Agronomic response of kangkung plants typical of Lombok Island with a hydroponic system treated with \textit{Trichoderma} bionutrients

I M Sudantha\textsuperscript{1}, Suwardji\textsuperscript{2}, N L P N Sriwarthini\textsuperscript{3}
\textsuperscript{1}Agroecotechnology Study Program, Faculty of Agriculture University of Mataram, Mataram, Indonesia
\textsuperscript{2}Soil Science Study Program, Faculty of Agriculture University of Mataram, Mataram, Indonesia
\textsuperscript{3}Primary School Teacher Education Study Program, Faculty of Teacher Training and Education, University of Mataram, Mataram, Indonesia

*Corresponding Author: sudantha@unram.ac.id

Abstract. The kangkung (\textit{Ipomoea aquatica} Forsk) is water spinach typical of Lombok Island, Indonesia with a crunchy texture and distinctive taste. It is very easy to be cultivated in the home garden organically in soil media, also to be planted hydroponically and aquaponically. Hydroponic system cultivation is the cultivation of plants by utilizing water without using soil with an emphasis on meeting the nutritional needs of plants. One of the nutrients that has good prospects is the Trichoderma bionutrient which is made from a mixture of bioactivator and biourin. The purpose of this study was to determine the agronomic response of water spinach plants typical of Lombok Island with a hydroponic system treated with Trichoderma bionutrients. The study used an experimental method carried out in a plastic house with a hydroponic system. The study used a completely randomized design with hydroponic nutrition treatment consisting of 6 levels, namely: without bionutrients, with bioactivator bionutrients, with biourin bionutrients, with a mixture of bioactivator and biourin, with AB mix nutrition, with a mixture of Trichoderma bionutrients and Ab mix nutrients. Each treatment was repeated 4 times so that there were 24 experimental units. The results showed that the treatment with a mixture of bionutrients with a mixture of bioactivators and Trichoderma biourin was as good as AB mix nutrition in promoting growth and wet weight of kangkung typical of Lombok Island.

Keywords: Agronomic, kangkung, Lombok Island, hydroponics, bionutrition, \textit{Trichoderma}

1. Introduction

Water spinach (\textit{Ipomoea reptans} Pair) is an important vegetable crop in Southeast Asia and South Asia. This vegetable is easy to cultivate and short-lived to harvest. In addition to vegetables, water spinach contains certain compounds that are useful for the pharmaceutical industry [1].

The best water spinach in Indonesia is Lombok kangkung, with a crunchy texture and distinctive taste [2]. Lombok's typical kangkung has a high quality with the characteristics of bright, attractive, and wide light green leaves [3]. Physically, Lombok kangkung is very easy to recognize from its fat, green and very fresh shape, inelastic and easily broken. Another specialty is the average length of 30-40 cm. [1]

Kangkung Lombok is generally cultivated in rice fields and rivers with irrigation from river water. Cultivation of water spinach in the river is carried out by installing a fence made of bamboo so that the planted water spinach is not washed away by the flow of river water, while the cultivation of water spinach is carried out in the fields by utilizing river water with a stagnant water system. The obstacle to kangkung cultivation is that river water is difficult to control, especially during the rainy season which causes flooding and the dry season the water discharge is greatly reduced. This causes the kale harvested area to decrease every year. In addition, river
Water has begun to be polluted by agricultural chemical waste which has reduced the quantity and quality of water spinach in Lombok [4]. The center for kangkung cultivation on Lombok Island is West Lombok with low yields, i.e. an average of 8 – 10 tons/ha, while the potential yields of kale can reach 20 – 35 tons/ha [5].

Water spinach plants grown in the fields use the remnants of existing water, besides that, kale is cultivated in rivers that have begun to be polluted by agricultural chemical waste which causes the quantity and quality of Lombok kangkung to be low. The Pb content of fresh water spinach cultivated in the upstream watershed is higher than that of the downstream. In contrast to the number of pathogenic microbes E. coli, fresh water spinach from downstream contains higher microbes than upstream [6]. Several studies have shown that water spinach can be contaminated with heavy metals such as Hg [7], Cd [8], Pb [9] and Cu [10]. Kangkung can also be contaminated by bacteria that cause diseases of food origin such as Campylobacter jejuni [11], Clostridium sp. and Bacillus sp. [12], Escherichia coli and Salmonella [13].

The market demand for Lombok kangkung, which continues to increase, has not been able to be fulfilled optimally by many kangkung farmers. The decrease in agricultural land and the low quality of kale produced by farmers are examples of problems faced in kangkung cultivation activities. The conversion of agricultural land to non-agricultural land, such as utilization for residential and industrial areas, reduces the availability of agricultural land for kangkung cultivation. Thus, a breakthrough in kale cultivation technology is needed that is environmentally friendly. One of the cultivation technologies that have good prospects is the hydroponic system. Hydroponics is a plant cultivation technique that uses planting media other than soil and utilizes water to distribute the nutrients needed so as not to cause excessive or reduced uptake [16].

An important aspect that needs to be considered in determining the success of hydroponic cultivation is plant management which includes preparation of media materials, nutrient solutions, maintenance, application of nutrient solutions, harvest and post-harvest [17]. According to Lingga [15], nutrition is the main factor that determines the success of hydroponic plant cultivation. The solution in the media must be rich in nutrients for growth. Hydroponic nutrients that are widely sold in the market and the price is quite expensive is AB Mix Fertilizer which is made from chemicals. Pohan and Oktoyournal [18] said that the nutrient A-B Mix or compound fertilizer is a solution made from chemicals that are given through the planting medium, which functions as plant nutrients so that plants can grow well. Nitisari and Wahidah [19] argue that the use of AB-Mix on water spinach plants with a hydroponic system can stimulate growth.

Hydroponic nutrients in the form of bionutrients made from cow dung waste have the potential to be developed because they are environmentally friendly. These bionutrients can be in the form of bioactivators and Trichoderma fermented biourons or a combination of both. Sudantha et al. [2] said that Trichoderma bionutrients are a source of nutrients for plants in the form of liquid derived from livestock manure from the fermentation of Trichoderma fungi which can stimulate plant vegetative growth, which is indicated by the increase in length, height, number of leaves and root length to increase the quality and quantity of crop yields. Sudantha et al. [20] reported that the fermented liquid bioactivator of Trichoderma spp. which is a stimulator inoculant containing the saprophytic fungus Trichoderma harzainum isolate SAPR0-07 can increase plant height, number of leaves and elongation of plant roots. Likewise, Sudantha et al. [21] said that the use of Trichoderma bioeurin could increase growth in height and number of leaves and increase yield.

Based on the description above, a research was conducted which aims to determine the agronomic response of water spinach plants typical of Lombok Island with a hydroponic system treated with Trichoderma bionutrients.
2. Materials and methods

The study used an experimental method that was carried out in a Green-house with a hydroponic system in Senteluk Village, Batu Layar District, West Lombok Regency.

2.1. Experimental Design

The study used a completely randomized design with hydroponic nutrition treatment consisting of 6 levels, namely: without bionutrients, with bioactivator bionutrients, with biourin bionutrients, with a mixture of bioactivator and biourin, with AB mix nutrition, with a mixture of Trichoderma bionutrients and AB mix nutrition. Each treatment was repeated 4 times so that there were 24 experimental units.

2.2. Preparation of Bionutrient BB Mix

Bionutrient BB mix is a nutrient made from a mixture of bioactivator and biourin fermented with *Trichoderma* spp. The bioactivator and biourin are made separately, after being fermented, the two bionutrients are mixed.

The process for making the bioactivator was as follows: *T. harzianum* fungus isolate Sapro-07 and fungus *T. koningii* isolate Endo-02 were grown on WA (Water Agar) medium containing 1% mixture of coffee leaf litter extract and cow manure. The mixture of coffee leaf substrate extract and cow manure was dissolved in sterile water (10 g of material/100 ml of sterile water). The mixture of coffee leaf substrate extract and cow manure was filtered through Whatman No. filter paper. 1 and sterilized by filtering method using a membrane filter (0.45 / m pore diameter). 100 ml of material extract with 900 ml of WA medium was mixed to get 1% ingredient extract, added 10 g of sugar and 0.2% yeast, then stirred until dissolved, the material extract was transferred to a sterile erlenmeyer. The fungal starter *T. harzianum* isolates Sapro-07 and *T. koningii* isolates Endo-02 were inoculated into liquid media and incubated using a fermentor [2] and [22].

The process of making biourin is as follows: cow urine is put in a holding tank, then aeration is carried out by pumping urine into a storage reservoir tower at a height of 2.5 meters using a water machine, then flowing back down through several stairs so that the urine that falls down will decompose and contact with air (aeration process), this is done for 24 hours until the urine does not smell of ammonia, because it has evaporated into the air. Furthermore, cow urine was fermented with Trichoderma spp. The method for making Trichoderma mother liquor is 50 ml of fungus culture *T. harzianum* isolate Sapro-07 and *T. koningii* isolate Endo-02 dissolved in 1 liter of water, then added 2.5 g of glucose. The material requirement for 50 liters of cow urine is 2.5 liters of mother liquor [2].

2.3. Trial Execution

The experiment was carried out in a Green-house made of mild steel measuring 3 m x 15 m, with a UV plastic roof and paranet walls. One experimental unit measuring 50 cm x 200 cm (there are 3 paralons with a length of 200 cm), the paralons are perforated with a spacing of 15 x 15 cm, thus there are 36 planting holes for kangkung seedlings.

Hydroponic kangkung growing media is made of styrofoam blocks and plastic cups. The top of the styrofoam is perforated so that the plastic cup block can enter halfway. The inside of the styrofoam block is plastic coated, so that the bottom styrofoam block does not come into direct contact with water.

The kangkung seeds used are those that sink because they are pithy and have good vigor. Next, sow the seeds by placing them on a thick cloth to hold water and wrapping them and wetting them with water so that the kangkung seeds break down into sprouts.
For one plastic cup container containing styrofoam that is inserted into the paralon requires 1 liter of water. In one experimental unit requires 36 liters of water that has been mixed with bionutrients. For one liter of water, 5 ml of bioactivator and 5 ml of biourin are added. Furthermore, at the age of 2 – 3 weeks, each bionutrient is added to 10 ml, this bionutrient water is used until harvest.

The kangkung seedlings were transferred after 3 days by transferring the seeds into a plastic cup container with a styrofoam block. Next, pour the hydroponic bionutrient solution on the paralon pipe until it hits the surface of the container and seeds. Hydroponic kangkung plant care by supervising and paying attention to the nutrients or water spinach needs for nutrients in liquid form. When the water spinach enters the age of 2 weeks, the concentration of the solution is added. Hydroponic kangkung is harvested at the age of 30 days after planting the seeds, when the kale leaves are still fresh green and do not look old or have not flowered.

2.4. Observation Variable
Observation variables are: Plant growth includes plant height, number of leaves, root length. The yield of kangkung includes weight per plant and weight in one experimental unit.

2.5. Data analysis
Data from observations were analyzed using Analysis of Variance (ANOVA) with a 5% level of significance using Minitab for Windows Rail. If there are variations, further testing is carried out using the Honestly Significant Difference (HSD) at the 5% level.

3. Results and Discussion
The results of the analysis of diversity on growth data and yields of Lombok kangkung showed that the nutritional treatment in hydroponics was significantly different. The results of further tests using HSD 0.05 to find out between treatments that were significantly different are presented in Tables 1 and 2.

Table 1. Average height and number of leaves of kangkung typical of Lombok Island treated with Bionutrients at the age of 30 days after planting.

| No. | Nutrition Treatment                      | Planting height (cm) | Number of leaves (strands) | Root Length (cm) |
|-----|------------------------------------------|----------------------|----------------------------|------------------|
| 1.  | Without Nutrients                        | 15.6 a              | 6.0 a                      | 15.0 a           |
| 2.  | Bionutrient Bioactivator                 | 30.8 b              | 12.0 b                     | 22.6 b           |
| 3.  | Bionutrient Biourin                      | 30.6 b              | 12.0 b                     | 22.5 b           |
| 4.  | Bioactivator and Biourin mixture (BB-Mix)| 38.5 c              | 15.0 c                     | 25.5 c           |
| 5.  | Nutrition AB-Mix                         | 88.0 c              | 14.0 c                     | 24.8 c           |
| 6.  | BB and AB Mix                            | 38.2 c              | 14.0 c                     | 24.5 c           |

Notes: 1 Numbers followed by the same letter are not significantly different in the 0.05 HSD Test

Table 1 shows that all treatments with nutrients were significantly different with control or without nutrition on plant height, number of leaves and root length. The nutrient treatment that most stimulated plant growth was a mixture of bioactivator and biourin (BB-Mix) which was not significantly different from AB-Mix nutrition and a mixture of BB-Mix and AB-Mix. The role of BB mix bionutrients and AB mix nutrition in promoting hydroponic kangkung plant growth is thought to be closely related to the content of each nutrient.

Bionutrient BB mix is a nutrient made from a mixture of bioactivator and biourin fermented with Trichoderma spp. bioactivator and biourin are made separately with different
basic ingredients and after being fermented then mixed together. Sudantha et al. [2] reported that bioactivator and biourin are solutions containing macro and microbial nutrients, namely N 3.10%, P2O5 3.50%, K2O 4.0%, pH 6.5; C-organic 7.50%; CEC 17.90 cmol kg⁻¹; C/N ratio 12.0; contains Trichoderma spp. 48 x 10⁶ propagules/ml bioactivator, yeast fungus Saccharomyces, and bacteria Lactobacillus. These macro nutrients can stimulate plant growth, in addition to the presence of the fungus Trichoderma spp. can stimulate the growth of plant roots and shoots as revealed by Sudantha [23]. Ethylene is a hormone produced by the fungus Trichoderma spp. which stimulates plant root growth [24]. The fungus T. harzianum produces hormones that have the same role as Benzyl Amino Purine Growth Regulators (BAP), which can stimulate plant root length, plant height and leaf shoot formation [20]. The successful use of Trichoderma spp. Hydroponic nutrition has also been reported by several foreign researchers, namely: The use of Trichoderma for hydroponic nutrition can increase root mass, increase plant shoots and disease resistance [25], [26], [27], [28], [29] and [30].

Hidayati et al. [31] said that the use of AB-Mix on hydroponic kangkung plants can increase plant height. Similarly, Nitasari and Wahidah [19] said that hydroponic water spinach media from AB-Mix could increase the growth of kangkung plants. Nugraha [32] said that AB mix is a nutrient solution consisting of stock A which contains macro nutrients such as N, P, K, S, Ca and Mg; while stock B contains micro nutrients such as Mn, Cu, Zn, Cl, Cu, Na, Cad and Mg. According to Winda [33], macronutrients function to stimulate plant height growth and plant roots, while micronutrients function as constituents of enzymes and vitamins. The success of using AB mix nutrition has also been reported by other researchers, namely: AB mix nutrition can increase red spinach plant height and number of leaves [34]. Hydroponic media has more advantages, namely faster growth, cleaner results and can also be planted anywhere even on a narrow land/place. [19]

Table 2. Average weight per kangkung plant and total weight in one paralon treated with Bionutrients at 30 days after planting.

| No. | Nutrition Treatment | Fresh kangkung weight per plant (g) | Fresh kangkung weight per experimental unit (g) |
|-----|---------------------|--------------------------------------|-----------------------------------------------|
| 1.  | Without Nutrients  | 3.6 a ¹                             | 129.6 a ¹                                     |
| 2.  | Bionutrient Bioactivator | 5.8 b                                 | 208.8 b                                       |
| 3.  | Bionutrient Biourin | 5.6 b                                 | 201.6 b                                       |
| 4.  | Bioactivator and Biourin mixture (BB-Mix) | 8.5 c                                 | 306.6 c                                       |
| 5.  | Nutrition AB-Mix   | 7.3 c                                 | 262.8 c                                       |
| 6.  | BB and AB Mix      | 7.4 c                                 | 266.4 c                                       |

From Table 2 it can be explained that the addition of nutrients in hydroponic kangkung showed a significant difference with control or without nutrition on the weight of fresh kangkung per plant and fresh kangkung weight per experimental unit. All nutritional treatments could increase the weight of fresh kangkung, but the nutrient that significantly increased the weight of fresh kangkung was a mixture of bioactivator and biourin (BB-Mix) which was not significantly different from AB-Mix nutrition and a mixture of BB-Mix and AB-Mix. The difference in weight of fresh water spinach due to nutritional treatment is thought to be due to the content of nutrients and the different roles of each of these hydroponic nutrients. The same thing happened in several studies, namely: AB mix nutrition can increase the wet weight of red spinach [34]. Muhadiansyah et al. [35] said that mixing liquid organic fertilizer and AB Mix for hydroponics can increase the fresh weight of lettuce. Setiawati et al. [36] reported that the use of organic growing media and AB Mix can increase the yield of cherry tomatoes in a hydroponic system.
From the results of this study, it can be said that AB Mix nutrients have the same role as BB Mix bionutrients in increasing plant fresh weight. However, the advantages of BB Mix are that the nutrients contained are organic elements and there are microbes, namely *Trichoderma* spp. which plays a role in stimulating the vegetative and generative growth of plants because it produces hormones in the form of IAA, IBA and BAP, besides that it can act as a decomposer of organic matter so that it is more easily absorbed by plants. For example, the use of *Trichoderma* spp. on shallots can increase the dry weight of harvest [37], [38] and [39], and on soybeans it can increase the weight of seeds [40].

4. Conclusion

The results showed that the treatment with a mixture of bioactivator and *Trichoderma* biourin (BB mix) was as good as the AB mix in promoting growth and wet weight of kangkung typical of Lombok Island. BB mix bionutrients can be used as a substitute for AB mix if it is not available in hydroponic kangkung cultivation.

Acknowledgements

Thank you to the Indonesian National Innovation Research Agency, the Rector of the University of Mataram and the Head of the Institute for Research and Community Service at the University of Mataram for providing community service scheme funds in the form of the Technology Product Program Disseminated to the Community (PTDM) for the 2021 Fiscal year.

References

[1] Djuariah, D. 1997. Evaluasi Plasma Nutfah Kangkung di Dataran Medium Rancaekek. *J. Hort.* 7 (3): 756-762.

[2] Sudantha, I M., Suwardji dan N L. P. N. Sriwarthini, 2021. *Produksi Bioaktivator Dan Biourin Fermentasi Trichoderma Dari Limbah Kotoran Sapi Untuk Nutrisi Hidroponik Kangkung Khas Puluau Lombok*. Laporan Program Produk Teknologi yang Diseminasi ke Masyarakat (PTDM). Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Mataram-Badan Riset dan Inovasi Nasional RI, Mataram.

[3] Abidin, Suwama, Veggel.1990. Pengaruh Cara Penanaman, Jumlah Bibit dan AplikasiPemberian Pupuk Nitrogen Terhadap Pertumbuhan Dan Hasil Kangkung Darat (*Ipomoea reptans* Poirs.) Pada Tanah Latosol Subang. *Bull.*

[4] Sridanti, N. K. dan I M. Sudantha. 2005. *Penerapan Teknologi Budidaya Kangkung Khas Pulau Lombok menggunakan Kompos Trichon dan Sistem Aliran Air Terus-Menerus di kelurahan Pagesangan Kota Mataram NTB*. Laporan IPTEKS. Fakultas Pertanian Universitas Mataram.

[5] Asosiasi Komoditas Kangkung Lombok. 2011. *Persyaratan Indikasi Geografis*. Mataram NTB.

[6] I Wayan Sweca Yasa, Zainuri dan M. Abbas Zaini. 2015. Efektivitas Perlakuan Ozon Terhadap Mutu Kangkung Khas Lombok Yang Dibudidayakan Pada Dua Lokasi Berbeda. *Pro Food* (Jurnal Ilmu dan Teknologi Pangan) Vol 1 No. 1 Mei 2015 ISSN online: 2443-3446. http://jurnal.unram.ac.id/index.php/profood/index

[7] Sofyan, M. 2012. *Pemanfaatan Tanaman Kangkung Air (Ipomea Aquatic Forsk.) Sebagai Indikator Perairan Tercemar Merkuri*. http://www.sobatbumi.com / inspirasi/view/543. Diakses tanggal 4 April 2013.
[8] Asmawati, A., T. Paulina, dan L. Syarifuddin, 2009. Fitoakumulasi Logam Berat Timbal, Krom, Dan Kadmium Dari Tanah Menggunakan Tanaman Kangkung Darat (Ipoma reptans poir). Teknosain. http://repository.unhas.ac.id/handle/123456789/3524. Diakses tanggal 4 April 2013.

[9] Mulyani, S., I.G.L. Triani dan A. Sujana, 2012. Identifikasi cemaran logam Pb dan Cd pada kangkung yang ditanam di kota Denpasar. Jurnal Bumi Lestari 12 (2) : 345-349.

[10] Kohar, I., Hardjo, P. H., dan Lika, I. I. 2004. Studi Kandungan Logam Pb dalam Batang dan Daun Kangkung (Ipomoea reptans) yang Direbus dengan Penmahan NaCl dan Asam Asetat. Jurnal Kimia Sains, 8 (3) : 85-88.

[11] Sahilah, A.M., T. Suraya, T. S., I. Noraida., A. A. Azuhairi, L.C. Chai and R. Son, 2010. Detection of virulence genes and enterobacterial repetitive intergenic consensus-PCR (ERIC-PCR) analysis among raw vegetables isolates of Campylobacter jejuni. International Food Research Journal 17: 681-690.

[12] Anshari K. L. O., 2010. Identifikasi Mikroba Dari Jaringan Tanaman Kangkung darat (Ipomeae reptans Poir). Fakultas Pertanian. Universitas Hasanuddin. Makasar

[13] Misgiyarta, 2008. Menurunkan Kontaminasi Mikroba pada Buah dan Sayuran Segar. Warta Penelitian dan Pengembangan Pertanian 30 (6): 3-5.

[14] Lingga, P. 2007. Hidroponik Bercocok Tanam Tanpa Tanah. Penebar Swadaya. Jakarta.

[15] Lingga, P. 1985. Petunjuk Penggunaan Pupuk. Cetakan ke- 10. Penebar Swadaya. Jakarta.

[16] Pertanian, T. 2014. Tanaman Kangkung pada Sistem Irigasi Hidroponik NFT (Nutrient Film Technique ). Vol. 1. pp. 2–6.

[17] Rosliana, R dan N. Sumarni, 2005. Budidaya Tanaman Sayuran dengan sistem hidroponik. Jurnal Monografi No. 27. Balai Penelitian Tanaman Sayuran.

[18] Pohan, S. A. dan Oktoyournal. 2019. Pengaruh Konsentrasi Nutrisi A-B Mix terhadap Pertumbuhan Caisim secara Hidroponik (Drip System). Jurnal Lambung Vol. 18, No. 1, Januari 2019. DOI: 10.32530/lambung.v18i1.179.

[19] Nitasari, L. dan B. F. Wahidah. Perbandingan Pertumbuhan Tanaman Kangkung Pada Media Hidroponik dan Media Tanah. Prosiding Seminar Nasional Biologi di Era Pandemi COVID-19 Gowa, 19 September 2020 http://journal.uin-alauddin.ac.id/index.php/psb/

[20] Sudantha, I.M., IGPM. Aryana, Suwardji, I. Jayadi, I M A. Pramadaya. 2021. Growth and yield response of shallots applied with growth regulators benzyl amino purine (GR BAP) and liquid bioactivator of Trichoderma harzianum fungus. Proceeding International Conference on Science (ICST). Jilid 2. 149-160.
http://proceeding.unram.ac.id/index.php/icst/article/view/88
[21] Sudantha, I. M., Suwardji, dan I. G. P. M. Aryana. 2019. Desiminasi Pembuatan Bioaktivator, Biokompos Dan Bioarin Limbah Kotoran Sapi Dengan Teknologi Fermentasi Trichoderma dan Aplikasinya Untuk Meningkatkan Hasil Bawang Merah. Laporan Akhir Produk Teknologi yang di Desiminasikan ke Masyarakat Kementerian Riset, Teknologi dan Pendidikan Tinggi Tahun Anggaran 2019.

[22] Sudantha, I M. 2019. Formulasi Biofungisida dan Bioaktivator Bahan Aktif Jamur Trichoderma koningii Isolat Endo-02 danT. harzianum Isolat Sapro-07. Paten Greanted No. Sertifikat Granted IDP000058447 tanggal 7 Mei 2019.

[23] Sudantha, I. M. 2007. Karakterisasi dan Potensi Jamur Endofit dan Saprofit Antagonistik Sebagai Agens Pengendali Hayati Jamur Fusarium oxysporum f. sp. vanillae Pada Tanaman Vanili di Nusa Tenggara Barat. Disertasi Program Pascasarjana Universitas Brawijaya, Malang. 337 hal.

[24] Salisbury, F. B. and C. W. Ross, 1995. Fisiology Tumbuhan Jilid 3. Perkembangan tumbuhan dan fisiologi Tumbuhan (Terjemahan D. R. Lukman dan Sumaryono). Penerbit ITB Bandung.

[25] Anonymous. 2014. Combining Trichoderma with other Beneficial Hydroponics Products. 2014. https://www.advancednutrients.com/articles/combining-trichoderma-with-other-beneficial-hydroponics-products/

[26] Anonymous. 2021. General Hydroponics BM Trichoderma harzianum. https://www.visionofhemp.ch/shop5/de/ghe-terra-aquatica/2263-general-hydroponics-bm-trichoderma-harzianum.html

[27] Morgan, L. 2021. *Trichoderma in Hydroponic Systems*. https://bestseedbank.com/trichoderma-in-hydroponic-systems/

[28] Neumann, B. J. 2003. *The effects of Trichoderma (Eco-T®) on biotic and abiotic interactions in hydroponic systems*. Doctor of Philosophy in the Discipline of Plant Pathology School ofApplied Environmental Sciences Faculty of Science and Agriculture University of Natal Pietermaritzburg Republic of South Africa.

[29] Hernández, H. 2019. Effect of foliar application of *Trichoderma* on the quality of tomato fruits grown in different hydroponic substrates. *Folia Hort.* 31(2) (2019): 355-364. DOI: 10.2478/fhort-2019-0028

[30] Iris Yedidia, I; A. K. Srivastva. Concentrations and Increased Growth of cucumber plants. *Plant and Soil* 235: 235–242, 2001

[31] Hidayati, N., Pienyani Rosawanti, Fitriadi Yusuf dan Nanang Hanafi. 2017. Kajian Penggunaan Nutrisi Anorganik Terhadap Pertumbuhan Kangkung (Ipomoea reptans Poir) Hidroponik Sistem Wick. *Jurnal Daun*, Vol. 4 No. 2, Desember 2017 : 75-81.

[32] Nugraha, R. U. 2014. *Sumber Hara Sebagai Pengganti AB mix pada Budidaya Sayuran Daun Secara Hidroponik*. DEpartemen Agronomi dan Hortikultura. Institut Pertanian Bogor.

[33] Windia, Y. 2013. *Dinamika Unsar Hara Makro di Dalam Tanah dan Tanaman*. Rineka Cipta. Jakarta.
[34] Hidayanti, L. dan T. Kartika. 2019. Pengaruh Nutrisi AB Mix Terhadap Pertumbuhan Tanaman Bayam Merah (Amaranthus tricolor L.) Secara Hidroponik. Jurnal Ilmiah Matematika dan Ilmu Pengetahuan Alam. Volume 16 No. 2, Desember 2019. DOI 10.31851/sainmatika.v16i1.3214 https://jurnal.univpgri-palembang.ac.id/index.php/sainmatika.

[35] Muhadiansyah, T.O., Setyono, S. A. Adimihardja. 2016. Efektivitas Pencampuran Pupuk Organik Cair dalam Nutrisi Hidroponik pada Pertumbuhan dan Produksi Tanaman Selada. Jurnal Agronida ISSN 2441-2541 Volume 2 Nomor 1, April 2016.

[36] Setiawati, R., T. Septirosya, M. Irfan, dan I Permanasari. 2020. Pertumbuhan dan Hasil Tanaman Tomat Cherry pada Sistem Hidroponik dengan Media Tanam Organik dan Nutrisi AB Mix. Jurnal Pertanian Presisi Vo. 4 No. 2 Desember 2020.

[37] Sudantha, I M. and S. Suwardji. 2021. The effect of biocompost Trichoderma spp. tablet in stimulating shallot growth and yield for climate change adaptation. 6th International Conference on Climate Change 2021 IOP Conf. Series: Earth and Environmental Science 824 (2021) 012032 IOP Publishing doi:10.1088/1755-1315/824/1/012032. https://iopscience.iop.org/article/10.1088/1755-1315/824/1/012032/pdf

[38] Sudantha, I M. and S. Suwardji. 2021. Trichoderma biofungicides formulations on shallot growth, yield and fusarium wilt disease resistance. 6th International Conference on Climate Change 2021 IOP Conf. Series: Earth and Environmental Science 824 (2021) 012032 IOP Publishing doi:10.1088/1755-1315/824/1/012032. https://iopscience.iop.org/article/10.1088/1755-1315/824/1/012032/pdf

[39] Sudantha, I. M., S. Suwardji, I G.P.M. Aryana, I M. A. Pramadya, I. Jayadi. 2020. The Effect of Liquid Bio Fungicides Dosage Trichoderma spp. against Fusarium Wilt Diseases, Growth and Yield of Onion. Journal of Physics: Conference Series 1594 (2020) 012013. IOP Publishing. doi:10.1088/1742-6596/1594/1/012013. https://iopscience.iop.org/article/10.1088/1742-6596/1594/1/012013/meta

[40] Elham K., M. A. Javeda, F. Huyop, S. Rayatpanah, S. Jamshidic and R. A. Wahab. 2016. Evaluation of Trichoderma isolates as potential biological control agent against soybean charcoal rot disease caused by Macrophomina phaseolina. Biotechnology & Biotechnological Equipment, 2016 Vol. 30, No. 3, 479–488. http://dx.doi.org/10.1080/13102818.2016.1147334