SALAGA Journal
Vol. 02, No. 1, June 2024, pp. 44~49
ISSN: 3032-2677
DOI: 10.70124/salaga.v2i1.1357

Aerator system of ventury nozzle in hydroponic for cultivating lettuce plants

Sitti Nur Faridah*[1], Abdul Azis[1], Tisha Aditya A. Jamaluddin[2], Alifah Agil Anugrah[2], Husnul Mubarak[1]
[1] Agriculture Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University
[2] Energy Conversion and Conservation Centre, National Research and Innovation Agency. South Tangerang Banten 15314, Indonesia

Article Info

Keywords:

Dissolved Oxygen
Lettuce
Microbubble
Ventury Nossle

ABSTRACT

Many lettuce plants are grown hydroponically because they produce better quality.The problem with hydroponic systems is that the plant roots are submerged in the nutrient solution, therefore it will rot easily due to lack of oxygen in the root area. To overcome this problem, hydroponics with microbubble technology is applied. This research aims to determine the performance of the ventury dual nozzle in producing microbubbles and its effect on the growth and productivity of lettuce plants. This research was carried out by assembling a hydroponic system equipped with a ventury model aerator, measuring bubble characteristics using the image processing method and analyzing plant parameters using variance analysis. Ventury nozzle with a pressure of 260 KPa produces microbubbles measuring between 200 - 300 m and a spray range of 6.13 cm with a resistance of around 3.2-4.6 seconds. The use of a ventury nozzle model aerator increases dissolved oxygen and distributes it evenly in the hydroponic nutrient solution, thereby increasing the growth and yield of lettuce plants.

Corresponding Author(s):

Sitti Nur Faridah
Agriculture Engineering Study program, Department of Argicultural Technology, Hasanuddin University
Jl. Perintis Kemerdekaan KM.10, 90245, Tamalanrea, Makassar, Sulawesi Selatan, Indonesia
Email: faridah_sn@agri.unhas.ac.id

1. INTRODUCTION

The increasing population growth, as well as public knowledge of nutritional needs, has resulted in an increase in demand for fresh vegetables [1], globally, the demand for vegetables is rising due to population growth and dietary shifts towards healthier foods. The global vegetable market is projected to witness substantial growth in the coming years. Lettuce (Lactuca sativa L) is a horticultural plant with promising commercial potential. Lettuce is often grown hydroponically because it produces better quality at a higher selling price on the market [2, 3, 4]. Hydroponically grown lettuce products are fresher, more hygienic, cleaner and more appealing to the customers. This practice also gave farmers more optimal agricultural results [5, 6, 7, 8]. Floating hydroponic systems are widely used because they are simpler, lower in investment and operational costs, also easy to use [9, 10, 11]. In this system, the plant is placed in a floating Styrofoam hole and the roots are submerged in a nutrient solution [4, 12]. The problem with floating hydroponics is that the roots tend to rot quicker due to the lack of dissolved oxygen in the root area [13, 14]. Innovation is needed to overcome the problem of plant growth in floating hydroponics, one of them is by applying microbubble technology. Microbubbles are small bubbles that contain oxygen and air, it can survive in water for a long time, and able to increase the diffusion of air into the liquid [15, 16, 17]. However, microbubble technology is mostly applied for fisheries, shipping, food processing, purification of polluted water and medical areas [18, 19]. Therefore, this research aims to determine the characteristics of microbubbles from ventury nozzles and their influence on lettuce plant production.

2. MATERIALS AND METHODS

This research uses a floating hydroponic system with a pond size of 150x75 cm, which is equipped with a ventury dual nozzle aeration system. The flow pressure will decrease if it flows through a narrow pipe section (Figure 1). The water in the hydroponic pond is pumped in by the pump machine and passed to the ventury nozzle which will produce microbubbles. The flow pressure is measured using a pressure gauge, then the flow rate is calculated. Measurement of the dimensions and range of bubbles uses image processing methods by recording the image using a digital camera. A completely randomized design with one factorial is used in this experiment, namely the distance of the lettuce plant from the aerator system (11.3cm, 34.30 cm and 61.30 cm) with 4 replications. Data were processed using Microsoft Excel applications and Analysis of Variance (ANOVA). ANOVA was chosen to determine if there were statistically significant differences between the means of the different treatment groups (distances from the aerator).

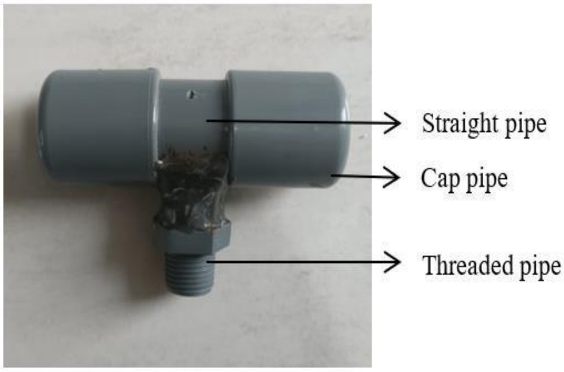

Figure1. Ventury dual nozzle.

3. RESULTS AND DISCUSSION

Differences in pipe cross-sectional area cause differences in velocity and pressure along the ventury. The pressure inside the pipe is lower than atmospheric pressure, therefore the air is sucked into the fluid flow through small hole in the pipe. The flow becomes turbulent in the downstream area and the shear stress causes the incoming air to be dispersed into microbubbles. According to Mawarni and Korawan [20], microbubbles are defined as bubbles which have a diameter in the range of millimeters and micrometers, with the highest probability, 150-300 μm. The ventury nozzle aerator system works at an average pressure of 260 KPa and an average discharge of 31,2 lpm to produce microbubbles with a size of 230 - 300 μm. The microbubbles produced by the ventury nozzle have a spray distance of around 6.13 cm (Figure 2). The size and range of the bubble is influenced by pressure and discharge. The greater the pressure, the smaller the bubble size and the farther the reach of the bubble to spread. Because the flow is more turbulent, the bubble will break more easily. In accordance with the statement of Afisna et al. [21]; Batubara et al. [22]; Mawarni and Korawan [20]; Warjito and Elizabeth [23], the important parameters in the bubble formation process are flow pressure and discharge, where the pressure will be inversely proportional to the discharge. Mawarni and Korawan's [20] research used a microbubble generator of orifice-porous tube type with an average discharge of 45 lpm to produce microbubbles with a diameter of 300 – 450 μm. Batubara et al. [22] used a microbubble generator of swirl flow type to produce microbubbles of 100 – 200 μm at an average discharge of 0.40 lpm.

Figure 2. Bubble from the dual nozzle ventury.

The bubbles have a resistance of 3.2-4.6 seconds before they burst, therefore they can reach plant roots. The presence of microbubbles in the root area results in increased oxygen which can stimulate plant roots to respire properly. This result agrees with the statement of Ebina et al. [24] which is microbubbles significantly increase the concentration of dissolved oxygen in water. Increasing oxygen in the hydroponic system can also maintain a stable ideal water temperature of 31ºC. From this result, the problem with floating hydroponics can be prevented by using ventury in floating hydroponics. Several studies from Ikeura et al. [25]; Park and Kurata [26]; Prasetyo et al. [27] found that using microbubble technology will result in optimal hydroponic systems. Oxygen absorbed by the roots affects the growth of lettuce plants. The average height of lettuce plants using the ventury dual nozzle 22 days after planting was 19.23 cm (Figure 3).

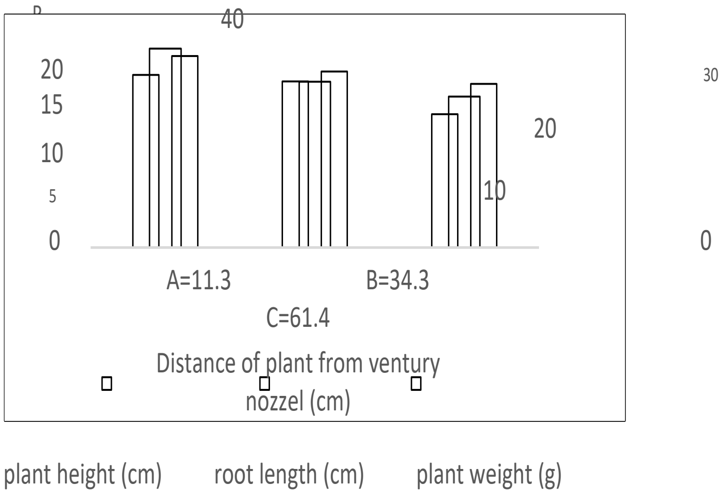

Figure 3. Lettuce crop yield.

According to Ikeuraa et al. [25]; Krisnawaty et al. [13], the use of microbubble increases plant vegetative growth in plant height and number of leaves. They also found that using a ventury nozzle will produce air bubbles which can increase the dissolved oxygen content in the water. Other studies by Majid et al. [28]; Maske et al. [29]; Mollah et al. [30] also stated that microbubble technology can increase the amount of oxygen concentration in water because more air bubbles are produced.

Research on the use of a hydroponic system with added nutrients by Romalasari and Sobari [31], resulted in a height of 15.60 cm for lettuce plants 20 days after planting. Research on several types of hydroponic growing media by Meriaty et al. [32], shows that the average height of lettuce plants 21 days after planting was 12.80 cm. Optimal oxygen content can improve root performance, especially the absorption speed of water and mineral nutrients [33]. The presence of oxygen in the root area will increase the respiration rate. Root respiration is useful for the development of root cells and absorption of plant nutrients. Aerobic respiration produces sufficient energy in the process of absorbing water and mineral nutrients which causes plants to grow and develop well. This is supported by research done by Dennis et al. [34]; Gardner et al [35]; Tamala et al. [36] where they found that oxygen plays an important role in the metabolic process that produces energy in cells, so a lack of oxygen in the root area will disrupt metabolic activity and energy production.

The average weight of fresh lettuce plants 22 days after planting was 33.6 grams. The oxygen produced by the microbubbles will push nutrients into the plant root cell walls. Rapid uptake of water and nutrients by roots will increase the net assimilation rate and plant growth rate, so that sufficient nutrition can increase plant growth and production. According to Fauzi et al. [6] lettuce growth and production elevated with an increase in oxygen concentration in the planting medium. Other research on the response of lettuce plants to various types of nutrients using a hydroponic system is done by Rahmawaty and Tysmoro [37]. They found that the average fresh weight of plants 28 days after planting was 26.62 grams. Siregar et al. [38] used a modified floating hydroponic system, and obtained that the average weight of fresh lettuce plants 35 days after planting is 23.53 grams. Roblero et al. [39]; Suyantohadi et al. [40], found that plant growth was 2.1 fold larger in the high concentration dissolved oxygen than plant grown in the normal dissolved oxygen. This resulted from increasing in the hydraulic conductivity of the roots that cause greater mineral absorption and more efficient photosynthesis.

According to Grishin et al. [41] and Virha et al. [42], plants that lack oxygen in the root area will have their metabolism affected and reduced productivity. Lack of oxygen also causes unstable nutrient transport and slows plant growth. This is in tune with the statement of Rahman et al. [43]; Rai [44], symptoms that occur when plants experience nutrient deficiencies, namely, stunted growth of roots, stems and leaves so that the yield will decrease. The results from analysis of variance showed that the distance of the plant from the venturi nozzle had no effect on lettuce yield (Table 1.). This shows that dissolved oxygen is homogeneous in the hydroponic pond and is not a factor causing differences in plant yields. The application of a ventury model aerator with double nozzles placed in the middle of the pond, produces microbubbles that are evenly distributed in the floating hydroponic nutrient solution.

Table 1. Analysis of variance effect of plant distance and aeratoron lettuce plant yields

Parameter	Significance
Plant height	0.000
Root length	0.710
Fresh weight	0.078

4. CONCLUSION

The application of a dual nozzle ventury in floating hydroponics with a pressure of 240 KPa produces a bubble size of 200 - 300 m and a spray range of 6.13 cm with a resistance of around 3.2-4.6 seconds. The average height and weight of fresh lettuce plants at 22 days after planting were 19.23cm and 33.6g respectively. The use of a venturi nozzle in a floating hydroponic system can increase dissolved oxygen in the root area, thereby increasing lettuce plant yields. From analysis of variance shows that the distance of aerator system had no effect on weight of fresh lettuce.

ACKNOWLEDGMENTS

The authors express their gratitude to the Chancellor of Hasanuddin University for the research funding.

REFERENCES

[1] Afisna L.P., Juwana W.E., Indarto I., Deendarlianto, Nugroho F.M. 2017. Performance of porous-venturi microbubble generator for aeration process. Journal of Energy, Mechanical, Material and Manufacturing Engineering, 2(2): 73-80.

[2] Barbosa G.L., Gadelha F.D.A., Kublik N., Proctor A., Reichelm L., Weissinger E., Wohlleb G.M., Halden R.U. 2015. Comparison of land, water, and energy requirements of Lettuce grown using hydroponic vs. conventional agricultural methods. International Journal of Environmental Research and Public Health, 12(6): 6879–6891.

[3] Batubara Y., Mawarni D.I., Indarto I., Deendarlianto. 2022. Characterization of bubbles produced by the swirl flow type microbubble generator using the image processing method. Proceedings The 13th Industrial Research Workshop and National Seminar Bandung, 13-14 July 2022: 880-888.

[4] Bok G., Choi J., Lee K., Park J. 2019. Microbubbles increase glucosinolate contents of watercress (*Nasturtium officinale R. Br.*) grown in hydroponic cultivation. Protected Horticulture and Plant Factory, 28(2): 158-165. DOI: org/10.12791/KSBEC.2019.28.2.158

[5] Bostanci K.B., Ulger S. 2022. Comparison of spinach cultivation in floating hydroponic system and soil in glasshouse and open field conditions. Mediterranean Agricultural Sciences,35(1): 7-14. DOI: 10.29136/mediterranean.1061475

[6] Darwiyah S., Rochman N., Setyono S. 2021. Production and quality of melon (*Cucumis melo L.*) of hydroponic floating rafts fed with different potassium nutrients. Journal of Agronida,7(2): 94-103

[7] Dharmayanti N.K.S.A., Sumiyati S., Yulianti N.L. 2022. The effect of providing aeration on the growth and production of Lettuce (*Lactuca sativa L.*) with a floating raft hydroponic system. Journal of Biosystems and Agricultural Engineering, 10(1): 121-128.

[8] Dennis E.S., Dolferus R., Ellis M., Rahman M., Wu Y., Hoeren F.U., Grover A., Ismond K.P., Good A.G., Peacock W.J. 2000. Molecular strategies for improving waterlogging tolerance in plants. Journal of Experimental Botany, 51(342): 89-97. DOI:org/10.1093/jexbot/51.342.89

[9] Deendarlianto, Wiratni A.E., Tontowi, Indarto, Iriawan A.G.W. 2015. The implementation of a developed microbubble generator on the aerobic wastewater treatment. International Journal of Technology, 6(6): 924–930.

[10] Ebina K., Shi K., Hirao K., Hashimoto J., Kawato J., Kaneshiro S., Morimoto M., Koizumi K., Yoshikawa H. 2013. Microbubble generator, oxygen and air nanobubble water solution promote the growth of plants, fishes, and mice. PLoS ONE, 8(6): e65339. DOI: 10.1371/journal.pone.0065339

[11] Fauzi R., Putra E.T.S., Ambarwati E. 2013. Oxygen enrichment in the root zone to increase growth and yield of Lettuce (*Lactuca sativa L.*) hydroponically. Vegetalika, 2(4):.63-74. Gardner F.B., Pearce R.B., Mitchell R.L. 1985. Physiology of Crop Plants. Iowa StateUniversity Press, Ames, IA.

[12] Grishin A., Grishin A., Semenova N., Grishin V., Knyazeva I., Dorochov A. 2021. The effect of dissolved oxygen on microgreen productivity. BIO Web of Conferences 30,05002 (2021). DOI: org/10.1051/bioconf/20213005002

[13] Gumisiriza M.S., Ndakidemi P.A., Mbega E.R. 2022. A simplified non-greenhouse hydroponic system for small-scale soilless urban vegetable farming. MethodsX, 9.101882: 1-7. DOI: org/10.1016/j.mex.2022.101882.

[14] Ikeuraa H., Tsukadab K., Tamaki M. 2017. Effect of microbubbles in deep flow hydroponic culture on Spinach growth. Journal of Plant Nutrition, 40(16): 2358-2364. DOI:10.1080/01904167.2017.1346663

[15] Ikeura H., Takahashi H., Kobayashi F., Sato M., Tamaki M. 2017. Effects of microbubble generation methods and dissolved oxygen concentrations on growth of Japanese mustard spinach in hydroponic culture. The Journal of Horticultural Science and Biotechnology,93(5): 1-8. DOI: 10.1080/14620316.2017.1391718.

[16] Juwana W.E., Widyatama A., Dinaryanto O., Budhijanto W., Indarto, Deendarlianto. 2019.Hydrodynamic characteristics of the microbubble dissolution in liquid using orifice type microbubble generator. Chemical Engineering Research and Design, 141: 436–448.

[17] Karne H., Iyer V., Joshi S., Diwan S., Gole M., Sunthankar S., Phansalkar S. 2023.Hydroponics: A review of modern growing techniques. European Chemical Bulletin, 12(4):11231-11256. DOI: 10.48047/ecb/2023.12.si4.1016

[18] Kodama Y., Kakugawa A., Takahashi T., Kawashima H. 2000. Experimental study on microbubbles and their applicability to ships for skin friction reduction. International Journal of Heat and Fluid Flow, 21: 582-588. DOI: 10.1016/S0142-727X(00)00048-5

[19] Krisna B., Putra E.E.T.S., Rogomulyo R., Kastono D. 2017. Effect of oxygen and calcium enrichment on root growth and yield of curly Lettuce (*Lactuca sativa L.*) in floating raft hydroponics. Journal of Vegetalika, 6(4): 14-27.

[20] Krisnawati D., Triyono S., Kadir M.Z. 2014. The effect of aeration on the growth of baby Kailan plants (*Brassica oleraceae var. achepala*) using floating hydroponic technology inside and outside the greenhouse. Lampung Agricultural Engineering Journal, 3(3): 213-222.

[21] Laksana M. 2008. Microbubble generator using the spherical ball method in a flowing pipe. Thesis, Department of Mechanical Engineering, Faculty of Engineering, University of Indonesia. Indonesia.

[22] Majid A.I., Nugroho F.M., Juwana W.E., Budhijanto W., Deendarlianto, Indarto. 2018. On the performance of venturi-porous pipe microbubble generator with inlet angle of 20° and outlet angle of 12°. Proceedings of the 9th International Conference on Thermofluids 2017. AIP Conference Proceedings. DOI: org/10.1063/1.5050000

[23] Majid M., Khan J.N., Ahmad Shah Q.M., Masoodi K.Z., Afroza B., Parvaze S. 2021.Evaluation of hydroponic systems for the cultivation of Lettuce (*Lactuca sativa L. var. Longifolia*) and comparison with protected soil-based cultivation. Agricultural Water Management, 245: 1-13. DOI: org/10.1016/j.agwat.2020.106572

[24] Mawarni D.I., Korawan A.D. 2019. Effect of water fluid discharge on bubble diameter distribution in orifice-porous tube type microbubble generator. Journal of Industrial, Mechanical, Electrical and Computer Science Engineering, 13(2): 17-21

[25] Maske S.J., Rai D.S., Kale V.S., Raut B.D., Chintale G.A. 2012. Microbubble and its applications. International Journal of Pharmacy & Life Sciences, 3(12) :2228-2235.

[26] Maluin F.N., Hussein M.Z., Nik Ibrahim N.N.L., Wayayok A., Hashim N. 2021. Some emerging opportunities of nanotechnology development for soilless and microgreen farming. Agronomy, 11(6): 1-28. DOI: 10.3390/agronomy11061213

[27] Meriaty M., Sihaloho A., Pratiwi K.D. 2021. Growth and yield of Lettuce plants (*Lactuca sativa L.*) due to the type of hydroponic growing media and AB Mix nutrient concentration. Agroprimatech, 4(2): 75-84.

[28] Mollah A., Prameswari D.A., Ashan M.A., Safitri W., Amal M.A.I., Anugrah A.A. 2021.

[29] Guide Book; Solar Cell Based Microbubble Technology to Increase Vegetable Yields in Floating Raft Hydroponic Systems. Ficus Press, Hasanuddin University Makassar, Indonesia.

[30] Muharomah R., Setiawan B.I., Purwanto M.Y.J., Liyantono L. 2020. Temporal crop coefficients and water productivity of Lettuce (*Lactuca sativa L.*) hydroponics in planthouse. Agricultural Engineering International: CIGR Journal, 22(1): 22-29.

[31] Nikolov N.V., Atanasov A.Z., Evstatiev B.I., Vladut V.N., Biris S.S. 2023. Design of a small- scale hydroponic system for indoor farming of leafy vegetables. Agriculture, 13(6): 1-13. DOI: org/10.3390/agriculture13061191

[32] Nurrohman M., Suryanto A., Wicaksono K.P. 2014. Use of fermented paitan extract and liquid rabbit Dung as a nutrient source in Ffoating raft hydroponic mustard cultivation. Journal of Crop Production, 2(8): 649–657.
[33] Park J.S., Kurata K. 2009. Application of microbubbles to hydroponics solution promotes Lettuce growth. HortTechnology, 19(1): 212-215. DOI: 10.21273/HORTSCI.19.1.212
[34] Parmar R., Majumder S.K. 2013. Microbubble generations and aided transport process intensification-A state–of–the art report. Chemical Engineering and Processing, 64: 79-97.
[35] Prasetyo J., Saqroth F.I., Hendrawan Y. 2023. Effect of microbubbles on the growth of mustard Pak Choi (*Brassica rapa L.*) in wick system hydroponics. Journal of Agricultural Technology, Special Issue [Februari 2023]: 9-16.
[36] Puspitahati P., Andica F. 2022. Floating raft hydroponic system using spray bars pumps on Pakcoy cultivation growth (*Brassica rapa L.*). Proceedings of the 3rd Sriwijaya International Conference on Environmental Issues, SRICOENV 2022, October 05-06, Palembang, Indonesia https://eudl.eu/proceedings/SRICOENV/2022
[37] Rahman M.J., Quamruzzaman M., Ali M.M., Ahmed S., Chawdhery M.R.A, Sarkar M.D. 2017. The effects of irrigation timing on growth, yield, and physiological traits of hydroponic lettuce. Azarian Journal of Agriculture, 4: 193-199
[38] Rahmawaty A.D., Tysmoro S.Y. 2018. Growth response of three varieties of Lettuce (*Lactuca sativa L.*) to various types of nutrients in the NFT hydroponic system. Journal of Crop Production, 6(10): 2491-2500.
[39] Rai I.N. 2002. Diagnosis of mineral nutrient deficiencies and toxicity in plants. Philosophy of Science Papers. IPB Postgraduate Program. Bogor. https://www.rudyct.com/PPS702- ipb/04212/i_nyoman_rai.htm
[40] Roblero M.J.M., Pineda J.P., León M.T.C., Castellanos J.S. 2021. Oxygen in the root zone and its effect on plants. Revista Mexicana de Ciencias Agricolas, 11(4): 931-943. DOI: org/10.29312/remexca.v11i4.2128
[41] Romalasari A., Sobari E. 2019. Lettuce (*Lactuca sativa L.*) production using a hydroponic system with different nutrient sources. Agriprima, Journal of Applied Agricultural Sciences,3(1): 36-41. DOI: 10.25047/agriprima.v3i1.158
[42] Siregar J., Triyono S., Suhandy D. 2015. Testing of several hydroponic nutrients on Lettuce (*Lactuca sativa L.*) using modified floating system hydroponic technology. Lampung Agricultural Engineering Journal, 4(1): 65-72
[43] Suyantohadi A., Kyoren T., Hariadi M., Purnomo M.H., Morimoto T. 2010. Effect of high consentrated dissolved oxygen on the plant growth in a deep hydroponic culture under a low temperature. IFAC Proceedings, 43(26): 251-255. DOI: org/10.3182/20101206-3-JP-3009.00044
[44] Tamala U., Al Habib I.M., Zuhro F. 2019.. Effect of waterlogging percentage to time of hypoxia some tobacco accessions (*Nicotiana tabacum L*). BIO-CONS, Journal of Biology and Conservation, 1(2): 29-37.