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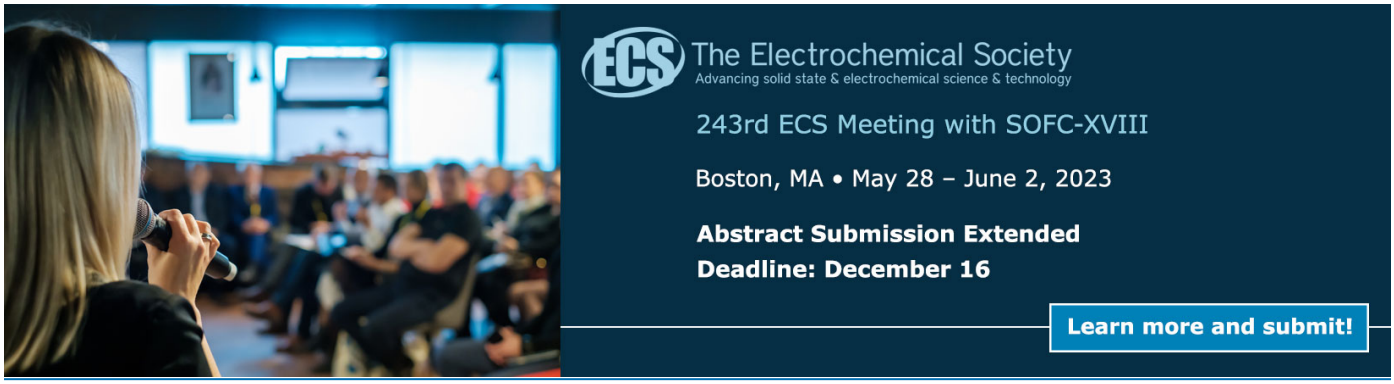

Efficacy of auxin foliar application on the growth and yield of green Romaine (*Lactuca sativa* L. var. Jericho) grown under nutrient film technique (NFT) hydroponic system

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Abstract. Green Romaine (*Lactuca sativa* L. var. Jericho) is one of Malaysia's trendiest salad greens. It provides many nutrients which vital for human health and body maintenance. This phenomenon has led to an increased in green Romaine production in Malaysia. However, there are several limitations to cultivate this vegetable since conventional planting techniques are still practiced in Malaysia. The present study was undertaken to investigate the efficacy of auxin foliar application on the growth performance and yield of green Romaine grown under the nutrient film technique hydroponic system. The green Romaine was treated with three different application rates of auxin (Indole-3-Acetic Acid); T0, control (0.0 ppm), T1 (50.0 ppm), T2 (100.0 ppm) and T3 (150.0 ppm). The mean value of growth and yield of green Romaine were significantly increased at a lower concentration of auxin application (T1). At this lower application rate, the leaves number of green Romaine significantly increased ($P \leq 0.05$) with mean value ranging from 17.0 to 22.0 leaves per plant as compared to the T0, T2 and T3. However, all treated plants do not show any significant increase in term of chlorophyll content. The yields of green Romaine (fresh weight and dry weight) exhibit similar pattern where the auxin foliar application at T1 significantly increased the mean value of the yield parameters with 113.0 – 130.0 g of plant fresh weight while 7.0-10.0 g of plant dry weight as compared to the highest concentration of T3, respectively. This result suggested that a low concentration of auxin helps to increase the growth performance and yield of green Romaine, thus highlights its potential as an effective plant growth promoter for plant grown under hydroponic system.

1. Introduction

Green Romaine (*Lactuca sativa* L. var. Jericho) is a famous type of lettuce cultivars in Malaysia and other Asian countries which forms long, upright, broad-stemmed leaves with loose heads. This lettuce comes from Asteraceae family which is also known as one of the high value vegetables due to it minerals and nutritional values that are important to the human body such as potassium, zinc, magnesium, iron, phosphorus, calcium, manganese and other substances [1]. In 2018, lettuce was listed as the third highest vegetable that have an adequate supply for domestic needs with the recorded self-sufficiency ratio (SSR) more than 100 per cent (114.5%) after tomato (126.5%), brinjal (115.4%) [2]. However, due to the continuous increasing demands, Malaysia has had to increase the production of lettuce from 40,358 mt (2017) to 51,647 mt (2019) [3]. Other ASEAN countries (Thailand, Philippines, Singapore and Brunei)

and the top three country worldwide (China, United State of America and India) had also increased their lettuce production in 2017 to 2018 [4].

Diverse lettuce cultivars have been conventionally grown on land. However, this practice had cause soil nutrients deficiency due to leaching, soil-borne disease, and environmental pollution that can affect the quality of produce [5]. Growing crops in controlled environments, were the water leached can be captured may be a possible solution for reducing the amount of nutrients leached into groundwater. Growing crops in hydroponic system can be a possible solution to these problems. Instead of using soil as a medium for the nutrients supply, hydroponic uses nutrient solutions to circulate the plants with correct amount of calibrated nutrition all of the time. The hydroponic system has been widely practiced by many around the world as it is very easy to cultivate. In addition, the growers are able to grow a much higher number of plants besides reduce the growing time and significantly increase the plant yield, as compare to the conventional methods [6]. In this case, the maturity of plants was 20% faster and can increase the yield more than 30% than plants that are grown using the soil substrate. Even though the costs for hydroculture equipment's is expensive than other conventional farming methods, the growers still achieve high profitability in the long term. Thus, through these benefits, the unprecedented demand for lettuce in Malaysia will be controlled in ways that ensure the sustainability of the vegetable supply [7].

Day to day encounters with farmers have shown a bigger interest in plant growth regulator application for their crops. For example, the application of auxin in agriculture is very important for plant growth including stem cell elongation, flowering, fruit production and seedling root production [8]. Many studies have been done on auxin as plant hormone and plant growth. The plant height of summer squash (*Cucurbita pepo* L. var. Rosina) increased from 40.78 cm to 51.75 cm at a low concentration of auxin at 10 ppm [9]. According Mir et al. [10], auxin at 10^{-8} M concentration had increased the plant growth, as well as boost the physical and biochemical activities of brown mustard (*Brassica juncea*). Furthermore, Alam et al. [11] found that foliar application of auxin at a concentration of 100 ppm increased the chlorophyll content of tomato (*Lycopersicon esculentum*) plant by 28% while also increased the plant height from 63.63 cm to 74.93 cm. However, there is no literature and study on the efficacy of auxin foliar application on the growth and yield of green Romaine (*Lactuca sativa* L. var. Jericho) under hydroponic culture. Thus, the objective of this study was to determine the effect of auxin foliar application on the growth and yield of green Romaine using nutrient film technique (NFT) hydroponic system.

2. Material and Methods

2.1. Plant materials and growth condition

Seed of bioassay species, *Lactuca sativa* L. var. Jericho and AB fertilizer were respectively bought from Lacjaya Grocery and NR Nursery at Jeli, Kelantan, Malaysia. Meanwhile, auxin was purchased from Sigma-Aldrich, Kuala Lumpur, Malaysia. The experiment was conducted at Agro-Technopark, University Malaysia Kelantan (UMK) Jeli Campus, Kelantan, Malaysia. The latitude and longitude of the study site was 5.7499411, 101.8716537. The experiment was conducted with humidity of 51% to 96% and temperatures ranging from 27 ºC to 39 ºC.

2.2. Treatment preparation

The auxin solution used is Indole-3-acetic acid (IAA). Auxin solution was prepared by dissolving 0.1 g of Indole-3-Acetic acid powder in 100 ml distilled water to provide 0.1% (1000 ppm) of stock solution. The stock solution was then diluted with distilled water into a series of concentration; 0.0, 50.0 ppm, 100.0 ppm and 150.0 ppm as in table 1.

Table 1. Application rate of auxin applied to the *Lactuca sativa* L. var. Jericho

Treatment	Application Rate of Auxin (ppm)
T0 (Control)	0.0
T1	50.0
T2	100.0
T3	150.0

2.3. Hydroponic plants growing

The green Romaine seeds were placed inside each of the sowing sponge hole. The sowing sponge was then immersed in the water inside the tray. Then, the tray was covered with black plastic and keep in the dark place to give seed some time to germinate. The seeds were regularly sprayed with water to keep the sowing sponge moist as they develop. After two weeks, the green Romaine seedlings that produce a few of mature leaves together with the sowing sponge were transplanted into permanent Nutrient Film Technique (NFT) hydroponic system. The bioassay plants were circulated with customized nutrient solution containing macronutrients and micronutrients: N, P_2O_5, K_2O, Ca, Mg, S, Fe, Mn, Mo and Cu of hydroponic AB fertilizer [12]. The AB fertilizer was prepared by diluted the fertilizer into water with the ratio of 1:1 until it reaches the desired nutrient's concentration level. The amount of soluble salts content (electrical conductivity) of the water solution was measured by using portable EC meter. As the seedling grows during the first week of planting, the seedlings were fertilized with AB fertilizer at nutrient concentration of 300 ppm. However, after 14 to 45 days of planting, the seedlings were re-circulated with the high concentration of AB fertilizer at 1200 ppm for the optimum plant growth. The hydroponic system was regularly monitored to ensure the nutrients was circulated the plants for the whole day during the study period. The plants leaves were treated with auxin at different concentrations of T0: 0.0 ppm, T1: 50.0 ppm, T2: 100.0 ppm and T3: 150 ppm. A total of 45ml auxin per plant was applied with the spraying volume of 160 L/ha at 10, 20 and 30 days after planting. Leaves of green Romaine that sprayed with sterile distilled water were served as control.

2.4. Measurement

The bioassay plants were measured in term of number of leaves, chlorophyll content, as well as the fresh and dry weights after 45 days of cultivation. The green Romaine leaves was manually counted and recorded while the chlorophyll content of the plants further was measured using the SPAD meter (model SPAD-502). After separating the plants from the media, the green Romaine were cleaned with clean water and washed well without leaving any dirt. Green Romaine fresh weight was taken with analytical balance while the dry weight was measured after drying the plants at 60^{o}C for 24 hours in the oven.

2.5. Statistical analysis

All the treatments were carried out with three replicates arranged in a completely randomized design (CRD). The data obtained was statistically elaborated further by using SPSS statistics V25. The percentage data of plant growth parameter and yield was subjected to one-way of variance (ANOVA). The differences between means for significance level of <0.05 was calculated. The Tukey test was used to compare the mean among the treatments at 5% significant.

3. Results and Discussion

Figure 1 shows the effect of auxin at different level of concentration on the number of leaves, chlorophyll content and fresh and dry weight of green Romaine (*Lactuca sativa* L. var. Jericho). It was found that the application of auxin solution at T1 (50.0 ppm) significantly increased ($P \leq 0.05$) the leaves number of green Romaine which cultivated under NFT hydroponic system (figure 1A). Except T1, other treatments had the same mean value of leaf number, ranging from 17-19 leaves per plant. Similar trend was also observed for the chlorophyll content at 50.0 ppm (T0) of auxin foliar application; however, it only shows small significant values with the control (T0) plants with increment from 18.0 nm to 22.0 nm (figure 1B). Nevertheless, there were no significant increase among the treatments where the mean values of T2 (100.0 ppm) and T3 (150.0 ppm) was 20 nm of chlorophyll content. Similarly, spraying plants with T1 (50.0 ppm) resulted in a significant increase ($P \leq 0.05$) in both fresh and dry weight of green Romaine as compared to the highest application of auxin at T3 (figure 1C and 1D). It was noted that the control (T0), T1 and T2 exhibit no significant difference in the plant fresh and dry weights, with the mean value ranging from 113.0 – 130.0 g and 7.0-10.0 g, respectively.

The outcome of the study shows that auxin foliar application at the lowest rate was efficient in promoting the growth and yield of green Romaine. This could be the main reason of T1 (50.0 ppm) showed good performance among other treatments. However, this current study was not in line with other similar previous works on auxin. Cabahug et al. [13] reported that the use of 100 ppm auxin resulted in the highest shoot height, diameter, and rooting and shooting rate of Echeveria species. In addition, Hanaa and Safaa [14] investigated that auxin at the concentration 100 ppm produced maximum plant height (92.36cm), chlorophyll content (51.04) SPAD, spike length (14.25 cm) number of spike/m^2 (365.3), 1000-grain weight (36.50g), and grain yield (6.61 t/ha^{-1}) of bread wheat (*Triticum aestivum* L.). Recent study by Abha Manohar et al. [15] found that highest plant survival of 93.33% was recorded for medicinal plant, *Stevia rebaudiana* at application of 100 ppm auxin. These results indicated that the rate of auxin application in promoting other plant growth under conventional cultivation was higher (100 ppm) as compared to this current study (50.0 ppm), thus highlights the potential of auxin or other phytohormones in enhance the growth and yield of green romaine under the NFT hydroponic system. As the most sustainable and affordable technology available, this new cultivation technique would give positive impact in fulfil the customer demand for local food production.

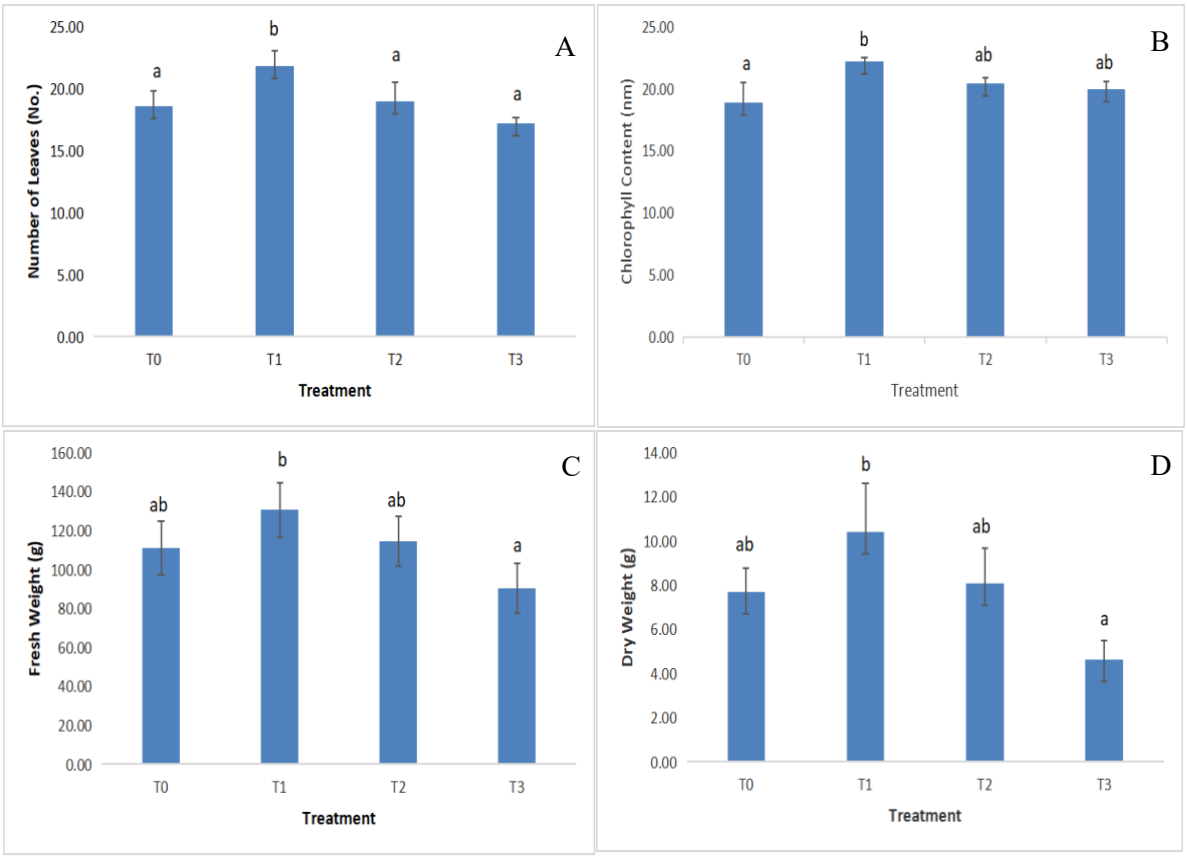

Figure 1. The effect of auxin foliar application on the number of leaves (A), chlorophyll content (B), fresh weight (C) and dry weight (D) of green Romaine (*Lactuca sativa* L. var. Jericho). T0: 0.0 ppm; T1: 50.0 ppm; T2: 100.0 ppm; T3: 150 ppm. Vertical bars represent Standard Deviation (SD) of the mean.

4. Conclusion

The results from the present study demonstrated that the application of auxin foliar increases the growth and yield of green Romaine plant. The enhancement in the plant's growth could be associated with an optimal selectivity of auxin concentration (50.0 ppm) might play a significant role in plant root elongation which in turn could be responsible for the nutrient uptake in hydroponic culture. Further works are required to elucidate the physiological and biochemical activities of the effect of auxin application for green Romaine plants.

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