Diseases & pests of cultivated seaweeds

*Kappaphycus & Eucheuma in Tanzania*
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GLOSSARY

ATTACHED ORGANISMS – micro- (microbes) and macro-organisms (crabs, amphipods) that attach themselves to the cultivated seaweed or the planting materials.

BIOFILMS – a collection of micro-organisms on the surface of the plant, enclosed in a matrix. It may have positive or adverse effects on the plant.

BIOFOULERS – organisms that attach onto submerged surfaces within the seawater causing biofouling.

BIOSECURITY – measures to prevent exposure or limit the spread of harmful biological agents.

COTTONII – commercial term for Kappaphycus alvarezii.

DISEASES – abnormal structures/functions occurring on or in the plants, negatively impacting them.

EPiphytes – other algae growing on the surface of the cultivated seaweed plants.

MUCOSAL – a membrane-like attachment, viscous and slippery in nature.

SPINOSUM – commercial name for Eucheuma denticulatum.

SUSTAINABILITY – ensuring that the use of resources is ideal for both present and future generations.
PUBLICATION DETAILS

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PREFACE

The manual “Diseases and Pests of Cultivated Seaweeds (Kappaphycus and Eucheuma) in Tanzania” seeks to outline the diseases and pests that affect crop production in the coastal areas of the country.

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This manual is produced as part of the GlobalSeaweedSTAR programme (BB/P027806/1) (2017–2021), funded by the UK Research and Innovation Global Challenges Research Fund (UKRI GCRF). This project seeks to grow the research and innovation capability of developing countries engaged in seaweed farming as well as providing practical solutions and long-term capacity building to many other seaweed-producing, developing countries through the GCRF GlobalSeaweedSTAR Fund, thus ensuring the sustainable economic growth of this global industry.

An interconnected mass of seaweed and sponge collected in Paje, Unguja in March 2020 (Credit IM).
Introduction

PURPOSE OF THE MANUAL

Changes in climatic conditions have led to the lowering of productivity rates of the seaweeds cultivated in seaweed farms. One of the major effects of this is the increase in outbreaks of diseases and pests within these areas. This manual aims to highlight the different forms of diseases and pests faced by seaweed farmers in a bid to help them and other stakeholders in the chain combat these challenges in a sustainable manner.

ABOUT THE MANUAL

The manual is divided into two sections:

1. **DISEASES AND PESTS**: this section covers the various pests and diseases found in the Indian Ocean and their impacts on the seaweeds.

2. **MEASURES TO COMBAT OCCURRENCES**: this section outlines different measures and actions that can be taken by the seaweed farmers and other stakeholders to limit occurrence and damage.

There is further information for interested parties on how to identify diseases in Appendix I.
In Tanzania, seaweeds are commonly found on rocky shores, seagrass beds, coral reefs, sandy beaches and lagoons. They are not normally free-floating, with exceptions in sheltered sites. They are typically attached to rocky substrata but can adapt to attach to soft, sandy or muddy substrata (Oliveira et al., 2003).

Green and red algae dominate the upper and lower intertidal zones while the mid to lower intertidal zones support a mixture of green, brown and red algae.

The seaweed industry in Tanzania began through the collection of wild varieties and selling to export companies by the fishers. This was between 1970 to the late 1980s for the Zanzibar Islands while there are reports that on mainland Tanzania (mostly in Mafia) the industry had been ongoing since the 1950s. In 1989, the commercial cultivation of seaweed began in earnest with a combination of local and introduced varieties in the shallow waters.

From the outset (in the late 1980s), the government expressed interest in seaweed cultivation, with three areas being of high interest in terms of cultivation: Zanzibar Islands, Tanga (northern Tanzania) and Mafia Island. Supportive documentation for seaweed cultivation includes a 1991 study by the FAO titled “Seaweed Collection and Culture in Tanzania” and “Marine Plants of Tanzania: A field guide to seaweed and seagrasses” by Oliveira et al. (2003). These are in addition to publications by Prof. Keto Mshigeni, Dr Flower Msuya and Dr Amelia Buriyo among others.

The seaweed industry is the third-highest export earner for Zanzibar. The practice of cultivating seaweeds in shallow waters is still the predominant method in use.
In Tanzania, there are different species of seaweed that have cultivation potential for the polysaccharide (carbohydrate) products that can be extracted from them, in addition to food. Products from these cultivable seaweeds can be grouped accordingly: carrageenan, agar and alginate.

Seaweeds are cultivated on the shores of both mainland Tanzania and the islands of Zanzibar.
A high percentage of cultivable seaweeds in Tanzania are in the category of red seaweeds, with species in the genera *Eucheuma* (*E. denticulatum*) and *Kappaphycus* (*K. alvarezii* and *K. striatus*) which are not only cultivated for industrial purposes but also for value-added products, especially for food. Another type which grows naturally is *E. denticulatum* and *K. alvarezii* (commercially known as *Spinosum* and *Cottonii*) produce the gel carrageenan.

Other cultivable red seaweeds that have been experimented on include those from the genera *Gracilaria, Gelidium, Pterocladia* and *Gelidiella*. Most common are *Gracilaria salicornia* (formerly *G. crassa*), others are *G. corticata, G. debilis, G. edulis* and *Gracilariopsis* sp. These species produce the gel agar.
The brown seaweeds that grow naturally in these waters and have potential to be used are Sargassum, Turbinaria, Hormophysa and Cystoseira. These seaweeds produce the gel alginate.

Economically viable cultivated species of green seaweed include Ulva which is used as a biofilter and fish bait. This seaweed can also be used in animal feed and as direct human food.
In the sea, as on land, pests and diseases exist that affect crops, reducing yield and generated income. This manual aims to spotlight the diseases and pests that affect the cultivation of seaweed, identifying the potential warning signals that farmers can look out for and ways of reducing the effects on their yield.
SEAWEEDS ARE CULTIVATED ON THE SHORES OF BOTH MAINLAND TANZANIA AND THE ISLANDS OF ZANZIBAR.

Image: Abandoned farm in Kidoti, Unguja. Photo taken in March 2020 (Credit IM).
IMPACT ON CULTIVATED SEAWEED AND THE INDUSTRY

The impact of pests and diseases is evident in the reduction of the yield, which has a carryover effect on the buyers and processors as they lack the raw materials needed to drive their businesses.

CHARACTERISTICS OF A HEALTHY SEAWEED

There are certain characteristics that can be used to visually determine whether a seaweed plant is healthy or not. These characteristics include:

A NO VISIBLE SCARRING. THE PLANT HAS NO SYMPTOMS OF GRAZING OR HOLES.

B NO DISEASE SYMPTOMS. THERE ARE NO SIGNS OF BLEACHING, ATTACHMENTS IN THE FORM OF EPiphyTES AND/OR VISIBLE FILMS THAT ALLOW MICROBIAL ACTIVITY.
HEALTHY SEAWEED LOOKS LIKE THIS

Images showing seaweed considered healthy in the farms (1-5) and in the laboratory (6) (Credit: FM, JBr, IM, JB).
Pests

Pests that affect cultivated seaweeds and lower their quality include grazers (such as sea urchins and fish) and attached organisms (such as epiphytes and biofoulers). They cause damage by consuming the crop or colonising the crop respectively.
Grazers commonly identified in the region include the Rabbitfish and sea urchins. These fish and urchins are also a health hazard to the farmer due to the sharp spines on their bodies that can become embedded in a person’s foot, increasing the potential for infection within the body through the introduction of bacteria.

These grazing pests consume the seaweed but do not attach (as opposed to epiphytes and other disease-causing agents which use the seaweed as a host). In some cases, consumption of entire lines and whole crops is possible. The action of grazing also has an additional effect of damaging the surface of the seaweeds, providing a point of entry for opportunistic pathogens and microbes which can then infect the seaweed.
Images showing a herd of sea urchins (1), near an abandoned farm line (2), an urchin at rest (3) and with defence mechanisms on display (4), rabbitfish removed from sea (5) and in the lab (6), a fish trap near the farm (7) and visible signs of grazing (8), (9) and (10) (Credit: IM, MA).
FISH AND FISHERS

Seaweed farms cause an increase in the presence of fish and other marine animals in the area. This in turn has the added effect of attracting fishers who set up traps near the farms.

The Rabbitfish belongs to the family Siganidae and is common in Tanzania. The species is found in tropical waters and is concentrated in areas with seaweed. Whilst it is a fish consumed by humans, it also acts as a pest as it grazes the seaweed.

The presence of fishers, especially when they pass seaweed farms with their boats, impacts the growth and yield of the seaweed. Ropes holding the seaweed may be entangled with the bottom of the boat and dragged away.

SEA URCHINS

Belonging to the phylum Echinodermata, commonly-found species are Tripneustes gratilla and Echinometra mathaei. They travel into shallow waters for food and tend to be found in areas with coverings, such as seagrass beds. In some cases humans consume them as food, especially the eggs (the reproductive glands, gonads) which are considered a delicacy.

ATTACHED ORGANISMS

“Attached organisms” refers to micro-organisms and macro-organisms that attach themselves to the cultivated seaweed or the planting materials such as the ropes or the poles. Epiphytes and biofoulers (algae and sponges) are commonly found in this region.
These are undesirable microorganisms and macro-organisms attached to the submerged living and non-living organisms in seawater.

The farms experience periods of engulfment with wild green algae that become intertwined with the planted crops and in some cases cause the crop to break off. The fouling alga may also slow the rate of growth of the seaweed by limiting access to resources (light/nutrients).

Pictures showing a farm covered by wild alga during (1) and after (2) low tide, as well as an individual plant intertwined with the alga (3) and the fouling alga (4). Photo taken in Paje (Credit: FM, JBr and IM).
The presence of different sponge species is common. In a few cases, the sponges can mimic the morphological pattern of the seaweed or attach and camouflage the plant in question. The major disadvantage of this is that they create a conducive habitat for micro-organisms to breed and infect the seaweed.

Images of sponges: sponge attached to seaweed (1 and 6), sponge collected in a farm (2), (3) shows a sponge with the morphology of the cultivated seaweed, (4) sponge attached to seaweed, and (5) another sponge with seagrass within it (Credit: FM, IM and JBr).
BIOFILMS

There is a recent notable trend of biofilms forming on the surface of cultivated seaweed. It is of concern as it may lead to the introduction of harmful micro-organisms into the seaweed crop.

Utilisation of nutrients needed by the seaweed for growth by micro-organisms associated with the biofilm is another impact on the crop and leads to a low-quality product being harvested by the farmers.

Some of the biofilms that have been noted within the farms are seen to be mucosal in nature and of different colours.

Biofilms as seen on seaweed plants: (1) is at the site and orange in colour, while (2-6) show black coloured biofilms in the lab (Credit: IM).
These are algal species that attach to other algal species’ surfaces. They are particularly noticeable during transitional periods, from hot weather to cool weather, although between 2017-2019 it was noted that they did not occur in the farms.

Epiphytes affect the growth of the seaweed and allow opportunistic pathogens to enter the plants, leading to diseases and die-offs.

Epiphytic algae on cultivated seaweed. Images 1-2 show epiphytes on seaweed in the field, (2-4) show the epiphytes in the lab (Credit: JBr, IM).
Seaweed disease in the region mostly consists of ice-ice, which is attributed to the climatic changes that are occurring. However, there are other notable symptoms, such as the presence of spots on the seaweed, which may also be contributing to detrimental effects.
IDENTIFICATION OF DISEASES

It is important for the farmers to monitor the farm for any changes in their farming environment, and it helps if they record the changes.

Identification relies on visual and touch data and can be corroborated by the recorded data. If there is interest in understanding the disease affecting the cultivated seaweed, then the farmer can contact experts in the university and research institutes.
Inside a plastic bag (ideally a ziplock bag) or a plastic container, place your sample with a small amount of seawater. Place this in a box or large bag with ice blocks, then send the package to the university for further analysis.
ICE-ICE DISEASE

One of the prevalent and most damaging of seaweed diseases in the region, ice-ice affects the seaweed by weakening its structure. The most visible symptom is the whitening of the thallus and its subsequent hardening. The disease causes damage to the crop, and the whole farm when it spreads, leading to loss of crops and reduction of generated yield.

Ice-ice symptoms: the whitening of the thallus noted on seaweeds in the laboratory (1-4) and in the field (5-6) (Credit: IM, MA).
While not yet sufficiently understood, the occurrence of spots on the seaweed thallus has also been noted. The spots appear to be black in colour. They may be indicative of the presence of endophytes; however further study is needed to definitively conclude this. Studies are also needed to determine their impact on the seaweed, as they are an atypical characteristic when compared to a healthy cultivated seaweed individual.

The potential impact of these spots is that they may affect the growth of the seaweed and allow the entry of opportunistic pathogens, leading to diseases and die-offs.

Spots along the thallus of different coloured seaweed plants: reddish brown (5–6), brown (1–4) (Credit: FM, JB, IM).
05. Additional natural hindrances
This fine material is mostly an irritant, as well as a potential pathway for microbes to infect the plant. It is mostly sediment (sand) from the ocean floor that gets trapped with the tidal patterns and then settles out on the seaweeds.

Different levels of sediments collected on the seaweed plants: lines of seaweed covered in sediment (1), sediment on a plucked sample (2), a small amount of sediment on the plant (3) and extensive sediment on the plant (with attachment organisms as well) (4) (Credit: FM, IM, JB).
ATTACHMENTS ONropes

Organisms that attach to the rope holding the seaweed (see the following figures), for instance other seaweed plants and barnacles, may provide micro-organisms and other pests a holding area for infection.

Deposits on the ropes used to hold the seaweed: sediments (1), barnacles (2,3 and 4) (Credit: IM, JB).
Measures to reduce occurrence

Reducing the occurrence of diseases and pests in the seaweed farms is important and it starts with the utilisation of good aquaculture practices.

In this section, we will outline the basic biosecurity measures that farmers and stakeholders can follow as a way to reduce the occurrence of disease and pests. The principles are the basis of pathogen management. It should be noted that many practices commonly used on land may not be feasible in a marine environment. In an attempt to reduce infestation and damage caused, the farmer/union may follow the measures below, initially testing on a small portion of their farm/farming materials before complete implementation.
Controlling disease-causing agents is paramount and relies on a robust cleaning protocol to be in place, with steps as seen in the figure shown on p.35 (adapted from https://thefishsite.com). As part of the farming activities, the farmers may incorporate cleaning and disinfecting protocols, especially with regards to the cuttings, within their maintenance practices. A detailed step guide is outlined on the following pages, expanding on the illustrated protocol.
The cuttings undergo a manual cleaning routine that involves the removal of physical debris and washing of the cuttings using sterilised seawater where possible. If sterilised seawater is not available/possible, farmers can use seawater filtered through a cloth (e.g., cheesecloth).

The selected cuttings can then be cleaned again with sterilised seawater and disinfected using a natural disinfectant such as lime water or fast dipping in freshwater.

Inspection practices to identify any visible defects that may contribute to disease occurrence such as spots, epiphytes, signs of bleaching.

The materials/equipment used for production (ropes, tie-ties) can be washed with sterilised/filtered seawater and disinfected. If chemical disinfectant is used, the materials/equipment should be cleaned with sterilised/filtered water and completely dried before insertion in the farming area.
MEASURE II – PERSONAL PROTECTION EQUIPMENT

Increasing the use of Personal Protection Equipment (PPE; e.g., gloves) by the farmers when handling the equipment and the cuttings during the “planting” to reduce the transfer of microbes to the new plantings. Personal hygiene measures such as washing of hands can also be applied.
MEASURE III – MONITORING AND REPORTING SYSTEMS

Understanding the local environment, and changes in it, is a strong foundation to limiting the damage caused by pests and diseases. Constant monitoring of parameters such as temperature, salinity and nutrient content will allow farmers to identify “trigger/warning” values that lead to infestations.

Recording changes can be formalised using the already existing community systems into a reporting system that will allow the farmers to be aware of potential infections and outbreaks and a way to obtain information concerning preventative measures.

MEASURE IV – ERECTING A BORDER

Planting a surrounding border around the farm(s) that will give the seaweed protection from grazers and pests, reducing the number of pests within the farm. Plants that can be used as borders include seagrass and algal species (e.g., Ulva).

MEASURE V –RESTRICTED ACCESS

Restricting access to the farm to exclude people who are not aware/knowledgeable in the appropriate handling of the crop to avoid introduction of pests and transmission of disease agents. Ideally, the farmers will be trained in such measures, that include appropriate clothing/changes and hygiene practices.

MEASURE VI – EDUCATION & AWARENESS PROGRAMS

Raising awareness among farmers on biosecurity – what it is, how to conduct/implement and document it – and the risks and subsequent risk management (how to reduce the risk of disease spreading).
Figure: Illustration showing a potential cleaning and disinfecting cycle that can be followed (adapted from fishsite.com)

01. **Manual Cleaning**
   (Removal of debris & particulates)

02. **Cleaning I**
   (Shaking of the seaweed in situ e.g. removal of debris & foulers)

03. **Removal of the Equipment from the Water**

04. **Cleaning II**
   (Onshore washing of ropes and poles)

05. **Rinse & Neutralize**

06. **Dry Completely**
   (Air drying/sun drying)

**Repeat as necessary**
(before every planting cycle)
INFORMATION FOR INTERESTED RESEARCHERS CONCERNING IDENTIFICATION OF DISEASE-CAUSING AGENTS IN THE LABORATORY

Disease causing agents can be identified in the laboratory using microscopy and followed with DNA extraction methods for confirmation.
Using wax embedding techniques, seaweed samples can be “fixed” using a fixative solution and alcohol and placed in wax blocks. Sections can be obtained using the microtome, stained and studied under the microscope.

Another way is “wet” microscopy; fresh samples are thinly sliced, placed on a slide and covered with a coverslip and studied under the microscope.

Images of epiphytes under the microscope (1–2) and a dissected black spot (3) (Credit: FM, JB, JBr, SR)
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