Comparative disease incidence and prevalence in green and brown varieties of *Kappaphycus alvarezii* cultivated in Pelakak Village, Lingga District

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Abstract. This study was aimed to analyze the disease incidence and prevalence development of *Kappaphycus alvarezii* from green and brown varieties. This study used a completely randomized design experimental method with two treatments and four replications. Seaweeds were reared with a longline culture method. The initial weight of seaweeds from each replication unit was 2.70 kg. Incidence and prevalence were observed every day until the 42-th day of culture period. All data obtained were analyzed with an independent t-test. The results showed that there were six incidents of pests and disease attack/infection on two seaweed varieties, namely: (1) Rabbitfish *Siganus* sp., (2) Epiphytic Filamentous Algae (EFA), (3) Green filamentous algae (*Chaetomorpha* sp.), (4) Brown seaweeds *Sargassum* sp., (5) *Ice-ice* disease, and (6) *Fusarium* sp. mold. Each attack/infection from six pests and disease was insignificantly different ($p>0.05$) on both seaweed varieties during observation. The weight gain of green variety slightly increased at 0.15±1.48kg, but the value was lower than brown variety at 0.73±0.39 kg. Therefore, both varieties of *K. Alvarezii* can be cultured at the same planting period. Pest and disease attacks can be reduced by moving the seaweed to other safer locations.

1 Introduction

Seaweeds are included in Thallophyta division and Algae subdivision that can be consumed by humans. Seaweeds are utilized in various industries, such as medical, food processing, cosmetics, textiles, and agriculture industries. Seaweeds have many beneficial contents, namely:

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(a) Various essential minerals, like iron, phosphorus, sulphur, chlor, potassium, iodine, calsium, cobalt, boron, and copper, (b) Protein, nucleic acids, amino acids, starchs, sugars, and vitamins A, D, C, D, E, K [1], (c) Carrageenan as a thickener, a stabilizer, a gel-forming agent, and an emulsifier, that can be applied in food industries as an additive, like ice cream, (d) Flavonoids and phlorotannins as chemical resistance agents against ultraviolet (UV) light and natural antioxidants [2].

Seaweed culture has long been developing widely as a main occupation of coastal communities in various regions in Indonesia, namely South Sulawesi, Lampung, Bali, and West Nusa Tenggara. As Indonesia's seaweed production is also high, seaweeds become the Indonesia's export commodities, which were recorded at USD 433.715.441 in 2023 year [3]. However, seaweed culture is relatively new in Riau Islands. Only a few sea areas are utilized for seaweed culture, such as on Jaga Island, Sugi Besar Island in Karimun Regency, Singkep Island in Lingga Regency, and several small islands in Batam [4]. In fact, Riau Islands have 2,408 islands and 95% of which is mostly shallow seas as a culture location potential. The seaweed types that are generally cultured are from *Kappaphycus* or *Eucheuma*, which are commonly referred by the community as *cottonii*. The quality of coastal waters is highly important in supporting the seaweed culture success. Good quality waters that meet the requirements for seaweed culture play an important role in providing nutrients, such as nitrogen, phosphorus, and other micronutrients for the growth and development of seaweed. Several organisms can be pathogenic or parasitic on seaweed, and poor water quality can facilitate disease distribution on these organisms.

Pest and disease control in seaweed culture is important. The presence of pests and diseases negatively impacts the seaweed by: (a) damaging and breaking the thallus, (b) blocking the sunlight for photosynthesis, (d) decreasing the seaweed quality of seaweed, and (d) gaining low production level. The next consequence is economic losses for local seaweed farmers. In relation to the resistance of cultivated seaweed to the disease emergence, two terms are known, namely (1) incidence and (2) prevalence of disease. Incidence is the number of new cases of disease found in a seaweed population regardless of the attack severity. Prevalence is the proportion of clumps in a seaweed population affected by disease at a certain time.

Studies on the resistance level comparison between *Kappaphycus alvarezii* green and brown varieties, that are cultured during the south monsoon season in the coastal waters of Pelakak Village, Lingga Regency are still limited. Therefore, this study intends to support the business sustainability and increase the production level of cultured seaweed that has been carried out by the community in Pelakak Village, Lingga Regency. This study aimed to analyze the disease incidence and prevalence development of *Kappaphycus alvarezii* from green and brown varieties.

2 Methods

The seaweed rearing treatment as referred to [4], who stated that the longline method produced the highest growth rate in *Kappaphycus striatum*, compared to the bottom method and the off-bottom method in Pelakak Village. This study was carried out during the south wind season in June-August, 2024 and located in the coastal waters of Pelakak Village, Lingga Regency (Figure 1). The materials and tools used included green and brown varieties of *Kappaphycus alvarezii* seaweed seeds (Figure 2), longline method culture tools, namely polyethylene (PE) rope, digital scales, and speedboats.

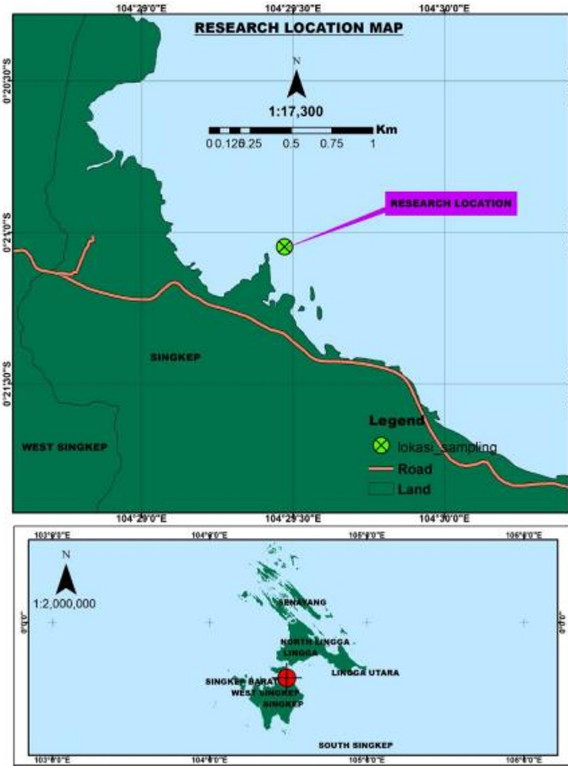

Fig. 1. Seaweed rearing treatment location in Pelakak Village, Lingga Regency

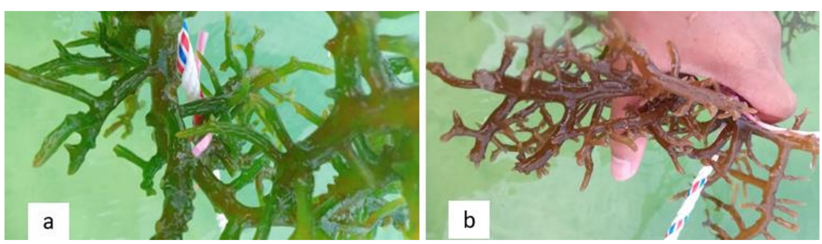

Fig. 2. *Kappaphycus alvarezii* seaweeds: Green (a) and Brown varieties (b)

2.1 Experimental design

For experimental design, a completely randomized design with two treatments and four replications were applied, namely:

(1) Green variety of *Kappaphycus alvarezii* with longline method and initial weight of 100g/seeds and seed distance of 30cm (P1)

(2) Brown variety of *Kappaphycus alvarezii* with longline method and initial weight of 100g/seeds and seed distance of 30cm (P1) (P2).

2.2 Longline Location

The location of the longline placement in the coastal waters of Pelakak Village was chosen in a commonly used area to culture seaweeds. For longline method, the seaweed seeds are placed using the polyethylene (PE) ropes. Three strands of rope at 3 m length in each

replication. There are nine clumps of seaweed seeds on each rope. The placement and distribution of seaweed seeds for the treatment were conducted randomly (Figure 3).

Fig. 3. Placing and stocking of *K. alvarezii* in the study location

2.3 Seaweed health monitoring and growth sampling

The health condition of the seaweed seeds to determine the incidence and prevalence of pest and disease attacks was monitored every day for 42 days. The first monitoring began on the next day, after stocking. Seaweed growth was sampled every 7 days until harvest on the 42nd day. The monitoring and sampling reports are presented weekly.

2.4 Parameters

Parameters that were observed included: (a) Incidence and prevalence; (b) Weight gain of seaweeds. The formula:

Incidence (*I*) = *number of infected seaweeds in t-time range* (1)
Prevalence (*P*) = *(infected seaweeds/number of seaweeds)* × *100%* (2)
Weight gain = (*Wt-Wo*)/*t* (3)
Note:
Wt = final weight of seaweeds (kg)
Wo = initial weight of seaweeds (kg)
t = total observational days (days)

3. Data analysis

The prevalence, incidence and weight gain data were analyzed by an independent t-test. Meanwhile, physical and chemical water quality were analyzed based on the optimal criteria for seaweed growth and presented qualitatively.

4. Results and discussion

There are four types of pests and two types of diseases that attacked both varieties of *K. alvarezii* seaweeds during the observation period. The initial time of pest attacks and disease infections are:

(1) *Siganus* sp. (rabbitfish) in brown seaweed variety was occurred a day after stocking, while in green variety was occurred on the 2nd day after stocking,

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(2) Epiphytic Filamentous Algae (EFA) were slightly occurred on the 2nd day after stocking on both varieties,
(3) Filamentous green algae (*Chaetomorpha* sp.) were found on the ropes and in clumps of brown variety on the 1st day after stocking, while green variety in the 8th day after stocking,
(4) *Sargassum* sp. that were appeared on the 15th day in brown variety and the 39th day in the green variety,
(5) *Ice-ice* began to emerge on the 14th day on the brown variety and the 15th day on the green variety, and
(6) *Fusarium* sp. was emerged on the bite marks of the rabbitfish on the 2nd day after stocking on both varieties. Characteristics for incidence and prevalence of pests and diseases are described below:

4.1 Pests

4.1.1 Siganus spp.

The first pest that attacked the seaweeds was a group of the rabbitfish (*Siganus* spp.). This fish consumes the seaweed thallus, which can cause the seaweed death and can also encourage secondary infections. A sign of this pest attack is presented as a bitemark (Figure 4). Prevalence of rabbitfish (*Siganus* spp.) is presented in Figure 5.

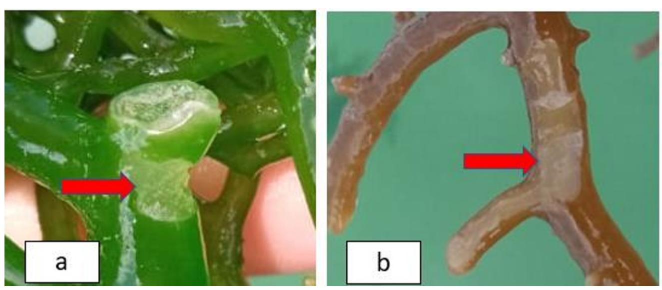

Fig. 4. Bitemarks of rabbitfish on green variety (a) and (b) brown variety of seaweeds

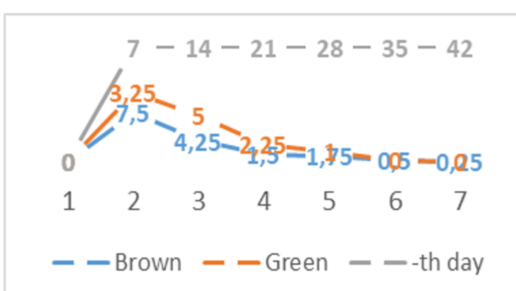

Fig. 5. Prevalence (%) of *Siganus* sp. on *Kappaphycus alvarezii* green and brown varieties

Rabbitfish attack the seaweeds seasonally, especially during the seed stocking season [5], as presented on this study at the initial stocking period (1-st day). The high rate of Rabbitfish attack on the seaweed was also experienced by [6] and [7]. The rabbitfish attack to *K. alvarezii* seaweed was up to 40% [8]. The weight of the seaweeds [7] decreased by 39.63 g from its initial weight due to being eaten by Rabbitfish.

4.1.2 Epiphytic Filamentous Algae (EFA)

Based on the morphological observations, the Epiphytes that lived attached to the seaweed surface are identified as Epiphytic Filamentous Algae (EFA) from *Melanothamnus* (previously called *Neosiphonia*) or commonly called as cat-fur epiphytes (Figure 6). The prevalence of EFA that attacked seaweeds is presented in Figure 7.

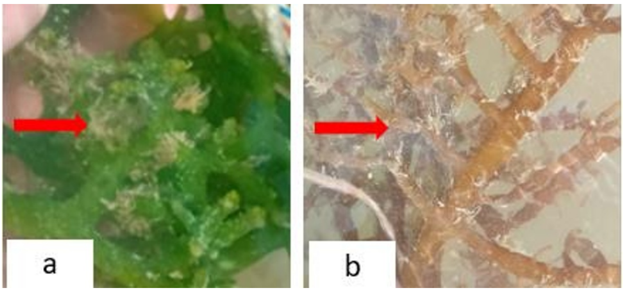

Fig. 6. Epiphytes *Melanothamnus* on two seaweed varieties: (a) green variety and (b) brown variety.

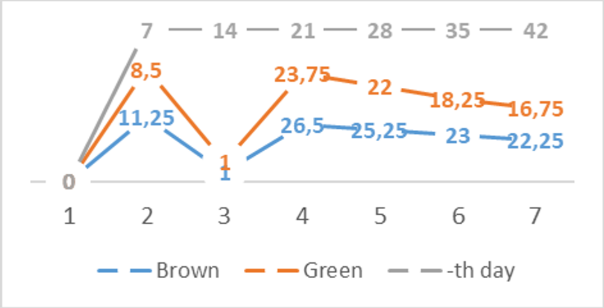

Fig. 7. Prevalence of EFA on *K. alvarezii* green and brown variety

Epiphytes have rhizoids to penetrate the seaweed tissue and cortex. This action causes the emergence of black spots followed by the development of reddish hair-like filaments in seaweeds. Increased number and size of Epiphytes damages the thallus tissue. The damaged seaweed thallus eventually breaks and is carried away by the sea current, while other thallus has difficulties in photosynthesizing and absorbing nutrients due to Epiphytes.

The present study showed a similar condition to seaweed culture in Sabah, Malaysia, which was also attacked by *Melanothamnus* spp. with high infection rates during the inter-monsoon season around June and September [9];[10]. The presence of EFA outbreaks in the seaweeds is strongly suspected due to free-floating *Sargassum* sp. contact that were previously infected with EFA on the seaweed ropes. In addition, the high content of organic matter at the bottom of the waters where the seaweeds were reared was a trigger for the rapid growth of the Epiphyte [4].

4.1.3 Filamentous green algae (Chaetomorpha sp.)

Other epiphytes found seaweeds are soft filamentous algae (*Chaetomorpha* sp.) as presented in Figure 8.

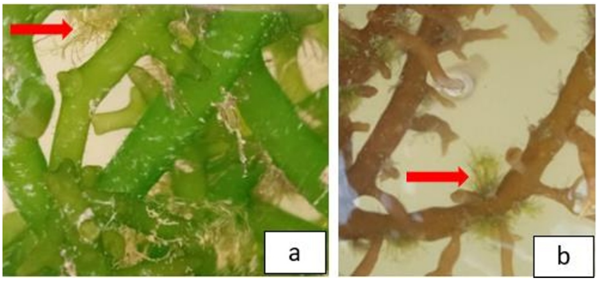

Fig. 8. Filamentous algae presented in seaweeds: (a) green variety, (b) brown variety

Attachment of filamentous algae (Figure 8) on thallus causes sunlight penetration block for photosynthesis and nutrient absorption by seaweeds, which then slowly leads to death. The prevalence of filamentous green algae (*Chaetomorpha* sp.) on seaweeds is shown in Figure 9.

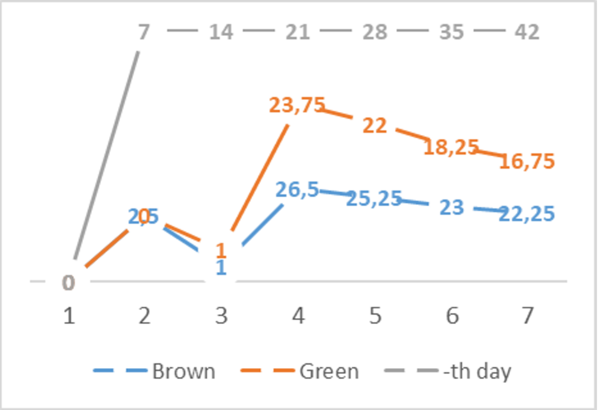

Fig. 9. Prevalence of *Chaetomorpha* sp. on *Kappaphycus alvarezii* green and brown variety

4.1.4 Sargassum sp.

Sargassum sp. (Figure 10) is classified as seaweeds, but remained uncultured in Riau Islands. The prevalence of *Sargassum* sp. that attacked the cultured seaweeds is presented in Figure 11.

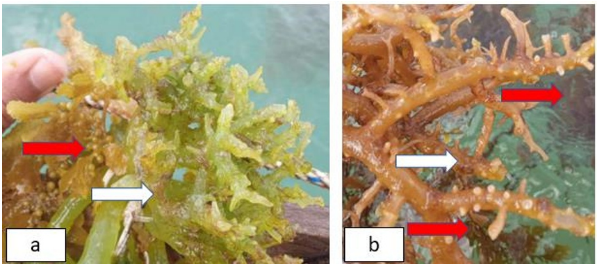

Fig. 10. *Sargassum* sp. emergence (red arrows)

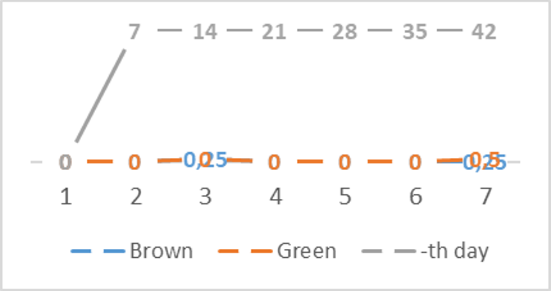

Fig. 11. Prevalence of *Sargassum* sp. on *Kappaphycus alvarezii* green and brown variety

Sargassum sp. are initially known as a waste that jeopardize the fishermen's activity, but this species has lately been included in traded seawater commodities. The average cost of dried *Sargassum* sp. is Rp 1,500-2,000/kg. A contact between *Sargassum* sp. and EFA, then sticks to the rope of the cultivated seaweed begins the EFA infection on seaweeds. *Sargassum* sp. becomes a competitor to the cultured seaweeds in obtaining nutrients, oxygen, and living space, thus inhibiting the cultured seaweed's photosynthesis and growth.

4.2 Diseases

4.2.1 Ice-ice Disease

Ice-ice disease is generally caused by a combination of low and sudden environmental factor, followed by bacterial attacks from *Vibrio* spp. and *Pseudomonas* spp. Seaweeds affected by this disease have whitened thalli with soft and easily broken texture (Figure 12). The prevalence of Ice-ice disease attacking the treated seaweed is shown in Figure 13.

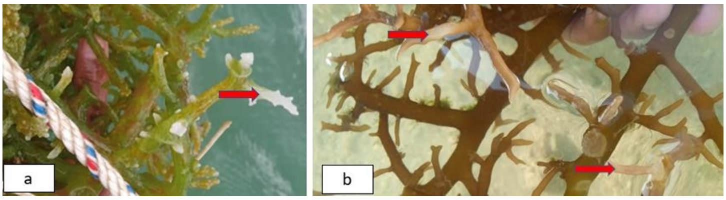

Fig.12. Ice-ice on seaweeds

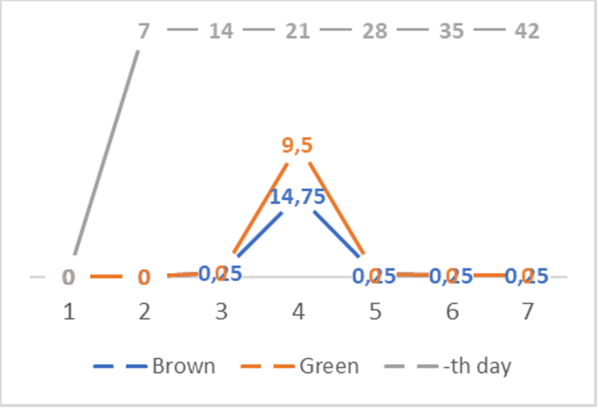

Fig. 13. Prevalence of the Ice-ice on *Kappaphycus alvarezii* green and brown variety

Ice-ice disease commonly attacks during the rainy season (October-April) and is contagious due to bacterial infection. This disease occurs along with elevated seaweed's age and lack of nutrition. Ice-ice is characterized by the emergence of red spots on the thallus, which then becomes pale yellow and gradually becomes white and finally falling-off. Sudden changes in environmental conditions, such as changes in salinity, water temperature, and light intensity are the main factors that trigger ice-ice disease.

4.2.2 Fusarium sp.

Secondary infection that occurred on the bitemarks of rabbitfish was *Fusarium* sp., as morphologically characterized by white threads as shown in Figure 14. Prevalence of *Fusarium* sp. that attacked seaweeds is presented in Figure 15.

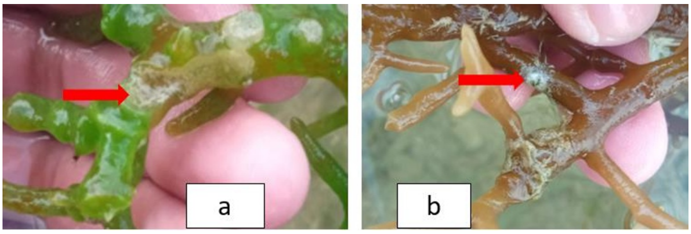

Fig. 14. *Fusarium* sp. on seaweeds (red arrows)

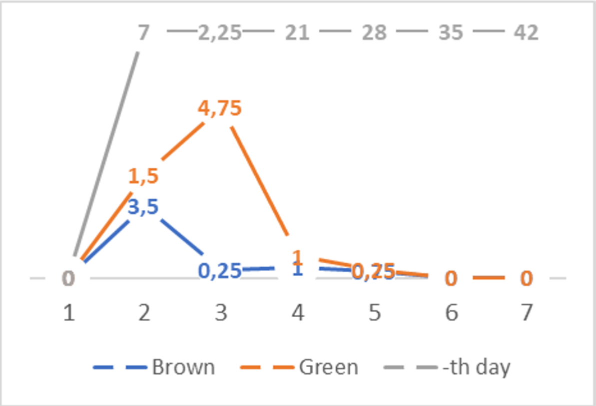

Fig. 15. Prevalence of the *Fusarium* sp on *Kappaphycus alvarezii* green and brown variety

Fusarium sp. are contagious parasites that attack seaweed thalli and usually preceded by wounds on the thallus. These fungi are detrimental that cause thallus to rot and break, then carried away by sea currents. This condition was in accordance with the previous study related to diseases in *K. alvarezii* [11].

A factor that leads to the proliferation of these fungi at the location is a closed distance between the seaweed cultivation rope and the muddy bottom of the waters when the low tide occurs. This condition triggers the development of these fungi as mud is rich in organic material that can become a source of nutrients.

The statistical analysis results showed no significant difference ($p>0.05$) in the incidence and prevalence of pests and diseases between green and brown varieties of *K. alvarezii*. This condition indicates that both varieties of *K. alvarezii* have relatively the same resistance level, so they can be cultured in the same planting period during the south monsoon season. However, the disease problems must be addressed to prevent significant

harm to the farmers. Several alternative solutions offered by the author to reduce pest and disease attacks are: (1) Removing and disposing the seaweeds that have been attacked by disease, (2) Applying excellent seeds, and (3) Moving the culture location to a deeper sea, because the current location is relatively shallow, which can be potentially contaminated by organic materials/mud as suggested by [4]. Additionally, knowledge of breeding and genetic diversity for each type of cultivated seaweed is essential to maintain seeds resistant to pests and diseases, ensuring the sustainability of the seaweed industry [12].

4.3 Water Quality

Each of the water quality parameters in the rearing location of *K. alvarezii* is presented in Table 1.

Tabel 1. Water quality parameters in the rearing location of seaweeds

No	Parameter	Values	Standard (SNI 7673: 2.2011)
1	Temperature (°C)	28-30	24-32
2	Salinity (ppt)	30-31	28-33
3	pH	7.1-7.4	7-8.5
4	Current velocity (m/s)	0.4-0.5	20-40 cm/s

In Table 1, the water quality parameters are considered suitable for seaweed culture, except for the current velocity. The current velocity conditions that are contradictory to standards have an impact on the thallus disruption, after being attacked by pests and diseases, such as rabbitfish and *Ice-ice* disease. Moreover, the presence of organic matter from the shallow waters triggers the development of disease germs due to the availability of nutrients. Therefore, relocating the culture site can be recommended as a solution for farmers.

5 Conclusion

Six incidents of attacks/infections by pests and diseases were occurred on both varieties of *K. alvarezii*, namely: (1) *Siganus* sp., (2) Epiphytic Filamentous Algae (EFA), (3) Filamentous green algae (*Chaetomorpha* sp.), (4) *Sargassum* sp., (5) Ice-ice, and (6) *Fusarium* sp. The prevalence of attacks/infections by the six pests and diseases were insignificantly different ($p>0.05$) between the two varieties during the observation. The weight gain of the green variety experienced a slight increase, namely 0.15±1.48 kg, but the value was lower than the brown variety at 0.73±0.39 kg. Both varieties of *Kappaphycus alvarezii* can be cultured at the same planting period. Relocating the culture site to a deeper seawater should considered as a solution for farmers.

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