



EFFECT OF VARIOUS SUBSTRATES IN NON-CIRCULATING HYDROPONIC SYSTEMS AND SOIL MEDIA ON THE GROWTH OF *Gynura procumbens*

Hanik Faizah¹, Ikhlasotul Fawaidah¹, Najmatul Millah¹, Ninik Fadhillah¹, Muh. Ma'arif¹
Department of Biology, Faculty of Science and Technology, UIN Sunan Ampel Surabaya, Jl. A.Yani No. 117,
Surabaya, East Java, Indonesia
Email korespondensi: hanikfaizah@uinsby.ac.id

Received: October 2020; Revised: November 2020; Accepted: December 2020

ABSTRACT

The limitations of conventional soil cultivation in producing medicinal plants emerge an interest in searching various alternative cultivation systems, one of which is the hydroponic system. This study aimed to investigate the effect of various substrates in non-circulating hydroponic systems and soil media on the growth of *Gynura procumbens*. Non-circulating hydroponic cultivation of *Gynura procumbens* was carried out using stem cuttings. The stem cuttings were transferred to each net pot containing substrates such as rockwool, tree fern fiber, and sawdust. The net pots were then placed in a tray comprising AB mix 6 ml/L of water. The lower 2-cm-portion of the net pots was immersed in a nutrient solution. Whereas in the conventional soil cultivation, the stem cuttings were transferred to the polybags containing soil media: compost (1: 1). After 28 days of cultivation, the plant growths were measured. The results showed that the use of various substrates in non-circulating hydroponics increased plant growth compared to conventional soil cultivation. Rockwool treatment obtained the highest number of leaves (14.833 ± 5.269 strands), number of roots (20.333 ± 6.121 stands), fresh weight (1.34 ± 0.511 g) and dry weight (0.088 ± 0.031 g).

Keywords: substrates, non-circulating hydroponic, plant growth, *Gynura procumbens*

Introduction

Gynura procumbens is a medicinal plant commonly found in tropical Asian countries such as Indonesia, Malaysia, China, Vietnam, and Thailand (Tan *et al.*, 2016). The plant is known in Indonesia as "Sambung Nyawa" which means "prolongation of life". It is generally used in the treatment of fever, constipation, migraine, kidney disease, hypertension, cancer, and diabetes mellitus (Perry and Metzger, 1980). The plant has been reported to exhibit various pharmacological activities including antioxidant, antimicrobial, anti-inflammatory, anticancer, organ protective, antihyperglycemic, and antihyperlipidemic activities (Kaewseejan *et al.*, 2015; Zheng *et al.*, 2014; Shwter *et al.*, 2014; Zahra *et al.*, 2011; Hassan *et al.*, 2010; Li *et al.*, 2015).

Because of its great health benefits, *G. procumbens* has been widely used as raw materials for manufacturing drugs by the pharmaceutical

industry. In addition, the plant is also used in various products in the cosmetic and food industries. The commercial importance of the plant as industrial raw materials has resulted in high demand for biomass (Tan *et al.*, 2016). Overharvesting on the natural resources will cause loss of genetic diversity and habitat destruction, whereas conventional cultivation on soil media (open field) has many limitations because it is influenced by the climate, geographic or topographical conditions, and requires large areas of land and large water volume. In addition, in soil media, the availability and concentration of nutrients vary and are difficult to control (Beibel, 1964). Therefore, many efforts have been attempted to develop alternative methods for plant cultivation.

Hydroponic is one of the alternatives and potential methods in overcoming the limitations of conventional soil cultivation. Hydroponics is a

method of plant cultivation using mineral nutrient solutions without soil as a planting medium (soilless cultivation)(Beibel, 1964). Hydroponic is a technology that can better control the availability of water and nutrients, increase crop productivity, and reduce pesticide use. The method is especially useful in areas where the soil or climate is not suitable for plant cultivation (Sheikh, 2006). The use of hydroponic methods has been proven to be more productive than conventional methods. In the greenhouse experiment, hydroponic cultivation has an average yield of 20-25% higher than conventional soil cultivation (Mugundhan et al., 2011). Mairapetyan et al. (2013) reported that the use of different types of hydroponic systems increased the productivity of the medicinal plants such as *Mentha piperita* L., *Salvia officinalis* L., *Ocimum basilicum* L., *Bidens tripartita* L., and *Leonurus quinquelobatus* Gilib.

One of the simplest types of hydroponic systems is non-circulating hydroponic. This system results in high productivity, cost-effectiveness, and efficient use of water or land. The system does not require aeration and circulation, so it does not need electricity and pumps. Several studies have shown the successful application of non-circulating hydroponic systems in growing various plants such as lettuce (*Lactuca sativa* L.), tomato (*Lycopersicon esculentum* Mill.), and cucumber (*Cucumis sativus* L.) (Kratky, 2005; Kratky et al., 2008; Mahlangu et al., 2016).

The hydroponics method of plant production requires a substrate to support the plant root system. The substrate can be in an organic form such as pine bark, peat, sawdust, and so on. They can also be in the form of inorganic minerals such as rockwool, sand, gravel, and others (Giurgiu et al., 2014). The use of various substrates such as rockwool, perlite, coconut coir, sawdust, pumice, and maize shredded stems have been reported to increase the growth of various plants (Jensen, 2010; Tzortzakis and Economakis, 2008; Klados and Tzortzakis, 2014). The selection of a suitable substrate is very important because it relates to the irrigation system (Giurgiu et al., 2014). The ability of the substrate to hold nutrient water will affect plant growth. However, there has been no type of substrate that can be used universally in various cultivation conditions, so it is very important to determine the type of substrate that ensure optimal and stable chemical-physical and nutritional conditions in growing a plant species in certain hydroponic systems (Maucieri et al., 2019).

The use of hydroponic systems due to the limitation of cultivation in soil media requires the

appropriate substrate to optimize plant growth. Hence, it is needed to investigate and compare the plant growth in soil media and hydroponic systems using various substrates. To the best of our knowledge, the effect of various substrates in a hydroponic system and soil media on plant growth have been reported in many plants (Pelesco and Bontor, 2013; Mulyadi et al., 2013; Saroh et al., 2017), however, there have been no related studies regarding the growth of *G. procumbens*. Therefore, this study was conducted to determine the effect of various substrates in non-circulating hydroponic systems and soil media on the growth of *G. procumbens*.

Materials and Methods

The research was conducted at the Integrated laboratory of UIN Sunan Ampel Surabaya. The research methods used a completely randomized design with four treatments and six replications. The treatments were non-circulating hydroponic cultivation using three substrates such as rockwool, sawdust, tree fern fiber, and conventional soil cultivation using soil media on polybags. The plant materials used were *G. procumbens* which were maintained in polybags with a mixture of soil media: organic fertilizers (1: 1). Trays with a size of 30 x 32.5x 12 cm were used as a growing system. The nutrients used in this study were AB mix 6 ml / L of water (Wibowo et al., 2018).

The non-circulating hydroponic system used in this study was a modification of the methods of Kratky (2004) and Pelesco and Bontor (2016). Cultivation of *G. procumbens* was carried out using stem cuttings. The stems of the plant were cut at a slope of 45° with a length of 5 cm from the tip of the plant. Apical buds and all the leaves were removed but two leaves were left. The remaining leaves were then cut in half crosswise. Stem cuttings were transferred to the net pots which have been filled with a substrate as much as 2/3 of the net pot volume. The substrates used were rockwool, tree fern fiber, and sawdust.

The net pots containing the stem cutting with each substrate were then placed in a tray (30 x 32.5x 12 cm) comprising AB mix 6 ml/L of water. The lower 2-cm-portion of the net pots was immersed in a nutrient solution (Figure 1). Whereas in the conventional soil cultivation (control treatment), the stem cuttings were transferred to the polybags containing soil media: compost (1: 1). After 28 days of cultivation, the plants were harvested. The numbers of leaves, the numbers of roots, fresh and dry weights of the plants

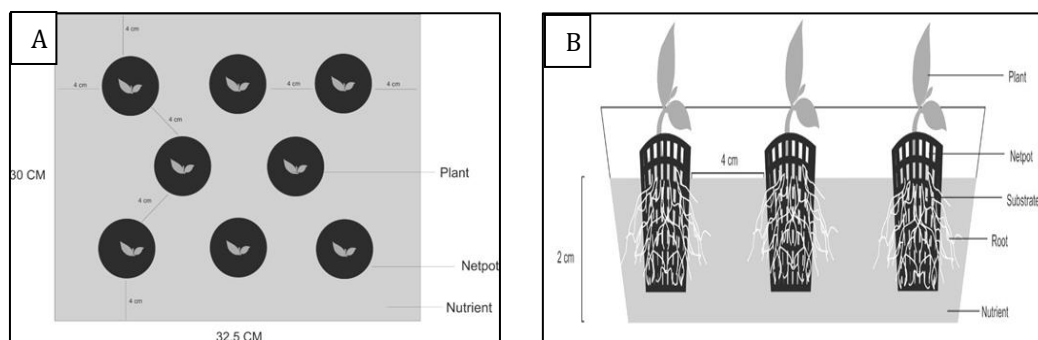


Figure 1. Schematic of non-circulating hydroponic system (A - top view; B - side view).

were measured. The Data were statistically analyzed using SPSS version 24. Data were subjected to Duncan's Multiple Range Test and reported as means \pm standard deviation(S.D.). A probability of $p \leq 0.05$ was considered to be significant.

Result and Discussion

The result of plants yields in all treatments of various substrates in non-circulating hydroponic system had a normal and healthy leaf, stem, and root morphology similar to the control treatment in the soil medium (Figure 2). The success of growing plants using a non-circulating hydroponic system was also reported by Pelesco and Bentor (2016), in which the lettuce grown in a non-circulating hydroponic system produced healthy plants similar to the plants grown using conventional production systems. The advantage of using a non-circulating hydroponic system is that it does not require electricity and pumps. The lower portion of the net pot is immersed in a nutrient solution so that the plants are automatically watered because all the growing media (substrate) in the net pot becomes wet due to capillary events.

The result of statistical analysis demonstrated that the use of various substrates in the non-circulating hydroponic system and soil media affected the number of leaves, fresh and dry weights of plants, but did not affect the number of roots. The use of various substrates in non-circulating hydroponic cultivation increased all observed variables of plant growth compared to the soil media cultivation. Soil media obtained the lowest number of leaves (6.333 ± 1.366 strands), number of roots (15.500 ± 2.881 strands), fresh weight (0.596 ± 0.319 g) and dry weight (0.036 ± 0.014 g) (Table 1). Gashgari et al. (2018) also reported that Cucumber and Armenian Cucumber grown using hydroponic systems produced higher growth rates than the conventional soil method. It indicated that the use of

the hydroponic method was proven to be more productive than the conventional method. The increase in plant growth is probably due to the advantages of hydroponic over soil-based systems. The nutrients in soil media are heterogeneous, the availability of nutrients and nutrient concentrations varies and is difficult to control, in the contrast, hydroponic nutrient solutions are homogeneous and formulated to provide complete nutrition for plants and can easily be changed during experiments (Beibel, 1964; Pelesco and Bentor, 2016).

Our result showed that the use of various substrates in hydroponic systems produced different responses of plant growth. Previous studies of Nurzyński (2005), Majdi et al. (2012) and Arancon et al. (2015) also showed that there were significant differences in the use of various substrates on plant growth in the variables such as the number of leaves, plant height, and total yield. Substrate plays an important role in plant growth. The substrate is needed for supporting the plant root system and also serves as a place for exchanging gas between the roots and the atmosphere outside the root substrate, and providing water and nutrients for plants. The variety of raw materials in various substrates affects plant growth and development. Each type of substrate has different characteristics so that it has different abilities to support plant growth (Asaduzzaman et al., 2015). Nurzyński (2005) and Komosa et al. (2010) reported that although applied to the same nutrients, various substrates such as sand, rockwool, wood fiber, and peat showed significant differences in nutrient content.

The present study showed that rockwool produced the highest plant yield followed by sawdust and tree fern fiber, respectively. Rockwool resulted in the highest number of leaves (14.833 ± 5.269 strands), number of roots (20.333 ± 6.121 strands), fresh weight (1.34 ± 0.511 g) and and dry weight (0.088 ± 0.031 g) compared to sawdust and

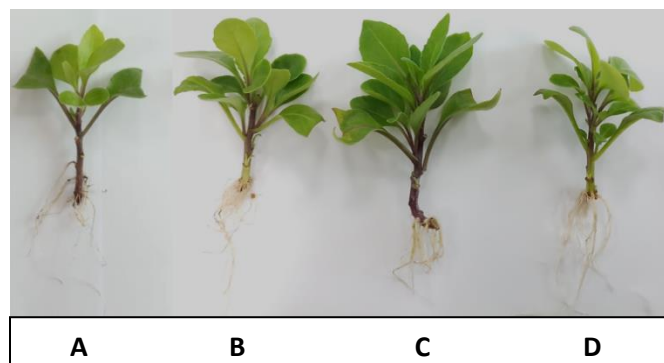


Figure 2. Morphology of stem cuttings of *G. procumbens* grown in a non-circulating hydroponic system and soil media. (A) Morphology of plants grown on soil media, (B) sawdust, (C) rockwool, and (D) tree fern fiber substrates.

Table.1 Effect of using various substrates in non-circulating hydroponic systems and soil media on the growth of *G. procumbens*

Treatment	Plant Growth			
	The number of leaves (strands)	The number of roots (strands)	Fresh Weight (g)	Dry Weight (g)
Soil media (control)	6.333 ± 1.366b	15.500 ± 2.881a	0.596 ± 0.319b	0.036 ± 0.014b
Sawdust	13.000 ± 2.449a	19.167 ± 6.585a	0.887 ± 0.524ab	0.062 ± 0.035ab
Rockwool	14.833 ± 5.269a	20.333 ± 6.121a	1.340 ± 0.511a	0.088 ± 0.031a
Tree fern fiber	10.667 ± 5.241ab	18.667 ± 9.585a	0.684 ± 0.294b	0.049 ± 0.024b

Each value represents mean ± S.D. of six replicate. Within a column, means followed by the same letter are not significantly different ($p = 0.05$) according to Duncan's Multiple Range Test.

fern substrates. Saroh et al. (2017) also reported that the use of rockwool resulted in higher lettuce (*Lactuca sativa* L) production than the sawdust substrate. Rockwool has several advantages such as not containing harmful microorganisms for plants, being porous, inert, and as noise and thermal insulation. Rockwool has a high porosity of 97.4%. A high porosity will provide good aeration and drainage. Moreover, it has a high water holding capacity. It can store water with a total volume of 374 ml / L (Urrestarazu et al., 2005). The water holding capacity of the substrate is very important because in this way plants can take nutrients and minerals from the solution at an optimal time (Giurgiu et al., 2014)

The use of sawdust substrate resulted in the average number of leaves, the number of roots, fresh and dry weights that were 13.000 ± 2.449 strands, 19.167 ± 6.585 g, and 0.887 ± 0.524 g, and 0.062 ± 0.035 g, respectively, while the use of tree fern fiber substrate resulted in the average number of leaves, the number of roots, fresh and dry weights that were 10.667 ± 5.241 , 18.667 ± 9.585 , 0.684 ± 0.294 gram, and 0.049 ± 0.024 gram, respectively. The use of tree fern fiber produced the lowest plant growth

compared to rockwool and sawdust. It is probably due to differences in the ability of these substrates to hold nutrient solution. Based on the study of Mulyadi et al. (2015), the fern substrate can hold nutrient water (16.54 ml/liter) lower than sawdust (24.88 ml/liter). However, on the contrary, the study of Mulyadi et al. (2015) showed that the use of sawdust substrate produced lower growth of tomato plants than the fern and other substrates. The high nutrient holding capacity of sawdust did not affect the growth of the tomato plant. It shows that various substrates have different effects on the growth of each plant, so the ideal substrate selection from various materials is very important to improve the productivity of each plant.

Conclusion

Our study indicated that the use of various substrates in non-circulating hydroponic systems and soil media affected the growth of *G. procumbens*. Non-circulating hydroponic systems using various substrates produced better growth of *G. procumbens* than conventional soil cultivation. Rockwool substrate produced the highest plant growth in all

observed variables such as the number of leaves (14.833 ± 5.269 strands), the number of roots (20.333 ± 6.121 strands), fresh weight (1.34 ± 0.511 g) and dry weight (0.088 ± 0.031 g). This method can be used as a simple alternative method for growing medicinal plants when there is limited land area, but it is also necessary to carry out further research to increase the plant production using various hydroponic systems.

References

- Arancon, N.Q., Schaffer, N., and Converse, C.E. (2015). Effects of Coconut Husk and Sphagnum Moss-Based media on Growth and Yield of Romaine And Buttercrunch Lettuce (*Lactuca sativa*) in a Non-Circulating Hydroponics System. *Journal of Plant Nutrition*, 38, 1218–1230. <https://doi.org/10.1080/01904167.2014.983117>.
- Asaduzzaman, M., Saifullah, M., Mollick, A.S.R., Hossain, M.M., Halim, G.M.A., and Asao, T. (2015). Influence Of Soilless Culture Substrate on Improvement Of Yield and Produce Quality Of Horticultural Crops. *Soilless Culture-Use of Substrates for the Production of Quality Horticultural Crops*. <http://dx.doi.org/10.5772/59708>
- Beibel, J. (1964). *Hydroponics-The Science Of Growing Crops Without Soil*. Florida : Department Of Agricultural.
- Gashgari, R., Alharbi, K., Mughrbil, K., Jan, A., and Glolam, A. (2018). Comparison Between Growing Plants in Hydroponic System and Soil Based System. in: *Proceedings of the 4th World Congress on Mechanical, Chemical, and Material Engineering*. Madrid, Spain : ICMIE, pp. 1–7. <https://doi.org/10.11159/icmie18.131>.
- Giurgiu, R., Morar, G., Adelina, D., Păunița, B., Duda, B., and Cristina, M. (2014). Study Regarding The Suitability Of Cultivating Medicinal Plants In Hydroponic Systems In Controlled Environment. *Research Journal Of Agricultural Science*, 46(2)), 84–92.
- Hassan, Z., Yam, M.F., Ahmad, M., and Yusof, A.P.M. (2010). Antidiabetic properties and Mechanism of Action of *Gynura procumbens* Water Extract in Streptozotocin-Induced Diabetic Rats. *Molecules*, 15 (12), 9008–9023. <https://doi.org/10.3390/molecules15129008>
- Jensen, M.H. (2001). Controlled Environment agriculture in deserts, tropics and temperate regions-A World Review, in: *International Symposium on Design and Environmental Control of Tropical and Subtropical Greenhouses* 578. pp. 19–25.
- Kaewseejan, N., Sutthikhum, V., and Siriamornpun, S. (2015). Potential of *Gynura procumbens* Leaves As Source Of Flavonoid-Enriched Fractions With Enhanced Antioxidant Capacity. *Journal of functional foods* ,12, 120–128. <https://doi.org/10.1016/j.jff.2014.11.001>.
- Klados, E. and Tzortzakis, N., 2014. Effects of Substrate and Salinity in Hydroponically Grown *Cichorium spinosum*. *Journal of Soil Science and Plant Nutrition*, 14, 211–222. <http://dx.doi.org/10.4067/S0718-95162014005000017>.
- Komosa, A., Kleiber, T., and Pirog, J. (2010). Contents of macro-and microelements in root environment of greenhouse tomato grown in rockwool and wood fiber depending on nitrogen levels in nutrient solutions. *Acta Scientiarum Polonorum Hortorum Cultus*, 9(3), 59–68.
- Kratky, B.A. (2004). A suspended pot, non-circulating hydroponic method. *Proceedings of the South Pacific Soilless Culture Conference, Acta Hort.* 648. p. 83-89.
- Kratky, B.A. (2005). Growing Lettuce in Non-Aerated, Non-Circulated Hydroponic Systems. *Journal of vegetable science*, 11(2), 35–42. https://doi.org/10.1300/J484v11n02_04.
- Kratky, B.A., Maehira, G.T., Magno, E.J., Orzolek, M.D., and Lamont, W.J. (2008). Growing Lettuce by a Float-Support Non-Circulating Hydroponic Method In Hawaii And Pennsylvania, in: *Proc. of the 34 Th National Agricultural Plastics Congress* .
- Li, X.-J., Mu, Y.-M., Li, T.-T., Yang, Y.-L., Zhang, M.-T., Li, Y.-S., Zhang, W.K., Tang, H.-B., and Shang, H.-C. (2015). *Gynura procumbens* Reverses Acute And Chronic Ethanol-Induced Liver Steatosis through MAPK/SREBP-1c-Dependent And-Independent Pathways. *Journal of agricultural and food chemistry*, 63 (38), 8460–8471. <https://doi.org/10.1021/acs.jafc.5b03504>.
- Mahlangu, R.I.S., Maboko, M.M., Sivakumar, D., Soundy, P., and Jifon, J., (2016). Lettuce (*Lactuca sativa* L.) Growth, Yield and Quality Response to Nitrogen Fertilization In A Non-Circulating Hydroponic System. *Journal of Plant Nutrition*, 39(12), 1766–1775. <https://doi.org/10.1080/01904167.2016.1187739>.
- Mairapetyan, S.K., Daryadar, M.K., Alexanyan, J.S., Tadevosyan, A.H., Tovmasyan, A.H., Stepanyan,

- B.T., and Galstyan, H.M. (2013). Comparative Description of Productivity and Content of Biologically Active Substances of Some Essential Oil-Bearing Plants In Conditions of New Water Stream Hydroponics. *Biological Journal of Armenia*, 65(3), 80–84. <https://doi.org/biology.asj-oa.am/11037/1/80>.
- Majdi, Y., Ahmadzadeh, M., and Ebrahimi, R. (2012). Effect of different substrates on growth indices and yield of green peppers at hydroponic cultivate. *Current Research Journal of Biological Sciences*, 4(4), 496–499.
- Maucieri C., Nicoletto C., Os E., Anseeuw D., Havermaet R.V., and Junge R. (2019) Hydroponic Technologies. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) A quaponics Food Production Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-15943-6_4.
- Mugundhan, R.M., Soundaria, M., Maheswari, V., Santhakumari, P., and Gopal, V. (2011). “Hydroponics”-a Novel Alternative for Geoponic Cultivation of Medicinal Plants and Food Crops. *International Journal of Pharma and Bio Sciences* 2.
- Mulyadi, M.N., Widodo, S., and Elida, N. (2015). Kajian Irigasi Hidroponik dengan Berbagai Media Substrat dan Pengaruhnya Terhadap Pertumbuhan Vegetatif Tanaman Tomat. *Berkala Ilmiah Teknologi Pertanian*, 1(1), 1–7.
- Nurzyński, J. (2005). Effect of different fertilization levels on yielding of greenhouse tomato grown on sand, peat or rockwool growth media. *Vegetable Crops Research Bulletin*, 69, 101–107. <https://www.cabdirect.org/cabdirect/20063057246>.
- Pelesco, V.A., and Bentor Jr, M.A., (2016). Head Lettuce (*Lactuca sativa L., asteraceae*) Production in a Non-Circulating Hydroponic System Under the Climatic Condition of Biliran, Philippines: A Preliminary Investigation. *Journal of Society and Technology*, 3(1), 1–7.
- Perry, L.M., and Metzger, J. (1980). *Medicinal plants of east and southeast Asia: attributed properties and uses*. MIT press.
- Saroh, M., Syawaluddin, S., and Harahap, I.S. (2017). Pengaruh Jenis Media Tanam dan Larutan Ab Mix dengan Konsentrasi Berbeda pada Pertumbuhan dan Hasil Produksi Tanaman Selada (*Lactuca sativa L*) dengan Hidroponik Sistem Sumbu. *Jurnal Agrohita*, 1(1), 29–37. <http://dx.doi.org/10.31604/jap.v1i1.191>.
- Sheikh, B.A. (2006). Hydroponics: Key to Sustain Agriculture in Water Stressed and Urban Environment. *Pak. J. Agric., Agril. Eng., Vet. Sci.*, 22, 53–57. <https://doi.org/10.1.1.514.4323>.
- Shwter, A.N., Abdullah, N.A., Alshawsh, M.A., Alsalahi, A., Hajrezaei, M., Almaqrami, A.A., Salem, S.D., and Abdulla, M.A. (2014). Chemoprevention of colonic Aberrant Crypt Foci by *Gynura procumbens* in Rats. *Journal of Ethnopharmacology*, 151(3), 1194–1201. <https://doi.org/10.1016/j.jep.2013.12.044>.
- Tan, H.-L., Chan, K.-G., Pusparajah, P., Lee, L.-H., and Goh, B.-H. (2016) . *Gynura procumbens*: An Overview of The Biological Activities. *Frontiers in pharmacology*, 7, 52. <https://doi.org/10.3389/fphar.2016.00052>.
- Tzortzakis, N.G. and Economakis, C.D. 2008. Impacts of the Substrate Medium On Tomato Yield and Fruit Quality in Soilless Cultivation. *Horticultural Science*, 35, 83–89. <https://doi.org/10.17221/642-HORTSCI>.
- Urrestarazu, M., Martínez, G.A., and del Carmen Salas, M. (2005). Almond shell waste: possible local rockwool substitute in soilless crop culture. *Scientia Horticulturae*, 103(4), 453–460. <https://doi.org/10.1016/j.scienta.2004.06.011>.
- Wibowo, A. W., Suryanto, A., & Nugroho, A. (2018). Kajian Pemberian Berbagai Dosis Larutan Nutrisi Dan Media Tanam Secara Hidroponik Sistem Substrat Pada Tanaman Kailan (Brassica Oleracea L.). *Jurnal Produksi Tanaman*, 5(7).
- Zahra, A.A., Kadir, F.A., Mahmood, A.A., Suzy, S.M., Sabri, S.Z., Latif, I.I., and Ketuly, K.A. (2011). Acute toxicity study and wound healing potential of *Gynura procumbens* leaf extract in rats. *Journal of Medicinal Plants Research* 5(12), 2551–2558. <https://doi.org/10.5897/JMPR.9000042>.
- Zheng, G.D., Shuai, L.Q.W., Li, D.M., and Zhu, Y.T. (2014). Extraction and Antibacterial Effects of *Gynura procumbens* Leaves. *Shipin Keji*, 39, 218–221.