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THE EFFECT OF PROBIOTICS ADDITION IN FEED ON THE SURVIVAL AND GROWTH OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IN THE AQUAPONIC SYSTEM

Pengaruh Penambahan Probiotik Pada Pakan Terhadap Kelangsungan Hidup Dan Pertumbuhan Ikan Nila (*Oreochromis niloticus*) dalam Sistem Akuaponik

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ABSTRACT

Tilapia (*Oreochromis niloticus*) is a freshwater fish with economic commodity value and an important commodity in the freshwater fish business in Indonesia. Problems often encountered in efforts to increase tilapia cultivation production are the reduction of empty land for cultivation activities and complex water sources in some areas. Land availability and water source supply are two main factors determining fisheries cultivation's success. Aquaponics is an alternative cultivation method that can save land and water use and optimize cultivation waste into plant biomass as a by-product with a selling value. The method used in this research is the Completely Randomized Design (CRD) experimental method, which consists of four treatments and three replications. The treatments used consist of (A) without mixing probiotics (negative control), (B) adding probiotics 5 $ml.kg^{-1}$ feed, (C) adding probiotics 7.5 $ml.kg^{-1}$ feed, and (D) adding probiotics 10 $ml.kg^{-1}$ feed. The test tilapia were cultured in an aquaponic system with lettuce plants for 40 days with a density of 20 fish/80L. Feeding was carried out using the feeding rate (FR) method of 5% of biomass. The results obtained during the study showed that treatment C with a dose of 7.5 $ml.kg^{-1}$ of feed produced positive conditions that were significantly different in terms of a specific growth rate of 2.30 ± 0.1%, 100% survival, and feed efficiency of 56.5 ± 1.6%, absolute length was 3.08 ± 0.07 cm and absolute weight was 13.14 ± 1.53 gram.

Keywords: Aquaponic, growth, probiotics, survival, tilapia.

ABSTRAK

Ikan nila (*Oreochromis niloticus*) merupakan salah satu ikan air tawar yang memiliki nilai komoditas ekonomis dan merupakan komoditas penting dalam bisnis ikan air tawar di Indonesia. Permasalahan yang sering ditemui pada upaya meningkatkan produksi budidaya ikan nila adalah berkurangnya lahan kosong untuk kegiatan budidaya serta sumber air yang sulit pada beberapa wilayah. Ketersediaan lahan dan pasokan sumber air merupakan dua faktor utama yang menentukan keberhasilan budidaya perikanan. Akuaponik merupakan salah satu alternatif metode budidaya yang mampu menghemat penggunaan lahan dan air, serta mengoptimalkan limbah budidaya menjadi biomassa tumbuhan sebagai produksi sampingan yang juga memiliki nilai jual. Metode yang digunakan dalam riset ini adalah metode eksperimental Rancangan Acak Lengkap (RAL), yang terdiri dari empat perlakuan dan tiga ulangan. Perlakuan yang digunakan terdiri atas (A) tanpa pencampuran probiotik (kontrol negatif), (B) penampahan probiotik 5 $ml.kg^{-1}$ pakan (C) penambahan probiotik 7,5 $ml.kg^{-1}$ pakan, (D) penampahan probiotik 10 $ml.kg^{-1}$ pakan. Ikan nila uji dibudidayakan dalam sistem akuaponik bersama dengan tanaman selada selama 40 hari dengan densitas 20 ekor ikan/80L air. Pemberian pakan dilakukan dengan metode *feeding rate* (FR) sebanyak 5% dari biomassa. Hasil yang didapatkan selama penelitian menunjukkan bahwa perlakuan C dengan dosis 7,5 $ml.kg^{-1}$ pakan menghasilkan kondisi positif yang berbeda secara signifikan ditinjau dari laju pertumbuhan spesifik yang bernilai 2.30 ± 0.1%, 100% sintasan, efisiensi pakan sebesar 56.5 ± 1.6%, panjang mutlak sebesar 3,08 ± 0,07 cm dan bobot mutlak sebesar 13,14 ± 1,53 gram.

Kata kunci: Akuaponik, ikan nila, probiotik, pertumbuhan, sintasan.

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a type of freshwater fish with high economic value and an essential commodity in the fisheries industry in Indonesia. The advantages of tilapia lie in its ease of cultivation, popularity in the community, affordable price, and ability to adapt to the environment (Istiqomah *et al.,* 2018). This fish also plays a role as one of the primary sources of increased nutrition in developing countries, including Indonesia. Based on data from the Ministry of Marine Affairs and Fisheries (MMAF) 2022, tilapia production shows an increase yearly, with production growth of 8.01% in 2022 compared to the previous year.

Tilapia (*Oreochromis niloticus*) to increase production, cultivation has been intensive. Intensification of cultivation with high stocking density and the provision of feed containing high protein (Setijaningsih and Bambang, 2016). However, intensive fish cultivation can reduce water quality, impacting tilapia's growth process and survival (Scabra *et al.,* 2024). This is caused by waste from leftover feed and tilapia metabolism (Effendi *et al.,* 2015). Accumulation of ammonia compounds from waste from leftover feed and metabolism can be toxic, reducing the productivity and survival of fish being cultivated (Marlina & Rakhmawati, 2016).

One of the challenges in increasing tilapia cultivation production is the limited empty land for cultivation activities and the difficulty of obtaining water sources in some areas. The availability of land and water supply are two key factors that significantly influence the success of fisheries cultivation efforts (Marlina & Rakhmawati, 2016). Therefore, the lack of land and limited water sources are the main obstacles that must be overcome to increase aquaculture production.

Aquaponics is an alternative cultivation method that utilizes waste from fish farming while saving land and water use. This system has the advantages of land and water efficiency and the potential to generate additional income from cultivated plants (Hormati *et al.,* 2023). Aquaponics integrates aquaculture technology and fish farming with hydroponic technology, which is plant cultivation without using solid planting media such as soil, in one mutually beneficial system. By utilizing fish waste and leftover feed as a source of nutrients for plants, aquaponics not only reduces water requirements in cultivation but also minimizes pollution caused by fishery waste (Irania *et al.,* 2022).

In an aquaponic system, fish and plants have different roles but support each other in a symbiotic mutualism (Krastanova *et al.,* 2022). Plants function as biofilters that clean the water before returning it to the cultivation pond, thus creating an environment that supports the growth and survival of fish. However, the ability of plants to absorb nutrients in water can decrease if the concentration of stable organic matter that has not been wholly decomposed increases. The accumulation of high-protein feed residues that are not decomposed aerobically will trigger anaerobic decomposition, producing by-products such as ammonia and sulfide acid, which are toxic to farmed fish (Hormati *et al.,* 2023).

Previous studies have revealed the effect of giving certain types of probiotic bacteria on the growth performance of specific fish farming. Various types of bacteria commonly used as probiotics in fish farming activities with aquaponic systems are *Bacillus* sp., *Nitrobacter* sp., and *Nitrosomonas* sp. (Amri, 2021; Listiani & Putra, 2024). Several types of fish that have been observed in the provision of probiotics on cultivation performance with aquaponic systems are catfish (*Clarias gariepinus*) (Primashita *et al.,* 2017), striped catfish (*Pangasius hypophthalmus*) (Jusadi *et al.,* 2007), and koi fish (*Cyrprinus rubrofuscus*) (Hasnidar *et al.,* 2023). This study was conducted to determine the best dose of probiotic addition to feed on the performance of tilapia (*Oreochromis niloticus*) cultivation in an aquaponic system. The probiotics used were *Bacillus* sp., *Nitrobacter* sp., and *Nitrosomonas* sp. The results of this study can provide recommendations for the best dose of probiotics in optimizing the performance of tilapia cultivation activities in an aquaponic system.

RESEARCH METHODS

Time and place of research

This research was conducted in December 2024. The research took place in Building 4, Joint Building of the Faculty of Fisheries and Marine Sciences and the Faculty of Agriculture, Universitas Padjadjaran.

Tools and Materials

Tools required. buckets with a capacity of 80L, water pump, water pipe 4 inc and ½ inc, plastics cups, pipe L ½, pipe dop, male threaded. Materials required. Black tilapia, pellets, lettuce seeds, rockwolls, probiotics.

Test Parameters

Absolute Weight Growth, Absolute length growth, specific growth rate, survival rate, feed efficiency, leaf width, plant height, root length, and plant weight, water quality. Fish and lettuce cultivation activities with an aquaponic system were carried out for 40 days in November-December 2024. The cultivation was carried out in the Greenhouse, Joint Building, Faculty of Agriculture with the Faculty of Fisheries and Marine Sciences, Padjadjaran University. The tilapia cultivation container was set in a bucket with a capacity of 80 liters containing 70 liters of water with a density of 20 fish. The tilapia used in this study were 8.2 $\pm$ 0.08 cm in size and weighed 8.70 $\pm$ 0.09 grams.

The lettuce (*Lactuca sativa*) used in the aquaponics system has undergone a seeding period of 10 days in Rockwool. After that, the lettuce seedlings were moved into an aquaponics system consisting of a 4-inch diameter PVC pipe. The pipe is given a hole with a diameter of 1 inch. Lettuce seedlings are placed in plastic cups with holes in them and placed in the holes in the PVC pipe. The distance between each hole is ± 2 inches. The number of lettuce in one aquaponics system is 19 plants (Figure 1).

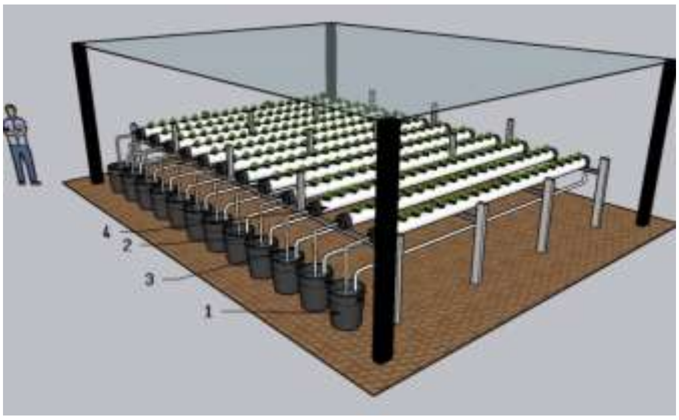

Figure 1. Aquaponic system design sketch (1. Cultivation media for fish, 2. Inlet, 3.Outlet, 4. Cultivation media plants)

Four observation groups were used, with each group having three replications. The four groups in question were (A) negative control without probiotics; (B) addition of probiotics at a dose of 5 ml.kg^{-1} feed; (C) addition of probiotics at a dose of 7.5 ml.kg^{-1} feed; and (D) addition of probiotics at a dose of 10 ml.kg^{-1} feed. The probiotics used were a mixture of three bacteria: *Bacillus* sp., *Nitrobacter* sp., and *Nitrosomonas* sp. These three bacteria are known to have an active role in the nitrogen cycle, especially breaking down organic matter from leftover feed and fish excretion into nutrients that plants can use in the aquaponic system (Listiani & Putra, 2024). In another study, Andriyani (2019) stated that the best dose of probiotics to be applied to farmed tilapia feed is 8.57 ml.kg^{-1} feed for cultivation activities with almost similar probiotic bacterial content. In this study, we tried tousey the probiotic content to tilapia feed cultivated with an aquaponic system.

The feed used in this study was commercial feed Hi Pro Vit 781-2 with a protein content of 31-33%. Feeding was done using the Feeding Rate method of 5% fish biomass. Probiotics were mixed into the feed based on the dose for each treatment and given at a frequency of 2 times in 1 day.

Length and weight sampling of fish were conducted every 10-day interval. To determine the performance of tilapia cultivation, an analysis of absolute length and weight growth, specific growth rate, survival rate, and feed efficiency was conducted. The performance of lettuce cultivation as supporting data was analyzed based on differences in lettuce length, leaf width, and lettuce plant weight, which were also observed every 10-day interval. Water quality parameters such as temperature, pH, dissolved oxygen, nitrate, nitrite, and ammonia were also checked at this interval.

Specific Growth Rate

The specific growth rate is calculated in percentage units of the average weight of fish at a particular time to the average weight at the beginning of cultivation. The specific growth rate value describes the daily average weight growth percentage during the cultivation period. The calculation of the specific growth rate refers to Zonnevald *et al.,* (1991) as follows:

$$SGR = \frac{\ln W_t - \ln W_0}{t} \times 100\% \quad \text{...(3)}$$

Note :
SGR : Specific Growth Rate (%)
W_t : Average weight at time-t (gram)

W_0 : Average weight at the start of cultivation (gram)
t : Time of observation (day)

Survival Rate

Survival rate is a value that describes the percentage of fish that survive at the end of the observation period compared to the number of fish at the beginning of cultivation. The survival of tilapia is calculated based on the formula proposed by Zonnevald *et al.,* (1991).

$$SR = \frac{N_o - N_t}{N_o} x\ 100\% \quad \ldots\ldots(4)$$

Note :
SR : Survival Rate (%)
N_t : Number of tilapia at time-t
N_o : Number of tilapia at the start of cultivation

Feed Efficiency

Feed efficiency is the percentage of weight produced during fish farming to the amount of feed given. The higher the feed efficiency value indicates the more optimal use of feed converted as weight in farmed fish. Feed efficiency is calculated based on the Zonnevald *et al.,* (1991) formula.

$$FE = \frac{W_t - W_o}{F} x\ 100\% \quad \ldots\ldots(5)$$

Note :
FE : Feed Efficiency (%)
F : The amount of feed given to fish during cultivation (gram)

Each observation parameter analyzed was compared for four treatment groups using Analysis of Variance (ANOVA) with a 95% confidence level. The Tukey Test was used to compare each significant treatment (Walpole, 1995).

RESULTS

The quality of the cultured water measured during the study showed a range of values that were still within good standard quality for fishery cultivation activities. The water temperature was at an average value of 28.3-28.5°C and did not differ significantly in the four treatments tested. The acidity level of the cultured water was at an average value between 6.1-6.7 and did not differ considerably in the four treatment groups. The dissolved oxygen values in the four treatment groups also did not differ significantly, with an average value between 5.3-5.9 $mg.L^{-1}$. The concentration of ammonia in the cultured water in the control group and the addition of 5 $ml.kg^{-1}$ feed probiotics tended to be higher (0.4-0.5 $mg.L^{-1}$) when compared to the average ammonia concentration in the 7.5 and 10 $ml.kg^{-1}$ feed probiotic addition groups (0.2 $mg.L^{-1}$). Meanwhile, the nitrate concentration, with the highest value in the control group, was significantly different from the 7.5 and 10 $ml.kg^{-1}$ feed probiotic administration groups but not substantially different from the 5 $ml.kg^{-1}$ feed probiotic administration group. The nitrate concentration in the 5 $ml.kg^{-1}$ feed group did not differ significantly from the other three groups. The lowest nitrite concentration was found in the 10 $ml.kg^{-1}$ probiotic treatment, which was substantially different from the control group and the addition of 5 $ml.kg^{-1}$ feed probiotics but not significantly different from the 7.5 $ml.kg^{-1}$ feed probiotic addition group.

Table 1. Water quality parameters measured during the research

Parameters	Measured Values in Each Treatment Group*				Standards of Quality
	Control	Probiotic 5 ml.kg^{-1}	Probiotic 7.5 ml.kg^{-1}	Probiotic 10 ml.kg^{-1}	
Suhu (°C)	28.5 ± 0.3^{a}	28.4 ± 0.2^{a}	28.3 ± 0.2^{a}	28.3 ± 0.3^{a}	25–32 (SNI 7550:2009)
pH	6.1 ± 0.4^{a}	6.5 ± 0.3^{a}	6.6 ± 0.3^{a}	6.7 ± 0.1^{a}	6,5–8,5 (SNI 7550:2009)
DO (ml.kg^{-1})	5.3 ± 0.4^{a}	5,9 ± 0.2^{a}	5.8 ± 0.1^{a}	5.9 ± 0.1^{a}	≥ 3 (SNI 7550:2009)
NH_3 (ml.kg^{-1})	0.5 ± 0.2^{a}	0.4 ± 0.1^{a}	0.2 ± 0.1^{b}	0.2 ± 0.1^{b}	< 0,02 (SNI 7550:2009)
NO_3^- (ml.kg^{-1})	54.2±12.9^{a}	37.5 ± 5.3^{ab}	31.3 ± 4.0^{b}	29.2 ± 2.4^{b}	5–150 (Deswati *et al.*, 2020)
NO_2^- (ml.kg^{-1})	0.5 ± 0.2^{a}	0.3 ± 0.1^{a}	0.2 ± 0.1^{ab}	0.1 ± 0.0^{b}	< 1 (Deswati *et al.*, 2020)

*Significance was analyzed at α 0.05

The average length and weight values measured every 10-day interval indicate growth in tilapia cultivated with an aquaponic system. During the observation period until the 30th day, there was no significant difference in the average length and weight of tilapia. A significant difference was only found on the 40th day of observation. The average length of tilapia was significantly different in the treatment groups with the addition of probiotics of 7.5 and 10 ml.kg^{-1} feed. The average length of tilapia was highest in the treatment group with the addition of 7.5 ml.kg^{-1} feed probiotics. Something that was not much different also occurred in the average weight value of tilapia during the observation period on the 40th day. The average weight value in the treatment group with the addition of probiotics of 7.5 ml.kg^{-1} feed was significantly higher compared to the other three groups (Figure 2).

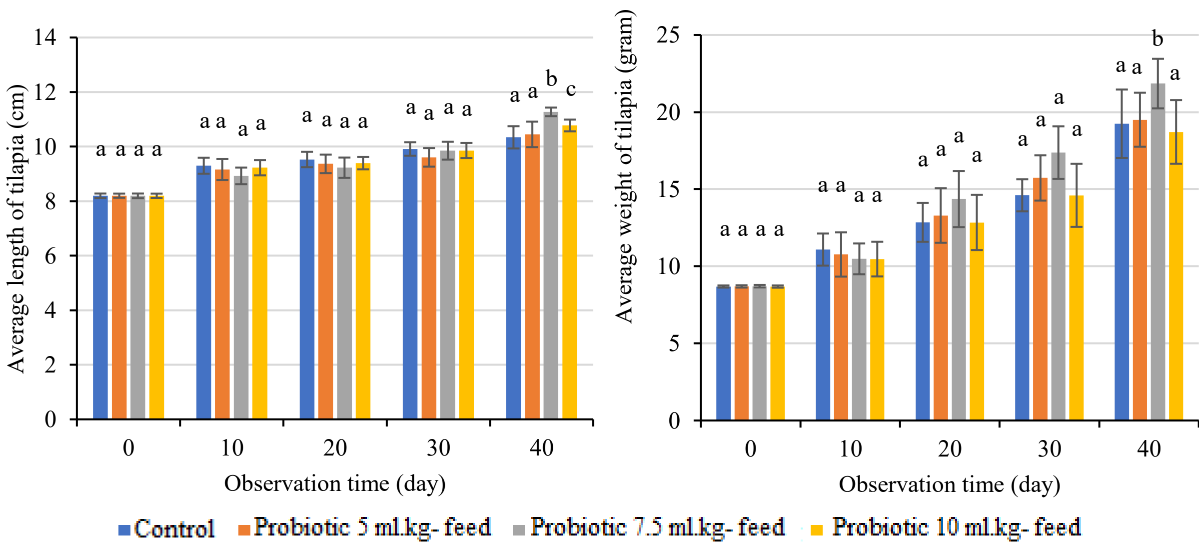

Figure 2. Average length and weight of tilapia during the observation period

The specific growth rate of tilapia did not significantly differ between the four treatment groups tested until the 30th day of observation. Meanwhile, there was a significant difference on the 40th day of observation, the highest in the 7.5 ml.kg^{-1} feed treatment group compared to the other three treatment groups (Table 2).

Table 2. Specific Growth Rate of Tilapia (%)

Observation time (day)	SGR (%)			
	Control	**Probiotic 5 ml.kg^{-1}**	**Probiotic 7.5 ml.kg^{-1}**	**Probiotic 10 ml.kg^{-1}**
10	2.43 ± 0.27^a	2.14 ± 0.29^a	1.85 ± 0.25^a	1.87 ± 0.27^a
20	1.96 ± 0.14^a	2.12 ± 0.16^a	2.50 ± 0.16^a	1.95 ± 0.16^a
30	1.73 ± 0.09^a	1.98 ± 0.10^a	2.30 ± 0.10^a	1.73 ± 0.11^a
40	1.99 ± 0.09^a	2.02 ± 0.08^a	2.30 ± 0.08^b	1.92 ± 0.08^a

*Significance was analyzed at α 0.05

The tilapia survival rate in the aquaponic system was best in the 7.5 ml.kg^{-1} feed treatment, with 100% survival until the end of the observation period. The lowest survival rate was in the control treatment group, with a value of 80.0 ± 2.5% at the end of the observation (Table 3).

Table 3. Survival Rate of Tilapia (%)

Observation time (day)	Survival Rate (%)			
	Control	**Probiotic 5 ml.kg^{-1}**	**Probiotic 7.5 ml.kg^{-1}**	**Probiotic 10 ml.kg^{-1}**
0	100.0^a	100.0^a	100.0^a	100.0^a
10	100.0^a	100.0^a	100.0^a	100.0^a
20	100.0^a	100.0^a	100.0^a	100.0^a
30	88.3 ± 1.4^a	100.0^b	100.0^b	100.0^b
40	80.0 ± 2.5^a	91.7 ± 1.4^b	100.0^c	93.3 ± 1.4^b

*Significance was analyzed at α 0.05

The average feed efficiency value showed the best cultivation performance in the treatment group, adding 7.5 ml.kg^{-1} feed probiotics (50.9 ± 1.5%), significantly different from the other three treatment groups. The lowest feed efficiency value was in the control treatment (29.5 ± 2.2%) (Figure 3).

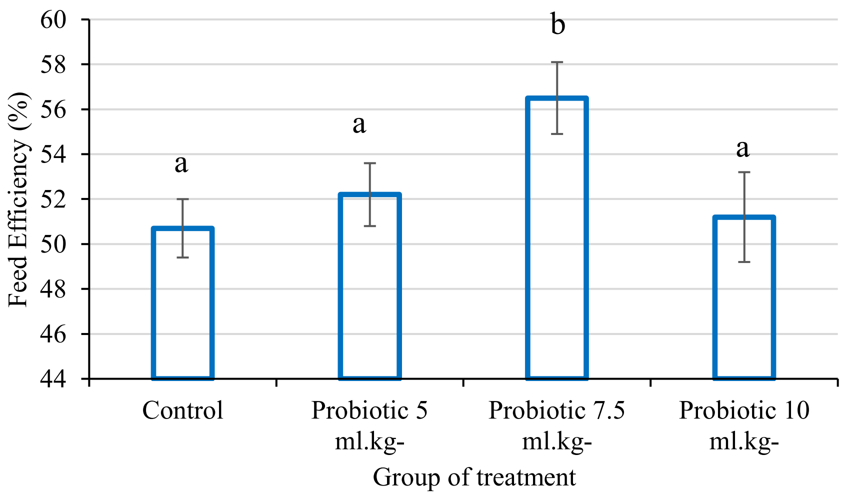

Figure 3. Feed efficiency (%) of tilapia in the aquaponic system

The performance of cultivation with the aquaponic system was also reviewed based on the growth of lettuce plants as a by-product with economic value. The performance of lettuce cultivation on the three parameters measured showed a better growth rate of lettuce plants in the treatment group with the addition of 10 $ml.kg^{-1}$ feed probiotics (Table 4).

Table 4. Performance of lettuce cultivation in an aquaponic system

Parameters	**Measured Values in Each Treatment Group***			
	Control	**Probiotic 5 $ml.kg^{-1}$**	**Probiotic 7.5 $ml.kg^{-1}$**	**Probiotic 10 $ml.kg^{-1}$**
Average length of lettuce (cm)	7.5 ± 1.3^{a}	10.9 ± 1.7^{b}	11.7 ± 1.7^{b}	13.5 ± 2.6^{b}
Average leaf width (cm)	3.5 ± 0.5^{a}	5.4 ± 1.1^{ab}	5.8 ± 1.3^{ab}	7.6 ± 1.7^{b}
Average weight (grams per lettuce plant)	19.7 ± 5.4^{a}	28.7 ± 5.3^{ab}	33.4 ± 5.3^{b}	40.2 ± 6.6^{b}

*Significance was analyzed at α 0.05

DISCUSSION

Aquaponics is an integrated system between fish farming and hydroponic plants (Puspa & Rawal, 2024). Water circulation is carried out in a rotating and continuous manner from the fish farming container to the hydroponic plants and back to the fish farming container. This circulation is carried out to increase the efficiency of water use and management of the quality of the cultivation water (Bregnballe, 2015). Plants are known to absorb excess nutrient levels produced from cultivation activities and convert them as biomass (Trang *et al.,* 2017). However, decomposer bacteria are needed to obtain nutrients from cultivated organic waste, such as leftover feed and excretion (Antika *et al.,* 2024). Therefore, in the general aquaponic system, probiotics consist of various decomposing bacteria (Kasozi *et al.,* 2021).

This study uses a mixture of good bacteria such as *Bacillus* sp., *Nitrosomonas* sp., and *Nictrobacter* sp. (Listiani & Putra, 2024). *Bacillus* sp. are often used as probiotics in mixed feed for farmed fish. These bacteria can produce enzymes such as protease, lipase, and amylase, breaking down protein, fat, and carbohydrates in feed and making them easier for fish to digest (Andriani & Pratama, 2022). In addition, *Bacillus* sp. can help decompose organic matter, such as fish food waste, dirt, and other organic particles, into simpler compounds (Hlordzi *et al.,* 2020). *Nitrobacter* sp. is a bacteria that is commonly added to aquaponic cultivation water. These bacteria play a direct role in the nitrogen cycle, namely oxidizing NO_2^- toxic compounds to fish into NO_3^- as nutrients aquaponic plants can absorb. In addition, Nitrobacter sp. can synergize with Nitrosomonas sp. in converting ammonia to nitrite (Dwiardani *et al.,* 2021). The role of these three bacteria is indicated to work in the research conducted. This can be seen from the significantly smaller ammonia, nitrate, and nitrite values in the treatment group adding probiotics at higher doses, 7.5 and 10 $ml.kg^{-1}$ feed.

Well-maintained aquatic environmental conditions will increase the productivity and performance of aquaponic cultivation (Fan *et al.,* 2025). Based on the observation results, we obtained that the treatment group of probiotic addition with a dose of 7.5 $ml.kg^{-1}$ feed provided the best tilapia cultivation performance in terms of average length and weight growth values, specific growth rate, survival rate, and tilapia feed efficiency. The addition of probiotics in improving fishery cultivation performance generally has specific optimum conditions at certain concentrations or doses. Cultivation performance conditions can increase to the optimum dose and concentration values and decrease again at values above. This can be because the bacteria contained in probiotics have different optimal conditions in carrying out their duties to decompose excess organic matter in the cultivation system. Adding probiotic doses or concentrations in the same organic material conditions does not provide a better effect because the decomposed material remains (Hasan *et al.,* 2020).

However, the performance of lettuce cultivation had the best value at the highest dose of probiotics tested, which was 10 $ml.kg^{-1}$ of feed (Table 4). This condition was assessed from the average lettuce length, leaf width, and lettuce plant weight. As an autotrophic organism, lettuce plants absorb free nutrients from the cultivation water that flows into the aquaponic system. These free nutrients are produced from the decomposition of organic matter by bacteria (Setijaningsih *et al.,* 2025). In this case, we found that adding 10 $ml.kg^{-1}$ of probiotics produced the most optimal free nutrients for lettuce plant growth in the aquaponics system.

CONCLUSION

The addition of probiotics containing *Bacillus* sp., *Nitrosomonas* sp., and *Nictrobacter* sp. in feed can increase the growth of tilapia (*Oreochromis niloticus*) with the most optimal conditions at a dose of 7.5 $ml.kg^{-1}$ feed. Adding probiotics to feed at a dose of 7.5 $ml.kg^{-1}$ feed is the most optimal treatment. It influences improving the growth performance of tilapia (*Oreochromis niloticus*) such as a specific growth rate of 2.30 ± 0.1%, 100% survival, and feed efficiency of 56.5 ± 1.6%.

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