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PRELIMINARY STUDY REGARDING THE INFLUENCE OF NUTRIENT CONCENTRATION ON PRODUCTION AND QUALITY PARAMETERS FOR LETTUCE GROWN ON PERLITE SUBSTRATE

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Abstract

The study was carried out in the research greenhouse, within the Horticultural Products Quality Research Center in 2021. On the mattresses filled with perlite, 2 varieties of lettuce were grown, oak leaf type, Kineta type, and Lollo Bionda type, variety Lugano. The nutrient solution was administered in 3 EC concentrations, respectively 1.5 mS, 2.5 mS and 3.5 mS. Three pH levels were used for each EC type. Differences were found between the experimental variants regarding the reaction of the varieties to these treatments. The aim of the study was to see the influence of nutrient solution concentration on some production and quality parameters of lettuce grown on perlite substrate.

Key words: *lettuce, soilless, perlite.*

INTRODUCTION

The specialized literature mentions the importance of the electrical conductivity (EC) of the nutrient solution as it can be one of the factors that can affect the lettuce production obtained in the culture in the soilless system.

Many researchers who have studied this factor has proven that prolonged use of the same nutrient solution leads to the accumulation of large amounts of trace elements such as zinc and copper (Steiner, 1980; 1984).

Abou-Hadidl et al., 1996, in the studies carried out on three varieties of lettuce grown in a soilless system tested different levels of electrical conductivity of the nutrient solution of 1.0, 1.5 and 1.8 dS/m, respectively, finding that the plant mass of salad, decreased with the increase in the EC level of the nutrient solution, an aspect also noticed by Serio et al., 2001.

Uttara et al., 2006, showed that with the increase in EC concentration from 1.4 dS/m to 2 dS/m, the concentration in plant nitrogen, phosphorus, potassium and calcium also increases without a significant content of the production.

Conversa et al., 2021, in the experiments carried out on two varieties of oak leaf lettuce grown in two seasons, spring and autumn, found that the nutrient solution with an EC of 2.5 and 3.5 dS/m influenced both the production as well as the quality of the plants.

Many researchers support soilless cultivation, as this system allows for improved lettuce plant quality in terms of both low nitrate content and product safety. On this basis, the studies conducted evaluated the effect of different EC nutrient solutions on the yield, quality and shelf life of lettuce after harvest.

Scuderi et al., 2009, showed that increasing the EC of the nutrient solution from 2.8 to 3.8 mS cm^{-1} led to a significant decrease in production from 6.1 kg/m^2 to 5.8 kg/m^2 for all varieties studied.

Enache, 2019, appreciates that the use of quantum structured water leads to a better efficiency of the use of the nutrient solution.

Quy et al., 2018, in an experimental study investigated different levels of the EC of the nutrient solution (0.5, 1.0, 1.5, 2.0 and 2.5 mS/cm) in a lettuce culture in a vertical hydroponic system and found that at the EC of

2.5 mS/cm and at a pH of 6-6.6 had obtain the maximum production

Cha et al., 2012, analyzed the influence of the electrical conductivity (EC between 0.5 and 6.0 dS/m) of the nutrient solution and the light intensity (120, 150 and 180 µmol/m²/s) on the growth and development of some lettuce varieties in a photoperiod of 16 hours/day at the temperature maintained in the range of 20~25°C, found that the best option was the one that used an EC of 2 dS/m, at an intensity of 180 µmol/m²/s.

Park and Yong, 2001, state that using an EC between 1.2 and 4.8 mS/cm led to adequate yields of lettuce, and Scuderi et al., 2009, relate that production decreases as EC increases from 2.8 mS/cm to 4.8 mS/cm, and Broadley et al., 2003, mention that nitrogen content is correlated with plant protein and nitrate levels.

Dharti et al., 2021, appreciate that the EC level but also the temperature and light conditions influence the carbohydrate content.

Al-Kinani et al., 2021, but also Asmaa et al., 2021, points out that regardless of the non-conventional cropping system used, production increases are superior to the conventional system.

The aim of the study was to see how the EC of the nutrient solution and the pH influenced the vegetative growth of lettuce grown in a non-conventional system, on mattresses filled with perlite.

MATERIALS AND METHODS

The present study was carried out at the research greenhouses, Faculty of Horticulture from UASMV Bucharest, this belongs to the Research Center for quality control of horticultural products.

The biological material used in the experiment consisted of two varieties of lettuce. The Kineta variety is of the oak leaf type, and the Lugano variety is of the Lollo Bionda type. Seedlings were obtained in the greenhouse between October 20 and November 10, 2021. Sowing was done often in pots filled with peat, and transplanting was done in Jiffy-type peat pots. Environmental factors, temperature, humidity, light was monitored during the growth of the seedlings. Determinations were made regarding the percentage of emergence, the growth of seedlings in height and the number of leaves.

The planting was carried out when the seedling was 23 days old from emergence, directly in the mattresses filled with perlite, on experimental variants. During the vegetation period, observations and measurements were made regarding the height of the plants, the number of leaves, the diameter of the plants. At the end of the culture, the height, diameter, total number of leaves, total mass of the edible part of the plants as well as root volume were determined.

Table 1. Experimental variants

Cultivars	EC value mS/cm	The pH value
Kineta	1.5	5
		6
		7
	2.5	5
Lugano		6
		7
	3.5	5
		6
		7

Correlations were performed between the analyzed parameters. Throughout the culture period, environmental factors regarding temperature and atmospheric humidity, CO2 level, as well as temperatures at the level of the culture substrate were monitored. Also, chlorophyll and nitrate content were measured directly in the greenhouse. Nitrate content was determined directly in the greenhouse, after harvest, with the apparatus Nitrate tester Greentest ECO 6 + TDS. The carbohydrate content was determined in the greenhouse after harvesting with Brix device. Data were statistically interpreted using the Duncan test (p=0.05).

RESULTS AND DISCUSSIONS

During the culture period, the temperature during the day was kept almost constant, according to the technological recommendations around the average values of 22.5ºC. The temperature values during the night period remained almost constant between 17.0ºC. The average temperature values were 19.6ºC (Figures 1 and 2).

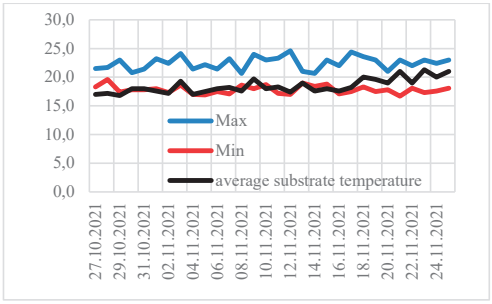

Figure 1. Temperature values during the day and night and those in the culture substrate

Figure 2. Determination of substrate temperature

In the greenhouse compartment, CO_2 values of over 237.85 ppm were maintained, reaching values of 480.43 ppm (Figure 3).

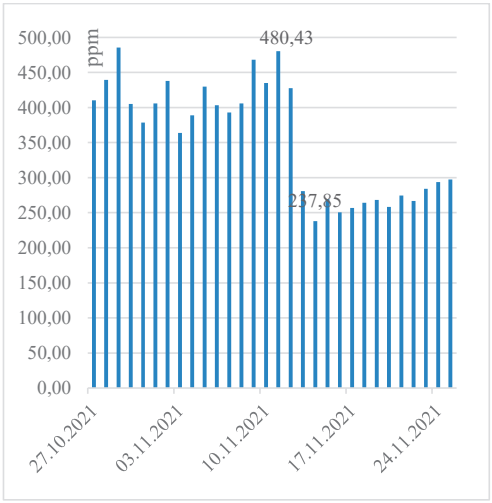

Figure 3. CO_2 content values determined in the greenhouse during the culture period

Analyzing the data regarding the height of the plants in the salad culture carried out on perlite substrate, we found that in the Kineta variety, the highest plant height of 21.67 cm was recorded in the variant cultivated at pH 6 and EC of 2.5, and the lower at 14.17 cm in the variant where we used an EC of 3.5 and a pH of 7. In the case of the Lugano variety (Lollo bionda type) the highest plant height was recorded in the variant with an EC of 1.5 and pH 7, and the lowest height was in the variant where we used EC of 3.5 and pH 7. After performing the Duncan test (p = 5), significant differences between the variants were noted (Figure 4).

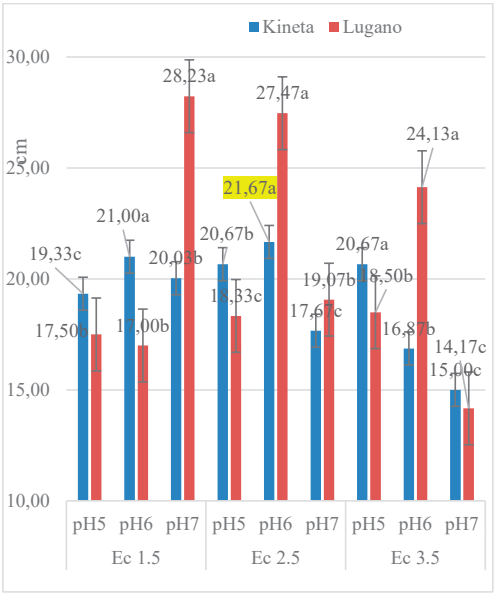

Figure 4. Height of lettuce plants 30 days after planting

In the case of the Kineta variety, a significant negative correlation (R^2 = 0.4149) was noted, which means that as EC and pH increase, plant height decreases (Figure 5).

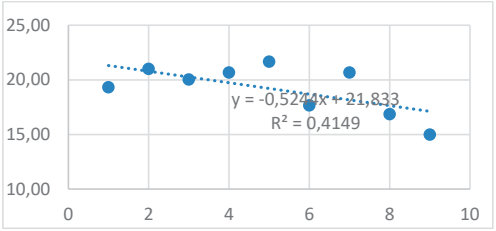

Figure 5 The influence of EC and pH values on the height of lettuce plants of the Kineta variety

The correlations carried out for the Lugano variety, regarding the influence of EC and pH on plant height growth, indicated an insignificant correlation (R^2 = 0.0098) (Figure 6.)

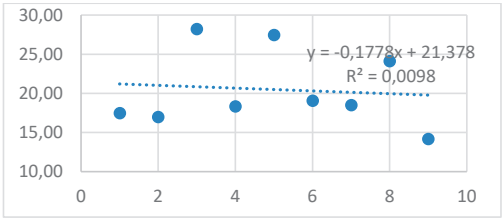

Figure 6 Influence of EC and pH values on the height of lettuce plants Lugano variety

Regarding the plant diameter, in the Kineta variety, we found that when using an EC of 2.5 mS and a pH of 6, the largest plant diameter of 37 cm and the smallest of 31.33 at an EC of 2.5 mS at pH 7. For Lugano, the largest diameter was 35.1 cm at an EC of 3.5 mS and pH 6, and the smallest 24.17 cm at an EC of 3.5 mS and a pH of 7 (Figure 7).

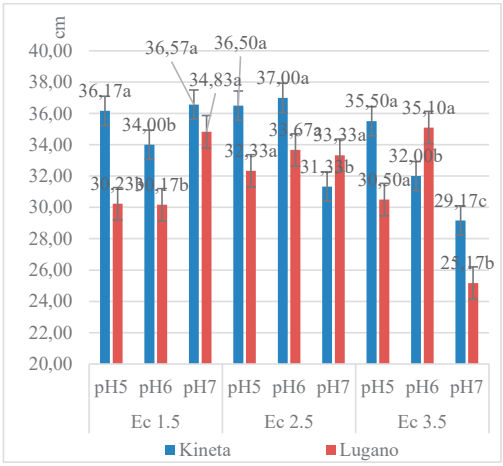

Figure 7. Diameter of lettuce plants as a function of EC and pH

We found a slightly significant negative relationship regarding the diameter of the lettuce plants of the Kineta variety (R^2 = 0.4534) (Figure 8).

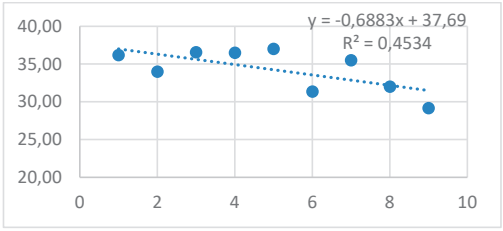

Figure 8. Influence of EC and pH values on the diameter of lettuce plants of the Kineta variety

In the case of the Lugano variety, we found an insignificant relationship, the value being R^2 = 0.0374 (Figure 9).

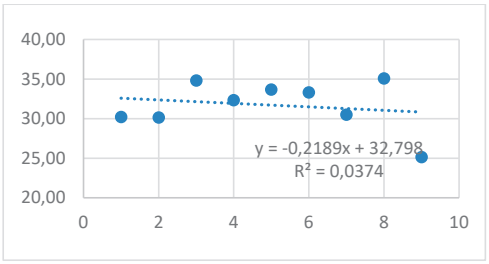

Figure 9. The influence of EC and pH values on the diameter of lettuce plants of the Lugano variety

Regarding the number of leaves formed per plant, it was found that in the Kineta variety, a number of 60.67 leaves were obtained at an EC of 1.5mS and a pH of 7. The lowest number of leaves was recorded in the plants which used an EC of 1.5 mS and a pH of 5 of 38.33 leaves. In the case of the variety Lugano, the highest number of leaves was recorded at an EC of 3.5 mS and a pH of 6 of 41 leaves/plant, and the lowest number of leaves was recorded at an EC of 1.5 mS and a pH of 5 being only 25, 67 leaves (Figure 10).

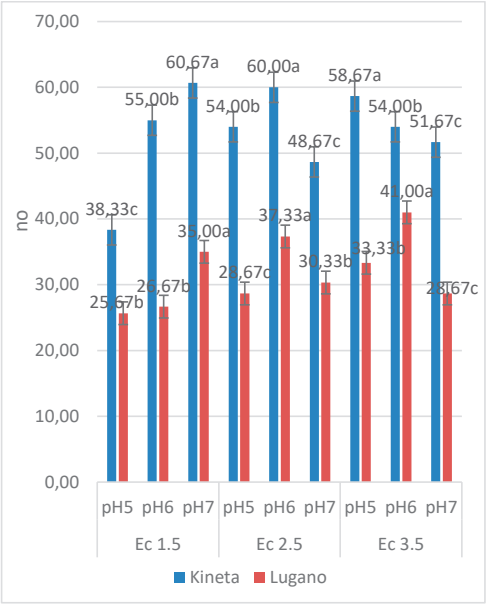

Figure 10. Number of leaves formed on lettuce plants

To see the influence of EC and pH on the formation of the number of leaves per plant, we

performed a correlation and found an insignificant influence (R^2 = 0.0738) in the Kineta variety (Figure 11).

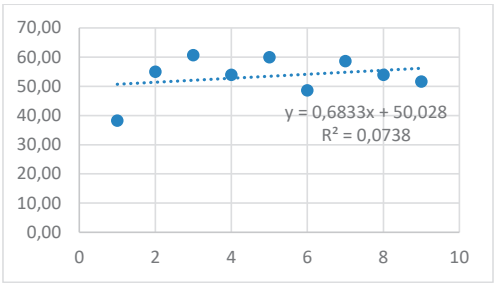

Figure 11. The influence of EC and pH values on the number of leaves in lettuce plants of the Kineta variety

In the case of the Lugano variety, we found a slightly significant positive relationship with the increase in EC (R^2 = 0.222) (Figure 12).

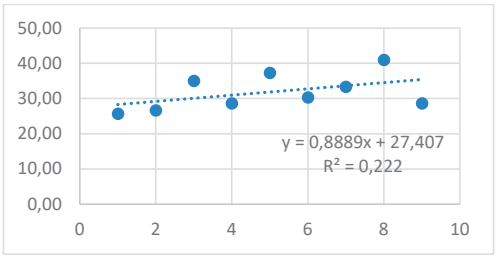

Figura 12. Influența valorilor EC-ului și pH-ului asupra numărului de frunze la plantele de salată soiul Lugano

The appearance of lettuce plants after 5 days and 20 days after planting is shown in Figures 13 and 14.

Figure 13 Appearance of lettuce plants after 5 days of planting

Figure 14. Appearance of lettuce plants 20 days after planting

Analyzing the mass of lettuce plants, we found that the highest values were recorded at an EC of 2.5mS in the case of all pH variants. The highest plant mass was recorded in the Kineta variety of 236 g at EC 2.5 mS and pH 6. The lowest value of the average mass of lettuce plants was recorded at EC 3.5 mS and pH 7, the mass being 174 g. In the case of the Lugano variety, the highest average mass of the plants was recorded in the plants grown in perlite substrate that were administered the nutrient solution with an EC of 2.5 mS and pH 6, The value being d 166.33 g per plant. The lowest value of the average mass was recorded in plants fertilized at an EC of 1.5 mS and pH 5, being only 73.33 g per plant.

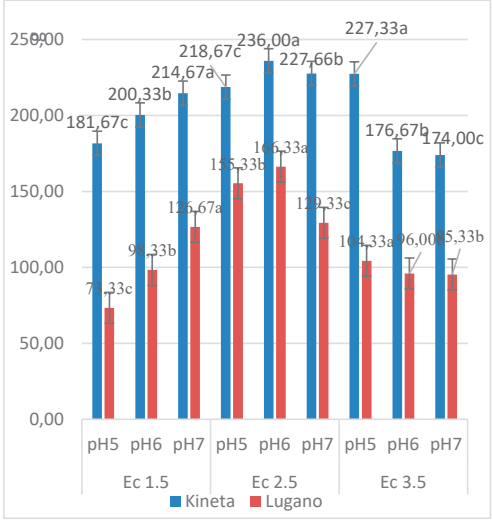

Figure 15. Total mass of lettuce plants at harvest

Figure 16. Appearance of the plants in the culture on perlite substrate after 25 days

Both in the case of Kineta and Lugano cultivars there were no significant relationships regarding the influence of EC and pH (Figures 17 and 18).

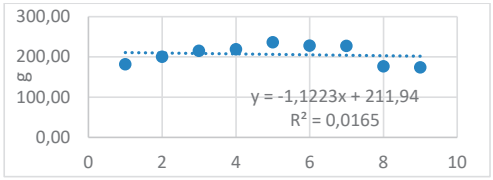

Figure 17. The influence of EC and pH values on the mass of lettuce plants of the Kineta variety

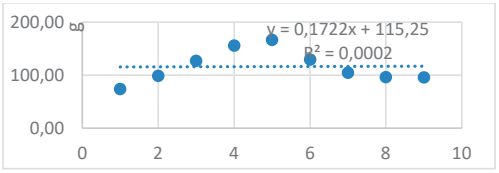

Figure 18. Influence of EC and pH values on the mass of lettuce plants Lugano variety

Regarding root volume, it was found that the highest root volume was recorded in plants grown in perlite substrate and fertilized with an EC of 2.5 mS, and pH 5, in the case of the Kineta variety (10.57 cm^3), and in the case of the Lugano variety, it was observed in the fertilized version with an EC of 3.5 and a pH of 7 (7.33 cm^3), which means that the varieties react differently to EC and pH values (Figure 19).

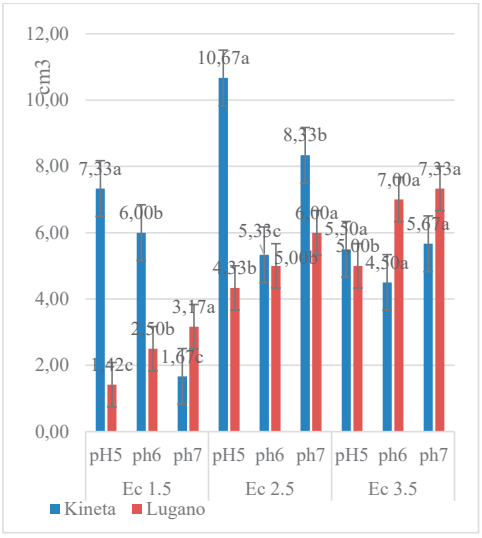

Figure 19. Root volume of lettuce plants

The appearance of lettuce plants and the distribution of the root system, in the varieties analyzed, are shown selectively in the Figures 20-21).

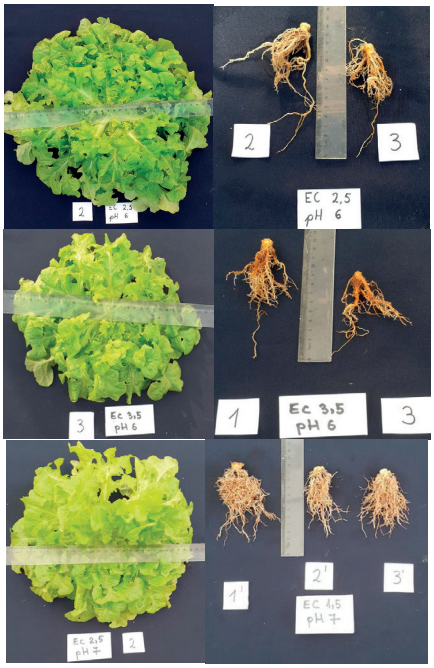

Figure 20 Appearance of plants and roots -Kineta

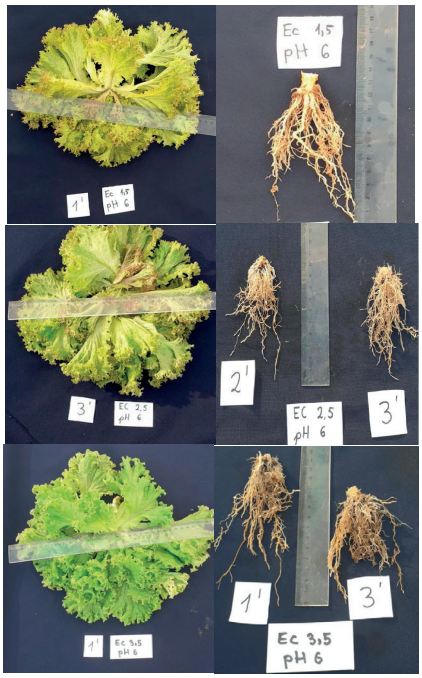

Figure 21. Appearance of plants and roots -Lugano

In the case of the Kineta variety there was no significant relationship, but in the Lugano variety a very significant relationship was found $R^2 = 0.9359$ (Figures 22 and 23).

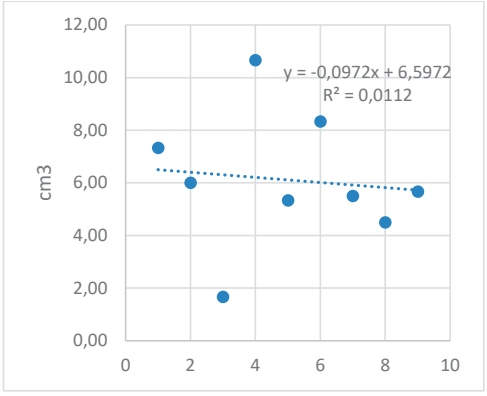

Figure 22. The influence of EC and pH values on root volume in lettuce plants of the Kineta variety

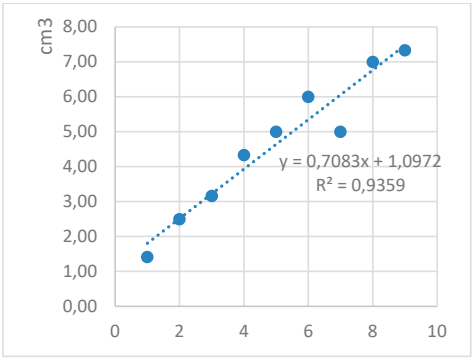

Figure 23. The influence of EC and pH values on root volume in lettuce plants of the Lugano variety

The determinations made during the test vegetation period show that on 7.12.2021, the differences are statistically insignificant at EC 1.5; 2.5 and 3.5, between variants with pH 5 and statistically significant differences at EC 1.5; 2.5 and 3.5, between the variants where a pH of 7 was used. The differences were statistically insignificant at EC 1.5 and 2.5 between the variants with pH 6 and statistically significant differences between them and the variant where an EC 3.5 was used (Figure 24).

Figure 24. Chlorophyll content Kineta

In the case of the Lugano variety on 07.12.2021 the chlorophyll content, determined during the vegetation period, presented the highest value (3.41) in the fertilized variant with an EC of 2.5 mS, an aspect also observed on 05.01. 2022, at the final harvesting of the plants (Figure 25).

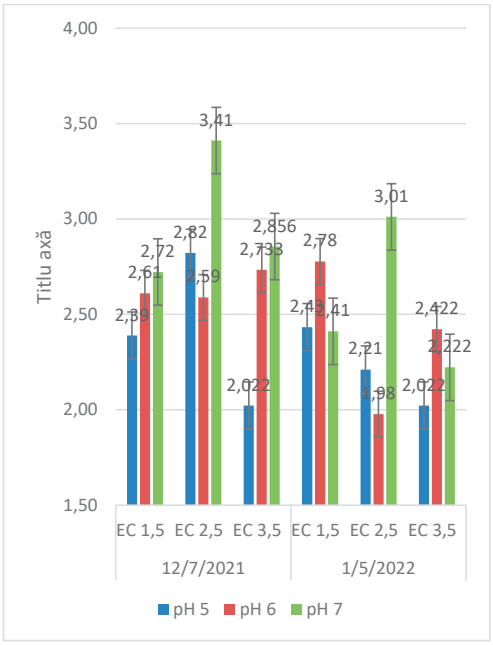

Figure 25. Chlorophyll content Lugano

In the case of the Kineta variety, we found that in the variant of the nutrient solution with pH 5, the basal leaves accumulated the highest amounts of nitrates. Thus, at an EC of 3.5 mS in the basal leaves an amount of 2833.3 mg/kg nitrites accumulated, and at an EC of 1.5 mS of 1766.7 mg/kg below the standard of 3000 mg/kg recommended for the winter period. The lowest amount was recorded in the leaves located in the middle of the plant, young, newly formed leaves. For these, the values were 520.0 mg/kg in plants to which an EC of 1.5 mS was applied. In the case of using pH 6 and at an EC of 2.5 mS, we found that the basal leaves accumulated 2100 mg/kg nitrates. In the case of using the nutrient solution with pH 7, the situation was similar, the highest amount of nitrates being determined in the basal leaves 19993.3 mg/kg at EC 3.5 (Figure 26).

The average nitrate content data showed that when using an EC of 3.5 mS and pH 5, a higher amount of nitrate accumulated at 2000 mg/kg. The lowest content in nitrates was recorded for all EC variants where pH 6 was used (Figure 27).

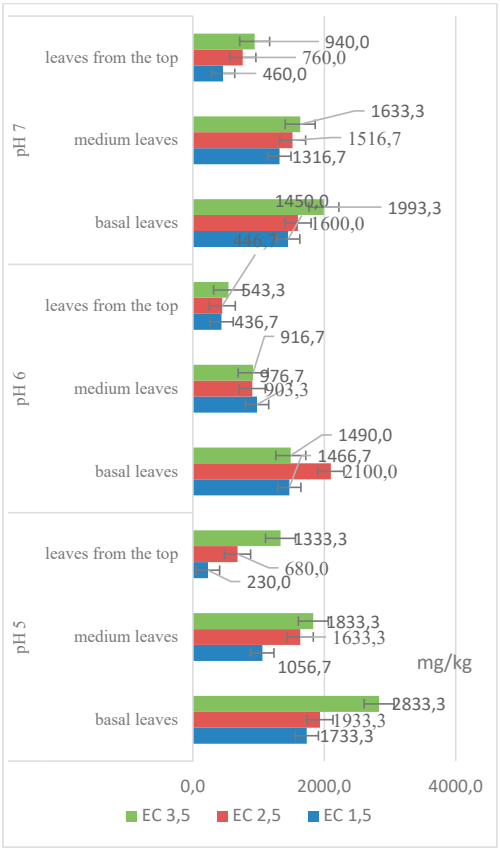

Figure 26. Nitrate content of the Kineta variety

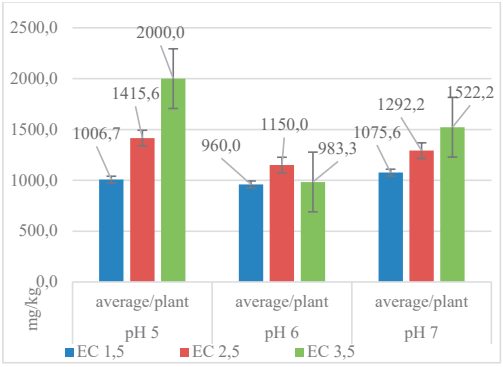

Figure 27. Nitrate content of the Kineta variety

In the case of the Lugano variety, the situation was similar to the Kineta variety, the basal leaves accumulated the highest amount of nitrates, but below the standard limit. In the

case of the EC of 3.5 mS, nitrate accumulation was higher compared to the rest of the EC values (Figure 28).

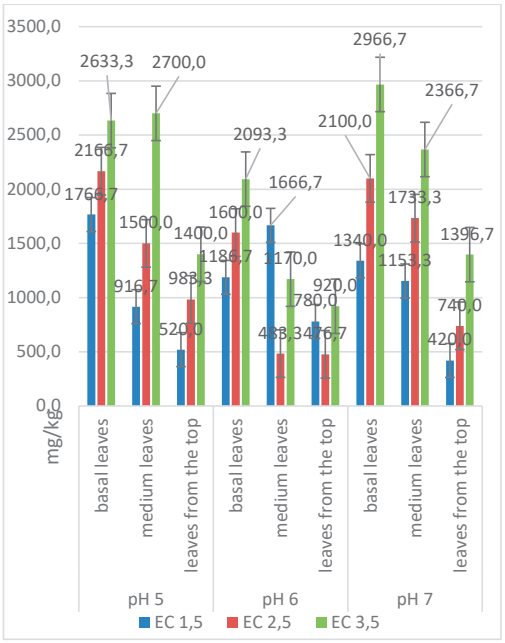

Figure 28. Nitrate content of Lugano variety

Average nitrate content data showed that the highest accumulations were found when using an EC of 3.5 and the lowest at an EC of 1.5 (Figure 29).

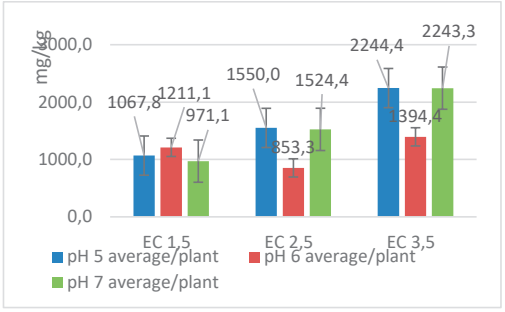

Figure 29. Average nitrate content of Lugano cultivar lettuce plants

The carbohydrate content accumulated in lettuce leaves was different depending on the position of the leaves. The basal leaves accumulated the lowest amounts and the young leaves the highest values for all pH values (Figures 30 and 31).

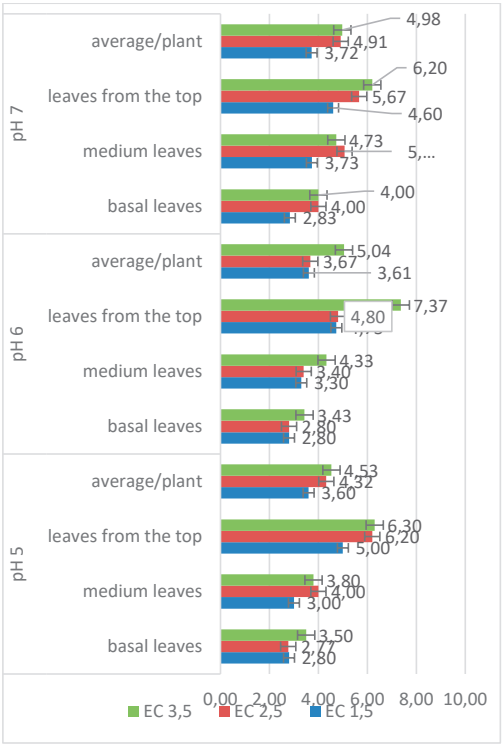

Figure 30. Carbohydrate content of the Kineta variety

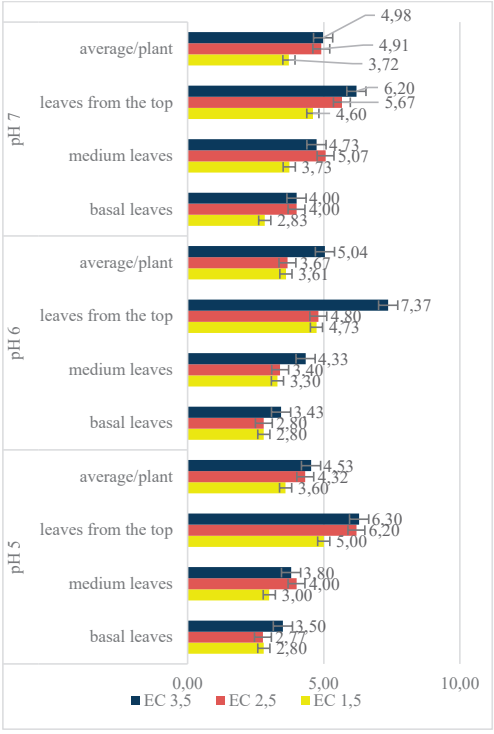

Figure 31. Lugano variety carbohydrate content

CONCLUSIONS

Soilless crops are starting to be practiced more and more because the product obtained ensures a much better productivity, a shortening of the vegetation period, commercial quality of the product, food safety and chemical composition. Another aspect to consider is that of keeping constant of the environmental factors. The temperatures provided in the greenhouse were maintained in the optimal parameters for crop development, they were between 20ºC and 25ºC during the day and at least 17ºC at night. Also, in the culture substrate, the temperatures were within the optimal limits for the good development of the plants.

There were differences in plant height. The highest height was noted in the variety Lugano, at an EC of 1.5 and a pH of 7. In this variety, at an EC of 3.5 and a pH of 7, the height of the plants was the lowest. We noticed that, in terms of plant height, the Lugano variety showed large variations compared to the Kineta variety. The diameter of the plants was larger in the Kineta variety compared to the Lugano variety. The root volume was greater in the case of plants grown at EC 2.5 and pH 5 and 7 respectively in the Kineta variety. In the case of the Lugano variety, the root volume increased with the increase in EC regardless of the pH value.

REFERENCES

Abou-Hadidl A.F., Abd-Elmoniem E.M., El-Shinawy M.Z, & Abou-Elsoud M. (1996). Electrical conductivity effect on growth and mineral composition of lettuce plants in hydroponic system, *Acta Horticulturae* 434, pp 59-66. https://www.researchgate.net/publication/284000383

Al-Kinani H.A.A., Jerca O.I., Bobuțac V. & Drăghici E.M. (2021). Comparative study on lettuce growing in NFT and Ebb and Flow System, *Scientific Papers. Series B, Horticulture*. Vol. LXV, No. 1, pp. 369-376.

Asmaa A.S.J., Jerca O.I., Badea M.L. & Drăghici E.M. (2021). Comparative study regarding the behavior of some varieties of basil cultivated in NFT system (Nutrient Film Technology), *Scientific Papers. Series B, Horticulture*. Vol. LXV, No. 1, 485-491,http://horticulturejournal.usamv.ro/index.php/scientific-papers/current-issu

Broadley, M.R., Seginer, I., Burns, A., Escobar-Gutierrez, A.J., Burns, I.G. & White, P.J. (2003). The nitrogen and nitrate economy of butterhead lettuce (*Lactuca sativa* var. *capitata* L.), *J. Expt. Bot.* 54 2081 2090.

Cha M.K., Kim, J.S. & Cho Y.Y., (2012), Growth response of lettuce to various levels of EC and light intensity in plant factory, *Journal of Bio-Environment Control,* ISSN: 1229-4675.

Conversa G., Bonasia A., Lazzizera C. & Elia A. (2021). Soilless cultivation system, electrical conductivity of nutrient solution and growing season on yield and quality of baby-leaf oak-leaf lettuce, *Agronomy*, nr. 11, 1220, pp 1-15.

Dharti T., Dunn B., Hu B., Goad C. & Maness N. (2021). Nutrient solution temperature affects growth and brix parameters of seventeen lettuce cultivars grown in an NFT hydroponic system.

Enache F., Matei S., Matei G.M., Jerca I.O. & Drăghici E.M. (2019). Stimulation of plant growth and rhizosphere microbial communities by treatments with structured water, *Scientific Papers. Series B, Horticulture.* Vol. LXIII, No. 1, pp. 365- 370, 2019, Print ISSN 2285-5653, CD-ROM ISSN 2285- 5661, Online ISSN 2286-1580, ISSN-L 2285-5653.

Park, M.H. & Yong Beom, L. (2001). Effects of CO2 concentration, light intensity, and nutrient level on growth of leaf lettuce in a plant factory *Acta Hort.* 548 377 383.

Quy N., Sinsiri W, Supharat Chitchamnong, K. Boontiang & W. Kaewduangta (2018). Effects of electrical conductivity (EC) of the nutrient solution on growth, yield and quality of lettuce under vertical hydroponic systems, *Khon Kaen Agr. J.,* 46 (3), pp 613-622 https://li01.tci-thaijo.org/index.php/agkasetkaj/

Scuderi, D., Giuffrida, F. & Noto, G. (2009). Effects of nutrient solution EC on yield, quality, and shelf life of lettuce grown in floating system *Acta Horticulturae,* 807, pp 221 226.

Scuderi, D., Giuffrida, F. & Noto, G. (2009). Effects of nutrient solution ec on yield, quality and shelf-life of lettuce grown in floating system. *Acta Horticulturae*. 807, 221-226. https://doi.org/10.17660/ActaHortic.2009.807.28

Serio, F., Elia, A., Santamaria, P., Rodriguez, G.R., Conversa, G., Bianco, V.V., Fernandez, J.A., Martinez, P.F. & Castilla, N. (2001). Lettuce growth, yield and nitrate content as affected by electrical conductivity of nutrient solution. *Acta Horticulturae* 559(2): 563-568

Steiner, A.A. (1980). The selective capacity of plants for ions and its importance for the composition and treatment of the nutrient solution. *Proc. Int. Soc. Soilless Culture, 1980*, 83-95.

Steiner, A.A. (1984). The universal nutrient solution. *Proc. Int. Soc. Soilless Culture* 1984, 633-649.

Uttara C. Samarakoon, Weerasinghe P.A., & WAP Weerakkody (2006). Effect of Electrical Conductivity [EC] of the Nutrient Solution on Nutrient Uptake, Growth and Yield of Leaf Lettuce (Lactuca sativa L.) in Stationary Culture, *Tropical Agricultural Research*, vol. 18, pp. 13-23. http://www.pgia.ac.lk/files/Annual_congress/journel/v18/2.pdf