Lagascalia 19(1-2): 179-186 (1997)

GELIDIUM SESQUIPEDALE (CLEM) THURET CULTIVATION IN GALICIA (SPAIN)

JUAN A. SEOANE-CAMBA

Abstract

An experiment on cultivation of *Gelidium sesquipedale* (Clem.) Thuret. by vegetative propagation, has been carried out in the coast of Galicia. Suitable substratum was obtained from different geological deposits, cracked into gravel and cemented to the surface of cylinders (1 m. long and 30 cm. diameter). The cylinders were made of a mesh of rigid plastic embedded in concrete, and containing expanded plastic material inside to give them a required buoyancy. The plant was inseminated placing fragments of thallus on the surface of the cylinders and binding them by a ribbon of nylon gauze. The cylinders were set up at 3-4 m. depth in four different places in the sea and fixed to a dolphin of concrete situated at 10-12 m. depth. This original system of farming, which we can call "reversed long line" is very simple, flexible and opposes little resistance to hydrodynamical forces. The cylinders responded perfectly to the physical demands of the experiment. The material suitable for algal fixation gave the positive results expected. The dolphin system of fixing the cylinders to the bottom individually was satisfactory. The location of the experiment was more problematic. All the cylinders placed in the "Rias" and bays, where mussel cultivation is abundant, soon showed poor condition; a layer of muddy material appeared on the algae and opportunistic and nitrophylous species, together with mussel larvae, were installed on them. Only in the experiment placed open to the ocean, and therefore more exposed to the surf and far from the "Rias", were the results positive. The muddy material was smaller and the plants grew without epiphytes (only some small specimens of *Polysiphonia* sp, *Laminaria* sp. and *Saccorhiza* sp. were detected)

Introduction

Gelidium sesquipedale (Clem) Thuret is a species of Rhodophyta which has a special interest from the point of view of the industry of agar-agar. It constitutes the main raw material of this industry in Spain, where it is collected by diving or from the drift material stored up on the coasts in determinated periods of the year.

This plant is 30-40 m long, ramified in one plane and with a somewhat hard and elastic consistency. Its chorological distribution area stretches from the Canary Islands to Great Britain, including all the ocean coast of the Iberian Peninsula.

Its yield in agar is high, up to 40% (dry weight) in laboratory conditions (ESTABLIER, 1964), and the product obtained is of high strength even at low concentration (1-1.5%). It also has a higher percentage of agarose than agar-agar from others species.

The main problems which we had to overcome for *Gelidium sesquipedale* cultivation were: a) We did not find previous information about industrial cultivation of any species of *Gelidium*. b) This species requires a strong hydrodynamic and relatively clean and clear oceanic water. c) It seems to have some difficulties in settling on a substrate, or, if it does so at all, it is in inferior conditions to those of other species which compete with it, as has been demonstrated before (SEOANE-CAMBA, 1966).

In contrast, the plant substitutes its difficulties in multiplying by spores by means of vegetative expansion through a stoloniferous system. Thus, for this plant, the strategy of vegetative reproduction seems more effective than that based on its biological cycle. Such behaviour allows us to avoid the laboratory hatching phase and to examine the vegetative regeneration.

The regeneration of the stoloniferous part, as well as the other parts of the thallus, gives rise to cylindrical and creeping structures when it takes place under low light intensity. These creeping structures give off tufts of rhizoids, which form a disc at the protruding point and afterwards become free themselves, forming a sort of "paint brush" (SEOANE-CAMBA, 1984,1989,1991).

These rhizoids are formed from the cortical cells of the cylindrical structure and they run through the intercellular spaces before protruding, hydrolysing the materials of such spaces (agar-agar) and enabling thus the penetration (SEOANE-CAMBA, 1989).

When protruding the tufts of rhizoids form a disc where the rhizoids seem to have a strong enzymatic and biological activity as they present, at electron microscopy observation, a destruction of the oldest by the youngest ones, as if the discs were continually building and destroying themselves. This could be interpreted as a strategy to perpetuate the attachment of stolons to the substratum, within certain limits (SEOANE-CAMBA, 1989).

When the "paint brush" of rhizoids meets a substratum, it can attach to it, or not, depending on the type of substratum. When a substratum is inert to the action of the rhizoid, both rhizoid and substratum remain separate (substratum is not suitable for cultivation). Other substrata may react to the action of the rhizoid, although they are not penetrate by it (substratum compatible but not suitable for cultivation). When the substratum is suitable, the rhizoid pierces it in all directions (SEOANE-CAMBA, 1989).

The generalized idea that these rhizoids penetrate the substratum by the interstices does not seem acceptable in the cases analyzed by us by electron microscopy, where rhizoids with a much larger diameter that of the interstices fitted exactly in their diameter, without any trouble in the collateral material. This suggests that these rhizoids had dissolved the material and had fitted themselves in the empty space.

So, the penetration of the rhizoid takes place by dissolving the material, but at the same time the cell wall of the rhizoid remains perfectly cemented to the substratum.

The biochemical mechanism of this process is not known, but it is probable complex. It may involve the action of galactose and enzymes (sulphatase-like?) produced by the rhizoids, carbonates and calcium provided by the substratum, and salts (sulphate and carbonates) supplied by the water and substratum. So, when the substratum is suitable, complex products would be formed from the attack on it by the rhizoids, which could be utilized again for cementation (SEOANE-CAMBA, 1989, 1991).

Design of the "Farm"

With all these data we were able to design a "farm" by:

1, Obtaining a suitable substratum. 2, Giving it an appropriate form. 3, Inseminating the plant on it by a vegetative way. 4, Setting it in the sea.

A suitable substratum was obtained using natural limestone (SEOANE-CAMBA, 1989) from different geological deposits: Cambrian (Lugo); Cretaceous (Santander), Travertine (Barcelona) and "maërle" material (*Phymatolithon* sp. and *Lithothamnion* sp. from Ria de Vigo).

These different materials were cracked into gravel and cemented to the surface of cylinders (1 m. long and 30 cm diameter), made of a mesh of rigid plastic embedded in concrete, and containing expanded plastic material inside to give them a required buoyancy. Forty cylinders were constructed in this way, ten for each type of substratum. The plant was inseminated putting fragments of thallus of 3-4 cm, which had been cut by a clipper, on the surface of the cylinders and binding them by a ribbon of nylon gauze, especially lax in texture.

Then, the cylinders were installed in four different places in the sea: two at the "Ría de Aldán" (one in a polygon of mussel cultivation near "Punta do Couso" , and the other near Cap Udra); one near Monteferro (Ría de Vigo), and one on the open coast near Oya (South of "Ría de Vigo"). The two sites at "Ría de Aldán" were used in the first year of experimentation; the other two, Monteferro and Oya, were used in the second.

The cylinders were placed vertically at 3-4 m depth, and fixed to a dolphin of concrete situated at 10-12 m depth. The "farm" looked like a field of cylinders, more or less aligned.

This original system of farming, which we can call "reversed long line" is very simple, flexible and opposes little resistance to hydrodynamical forces. Strong currents cause the cylinders to bend over the bottom like cereal fields when the wind blows over them. If the dolphins are heavy enough and the cylinders separated enough from one another, this "farm" can withstand heavy seas.

The cleaning and revision of the cylinders was done monthly, but sometimes fortnightly (when the mussels were in reproduction) as the larvae, and other organic materials from the polygons of mussels , invaded and eventually covered all the algal plants in some localities. The cleaning and revision of cylinders was done unfastening them from the dolphins by divers and collecting them from the sea surface by the ship.

The harvest was done by cutting or shaving.

Results after the first year of cultivation

After the first year of cultivation the following results can be set down:

1, The cylinders responded well to the physical demands of the experiment. Some of them had the fixing rope slightly damaged by friction. 2, The material suitable for algal fixation gave the expected positive results, although the one that came from Cretaceous deposits was the best. 3, The dolphin system of fixing the cylinders to the bottom individually was very effective; there was not abrasion in the connection between dolphin and cylinder. 4, The fixation of the plant to the substratum was 100% effective. 5, After the first month (12th March- 19th April 1993), the plant transformed the apex of main stem and branches into stoloniferous elements which started to form the tufts of rhizoids. 6, After 56 days (7th May) the fixation of the rhizoids to the substratum was generalized and the first erectile shoots started to be observed but of few mm. 7, After 70 days (21th may) the rhizoids were abundant and the erectile shoots formed an ostensible lawn, some of them of 1 cm high. 8, Some epiphytes (mainly animals: Hydrozoa, sea-squirts, sponges; and plants: Polysiphonia sp, Ectocarpus sp, Ulva sp, Ceramium sp) and other opportunist species appear, as well as organic material increase. The cleaning become necessary. 9, After 90 days (10th June) the young shoots measured up to 2.8 cm. 10, After 126 days (16th July) the epiphytes appeared once again; the shoots reached up to 3.5 cm. 11, After 170 days (30th August) the shoots measured up to 4.2 cm, the epiphytes are also present but small mussels appear in very great quantities on the heads of the cylinders. 12, After 246 days (15th November) all the cylinders were covered by two or three layers of mussels, which forced the withdrawal of all of them for cleaning in the harbour. When they were cleaned of the mussels by a very vigorous method (scraped by a rake), the creeping part of the plants remained nearly in its totality.

The results were similar in both places of the "Ría de Aldán" and the experiment was withdrawn from these localities.

The second year of experimentation

The second year of experimentation was also carried out in two localities: one near Monteferro (Ría de Vigo), locality A, and other near Oya, locality B, as stated above.

In the second year of trials the structures was improved by injecting liquid cement into the cylinders, so the expanded plastic material was united with the fixing rope; and, in addition, such treatment prevented this material from swamping

The experiment, in the second year, was started on the 16th June 1994 by placing and setting four cylinders in locality A and three others in locality B .

The experiment finished in December, as planned; and, although the results of two years of experiment are incomplete because of the unexpected need to change the place of experimentation, they are positive, and especially suitable as a new technique to exploit the strong hydrodynamic zones of the coast by plant (or animal) cultivation.

Results after de second year of cultivation

After the second year of cultivation the results are the following:

1, In Monteferro localization the results were more or less similar to those of the "Ría de Aldán". 2, In contrast, the results at Oya were especially positive; the plants were nearly always unpolluted and the growth was spectacular. 3, After 112 days of settlement (6th October) the plants were about 3-5 cm long and they were first harvested by cutting. The purpose of this cutting was to induce the shooting, which increases the population density, also eliminating the epiphytes.

Main conclusions after two years of experience

1, The injection of liquid cement into the cylinders prevented them from swamping and the rope from damage by friction. 2, The material suitable for algal fixation gave the expected positive results, especially those that came from Santander (Cretaceous), and the fixation of the plant to the substratum was very effective. 3, The dolphin system of fixing the cylinders to the bottom individually is good, but a creeping system of ropes forming a large net on the bottom and fixed by pipe anchors may be more effective, suitable and less expensive for a "farm" exploitation. 4, The location of the experiment was a more problematic question to be answered in this project. The first option, the two points in "Ría de Aldán", soon showed its bad conditions, when a layer of muddy materials appeared on the algae and opportunist and nitrophylous species were installed on them. 5, The most unfortunate consequence, however, of this bad placement was when the mussels started their reproduction period, July-August, and their larvae invaded and covered the algal plants. 6, The second option, the two points: A (near Monteferro) and B (near Oya) gave different results. 7, The behaviour of the experiment in A was very similar to that found in "Ría de Aldán". The presence of muddy material and the large mass of mussel larvae settled on the algae during July, August and September was identical. 8, However, in the experiment in B, open to the Ocean and therefore more exposed to the surf and far from the Rias, the results were very positive. The muddy material was smaller and the plants grew without epiphytes, (only some small specimens of *Polysiphonia sp Laminaria sp* and *Saccorhiza sp* were detected)

The main positive characteristics of this cultivation which can be deduced from this experiment

From the results of these two years of experimentation, the main characteristics and advantages of this type of culture, compared with others, are the following:

1, Techniques

a, The main structure of the "farm" can be really considered as perennial; the insemination of the plant is done once and for all, and the plant can stay on the cylinder indefinitely (theoretically).
b, Possibility of automation in the process of the plant insemination and harvesting.
c, Possibility of indefinite expansion of such culture.
d, Possibility of establishing such culture in zones exposed to heavy swell.

2, Biological

a, Possibility of crossing and selecting the best races of plants (this would be the next step in the research of these cultures).

b, Possibility of growing animals in this culture, making use of the organic materials produced by the algae, without any secondary effects of eutrophication.

3, Ecological

a, Possibility of using these cultures for natural decontamination of sea water.
b, Possibility of protecting the sea bottom with them increasing the general production.

The main negative points found in this experience

a, Except point B, near Oya, the places on the coast chosen for this type of experiment were inappropriate because of the proximity of the polygons of mussel cultivation.
b, As a consequence, the excessive deposit of organic materials and larvae of mussels settled on the culture in "Ría de Aldán" and Monteferro, would make such industrial cultivation prohibitive, because of the high cost in labour of cleaning it.
c, The absence of sufficient hydrodynamics in "Ría de Aldán" and Monteferro to disperse the organic materials and eliminate part of the epiphytes and competitors.

Suggestions

a, The expanded plastic material in the interior of the cylinders must be less permeable to the water and less soft to the water pressure.
b, The depth of 2-3 m. seems correct
c, The dolphins must be substituted by pipe anchors when extensive culture is required
d, It would be advisable to embark on research into automation of the substratum building, as well as the plant insemination and harvesting.

Acknowledgements

I wish to thank the "Conselleria de Pesca" of the Government of Galicia (Spain) for financial support to carry out this work; and I also thank the "Centro de Investigaciones Submarinas" (CIS) for their skilful assistance.

References

ESTABLIER, R. (1964). Variación estacional de la composición química, extracción y características del agar-agar de algunas algas (género *Gelidium*) de la costa sudatlántica española. *Inv. Pesq.* **26:** 165-94.

SEOANE-CAMBA, J. A. (1966). Algunos datos de interés en la recolección de Gelidium sesquipedale. *Publ. Técn. Junta Est. Pesca.* **5**.

— (1984). Sistema de cultivo acuático de algas bentónicas marinas de tipo estolonífero. Patente nº 527367.

— (1989). On the possibility of culturing Gelidium sesquipedale by vegetative propagation. *Aquatic Primary Biomass-Marine Macroalgae. Outdoor Seaweed cultivation.* Proc. Second Workshop of COST 48 Subgroup 1. Port Erin, Isle of Man, British Isles, 21-23 April.

— (1991). Biology and possible industrial cultivation of Gelidium sesquipedale (Clem.) Thuret. *Oebalia,* **17**: 89-95.

Address of the autor:

Prof. J. A. Seoane-Camba, Departamento de Botánica, Facultad de Farmacia, Universidad de Barcelona, 08028 Barcelona, Spain.