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Effect of Pot Size and Hydroponics Technique on Growth and Yield of Lettuce (*Lactuca sativa* L.)

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ABSTRACT

The current experiment was conducted from November 2021 to January 2022 at Nursery of the Directorate of Agriculture Kirkuk / Kirkuk governate, Iraq, to study the effect of pot size (250, 150, 100 ml) and hydroponics technique (Deep Water Culture and Nutrient film) on growth and yield of lettuce, which were placed in the main panels of statistical design. The experiment design was split plot System, within the design of the complete random sectors and four replications while, the averages were compared according to the Duncan polynomial test at the level of probability of 5% ≥ p. The main results exceeded that the size of the pot 150 ml in deep water culture significantly in most of the studied characteristics, including the average weight of the head, total and total quotient, with a significant increase of 17.53 and 17.70%, respectively.

Keywords: Lettuce (*Lactuca sativa* L.), pot size, Hydroponic, Deepwater culture technology, Nutrient film Technique.

1. Introduction

Lettuce (*Lactuca sativa* L.) is one of the Asteraceae family crops, it's one of the important winter leafy vegetables worldwide. Lettuce is grown in Iraq and the world due to its high nutritional value and rapid growth. It is believed that the original homeland of lettuce is the Mediterranean regions, especially Europe and Asia, and it is often believed that it originated in Egypt 4.500 years ago (Zaki, 2011), Although lettuce ranks twenty-sixth in nutritional value among vegetable and fruit crops, its consumption in large quantities makes it fourth after tomatoes, oranges, and potatoes in terms of consumption in America (Hassan and Abdel Moneim 2003). United States of America, Spain, Italy, Japan, and France are the main producers of lettuce in the world (Al-Saadawi *et al.,* 2003).

The cultivated areas of lettuce in Iraq amounted 17,766 dunums in year 2019, throughout Iraq, and the average production reached 7.03 tons hectare^{-1}, and the total productivity reached 31.232 tons (Central Statistical Organization, 2018), and we find that there is a decrease in the production rate per unit area if compared with the rest of the world, as production in China reached more than 35 tons hectare^{-1} (FAO, 2020).

The deterioration of the soil over time is one of the problems facing farmers, as its natural composition deteriorates because of the continuous use of fertilizers in high concentrations for the purpose of obtaining a high yield. Consequently, salts accumulate in it and lead to salinization of the soil, in addition to the widespread spread of diseases and pests in the soil, which reduces the possibility of cultivation of the same crops. In the soil (Farran, and Mingo-Castel, 2006). These reasons prompted scientists in the agricultural sciences sector to search for alternative solutions to using soil, such as soilless farming systems, in which plants are grown in media other than the soil of the earth, which depends mainly on the type of nutrient solution and the media. Used to stabilize and embrace the plant.

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Hydroponics is one of the modern agricultural techniques applied in many countries around the world used in lettuce production because of its importance in reducing water consumption (Nasih *et al.,* 2022).

Hydroponics comes as one of the proposed alternatives to reduce the deficit in the food balance and increase the self-sufficiency rate of the most important strategic food crops (Schmautz *et al*., 2016). These alternatives depend on the application of hydroponics technology. In greenhouses in new lands to produce the same vegetable production obtained from old lands (Mahmoud, 2018), hydroponics has many advantages, as plants can be grown densely because water and nutrients are available, with a significant reduction in agricultural operations such as plowing, combating weeds, and saving water by 80% of the water. Used in traditional agriculture (Bo *et al*., 2018; Schmautz *et al*., 2016), hydroponics can be used for commercial production of crops and in places where soil is not available, as hydroponics is an effective alternative to agricultural media (Al-Saadawi *et al*., 2003), and hydroponics is one of the Good scientific methods in plant nutrition research in order to fully control the quantity and quality of nutrients that include all elements (Muhammad *et al.,* 1991).

In a study conducted by (Pérez-Urrestarazu *et al*., 2019) to produce lettuce in two production cycles in three hydroponic systems: the nutritious film system (NFT), the floating raft system, and the vertical felt system, the yield was significantly higher, and the amount of water consumed was better in the film system. NFT nutrient. Another experiment was conducted to compare the growth and yield of tomatoes, basil, and lettuce grown in two systems, hydroponics and aquaponic, by Yang and Kim, (2020). They found that the biomass of vegetative plants had decreased in the aquaponic system compared to the hydroponic system, and a decrease in the production of basil and lettuce was also observed in the system. Aquaponic by 56% and 67%, respectively, and the marketable tomato yield was similar between the two systems.

Due to the lack of studies on the use of hydroponic system applications in Iraq, the research aimed to increase the horizontal and vertical plant density using hydroponic farming techniques under a protected environment, determine the most appropriate technique, and determine appropriate pot sizes for hydroponic cultivation of lettuce, as well as producing lettuce under a protected environment and throughout the year through Determining the success of hydroponics and its related aspects, thus providing appropriate environmental conditions throughout the year for the production of lettuce.

2. Material and Methods

This study was carried out in the nursery of the Kirkuk Agriculture Directorate, one of the formations of the Ministry of Agriculture in Kirkuk Governorate, Iraq, during the 2021-2022 season. The experiment was implemented using two techniques (deep planting technique and nutrient film technique), as three ponds were built inside one of the greenhouses with an area of 1 x 3m^2 for each pond, then covered with an opaque plastic material to provide an opaque environment like the soil environment. The lettuce plants were grown using this technique by completely submerging the roots of the plants in the nutrient solution in deep basins 20 cm deep and placing sheets of cork floating above the water, as the area of one cork is 0.5m^2, holes were drilled inside the cork, and the seedlings were placed inside special anvils, with their roots directly inside the water. An oxygen pump was used to supply the solution with oxygen, and the lack of water and salts, as well as the pH, were monitored. Also, 12 tubes were made. Each tube was 3 meters long, 6 inches in diameter, and 10 holes were perforated depending on the number of plants grown in each tube and according to the size of the pots used in cultivation, which were 100ml, 150ml, and 250ml. These tubes were fixed on iron supports vertically within a slope of 1cm. At a certain angle in a way that allows the nutrient solution to flow smoothly and without obstacles within a thin layer in which the roots of the plants grow. The tubes were connected to each other using plastic connectors. The tubes were also connected to a 180-litre tank equipped with the nutrient solution that fed the tubes. At the end of the tubes, two tanks were placed to collect the nutrient solution. exits the system and is pumped back to the beginning of these channels. The seeds were planted in the beds on 10/October/2021, and the seedlings were transferred into the ponds and pipes on 11/August/2022, noting that the ponds and pipes were sterilized using the fungicide (Avecuor) at a concentration of 50 mg l^{-1} before transporting the seedlings inside. Basins and pipes for two days.

The experiment included two factors: the size of the planting pots, symbolized by (C). Three different sizes of planting pots were used: (pot size 250 ml (C1), pot diameter 9 cm), (pot size 150ml (C2), pot diameter 7 cm), (pot volume 100 ml (C3), pot diameter 5 cm), and the second factor was two hydroponic systems symbolized by (S) (S1 deep cultivation technique), (S2 nutrient film technique), with twenty-four experimental units divided into four replicates each. An experimental unit with an area of 0.5 m^2 included ten plants. The distance between one plant and another was 20 cm. Data were taken from five plants for each experimental unit to study the following characteristics: number of leaves (leaf plant^{-1}), head circumference (cm head^{-1}), and the percentage of heads wrapped. It is calculated by calculating the number of wrapped heads divided by the total number of heads multiplied by 100, the average weight of the total head (g plant^{-1}), and the total yield (kg house^{-1}) were calculated according to the equation (total yield = experimental unit yield/experimental unit area). × house area), the experiment was designed using a split plot design within a randomized complete block design (RCBD), where the hydroponic farming technique was placed in the main plot and the pot sizes in the sub plot as more important, with four replications (Al-Rawi *et al.,* 2000). The results were analyzed according to the SAS program (2001) and the means were compared according to the Duncan multinomial test at a significance level of P≤ 0.05.

3. Result and Discussion

3.1. Vegetative growth and yield characteristics.

3.1.1. Number of leaves (leaf plant^{-1})

Data in Figure (1) shows that the pot size of 150 ml (C2) was significantly superior to the pot size of 100 ml (C3), as it showed the highest mean value for number of leaves, which amounted to 47.65 leaf plant^{-1}. There were no significant differences between number of leaves and the pot size of 250 ml (C1), which in turn, it did not differ significantly with the pot size of 100 ml (C3), and with regard to the effect of the type of hydroponic system, it appears from the figure below that the deep hydroponic cultivation technique (S1) showed a significant superiority in the number of leaves trait and gave the highest value for this trait amounting to 50.05 leaf plant^{-1}. Compared with the nutrient film technique (S2), and regarding the effect of the interaction between pot size and hydroponic cultivation technique, it is noted that the (C2S1) treatment showed a significant superiority in this trait, reaching 51.90 leaf plant^{-1} compared to the lowest value for this trait in the (C3S2) treatment, which amounted to 36.20 leaf plant^{-1}.

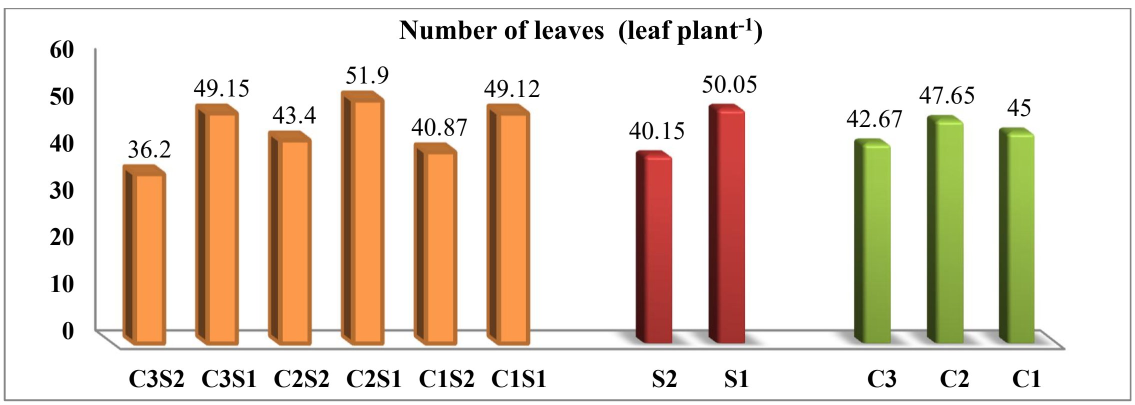

Fig. 1: The effect of pot size, hydroponics technique, and their interaction on the number of leaves of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

3.1.2. Average area of one plant leaf (cm^2 leaf^{-1})

It is observed from Figure (2) that the cup diameter did not significantly affect the leaf area characteristic. Regarding to the impact of the type of hydroponic system, the data in the same figure showed that the deep-water culture technique (S1) provided a significant superiority of 81.8 cm² per plant compared to the nutrient film technique (S2), which recorded 63.3 cm² per plant. The figure also indicates the presence of significant differences between the two studied factors when they interacted.

The deep-water culture treatment with all pot sizes outperformed the nutrient film technique, with values of 84.27 cm² per plant, 81.15 cm² per plant, and 80.00 cm² per plant for pot sizes of 7 cm, 9 cm, and 5 cm, respectively, in deep-water culture. In contrast, the lowest recorded value among the studied treatments was (C3S2), which reached 62.67 cm² per plant.

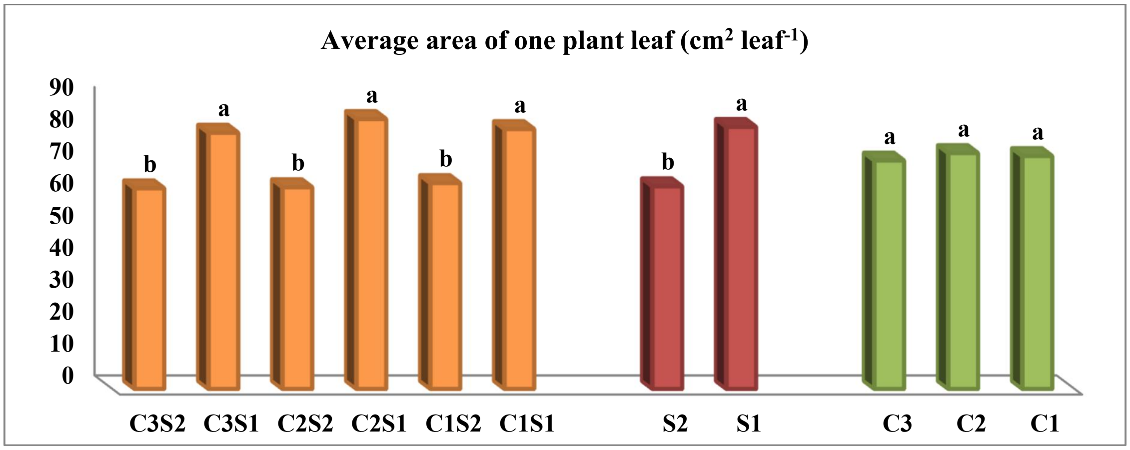

Fig. 2: The effect of pot size, hydroponics technique, and their interaction on the average area of one plant leaf of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

3.1.3. Percentage of dry matter in leaves (%)

The pot size coefficients did not show any significant effect on the dry matter percentage trait in the leaves (see Figure 3), while it appears in the same figure that there are differences between the coefficients of the hydroponic system type. It is noted that the deep hydroponic technology (S1) is significantly superior with an increase of 15.28% compared to the nutrient film technology (S2). As for the interaction coefficients, it is noted that the (C2S1) treatment is significantly superior with an increase of 34.94% compared to the (C2S2) treatment, which gave the lowest value for this trait, followed by the (C3S2) treatment.

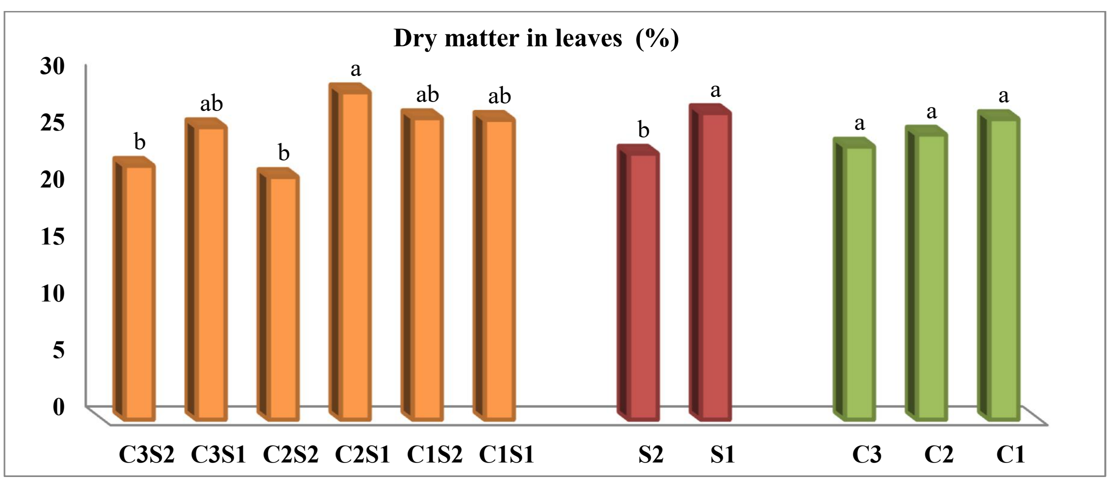

Fig. 3: The effect of pot size, hydroponics technique, and their interaction on the dry matter in leaves of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

3.1.4. Percentage of dry matter in roots (%)

From the results in Figure (4) there are significant differences between the pot size coefficients in the percentage of dry matter in the roots, as the pot size of 250 ml (C1) was significantly superior by showing the highest value of 16% compared to treatments (C2) and (C3). It is also noted that from the Figure 4 that there are significant differences between the coefficients of the hydroponic system type, as it is noted that the deep hydroponic technology (S1) was significantly superior, which gave 17.56%. As for the binary interaction coefficients, it is noted that the coefficients (C3S1), (C2S1), (C1S2), and (C1S1) were significantly superior compared to the treatments (C2S2) and (C3S2), which gave the lowest values for this characteristic, which amounted to 9.92% and 9.37%, respectively.

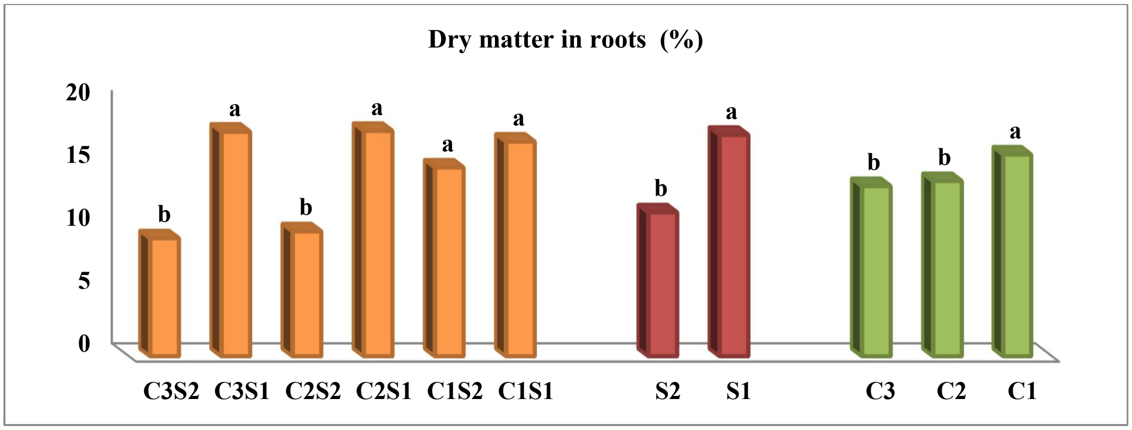

Fig. 4: The effect of pot size, hydroponics technique, and their interaction on the dry matter in roots of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

3.1.5. Head circumference (cm head^{-1})

It appears from Figure (5) that there are no significant differences between the pot size parameters in the head circumference characteristic, but there were significant differences between the parameters of the type of system for hydroponics, where the (S1) treatment excelled significantly in this characteristic by giving it the highest value of 35.23 cm compared to the treatment (S2), which gave 30.29 cm. With regard to the bilateral interaction between the pot size treatment and the hydroponic farming technique, it is noted that the (C2S1) treatment gave the highest value in this characteristic, amounting to 36.12 cm, and did not differ significantly with the remaining interaction treatments, except for the (C3S2) treatment, which gave the lowest value of 26.42 cm, which in turn did not differ significantly with (C2S2) treatment.

3.1.6. Head wrap (%)

In addition, the results in Figure (6) showed that the pot size parameters did not significantly affect the head wrapping characteristic, while the same figure shows that there are significant differences between the parameters of the type of system for hydroponics for the same mentioned characteristic, as it is noted that the treatment of the cultivation system using the DWT (S1) technique is significantly superior, as It reached 94.16% compared to the other system treatment, and in the bilateral interaction coefficients between the pot size treatment and the hydroponic cultivation technique, it is noted that the (C2S1) treatment gave the highest value for the head curl characteristic, as it reached 97.5% and thus it was significantly superior to the (C3S2) treatment, which gave the lowest value. For this trait, it amounted to 70%, as well as for the (C2S2) treatment, which gave the second lowest value for the same mentioned characteristic, which amounted to 80%.

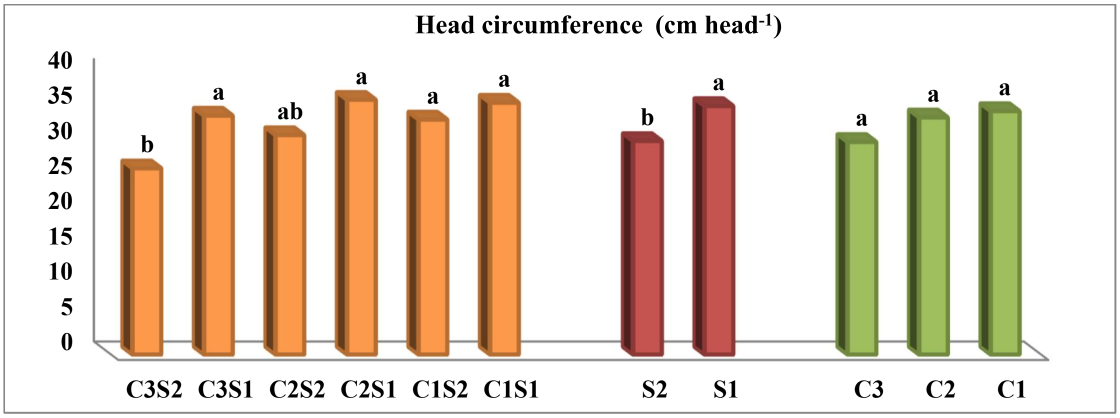

Fig. 5: The effect of pot size, hydroponics technique, and bilateral interaction between the two factors on the head circumference of lettuce plants.

❖The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

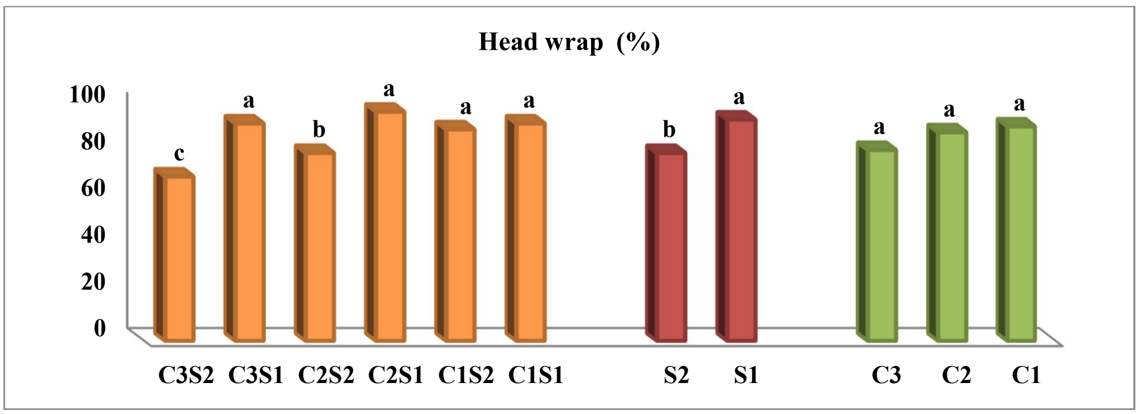

Fig. 6: The effect of pot size, hydroponics technique, and their interaction on the head-turning characteristic of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

3.1.7. Average total head weight (g head^{-1})

It is noted that in Figure (7) that the pot size of 150 ml (C2) was superior in terms of average total head weight, with a significant increase of 7.19% compared to the pot size of 100 ml (C3), while there were no significant differences between the pot size of 150 ml (C2) and 100 ml (C1). Between the two sizes: 250 ml (C1) and 100 ml (C3), this is with regard to the effect of pot size parameters, while in the parameters of the type of system for hydroponics, it is noted that the deep hydroponics technique (S1) is superior, with a significant increase of 7.8% compared to the nutrient film technique (S2), and with regard to the parameters The interference observed that the (C2S1) treatment was superior, with a significant increase of 17.53% compared to the (C2S2) treatment, and thus it was significantly superior to all the interference treatments except for the (C1S1) treatment.

3.1.8. Total yield (ton house^{-1})

Figure (8) shows that the pot size of 150 ml (C2) was superior in terms of total yield, with a significant increase of 7.49% compared to the pot size of 100 ml (C3), while there were no significant differences between the pot size of 150 ml (C2) and 100 ml (C1), as well as between the two sizes of 250 ml. (C1) and 100 ml (C3) This is with regard to the effect of the pot size parameters, while the hydroponic system type parameters and the overlap parameters behaved the same way in terms of the average weight of the marketing head, as both the S1 and C2S1 treatments gave a significant superiority in this characteristic by giving them the highest values amounting to 5.681 tons. house^{-1}, 6.102 tons house^{-1} respectively.

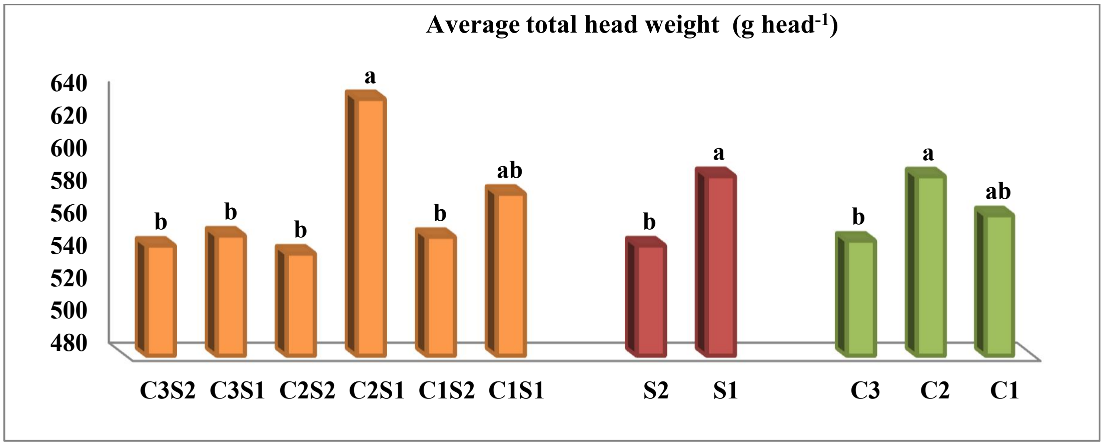

Fig. 7: The effect of pot size, hydroponics technique, and bilateral interaction between the two factors on the average weight of the total head of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

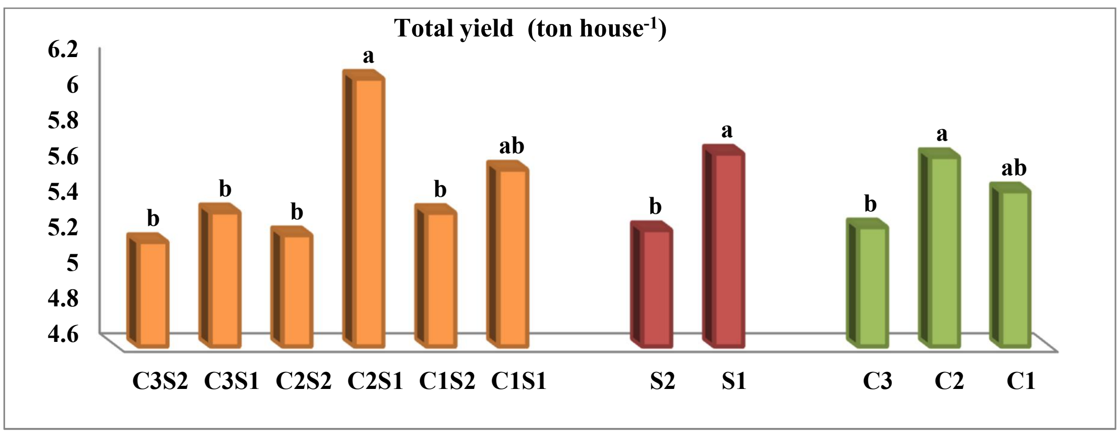

Fig. 8: The effect of pot size, hydroponics technique, and the bilateral interaction between the two factors on the total yield of lettuce plants.

❖ The means that bear the same alphabet are not significantly different from each other according to Duncan's multinomial test at the probability level P≤ 0.05. So, C1 = pots with a size of 250 ml, C2 = pots with a size of 150 ml, C3 = pots with a size of 100 ml, S1 = hydroponic growing technique (DWT), and S2 = growing system with NFT technology.

The reason for the superiority of the pot sizes of 150ml (C2) and 250ml (C1) in the number of leaves is due to the fact that these sizes provided appropriate amounts of the growing medium of peat moss around the perimeter of the pot, especially at the beginning of the plant's growth stages, thus increasing the moisture content and nutrients around the root area in addition. The physical tension in these two sizes of pots is less than the physical tension caused by the 100ml pot size (C3). As a result, the reasons that led to increased vegetative growth in these two sizes of pots also led to their superiority in yield characteristics (average total head weight and total yield).

As for the cultivation system, the reason for the superiority of the cultivation system using the deep cultivation technique (S1) in all vegetative characteristics may be attributed to the fact that the deep cultivation system inside the beds allows sunlight to reach all plants without shading one over the other, in contrast to the nutrient film technique (S2), which was created in a simple manner. Vertical and in the shape of an inverted letter (V), and despite the presence of a distance between one line and another of no less than 35 cm, the dense growth of plants due to the availability of nutrients for them led to one of them shading the other, which resulted in some physiological processes being affected, which would improve the vegetative and root characteristics. When the reason for the differences between the bilateral interaction factors between the size of the pots and the type of hydroponic system is attributed to the combined or additive effect of the individual factors.

4. Conclusions

From the previous results it could concluded that, using pot sizes of 150ml and 250ml led to an increase in the number of leaves and average total weight. The deep cultivation technique also gave a significant superiority in all vegetative and yield traits, while the interaction between the 150ml pot size and the deep hydroponics technique was superior in most of the traits studied.

References

Al-Rawi, Kh.M. and Kh. Abdul-Azim, 2000. Design and analysis of agricultural experiments. Second edition, University of Mosul, Ministry of Education and Scientific Research. The Republic of Iraq, 19, 487.

Al-Saadawi, I.Sh. and H.A. Fadel, 2003. Production of vegetable crops through soilless agriculture. Journal of Agricultural Sciences, 34(2): 67-82.

Bo, L.E.I., Z.H. Bian, Q.C. Yang, W.A.N.G. Jun, R.F. Cheng, L.I. Kun, W.K. Liu, Y. Zhang, H. Fang and Y.X. Tong, 2018. The positive function of selenium supplementation on reducing nitrate accumulation in hydroponic lettuce (*Lactuca sativa* L.). Journal of Integrative Agriculture, 17(4): 837-846.

Central Statistical Organization, 2018. Directorate of Agricultural Statistics. Ministry of Planning / Republic of Iraq.

FAO. 2020. World Food and Agriculture, Statistical Yearbook 2020. Rome. Italy.

Farran, I., and A.M. Mingo-Castel, 2006. Potato minituber production using aeroponics: effect of plant density and harvesting intervals. American Journal of Potato Research, 83(1): 47-53.

Hassan, A.A., 2003. Production of complex vegetables, mallow and taro. First edition, Arab Publishing and Distribution House, Cairo, Arab Republic of Egypt.

Mahmoud, Kh.S.T., 2018. Hydroponics for vegetable crops and its expected role in improving the self-sufficiency rate is one of the most important strategic crops. Journal of the Association of Arab Universities for Agricultural Sciences, 26(1):35-52.

Muhammad, A.K. and A.A. Moayed, 1991. Fundamentals of plant physiology. Parts two and three. University of Baghdad, Ministry of Higher Education and Scientific Research, Republic of Iraq.

Nasih, H.B., H.B. Abdulrahman, and J.Z. Ghassan, 2022. Effect of Agricultural Medium in Hydroponic System on Growth and yield of Two Hybrids of Lettuce (*Lactuca sativa* L.). In *IOP Conference Series: Earth and Environmental Science* (1060(1): 012052). IOP Publishing.

Pérez-Urrestarazu, L., J. Lobillo-Eguíbar, R. Fernández-Cañero, and V.M. Fernández-Cabanás, 2019. Suitability and optimization of FAO's small-scale aquaponics systems for joint production of lettuce (*Lactuca sativa*) and fish (*Carassius auratus*). Aquacultural Engineering, 85: 129-137.

SAS. 2001. User Guide, Statistics (Version 6.121) SAS. Inst. Cary, N.C.U.S.A.

Schmautz, Z., F. Loeu, F. Liebisch, A. Graber, A. Mathis, T. Griessler Bulc, and R. Junge, 2016. Tomato productivity and quality in aquaponics: Comparison of three hydroponic methods. Water, 8(11): 533.

Yang, T., and H.J. Kim, 2020. Characterizing nutrient composition and concentration in tomato-, basil-, and lettuce-based aquaponic and hydroponic systems. Water, 12(5):1259.

Zaki, M.H., 2011. Lettuce cultivation. Electronic bulletin, Egyptian Agricultural Research Center, Arab Republic of Egypt.