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THE EFFECT OF FERTILIZATION ON THE GROWTH PARAMETERS OF SEEDLINGS AND LETTUCE PLANTS GROWN IN THE NFT SYSTEM (NUTRIENT FILM TECHNIQUE)

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Abstract

Lettuce is one of the important vegetable crops being grown worldwide both in the open field and in greenhouses due to its nutritional benefit. Growing lettuce in hydroponic especially in the NFT system always gets attention from the growers and scientist communities, and for farmers, it challenges when it comes to selecting appropriate fertilizers and cultivars for growing to reach optimal growth and at the same time with high yield performance together with market preferences. The aim of the study was to identify the most favorable effect of fertilizers on the growth of the lettuce seedlings as well as the cultivars growth grown in the NFT system. The study was conducted in Hortinvest greenhouse using seven varieties of lettuce. Three types of fertilizers were used during the seedlings stage including Universol, Formulex, and Bio-Grow. We found the differences in the duration of plant emergence, vegetative growth of seedlings as well as varieties growth cultivated in NFT.

Key words: *Lettuce, seedlings, NFT, Fertilizer.*

INTRODUCTION

Vegetables play an important role as a source of food providing vitamins and other necessary nutrients for a human being. It was estimated that the world population will reach 9 billion by 2050 (Tilman et al., 2002), in this context, more food is needed especially vegetables to feed such a huge population while agricultural land will be decreased due to urbanization. Relying on conventional farming alone, cannot solve the problem of food shortage and environmental issues.

Hydroponics is commonly used in crop production practice worldwide, especially in developed countries with big-scale production. It is regarded as a high-tech cultivation system or the soilless cultivation in which plants basses on the mineral nutrient solution (Jones, 1982; Sardare & Admane, 2013; Becherescu et al., 2018; Phibunwatthanawong & Riddech, 2019). In the system, the nutrients are fed to the roots directly (van Os et al., 2019). The hydroponic system, it is divided into two systems (open and closed), the surplus nutrient solution is not collected for recycling in the open system. It is collected and recycled back into the nutrient tank in the closed system. There are three types of open systems for hydroponic based on water and nutrient distribution, it includes the Deep Flow Technique (DFT), Nutrient Film Technique (NFT), and the Aeroponic system (Kovácsné et al., 2019 and Göddeke et al., 2019). Hydroponic system by using a nutrient film technique (NFT) was first developed by Allen Cooper and his teamwork in the 1960 s at the Glasshouse Crops Research Institute in Little Hampton, UK. It is the type of growing the crops in the shallow film by using nutrients solution that flows near the roots, so the plant easily directly absorb nutrient from the solution (Hardeep et al., 2019). Currently, the worldwide cultivated area of vegetable production was about 3.5% growing under tunnels and greenhouses based on the hydroponic system by using floating system, NFT or aeroponic (Sambo et al., 2019). World vegetable production increased almost double between the year 2000 to 2019 from a volume of 682.43 million metric tons to 1130.2 million metric tons. The leading country producing fresh vegetables in 2019 was China with an amount of 588.26 million metric tons, followed by India, with 132.03 million metric tons, and the United States, with 29.29 million metric tons (Shahbandeh, 2021). In Romania, around 80% of vegetables come from imports and in 2019, approximately 740000 tons of vegetables worth 516 million euros were imported (Drăghici et al., 2021).

Lettuce is one of the popular crops are being grown in hydroponics especially in the NFT system due to its nutritional values, contains a large variety of phytonutrients, fibres and other elements necessary to a proper functioning of the human body (Hoza et al., 2020). Lettuce belongs to the family of *Asteraceae* within the order *Asterales*. It has more than 1.620 genera and 23.600 species distributed worldwide (Petruzzello, 2018,).

The urban cultivation system, also known as the hydroponic system, is now seen as a viable solution to the limited land area suitable for agriculture. It is also an alternative option for increasing vegetable yield, nutrient, and water efficiency, environment friendly and can support vegetables year-round which are better opportunities for sustainable food supply in both developed and developing countries (Daniel, 2014, Chow et al., 2017). Cultivation of lettuce on NFT always challenging for the grower in terms of choosing the type of fertilizers to have a good healthy seedling and suitable cultivar with high yield performance due to abundant products available on the market. The objective of our study was to evaluate the effect of fertilizer on the growth of lettuce seedlings and cultivar in NFT system.

MATERIALS AND METHODS

The study was carried out in the greenhouse under the natural light condition at the Hortinvest, Research Center for Quality Control of Horticultural Produce, Faculty of Horticulture, UASMV, Bucharest, for one growing cycle from Dec 07, 2021, to Jan 30, 2022.

Seven cultivars of lettuce were used in the experiment including four cultivars of Lollo Bionda, Fast fall lettuce (V1) from Seng van company, and KKL (V2) from Kbal Koh, these two cultivars were the type of loose-leaf lettuce brought from Cambodia, and other two were from Romania, Lollo Bionda (V3) from Amia, Lugano (V4) from RZ. Another two types of Lollo Rosa lettuce – Carmesi (V5), Lollo Rosa (V6) from Holland Farming company, and one Chinese purple leaf (V7) which was a type of oak leaf lettuce from YingKe seeds company. All the lettuce seeds were sown on 07 December 2021 in the plastic tray (40 x 60 cm) filled with substrate from Plantobalt mixed with perlite in the proportion of 75% and 25%. The seeds were placed in the row covered by vermiculite. A week after sowing, the young seedlings were transferred into jiffy peat pellets and treated with different nutrient solutions from the beginning of sowing until the seedling stage, the solutions were used including Universol, which the composition of 18N-11P-18K+2.5MgO, Formulex, 2.3N-0.9P-3.4K, Ca 1.85, Cu 0.002, Fe 0.040, Mn 0.010, Mo 0.001, and Zn 0.0025 (%w/v), Bio-Grow, 4N-3P-6K, and control treatment was tap water. The nutrient solutions were mixed with water at the rate of 2g/l and applied daily to seedlings.

The seedlings were transferred into NFT when the plant had 3-4 true leaves about 20 days from the date of sowing. The experimental design was RCBD with 3 replications, five plants for each variety. pH and EC were checked on a daily basis by maintaining at a certain level, during the first week in the NFT, the EC was maintained at 1.2-14 mS/cm, while increased to 1.8-2.1 mS/cm until harvest, and pH was 6.0 during the growing cycle. The temperature and humidity were monitored in the greenhouse (Figure 1). CO_2 was maintained (550-650 ppm).

Data collected on seedlings stage including plant height, and the number of leaves per plant were recorded on the day transfers into NFT, and growth rate was recorded two times (10 days before transfers into NFT, and on the day transfers in the NFT system), the date of emergence true leaf was observed and recorded when the 50% of the seedling emerge true leaf.

In NFT, all data were determined at the harvesting stage. includes the number of leaves per plant, plant height, plant spread (measured manually), Leaf area using scanner, while fresh mass using an electronic scale, and dry mass were taken 1 gram of fresh leaves by cutting leaves into fine pieces dried at constant temperature 105°C for 24 hours. Statistical analysis was used STATISTICA, StatSoft software (version 10) to perform ANOVA analysis, and Tukey HSD was used to compare the significant difference of each dependent variable at $p \leq 0.05$, or 0.01 levels.

RESULTS AND DISCUSSIONS

The date emergence true leaf: The result obtained showed that the date of emergence of true leaf of the lettuce cultivars was 12-15 days counted from the date of sowing. Universol, Formulex, and water treatment had a similar date of emergence but Bio-Grow showed a delay in the emergence true leaf (Table 1).

Plant height: There was a strong interaction between fertilizers and cultivars over plant height at $p \leq 0.01$ (Table 2). Each fertilizer influences differently over plant height at $p \leq 0.01$. The plant height of the seedling used nutrient solution from Formlex was higher than other fertilizers, followed by Universol (7.22 cm and 7.11 cm). Nutrient from Universol was not significant with the control treatment (tap water), but the plant height was slightly higher than the control. There was a negative effect of using Bio-Grow while its value was lower than the control treatment (4.05 cm and 6.82 cm). For cultivars, the mean value across all fertilizer treatments were significance difference at $p \leq 0.01$, Fast Fall lettuce and KKL had a higher plant height than other cultivars (7.65 cm and 7.31 cm) followed by Chinese purple leaf, Carmesi (6.57 cm and 5.98 cm), while the plant height of Lollo Rossa, Lugano and Lollo Bionda was shorter than other varieties (5.60, 5.51 and 5.49 cm). There was a correlation between plant height and cultivars in control treatments (R^2= 0.2587) (Figure 2), and this correlation was higher in Universol nutrient solutions (R^2= 0.4183) (Figure 3), whereas in Formulex and Bio-Grow were R^2=0.2587 and R^2=0.2493) (Figures 4 and 5).

The number of leaves: There was a significant difference at $p \leq 0.05$ between the cultivar and the fertilizers, and also among the fertilizers types was different at $p \leq 0.01$ over the number of seedling leaves (Table 2). Universol, and Formulex had a greater number of leaves (3.69 and 3.60) than the control treatment, and Bio-Grow (3.36 and 3.17). For cultivars, there was a significant difference at $p \leq 0.01$. The cultivar which had a greater number of leaves was Chinese leaf purple, followed by Lugano and Carmesi (4.15, 3.70 and 3.65). While Lollo Bionda had a lower number of leaves than other varieties (2.90). There was a correlation between the number of leaves and cultivars in the control treatment but was very low (R^2=0.0773) (Figure 2), and this correlation continued to increase in Universol and Bio-Grow (R^2=0.2704 and R^2=0.6849) (Figures 4 and 5).

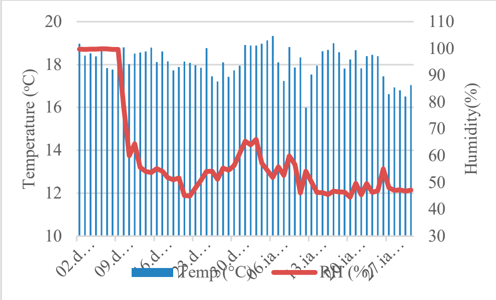

Figure 1. The temperature and relative humidity in the greenhouse

Table 1. The date of emergence true leaf of lettuces seedlings

Cultivar	Water	Universol	Formulex	Bio- Grow
V1	12	13	12	15
V2	12	12	12	15
V3	14	14	13	15
V4	13	12	13	14
V5	13	13	13	15
V6	14	13	13	15
V7	13	13	14	15
Mean	13.0	12.9	12.9	14.9

Table 2. The interaction of fertilizers and cultivars on the lettuce seedlings for plant height and the number of leaves

Cultivar (C)	Plant height (cm)	Number of Leaves
Fast Fall lettuce (V1)	7.65 ± 0.49 a	3.45 ± 0.14 bc
KKL (V2)	7.31 ± 0.55 a	3.25 ± 0.10 cd
Lollo bionda (V3)	5.49 ± 0.27 d	2.90 ± 0.07 d
Lugano (V4)	5.51 ± 0.22 d	3.70 ± 0.11 b
Carmesi (V5)	5.98 ± 0.21 c	3.65 ± 0.11 bc
Lollo rossa (V6)	5.60 ± 0.17 d	3.25 ± 0.10 cd
Chinese purple leaf (V7)	6.57 ± 0.35 b	4.15 ± 0.13 a
Fertilizer (F)		
Contol	6.82 ± 0.19 b	3.36 ± 0.10 b
Uniersol	7.11 ± 0.24 ab	3.69 ± 0.09 a
Formulex	7.22 ± 0.22 a	3.60 ± 0.10 a
Organic Grow	4.05 ± 0.10 c	3.17 ± 0.10 b
Cultivar (C)	**	**
Fertilizer(F)	**	**
C x F	**	*

n=20 for cultivar and n=35 for fertilizer.
Means and standard error followed by the same letters are not significantly different at p < 0.05 or 0.01

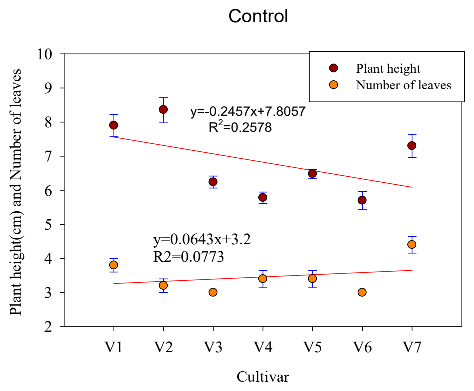

Figure 2. The correlation between cultivar, plant height and number of seedlings leaves in control treatment at seedling stage

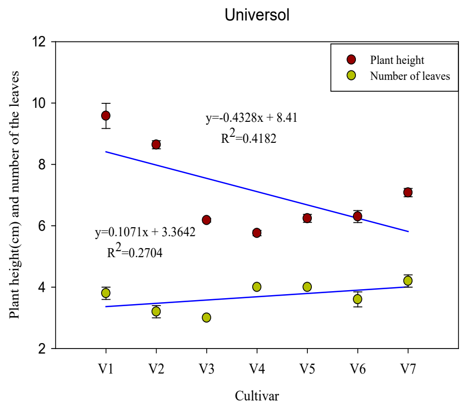

Figure 3. The correlation between the cultivar, plant height and number of seedlings leaves in Universol nutrient solution

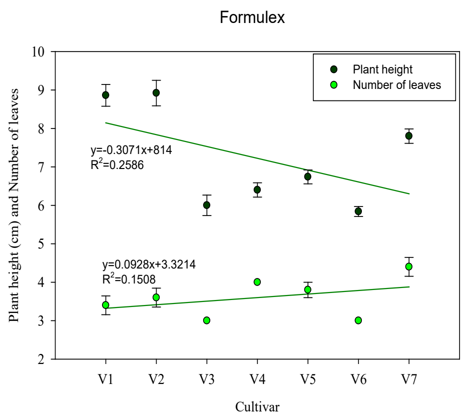

Figure 4. The correlation between the cultivar, plant height, and number of seedlings leaves in Formulex nutrient solution

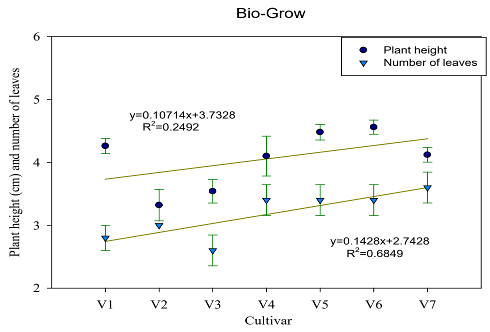

Figure 5. The correlation between the cultivar, plant height and number of seedlings leaves in Organic Grow nutrient solution

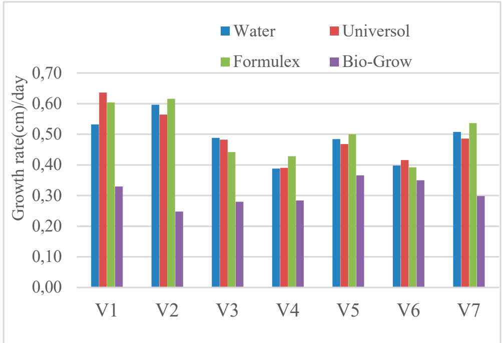

Figure 6. The growth rate of lettuce seedlings in different nutrient solutions

The growth rate of lettuce seedlings among cultivars in the control treatment, Universol, and Formulex was the same minimum value (0.39 cm/day) while the maximum value was (0.60-0.64 cm/day). In contrast, Bio-Grow had poor seedlings growth (0.25 -0.37 cm) compared to the other (Figure 6).

Plant height: The performance of the lettuce cultivars over plant heigh showed a significant difference at $p < 0.01$. V7 had a greater plant height (40 cm) followed by V1 and V2 (26.2 and 26.5 cm). The shortest cultivar was observed with V3 and V6 (15.9 cm and 16.9 cm) (Figure 7).

The number of leaves: There was a highly significant difference at $p< 0.01$ for the number of leaves among the cultivars. V7 was found higher in the number of leaves, followed by V6 and V4 (58, 35, and 33 leaves). V1 and V2 were lower in the number of leaves (25 leaves) (Figure 7).

The plant spread: There was also a highly significant difference at $p < 0.01$ for the leaves of the plant spread. V7 had a bigger plant spread followed by V1 and V2 (56.3, 41.2, and 39.4 cm) while the smaller plant spread was found with V6 and V3 (26.4 and 24.9 cm) (Figure 7).

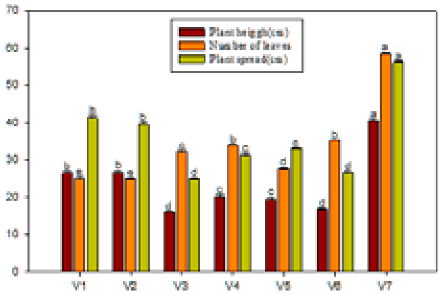

Figure 7. Plant height, number of leaves and plant spread analysis of lettuce cultivars grown in NFT system. Means and standard error followed by the same letters are not significantly different at p < 0.05, n=5

A correlation was also found between the plant height and the number of leaves (R^2=0.4474) (Figure 8), and the plant height with the plant spread had a strong correlation (R^2=0.9806) (Figure 9).

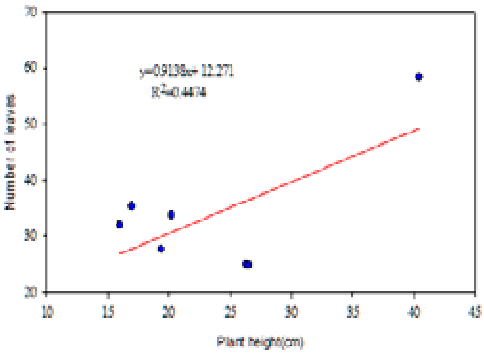

Figure 8. The correlation between the plant height and the number of leaves of lettuce cultivars

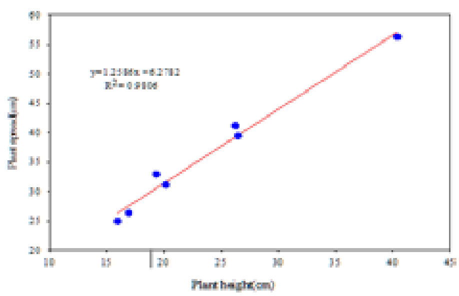

Figure 9. The correlation between the plant height and the plant spread

The differences of plant height, number of leaves and the plant spread of each cultivar possibly related to the characteristic of cultivars, this result supported Dahal et al., (2021).

Total leaf area: There was a highly significant difference at p < 0.01 for the leaf area of the lettuce cultivar. V1 and V2 had a bigger leaf (25.9 and 245.0 cm^2/leaf), V5 and V7 medium size leaf (192.5 and 187.7 cm^2/leaf), while V4, V3, and V6 had a smaller in leaf (150.1 137.0 and 127.5 cm^2/leaf) (Figure 10).

Fresh mass: The result from the analysis showed highly significant at p < 0.01 among the lettuce cultivars on the NFT system. V7 performed well with fresh weight (374.8 g/plant), followed by V1, V2 and V4 (192.5, 177.0, and 173.3 g/plant). V6 was observed lowest in fresh mass (134.5 g/plant) (Figure 10).

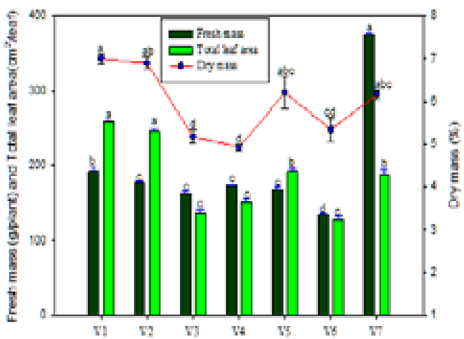

Figure 10. Fresh mass, total leaf area, and dry mass analysis of lettuce cultivars grown in the NFT system. Means and standard error followed by the same letters are not significantly different at p < 0.05. n=5 for fresh mass, and total leaf area and dry mass n=3

Dry mass (%): The highly significant difference level was found with dry mass at p < 0.01 for lettuces. V1, V2, V5, and V7 were not significant difference with the percentage of the dry mass was 7.01%, 6.89, 6.21, and 6.17%. In contrast, three cultivars including V6, V3, and V4 had a lower dry mass (5.34, 5.17, and 4.92%), respectively (Figure 10).

The total leaf area and plant height had a correlation with the value of R^2=0.220, while the fresh mass had a higher correlation with plant height R^2=0.8717 (Figures 11 and 12). There was a strong correlation found between the dry mass and the total leaf area R^2=0.9107 (Figure13).

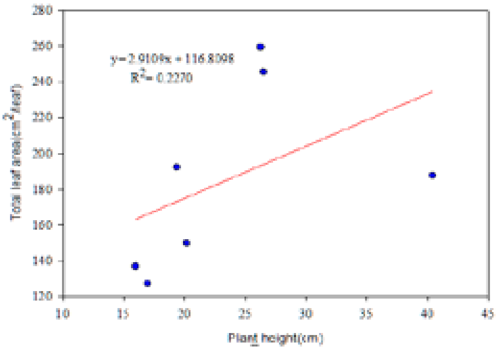

Figure 11. The correlation between the plant height and total leaf area of lettuce cultivars

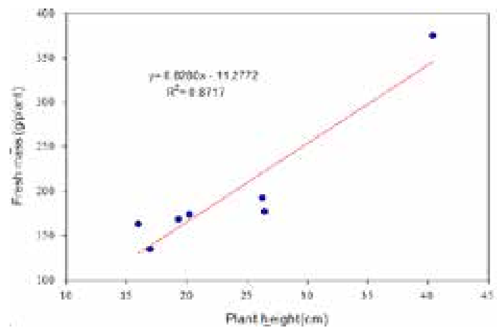

Figure 12. The correlation of plant height and fresh mass of lettuce cultivar

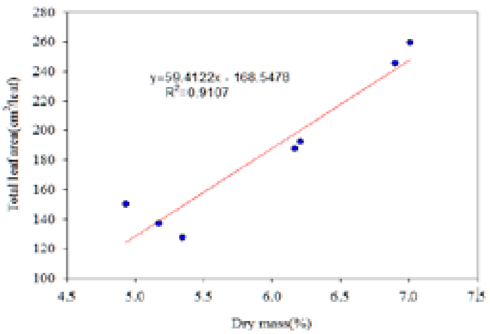

Figure 13. The correlation of dry mass and total leaf area of lettuce cultivar

CONCLUSIONS

Based on our result from the experiment on seedlings stage used different nutrients solution, there was the effect on the lettuces cultivar treated solution on the plant height, the number of leaves, date of emergence of true leaf and the growth rate. Formulex and Universol had a better performance on the seedling growth and emergence of true leaf but slightly different with using water while using Bio-Grow showed lower in plant growth and late emergence true leaf compared with the other treatment. Choosing the type of fertilizers for using during the seedlings might have a positive and negative effect on the growth of the plant. Further research should be carried out to investigate the type of fertilizers appropriate for use during the seedling stage.

For the experiment of lettuces grown on the NFT system, V7 had a very great performance in all parameters observed in both growth and the yield than other cultivars. V7 is a suitable cultivar for the NFT system, however, this cultivar is an oak leaf lettuce, the market preferences might be the influence factor for the grower in making decisions on type of cultivar to grow.

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