The Effect of Ab mix Nutrient on Growth and Yield of Pak choi (Brassica chinensis L.) Plants under Hydroponic Wick System Condition

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Abstract. This research was conducted to find out the effect of ab mix nutrient on growth and yield of Pak choi (Brassica chinensis L.) plants under hydroponic wick system condition. The research design used was non factorial Complete Randomized Design (CRD) with 5 levels of ab mix nutrient concentrations (0, 650, 1300, 1950, 2600 ppm), with 3 replications in each treatment. Each repetition consists of 6 plants, making a total 90 experimental units. The parameters observed were plant’s height, number of leaves, leaves area, fresh and dry weight, harvest index, leaf chlorophyll content, and root volume. Data was analyzed by using one way ANOVA, and DMRT as follow up. Research result shows that in hydroponic wick system ab mix nutrient gave very significant effect on pak choi (Brassica chinensis L.) parameters, such as: 1) plant’s height, 2) number of leaves, 3) leaves area, 4) dry weight 5) harvest index, and significantly effect on 6) fresh weight. However, it did not gave significant effect on root volume. The best results for each parameters observed were: number of leaves was 18.78, leaves area was 47.32 cm², fresh weight was 33.57 gr, dry weight was 2.40 gr and harvest index was 99.15%, all were obtained from ab mix 1950 ppm treatment. The best results for plant height parameter was 8.71 cm obtained from ab mix 2600 ppm treatment.

1. Introduction
Vegetables become important needs that have to be fulfilled every day. Brassica is a very popular vegetable in Indonesia [1]. Brassica belongs to the Brassicaceae family which consists of various species. One of the species in Brassicaceae family is Pak choi or often called as “sawi sendok” in Indonesia [2]. The popularity and interest in Brassica vegetable consumption continues to increase because of its nutritional value [3]. Pak choi is one of the vegetable plants that has high economic and nutritional values [1][4]. Poor cultivation techniques will reduce the growth rate of pak choi which then decrease pak choi productivity. In order to overcome these obstacles, improving the existing cultivation techniques should be done continuously. Other than conventional techniques, hydroponic system is one of expected solution that able to improve growth and productivity of pak choi [5]. In addition to paying
attention to cultivation techniques, the success of plant breeding programs in repairing a plants are largely determined by genetic sources [6].

Hydroponics is a plant cultivation system without using soil as a growth medium with additional nutrients rich solution for plant growth. Hydroponics has become one of the agricultural cultivation systems used to improve the quality of vegetables produced [7]. Hydroponic system can be done in relatively small area [4]. Based on how nutrient supplied to plant roots, hydroponic grouped into several types [8]. The first type is hydroponics that use solid media (substrate) as a planting medium. The second type is hydroponics which only uses water as their growing media (non-substrates) [9]. One of the simplest hydroponic systems is the wick system. In this research, we used flannel fabric/wick that served as distributor of nutrient solution from container containing nutrient to growing media (rockwool). This is passive system because there are no moving parts [10]. This system also does not require electricity in its work.

The availability of macro, micro and additional nutrients are always required by plants for its metabolism process [11]. Therefore, their availability are essential for plants. Nutrients are converted into energy and increase plant mass during their lifetime [12]. One of the advantages of cultivation by hydroponic techniques is that the nutrients content for plants can be maintained. Ab mix is one of the nutritional formulas made specifically for the cultivation of hydroponic vegetables. Ab mix contained of formula A and formula B. Formula A in Ab mix special for vegetables contain: calcium ammonium nitrate {5Ca(NO$_3$)$_2$.NH$_4$NO$_3$.10H$_2$O}, potassium nitrate (KNO$_3$), Fe-chelate, Fe-EDTA, whereas Formula B contains potassium dihydrophosphate (KH$_2$PO$_4$), ammonium sulphate{(NH$_4$)$_2$SO$_4$}, potassium sulphate (K$_2$SO$_4$), magnesium sulphate (MgSO$_4$.7H$_2$O), manganese(II) sulphate (MnSO$_4$.4H$_2$O), copper sulphate (CuSO$_4$.5H$_2$O), zinc sulphate (ZnSO$_4$.7H$_2$O), boric acid (H$_3$BO$_3$), ammonium heptamolybdate {{(NH$_4$)$_6$Mo$_7$O$_{24}$.4H$_2$O} [13]. Ideally, optimal growth of pak choi plant is in line with its yield. Therefore, this study was conducted to determine the effect of ab mix nutrition on the growth and yield of pakchoy (Brassica chinensis L.) plants through the wick system hydroponic technique.

2. Method
This research was held in Green House, Biology Laboratory and Chemistry Laboratory of Universitas Negeri Medan, North Sumatra, Indonesia. This research was held in November 2018 to February 2019. The research was conducted in two steps, planting and yield data analysis. The tools and materials used in planting step were: tray, ruler, styrofoam, flannel, net pot, rockwool, label paper, graduated cylinder, TDS, pH meter, pak choi seeds (Brassica chinensis L.), water, sulphate acid (H$_2$SO$_4$), ab mix nutrient special for leafy green vegetables. The tools and materials used in yield data analysis step were: rulers, paper, ovens, analytical balance, graduated cylinder, and water.

The research design used was non factorial Complete Randomized Design (CRD) with 5 levels of ab mix nutrient concentrations (0, 650, 1300, 1950, 2600 ppm), with 3 replications in each treatment. Each repetition consists of 6 plants, making a total 90 experimental units. Data obtained from observations were analysed by using ANOVA. If the ANOVA results shows significant effect then analysis continues using the DMRT (Duncan's Multiple Range Test) test at a significance level 5%.

The research includes seeding, maintenance, pest management, harvesting, and analysis of yields. Seeding was done until the plants have 4-5 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, to avoid abnormal growth, pH and nutrient levels controls were carried out every day.

Parameters observed consisted of plant height and number of leaves, and the both data were taken every week for 4 week after planting (WAP). Other parameters such as leaves area, fresh weight, dry weight, harvest index, and root volume data were taken at 33 day after planting (DAP). Plant height was measured starting from the base of the stem to the highest tip of the leaf. The number of leaf was measured by counting the number of the open leaves. Leaves area parameter was measured by gravimetric method [14]. Plant’s fresh weight was measured by weighing all parts of the plant except
the roots at the time of harvest. Dry weight was calculated by drying the plant parts oven at 80°C for 24-48 hours. Root volume was measured by using graduated cylinder by putting the roots inside water contained graduated cylinder, the volume difference before and after roots inserted then became the roots volume. Harvest index was calculated by comparing economical and biological values of the plant [2].

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\text{Harvest index} = \frac{\text{Stem weight + leaf weight (gr)}}{\text{Stem weight + leaf weight + root weight (gr)}} \times 100\% 
\]

3. Result and Discussion

The effect of different concentration of ab mix on height, number of leaves, leaves area, fresh weight, dry weight, roots volume and harvest index of pak choi (Brassica chinensis L.) under hydroponic wick system condition are explained below:

3.1. Plant’s Height (cm)

Analysis by using Anova showed ab mix nutrient very significantly affect pak choi’s height at first and fourth weeks after planting. Further analysis by using Duncan’s test showed there was no significant difference between ab mix treatments (650, 1300, 1950, 2600 ppm). However, there was significant difference in control (without ab mix). The tallest plant’s height obtained at fourth week after planting by ab mix 2600 ppm treatment, and the shortest plant’s height occurred in control (without ab mix). Although at treatment of ab mix 2600 ppm there were plants that shorter than others, the average height in this treatment was higher compared to other treatments. Observation results on pak choi height from week 1 to week 4 are displayed in table 1 below:

| Treatments     | Week After Planting (WAP) | 1      | 2      | 3      | 4      |
|----------------|---------------------------|--------|--------|--------|--------|
| N₀(without ab mix) | 2.68 a                  | 3.62 a | 4.35 a | 5.01 a |
| N₁(ab mix 650 ppm)   | 3.95 b                  | 5.36 b | 7.16 b | 7.76 b |
| N₂(ab mix 1300 ppm)   | 4.44 b                  | 5.57 b | 7.36 b | 8.25 b |
| N₃(ab mix 1950 ppm)   | 3.99 b                  | 5.49 b | 7.03 b | 7.82 b |
| N₄(ab mix 2600 ppm)   | 4.07 b                  | 5.97 b | 7.12 b | 8.71 b |

F test ** ** ** **

Notes : F test (Anova) notes : = no significant effect, * = has significant effect (F count > F 5%), ** = has very significant effect (F count > F 1%). The number followed by same letter in the same column, states it is not significantly different at significant level 5% in Duncan Test (DMRT).

Addition of Ab mix nutrient in growth medium can increase growth of hydroponic pak choi. It is because ab mix contain almost similar compounds with nutrient that required by plants. Ab mix is a good fertilizer for hydroponic pak choi plants because its nutrients easily absorbed by plants [2]. The high concentration of Nitrogen in the highest ab mix concentration in this research was able to promote increasing in plant’s height. The higher concentration of the ab mix, the higher nutrients it contains [15]. Solutions in the media must be rich in nutrients to be able to support plant growth [1]. In vegetative growth such as the increase in length, the nutrient that plays a role is nitrogen (N). Nitrogen is absorbed by plants in the form of NO₃⁻ (nitrate) and NH₄⁺ (ammonium). NH₄⁺ functions are to make plants grow rapidly, cells growth and resistant to disease. Inadequate supply nitrogen in plants will slowing down plant growth as occurred in control treatment [1-4]. According to Sundari et al (2016) addition of 1.800 ppm ab mix nutrient able to give optimum result in plants height growth [2].
However in this research, at concentration 2600 ppm of ab mix, the result of all parameter observed still not optimum beside plant’s height parameter.

3.2. Number of Leaves
Analysis by using Anova showed ab mix nutrient very significantly affect pak choi’s number of leaves at first to fourth week after planting. Further analysis by using Duncan’s test showed there was significant difference between control (without ab mix) treatment and ab mix 650 and 1950 ppm treatments, but not significantly different with ab mix 1300 and 2600 ppm treatments. The highest number of leaves obtained from ab mix concentration 1950 ppm, and the lowest number of leaves obtained from control treatment.

Observation results on pak choi number of leaves from week 1 to week 4 are displayed in table 2 below:

| Treatments             | Week After Planting (WAP) |
|------------------------|---------------------------|
|                        | 1     | 2     | 3     | 4     |
| N₀ (without ab mix)    | 5.11 a | 6.22 a | 7.20 a | 8.40 a |
| N₁ (ab mix 650 ppm)    | 5.83 b | 8.17 b | 11.87 b | 15.87 b |
| N₂ (ab mix 1300 ppm)   | 5.83 b | 8.50 bc | 12.47 bc | 17.73 bc |
| N₃ (ab mix 1950 ppm)   | 5.78 b | 8.50 bc | 13.03 c | 18.78 c |
| N₄ (ab mix 2600 ppm)   | 5.94 b | 8.83 c | 13.13 c | 17.73 bc |
| F test                 | **    | **    | **    | **    |

Notes: F test (Anova) notes: k = no significant effect, * = has significant effect (F count > F 5%), ** = has very significant effect (F count > F 1%). The number followed by same letter in the same column, states it is not significantly different at significant level 5% in Duncan Test (DMRT).

The leaf is a plant organ where the plant’s food synthesizes as well as food storage. Leaves have chlorophyll which plays a role in photosynthesis [16]. At fourth week after planting, the number of leaves increases as concentration of ab mix increased. However, at the concentration of ab mix 2600 ppm the number of leaves decreased. Although the highest plant height was produced by the ab mix treatment of 2600 ppm, the highest number of leaves was produced by treatment of 1950 ppm. Looking from plants performance, there were some plants height that shorter in height compared to others in ab mix 2600 ppm, so the number of leaves of these plants was also low.

3.3. Leaves Area (cm²), Fresh Weight (gr), Dry Weight (gr), Harvest Index (%), and Roots Volume(ml)
Anova result showed ab mix nutrient is very significantly affect pak choi’s leaves area at 33 days after planting. Further analysis by using Duncan’s test showed there was significant difference between control (without ab mix) treatment with ab mix 650 and 1950 ppm treatments. Treatments of ab mix treatment of 2600 ppm, the highest number of leaves was produced by treatment of 1950 ppm. Looking from plants performance, there were some plants height that shorter in height compared to others in ab mix 2600 ppm, so the number of leaves of these plants was also low.

Anova result of pak choi’s fresh weight parameter showed ab mix nutrient is significantly affect pak choi’s fresh weight at 33 days after planting. Duncan’s test showed there was no significant difference between ab mix treatments (650, 1300, 1950, 2600 ppm). However, there was significant difference between control treatment (without ab mix) with all ab mix treatments. The highest score of fresh weight obtained from ab mix concentration 1950 ppm, and the lowest score for fresh weight obtained from control treatment.

Anova result of pak choi’s dry weight parameter showed ab mix nutrient is very significantly affect pak choi’s dry weight at 33 days after planting. Duncan’s test showed there was no significant difference between ab mix treatments (650, 1300, 1950, 2600 ppm). However, there was significant
difference between control treatment (without ab mix) with all ab mix treatments. The highest score of dry weight obtained from ab mix concentration 1950 ppm, and the lowest score for dry weight obtained from control treatment.

Anova result of pak choi’s harvest index parameter showed ab mix nutrient is very significantly affect pak choi’s harvest index at 33 days after planting. Duncan’s test showed there was no significant difference between ab mix treatments (650, 1300, 1950, 2600 ppm). However, there was significant difference between control treatment (without ab mix) with all ab mix treatments. The highest score of harvest index obtained from ab mix concentration 1950 ppm, and the lowest score for harvest index obtained from control treatment.

Observation results of leaves area (cm$^2$), fresh weight (gr), dry weight (gr), harvest index (%), and root volume (ml) parameters displayed in table 3 below:

| Treatments          | Leaves area (cm$^2$) | Fresh weight (g) | Dry weight (g) | Harvest index (%) | Roots volume (ml) |
|---------------------|----------------------|------------------|----------------|-------------------|-------------------|
| $N_0$ (without ab mix) | 4.58 a               | 1.40 a           | 0.20 a         | 83.39 a           | 0.50              |
| $N_1$ (ab mix 650 ppm) | 33.07 b             | 32.50 b          | 2.13 b         | 98.05 b           | 1.67              |
| $N_2$ (ab mix 1300 ppm) | 36.89 bc           | 32.97 b          | 1.93 b         | 98.98 b           | 1.00              |
| $N_3$ (ab mix 1950 ppm) | 47.32 c             | 33.57 b          | 2.40 b         | 99.15 b           | 1.00              |
| $N_4$ (ab mix 2600 ppm) | 32.52 b             | 32.40 b          | 2.33 b         | 98.98 b           | 1.17              |

Notes : F test (Anova) notes : $^a$ = no significant effect, $^*$ = has significant effect (F count > F 5%), $^{**}$ = has very significant effect (F count > F 1%). The number followed by same letter in the same column, states it is not significantly different at significant level 5% in Duncan Test (DMRT).

The highest fresh weight, dry weight, number of leaves, leaves area and harvest index were obtained from ab mix 1950 ppm treatment. The parallel relations between number of leaves and leaves area, fresh weight, dry weight and harvest index makes if there is increasing in number of leaves and area, then fresh weight, dry weight and harvest index of the plants will be increase. Leaves area parameter showed how big the assimilate content that stored and produce by plants. The wider leaf area is then the more assimilate it produce, then its photosynthesis rate will also increase. Wider leaf area makes plants easier to capture the sunlight, and makes translocation assimilates to plant organs is even greater [15]. The increasing in plant weight of course influenced by increasing in plant’s height, number of leaves and area [17]. Plant’s fresh weight parameter is parallel with its dry weight.

Out of seven parameters observed, five parameters (number of leaves, leaves area, fresh weight, dry weight, harvest index) showed their best result at ab mix concentration 1950 ppm. Looking from overall plant’s performances, ab mix 2600 ppm was assumed to be too strong for plants growth, indicated decrease in 5 parameters observed. Plant growth regulators in suitable amount can increase plant morphogenesis, but in excessive amount it became obstacle in plant morphogenesis [18].

Anova result of root volume parameter showed no significant effect of ab mix at 33 days after planting. The highest score of roots volume parameter obtained from ab mix concentration 1950 ppm, and the lowest score of roots volume parameter obtained from control. In roots volume parameter, the highest roots volume was not obtained from the highest ab mix concentration, but from the lowest concentration of ab mix. It is occurred because the amount of nutrient content in ab mix 650 ppm was smaller compared to other treatments (1300, 1950, and 2600 ppm). Therefore, plants should physiologically adapting by producing more roots to be able to absorb more nutrient. If plants facing water and nutrient deficiencies, plants will produce more roots, possibly to increase absorption rate [14]. The lack of water and nutrient availability in hydroponic techniques resulting elongation in roots
When conditions are unfavorable, root growth will be encouraged to obtain more nutrients and water. It is also said that root growth will be encouraged when nitrogen deficiency is limited [20].

Pakchoi plant’s performances at 4 weeks after planting is display in figure 1 below:

Figure 1: Pak choi plant’s performances at 4 WAP. a) 1st repetition of control group; b) 2nd repetition of control group; c) 3rd repetition of control group; d) 1st repetition of ab mix 650 ppm group; e) 2nd repetition of ab mix 650 ppm group; f) 3rd repetition of ab mix 650 ppm group; g) 1st repetition of ab mix 1300 ppm group; h) 2nd repetition of ab mix 1300 ppm group; i) 3rd repetition of ab mix 1300 ppm group; j) 1st repetition of ab mix 1950 ppm group; k) 2nd repetition of ab mix 1950 ppm group; l) 3rd repetition of ab mix 1950 ppm group; m) 1st repetition of ab mix 2600 ppm group; n) 2nd repetition of ab mix 2600 ppm group; o) 3rd repetition of ab mix 2600 ppm group.
4. Conclusion and Suggestion

Research result shows that in hydroponic wick system ab mix nutrient gave very significant effect on pak choi \textit{(Brassica chinensis} L.) parameters, such as: 1) plant’s height, 2) number of leaves 3) leaves area 4) dry weight 5) harvest index, and significantly effect on 6) fresh weight. However, it did not gave significant effect on root volume. The best results for each parameters observed were: number of leaves was 18.78, leaves area was 47.32 cm$^2$, fresh weight was 33.57 gr, dry weight was 2.40 gr and harvest index was 99.15%, all were obtained from ab mix 1950 ppm treatment. The best results for plant height parameter was 8.71 cm obtained from ab mix 2600 ppm treatment.

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