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COMPARISON BETWEEN HYDROPONIC AND TRADITIONAL METHOD FOR LETTUCE PRODUCTION

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ABSTRACT: This study's primary goal is to compare the hydroponic system and the conventional soil approach for growing lettuce. The following is a summary of the results obtained: Six weeks after transplanting, the average plant height rose from 17.5 to 40.25 cm in the hydroponic system and from 16 to 35.85 cm in the conventional technique. The average root length increased from 8.25 to 25 cm in hydroponic system and increased from 5 to 10.85 cm in traditional method after 6 weeks from transplanting. The hydroponic system produced the highest fresh mass values of shoots (358 g plant^{-1}), while the traditional approach produced the lowest fresh mass values (315 g plant^{-1}). The hydroponic system produced the maximum fresh mass of roots (58 g plant^{-1}), while the traditional approach produced the lowest fresh mass of roots (52 g plant^{-1}). Compared to the hydroponic system, the traditional method's water consumption values were higher. The findings demonstrated that the hydroponic system used less water than the conventional approach. The hydroponic system's average water use efficiency was 185.83 kg m^{-3}, whereas the traditional method's average water use efficiency was 4.3 kg m^{-3}. In the end, the hydroponic method yielded the fastest growth rates compared to the traditional method.

Key words: Hydroponic, Traditional, Lettuce, Production.

INTRODUCTION

The term "soilless cultivation" refers to any system that manages plants in soilless settings where a nutrient solution provides water and minerals, either with or without a growing medium such as rockwool, peat, perlite, pumice, coconut fiber, etc. The hydroponic system is a technique for growing plants without soil by utilizing a mineral nutrition solution in water. In conventional farming practices, soil serves as a medium for the dissolution of nutrients in water, which the plant roots can subsequently absorb. It uses water far more efficiently than ground agriculture since water does not seep through the soil and eventually replenish groundwater supplies; instead, it remains in the system and may be reused.

Furthermore, hydroponics offers more control over nutrient levels, which leads to healthier crops, the avoidance of fertilizers that frequently contribute to pollution, the elimination of the need for pesticides to manage pests, and eventually, much higher and more consistent crop yields (**Johanson, 2009**). Development of advanced techniques to ensure high yields of high-quality agricultural products while providing farmers with motivation through maximum economic return is becoming more and more urgent due to the decline of soil quality in greenhouses under traditional soil cultivation, the growing demand for premium vegetables, and the scarcity of farmland and water resources (**Lichun Wang *et al.*, 2023**). As the world's population grows, there is a growing

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demand for food production. In the meantime, the world's expanding food demand cannot be met by traditional soil-based farming methods. Therefore, creating new farming and planting methods is necessary to prevent future food crises.

The purpose of this study was to investigate the hydroponic system, an effective method for an alternate planting system. The hydroponic system and conventional soil method were compared using the experimental design approach.

MATERIALS AND METHODS

The experiments were constructed and carried out with two growing conditions open field condition (traditional cultivation method) and circulated vertical NFT (Nutrient Film Technique) hydroponic system were adapted for this study and the experiments were conducted during two successive winter seasons of 2021/2022 and 2022/2023 at the greenhouse at the roof of Agricultural Engineering Department, Faculty of Agriculture, Zagazig University, Zagazig and traditional cultivation method located at Awlad Saqer city, Sharqia Governorate, Egypt.

Treatment

Two separate experiments were carried out the first for hydroponic system NFT (Nutrient Film Technique) system and the second for traditional cultivation method.

Lettuce Plants

Seedlings of lettuce (*Lactuca sativa* L.) were planted in plastic cups that were filled with rocks and measured 7 cm in diameter and height. Every day, water containing **Cooper's (1979)** nutritional solution was used to irrigate the cups.

In both the 2022 and 2023 seasons, the seedlings were sowed on November 1st and lasted for six weeks. On the same day, the transplants were put in net cups and put into the open field and NFT hydroponic system. Every agricultural procedure needed to produce lettuce in a greenhouse and an open field was followed.

System Description

The NFT system was constructed from three-meter-long, four-inch-diameter plastic PVC tubes, and the vertical NFT unit had three levels with dimensions of 300 x 90 x 280 cm (L x W x H) with a 500-liter capacity.

One seedling was transplanted into each of the 72 net cup spaces in a single vertical NFT system. **Cooper (1979**) was the method utilized to prepare the Hoagland nutrient solution, which was used in this study to cultivate hydroponically grown lettuce. A hidden pump in the reservoir circulates water. The nutritional solution in a circulating system is pumped from the reservoir, moved from the upper layer to the lower layer, and any extra solution is gathered, refilled, and utilized again.

Instead of being replenished, the nutrient solution in the NFT system was recycled and modified in accordance with pH and EC readings. Daily pH and electrical conductivity (EC) measurements and adjustments were made to the nutrient solutions.

For the sake of comparison with the NFT circulating hydroponic system, lettuce was also grown conventionally in the soil in an open field setting with a spacing of 6 x 12 meters.

Measurements

Growth parameter viz. plant height, root length was measured every week. The fresh mass of shoot and root, water consumption and water use efficiency were measured at the end of the experiment.

Water use efficiency

Water use efficiency (WUE) was determined by the following formula **(Djidonou *et al.*, 2013**):

$$WUE = \frac{CY}{CWU}$$

Where:- CY is the crop yield, kg plant^{-1} and CWU is the crop water uptake, m^3 plant^{-1}

RESULTS AND DISCUSSION

Comparison Between Hydroponic System and Traditional Method

Plant height

The average plant height of lettuce plants cultivated using a hydroponic system and the conventional approach at the conclusion of the 6-week period is displayed in Fig. 1. According to the findings, plants grown in hydroponic systems grew taller than those grown using conventional methods. The hydroponic system showed a rise in plant height from 17.7 to 48 cm, while the traditional approach showed an increase from 16 to 41.2 cm after 6 weeks after transplanting during the first season. It was evident that the plant height rose from 16.5 to 32.5 cm in the hydroponic system and from 13.8 to 30.5 cm in the traditional system at the second season, respectively, after 6 weeks after transplanting. The plant height of traditionally grown lettuce was much less as compared to hydroponically grown lettuce.

The findings showed that the hydroponic system produced higher average plant height values than the conventional approach. In the hydroponic system, the average plant height rose from 17.5 to 40.25 cm, while in the traditional approach, it rose from 16 to 35.85 cm after 6 weeks after transplanting. It can be the result of inadequate use of fertilizers and water. According to **Maher *et al.* (2008**), the findings are likely related to moisture conservation and microclimate enhancement below and above the soilless surface. Previous research indicates that the main determinants of plant development and biomass production in hydroponic culture are nutrients (**Sublett *et al.*, 2018**). These results agreed with those obtained by **Raneem *et al.* (2018**) found that the hydroponic produced fastest growth rates of traditional produced.

Root length

The average root length of lettuce plants cultivated hydroponically and conventionally is displayed in Fig. 2. The findings showed that compared to the traditional approach, the root length increased in the hydroponic system. In the hydroponic system, the root length increased from 10 to 34 cm, while in the traditional approach, it increased from 4.4 to 11.2 cm after 6 weeks after transplanting during the first season. It could be seen that in the hydroponic system, the root length grew from 6.5 to 16 cm, whereas in the traditional approach, it increased from 5 to 10.5 cm after 6 weeks after transplanting during the second season. It can be the result of inadequate use of fertilizers and water. The findings showed that the hydroponic system's average root length values were higher than those of the conventional approach. In the hydroponic system, the average root length increased from 8.25 to 25 cm, while in the traditional approach, it increased from 5 to 18.85 cm after 6 weeks of transplanting. According to **Maher *et al.* (2008**), the findings are likely related to moisture conservation and microclimate enhancement below and above the soilless surface. These results agreed with those obtained by **Raneem *et al.* (2018**) found that the hydroponic produced fastest growth rates of traditional method produced.

Fresh mass of shoot and root:

At the conclusion of the 6-week growing period, Figure 3 displayed the fresh mass of shoot production of lettuce plants cultivated using both the hydroponic and conventional methods. The findings showed that compared to the traditional approach, the fresh mass of shoots in the hydroponic system rose. It was evident that the hydroponic system produced an average fresh mass of 358 g plant^{-1}, whereas the traditional approach produced an average fresh mass of 315 g plant^{-1}. The optimal amount of plant nutrients was supplied, which could aid in raising the concentration of nutrients in the plant body is displayed in figure (3). **Frezza *et al.* (2005)** these results agreed with those obtained by **Maher *et al.* (2008**) and **Raneem et al (2018**) who have found that the plants grown hydroponic system were as high as those in traditional method.

The findings showed that compared to the traditional approach, the fresh mass of roots in the hydroponic system increased. It was evident that the hydroponic system produced an average fresh mass of roots of 58 g plant^{-1}, whereas the traditional approach produced an average fresh mass of roots of 52 g plant^{-1}. NFT-grown lettuce had a mean plant fresh weight of 356 grams,

which was 21% more than lettuce cultivated the old-fashioned way. The shoot and root weights of lettuce grown using the NFT method showed similar trends, with mean values 358 grams and 58 grams higher than those obtained using the traditional method, respectively. Thus, increased lettuce root weight was observed in the NFT system. Based on these results, NFT system performs better as compared to traditional method in producing hydroponic lettuce with higher biomass. These results agreed with those obtained by **Maher *et al.* (2008) and Raneem et al (2018)** whose found that the fresh mass of root were increased in hydroponic system over those of traditional method.

Water consumption:

At the end of the 6-week growing period, the water consumption of lettuce plants cultivated hydroponically and conventionally is displayed in figure (4). The findings showed that the old approach used more water than the hydroponic system did. The findings demonstrated that the hydroponic system used less water than the conventional approach. It was evident that the water consumption for fed using the traditional method was 460.83 m^3, whereas the water consumption for fed using the hydroponic system was 72.97 m^3. The hydroponic technology uses 84.2% less water than the conventional approach. Therefore, compared to the conventional approach, the hydroponic system used less water. According to **Albright and Langhans (2014),** a closed-loop system that circulates a nutrient solution through shallow tubes is used in hydroponic NFT cultivation. These findings concurred with those of **Raneem *et al.* (2018**), who claimed that the hydroponic system offers a number of benefits, including water conservation, year-round production, yield enhancement, and reduced pesticide use.

Water use efficiency:

At the conclusion of the 6-week growing period, Figure 4 showed the water consumption efficiency for lettuce plants grown using the hydroponic and conventional methods. The findings showed that the hydroponic system's water use efficiency was higher than that of the conventional approach. It was observed that the hydroponic system yielded an average water use efficiency of 185.5 kg m^{-3}, which was in agreement with the findings of the traditional approach, which yielded an average water use efficiency of 4.32 kg m^{-3} (**Bozkurt et al., 2009**). When compared to conventional agriculture, **Majid *et al.* (2021**) discovered that hydroponics and other agricultural techniques can be utilized to grow plants with excellent quality and productivity, no reliance on soil, shorter crop durations, less fertilizer, and water savings.

CONCLUSIONS

The purpose of the experiment was to compare the hydroponic system with the conventional technique of growing lettuce. The following is a summary of the results obtained:
- The average plant height rose from 17.5 to 40.25 cm in the hydroponic system and from 16 to 35.85 cm in the traditional method after 6 weeks of transplanting.

- The average root length rose from 8.25 to 25 cm in the hydroponic system and from 5 to 10.85 cm in the traditional method after 6 weeks of transplanting.

- The hydroponic system produced the highest fresh mass values of shoots (358 g $plant^{-1}$), while the traditional approach produced the lowest fresh mass values (315 g$plant^{-1}$).

-The hydroponic system produced the maximum fresh mass of roots (58 g $plant^{-1}$), while the traditional approach produced the lowest fresh mass of roots (52 g $plant^{-1}$).

- Compared to the hydroponic system, the old method's water consumption values were higher. The findings demonstrated that the hydroponic system used less water than the conventional approach.

- Compared to the conventional approach, the hydroponic system's average water consumption efficiency was greater.

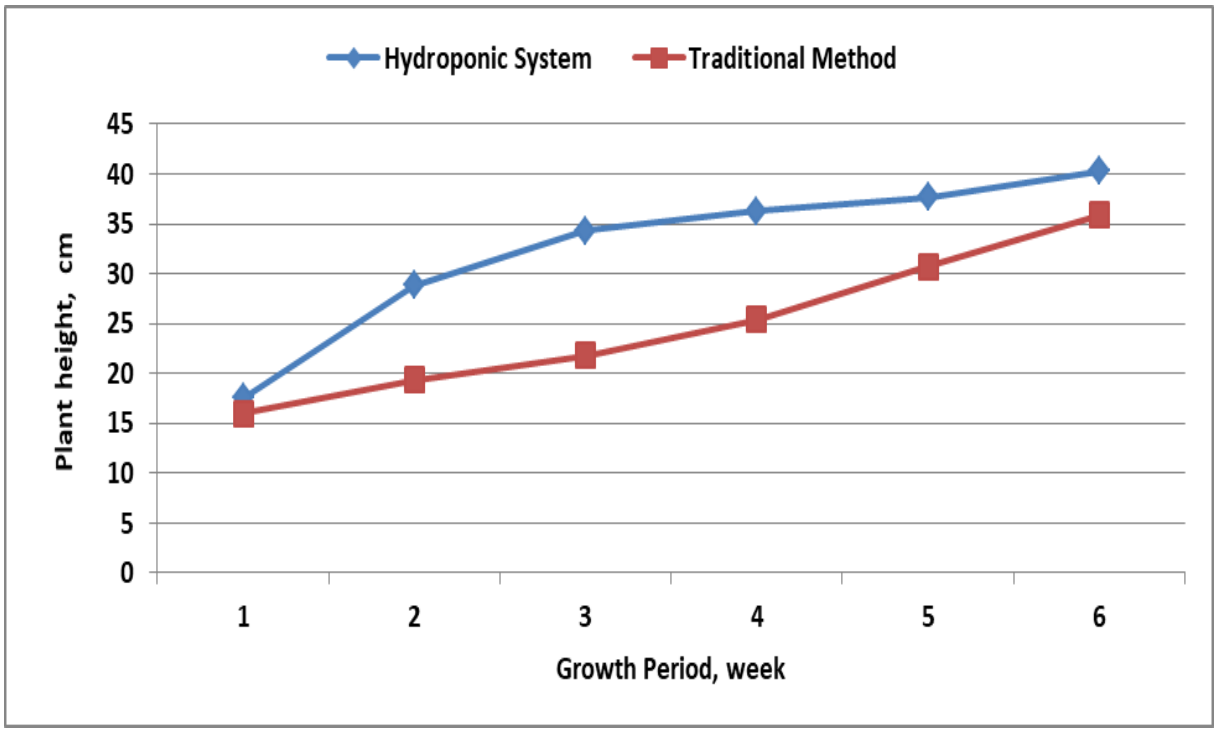

Fig. 1. The average height of lettuce plants at the end of the growing season, both hydroponically and conventionally.

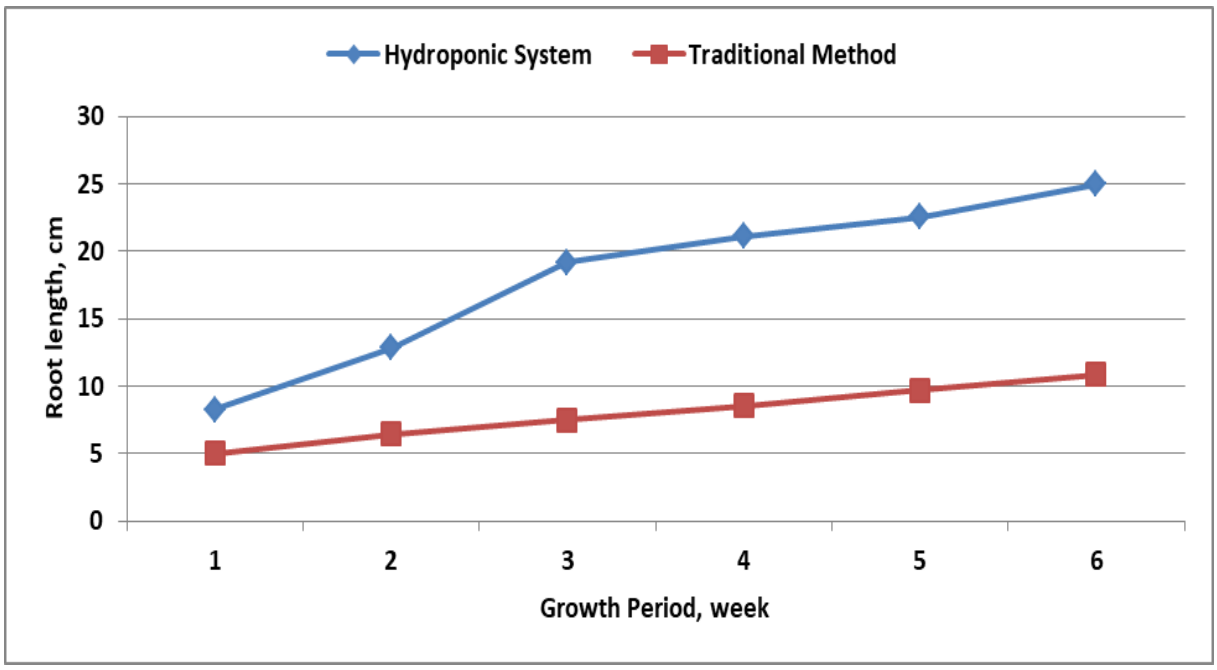

Fig. 2. The average root length of lettuce plants at the end of the growing season, both hydroponically and conventionally.

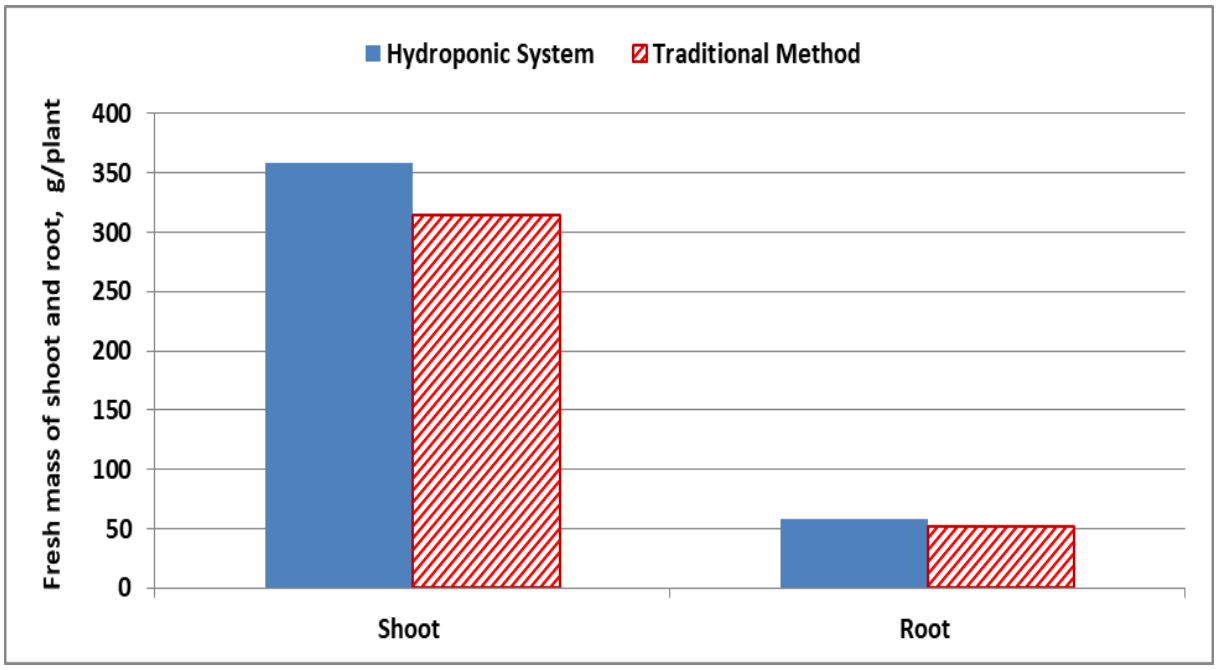

Fig. 3. The fresh mass of shoot and root of lettuce plants at the end of the growing season, both hydroponically and conventionally.

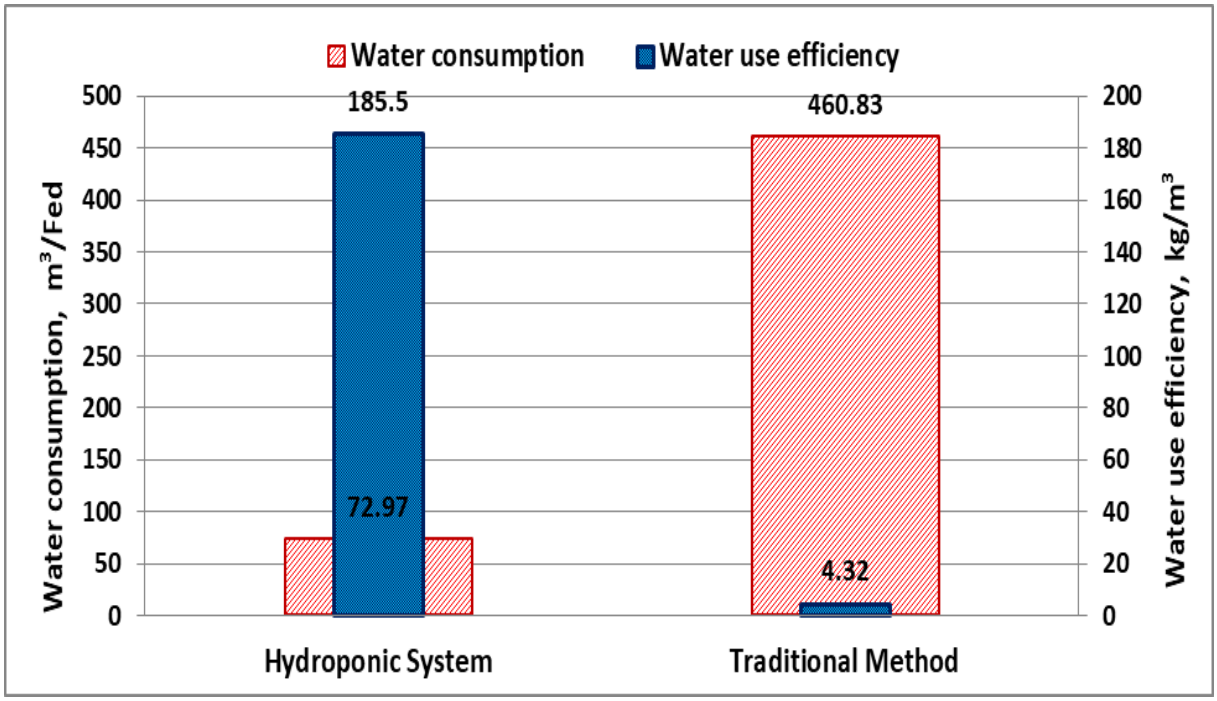

Fig. 4. The water consumption and water use efficiency of lettuce plants at the end of the growing season, both hydroponically and conventionally.

REFERENCES

Albright, L.D. and Langhans, R.W. (2014). Controlled Environmental Agriculture Scoping Study. Controlled Environment Agriculture Program, Cornell University. Available online:ttp://www.cornellcea.com/attachments/Controlled Environment Agriculture Scoping Study (accessed on 11 November 2014).

Bozkurt, S., G. S. Mansuroğlu, M. Kara and S. Önder (2009). Responses of lettuce to irrigation levels and nitrogen forms. African J. of Agric. Res., 4 (11): 1171-1177.

Cooper, A.J. (1979). "The ABC of NFT", 2nd. Ed. Grower Books. England.

Djidonou, D., X. Zhao, E. H. Simonne, K. E. Koch and J. E. Erickson (2013). Yield, water and nitrogen use efficiency in field grown grafted tomatoes. Hort. Science, 48(4): 485 – 492.

Frezza, D., Leon, A., Logegaray, V., Chiesa, V., Desimone, M. and Diaz, L. (2005). Soilless culture technology for high quality lettuce. Proc. IS on Soilless Culture and Hydroponics. Acta Horticulture 697: 43-47.

Johanson, E. K. (2009). Aquaponics and Hydroponics on a budget. Tech Directions 69 (2): 21-23.

Lichun Wang, Songrui Ning, Wengang Zheng, Jingyu Guo, Youli Li, Yinkun Li, Xiaoli Chen, Alon Ben Gal and Xiaoming Wei. (2023). Performance analysis of two typical greenhouse lettuce production systems: commercial hydroponic production and traditional soil cultivation 10.3389/fpls.2023.1165856.

Maher, M., Prasad, M. and Raviv, M. (2008). Organic soilless media components. In: Raviv, M., Lieth, J.H. (Eds.), Soilless culture: Theory and practice. Academic Press, San Diego, USA, pp. 459-504.

Majid, M., Khan, J. N., Shah, Q. A., Masoodi, K. Z., Afroza, B., and Parvaze, S. (2021). Evaluation of hydroponic systems for the cultivation of lettuce (lactuca sativa l. var.longifolia) and comparison with protected soil-based cultivation. Agr. Water Manage.245,106572.doi:10.1016/j.agwat.2020.106572.

Raneem Gashgari, Khawlah Alharbi, Khadija Mughrbil, Ajwan Jan, Abeer Glolam. (2018). Comparison between Growing Plants in Hydroponic System and Soil Based System Proceedings of the 4th World Congress on Mechanical, Chemical, and Material Engineering (MCM'18) Madrid, Spain – August 16 – 18, 2018 Paper No. ICMIE 131 DOI: 10.11159/icmie18.131.

Sublett W. L, Barickman T, and Casey Sams C. E. (2018). The effect of environment and nutrients phytonutrients. Horti. 4 (4) :48. https://doi.org/10.3390/ horticulturae4040048

المقـارنة بيـن الزراعــة المائيــة وطريقــة الزراعــة التقليديــة في انتــاج الخــس

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الزراعة المائية هو النظام الأمثل الذي يُلبي الطلب الحالي والمستقبلي بأقل تكلفة واستهلاك للموارد الطبيعية. الهدف الرئيسي من هذا البحث هو دراسة مقارنة نظام الزراعة المائية مع طريقة الزراعة التقليدية لانتاج الخس.

ويمكن تلخيص النتائج المتحصل عليها كما يلي:

زاد متوسط ارتفاع النبات من 17.5 الي 40.25 سم بعد 6 اسابيع من الزراعة في نظام الزراعة المائية ، ومن 16 الي 35.85 سم بعد 6 اسابيع من الزراعة في الطريقة التقليدية. زاد متوسط طول الجذر من 8.25 الي 25 سم بعد 6 اسابيع من الزراعة في نظام الزراعة المائية ، وزاد من 5 الي 10.85 سم بعد 6 اسابيع من الزراعة بالطريقة التقليدية.

كانت اعلي قيم للوزن الطازج للمجموع الخضري 358 جرام لكل نبات مع نظام الزراعة المائية بينما كانت اقل قيم للوزن الطازج 315 جرام لكل نبات مع الطريقة التقليدية. كانت اعلي قيم للوزن الطازج للمجموع الجذري 58 جرام لكل نبات مع نظام الزراعة المائية، بينما كانت اقل قيم للوزن الطازج للجذر 52 جرام لكل نبات مع الطريقة التقليدية.

اظهرت النتائج ان نظام الزراعة المائية استهلك مياة اقل من الطريقة التقليدية. كان متوسط كفاءة استخدام المياة في نظام الزراعة المائية 185.83 كجم/م^3 ، بينما كان متوسط كفاءة استخدام المياة في الطريقة التقليدية 4.3 كجم/^{3} . وتوصي الدراسة باستخام الزراعة المائية حيث تعمل علي زيادة الانتاج وتوفير في استهلاك المياة واسرع في معدلات النمو مقارنة بطريقة الزراعة التقليدية.

المحكمـــون:

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