RESEARCH ARTICLE | FEBRUARY 06 2024

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AIP Conf. Proc. 2957, 040041 (2024)
https://doi.org/10.1063/5.0184990

Growth and Yield of Arugula *(Eruca vesicaria* ssp. sativa) in Static Hydroponic with $CaCl_2$ Application

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Abstract. Arugula (*Eruca vesicaria* ssp. sativa*)* is a leaf vegetable plant from the *Brassicaceae family*. The high calcium content in Arugula tissue made it one of the recommended sources of nutrients. However, the dynamics of tissue formation and calcium content in Arugula plants depend on the cultivation practices. To intensify Arugula cultivation, hydroponic techniques can be an option. Plant inputs according to the need is beneficial for nutritional efficiency. This study aimed to evaluate the effect of $CaCl_2$ application on the growth and yield of Arugula plants in a static hydroponic system. The research was conducted between April – July 2021 at Jakarta AIAT greenhouse. Five levels of $CaCl_2$ application, namely: 1) 0 ppm as control, 2) 350 ppm, 3) 450 ppm, 4) 550 ppm, and 5) 650 ppm, were tested in a completely randomized block design with 5 replications. AB Mix 750 ppm solution was given as the essential treatment in this study. The results showed that the $CaCl_2$ application was not affected significantly either on plant height or wet weight. AB Mix solutions application without the addition of $CaCl_2$ was sufficient to increase plant height, number of leaves, total weight, as well as root weight. In conclusion, the $CaCl_2$ application did not improve the Arugula's growth and yield. However, application of 450 ppm $CaCl_2$ gave the lowest risk of crop failure (5%) compared to other treatments.

INTRODUCTION

Arugula is a type of lettuce plant. Lettuce is a favored vegetable plant because of its crisp and fresh taste. This lettuce has the potential to be cultivated because the demand and the price are quite high. Arugula, also known as rocket lettuce, is usually used as a sandwich filling or salad mix. Rocket lettuce has a slightly spicy taste [1].

Furthermore, this vegetable is usually used as a burger filling, sprinkling soup or pasta, or flavoring ingredient with a distinctive spicy taste. Most varieties of Arugula have thin leaves. The flowers are also edible, with yellow or white blooms. This vegetable also contains high sulfur, the so-called sulforaphane, which gives a bitter taste that can inhibit the growth of melanoma cancer, esophagus, prostate, and pancreas [2]. The arugula is also useful for helping maintain healthy bones and teeth, muscle and nerve function, as well as helping the blood clotting process, heart health, and helping people with high blood pressure [3]. In addition, Arugula contains Folic acid (Vit B9) 97 mg, Ascorbic Acid/Vitamin C (15 mg), Fillohinon/Vitamin K (108.6 g), potassium (369 mg), Calcium (160 mg) and contains other compounds that are needed by the human body [4].

The vegetable requirement increases continuously. However, it was not supported by the increasing area of land used to develop their cultivation. To overcome the problem, it is necessary to find alternative cultivation, one of which is hydroponics. With a hydroponic system, lettuce cultivation does not require a large area and does not depend on environmental conditions. Plants get their nutrition and oxygen from water as well as nutrient and mineral solutions [5] and arranged according to the plant requirement [6] and carried out in a controlled environment [7]. This cultivation

Proceedings of the 1st International Conference on Food and Agricultural Sciences (ICFAS) 2022
AIP Conf. Proc. 2957, 040041-1–040041-7; https://doi.org/10.1063/5.0184990
Published by AIP Publishing. 978-0-7354-4817-9/$30.00

system can be carried out with or without substrate [8] or only by using water as a growing medium. Thus, plants will steadily grow without soil whenever water, nutrients, and other support substances are provided [9].
The hydroponic system is divided into active and passive systems. A passive hydroponic system does not require any pump, one of which is a wick system [10]. This system is the simplest because it uses an intermediate axis as a conduit for nutrient solution to supply the plants in a net pot with a nutrient solution.

Hydroponic Nutrition (AB Mix) is formulated according to the plant type, vegetables, or fruit plants. According to Sutiyoso [11], the A nutrition contains Calcium Nitrate, Fe, and Potassium Nitrate. While B nutrition contains KH_2PO_4, Mono Ammonium Sulfate, Potassium Sulfate, Magnesium Sulfate, Manganese Sulfate, Cupro sulfate, Zinc sulfate, Sour borate, Ammonium HeptaMolybdate or Sodium Molybdate. The nutrient solution in hydroponics comes from AB Mix [12]. AB Mix is an organic fertilizer that contains complete nutrients because there are micro fertilizers (A) containing potassium and macro fertilizers (B) containing sulfates and phosphates. AB Mix nutrition is given through planting media so plants can grow optimally [13].

Calcium chloride ($CaCl_2$) is one of the inorganic compounds shaped as a crystalline solid with silvery white, soluble easily/hygroscopic in water, and odorless. It is a type of salt consisting of the elements Calcium (Ca) and Chlorine (Cl) [14]. Ca is one part of the amylase enzyme and is present in the form of Ca Oxalate and Ca Carbonate crystals. Besides that, Calcium is also the most crucial nutrient after the essential elements (N, P, and K) as a supply of plant nutrients [15].

Calcium (Ca) in plants plays the most important role in cell growth, caring for cell walls found at the growing point of roots, cell division and elongation, and regulating the distribution of photosynthetic products. The addition of 650 ppm of $CaCl_2$ gave a significant effect on the fresh weight of Lolorosa lettuce, even though the addition of $CaCl_2$ did not significantly affect the number of leaves and plant height [16]. Moreover, the addition of $CaCl_2$ as much as 250-350 ppm will provide a growth response on lettuce during sowing [17]. Lack of Ca may disrupt the formation and growth of roots, as nutrient absorption is inhibited. In addition, it causes the growing point of the plant to be weak, changes in leaf shape, curl, small, and eventually fall off, the plant is not stocky, and flower production is inhibited and falls off [18]. Furthermore, a lack of Ca in plants will cause the cessation of mitosis and the occurrence of abnormal cells with double nuclei. This causes stunted root growth, causing damage to the plant, causing changing color, and death [19]. With such conditions, it is necessary to add nutrients, which are expected to increase the Ca content in the tissue plants. However, the Ca additional should be adjusted to the plant's needs. Excess Ca leads to poisoning (toxic), which precisely inhibits plant growth. Conversely, lacking Ca results in non-optimal plant growth [20]. The $CaCl_2$ application might improve the Ca content, which plays a role in strengthening plant tissue and increasing the crispness of vegetable crops [21]. $CaCl_2$ in solution also strengthens cell walls and inhibits hydrolysis, which causes the breakdown of pectin and starch [22]. This study aimed to evaluate the effect of the $CaCl_2$ application on the growth and yield of Arugula plants in a static hydroponic system. Information on the exact amount of $CaCl_2$ needed by lettuce in a hydroponic system is useful for nutritional efficiency purposes.

MATERIALS AND METHOD

Time and Place

The research was carried out between April - July 2021 at the Greenhouse of Jakarta Assessment Institute for Agricultural Technology (BPTP Jakarta) Jl. Raya Ragunan No. 30, Jati Padang, Pasar Minggu, South Jakarta, DKI Jakarta 12540.

Tools and Materials

The equipment used, i.e., hydroponic tubs (capacity 8 L), net pot, ruler, scale, bucket, stationery, tray, measuring cup, TDS, and pH meters. The materials used were the arugula seeds of the Ishana variety, sponge, impraboard, $CaCl_2$, AB Mix, label, water, and marker.

Design Experimental

Five levels of a single treatment in the form of CaCl (P) application, namely: without CaCl as a control (P_0), 350 ppm CaCl (P_1), 450 ppm CaCl (P_2), 550 ppm CaCl (P_3), and 650 ppm CaCl (P_4) tested in a completely randomized block design with 5 replications and treatment unit size of 4 plants. Each of the five treatments was given basic

treatment in the form of an application of 750 ppm AB Mix Full. A*nalysis of Variance* (ANOVA) analyzed all observation data, and if the effect was significant, then the *Duncan Multiple Range Test* (DMRT) was followed. The main observation parameters include plant height, number of leaves, fresh biomass weight, root length, root weight, and percentage of plant mortality. Plant height was measured from the base of the stem to the end leaf highest. Determination of the number of leaves only on leaves which has opened perfectly. The total wet weight of the plants was measured at harvest using a digital scale. After the root tissue was separated from other tissues, it was weighed similarly to determine the root weight. The plant mortality rate is determined at harvest by calculating the percentage.

Stages of Research Implementation

1. Sowing. The sowing medium used was a sponge sized 4×3 cm and split as deep as 1.5 cm. Before sowing, the seeds were soaked in warm water for 10-15 minutes, then the seeds were drained and sown on a sponge placed on a tray which was placed in a place protected from sunlight. Watering was done every day and watering with the addition of 300 ppm AB Mix was carried out when the plants were 7 days to 14 days old. After the seeds germinate, the tray is placed in a place exposed to sunlight.
2. Preparation of Nutrient Solutions. 1). Preparation of AB Mix solution. Several milliliters of AB Mix A fertilizer and AB Mix B fertilizer were dissolved in a water bath (8 L) to the specified ppm, to obtain the starter solution. 2). Preparation of $CaCl_2$ solution. $CaCl_2$ was dissolved with 8 liters of water until the concentration according to the treatment was obtained. For $CaCl_2$ 350 ppm required $CaCl_2$ 2 g / 8 L of water, 450 ppm required $CaCl_2$ 2.5 g / 8 L of water, 550 ppm required 3.2 g $CaCl_2$ / 8 L of water, and 650 ppm required 4.1 g $CaCl_2$ / 8 L water.
3. Transplanting. Transplanting was done when the plant was 14 days after sowing. By moving the seedlings on the sponge into a net pot, then placing them in a hydroponic tub that has been given a nutrient solution. Plants were transferred in the afternoon, then covered with a paranet for 3 days, to adapt to the environment.
4. Provision of Nutrition Solutions. The nutrient solution was given by using the root solution from AB Mix (A and B), namely when transplanting (14 days). Meanwhile, the addition of $CaCl_2$ was given twice. The first was when the arugula was 1 WAP, while the second was given at 2 WAP.
5. Maintenance. The maintenance carried out includes controlling the pest, ppm and water pH. Pest control is carried out mechanically by cleaning the plant parts that have fleas. The control of solution concentration and pH was carried out using a TDS meter and a pH meter. Controls are carried out twice a week.
6. Harvesting. Harvesting was carried out on the 6th week in the afternoon so that the plant samples do not wither quickly. Furthermore, data were collected according to the observed parameters, including plant height, number of leaves, plant wet weight, and plant root weight, which was carried out once a week, starting at 14 dap until the plants were ready to be harvested (6 weeks). The percentage of dead plants was measured at the time of harvesting.

RESULTS

The average temperature conditions during the study ranged from 31−36°C. The implementation of planting and providing nutrition was carried out according to the treatment. However, plant growth conditions from transplanting to harvesting appeared to be suboptimal. This was indicated by the color of stems and leaves becoming dark green and reddish, the leaf structure becoming tougher and the segments becoming smaller and shorter. Symptoms of plants that are less adaptive at high temperatures are reddish leaf color, dryness, and burning of the leaves, the flow of respiration and water absorption become chaotic which causes dehydration due to high temperatures [23]. The sub-optimum growth of Arugula probably due to the hot temperature in the lowlands was not suitable for Arugula [24,25].

From the aspect of plant growth, the addition of $CaCl_2$ did not significantly affect the increase of plant height between treatments. Although there was a tendency to increase plant height when given 450 and 650 ppm of $CaCl_2$. The addition of leaves occurred at the age of 3 weeks after planting on average. At 6 weeks after planting, the addition of 650 ppm $CaCl_2$ gave the highest number of leaves compared to the addition of 550 ppm. Even though the application of $CaCl_2$ affected significantly the root weight, it was not affected significantly on the wet weight.

Plant Height (cm).

The main product of arugula cultivation is the canopy of leaf biomass, which is essential for consumption. The crown growth was assessed based on the response to the parameters of plant height and the number of leaves. The observations showed that the application of $CaCl_2$ did not significantly affect the height of the Arugula plant during the study period (Table 1). Arugula plant height ranged from 6.26 to 7.67 cm at the end of the study.

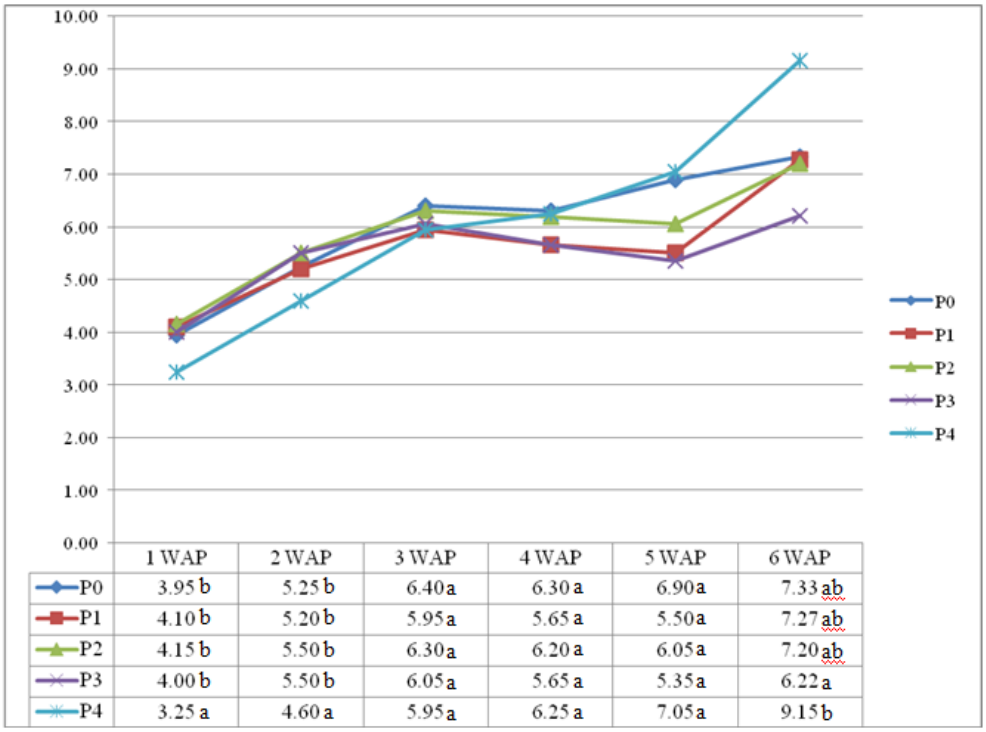
TABLE 1. The effect of $CaCl_2$ on plant height of Arugula

Treatment	Plant Height (cm)					
	1 WAP	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
P_0 (AB Mix 750 ppm)	1.91[a]	2.73[a]	3.60[a]	4.57[a]	5.45[a]	6.46[a]
P_1 (AB Mix 750 ppm + $CaCl_2$ 350 ppm)	2.07[a]	2.71[a]	3.50[a]	4.24[a]	5.09[a]	6.25[a]
P_2 (AB Mix 750 ppm + $CaCl_2$ 450 ppm)	2.04[a]	3.33[a]	4.26[a]	5.28[a]	6.38[a]	7.67[a]
P_3 (AB Mix 750 ppm + $CaCl_2$ 550 ppm)	2.03[a]	2.92[a]	3.71[a]	4.47[a]	5.30[a]	6.32[a]
P_4 (AB Mix 750 ppm + $CaCl_2$ 650 ppm)	1.82[a]	2.90[a]	3.65[a]	4.41[a]	5.27[a]	7.39[a]

Numbers followed by the same letter on the same column were insignificantly different based on DMRT level 5%

Number of Leaves (strand)

The formation of Arugula leaf tissue was shown to be affected by the $CaCl_2$ application (Figure 1). However, the pattern of the effect of $CaCl_2$ is reasonably varied between the sequences of the study period. In the first two weeks, $CaCl_2$ treatment increased the number of Arugula leaves, except for the P4 treatment. At the age of third week to the fifth week, the leaf formation was not significantly different. On the contrary, at the end of the study period, the variation in leaf formation was significantly different, with the lowest range of 6.22 strands on P3 plants and the highest of 9.15 strands on P4 plants. However, the single use of AB Mix without the addition of $CaCl_2$ was sufficient to increase the number of leaves. This is probably due to the Ca content in AB Mix being sufficient to meet the needs of plants.



	1 WAP	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
P0	3.95 b	5.25 b	6.40 a	6.30 a	6.90 a	7.33 ab
P1	4.10 b	5.20 b	5.95 a	5.65 a	5.50 a	7.27 ab
P2	4.15 b	5.50 b	6.30 a	6.20 a	6.05 a	7.20 ab
P3	4.00 b	5.50 b	6.05 a	5.65 a	5.35 a	6.22 a
P4	3.25 a	4.60 a	5.95 a	6.25 a	7.05 a	9.15 b

FIGURE 1. The effect of $CaCl_2$ application on the formation of Arugula leaves

Root Growth

Parameters of total plant weight and root weight were used to evaluate the growth response of Arugula roots to the application of $CaCl_2$ (Table 2). The results showed that the application of $CaCl_2$ treatment only significantly affected the plant root weight, but not on the wet weight. Administration of $CaCl_2$ tended to suppress root growth when compared to control plants. Whereas the risk of plant death varied among the treatments tested. P2 plants showed the lowest risk of death compared to others, which was only 5%. The plant's performance displayed on Figure 2.

TABLE 2. The effect of $CaCl_2$ application on total wet weight, root weight, and plant mortality rate

Treatment	Wet weight (g)	Root weight (g)	Mortality Rate (%)
P_0 (AB Mix 750 ppm)	27.13[a]	0.69[c]	10
P_1 (AB Mix 750 ppm + $CaCl_2$ 350 ppm)	27.35[a]	0.43[ab]	10
P_2 (AB Mix 750 ppm + $CaCl_2$ 450 ppm)	31.47[a]	0.35[a]	5
P_3 (AB Mix 750 ppm + $CaCl_2$ 550 ppm)	27.46[a]	0.48[ab]	25
P_4 (AB Mix 750 ppm + $CaCl_2$ 650 ppm)	29.04[a]	0.66[bc]	15

Numbers followed by the same letter on the same column were insignificantly different based on DMRT level 5%

FFIGURE 2. Sowing stage at the age of 2 weeks (A); At the age of 6 WAP (B); Leaves performance of Aragula (C)

DISCUSSION

This study's results indicate that adding $CaCl_2$ to a hydroponic solution with 750 ppm AB Mix did not significantly affect the plant height parameters (Table 1) but had a significant effect on leaf formation (Figure 1). This contradiction can be explained by using the plant height parameter, which is a measure of the highest leaf blade, which looks less accurate in describing the growth of the whole leaf crown of Arugula. This causes the plant height parameter not to show a positive correlation with the number of leaf formation parameters. However, the results of another study showed the effect of increasing plant height through the application of $CaNO_3$ and $CaCl_2$ in potatoes [26], curly lettuce [27], and tomato [28].

The hydroponic solution in this study used nutrient sources from AB Mix, which contained quite complete nutrients, from a mixture of micro fertilizers (A), which had potassium and macro fertilizers (B) with sufficient sulfate and phosphate content [13]. The addition of 650 ppm $CaCl_2$ to the hydroponic solution was proven to have an increasing effect on the leaf formation of P_4 plants (Figure 1). It is known that the element Ca in plants plays an important role in cell growth, maintains cell walls at the point of root growth, cell division, and elongation, and regulates the distribution of photosynthetic products [20]. The pattern of response to the formation of the number of Arugula leaves (Figure 1) in this study confirmed the importance of the Ca function. In addition, the results of this study also confirmed that the use of 750 ppm AB Mix on control plants (P_0) could still be enriched with the addition of $CaCl_2$ to stimulate increased leaf formation in Arugula plants. The study on tomato plants also found the same result, that $CaCl_2$ could increase the leaf number [28]. Sufficient Ca elements can increase cell permeability and plant photosynthetic activity.

On the other hand, the application of $CaCl_2$ in the hydroponic solution of this study did not provide regularity of its effect on the weight of the biomass of the arugula roots (Table 2). This means that the Ca content in the hydroponic solution with a source of 750 ppm AB Mix is sufficient to support the development of the root tissue of the Arugula plant. These results align with the findings by Nugraheni *et al.* [29] in his study on *Crotalaria juncea*. On the other hand, a positive effect of Ca application on root tissue development was reported in curly lettuce plants [30].

The effect of $CaCl_2$ application is still a matter of debate. Using $CaCl_2$ at high doses might cause an increase in pH, followed by a lack of available micronutrients such as Zn, Cu, B, Fe, and Mn [31]. On the other hand, the $CaCl_2$ application did not risk toxic effects on plants, even at high concentrations [32]. This is because Calcium is a divalent cation that readily enters the *apoplast* and is bound in exchange from the cell wall, exterior surfaces, and cell membranes. In his study on lettuce, he found that the increase in growth occurred in line with the increase in Ca dose and aeration pressure hydroponic growing media up to 600 ppm and 0.012 mPa, respectively. Other effects of this kind of conditioning have also been shown to be effective in increasing lettuce time harvest, which is 21 days. More

applications of $CaCl_2$ at a concentration of 550 ppm gave the best results on *green lollo* lettuce, while for *lollo rossa* and *red romaine it is at* a concentration of 650 ppm.

In addition to the nutritional factors in the hydroponic solution, the response of the Arugula plant in this study is also inseparable from the influence of the microclimate. Even though it is not the focus of this research, it can be explained briefly that as an introduced plant from the subtropics, it naturally requires a habitat similar to the highlands. The microclimate at the location of this study, which is in the lowlands (DKI Jakarta), certainly impacts temperature stress for the growth of the Arugula plant. The factors that affect plant hydroponics growth could distinguish between primary and secondary factors [9]. The primary factors included raw water, mineral and nutrition/fertilizer, media plants, and seeds. At the same time, the secondary factors (environment) included light, oxygen, temperature, humidity, rainfall, and wind.

CONCLUSION

Generally, the yield of the arugula plants appeared to be suboptimal and showed the symptom of less adaptive. Applying $CaCl_2$ in a hydroponic solution with a nutrient base of 750 ppm AB Mix was not significantly affected on the growth and yield of arugula plants. Either the plant height or the wet weight was not affected significantly by the $CaCl_2$ application. Even though the addition of 750 ppm $CaCl_2$ has increased the number of leaves at 6 WAP, the single use of AB Mix solutions without $CaCl_2$ addition was sufficient to increase plant height, number of leaves, total wet weight, as well as root weight. However, the application of 450 ppm $CaCl_2$ provided the lowest risk of crop failure (5%).

ACKNOWLEDGEMENTS

The authors would like to thank Jakarta Assessment Institute for Agricultural Technology (BPTP Jakarta) for the research facilities.

REFERENCES

1. Pertanian UMA [Internet]. Medan: Faculty of Agriculture, Universitas Medan Area [cited 2022 March 1]. Available from: https://pertanian.uma.ac.id/tipe-selada-yang-potential-dibudidayakan-hidroponik.
2. J.K. Kim, and S.U. Parks, Experiment. Clinic. Sci. J. **15**, 571–577 (2016).
3. K. Shubha, A. Mukherjee, M. Tamta, and T.K. Koley, Agri. Food. **1**, 22301 (2019).
4. United States Department of Agriculture [Internet], Arugula FDC ID: 169387 NDB Numbers: 11959; 2019 [cited 2021 January 21]. Available from: https://fdc.nal.usda.gov/fdc-app.html#/food-details/169387/nutrients.
5. M.J.B. Fernandes, B.A. da Costa, and J.M. Lemos, "Hydroponics Greenhouse Crop Optimization," Thesis, Instituto Superior Técnico, 2018.
6. K. Al-Kodmany, J. Buildings **8(2)**, 24 (2018).
7. A.D. Susila, *Planning Technical Technology Hydroponics System is floating* (Institut Pertanian Bogor, Bogor, 2017).
8. I.S. Roidah, Jurnal Universitas Tulungagung BONOROWO **1(2)**, 43–49 (2014).
9. Susilawati, *Dasar-Dasar Bertanam Secara Hidroponik* (Unsri Press. University Sriwijaya, Palembang, 2019).
10. S. Swastika, A. Yulfida, and Y. Sumitra, *Budidaya Sayuran Hidroponik: Bertanam Tanpa Media Tanah* (Balai Pengkajian Teknologi Pertanian Riau, Pekanbaru, 2018).
11. Y. Sutiyoso, *Meramu Pupuk Hidroponik: Tanaman Sayuran, Tanaman Buah, Tanaman Bunga* (Penebar Swadaya, Jakarta, 2003).
12. A.D. Susila, *Fertigasi Pada Budidaya Tanaman Sayuran di dalam Greenhouse* (Fakultas Pertanian, Institut Pertanian Bogor, Bogor, 2006).
13. S.A. Pohan, and Oktoyournal, Journal Study Agriculture. **18(1)**, 20–32 (2019).
14. T. Alfionita, and R. Zainul, *Calcium Chloride (CaCl2): Characteristics and Molecular Interaction in Solutions* (Faculty of Math and Science. Universitas Negeri Padang. West Sumatra, 2019).
15. H.H. Widodo, Sudradjat, Agrohort. Bul. **4**, 276–281 (2016).
16. S. Kamalia, P. Dewanti, and R. Soedrajad, J. Agrotech. **11(1)**, 96–104 (2017).
17. J.S.T. Siregar, and D. Suhandy, *Agric. Technic*, **4**, 65–72 (2015).

18. C. Hanum, *Teknik Budidaya Tanaman Jilid 1* (Direktorat Pembinaan Sekolah Menengah Kejuruan, Jakarta, 2008).
19. Djukri, "Regulasi ion kalsium (Ca^{++}) dalam tanaman untuk menghadapi cekaman lingkungan," in *Prosiding Seminar Nasional Penelitian, Pendidikan, dan Penerapan MIPA* (Fakultas MIPA, Universitas Negeri Yogyakarta, Yogyakarta, 2009.
20. S.W. Ningsih, "Biofortification of Calcium (Ca) Mustard (*Brassica juncea* L.) and Lettuce (*Lactuca sativa*) with Floating Raft Hydroponic System," M.Sc. thesis, Sriwijaya University, 2020.
21. S. Kamalia, "The Effect of CaCl2 Concentration on Axis Hydroponic Nutrient System on the Quantity and Quality of Production of Three Varieties of Lettuce (*Lactuca sativa* L.)," M.Sc. thesis, University of Jember, 2017.
22. E.M. Faiqoh, N. Elmaulida, "Effect of Concentration and Soaking Time in $CaCl_2$ (Calcium Chloride) on Quality and Shelf Life of Super Red Dragon Fruit (*Hylocereus costaricensis*)," M.Sc. thesis, State Islamic University Maulana Malik Ibrahim Malang, 2014.
23. I.W. Wiraatmaja, *Suhu, Energi Matahari, dan Air dalam Hubungan dengan Tanaman* (Fakultas Pertanian, Universitas Udayana, Bali, 2017).
24. M. Ichimura, A. Noguchi, and M. Kimura, J. Agric. Sci. **53**, 1–4 (2008).
25. J. Jasper, C. Wagstaff, and L. Bell, Postharvest Bio. Tech. **163**, 1–11 (2020).
26. Y.W. Seifu and S. Deneke, J. Hort. **4**, (1–4) 2017.
27. N.N. Suryantini, G. Wijana, and R. Dwiyani, Journal of Agrotrop. **10**, 190–200 (2020).
28. M.C. Ayub, M.A. Pervez, M.R. Shaheen, M.I. Ashraf, M.W. Haider, S. Hussain, and N. Mahmood, Pakistan Journal of Life and Social Science. **10**, 102–105 (2012).
29. I.T. Nugraheni, Solichatun, and E. Anggarwulan, J. Biosmart. **5**, 98–101 (2003).
30. P.H. Almeida, F. Mógor, A.Z. Ribeiro, and J. Heinrichs, Aust. J. Basic App. Sci. **10**, 161–167 (2016).
31. R. Breemer, P. Picauly, and F.J. Polnaya, J. Tech. Agricult. Agritech. **4**, 56–62 (2015).
32. L.A. Wulandari, T.A. Siswoyo, and K. Hariyono, "Concentration Effect and Time of Application of $CaCl_2$ on the Physicochemistry of Tomato Fruit (*Lycopersicum esculentum* Mill.)," M.Sc. thesis, University of Jember, 2019.