A METHOD FOR THE CULTURE OF TROPICAL SEAGRASSES

FREDERICK T. SHORT*

Harbor Branch Foundation, Inc., Link Port, Fort Pierce, FL 33450 (U.S.A.)

ABSTRACT

Three tropical seagrass species were planted into 1.5 m^2 culture tanks and grown under the same conditions for 2 years. New shoot production and vegetative growth of both *Syringodium filiforme* Kütz. and *Halodule wrightii* Aschers. resulted in complete cover in monoculture tanks within the first year. The vegetative spread of *Thalassia testudinum* Banks ex König was slower than that of the other species. The culture of seagrasses in open mesocosm systems was most successful when continuous current circulation was maintained, water column nutrients were kept low, and extreme high temperatures (>36°C) were avoided. Seagrass colonized and grew equally well in Indian River mud substratum and in quartz sand.

INTRODUCTION

The use of bounded and partially enclosed outdoor mesocosms has been promoted as a method of bridging the gap between laboratory studies and in situ studies in the natural environment (Odum, 1984). Mid-scale marine systems have been developed to simulate natural environmental conditions in enclosed and isolated containers. An example of these systems is the series of 12 large tanks at the Marine Ecosystem Research Laboratory (MERL), University of Rhode Island; Pilson and Nixon, 1980; Pilson et al., 1980). Similarly, aquaculture efforts have been successful in growing marine and freshwater plants at near optimal conditions (Goldman et al., 1975; Ryther et al., 1978). The aim of this research was to develop culture mesocosm systems to grow rooted marine macrophytes under conditions most favorable to the plant.

A number of seagrass species have been successfully cultured in containers ranging in surface area from 0.07 to 0.25 m^2 (McMillan and Moseley, 1967; Fuss and Kelly, 1969; Kirkman, 1978; McMillan, 1980; Zimmermann

*Present address: Jackson Estuarine Laboratory, University of New Hampshire RFD No. 2, Adams Point Road, Durham, NH 03824, U.S.A.

et al., 1981; Pulich, 1982). The successful culture of *Thalassia testudinum* Banks ex König (Fuss and Kelly, 1969) provided useful insight into its growth patterns as well as measurements of rhizome propagation and new shoot production. Thus, this study provides an examination of Fuss and Kelly's (1969) expectation that culture methods represent useful tools in studies of seagrass growth characteristics and environmental requirements (Short and Short, 1984).

CULTURE METHODS

Seagrass cultures were set up in the tank farm at the Center for Marine Biotechnology, Harbor Branch, Fort Pierce, FL, U.S.A. (27°30′N, 80° 15′W). The tanks were 0.5 × 0.7 × 2.2 m cement vaults with a standpipe drain at one end and seawater inflow at the other (Fig. 1). Seawater inflow was low, ca. 43 l h^{-1}, providing total water turnover of 2.7 times per day. The incoming water was pumped from the Indian River into a settling tank, then through a 50 μm filterbag and into a well-mixed tank of nutrient-starved algae, *Gracilaria* spp. These processes removed the suspended sediments, filtered out some zooplankton and reduced inorganic nutrient levels to < 2.0 μM (NH_4^+, NO_3^- and PO_4^{3-}).

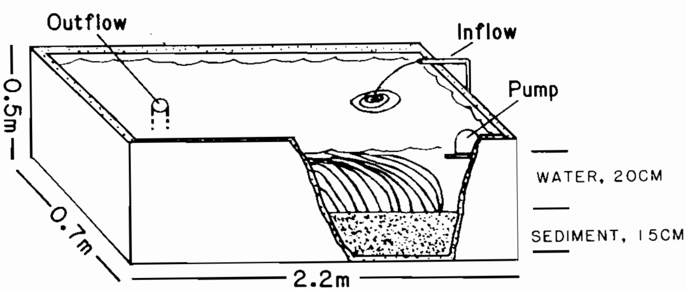

Fig. 1. Diagrammatic cutaway representation of a seagrass culture tank.

The seagrass culture tanks were filled with 15 cm of sediment, and then flooded with 20 cm of seawater and allowed to stabilize. Two sediment types were used: fine-grained mud obtained from the seagrass beds in the Indian River Lagoon and coarse-grained pure quartz sand obtained from a local sand pit. The Indian River mud that was collected from beds of *Halodule wrightii* Aschers. contained enough living root/rhizome material and seeds so that no additional planting was necessary in these tanks. Sediments for other tank cultures were collected from a bed of *Syringodium filiforme* Kütz. in the Indian River Lagoon. Additionally, nine 0.1-m^2 sediment plugs of *S. filiforme* were transplanted directly into the culture tanks and covered 60% of the sediment surface area. In the sand culture tanks, individual *S. filiforme* plants cleaned of sediment were marked for identification and rooted in the loose sand substrata. The plants covered

< 1% of the sediment surface. *Thalassia testudinum* seedlings, collected in the Florida Keys (Lewis and Phillips, 1980), and donated by Mangrove Systems, Inc., were weighed, marked and rooted in both sediment types. Also, plugs of *T. testudinum* growing in fine-grained mud were collected from a shallow area in the Indian River, transplanted into 15-cm diameter pots and grown in the tank culture conditions.

ENVIRONMENTAL CONTROLS

A number of environmental factors were manipulated in the various culture tanks. Water circulation was established in each tank with a "Little Giant" submersible pump positioned on a PVC holding rack at mid-water in one end of the tank. Two pump sizes were tried, one providing high velocity conditions (300 g.p.h. model), the other a low velocity circulation (170 g.p.h. model). Directing the pump jet down the long side of the tanks established a circular current flow. Currents were measured with a Marsh—McBirney electromagnetic current meter (provided by Mark Fonseca, NMFS, Beaufort, NC).

Light and temperature were not specifically regulated during most of these experiments, except when necessary to reduce water temperatures exceeding 36°C. This was accomplished by using screen to shade individual tanks or by increasing the rate of inflow during high temperature periods.

Epiphytic algal growth on the seagrass leaves was controlled by large populations of herbivorous snails (*Modulus modulus* (Linné), *Cerithium muscarum* Say and *Bittium varium* (Pfeiffer)) and amphipods (*Cymadusa compta* (Smith) and *Grandidierella bonnieroides* Stephenson) in the culture tanks. Additionally, epiphytic algal growth was discouraged by the low nutrient levels maintained in the tank and the inflow. Population density of snails was controlled by addition or removal with a hand net, while crustacean numbers were controlled by adding or removing carnivorous fish.

AN EXAMPLE OF SEAGRASS CULTURES

Three seagrass species were successfully grown in tank cultures for two years in east central Florida. *Syringodium filiforme*, transplanted into pure sand substratum as marked individual plants at < 1% cover, vegetated the tank to > 90% cover in 18 months. Plant density and biomass were generally greatest in the high current area (21 cm s^{-1}), where shoot height exceeded twice the 20 cm water depth (Table I). Rhizome length and dry wt were higher in the faster current; root biomass appeared greater in the slower current area (3 cm s^{-1}). *Thalassia testudinum* was transplanted as plugs from the field into pots in culture tanks; leaf morphology and plant abundance changed very little after the move from the shallow environment where the plants were collected. The third species, *H. wrightii*, was the most prolific of the seagrasses grown in culture. Two tanks filled with mud collected from a *H. wrightii* bed were initially stripped of surface vegetation. Within 5 months a dense growth of *H. wrightii* developed in the tank having the faster current regime; in the slow current tank (3 cm s^{-1}) only a few sparse patches of seagrass grew. The abundance of *H. wrightii* showed a maximum shoot density and whole-plant biomass in July (Table I).

The morphology of seagrass leaves in the cultures varied throughout each tank in relation to current velocities. Plants of *H. wrightii* in the highest current area (> 14 cm s^{-1}) were greater than 35 cm, while at the lowest current end of the tank maximum length was 18 cm. *Syringodium filiforme* reached a leaf length of 54 cm in a high current area (21 cm s^{-1}) and 29 cm in a low current area.

Syringodium filiforme was planted according to 2 methods (Phillips and Lewis, 1983): as individual shoots in sand-filled tanks and as sediment plugs in mud-filled tanks. Both culture methods successfully produced dense beds of *S. filiforme* with leaves that grew longer than the water depth (Table I). The successful and rapid colonization of pure sand by *S. filiforme* is counter to findings of field transplant studies (Phillips and Lewis, 1983), and indicates that the lack of transplanting success in sand areas may be related to local environmental conditions rather than actual sediment type.

Halodule wrightii totally covered a culture tank from rhizome material and seeds in 5 months (Fig. 2). Shoot density and biomass of *H. wrightii* in the higher current speed tank were similar to in situ measurements (R. Virnstein, personal communication, 1983). However, the plants' shoot height of 25 cm (Table I) in the clear tank water was greater than the 16.2 cm height observed in the Indian River (Virnstein, 1982). The use of tank culture

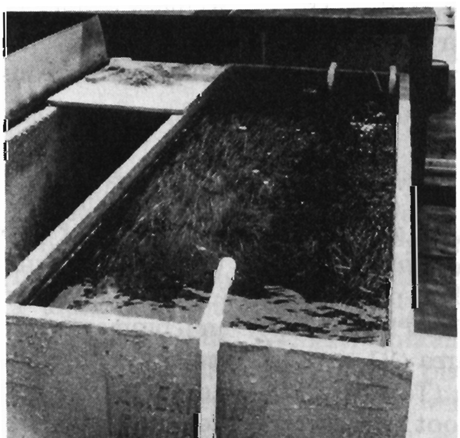

Fig. 2. Photograph of seagrass culture tanks showing *Halodule wrightii* growing in mud substrata.

TABLE I

Abundance of seagrass in culture tanks

Seagrass	Date	Shoot density (no. m^{-2})	Leaf (g dry m^{-2})	Root (g dry m^{-2})	Rhizome (g dry m^{-2})	Rhizome length (m m^{-2})	Shoot height (cm)	Leaf width (mm)	Substrata/ current
Syringodium	14 Jan. 1982	48	1.7	<1	3	2	12	1.0	Sand/high and low
	5 Aug. 1983	2950	144	26	57	52	44	0.8	Sand/high
	5 Aug. 1983	2200	90	49	36	30	23	0.8	Sand/low
Halodule	10 Oct. 1982	150	2	ND	ND	ND	13	0.7	Mud/moderate
	4 March 1983	3850	61	55	71	ND	15	1.0	Mud/moderate
	21 July 1983	9078	190	63	189	ND	25	1.3	Mud/moderate

ND = no data.

methods and monitoring of *H. wrightii* leaf death provided measurements of seasonal leaf production as well as vegetative growth. Yearly shoot and rhizome production was very high for *H. wrightii*, confirming the fact that it revegetates disturbed areas more rapidly than other seagrass species in Florida (Derrenbacker and Lewis, 1983).

Thalassia testudinum was grown successfully from seedlings in both sand- and mud-filled tanks and from plugs in mud-filled pots. Vegetative expansion measured by new shoot production was substantially less in *T. testudinum* than in other seagrasses. This difference in growth may explain the lack of extensive *T. testudinum* beds in the nearby Indian River Lagoon (Thompson, 1978).

Seagrass culture mesocosms are useful in evaluating seagrass growth and morphology in relation to environmental conditions. These systems also provide a tool for experimental studies of seagrass physiology, ecology and ecosystem dynamics. Experimental research with such tank cultures has been used to examine the role of seagrasses in removing suspended sediments and nutrients from the water column (Short and Short, 1984), as well as the impact of animal grazing on seagrass epiphytes and the influence of epiphyte removal on seagrass growth and morphology (Howard and Short, 1985). Research on the geochemistry of *H. wrightii* sediments has led to an understanding of diel changes in sediment conditions relating plant metabolism (Short et al., 1985). The use of mesocosm culture systems is recommended for seagrass research where careful monitoring is necessary or where specific environmental factors must be independently controlled.

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REFERENCES

Derrenbacker, J., Jr. and Lewis, R.R., III, 1983. Seagrass habitat restoration, Lake Surprise, Florida Keys. Proc. Ninth Ann. Conf. Wetlands Restoration and Creation.

Fuss, C.M. and Kelly, J.A., 1969. Survival and growth of seagrass transplanted under artificial conditions. Bull. Mar. Sci., 19: 351—365.

Goldman, J.C., Ryther, J.H. and Williams, L.D., 1975. Mass production of marine algae in outdoor cultures. Nature (London), 254: 594—595.

Howard, R. and Short, F.T., 1985. The impact of seagrass epiphytic grazers on the morphology and growth of *Halodule wrightii*. Mar. Biol., submitted for publication.

Kirkman, H., 1978. Growing *Zostera capricorni* Aschers. in tanks. Aquat. Bot., 4: 367—372.

Lewis, R.R. and Phillips, R.C., 1980. Occurrence of seed and seedlings of *Thalassia testudinum* Banks ex König in the Florida Keys (U.S.A.). Aquat. Bot., 9: 377—380.

McMillan, C., 1980. Cuture methods. In: R.C. Phillips and C.P. McRoy (Editors) Handbook of Seagrass Biology. Garland STPM, New York, pp. 57—68.

McMillan, C. and Moseley, F.N., 1967. Salinity tolerance of five marine spermatophytes of Redfish Bay, Texas. Ecology, 48: 503—506.

Odum, E.P., 1984. The mesocosm. Bioscience, 34: 558—562.

Phillips, R.C. and Lewis, R.R., 1983. Influence of environmental gradients on variation in leaf widths and transplant success in North American seagrasses. Mar. Technol. Soc. J., 17: 59—68.

Pilson, M.E.Q. and Nixon, S.W., 1980. Marine microcosms in ecological research. In: J.P. Giesy (Editor), Microcosms in Ecological Research. U.S. Dept. of Energy, Symp. Ser. 52 (CONF-781101), pp. 724—741.

Pilson, M.E.Q., Oviatt, C.A. and Nixon, S.W., 1980. Annual nutrient cycles in a marine macrocosm. In: J.P. Giesy (Editor) Microcosms in Ecological Research. U.S. Dept. of Energy, Symp. Ser. 52 (CONF-781101), pp. 753—778.

Pulich, W.M., Jr., 1982. Culture studies of *Halodule wrightii* Aschers. edaphic requirements. Bot. Mar., 25: 477—482.

Ryther, J.H., DeBoer, J.A. and Lapointe, B.E., 1978. Cultivation of seaweeds for hydrocolloids, waste treatment, and biomass for energy conversion. Proc. Int. Seaweed Symp., 9: 1—16.

Short, F.T. and Short, C.A., 1984. The seagrass filter: purification of coastal waters. In: V.S. Kennedy (Editor), The Estuary as a Filter. Academic Press, London, pp. 395—413.

Short, F.T., Zimmermann, C.F. and Montgomery, J.R., 1985. Day/night cycles in the phytosphere and rhizosphere of *Halodule wrightii*. In preparation.

Thompson, M.J., 1978. Species composition and distribution of seagrass beds in the Indian River Lagoon, Florida. Florida Sci., 41: 91—96.

Virnstein, R.W., 1982. Leaf growth rate of the seagrass *Halodule wrightii* photographically measured in situ. Aquat. Bot., 12: 209—218.

Zimmermann, C.F., French, T.D. and Montgomery, J.R., 1981. Transplanting and survival of the seagrass *Halodule wrightii* under controlled conditions. N.E. Gulf Sci., 4: 131—136.