Use of Common Lantana (Lantana camara Linn) Extract to Prevent Ice-ice Disease and Trigger Growth Rate of the Seaweed Kappaphycus alvarezii

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Abstract. This research aimed to determine and assess the growth, production, and quality of seaweed after pre-treating seedlings using lantana extract. Research on the use of common lantana Lantana camara extract in the culture of the seaweed Kappaphycus alvarezii was carried out both at experimental and mass culture scales at several locations in the coastal waters of South Konawe in Southeast Sulawesi Province, Indonesia. The treatments were soaking seaweed seedlings in solutions of lantana extract with various dosages and soaking times before planting them out in coastal waters. Observed parameters were incidence of ice-ice disease and seaweed growth rate. Results showed that, during the culture period, there was no incidence of ice-ice disease on seaweed seedlings pre-treated with Lantana extract. Thalli were healthy and dark-coloured with no ice-ice disease symptoms, while seaweed seedlings (controls) without extract soaking pre-treatment were paler in colour and ice-ice infected parts of the thalli were white. The result also showed that pre-treatment with lantana extract could increase the growth rate, with the highest net growth at a treatment dosage of 500 ppm with 30 minutes soaking time. The average value of net (absolute) growth (AG) was 387.15 g/clump, equivalent to a 12.9-fold increase from the initial weight of 30 g/clump. The average highest specific growth rate (SGR) was 6.43 %/day, while for seaweed seedlings without immersion in Lantana extract the highest SGR was only 5.86%/day. The highest average production was 417.15 g/clump, while seaweed seeds without extract yielded on average 295.70 g/clump. The highest average carrageenan content was 53.5%, compared to 38.6% for untreated (control) seaweed.

1. Introduction
Seaweed cultivation has recently grown very rapidly as a result of the increasing demand for seaweed as an export commodity. Contributing factors also include the relative ease of seaweed farming, the short cultivation cycle, and the capacity to absorb a lot of labour. But along with this development problems have arisen in seaweed farming including ice-ice, a disease which can cause low growth, low production and low quality in seaweed, and can even lead to a decline of the growing season carried over to the next planting season.

This study was motivated by the results of previous studies showing that an extract from the common lantana Lantana camara has antibacterial properties and can inhibit E. coli and Acinetobacter bacteria that are implicated in the seaweed disease ice-ice. Chemical compounds thought to inhibit the growth of ice-ice disease-causing bacteria contained in this plant are from the class of quinones, polyphenols and saponins [1]. The results of this study also showed that seeds of the seaweed Kappaphycus alvarezii pre-soaked in lantana extract had a significantly higher growth compared with
untreated (control) seedlings. Furthermore, seaweed thallus morphology in the early weeks of culture was characterized by the emergence of many new shoots in the pre-treated seedlings, suggesting that *Lantana camara* may contain growth stimulating compounds [2,3]. Based on the above, this study continued to investigate further the influence of lantana extract, which was suspected to contain compounds stimulating *K. alvarezii* growth, health and quality. The research was conducted in order to determine and assess the growth, production, and quality of farmed seaweed after pre-treating the seeds by soaking in solutions of lantana extract with a range of concentration and immersion time treatments.

2. **Materials and Methods**

2.1. **Location and Time**

This research was carried out in the coastal waters of Bungin Island, Tinanggea, South Konawe in Southeast Sulawesi Province, Indonesia. This study was conducted over 3 months, with a seaweed farming cycle of 42 days. Seaweed quality checks were carried out in the Laboratory of the Department of Fisheries, Faculty of Marine Sciences and Fisheries, Halu Oleo University.

2.2. **Materials and equipment**

Materials used in this study were seeds of the seaweed species *Kappaphycus alvarezii* and extract from the common lantana *Lantana camara*. The part of the seaweed used as seed was the end of the thallus, with an average length of 10 cm from the tip. Laboratory equipment and chemicals from the laboratory were used for analysis of the quality of seaweed. Seaweed farming equipment and materials included ropes, buoys, wooden stakes and anchors.

2.3. **Implementation of the experiment**

The research was conducted in the form of a seaweed farming trial in the coastal waters in a seaweed farming area. The cultivation method used was the floating monoline method. Seaweed seedlings were tied to the monoline at a spacing of 30 cm with a distance of 50 cm between lines. Along one 25 m line 60 seaweed clumps were attached for each treatment. The initial weight of the seaweed seeds used was 30 grams. The monolines were placed such that the planting depth was 25 cm below the sea surface. The treatments were soaking seeds in a solution of lantana extract with different doses (100 ppm, 500 ppm and 1000 ppm) and duration of immersion (soaking times of 30 minutes, 60 minutes and 90 minutes). A treatment without soaking the seeds was used as a control.

2.4. **Observations on the disease ice-ice**

Observation of the onset of ice-ice disease in seaweed was done visually and analysed descriptively.

2.5. **Seaweed growth**

Observations of growth were made by weighing samples of cultivated seaweed (wet weight) every 7 days during the 42-day cultivation period. The net (absolute) growth and the specific growth rate (SGR) were calculated. The SGR was calculated using the equation in [4–6]:

\[ LPS = \left\{ \left( \frac{W_t}{W_0} \right)^{1/t} - 1 \right\} \times 100\% \]

where:

- **SGR** = Specific growth rate (in % day\(^{-1}\))
- **W\(_t\)** = seaweed weight at time \(t\) (g)
- **W\(_0\)** = initial weight of the seaweed (g)
- **t** = length of cultivation time (day)
2.6. Seaweed Production.
Seaweed production (Pr) was calculated based on net production which was the weight of wet seaweed per clump at the end of the cultivation period (t = 42) minus the initial weight (t = 0) of the seaweed seedlings. The formula used was:

\[ Pr = \frac{Wt - W0}{rp} \]

where:
- Pr = seaweed production (g/clump)
- Wt = weight of the end of seaweed (g)
- W0 = initial weight seaweed (g)
- rp = clump

2.7. Seaweed Quality
Analysis of the quality of seaweed included the levels of carrageenan (LC) in terms of percentage (%); the water content (WC) in terms of percentage (%); and gel strength in grams per cubic centimetre (g/cm³), measured by using Gel Fira. The parameters LC and WC were calculated using the formulae:

\[ LC = \left( \frac{\text{carrageenan isolation weight}}{\text{dry sample weight}} \right) \times 100 \% \]

\[ WC = \left( \frac{\text{weight of seaweed samples} - \text{dry weight}}{\text{weight of seaweed samples}} \right) \times 100 \% \]

3. Results and Discussion
3.1. Observations of Ice-Ice Disease
Observation of the onset of ice-ice disease in the seaweed *K. alvarezii* showed that seaweed seedlings initially soaked in the lantana extract solutions remained healthy and free of ice-ice disease, and were characterized by dark coloured thalli. The seaweed seedlings not initially soaked in the lantana extract varied in condition, some appearing healthy and others with ice-ice disease characterized by pale coloured thalli with white areas appearing (Figure 1).

![Figure 1. Healthy seaweed (a) and seaweed with ice-ice disease (b)](image_url)

3.2. Seaweed Growth
During the cultivation period of 42 days, the *Kappaphycus alvarezii* seaweed seeds showed a weight gain over time, which means that the seaweeds kept growing. The soaking pre-treatment of seedlings in lantana (*Lantana camara*) extract with different treatment doses (ppm) and soaking time (hours), resulted in different mean growth (Table 1). The mean final weight at the end of the 42-day cultivation...
period was highest for the dose treatment of 500 ppm solution with 0.5 hours soaking time (417.15 g) and the average final weight at the lowest dose treatment of 100 ppm solution with 1.5 hours soaking time was 346.45 g per clump. The data showed that the heaviest seaweed clumps had grown to approximately 14 times their initial weight in 42 days. A few clumps of seaweed weight over 500 grams at the end of the study period.

Table 1. The average weight (g) of seaweed *Kappaphycus alvarezii* every week, after pre-treatment of soaking the seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

| Dose    | Soaking time | Average weight per clump of seaweed on day (t) | t-0 | t-7 | t-14 | t-21 | t-28 | t-35 | t-42 |
|---------|--------------|-----------------------------------------------|-----|-----|------|------|------|------|------|
| 100 ppm | 0.5 hour     | 30.00                                         | 44.60| 72.65| 127.50| 172.95| 241.00| 355.75|
| 1.0 hour| 30.00        | 45.20                                         | 72.70| 112.70| 179.75| 252.60| 370.60|       |
| 1.5 hour| 30.00        | 45.95                                         | 71.50| 108.65| 173.70| 246.60| 346.45|       |
| 500 ppm | 0.5 hour     | 30.00                                         | 48.80| 74.60| 128.25| 204.80| 290.20| 417.15|
| 1.0 hour| 30.00        | 46.50                                         | 81.25| 120.40| 189.30| 277.35| 393.05|       |
| 1.5 hour| 30.00        | 46.70                                         | 78.45| 128.55| 189.95| 271.75| 380.75|       |
| 1000 ppm| 0.5 hour     | 30.00                                         | 50.85| 74.00| 126.90| 176.80| 260.90| 356.15|
| 1.0 hour| 30.00        | 49.45                                         | 81.15| 129.15| 198.55| 277.20| 365.35|       |
| 1.5 hour| 30.00        | 46.20                                         | 83.35| 134.60| 216.50| 293.00| 409.15|       |

3.3. Net (absolute) growth

Net or absolute growth of *Kappaphycus alvarezii* during the cultivation period of 42 days (Table 2) shows that the highest average growth was obtained with the pre-treatment dose of 500 ppm and 0.5 hours soaking time (387.15 g per clump). The lowest mean net growth came from the treatment with a solution of 100 ppm and soaking time of 1.5 hour (316.45 g per clump). The graph in Figure 2 shows the absolute growth of the seaweeds after cultivation for 42 days.

Table 2. The average absolute growth (g) of seaweed *Kappaphycus alvarezii* pre-treated by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

| Dose    | Soaking time | Absolut growth (g) |
|---------|--------------|--------------------|
| 100 ppm | 0.5 hour     | 355.75             |
|         | 1.0 hour     | 370.60             |
|         | 1.5 hour     | 346.45             |
| 500 ppm | 0.5 hour     | 417.15             |
|         | 1.0 hour     | 393.05             |
|         | 1.5 hour     | 380.75             |
| 1000 ppm| 0.5 hour     | 356.15             |
|         | 1.0 hour     | 365.35             |
|         | 1.5 hour     | 409.15             |
Figure 2. Absolute growth of Kappaphycus alvarezii seed pre-treated by soaking seeds in a solution of lantana (Lantana camara) extract with different doses and soaking times after cultivation for 42 days is presented in Table 3.

3.4. Specific Growth Rate.
Specific growth rate (SGR) of the seaweed Kappaphycus alvarezii during the cultivation period of 42 days is presented in Table 3.

Table 3. Specific growth rate (LPS) on average seaweed Kappaphycus alvarezii, pre-treated by soaking seeds in a solution of lantana (Lantana camara) extract with different doses and soaking times

| Dose  | Soaking time | t-7   | t-14  | t-21  | t-28  | t-35  | t-42  |
|-------|--------------|-------|-------|-------|-------|-------|-------|
| 100 ppm | 0.5 hour     | 5.76  | 6.35  | 7.04  | 6.33  | 6.03  | 5.98  |
| 100 ppm | 1.0 hour     | 5.86  | 6.44  | 6.46  | 6.54  | 6.23  | 6.11  |
| 100 ppm | 1.5 hour     | 6.20  | 6.33  | 6.28  | 6.42  | 6.16  | 5.97  |
| 500 ppm | 0.5 hour     | 7.08  | 6.65  | 7.11  | 7.04  | 6.65  | 6.43  |
| 500 ppm | 1.0 hour     | 6.38  | 7.33  | 6.79  | 6.76  | 6.53  | 6.30  |
| 500 ppm | 1.5 hour     | 6.39  | 6.98  | 7.13  | 6.78  | 6.48  | 6.22  |
| 1000 ppm | 0.5 hour    | 7.67  | 6.52  | 7.04  | 6.39  | 6.30  | 5.99  |
| 1000 ppm | 1.0 hour    | 7.24  | 7.18  | 7.11  | 6.91  | 6.50  | 6.08  |
| 1000 ppm | 1.5 hour    | 6.20  | 7.49  | 7.34  | 7.27  | 6.70  | 6.39  |

For most treatments, the mean daily growth rate of seaweed reached a peak towards the beginning or middle of the cultivation period, and then the rate decreased over the following days until the end of the cultivation period (t-42) (Figure 3). The dosage of 1000 ppm solution with 1.5 hours soaking time showed the highest overall daily growth rate (6.39 %/day). The lowest mean daily growth rate was obtained with a 100 ppm solution and 0.5 hours soaking time (5.76 %/day), and increased in the following days as well as experience the peak of the highest growth rates on the twentieth day one (t-21) after planting, then declined in the following days until the end of the cultivation period (t-42) to 5.98 % per day.
Figure 3. Specific growth rate (SGR) of Kappaphycus alvarezii cultivated during 42 days after pre-treatment by soaking seeds in a solution of common lantana (Lantana camara) extract with different doses and soaking times.

Based on the continued decline in the daily growth rate of seaweed towards the end of the cultivation period of 42 days (t-42), it can be recommended that seaweed could be harvested on the thirtieth day five (t-35) after planting. In fact, the field observations showed that after the thirty-fifth day (t-35) seaweed thallus was very dense and was more easily broken.

Several studies reported specific growth rates as follows: Patajai [7] found specific growth rates between 5.07 to 9.64% day⁻¹, Ohno [8] reported rates of 2.5 - 3.5% day⁻¹, Kune of 1.11 to 1.40% day⁻¹ [9], Hurtado of 3.9 to 4.2% day⁻¹[5], Kadarusman of 2.12 to 2.67% day⁻¹ [10], and Yusuf of 4.49 to 5.58% day⁻¹ [11].

3.5. Seaweed Production

The average production of seaweed Kappaphycus alvarezii obtained at the end of cultivation (t-42) is shown in Table 4.

Table 4. The average production at the end of cultivation (t=42) of seaweed Kappaphycus alvarezii pre-treated by soaking seeds in a solution of lantana (Lantana camara) extract with different doses and soaking times

| Dose   | Soaking time | Production (g) |
|--------|--------------|----------------|
| 100 ppm| 0.5 hour     | 355.75         |
|        | 1.0 hour     | 370.60         |
|        | 1.5 hour     | 346.45         |
| 500 ppm| 0.5 hour     | 417.15         |
|        | 1.0 hour     | 393.05         |
|        | 1.5 hour     | 380.75         |
| 1000 ppm| 0.5 hour   | 356.15         |
|        | 1.0 hour     | 365.35         |
|        | 1.5 hour     | 409.15         |
The highest average production of seaweed *Kappaphycus alvarezii* at the end of cultivation (t-42) was 417.15 grams per clump at treatment with a dose of 500 ppm and a soaking time of 0.5 hours. While the lowest production was 346.45 grams per clump with 100 ppm and immersion soaking time of 1.5 hours (Figure 4).

Figure 4. The average production of seaweed *Kappaphycus alvarezii* cultivated for 42 days after pre-treatment by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

### 3.6. Seaweed quality.

The quality of the seaweed *Kappaphycus alvarezii* was evaluated based on water content, gel strength and levels of carrageenan. The results of analysis of laboratory data regarding the quality of the seaweed studied are shown in Table 5.

Table 5. The water content, gel strength and concentration of carrageenan from *Kappaphycus alvarezii* pre-treated by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

| Dose      | Soaking time | Water Content (%) | Gel Strength (g/cm²) | Carrageenan Content (%) |
|-----------|--------------|-------------------|----------------------|-------------------------|
| 100 ppm   | 0.5 hour     | 10.4              | 750                  | 49.9                    |
|           | 1.0 hour     | 10.0              | 650                  | 58.6                    |
|           | 1.5 hour     | 14.0              | 800                  | 45.0                    |
| 500 ppm   | 0.5 hour     | 9.4               | 500                  | 51.0                    |
|           | 1.0 hour     | 9.0               | 820                  | 50.7                    |
|           | 1.5 hour     | 11.4              | 600                  | 49.0                    |
| 1000 ppm  | 0.5 hour     | 13.0              | 620                  | 49.3                    |
|           | 1.0 hour     | 10.6              | 650                  | 50.7                    |
|           | 1.5 hour     | 11.0              | 600                  | 53.5                    |
| Average   |              | 11.0              | 665.6                | 50.9                    |

The water content of seaweed was analysed after the seaweed had been dried in the sun for approximately 3-4 days. The mean water content was 11.0 %. The water content obtained met the
specified standard (less than 30%) recommended by the manufacturer as the largest consumer of the seaweed. The water content was not affected by the activities during the cultivation period but greatly influenced by the ways and techniques of drying after harvest. Good drying methods should avoid sea grass contamination with foreign material. In the system used, drying time was also speeded up because direct solar heating was accelerated by the flow of air or wind in the drying area.

![Water content (%) of Kappaphycus alvarezii pre-treated by soaking seeds in a solution of lantana (Lantana camara) extract with different doses and soaking times](image1)

**Figure 5.** The water content (%) of *Kappaphycus alvarezii* pre-treated by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

Gel strength obtained during the study ranged from 600 to 820 (mean 665) (Figure 6). Higher gel strength is rated as an improvement in the quality.

![Gel Strength (g/cm²) of Kappaphycus alvarezii pre-treated by soaking seeds in a solution of lantana (Lantana camara) extract with different doses and soaking times](image2)

**Figure 6.** Gel Strength (g/cm²) of *Kappaphycus alvarezii* pre-treated by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times

Carrageenan content is the proportion of carrageenan yielded from the thallus. A higher yield of carrageenan is considered an improvement in the quality of seaweed. The carrageenan concentration obtained varied from 49.0 to 58.6% (Figure 7) and the lowest was 49.0%.

![Carrageenan concentration obtained varied from 49.0 to 58.6%](image3)
Figure 7. Carrageenan content of *Kappaphycus alvarezii* pre-treated by soaking seeds in a solution of lantana (*Lantana camara*) extract with different doses and soaking times.

Several studies have reported carrageenan yield of *Kappaphycus alvarezii*. These include 61.82 to 73.03% [7], 61 to 67% [12], 18 to 56.65% [13], 27.72 to 35.15% [14], and 74 to 80% [10]. The carrageenan content of seaweed is strongly influenced by the growth conditions during each cultivation period. Carrageenan in the seaweed thallus tends to increase with thallus diameter and age [13–15]. Carrageenan yield also depends on seaweed treatment during production and post-harvest; if the thalli are broken during harvest, gel and therefore carrageenan can be lost from the thallus, while contact with soil during drying can degrade carrageenan. Ideally, drying should take place quickly until moisture content is below 20%.

4. Conclusion

Based on the results of research and discussion that has been described previously, the researchers concluded the pre-soaking in a solution of common lantana (*Lantana camara*) extract can prevent ice-ice disease in the seaweed *K. alvarezii* cultured in coastal waters. The mean specific growth rate and highest average production were obtained from pre-treated *K. alvarezii* treated with a lantana extract dosage of 500 ppm and soaking time of 0, 5 hours. The highest mean carrageenan concentration was obtained with a dose of 100 ppm and 1 hour soaking time.

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