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Effect of organic fish and inorganic fertilizers on the growth and yield of lettuce "Batavia" in aeroponic system

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Abstract
Study on the effects of organic fertilizer decomposed from fish waste combined with inorganic fertilizer on the growth and yield of lettuce *Lactuca sativa* "Batavia" in an aeroponic system was carried out at Tien Giang Center of Applied Research and Science Technology Services in 2022. The study aimed to determine the effectiveness of the organic fish fertilizer solution combined with the inorganic fertilizer solution on the promotion of plant growth and yield of lettuce "Batavia" in an aeroponic system. The experiment was arranged in a completely randomized design (CRD) with five treatments and four replications. The five treatments of fertilizers included (T_1): 3000 ppm organic fish; (T_2): 2500 ppm organic fish + 250 ppm inorganic; (T_3): 1500 ppm organic fish + 500 ppm inorganic; (T_4): 750 ppm organic fish + 750 ppm inorganic; (T_5): 1000 ppm inorganic (Control). All the treatments of organic fish fertilizers were supplemented with microorganism 0.1% EM2. The results showed that lettuce "Batavia" grew well in the aeroponic systems when treated with 1500 ppm organic fish + 500 ppm inorganic and 2500 ppm organic fish + 250 ppm inorganic which gave high results in terms of total number of leaves (32.5 g; 32.05 g); plant weight (122.45 g; 115.81 g) and yield (3.06 kg/m2; 2.90 kg/m^2), respectively compared with the other treatments.

Keywords: Aeroponic, *Lactuca sativa*, lettuce Batavia, organic fish nutrient

Introduction
Lettuce "Batavia" is high in vitamins K and A, as well as folate and iron. Lettuce is highly adaptable to a variety of weather conditions. Vegetables cultivated on the ground, on the other hand, are extremely vulnerable to pests and illnesses. Irrigation water contamination has harmed food quality and safety. Nutrient deficiencies in the soil have affected the growth and yield of vegetables [1]. Soilless farming techniques offer many socio-economic benefits including the ability to cope with the growing challenges of global food, environmental, climate, management and use changes efficiency of natural resources [3]. Hydrolyzed earthworms into liquid organic fertilizers used in aeroponics systems for potato seed production [11]. Molasses, waste materials from beer brewing and sugarcane leaves are carbon-rich raw materials for the creation of liquid organic fertilisers that produce lettuce plants with the same yield and quality as inorganic nutrients in the hydroponic system [12]. Fish by-products, beer residues, maize cakes, fishmeal, plant residues were treated as liquid organic fertilizers, the hydrolyzed solution from earthworms was used as an organic solution in the hydroponic systems and aeroponics [12, 9]. The use of liquid organic fertilizer as a replacement or supplement to chemical fertilizer is a better solution for hydroponic planting [10]. Soilless vegetable growth, which includes hydroponics and aeroponics, was one of the more innovative agricultural systems that saves water and irrigation resources [13], increase output per unit area [3]. Aeroponics was a promising technology that grows plants with their root systems exposed to a nutrient mist in a closed chamber [8]. Aeroponics supplied the appropriate amount of water and nutrients required by plants via the root system, resulting in improved yields per plant and per unit area [14].

Materials and Methods
Materials
Variety: Lettuce Batavia variety (supplied by Rizk Zwaan Vietnam Co., Ltd.).
Horizontal aeroponics system: Each square metre of horizontal surface has 25 vegetable-growing holes.

Inorganic nutrients solution: Solution (A) $Ca(NO_3)_2.4H_2O$, Fe(EDTA), KNO_3 and Solution (B) H_3BO_3, $CuSO_4.5H_2O$, $MgSO_4.7H_2O$, $MnSO_4.H_2O$, H_3PO_4, KH_2PO_4, $Na_2MoO_4.2H_2O$, $ZnSO_4.2H_2O$.
Organic fish fertilizer and EM2 (Microbial product): Prepared at lab of Tien Giang Center of Applied Research and Science Technology Services. Organic fish fertilizer was analyzed for organic matter, organic carbon, total P, total N, total K, EC and pH (Table 1).

Table 1: Composition of substances in organic fish fertilizer solutions

Parameters	Testing method	Result
Organic matter	TCVN 9294 : 2012	42.9%
Organic carbon	TCVN 9294 : 2012	19.5%
Total N	TCVN 8557 : 2010	1.14%
Total P	TCVN 8563 : 2010	0.37%
Total K	SOP.01-145: 2020 (Ref. TCVN 8562 : 2010)	0.38%
EC	TCVN 6650 : 2000	13 470 µS/cm
pH	TCVN 13263-9:2022	4.40

TCVN: Vietnam standards

Preparing the planting medium and seedlings
Rockwool was cut into pieces the size of the hole in the foam tray and placed in the holes, watering evenly to absorb the water. Then sow the seeds into the holes of tray (tray size 49 long, 28 cm wide, 5 cm high, contains 84 holes). After 2-3 days of seed germination, the nursery trays are put into the nursery system by aeroponic technology. The seedling roots are now developed in the dark chamber. The fertilizer solution for seedling was kept stable at 500 ppm, pH = 5.6- 6.8 and sprayed directly into the roots as fine mist from 50 µm with a certain time. After 7-10 days, the plant reached 3-5 leaves, when transplanting letture in aeroponic system to conduct the experiment.

The experiment treatment
The experiment was arranged in a completely randomized design (CRD) with 5 treatments and 4 replications. The five treatments were as follows: (T_1): 3000 ppm organic fish; (T_2): 2500 ppm organic fish + 250 ppm inorganic; (T_3): 1500 ppm organic fish + 500 ppm inorganic; (T_4): 750 ppm organic fish + 750 ppm inorganic; (T_5): 1000 ppm inorganic (Control). The treatments organic fish fertilizers (T_1, T_2, T_3, T_4) made addition to microorganism EM2 (1000ppm) (Table 2), whereas the control was 100% inorganic nutrient.
The planting density was 25 plants per square meter. Spraying systems was implemented to monitor and alter the spraying pattern, flow rate, droplet size, time and atomizing air pressure automatically. Misting lasted 30 seconds, followed by a 15 munite pause before misting again. The droplet size was 50 µm and the nutrient solution recycled. The pH was adjusted 5.8-6.8.

Table 2: Experimental treatments

Treatment		Note
T_1	3000 ppm organic fish + EM2	0.1 % EM2 added to all organic fish fertilizer treatments
T_2	2500 ppm organic fish + 250 ppm inorganic + EM2	
T_3	1500 ppm organic fish + 500 ppm inorganic + EM2	
T_4	1250 ppm organic fish + 750 ppm inorganic + EM2	
T_5	1000 ppm inorganic	Control

EM2: Microbial products

Data collection
Number of leaves (leaves/plant): Count the total number of leaves on the plant; Plant height (cm): Measured from the base of the stem to the tip of the leaf (Record every 5 days); Root length (cm): Measured at the harvest from the base of the stem to the tip of the root; Plant Fresh weight (g/plant): Cut near to the base of stem, weigh at harvest. Actual yield (kg/m2): Calculated by weighing 25 plants per square meter.

Data analysis
Data was collected and analyzed using analysis of variance (ANOVA), and Duncan's Multiple Range Test (DMRT) was used for means comparison when treatments were significant using MSTATC program.

Results and Discussions
The temperature and pH of the nutrient solution
The temperature of the treatments was maintained between 28.3 ºC and 32.7 ºC, according to the data shown in Table 3. This temperature range was suitable for mineral and nutrient solubility, however it is not optimal for lettuce growth. The pH of the nutrient solution recorded interval five days the results indicated that under experimental conditions pH was adjusted 6.2 to 6.5. In aeroponics and hydroponic, most plants are suitable for slightly acidic to near neutral environments, with optimum pH ranging from 5.8 to 6.5. When the pH value exceeds the allowable threshold for usage in aeroponics, it is adjusted with HNO_3 solution to maintain the pH in the appropriate range. The suitable pH for lettuce *Lactuca sativa*, *Brassica pekinensis* grown aeroponically was from 5.8-6.8 [7]. The pH and nutrient solution content in the growth system should be examined on a regular basis [15]. The optimum pH values of nutrient solution in aeroponics system from 5.5 to 6.5 for letture [14, 4].

Table 3: The temperature and pH of the nutrient solution recorded throughout the growth stages of lettuce "Batavia"

Treatment	Temperature (ºC) (DAT)							
	1	5	10	15	20	25	30	35
T_1	32.0	30.3	29.7	30.7	32.2	29.3	29.0	30.7
T_2	32.3	31.2	29.0	29.8	31.2	28.5	29.0	32.0
T_3	31.3	30.7	28.8	30.7	31.3	28.7	29.0	32.0
T_4	32.3	31.3	29.0	29.8	31.3	28.5	29.0	32.0
T_5	32.7	30.3	30.0	31.7	31.0	28.3	29.0	30.7
Treatment	**pH (DAT)**							
T_1	6.30	6.50	6.43	6.40	6.30	6.50	6.30	6.50
T_2	6.30	6.33	6.27	6.33	6.30	6.50	6.50	6.50
T_3	6.43	6.33	6.33	6.33	6.33	6.43	6.30	6.27
T_4	6.30	6.50	6.50	6.30	6.33	6.27	6.30	6.27
T_5	6.27	6.51	6.44	6.40	6.30	6.42	6.53	6.25

DAT: Day after transplanting

The number of leaves, height plant, root length of lettuce "Batavia"

The number of leaves per plant of "Batavia" lettuce was consistently increased throughout the growth stages (Fig 1) and rapidly developed at 20 days after transplanting (DAT) the lettuce in the aeroponic system. Stage 5 day after transplanting the total number of leaves did not have a significant difference between treatments, the number of leaves varied from 7.00 to 7.25 leaves/plant. From the 10th to the 35th day the number of leaves per plant always increased. At the period of 35 days, there was a difference in the number of leaves per plant in all treatments, T_2 (35.50 leaves/plant) and T_3 (36.25 leaves/plant) had high leaf count and these two treatments were significantly different compared to T_1, T_4 and T_5 (31.25 leaves/plant) (Table 4).

Table 4: The number of leaves of lettuce "Batavia" recorded during the experiment

Treatment	Number of leaves (DAT)						
	5	10	15	20	25	30	35
T_1	7.25	10.00	13.00^{b}	18.75^{bc}	22.00^{b}	27.75^{a}	31.50^{b}
T_2	7.00	10.00	13.25^{ab}	17.75^{ab}	23.75^{a}	27.75^{a}	35.50^{a}
T_3	7.00	10.50	13.75^{a}	19.25^{a}	24.25^{a}	28.25^{a}	36.25^{a}
T_4	7.25	10.00	13.00^{b}	18.75^{bc}	22.00^{b}	27.75^{a}	30.25^{b}
T_5	7.00	9.50	12.75^{b}	17.50^{c}	22.25^{b}	25.25^{b}	31.25^{b}
F	ns	ns	*	**	**	**	**
CV (%)	11.24	4.09	3.29	3.62	3.13	2.80	2.59

*, **Significant at 5, 1% level, respectively, mean with the same letters are not different by Duncan, ns: Non-significant; DAT: Day after transplanting.

There was not statistical difference in plant height between treatments at 5 days and 10 days after planting in the aeroponic system. Plant height fluctuated between 3.96 cm - 4.27 cm and 4.56 cm - 4.96 cm, respectively. At 15 days after planting in the aeroponic system, there was a statistically significant difference in plant height among treatments. Treatment T_2 (7.32 cm) achieved the highest in plant height and was significantly different from the other treatments T_3, T_5, T_4 and T_1 (6.75 cm, 6.59 cm, 6.55 cm and 6.45 cm), respectively. The height of lettuce "Batavia" increased steadily from day 15 to day 35. At day 35, the highest plant height in treatments T_2 (15.30 cm) and T_3 (15.75 cm) was significantly different from the other treatments (Table 5).

Table 5: The height of lettuce "Batavia" recorded during the experiment

Treatment	The plant height (cm) (DAT)						
	5	10	15	20	25	30	35
T_1	4.27	4.71	6.45^{b}	9.50^{ab}	12.57^{b}	13.32^{b}	13.50^{b}
T_2	4.10	4.84	7.32^{a}	10.08^{a}	13.50^{a}	14.91^{a}	15.30^{a}
T_3	4.10	4.96	6.75^{b}	9.06^{b}	13.63^{a}	15.03^{a}	15.75^{a}
T_4	4.20	4.60	6.55^{b}	9.00^{ab}	12.50^{b}	13.30^{b}	13.55^{b}
T_5	3.96	4.56	6.59^{b}	8.94^{b}	12.12^{b}	13.91^{b}	13.63^{b}
F	ns	ns	**	*	**	**	**
CV (%)	16.7	6.73	3.73	6.18	3.77	2.81	4.45

*, **Significant at 5, 1% level, respectively, mean with the same letters are not different by Duncan test, ns: Non-significant. DAT: Day after transplanting.

The result from Table 6 indicated that there was no statistical difference in root length between treatments at 5 days and 10 days after planting in the aeroponic system and root length ranging from 3.25 cm - 3.85 cm and 7.14 cm – 7.80 cm, respectively. From day 20 to day 35, two treatments T_2 and T_3 always had a high root length and they were significantly different from the other treatments. At 35 days after planting in the aeroponic system root length of "Batavia" lettuce of treatment T_2 (33.5 cm) and T_3 (32.13 cm) were higher than the other treatments T_4 (24.50 cm), T_1 (23.00 cm). Treatment T_5 (16.75 cm) had the shortest root length.

Table 6: Root length of lettuce "Batavia" recorded during the experiment

Treatment	Root length (cm) (DAT)						
	5	10	15	20	25	30	35
T_1	3.35	7.34	11.44^{b}	15.60^{b}	18.28^{bc}	20.10^{b}	23.00^{b}
T_2	3.48	7.14	13.40^{a}	18.66^{a}	24.75^{a}	28.68^{a}	33.50^{a}
T_3	3.85	7.80	12.30^{b}	18.22^{a}	24.06^{a}	25.50^{a}	32.13^{a}
T_4	3.25	7.30	11.34^{b}	15.50^{b}	19.25^{b}	21.15^{b}	24.50^{b}
T_5	3.60	7.35	7.12^{c}	11.15^{c}	12.47^{d}	15.44^{c}	16.75^{c}
F	ns	ns	**	**	**	**	**
CV (%)	11.72	5.20	9.95	12.04	7.54	12.51	14.81

**Significant at 1% level, mean with the same letters are not different by Duncan, ns: Non-significant. DAT: Day after transplanting.

Fig 1: Growth of letture "Batavia" at 15, 20, 25, 30, 35 days in aeroponic system: a-e (T_2): 2500 ppm organic fish fertilizer + 250 ppm inorganic fertilizer; f-k (T_3): 1500 ppm organic fish fertilizer + 500 ppm inorganic fertilizer; l-p (T_5): 1000 ppm inorganic fertilizer (Control).

Fresh weight and yield of lettuce "Batavia" at harvest

At harvest, the total number of leaves obtained from the T_2 and T_3 treatments was high but the number of yellowing base leaves was low, accounting for only 3.75 - 3.55 leaves/plant. While total number leaves were lower in treatment T_4 and T_5, but the number of withering base leaves accounted for 4.75 - 5.00 leaves/plant, respectively (Table 7). The fresh weight of the treatments differed statistically significantly. Treatments T_2 (115.81 g) and T_3 (122.45 g) exhibited significantly higher fresh weights than treatments T_1, T_4, and T_5 (78.98, 79.05, and 79.14 g/plant). There were a statistically significant difference among treatments in terms of plant yield per square meter. The yield of lettuce "Batavia" in treatments T_2 (2.90 kg/ m^2) and T3 (3.06 kg/ m^2) was highest, followed by treatments T_5 (1.98 kg/ m^2) and T_1 (1.97 kg/ m^2), treatment T_4 had the lowest yield of 1.79 kg/m2 (Table 7).

Table 7: The number of leaves, number of base leaves, fresh weight and yield of lettuce "Batavia" at harvest

Treatment	Total number of leaves	The number of withering base leaves	Plant fresh weight (g)	Yield (kg/m^2)
T_1	28.25^b	3.55^b	78.89^b	1.97^b
T_2	32.25^a	3.75^b	115.81^a	2.90^a
T_3	32.50^a	3.50^b	122.45^a	3.06^a
T_4	29.50^b	5.00^a	79.05^b	1.79^c
T_5	28.25^b	4.75^a	79.14^b	1.98^b
F	*	*	**	**
CV (%)	12.5	13.81	9.60	6.41

*, **Significant at 5, 1% level, respectively, mean with the same letters are not different by Duncan

Aeroponics remarkably improved root growth with a significantly greater root biomass, root/shoot ratio, and greater total root length [8] . The plants grown in the aeroponic system had a higher yield as compared to those grown in the soil [5]. Organic fertilizers used in aeroponics can be hazardous substances, reducing plant growth and development due to mineral and organic acid accumulation [6, 16]. In this experiment, the organic fish fertilizer treatments were supplemented with EM2 microorganism to better decompose organic matter due to organic acid accumulation during the trial.

Conclusion

Application 1500 ppm organic fish fertilizer + 500 ppm inorganic fertilizer and 2500 ppm organic fish fertilizer + 250 ppm inorganic fertilizer increased total number of leaves (32.5 g; 32.05 g); plant weight (122.45 g; 115.81 g) and yield (3.06 kg/m2; 2.90 kg/m2), respectively. Therefore, it can be indicated that organic aeroponic based on this method is a practical solution using organic and inorganic combined as nutrients liquid. The application organic fish combined inorganic fertilizers with suitable concentrations can be improved fresh weigh and yield of letture "Batavia" growing aeroponic system.

References

1. Bradley FM, Ellis BW, Martin DL eds. 2009. The Organic gardener's handbook of natural pest and disease Control. Rodale. ISBN 978-1-60529-677-7.
2. Buckseth T, Sharma AK, Pandey KK, Singh BP, Muthuraj R. Methods of pre-basic seed potato production with special reference to aeroponics. A review. Scientia Horticulturae. 2016;204:79-87.
3. Butler JD, Oebker NF. 2006. Hydroponics as a Hobby - Growing plants without soil. Circular 844. Information Office, College of Agriculture, University of Illinois, Urbana, IL 61801.
4. Chadirin Y, Matsuoka T, Suhardiyanto H, Susila AD. Application of deep sea water (DSW) for nutrient supplement in hydroponics cultivation of tomato: effect of supplemented DSW at different EC levels on fruit properties. Bullet Agro. 2007;35:118-126.
5. Chandra, S., Shabansa Khan, BharathiAvula, Hemant Lata, Min Hye Yang, Mahmoud A. ElSohly, and Ikhlas A. Khan. 2014. Assessment of total phenolic and flavonoid content, antioxidant properties, and yield of aeroponically and conventionally grown leafy vegetables and fruit crops: A comparative study. Hindawi Publishing Corporation.1-9.
6. Foucard P, Tocqueville A. Aquaponie: associer aquaculture et production végétale; c2019.
7. Hang NT, Ha VN, Phong NT. The model horizontal aeroponics culture of vegetables (*Lactuca sativa*) and (*Brassica pekinensis*) to increase yield, save water and efficiency. Can Tho University Journal of Science. 2022;58(SDMD):24-30.
8. Jones JrJB. Complete guide for growing plants hydroponically. CRC Press; c2014 Feb 13.
9. Kano K, Kitazawa H, Suzuki K, Widiastuti A, Odani H, Zhou S, *et al*. Effects of Organic Fertilizer on Bok Choy Growth and Quality in Hydroponic Cultures. Agronomy. 2021;11:491.
10. Kawamura-Aoyama C, Fujiwara K, Shinohara M, Takano M. Study on the hydroponic culture of lettuce with microbially degraded solid food waste as a nitrate source. Japan Agricultural Research Quarterly: JARQ. 2014;48(1):71-6.
11. Moradpoor F, Khorami Vafa M, Zolnurian H. "Effect of various nutrition methods on potato minituber production in aeroponic condition". Iranian Journal of Field Crop Science, Autumn. 2019;50(3):79-87. DOI: 10.22059/ijfcs.2018.242019.654382.
12. Phibunwatthanawong T, Riddech N. Liquid organic fertilizer production for growing vegetables under hydroponic condition. Int J Recycl Org Waste Agricult.2019;8:369–380. doi.org/10.1007/s40093-019-0257-7
13. Raviv M, Lieth JH. Significance of soilless culture in agriculture. In Soilless Culture Theory and Practice. Elsevier Science; c2008. p. 1-11.
14. Resh HM. Hydroponic food production. Mahwah (NJ, USA): Newconcept Press; c2004. Inc. ISBN-10:093123199X.
15. Singh MC, Singh KG, Singh JP. Nutrient and water use efficiency of cucumbers grown in soilless media under a naturally ventilated greenhouse. Journal of Agricultural Science and Technology. 2019;21(2):193-207.
16. Upendri HFL, Karunaratna B. Organic nutrient solution for hydroponic system. Academia Letters, Article; c2021, 1893. doi.org/10.20935/AL1893.