Growth and production of potato mini tubers (*Solanum tuberosum* L.) in the aeroponic system by root zone treatment and concentration of leaf-fertilizer

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**Abstract.** This study was conducted to increase the growth of potato and its mini tuber yield by root zone treatment and the concentration of leaf-fertilizer in the aeroponics system. This research was done at Experimental Farm of The Agriculture Faculty, Universitas Syiah Kuala from October 2019 until July 2020. There were 2 levels of root zone treatment; control (without cooling) and root zone cooling. Meanwhile the concentration of leaf-fertilizer consists of 5 levels; control, 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm. The results showed that the root zone treatment significantly affected the plant dry weight. The heaviest plant dry weight obtained from the plant grown in root zone cooling treatment. The concentration of leaf-fertilizer very significantly affected the plant dry weight, which the best concentration of 500 ppm produced 751.28 mg plant-dry-weight. There was a very significant effect at a combination of root zone treatment and concentration of leaf-fertilizer on plant dry weight, which the best treatment was found in a combination of root zone cooling and 500 ppm concentration of leaf-fertilizer. The plant with that treatment produced mini tuber, while the others did not.

1. **Introduction**

Potato (*Solanum tuberosum* L.) is a horticultural commodity that is generally cultivated with a vertical mound system or along the slope. Potato plants cultivated conventionally produce mini tubers of around 3-5 tubers per plant [1]. Potato development in Aceh Province is centred in Bener Meriah and Aceh Tengah districts. Based on data from Badan Pusat Statistik and Kementerian Pertanian, in 2016, potato production in Aceh was only 63,022 tons, decreasing in 2017 to 47,960 tons, then the lowest in 2018, 14,842 tons [2]

The difficulties to increase the production of mini potato tubers in the medium lands is because the high temperature problems inhibit the expansion of the potato planting area in the medium plains [3]. As a solution to this problem, aeroponic cultivation is considered as an alternative for increasing the production of mini potato tubers in the lowlands as well as environmental conservation efforts. Aeroponics is a soilless cultivation system by hanging plants in the air. Some of the advantages of aeroponic systems are ease of harvesting, nutritional control, efficient use of land and water as well as sufficient oxygen levels in nutrient solutions to benefit plants [4]. An aeroponic system minimizes the occurrence of disease attacks through the soil and facilitates plant maintenance.
Aeroponic cultivation of potatoes can be carried out using the limited cooling method (zone cooling). The concept of zone cooling is to cool the limited zone of plant growth areas, for example, cooling the plant root (root zone cooling). This technique does not aim to cool the entire volume of air in the planted area [5]. Based on the research of Sumarni et al., the aeroponic system of potato seed production with root zone cooling and yield test in the lowlands of 250 m asl were able to produce 14.85 tubers per plant with an average tuber weight of 409.15 mg per tuber [6].

In addition to modifying the microclimate in the root area of potato plants, to increase the induction of tuber, can be done by increasing the vegetative growth of the plant. This can be done by applying leaf fertilizers. Fertilizers are often applied at potato cultivation in both conventional and aeroponic systems, however, their effects vary widely [7,8]. Massive dose fertilizer can cause burned leaves and interfere the plant growth. Meanwhile, a lower dose does not affect plant growth and yield [9]. In connection with the benefits of root zone cooling and leaf fertilizers in aeroponic cultivation of potato plants, it is necessary to study these treatments. This study aims to optimize the production of aeroponically cultivated mini potato tubers with root zone treatment and concentration of leaf fertilizers.

2. Materials and methods

This research was conducted at the Experimental Farm and Horticulture Laboratory, Department of Agrotechnology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam, Banda Aceh. The research was carried out from October 2019 to July 2020.

The main equipment used in this research was two Aeroponic containers (1.6 m x 1.2 m x 1 m) designed by plant spacing of 20 cm x 20 cm. The other tools were a high-pressure pump to flow nutrients through a nozzle to the plant roots, the chiller to cool the nutrients, a pump to flow the nutrients to be cooled into the chiller, 90 netpots, Total Dissolved Solids (TDS) to measure the concentration of dissolved nutrients, a thermometer to measure the temperature in an aeroponic container and a hygrometer to measure the humidity in the aeroponic container. The materials were 200 Granola potato tubers, 2 Styrofoam pods (1.6 m x 1.2 m with a thickness of 3 cm), 1 sack of husk charcoal in a 15 kg bag, 2 packs of 1 kg AB mix nutrition, and 100 g of Growmore leaf fertilizer (32:10:10).

This research used a Randomized Block Design with a split-plot design. The research used two factors, those were
1) The mainplot; the root zone treatment which consists of 2 levels,
   a) T<sub>0</sub> = Control (without cooling unit)
   b) T<sub>1</sub> = Root zone cooling (with cooling unit)
2) The subplot; concentration of leaf-fertilizer which consists of 5 levels
   a) P<sub>0</sub> = Control (0 ppm)
   b) P<sub>1</sub> = 500 ppm
   c) P<sub>2</sub> = 1000 ppm
   d) P<sub>3</sub> = 1500 ppm
   e) P<sub>4</sub> = 2000 ppm

There were 10 treatment combinations. Each treatment combination was repeated 3 times, so there were 30 experimental units. Each experimental unit contained 3 plants so that the total population was 90 plants. The data analysis used ANOVA and Duncan’s New Multiple Range Test at 5% level by Ms. Excel program.

2.1. Potato seed propagation

Potato seedlings from potato tubers grown in husk charcoal planting media as hydroponic substrate in polybags. A total of 200 Granola Potato mini tubers of 5-7 cm in diameter and at 3 months old were used for nurseries. Maintenance was carried out, including watering once a day in the afternoon and manual pest control. The nursery was provided with a 2-layer parnet shade to control the intensity of received sunlight. When the seedlings were 4 weeks old, the seedlings were transplanted into an aeroponic system.
2.2. Aeroponic installation system
There were two aeroponic installations, each of them consists of an aeroponic surface and an aeroponic nutrient container. The surface of the container was made of 1.6 m x 1.2 m styrofoam. One aeroponic unit consisted of 45 plants with a spacing of 20 cm x 20 cm. The nutrition container was 1.6 m x 1.2 m x 0.2 m in size. The first aeroponic installations without a chiller as the control treatment and the other installation was equipped with a chiller as root zone cooling treatment. Nutrient circulation used a paralon pipe that was driven by a pressurized water pump. The nutrients used were AB mix solution. AB mix solution has flowed through the nozzle automatically.

2.3. Root zone cooling treatment
Zone cooling was a method of cooling a limited area (roots) so not intended to cool the entire room. The root zone cooling system was carried out by cooling the nutrient solution before it has flowed into the plant root area [5]. The treatment used a water cooling system chiller CL120 (unit size: 200 x 150 x 70 mm). The water-cooling system components are a Peltier TEC12706, a Water-block 40 x 40 mm, a Heat-sink 200 x 120 x 35 mm, a Fan 80 x 80 cm, and a Power Supply 220VAC/12 VDC-5A. In this research only use one chiller for one aeroponics container. The nutrients would be flowed through a submersible pump to the chiller to be cooled then flowed back to the nutrition container. Then the nutrients were sprayed on the plant roots through a nozzle connected to a high pressure pump.

2.4. Application of leaf fertilizer
The leaf fertilizer used in this research was Growmore (32:10:10) with a content of 32% N. The concentration of Growmore leaf fertilizer given is 500 ppm, 1000 ppm, 1500 ppm, and 2000 ppm. The fertilizer was sprayed onto the leaves using a hand sprayer, each treatment was given approximately 200 ml and sprayed once a week from 1 to 4 weeks after planting (WAP).

2.5. Plant maintenance
Plant maintenance was carried out by maintaining electrolyte conductivity (EC) and nutrient acidity (pH) of 1.5–2 mS / m and 5.8–6, respectively. The conductivity of the electrolyte was adjusted by the addition of nutrients, while the acidity was adjusted by the addition of a solution of H₂SO₄ or NaOH, if the pH was high then added H₂SO₄ 1 N and if the pH was low 1 N NaOH will be added. Measurement of pH and nutrient concentration was carried out once a week using TDS. Then given AB mix nutrition by flowing the nutrient solution continuously through the nozzle as much as 1000 ppm in the first week and 1200 ppm in the next four weeks. Five days before harvest, nutrient spraying through the sprinkler was stopped. Maintenance of the aeroponic unit included cleaning the nozzle, checking nutrient solution temperature, and air humidity in the aeroponic tub as well as manual pest control.

2.6. Observed parameters
Parameters were observed on all plants. The observed variables were plant height (cm) observed since the plant was transferred to an aeroponic system up to 7 WAP, number of stolons per plant, percentage of effective stolons (%), number of tubers per plant, tuber wet weight per plant (mg), tuber dry weight per plant (mg) and plant dry weight (mg) at 7 WAP.

3. Results and discussions

3.1. The effect of root zone cooling and leaf fertilizer concentration treatment on plant height
The results of the ANOVA analysis showed that both root zone cooling and leaf fertilizer treatment had no significant effect on the height of potato plants 1-7 weeks after planting (WAP). In addition, the interaction between both treatments did not significantly affect the growth of potato plant height 1-7 WAP (Table 1).
Table 1. The effect of root zone cooling and leaf fertilizer concentration treatment on plant height 1-7 weeks after planting (WAP).

| Parameter          | Treatment | T (%) | P (%) | CV T (%) | CV P (%) |
|--------------------|-----------|-------|-------|----------|----------|
| Plant Height 1 WAP | 0.09 ns   | 1.09 ns | 2.35 ns | 2917     | 19.17    |
| Plant Height 2 WAP | 0.71 ns   | 1.09 ns | 2.43 ns | 23.59    | 17.99    |
| Plant Height 3 WAP | 1.83 ns   | 1.06 ns | 2.35 ns | 17.96    | 18.74    |
| Plant Height 4 WAP | 5.24 ns   | 1.46 ns | 1.69 ns | 15.00    | 20.91    |
| Plant Height 5 WAP | 1.03 ns   | 1.15 ns | 0.64 ns | 17.79    | 22.92    |
| Plant Height 6 WAP | 7.15 ns   | 1.00 ns | 0.91 ns | 8.79     | 27.61    |
| Plant Height 7 WAP | 7.33 ns   | 0.96 ns | 0.89 ns | 9.21     | 27.35    |

ns: has no significant effect; *: significant; **: very significant; CV: Coefficient of Variation; T: Root zone treatment; P: Concentration of Leaf Fertilizer; TxP: Interaction between Root zone treatment and Concentration of Leaf Fertilizer

Variation in plant height growth for each treatment and between replications were due to the limitation growth of potato seedlings before transferred to the aeroponic system. In this study, observations was done until 7 weeks after planting because plants started showing death characteristics, marked by burnt wilt on top of shoots, but the bottom of shoots to the roots of the plants was still fresh. The average height of potato plants due to root zone cooling treatment and various concentrations of leaf fertilizers can be seen in Table 2.

Table 2. Average plant height due to root zone treatment and concentration of leaf fertilizer treatment.

| Root Zone Treatment | Concentration of leaf fertilizer | Plant Height (cm) |
|---------------------|----------------------------------|-------------------|
|                     |                                  | 1 WAP | 2 WAP | 3 WAP | 4 WAP | 5 WAP | 6 WAP | 7 WAP |
| Control (Without Cooling) | 0 ppm                           | 13.45 | 15.67 | 15.89 | 16.33 | 17.83 | 18.5  | 18.57 |
|                      | 500 ppm                          | 9.89  | 12.28 | 12.63 | 13.22 | 14.67 | 14.73 | 14.79 |
|                      | 1000 ppm                         | 12.00 | 14.06 | 14.75 | 15.72 | 16.14 | 18.42 | 18.52 |
|                      | 1500 ppm                         | 10.24 | 12.50 | 12.95 | 13.78 | 15.50 | 15.50 | 15.57 |
|                      | 2000 ppm                         | 12.20 | 14.11 | 15.13 | 16.28 | 18.73 | 18.73 | 18.80 |
| Root Zone Cooling   | 0 ppm                            | 10.50 | 13.88 | 14.57 | 15.47 | 15.83 | 16.25 | 16.47 |
|                     | 500 ppm                          | 11.44 | 15.70 | 16.86 | 17.87 | 18.48 | 18.83 | 19.08 |
|                     | 1000 ppm                         | 8.44  | 10.94 | 11.44 | 12.99 | 14.92 | 15.53 | 15.78 |
|                     | 1500 ppm                         | 12.78 | 16.58 | 17.59 | 17.69 | 17.87 | 18.62 | 18.77 |
|                     | 2000 ppm                         | 12.78 | 16.67 | 17.52 | 21.39 | 21.42 | 24.33 | 24.37 |

Table 2 shows the average height of potato plants from the age of 1 to 7 WAP due to root zone treatment and application of various concentrations of leaf fertilizers. Overall, the increase in plant height from 1 WAP to 2 WAP was higher than in the following weeks. Potato plant height grow very slowly. When there is an increase in plant height, it is possibly because the plants need additional nutrients that are higher than the nutrients provided in AB mix because leaf fertilizer is only given to plants at the age of 1 to 4 WAP.

The aeroponic unit with a chiller (root zone cooling) had a nutrient temperature range of 27-29°C during the day and 20-22°C at night, while the aeroponic unit without a chiller (without cooling) had a nutrient temperature range of 28-29°C during the day and 21-23°C at night. The burning of potato shoots...
can be caused by the high temperature of the air above the plant during the day which reaches 35.9°C and night temperatures reaching 25°C [6]. Potato plants without root zone cooling got burnt wilt since the age of 5 WAP (Figure 1), while potato plants in the root zone cooling treatment started burnt wilt at the shoots for 6 WAP, thus the measurement of height parameter had to stop at 7 weeks (Figure 2). This shows that the root zone cooling treatment is able to inhibit burnt wilting of plant shoots due to high air temperatures. Root zone temperature at conditions above the optimal temperature required by plants can cause water shortages in the plant canopy, thereby changing the balance of water absorption by roots and loss of water from shoots [10].

![Figure 1](image1.png)

**Figure 1.** Potato plants in the control temperature experienced burnt wilt on the shoots at 5 weeks at concentration (a) 0 ppm, (b) 500 ppm, (c) 1000 ppm, (d) 1500 ppm, (e) 2000 ppm.

![Figure 2](image2.png)

**Figure 2.** Potato plants with root zone cooling treatment experienced burnt wilt on the shoots at 6 WAP at concentration (a) 0 ppm, (b) 500 ppm, (c) 1000 ppm, (d) 1500 ppm, (e) 2000 ppm.

3.2. *The effect of root zone cooling and leaf fertilizer concentration treatment on number of stolons per plant, number of tuber per plant, and percentage of effective stolons*

Table 3 shows the potato plants with root zone cooling and 500 ppm of leaf fertilizer (T1P1) forming stolons and successfully forming mini potato tubers. From the results above, it can be stated that potato plants treated with root zone cooling showed better tuber growth than those without root zone cooling treatment (control). This is in accordance with previous research on application root zone cooling treatment on aeroponic system by Sumarni *et al.* that the number of tubers with high potential was obtained in the 19°C in afternoon, which was 119 bulbs/m², 72 bulbs/m² at 19°C during the day, and 51 bulbs/m² in the 15°C day and night cooling zone [11].
Table 3. Average number of stolons, number of tubers per plant and percentage of effective stolons on plant due to the root zone treatment and concentration of leaf fertilizer treatment.

| Treatment | Number of Stolon | Number of Tubers per Plant | Effective Stolon (%) |
|-----------|-----------------|-----------------|---------------------|
|           | 4 WAP | 5 WAP | 6 WAP | 7 WAP | | |
| Root zone cooling and 500 ppm concentration of leaf fertilizer | 0.44 | 0.56 | 0.78 | 1.11 | 0.33 | 29.73 |

The potato plant grown with root zone cooling treatment and given 500 ppm concentration of leaf fertilizer formed stolons since 3 WAP. At that age, the tubers have not yet formed, but tuber initiation had occurred. Tubs were formed in the fourth week after the leaf fertilizer treatment. The tip of the stolon looks swollen at the age of 3 weeks and then at the age of 4 weeks the tubers were formed. Effective stolons are stolons that can form tubers [12]. The percentage of effective stolons is the ratio of the number of stolons forming the tubers to the total number of stolons per plant multiplied by 100%. The average number of stolons can be seen in Table 3. Potato plants with root zone cooling treatment formed more stolons and produced a higher percentage of effective stolons (29.73%) than potato plants with control temperature. High root temperature results in an increase in plant height due to elongation and an increase in the number of stem internodes, which is due to the increased content of gibberellin acid due to high temperatures [13]. This stimulates the growth of the upper part of the plant through the increase and extension of cells, while the increase in gibberellin acid can inhibit tuber initiation [14].

3.3. The effect of root zone cooling and leaf fertilizer concentration treatment on wet weight and dry weight of tubers per plant

Table 4 shows the average wet weight of tubers per plant which does not reach 1 g (<1 g). The average tuber wet weight and tuber dry weight per plant in the T1P1 were 73.6 mg and 29.8 mg. Based on the Badan Standarisasi Nasional, the standard of fresh potato tuber fresh weight is large (> 10 g), medium (1–10 g), and small (<1 g) tuber weight, the mini tubers produced in this study included in the weight of small tubers (<1 g) [15].

According to Liu et al., a relatively high temperature of 24°C can cause the activity of several enzymes in starch metabolism to be suppressed, resulting in a decrease in starch content in tubers and inhibit the conversion of sugar into starch [16]. Some research results indicate that dry matter accumulation can be delayed due to soil temperatures that exceed 24°C. This is because the rate of respiration will increase where most of the carbohydrates will be used for respiratory activities [6] [13].

Table 4. Average tubers fresh and dry weight per plant due to the root zone treatment and concentration of leaf fertilizer treatment.

| Treatment | Parameter | Tubers Fresh Weight (mg) | Tubers Dry Weight (mg) |
|-----------|-----------|--------------------------|------------------------|
| Root zone cooling and 500 ppm concentration of leaf fertilizer | 73.6 | 29.8 |

3.4. The effect of root zone treatment and leaf fertilizer concentration treatment on plant dry weight

Based on the ANOVA test (Table 5), it shows that root zone treatment has a significant effect on plant dry weight and concentrations of leaf fertilizer has a very significant effect on plant dry weight and the interaction between both treatments was significantly affected the dry weight of potato plants. This
shows that the different responses of potato plants to various concentrations of leaf fertilizers depend on root zone treatment. The potato plants without the root zone cooling treatment did not produce tubers.

**Table 5.** The effect of root zone cooling and leaf fertilizer concentration treatment on plant dry weight.

| Parameter               | Treatment | CV T (%) | CV P (%) |
|-------------------------|-----------|----------|----------|
| Plant Dry Weight (mg)   | T         | P        | TxP      |
|                        | 35.76 *   | 11.03 ** | 7.25 **  |

ns: has no significant effect; * significant; **: very significant; CV: Coefficient of Variation; T: Root zone treatment; P: Concentration of Fertilizer; TxP: Interaction Between root zone treatment and concentration of leaf Fertilizer

**Table 6.** Average plant dry weight due to the root zone cooling and concentration of leaf fertilizer treatment.

| Treatment                        | Parameter          |
|----------------------------------|--------------------|
| **Root Zone Treatment**          | Plant Dry Weight (mg) |
| Control (without cooling)        | 665.73 a           |
| Root zone cooling                | 730.40 a           |
| **Leaf Fertilizer Concentration**|                    |
| Control (0 ppm)                  | 656.44 ab          |
| 500 ppm                          | 751.28 c           |
| 1000 ppm                         | 709.28 b           |
| 1500 ppm                         | 692.94 b           |
| 2000 ppm                         | 624.83 a           |

The numbers followed by the same letter in the same column show no significant difference in the DNMRT test ($\alpha = 0.05$)

In the treatment, concentrations of leaf fertilizer showed a very significant effect on plant dry weight. The heaviest dry weight was in the 500 ppm leaf fertilizer concentration which was 751.28 mg, and the increase in the concentration of leaf fertilizers caused the decreased of the plant dry weight.

In Table 6, it can be seen that plants grown in root zone cooling treatment had a heavier dry weight (730.40 mg) when compared to plants without cooling treatment (665.73 mg), although, in the DNMRT test the two of them were not significantly different. The results of research by Sumarni et al also showed that the cooling temperature of the root area was 15°C, pump pressure > 1.5 atm gave the highest number of tubers per plant, while plants with control temperature or without cooling did not produce any tubers at all [17].

The high ambient temperature and the aeroponic tub temperature which was also still above the standard temperature for potato seedling caused at least stolons and tubers to be formed in this study. Figure 3 shows the comparison of potato plant growth in the root zone treatment with concentrations of leaf fertilizers. The addition of 500 and 1000 ppm of N leaf fertilizer caused the number of stolons and the number of tuber initiations tend to be higher than other treatments. Meanwhile, the higher leaf fertilizer concentration of up to 2000 ppm can inhibit tuber initiation [18]. In her research, Dianawati used a 13.72% of N leaf fertilizer while in this study using Growmore leaf fertilizer consist 32% of N. Mishra stated that giving excessive N to plants could potentially delay or prevent the formation of tubers, tuber quality and decreased tuber yield as was the case in this study [9]. The delay in tuber formation caused by excessive N allocation occurred due to low carbon translocation from leaves to tubers, while N translocation to leaves increased [4].
Figure 3. 7 WAP potato plants (a) potato plants were grown without cooling on various concentrations of leaf fertilizer (b) potato plants were grown with root zone cooling on various concentrations of leaf fertilizer.

Table 7. Interaction of root zone treatment and leaf fertilizer concentration treatment on average dry weight of potato plants.

| Root Zone Treatment | The Concentration of Leaf Fertilizer (mg) |
|---------------------|------------------------------------------|
|                     | Control (P₀)                             | 500 ppm (P₁) | 1000 ppm (P₂) | 1500 ppm (P₃) | 2000 ppm (P₄) |
| Control (without cooling) | 583.11 Aa | 733.22 Ba | 680.67 Ba | 730.33 Ba | 601.33 Aa |
| Root zone cooling   | 729.78 Bb | 769.33 Ba | 737.89 Ba | 655.56 Aa | 648.33 Aa |

The numbers followed by the same letter show no significant difference (vertical lowercase and horizontal capital letters) on the DNMRT test (α = 0.05)

Table 7 shows the interaction between root zone cooling treatment and leaf fertilizer concentration. Plants grown in control (without cooling) treatment had a trend increase the dry weight of the plant by the increase in of leaf fertilizer concentration from 0 ppm (control) to 500 ppm, but when the concentration is increased to 2000 ppm the dry weight of the plant has decreased. This can also be seen in the plants grown in root zone cooling treatment, which the dry weight increased in the concentration of the 500 ppm and 1000 ppm, while the increase in the 1500 ppm and 2000 ppm caused the plant dry weight to decrease. The heaviest plant dry weight was seen in the root zone cooling treatment and the concentration of leaf fertilizer at 500 ppm (769.33 mg). Moreover, that combination treatments resulted in 3 mini potato tubers with an average weight of 662 mg (Figure 4).

Figure 4. Stolons in potato plants (a) Stolons that form tubers (b) Stolons that do not form tubers
4. Conclusions
The potato plant grown in root zone cooling treatment formed tubers, while plants without cooling system did not produce tubers. The concentration of Growmore leaf fertilizer (32:10:10) 500 ppm resulted in the heaviest average dry weight of potato plants (751.28 mg). The interaction between the two treatments had a very significant effect on plant dry weight. The best treatment was found in the combination of root zone cooling with 500 ppm leaf fertilizer that form tubers.

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References
[1] Adiyoga W, Suherman R, Soetiarso T A, Jaya B, Udiarto B K, Rosliani R and Mussadad D 2004 Profil komoditas Kentang (Bandung: Balai Penelitian Tanaman Sayuran)
[2] Kementerian Pertanian 2019 Produksi Kentang Menurut Provinsi , Tahun 2015-2019 vol 2019 p 2019
[3] Diny D, Handayani T and Sofiari E 2017 Tolerans Tanaman Kentang ( Solanum tuberosum ) terhadap Suhu Tinggi Berdasarkan Kemampuan Berproduksi di Dataran Medium [ Heat Stress Potato ( Solanum tuberosum ) Tolerance Based on Tuber Production in Medium Altitude ] J. Hortik. 27 1–10
[4] Corrêa R M, Pinto J E B P, Pinto C A B P, Faquin V, Reis É S, Monteiro A B and Dyer W E 2008 A comparison of potato seed tuber yields in beds, pots and hydroponic systems Sci. Hortic. (Amsterdam). 116 17–20
[5] Suhardiyanto H 2009 Teknologi Rumah Tanaman untuk Iklim Tropika Basah, Pemodelan dan Pengedalian Lingkungan (Bogor: IPB Press)
[6] Sumarni E, Suhardiyanto H, Seminar K B and Saptomo S K 2013 Pendinginan Zona Perakaran ( Root Zone Cooling ) pada Produksi Benih Kentang menggunakan Sistem Aeroponik Root Zone Cooling on Seed Potato Production using Aeroponics System 41 154–9
[7] Hayati R, Synthia D, Marliah A and Munawar A A 2021 Water sorption isotherm of Aceh Rice (Oryza sativa): Study on chemical properties and characteristics Int. J. Agric. Technol. 17 1753–66
[8] Munawar A A and Sabaruddin Z 2021 Fast classification of rice (Oryza sativa) cultivars based on fragrance and environmental origins by means of near infrared spectroscopy IOP Conf. Ser. Earth Environ. Sci. 644 012003
[9] Mishra N 2018 Effect of Fertilizers on Growth and Productivity of Potato Int. J. Agric. Sci. 10 5183–6
[10] Sellin A and Kupper P 2007 Temperature, light and leaf hydraulic conductance of little-leaf linden (Tilia cordata) in a mixed forest canopy Tree Physiol. 27 679–88
[11] Sumarni E, Sumartono G H and Saptomo S K 2013 Aplikasi Zone Cooling pada Sistem Aeroponik Kentang Di Dataran Medium Tropika Basah J. Keteknikan Pertan. 1 99–106
[12] Kusumiyati, Hadiwijaya Y, Putri I E and Munawar A A 2021 Enhanced visible/near-infrared spectroscopic data for prediction of quality attributes in Cucurbitaceae commodities Data Br. 39 107458
[13] Alexopoulos A, Aivalakis G, Akoumianakis K and Passam H 2008 Effect of gibberellic acid on the duration of dormancy of potato tubers produced by plants derived from true potato seed Postharvest Biol. Technol. 49 424–30
[14] Hamdani J S 2009 Pengaruh Jenis Mulsa terhadap Pertumbuhan dan Hasil Tiga Kultivar Kentang (Solanum tuberosum L.) yang Ditanam di Dataran Medium J. Agron. Indones. (Indonesian J. Agron. 37 14–20
[15] Badan Standarisasi Nasional 1992 Kentang segar (Jakarta: BSN)
[16] Liu F, Jensen C R, Shahanzari A, Andersen M N and Jacobsen S E 2005 ABA regulated stomatal control and photosynthetic water use efficiency of potato (Solanum tuberosum L.) during progressive soil drying Plant Sci. 168 831–6
[17] Sumarni E, Sudarmaji A, Suhardiyanto H and Saptomo S K 2016 Produksi Benih Kentang Sistem Aeroponik dan Root Zone Cooling dengan Pembedaan Tekanan Pompa di Dataran Rendah J. Agron. Indon. (Indonesian J. Agron. 44 299
[18] Dianawati M, Ilyas S, Wattimena G A and Susila A D 2013 Produksi Umbi Mini Kentang Secara Aeroponik Melalui Penentuan Dosis Optimum Pupuk Daun Nitrogen J. Hortik. 23 47