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Effect of nutrient type on stability and quality of lettuce (*Lactuca sativa* L.) yield in hydroponic nutrient film technique at different planting times

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Abstract

This study aims to evaluate the effect of nutrient types on the stability and quality of lettuce (*Lactuca sativa* L.) yields in the Nutrient Film Technique (NFT) hydroponic system with different planting times. The research was conducted at PJ Fresh Hydroponic, Malang, East Java, Indonesia from July to October 2024, using a split plot group randomized design in time. The main factor was planting time (July-August and September-October) and the subplot factor was nutrient type (AB Mix Kryptonium and AB Mix Supernova). Observational variables included fresh weight, plant height, leaf thickness, chlorophyll content, light intensity, and others. Results showed that July-August planting time produced the highest fresh weight (230.03 grams) compared to September-October (182.50 grams), with better leaf area, leaf thickness, and light intensity. AB Mix Kryptonium nutrition gave the highest fresh weight (223.25 grams) and best plant height (19.16 cm) compared to AB Mix Supernova. However, AB Mix Supernova produced higher leaf thickness and chlorophyll content. The interaction between planting time and nutrient type did not have a significant effect on the observation variables. This study concludes that the combination of July-August planting time and AB Mix Kryptonium nutrition is optimal for high quality lettuce yields.

Keywords: AB Mix nutrition; Lettuce; Hydroponics; Fertilizers; Nutrition; Planting time

1. Introduction

Lettuce (*Lactuca sativa* L.) is a horticultural commodity that has a fairly high level of use because it is widely used in restaurants and hotels as a complement or main component of food. The Ministry of Industry [1] noted that the growth of the food and beverage industry increased by 3.57%, meaning that the need for lettuce is increasing, so it is necessary to increase lettuce production. One way to increase it is through a hydroponic system.

There are various types of hydroponics, such as aquaponics, wick hydroponics, and so on. The type of hydroponics suitable for lettuce is NFT (Nutrient Film Technique) hydroponics because lettuce has a light weight with shallow roots. NFT hydroponics uses shallow channels with nutrients flowing around the plant roots, allowing for efficient nutrient absorption and good aeration for the lettuce plants. Water containing nutrients will only flow over the roots so that the roots are not stagnant and avoid damage that can be caused [2].

The use of NFT hydroponics for commercial lettuce cultivation has been widely practiced in Indonesia, one of which is at PT Kebun Sayur Surabaya, a company that focuses on the production of horticultural crops in NFT hydroponics. The lettuce production process is carried out by PT Kebun Sayur Surabaya with AB Mix nutrient type [3].

AB Mix nutrition is in the form of granules which are then dissolved and applied to irrigate lettuce. AB Mix nutrition has a special nutritional formulation consisting of two types of packaging, namely Mix A and Mix B [4]. Some types of AB

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Mix used by PT Kebun Sayur Surabaya for its lettuce are AB Mix Kryptonium and AB Mix Supernova. AB Mix Kryptonium contains 17 nutrients, while AB Mix Supernova contains 19 elements. These advantages are expected to provide superior and stable quality lettuce yields, but in reality, the application of AB mix has not been able to provide stable lettuce yields with good quality every month.

Yield stability and quality cannot provide good results every month can be caused by different planting times, which are influenced by climate change and environmental factors. The right planting time for lettuce is at the beginning of the dry season, namely July-August because there is a gradual change in climate and lettuce still gets enough sunlight [5, 6].

The type of nutrients and differences in planting time are thought to affect the stability and quality of lettuce yields at PT Kebun Sayur Surabaya because these two factors can affect the growth and development process of lettuce. This research needs to be done to determine the effect of the type of nutrients on the stability of yield and quality of lettuce yield in hydroponic NFT systems at different planting times at PT Kebun Sayur Surabaya so that lettuce production can continue to be stable and of good quality.

2. Materials and methods

2.1. Materials

The tools needed consist of jerry cans, NFT hydroponic equipment (NFT hydroponic gullies and hoses, reservoirs), netpots, 1 liter measuring cups, branch shears, scissors, rulers, digital vectors, hygrometers and thermometers, 0.01 accuracy scales, luxmeter, ph meter, TDS, SPAD chlorophyll meter, leaf color chart, permanent marker, solution, 150 ml beaker, 3ml and 10ml syringes, 40mm funnel, cake scale, stationery, cooler box / styrofoam, 50 liter bucket, cable, light fittings, 40 watt fluorescent lamp, stative + glue, mortar and pestle, 50 ml burette, sieve, 200 ml thinwall, oven, blender, tools for NPK test kjeldahl, olsen and bray methods.

The materials needed consist of baby romaine lettuce seeds, ab mix kryptonium nutrient, ab mix supernova nutrient, distilled water, starch, iodine 0.01N, tissue, ice gel, brown envelope, raw water, water, millimeter block, large and small plastic clips, and labels.

2.2. Methods

The research was conducted at PJ Fresh Hydroponic, a partner of PT Kebun Sayur Surabaya located in Malang, East Java, Indonesia (7°56'29.6 "S 112°34'08.6 "E) with an altitude of 698 meters above sea level from July to October 2024. The research using a split plot group randomized design in time with 2 factors. The first factor as well as the main factor is planting time (W) with 2 levels, namely: W_j = July-August planting time and W_s = September-October planting time. The second factor is the type of nutrient (N) as a subplot with 2 levels, N_k = AB Mix Kryptonium nutrient and N_s = AB Mix Supernova nutrient. AB Mix nutrition consists of mix A which contains macro nutrients and mix B which contains micro nutrients. AB Mix Kryptonium nutrition consists of 17 nutrients, namely N-NO₃, N-NH₄, P, K, Ca, Mg, S, Fe, B, Mn, Zn, Cu, Mo, Na, Cl, Ni, Co, and I. AB Mix Supernova nutrients consist of N-NO₃, N-NH₄, P, K, Ca, Mg, S, Fe, B, Mn, Zn, Cu, Mo, Na, Cl, Ni, Co, I, V, and Ag. There were a total of 4 treatment combinations with 8 replications, so 32 plants were needed. The observation variables consisted of plant height, leaf number, leaf thickness, leaf color, leaf chlorophyll content, leaf relative water content, light intensity, temperature and relative air humidity, vitamin C content, leaf area, and fresh weight per plant.

The research started from sowing seeds on rockwool, when the seeds reached 6-7 days old, they could be transferred to NFT hydroponics. Before transplanting, nutrients were prepared by dissolving mix A and mix B with raw water in each type of nutrient into different buckets. Mix A and mix B of each nutrient should not be mixed in concentrated conditions because it can cause toxicity. The dissolved Mix A and Mix B are mixed with the irrigation water in the reservoir. The nutrients needed for 1 reservoir have 1.5-1.6 EC. After the hydroponic system is ready and the lettuce is ready to be transferred to the netpot, it is then inserted into the hole in the gully. The water as well as the nutrients are then turned on and will be pumped into the gullies and will flow lettuce 24 hours nonstop until its harvest times. Harvesting is done when the lettuce has reached 45 Days After Planting (DAP) or 90% of the leaves have opened and the plant is 15 cm tall.

3. Results and discussion

The results of the variance test showed that the interaction of different planting times and types of nutrients had no significant effect on all observation variables. The single factor of planting time had a significant effect on the number

of leaves, leaf thickness, leaf chlorophyll content, light intensity, leaf area, and fresh weight of plants. The single factor of nutrient type had a significant effect on fresh weight, plant height, leaf thickness, light intensity, and chlorophyll content. Planting time, nutrient type, or their interaction did not significantly affect the relative water content of leaves, leaf color, and vitamin C content of lettuce. The results of the variance test showed that the stability and quality of lettuce yields were not well maintained. This happens because the standard operating procedures at PJ Fresh Hydroponic are not well implemented, namely employee negligence in controlling commodities.

Table 1 Two-way table of the treatment of planting time (W) with nutrient type (N) on plant fresh weight, number of leaves, plant height, leaf thickness, and leaf area.

Treatment	Fresh Weight (g)	Number of Leaves (strands)	Plant Height (cm)	Leaf Thickness (mm)	Leaf Area (cm ²)
Planting Time					
Wj	230,03 a	16,47 b	18,37 a	0,24 (0,95) a	108,31 a
Ws	182,50 b	19,97 a	17,74 a	0,19 (0,90) b	85,94 b
5% LSD	24.25	1.10	0.38	0,03	16.12
Nutrition Type					
Nk	223,25 a	19,16 a	19,18 a	0,19 (0,91) b	103,06 a
Ns	189,28 b	17,28 a	16,94 b	0,24 (0,95) a	91,20 a
5% LSD	19.15	1.20	0.68	0,03	12.60

(Wj): Planting time (July-August). (Ws): Planting time (September-October); (Nk): AB Mix Kryptonium nutrition; (Ns): AB Mix Supernova Nutrition; Values in the same vertical columns followed by one or more of the same letters were not significantly different at the 0.05 significance level according to Least Significant Difference (LSD) test.

Table 2 Two-way table of the treatment of planting time (W) with nutrient type (N) on light intensity, leaf chlorophyll content, leaf relative water content, leaf color, and vitamin C content.

Treatment	Light Intensity (%)	Chlorophyll Content of Leaves (SPAD)	Relative Water Content (%)	Leaf Color Chart	Vitamin C content (mg/g)
Planting Time					
Wj	4.66 (1,45) a	36,96 b	79,48 a	3.24 a	44,00 (6,64) a
Ws	2.94 (1,30) b	38,68 a	80,83 a	3.40 a	45,10 (6,72) a
5% LSD	0,07	0.41	7.72	1.02	0,81
Nutrition Type					
Nk	2.70 (1,27) b	37,24 b	80,63 a	3.30 a	42,90 (6,55) a
Ns	4.91 (1,47) a	38,4 a	79,68 a	3.34 a	46,20 (6,80) a
5% LSD	0,04	0.89	4.74	0.13	0,42

(Wj): Planting time (July-August). (Ws): Planting time (September-October); (Nk): AB Mix Kryptonium nutrition; (Ns): AB Mix Supernova Nutrition; Values in the same vertical columns followed by one or more of the same letters were not significantly different at the 0.05 significance level according to Least Significant Difference (LSD) test.

3.1. Effect of different planting times on lettuce yield stability and quality

The best fresh weight of lettuce was obtained at the first planting time (July-August), with 230.03 grams, 20.66% heavier than the second planting time, which was 182.50 grams. The fresh weight was supported by leaf area, leaf thickness, and light intensity in that period reaching the highest values compared to other treatments, namely 108.31 cm², 2.31 mm² and 6.26%. In addition to these 3 factors, lettuce growth was supported by optimal temperature and relative humidity, giving the best fresh weight. Previous research showed a positive relationship between lettuce leaf area and fresh weight [7]. The Wj treatment has the widest leaves that will block the growth of the leaves underneath so that the leaves underneath experience light stress and then their growth is disrupted, until they die [8]. As a result, Wj has fewer

leaves than Ws. Light intensity increases leaf area and transpiration rate so that the process of plant cell division stops and a waxy layer forms on the leaves resulting in thick leaves [9, 10]. Light intensity also affects the production and distribution of leaf chlorophyll. Previous research states that the higher the light intensity, the distribution of chlorophyll a increases and when the light intensity is low, chlorophyll b production increases to optimize light absorption [11, 12, 13]. This caused the leaf chlorophyll content in the Wj treatment, 36.96 SPAD, to be lower than Ws, 38.68 SPAD, even though the leaf area and thickness as well as the light intensity in Wj were higher than Ws.

Temperature and humidity between the two planting periods did not differ drastically. The average temperature in both the July-August and September-October Wj periods was 29.06°C. The average relative humidity in the July-August and September-October periods had a slight difference. The average relative humidity in the July-August period was 62.24%, while in September-October it was 63.77%. The relative humidity in the September-October period is closer to the ideal humidity of lettuce, which is 70-80% [5].

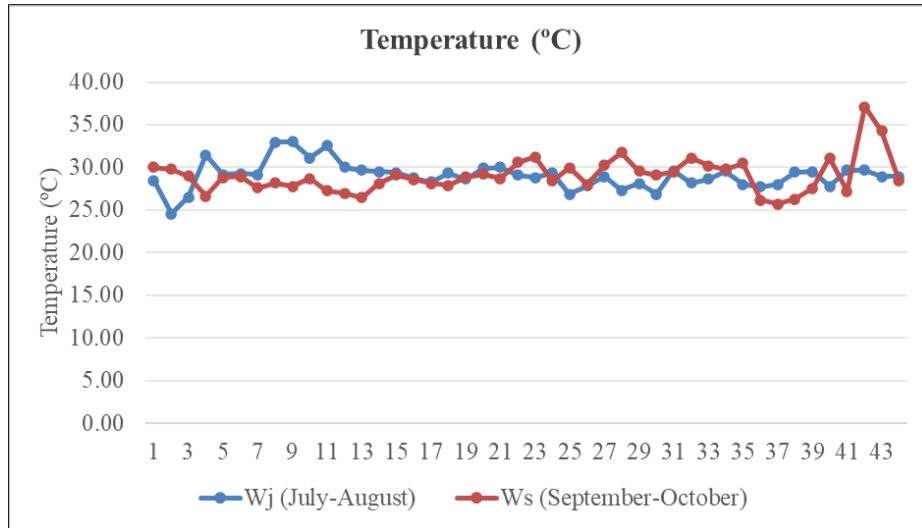


Figure 1 Average daily temperature during the July-August and September-October periods

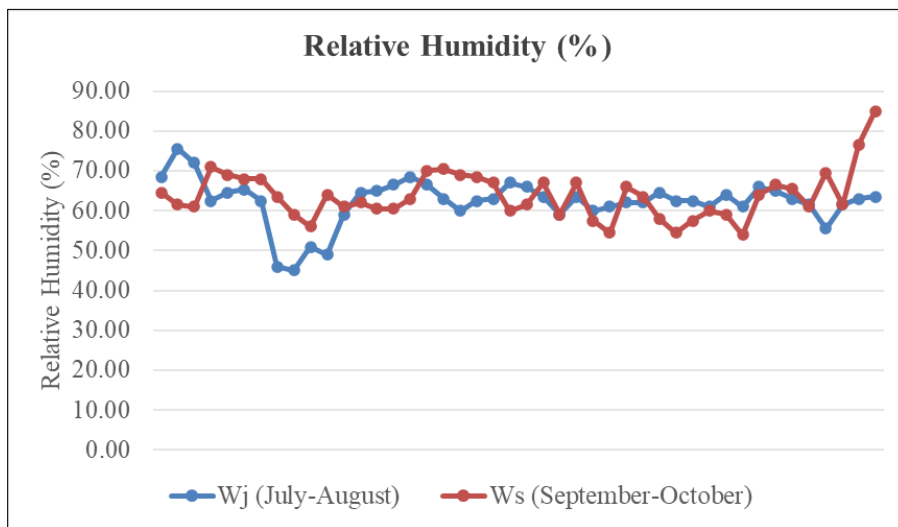


Figure 2 Average daily relative humidity during the July-August and September-October periods

3.2. Effect of Nutrient Type on Lettuce Yield Stability and Quality

The best fresh weight of lettuce was the Nk (AB Mix Kryptonium) nutrient type treatment, which was 223.25 grams, 15.22% heavier than the AB Mix Supernova nutrient, which was 1989.28 grams. AB Mix Kryptonium also gave the best

plant height, which was 19.16 cm compared to AB Mix Supernova, which was 16.94 cm. AB Mix Kryptonium nutrition is able to maintain a better balance between nutrients, thus providing a better and more stable fresh weight of plants than Ns (Supernova). The stability of nutrients in Nk encourages the rate of assimilation so as to accelerate the growth of plant height up to 31% [14]. Taller plants will accumulate more biomass, resulting in heavier plant fresh weight [15, 16]. On the other hand, the Ns treatment did not have better fresh weight and plant height than Nk even though Ns had more nutrients in it. This happened because it is suspected that there is an imbalance between the nutrients, thus giving lower fresh weight and plant height [17, 18].

The Nk treatment had superior fresh weight and plant height than Ns, but the Ns treatment had higher leaf thickness, light intensity, and chlorophyll content. The Ns treatment had 0.05 mm thicker leaves, which were 0.24 mm thicker than the Nk treatment which had 0.19 mm thick leaves. The chlorophyll content of Ns reached 38.4 SPAD, while Nk was only 37.24 SPAD. This result is in accordance with previous research showing that lettuce with the highest plant height has lower chlorophyll content. Taller lettuce tends to experience stem growth rather than leaf area that can be used for photosynthesis [19]. Another reason why Ns has more leaf thickness and chlorophyll than Nk is the addition of nutrients V and Ag in AB Mix Supernova nutrition. Vanadium plays a role in increasing the activity of enzymes that support photosynthesis and nitrogen metabolism, so that the formation of leaf chlorophyll increases. Other research shows that vanadium can increase the concentration of chlorophyll a, chlorophyll b, and total chlorophyll. Vanadium also strengthens cell walls and increases palisade tissue development so that leaves become thicker [20]. Other studies have also shown that Ag can increase chlorophyll content by up to 25% [21]. Ag nutrients can increase the cytokinin hormone and stimulate the formation of leaf tissue by stimulating cell division and expansion so that leaf thickness increases. These two nutrients can increase plant productivity if given in the right dose and concentration, but if excessive, it will become toxic and inhibit plant growth [22].

The Ns treatment had higher leaf thickness and chlorophyll content also because it was supported by high light intensity and more suitable humidity, as happened in the planting time treatment. The Ns treatment had 2.20% higher light intensity, which was 4.90%, while the intensity of the Nk treatment was only 2.70%. Light intensity in the Ns treatment increased leaf area and transpiration rate so that the process of plant cell division stopped and a waxy layer formed on the leaves so that the leaves became thick [9, 10]. Higher light intensity stimulates the rate of photosynthesis so that chlorophyll formation increases [23]. In addition, nutrient V in the Ns treatment helps metabolize nitrogen as a chlorophyll-forming material and nutrient Ag is able to protect chlorophyll damage from oxidative stress [20, 21].

4. Conclusion

Different planting times affect the stability and quality of lettuce yield. The best planting time is during July-August with the fresh weight of lettuce 230.03 grams and leaf area 108.31 cm²; leaf thickness 0.25 mm; and light intensity 4.66%. The best type of nutrition is AB Mix Kryptonium which obtained fresh weight of lettuce 223.25 grams and plant height 19.16 cm.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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