

THE EFFECT OF AB MIX NUTRIENT SOLUTION ON THE HEIGHT, NUMBER OF LEAVES AND FRESH WEIGHT OF LETTUCE (*Lactuca sativa* L.) IN HYDROPHONICS CULTIVATION SYSTEM

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Abstract: This study focuses on the effects of AB mix nutrient solution to the height, number of leaves, and fresh weight of lettuce (*Lactuca sativa* L.) in hydroponics cultivation system. The growth of lettuce was assessed by comparing the plants' height, number of leaves, and fresh weight of the different levels of AB mix nutrient concentrations (0, 650, 1300, 1950, 2600 ppm) with 2 replications in each treatment. HydroPlus hydroponic nutrients by Green Garages and an AB mix nutrient solution were used in this study. The duration of the research investigation started from September 2022 until November 2022.

Data obtained from observations were analyzed by using Analysis of Variance (ANOVA) at the accuracy level of 1% and 5%.

Data revealed that during the first and second weeks after planting, the AB mix nutrient solution showed positive results on the plant's height in all of the treatments. Moreover, plants began to wilt in the AB mix treatment at 1950 ppm and in the treatment at 2600 ppm during the third and fourth weeks after planting, resulting in significant negative results. The tallest plant's height was obtained in the fourth week after planting with an AB mix of 650 ppm treatment, and the shortest plant's height occurred with an AB mix of 2600 ppm treatment. Although in the AB mix 650 ppm treatment there were plants that were shorter than others, the average height in this treatment was higher compared to other treatments.

Data analysis showed that AB mix nutrients have a very significant effect on lettuce's (*Lactuca sativa* L.) number of leaves in the first to the fourth week after planting. The highest number of leaves was obtained from an AB mix concentration of 650 ppm, and the lowest number of leaves was obtained from an AB mix treatment of 2600 ppm. The research investigation revealed that the AB mix nutrient has a very significant effect on the lettuce's fresh weight 30 days after planting. The highest fresh weight was obtained from an AB mix concentration of 650 ppm, and the lowest fresh weight was recorded from an AB mix concentration of 2600 ppm. Based on the results of this study, having too much or too little of the AB mix nutrient solution has a bad effect on the fresh weight of lettuce.

Keywords: nutrient solution, hydroponics, growth effect

1. INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an annual leafy vegetable that belongs to the family Compositae. It is one of the most popular salad crops and occupies the largest production area among crops in the world. It has a delicate, crispy texture and slightly bitter taste with milky juice as fresh condition. It is a representative of green leafy vegetables that can be easily produced in several cultivation systems which demands a nitrogen content for optimal growth and

development (Sala & Costa, 2012; Johnson & Waterland, 2016). Comparing lettuce quality can also be challenging because the quality of fresh produce is a complex combination of attributes (Gruda, 2005). Generally, the biological qualities of lettuce include its height, number of leaves and weight and were considered as factors in determining its market value and consumer preference.

Plant growth is a biological process in which plant structures mature in response to required inputs into the natural system. Lettuce possesses embryonic tissues that constantly create new tissues from their meristems for growth. Positional effects, environmental influences, temperature change, exposure, and juvenility are the primary causes of morphological variation (De Almeida et al., 2017). It proposes directional growth based on certain potent stimuli such as light, gravity, water, and physical contact for phototropism, gravitropism, hydrotropism, and thigmotropism. The development consists of three distinct growth stages that are separated and ranked according to the number of days planted, namely vegetative, head development, and harvest (Loresco et al., 2018). The vegetative growth stage lasts 12 days, beginning with the sowing phase and ending with the germination stage. The head development growth stage begins once the lettuce plant is transplanted, which occurs between the third and sixth weeks of the plant's life cycle. The harvest growth stage occurs 45 to 65 days after the lettuce seed is planted. A full generic plant life cycle consists of four stages: seed germination, seed development, head development, and bolting harvest.

Lettuce serves as a good model vegetable to evaluate whether different nutrient media affect product quality since its internal and external quality are likely impacted by its mode of production. Hydroponics cultivation system also known as soil-less method of growing plants in a water-based, nutrient-rich solution offers several advantages and disadvantages in the plant development. Although there are few studies that have quantified crop production in relation to hydroponics cultivation systems, there have been little information on the effects of different levels of AB mix nutrient concentration to the growth and biological quality of lettuce in relation to its height, number of leaves and fresh weight.

2. MATERIALS AND METHODS

The investigation conducted is an experimental study that used a non-factorial Complete Randomized Design to examine the effects of different levels of concentrations of AB mix nutrient solution to the height, number of leaves and fresh weight of lettuce (*Lactuca sativa* L.). The quantitative data were collected based on the plant growth attribute results.

The tools and materials used in planting stage were LolloBionda variety of lettuce seedlings, big plastic containers, Styrofoam cups, ruler, scissors, tray, label papers, marker, TDS, pH meter, lettuce seeds (*Lactuca sativa* L.), coco peat, distilled water, and HydroPlus hydroponic nutrients by Green Garages - AB mix nutrient solution were used in this study. Additionally, the materials used in growth data analysis were ruler, pen and data notebook. The study examined the lettuce plant growth in relation to its height, number of leaves, and fresh weight using five (5) levels of AB mix nutrient concentrations (0, 650, 1300, 1950, 2600 ppm) with 2 replications in each treatment. Each repetition consists of 5 plants, making a total of 75 experimental units.

AB mix is one of the nutritional formulas made specifically for the cultivation of hydroponic vegetables. Formula A in AB mix special for vegetables contain: calcium ammonium nitrate $\{5\text{Ca}(\text{NO}_3)_2 \cdot \text{NH}_4\text{NO}_3 \cdot 10\text{H}_2\text{O}\}$, potassium nitrate (KNO_3), Fe-chelate, Fe-EDTA, whereas Formula B contains potassium dihydrophosphate (KH_2PO_4), ammonium sulphate $\{(\text{NH}_4)_2\text{SO}_4\}$, potassium sulphate (K_2SO_4), magnesium sulphate ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$), manganese(II) sulphate ($\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$), copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), zinc sulphate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$), boric acid (H_3BO_3), ammonium heptamolybdate $\{(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}\}$

The research includes seeding, maintenance, pest management and analysis of plant growth. Seeding was done until the plants have 3-5 true leaves (seed age ± 14 days), then the plants transferred to planting media. Pest removal was done manually by checking the plants every day. Further, the pH and nutrient level controls were monitored every week. Parameters observed consisted of plant height, number of leaves, and fresh weight and both data were taken every week for about 4 (four) weeks after planting (WAP). Plant height was measured starting from the base of the stem to the highest tip of the leaf, the number of leaves was measured by counting the number of the open leaves, while the fresh weight was measured by weighing the plants weight after harvest.

Data obtained from observations were analyzed by using Analysis of Variance (ANOVA) at the accuracy level of 1% and 5%. If the ANOVA results show significant effect then the analysis continues using the DMRT (Duncan's Multiple Range Test) test at a significance level 5%.

3. RESULTS AND DISCUSSION

3.1 Plant's Height

Table 1. Average height (cm) of Lettuce (*Lactuca sativa* L.) on the different weeks after Planting

Treatments	Week After Planting (WAP)			
	1	2	3	4
N0 (without AB mix)	7.00	7.86	9.64	12.19
N1 (AB mix 650 ppm)	10.12	12.41	16.24	18.69
N2 (AB mix 1300 ppm)	10.24	12.51	12.95	14.17
N3 (AB mix 1950 ppm)	10.70	12.88	11.60	12.49
N4 (AB mix 2600 ppm)	10.82	13.48	10.60	8.81
F test	**	**	**	**

Notes: F test (Anova) notes: ^m = no significant effect, * = has significant effect (F count > F 5%), ** = has very significant effect (F count > F 1%).

The plant's height (cm) under the hydroponic cultivation system in table 1 showed AB mix nutrient solution very significantly affect lettuce's (*Lactuca sativa* L.) height at different weeks after planting (WAP). Further analysis by using Duncan's test showed there was a significant difference between AB mix treatments (0, 650, 1300, 1950, 2600 ppm). Data revealed that during the first and second week after planting, AB mix nutrient solution showed positive results to the plant's height in all of the treatments. However, during the third and fourth week after planting, plants began to wilt in treatment 3 (AB mix 1950 ppm) and treatment 4 (AB mix 2600 ppm) thus, negative results were notably observed. The tallest plant's height was obtained in the fourth week after planting with AB mix 650 ppm treatment, and the shortest plant's height occurred with AB mix 2600 ppm treatment. Although at treatment 1 (AB mix 650 ppm) there were plants that were shorter than others, the average height in this treatment was higher compared to other treatments.

The addition of AB mix nutrients in the growth medium can increase the growth of leafy vegetables in a hydroponic system. It contains similar compounds to nutrients required by plants, making it an excellent fertilizer that is easily absorbed by hydroponic lettuce plants (Khodijah et al., 2021). The higher concentration of the AB mix solution, the higher nutrients it contains which support the plant's vegetative growth such as an increase in length. Similarly, plants take nitrogen in the form of NO₃⁻ (nitrate) and NH₄⁺ (ammonium) to stimulate plant growth, cell proliferation, and disease resistance (Leghari et al., 2016). Inadequate nitrogen absorbed in plants will limit plant growth, as seen in the control treatment. However, in the premise of this study, increasing the amount of AB mix concentration doesn't always stimulate plant height, thus, the appropriate amount of Nitrogen in the AB mix concentration was necessary for plant growth. A similar result was obtained in the study of Hidayat et al., (2021)

which revealed that a concentration of 600 - 1000 ppm of AB mix nutrients produces the best growth and yield. Additionally, the lettuce plant is very sensitive to a higher temperature, and increasing the AB mix nutrient concentration also increase the temperature of the solution, thus affecting the plant growth. Here, data revealed that plants in AB mix 2600 ppm treatment show a decrease in height during the third and fourth week after planting which is a critical stage for plant development. This contradicts the result of Harahap et al., (2020) who reported an increased height with increased AB mix concentration in their research on pakchoi (*Brassica chinensis* L.).

3.2 NumberofLeaves

Table 2. Average number of leaves of lettuce (*Lactuca sativa* L.) on the different weeks after Planting

Treatments	Week After Planting (WAP)			
	1	2	3	4
N0 (without AB mix)	3.40	5.80	6.00	6.40
N1 (AB mix 650 ppm)	5.40	5.80	7.40	7.80
N2 (AB mix 1300 ppm)	6.80	7.20	6.60	5.60
N3 (AB mix 1950 ppm)	7.20	7.60	5.80	4.20
N4 (AB mix 2600 ppm)	7.60	7.80	4.20	3.40
F test	**	**	**	**

Notes: F test (Anova) notes: ^{tn} = no significant effect, * = has significant effect (F count > F 5%), ** = has very significant effect (F count > F 1%).

The effect of the different levels of concentration of AB mix nutrients on the average number of leaves of lettuce (*Lactuca sativa* L.) is displayed in table 2. As shown, analysis by using ANOVA showed AB mix nutrient has a very significant effect on lettuce's (*Lactuca sativa* L.) number of leaves in the first to the fourth week after planting. Further analysis by using Duncan's test showed that there were no significant differences between the control (without ab mix) treatment and AB mix 650, 1300, 1950, and 2600 ppm treatments. The highest number of leaves was obtained from AB mix concentration 650 ppm with a 7.80 average number of leaves and the lowest number of leaves was obtained from AB mix 2600 ppm treatment with a 3.40 average number of leaves.

The leaf is a plant organ where the plant's food synthesizes as well as food storage and has chlorophyll which plays a role in photosynthesis. As notably observed, in the third and fourth week after planting, the number of leaves of AB mix 1300, 1950, and 2600 ppm treatments decreases as the concentration of AB mix increased. However, in control (without ab mix) and AB mix 650 ppm treatment, the number of leaves increased as the concentration of AB mix increased. The study of Rosnina et al.(2020), revealed positive results on lettuce varieties, showing an increasing number of plant leaves as the AB mix concentrations increase.

In addition, Hermanto et al., (2021) reported that the growth rate of the lettuce plant which includes its stem and leaves must be physiologically balanced so that the supply of nutrients is following the nutrient requirement needed by plants. Plants that are fulfilled with appropriate nutrients get enough nitrogen that promotes the growth of new leaves. Further, the root-zone temperature tends to restrict plant growth namely its height, stems, and the number of leaves. For instance, during the third and fourth week after planting, the AB mix 1300, 1950, and 2600 ppm treatments exhibited a decreased number of lettuce leaves and the plants started to wilt. It could then be inferred that increasing the AB mix concentration also increases the root-zone temperature thus, affecting the number of leaves of the lettuce plant. Sakamoto et al., (2015) suggest that an appropriate amount of nutrient uptake by plants is also an important growth factor affecting the production of plants. An excessive amount of nutrients affects the balance of the biological activity of plants thus, resulting in poor plant growth and low production.

3.3 Fresh Weight

Table 3. Average fresh weight (g) of lettuce (*Lactuca sativa* L.) at 30 days after planting

Treatments	Weight (g)
N0 (without AB mix)	25.00
N1 (AB mix 650 ppm)	51.00
N2 (AB mix 1300 ppm)	30.00
N3 (AB mix 1950 ppm)	18.00
N4 (AB mix 2600 ppm)	10.00
F test	**

Notes: F test (Anova) notes: ^{ns} = no significant effect, * = has significant effect (F count > F 5%), ** = has very significant effect (F count > F 1%).

As shown in table 3, the analysis using ANOVA revealed that the AB mix nutrient has a very significant effect on the lettuce’s fresh weight 30 days after planting. Further analysis using Duncan’s test showed that there was no significant difference between the control (without AB mix) treatment and the 650, 1300, 1950, and 2600 ppm treatments with AB mix. The highest fresh weight was obtained from an AB mix concentration of 650 ppm, and the lowest fresh weight was recorded from an AB mix concentration of 2600 ppm.

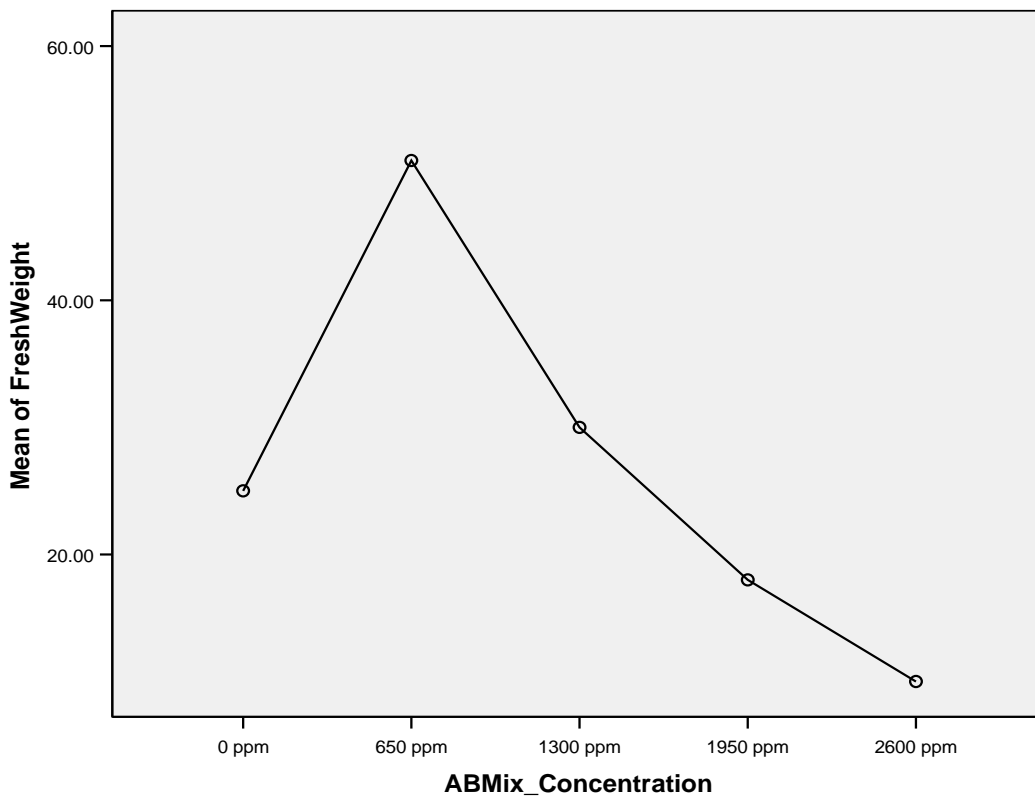


Figure 1. Lettuce fresh weight in different AB mix concentration

As presented in Figure 1, increasing the nutritional concentration of the AB mix does not ensure an increase in the fresh weight of lettuce. On the premise of this research investigation, it is obvious that raising the nutrient concentration of the AB mix beyond the required level may negatively affect the growth of the lettuce plant. Lettuce grown in a hydroponic system was found to have better condition with oxygen enrichment done in

nutrient solution with a concentration of 600 ppm, with indicators of increasing length and total root surface area (Moaed Ali, 2022).

This contrasts to the findings of Harahap et al. (2020), who found that increasing the nutritional concentration of the AB mix increased the weight of Pak Choi (*Brassica chinensis*). More so, Levine et al., (2021) stated that one of the most important factors for a successful hydroponics system is the use of the appropriate nutrient solution, and it is important to control the amount of nutrients to allow or deny plants the nutrient accumulation. Based on the findings of this research investigation, excessively high or low levels of the AB mix nutrient solution have a negative effect on lettuce fresh weight.

More so, the success of hydroponic cultivation of vegetables is determined by the nutrient solution given, therefore all nutritional needs are strived to be available in the right amount for easily absorption by plants (Jones, 2005). As observed, there is a parallel relationship between plant's height, number of leaves and the lettuce's fresh weight; in other words, if there is an increase in the number of leaves, the fresh weight of the plants will also increase. The more leaves it has, the more assimilation it produces, thus also increasing the photosynthesis rate (Harahap et al., 2020).

Lettuce plant's performances at 4 (four) weeks after planting



Lettuce plant's performances at 4 (four) weeks after planting



4. CONCLUSIONS AND RECOMMENDATIONS

The plant's height (cm) under the hydroponic cultivation system showed that the AB mix nutrient (0, 650, 1300, 1950, and 2600 ppm) solution had a very significant effects on lettuce's (*Lactuca sativa* L.) height at different weeks after planting (WAP). Data revealed that during the first and second weeks after planting, the AB mix nutrient

solution showed positive results on the plant's height in all of the treatments. Moreover, plants began to wilt in the AB mix treatment at 1950 ppm and in the treatment at 2600 ppm during the third and fourth weeks after planting, resulting in significant negative results. The tallest plant's height was obtained in the fourth week after planting with an AB mix of 650 ppm treatment, and the shortest plant's height occurred with an AB mix of 2600 ppm treatment. Although in the AB mix 650 ppm treatment there were plants that were shorter than others, the average height in this treatment was higher compared to other treatments.

Data analysis showed that AB mix nutrients have a very significant effect on lettuce's (*Lactuca sativa* L.) number of leaves in the first to the fourth week after planting. The highest number of leaves was obtained from an AB mix concentration of 650 ppm, and the lowest number of leaves was obtained from an AB mix treatment of 2600 ppm. For instance, during the third and fourth weeks after planting, the AB mix 1300, 1950, and 2600 ppm treatments exhibited a decreased number of lettuce leaves, and the plants started to wilt. Then, it could be concluded that increasing the amount of AB mix also raises the temperature of the root zone, which changes the number of leaves on the lettuce plant. More so, an excessive amount of nutrients affects the balance of the biological activity of plants, resulting in a lesser number of plant leaves.

The research investigation revealed that the AB mix nutrient has a very significant effect on the lettuce's fresh weight 30 days after planting. The highest fresh weight was obtained from an AB mix concentration of 650 ppm, and the lowest fresh weight was recorded from an AB mix concentration of 2600 ppm. Based on the results of this study, having too much or too little of the AB mix nutrient solution has a bad effect on the fresh weight of lettuce.

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