensity was set at 232 μmol/m^2/s with a photoperiod of 16/8 hours of light/dark. Conversely, under natural light conditions, the light intensity ranged from 300-500 μmol/m^2/s. Data were recorded once during the harvesting stage, and a factorial ANOVA analysis was performed using Statistica software.

Based on the results obtained over two years, we conclude that lighting conditions significantly influence all observed parameters except for the widest diameter. Lettuce varieties cultivated under natural light conditions exhibited superior growth and quality characteristics, including higher plant height, larger leaf area, greater number of leaves, heavier fresh weight, and higher dry matter content. Additionally, these plants showed increased levels of brix, chlorophyll, and carotenoids.Conversely, lettuce grown under LED light conditions displayed an increasing root volume, longer root length, and higher nitrate content in fresh leaves.

Chapter IV: Regarding the production of *Brassica* species on the NFT system, we include an introduction, research material and methods, a result, and a conclusion. Four brassica species were used: mustard green (V1), a variety from the Kbal Koh vegetable research station in Cambodia; mustard green (2); choy sum (V3), a variety from Nam Viet Seeds Company; and Chinese kale (V4), a variety from KsSeed Company. The cultivation begins with sowing seeds in the substrate, transferring them to jiffy peat, and then transplanting them in the NFT chamber at 20-25 days old (3-4 true leaves). Each variety was given 50 plants in the cultivation system, with no repetitions. The EC and pH were monitored regularly. All data were collected during the harvesting period.

Based on the data collected from our experiments, we conclude that the growing seasons significantly influence several key parameters, including plant height, leaf length, chlorophyll content index, fresh mass, dry matter, and nitrate content in the leaves. However, the number of leaves, leaf width, and brix levels were not significantly affected by the season. Notably, all measured parameters varied significantly across the four Brassica species. Of these, two mustard green varieties and choy sum yielded better in January 2022, whereas Chinese kale reached its maximum yield in October 2022.

Chapter V: includes the introduction, research material and method, results, and conclusion on the production of amaranth on the NFT system. One variety of amaranth brought from Cambodia was used in the testing during 2022 and 2023.

Initially, amaranth seeds were sown in a substrate composed of 75% cocopeat and 25% perlite, and were watered daily. Seven days post-germination, the seedlings were transferred to jiffy peat until three true leaves developed, which typically occurred around 28–30 days after sowing. Subsequently, the seedlings were moved to a Nutrient Film Technique (NFT) system. Throughout the growth period, EC and pH levels were regularly monitored. Data collection occurred once at the harvesting stage.

We conclude that the production of amaranth was significantly influenced by the year of cultivation in terms of several key growth parameters, including plant height, number of branches, leaf width, petiole length, root length, fresh weight, stem weight, leaf weight, number of leaves per plant, brix, % dry matter (DM), and nitrate content. However, the number of leaves on the main stem, leaf length, and root volume remained consistent across years. The 2023 cultivation season resulted in better plant growth and yield compared to the 2022 season.

Chapter VI presents the micro and macronutrient analyses of all vegetable species examined in this thesis. This chapter comprises an introduction, a description of the analytical methods used, and the presentation of results. Mineral analyses for all species were conducted in 2023 at the Physical-Chemical Analysis Laboratory, part of the Research Centre for the Study of Food and Agricultural Products Quality at USAMV Bucharest, following established protocols. Our findings indicate that all lettuce varieties cultivated under natural light conditions exhibited higher levels of phosphorus (P), iron (Fe), copper (Cu), and

aluminum (Al), whereas those grown under LED light showed enhanced levels of potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and zinc (Zn).

Additionally, nine micro- and macro-elements, including K, Ca, P, Mg, Zn, Fe, Na, Al, and Cu, were identified in the leaves of Brassica species and amaranth. Choy sum and Chinese kale were particularly rich in calcium, phosphorus, and iron compared to mustard greens. Amaranth was found to contain a higher concentration of both micro- and macronutrients than the other species tested.

Chapter VII, include the conclusion and recomemdations part from all species in this thesis that provide insightful results.