Development of Seagrass *Enhalus acoroides* Planting Techniques Using Natural Materials for Anchoring to Enhance Survival and Growth Rates.

Student Name

Mr. Abdulfatta Ouankhong

Mr. Pannatorn Wunkaeo

Teacher Name

Miss Apasri Chumcheun

Mrs. Sirikwan Nuphuti

.

Princess Chulabhorn Science High School Trang

Thailand

5th March 2025

Abstract

Tape Seagrass (*Enhalus acoroides*) is a vital ecosystem with the potential to significantly lower the amount of carbon dioxide, one of the primary greenhouse gases responsible for global warming, because it has greater carbon sequestration ability. Seagrass ecosystems have been severely damaged all over the world, and restoration is urgently needed. This present research intended to innovate and experiment on processes based on natural materials with the goal of optimizing the survival of E.*acoroides*. There were four methods used during testing: (1) Bamboo Quadrat, (2) Sugarcane pot, (3) Sugarcane pot and Bamboo quadrat, and (4) Traditional Wooden Stake Anchoring and control group. The average survival percentage was highest of Sugarcane pot and Bamboo quadrat with 74.07%, and lowest in the control group with 7.41%. An ANOVA test at a 0.05 significance level revealed that there was a significant relationship between planting technique and seagrass survival percentage. There were no statistically significant differences at the 0.05 level for the growth measurements of leaf length, leaf width, and number of leaves among the surviving samples. Soil quality, both before and after planting in terms of pH and organic content, did not reveal any significant difference. Whereas, after planting, nitrogen (N), phosphorus (P), and potassium (K) content was greater.

Keywords: Sugarcane pot, Bamboo Quadrat, Sugarcane pot and Bamboo quadrant, Seagrass, Seagrass restoration

Research Questions

1) Is the Improved Seagrass Planting Method with Natural Anchoring Materials Capable of Increasing the Survival Rate and Growth Rate of Seagrass?

2) Does Seagrass Planting Technique using Natural Anchoring Materials Affect the Soil Quality in Seagrass Planting Areas?

Hypothesis

1) Planting seagrass with a variety of natural anchoring materials yields a variety of seagrass survival rates and growth rates.

2) The soil quality before and after seagrass planting with different methods is most likely to differ.

Introduction

Seagrasses are the only flowering plant family that can thrive in seawater. They occur in both cylindrical-leafed and flat-bladed forms. Seagrasses offer vital nurseries for juvenile marine fauna, habitat, and food sources. They also serve as significant blue carbon sinks. Seagrass meadows occupy less than 0.2% of the ocean floor but are able to store 10-18% of the ocean's annual carbon (Department of Marine and Coastal Resources, 2023). Seagrass consists of 13 species in Thailand, including Tape seagrass (*Enhalus acoroides*). Tape seagrass has the highest carbon storage among Thai seagrasses with a maximum of 4,100.12 g·cm² of carbon (Patama Rinnamngern, 2020). This renders seagrass a critical component in the minimization of atmospheric carbon dioxide, one of the causative factors for global warming. Presently, seagrass meadows throughout the globe are degrading immensely.

The latest survey indicates that around 7% of seagrass meadows are lost yearly due to industrial pollution, agricultural pollution, coastal development, and global climate change (Petch Manopit, 2024). Seagrass meadows in Thailand are found in various locations, the largest meadow being that around Libong Island, Trang Province. The meadows have, however, during the past decade, shown signs of deterioration (Department of Marine and Coastal Resources, 2017). Thailand's dwindling number of dugongs is also a concern. The latest 2022 survey in Trang Province, which has the highest number of dugongs in Thailand, estimated the population to be around 273. Dugong strandings and fatalities are still being recorded annually, and one of the significant causes is the degradation of their main food source—Tape seagrass—that is decreasing at a high level (Department of Marine and Coastal Resources, 2024). Previously, Mod Tanoi Village residents on Koh Libong, Trang Province, planted seagrass by seeding for three months prior to transplanting.

However, they have now developed more effective planting techniques, such as burying seagrass rhizomes with seashells to stabilize the soil better and deter plant dislodgement. Although this method gives weight to the soil, it does not completely avert the washing away of seagrass. Metal hooks to secure the seagrass rhizomes were subsequently developed and effectively reduced plant loss. However, metal hooks rust and lead to marine pollution and are thus not a solution in the long term. Globally, techniques like PVC quadrats and metal hooks have been employed in seagrass rhizome anchoring (Edward JK Patterson et al., 2019). While these techniques improve anchoring effectiveness, they are ecologically risky through plastic and metal pollution of the marine ecosystem. Hence, more environmentally friendly and sustainable techniques are required. It is our objective as a research team to come up with an improved planting technique that employs naturally occurring anchoring materials. This research will utilize washed-up drift seagrass, resuscitate it, and re-plant it based on our new technique. The research will take place at Modtanoi Beach, Koh Libong, Trang Province, over a period of three months. The aims are to study the survival rate and growth rate of re-planted Tape seagrass using the enhanced method and compare soil quality prior to and following planting through various methods. Our group firmly believes that this novel approach has the potential to enhance the growth and survival of Tape seagrass and achieve long-term seagrass bed restoration.

Materials

1) pH meter
2) Hi3895 Hanna Quick Soil
3) Hot air oven
4) Jute fibre rope 4 mm diameter
5) Traditional wooden stake anchoring
6) Sugarcane pot size 8×8×9.1 cm
7) Bamboo 7-9 cm diameter
8) PVC tank size 110×110×46 cm
9) oxygen pump 240 V 5 W
10) Vernier caliper

Methods

1) Study sites

In the case of this research, the researcher carried out fieldwork on seagrass on Modtanoi Beach, Koh Libong Subdistrict, Kantang District, Trang Province, which has the coordinates Latitude 7.609159°N and Longitude 99.27742°E, as indicated in Figure 1. In collaboration with the Ban Mod Tanoi Community Enterprise Group, we conducted a survey to assess the issues affecting Tape seagrass (*Enhalus acoroides*). Research was done at three stations: Site 1, 200 meters away from the beach; Site 2, 250 meters away from the beach; and Site 3, 300 meters away from the beach.

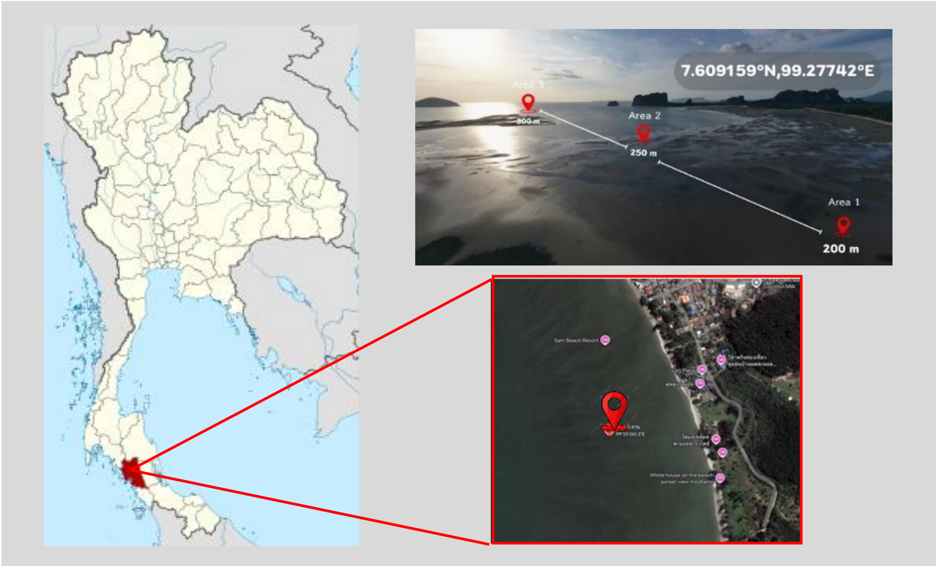


Figure 1: Show the study sites.

2) Soil data collection

Soil quality was determined through the GLOBE approach, which consists of pH, organic matter, soil nutrient, and soil texture analyses.

1. The sampling points were established by subdividing the sampling area randomly into 15 points (3 areas, 5 points each, based on the planting technique).

2. Sediment was gathered from inside the seagrass planting zone, both prior and after planting for both techniques. Samples were obtained through digging to a depth of 5 cm on the soil surface, mixing the soil before taking 600 grams of the soil from each sample randomly (a total of 30 samples). The samples were put into different bags to take to the laboratory to examine the properties of the soil against a number of different indices. They include pH, nitrogen, phosphorus, potassium, and organic matter. The pH of the soil was measured using a pH meter, and nutrient levels were analyzed using an NPK soil testing kit. Remaining soil samples were analyzed for content of organic matter by measuring the weight of soil prior to drying, deducting the moisture, and then incinerating the soil at 450°C for 5 hours. The weighing of the soil was repeated, and the organic matter content was calculated, and soil texture analysis was performed.

3) Seagrass Restoration

1. Collect damaged seagrass rhizomes from Modtanoi Beach, Koh Libong Subdistrict, Kantang District, Trang Province.

2. Treat the harvested seagrass rhizomes by removing any rotten parts and placing them in a controlled cultivation tank. The tank is maintained with conditions like the use of

seawater, 24-hour oxygenation, weekly water exchange, and the placement of the tank in a shaded place but with adequate exposure to light. The duration of culture lasts for 2 months (July to September 2024).

Select 10 to 12 centimeters long seagrass rhizomes, and a total of 405 plants, for the experiment.

4) Designing Seagrass Planting Techniques and Methods

The researchers carried out a field survey to study the survival of seagrass on Modtanoi Beach in Koh Libong Subdistrict, Kantang District, Trang Province. They also interviewed Ban Modtanoi local community tourism business to investigate the issue of declining seagrass density. This prompted the creation of a research project that aimed to create a seagrass planting process using natural materials to anchor the plants, thereby increasing their rates of survival and promoting growth. The study further included a soil quality analysis prior to and after seagrass planting. Four techniques form the created seagrass planting process, which are outlined as below:

Technique 1 Bamboo Quadrat : Bamboo of 7-9 cm diameter is cut into 4 parts, each 110 cm, and 3 holes are made in each part, 25 cm apart. They are assembled to create a square frame measuring 110 cm x 110 cm and Jute fibre rope tied at the corners, drawn through the holes, 9 points of intersection. These points are utilized for anchoring nine seagrass plants. When planting, a hole about 10 to 12 centimeters deep is dug, then the bamboo quadrat with the nine seagrass plants, previously fastened, is placed over the hole. The soil is then refilled so that only the leaves are exposed above the ground. Wooden stakes are inserted 30 centimeters deep at all four corners of the bamboo quadrat to hold the frame firm. It is planted in three locations with three replications in each location, making a total of 81 plants.

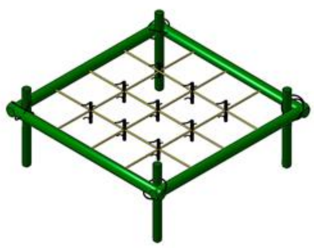


Figure 2: Bamboo quadrat technique

Technique 2 Sugarcane Pot : The new restored seagrass is transplanted in 6 cm diameter and 6.3 cm height sugarcane pots for the duration of one month. The duration provided guarantees that the seagrass anchors itself to the pot prior to transplantation. The planting operation starts with the digging of a hole that is a bit bigger than the size of the sugarcane pot, where the pot containing the anchored seagrass is inserted. Soil is then poured around the pot, with only the leaves above the ground exposed. There are three planting sites, each with three replicates, for a total of 81 plants.

Figure 3: Sugarcane Pot technique

Technique 3 Sugarcane Pot and Bamboo Quadrat : Seagrass anchored in sugarcane pots (Technique 2) is placed inside a bamboo quadrat (Technique 1), and the sugarcane pot is secured using jute fiber rope. To plant, a hole slightly larger than the sugarcane pot is dug, and the bamboo quadrat, with the sugarcane pot still attached, is planted into the hole. The soil is then filled in, leaving just the leaves above the ground. There are wooden stakes placed approximately 30 cm deep in the four corners of the bamboo quadrat to hold the quadrat in position. Planting is carried out at three locations, with three repetitions conducted at each location, totaling 81 plants.

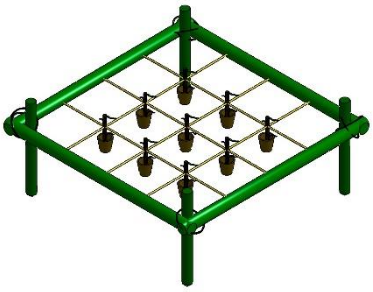


Figure 4: Sugarcane Pot and Bamboo Quadrat technique

Technique 4 Traditional Wooden Stake Anchoring : involves the process of digging a hole approximately 10 to 12 centimeters in depth. The seagrass is inserted in the hole with the rhizome at an angle of approximately 45 degrees. A wooden stake is then pounded into the ground in close proximity to the rhizome, and the rhizome is attached to the wooden stake using hemp rope. Finally, the hole is covered with soil so that only the leaves are above ground. It is planted in three locations with three replications in each location, giving a total of 81 plants.

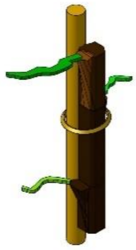


Figure 5: Traditional Wooden Stake Anchoring technique

Control Group : For planting, a hole about 10-12 cm in depth is made. Seagrass is planted in the hole with the rhizome at an angle of about 45°, and the soil is filled in, with just the leaves left above ground. Planting at three sites and with three repetitions at each site, a total of 81 plants are planted.

The researchers conducted a field experiment where seagrass was planted using four constructed planting methods together with one control group. The experimental sites were placed at three different locations: Site 1, 200 meters from the shoreline; Site 2, 250 meters from the shoreline; and Site 3, set up at 300 meters from the shoreline. In each location, seagrass was cultivated using each technique in triplicate, and the growth rate and survival rate were measured. This measurement involved leaf length, leaf width, and leaf number, over a three-month period from September to December 2024. The data were subsequently analyzed to derive results.

5) Statistical analysis

1. Compute the percentage survival rate of seagrass planted using different methods and the survival rate of each site using the arithmetic mean, standard deviation, and the

$$\text{survival rate} = \frac{\text{Number of surviving plants}}{\text{Number of planted plants}} \times 100$$

following equation:

2. Compare the percentage survival of seagrass cultivated under varying techniques using One-way ANOVA at a significance level of .05

3. Compare the seagrass growth rate with the arithmetic mean and the standard deviation. In addition, compare the seagrass growth rate between each technique with One-way ANOVA at .05 significance level.

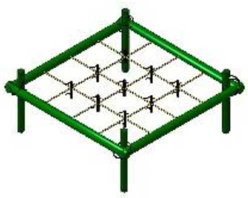
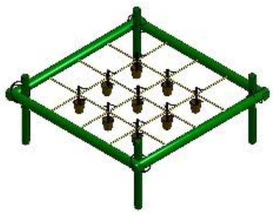
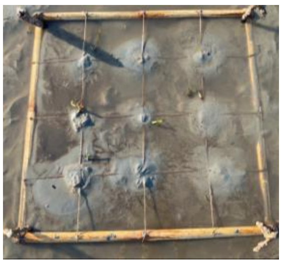
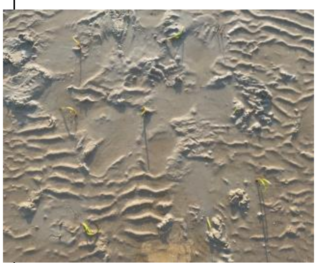
4. Compare the soil quality data like pH, organic matter, soil nutrients, and soil texture of all planting methods in three sites, before and after planting, by using arithmetic mean and standard deviation.

Results

1) Development of Seagrass Planting Techniques to Increase Survival and Growth Rates

1.1 Development of Seagrass Planting Techniques to Increase Survival Rate : The draft of the developed seagrass planting techniques includes 4 techniques.

Table 1 shows the draft and images of seagrass planting using different techniques.

Technique 1 Bamboo Quadrat	**Technique 2** Sugarcane pot	**Technique 3** Sugarcane pot and Bamboo quadrant	**Technique 4** Traditional Wooden Stake Anchoring
			
			

Results of the Study on the Survival Rate of Seagrass Planted with Different Techniques. The study was conducted at all three locations with three repetitions. The results are shown in Table 2.

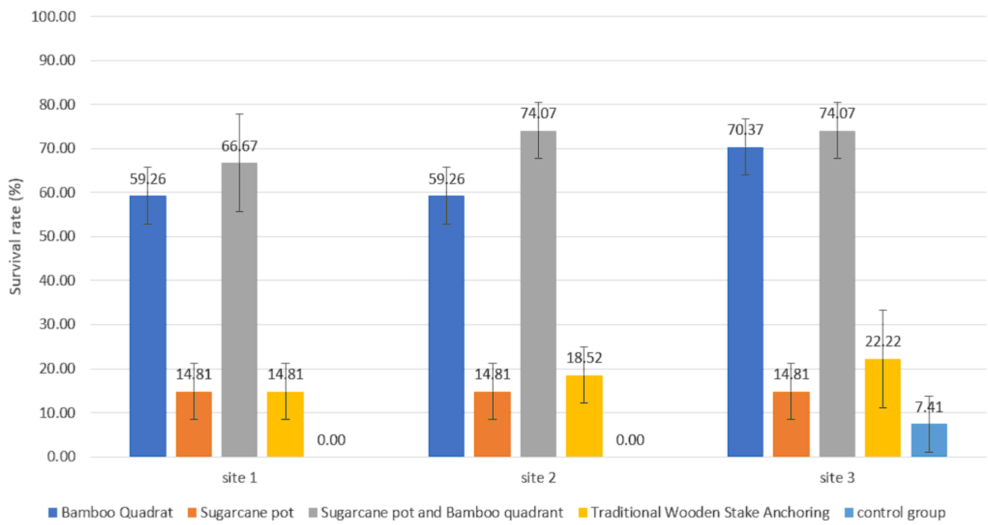
Table 2 shows the average survival rate of seagrass planted with different techniques at all three locations with three repetitions.

Techniques	Average surviving plants (plant)			Total (plant)
	site 1	site 2	site 3	
Bamboo Quadrat	5.33±0.58[a]	5.33±0.58[a]	6.33±0.58[a]	16.99±0.58[a]
Sugarcane pot	1.33±0.58[b]	1.33±0.58[b]	1.33±0.58[b]	3.99±0.00[b]
Sugarcane pot and Bamboo quadrant	6.00±1.00[c]	6.67±0.58[c]	6.67±0.58[c]	19.34±0.39[c]
Traditional Wooden Stake Anchoring	1.33±0.58[d]	1.67±0.58[d]	2.00±1.00[d]	5.00±0.36[d]
Control group	0.00±0.00[e]	0.00±0.00[e]	0.67±0.58[e]	0.67±0.39[e]
Total (plant)	13.99±2.68	15.00±2.85	17.00±2.87	**45.99±1.53**

Note: The different letters shown in the column indicate a statistically significant difference ($p \leq 0.05$)

Experimental results indicated that the highest seagrass survival was achieved from the Sugarcane Pot and Bamboo Quadrat planting method, ranging from 18.95 to 19.73 plants, whereas the lowest mean survival was found in the control group, ranging from 0.28 to 1.06 plants. When the relationship between seagrass survival rate and planting method was analyzed using ANOVA at the 0.05 level, it was revealed that the survival rate of seagrass was indeed connected with the planting method used. Upon comparing the data on the percentage survival rate of seagrass planted using various methods, the findings are presented in Figure 6.

Figure 6: A chart showing the percentage survival rate of seagrass planted with different techniques in site 1, 2, and 3.



The Cost-Effectiveness Study of Seagrass Planting Techniques on Survival Rate

Table 3 shows the cost-effectiveness of seagrass planting techniques on the survival rate.

Technique	Capital cost (Bath)	Time required (hour)	Survival Rate (%)	Cost-Effectivene
Bamboo Quadrat	72	1.25	62.96	44.04
Sugarcane pot	45	0.37	14.81	13.17
Sugarcane pot and Bamboo quadrant	90	1.67	71.60	34.11
Traditional Wooden Stake Anchoring	45	0.67	18.51	11.36
Control group	27	0.12	2.47	1.88

The analysis of cost-effectiveness of the survival rate of seagrass using different planting methods showed that the Bamboo quadrat method had the highest cost-effectiveness with a value of 44.04 and is therefore the most cost-effective method for planting seagrass.

Regardless, however, the selection of a planting method for seagrass restoration is based on several variables such as budget constraints and the desired percentage survival of the seagrass.

1.2 Development of Seagrass Planting Techniques to Enhance Growth Rate

The study results on the growth rate of surviving seagrass planted using different techniques across the three sites are as follows.

1) Growth rate of seagrass leaf length using different planting techniques

Table 4 shows the average leaf length of seagrass planted using different techniques from the beginning to the third month.

Techniques	Average leaf length (cm.)			
	Before planting	Month 1	Month 2	Month 3
Bamboo Quadrat	11.94 ± 0.52^{a}	12.59 ± 0.53^{a}	14.63 ± 0.65^{a}	15.79 ± 0.62^{a}
Sugarcane pot	12.38 ± 0.60^{a}	13.27 ± 0.74^{a}	14.58 ± 0.56^{a}	16.04 ± 0.48^{a}
Sugarcane pot and Bamboo quadrant	11.98 ± 0.83^{a}	12.77 ± 0.50^{a}	14.49 ± 0.63^{a}	16.49 ± 0.54^{a}
Traditional Wooden Stake Anchoring	11.36 ± 0.24^{a}	12.31 ± 0.62^{a}	14.46 ± 0.65^{a}	15.91 ± 0.43^{a}
Control group	11.12 ± 0.52^{a}	12.59 ± 0.46^{a}	14.27 ± 0.27^{a}	15.34 ± 0.36^{a}

Note: The different letters shown in the column indicate a statistically significant difference ($p \leq 0.05$)

The findings of the experiment indicated that seagrass cultivated with the Sugarcane pot and Bamboo quadrant technique exhibited the longest average leaf length, ranging from 15.95 to 17.03 cm. Conversely, the control group exhibited the shortest average leaf length, ranging from 14.98 to 15.70 cm.

2) Growth rate of seagrass leaf width using different planting techniques

Table 5 shows the average leaf width of seagrass planted using different techniques from the beginning to the third month.

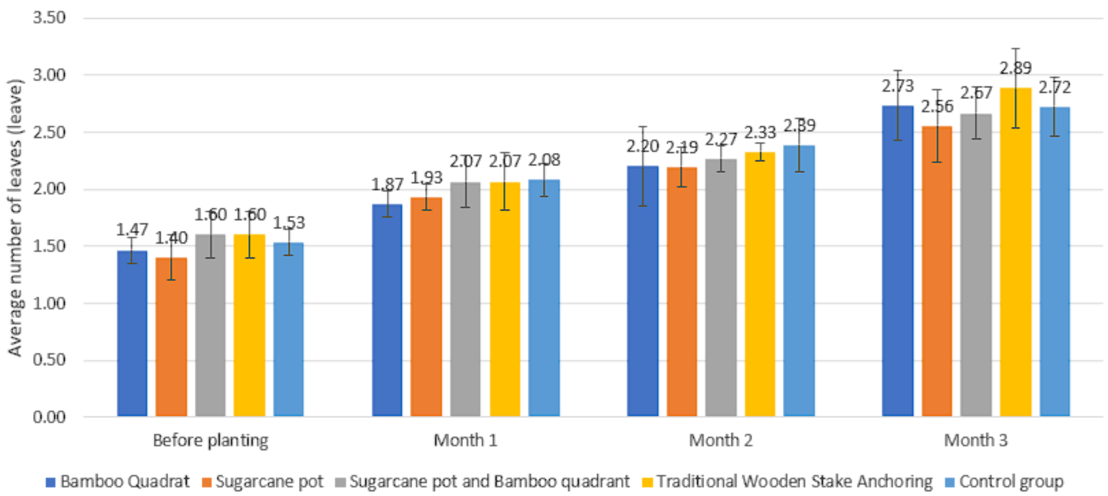
Techniques	Average leaf width (cm)			
	Before planting	Month 1	Month 2	Month 3
Bamboo Quadrat	0.61 ± 0.05^{a}	0.62 ± 0.07^{a}	0.66 ± 0.10^{a}	0.68 ± 0.11^{a}
Sugarcane pot	0.61 ± 0.03^{a}	0.63 ± 0.04^{a}	0.65 ± 0.08^{a}	0.67 ± 0.09^{a}
Sugarcane pot and Bamboo quadrant	0.62 ± 0.08^{a}	0.64 ± 0.08^{a}	0.66 ± 0.09^{a}	0.67 ± 0.09^{a}
Traditional Wooden Stake Anchoring	0.62 ± 0.04^{a}	0.63 ± 0.02^{a}	0.64 ± 0.06^{a}	0.65 ± 0.06^{a}
Control group	0.62 ± 0.04^{a}	0.62 ± 0.04^{a}	0.63 ± 0.04^{a}	0.64 ± 0.06^{a}

Note: The different letters shown in the column indicate a statistically significant difference ($p \leq 0.05$)

The findings of the experiment indicated that, at three months, seagrass cultivated using the Bamboo quadrat method exhibited the highest mean leaf width of between 0.57 and 0.79 cm. The control seagrass had the lowest mean leaf width of between 0.58 and 0.70 cm.

3) Growth rate of the number of leaves of seagrass planted using different planting techniques.

Figure 4 shows the number of leaves of seagrass planted using different planting techniques.



The graph indicates that, during the three months, seagrass cultivated through the Traditional Wooden Stake Anchoring method averaged the most number of leaves, compared to seagrass cultivated using the Sugarcane pot method, which had the least mean number of leaves. It is important to mention, however, that no difference at the 0.05 level was detected.

2) Study of Soil Quality Before and After Seagrass Planting Using Different Techniques

The pH, organic matter, soil nutrients, and texture of the three test sites were analyzed in three replications prior to and after seagrass planting with three methods. The findings are shown in Tables 6 and 7.

Table 6 shows the soil texture, pH, and organic matter content before and after planting for each technique and location.

Sites	Techniques	Soil Texture	pH		Oraganic Matter	
			before	after	before	after
1	Bamboo Quadrat	Sand	8.6±0.1[a]	8.5±0.1[a]	1.48±0.05[a]	1.01±0.04[a]
	Sugarcane pot	Sand	8.6±0.1[a]	8.4±0.1[a]	1.59±0.02[a]	1.26±0.03[a]
	Sugarcane pot and Bamboo quadrant	Sand	8.4±0.0	8.6±0.1[a]	1.52±0.10[a]	1.15±0.16[a]
	Traditional Wooden Stake Anchoring	Sand	8.4±0.1[a]	8.6±0.1[a]	1.35±0.08[a]	0.91±0.16[a]
	Control group	Sand	8.4±0.1[a]	8.5±0.1[a]	1.69±0.04[a]	1.39±0.04[a]
2	Bamboo Quadrat	Loamy Sand	8.6±0.1[a]	8.6±0.1[a]	3.17±0.09[a]	2.60±0.13[a]
	Sugarcane pot	Loamy Sand	8.5±0.1[a]	8.6±0.1[a]	3.40±0.08[a]	3.09±0.10[a]
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5±0.0	8.6±0.1[a]	3.04±0.06[a]	2.5±0.26[a]
	Traditional Wooden Stake Anchoring	Loamy Sand	8.6±0.1[a]	8.5±0.1[a]	3.43±0.13[a]	3.05±0.27[a]
	Control group	Loamy Sand	8.5±0.1[a]	8.6±0.1[a]	3.07±0.17[a]	2.98±0.06[a]
3	Bamboo Quadrat	Loamy Sand	8.6±0.1[a]	8.5±0.2[a]	4.08±0.20[a]	3.55±0.33[a]
	Sugarcane pot	Loamy Sand	8.5±0.1[a]	8.4±0.2[a]	4.09±0.12[a]	3.65±0.20[a]
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5±0.1[a]	8.4±0.1[a]	4.39±0.11[a]	3.92±0.19[a]
	Traditional Wooden Stake Anchoring	Loamy Sand	8.5±0.1[a]	8.6±0.1[a]	4.60±0.15[a]	4.44±0.08[a]

Sites	Techniques	Soil Texture	pH		Oraganic Matter	
			before	after	before	after
	Control group	Loamy Sand	8.5±0.1[a]	8.6±0.1[a]	4.63±0.16	4.48±0.11[a]

Note: The different letters shown in the column indicate a statistically significant difference ($p \leq 0.05$)

Table 7 shows content soil nutrients before and after planting for each technique and location.

Sites	Techniques	N		P		K	
		before	after	before	after	before	after
1	Bamboo Quadrat	trace	trace	low	low	trace	low
	Sugarcane pot	trace	low	trace	low	low	low
	Sugarcane pot and Bamboo quadrant	trace	low	trace	low	low	low
	Traditional Wooden Stake Anchoring	trace	trace	low	low	low	low
	Control group	trace	trace	trace	trace	trace	trace
2	Bamboo Quadrat	trace	trace	trace	trace	low	medium
	Sugarcane pot	trace	low	low	low	trace	low
	Sugarcane pot and Bamboo quadrant	trace	low	trace	low	low	low
	Traditional Wooden Stake Anchoring	low	medium	trace	low	trace	trace
	Control group	trace	low	low	low	low	low
3	Bamboo Quadrat	low	low	trace	low	trace	low
	Sugarcane pot	low	medium	low	low	low	medium
	Sugarcane pot and Bamboo quadrant	low	low	low	medium	low	low
	Traditional Wooden Stake Anchoring	trace	low	trace	low	trace	trace
	Control group	low	low	low	low	low	low

Soil quality analysis conducted in the seagrass planting areas, through various methods, indicated that prior to planting, the levels of nitrogen (N), phosphorus (P), and potassium (K) nutrients ranged from trace to low. However, after planting, the levels of these nutrients were higher. This result is consistent with the research by Jirayawadee Suriyaphan (2019), which indicated that seagrass helps in the enrichment of nitrogen and phosphorus in the soil.

Discussion and Conclusions

The development of a planting technique for Tape seagrass (Enhalus acoroides) with the help of natural anchoring materials to enhance the survival rate and growth rate consisted of four techniques: (1) Bamboo quadrat, (2) Sugarcane pot, (3) Sugarcane pot and Bamboo quadrat, and (4) Traditional Wooden Stake Anchoring. The results were that both Bamboo quadrat and Sugarcane pot planting methods shared the largest average survival rate of 74.07%, with the control method having the least survival rate at 7.41%. Moreover, statistical analysis conducted through ANOVA at a significance level of 0.05 showed that there existed a significant connection between the survival rate and the planting method applied. Bamboo quadrat provided structural support for seagrass in line with Edward JK Patterson et al.'s study, which revealed that Bamboo quadrats enhance seagrass stability and thus increase survival rates. Sugarcane pot increased anchoring strength in alignment with Prasert Thongnui's study, which revealed that the use of biodegradable cups for seagrass restoration provided appropriate survival rates. Contrastingly, the control group had the lowest rate of survival as the absence of anchoring material led to seagrass being removed easily. This result corroborates the observation by Katie M. Watson et al., where planted seagrass without the use of anchoring material registered the lowest survival rates.

A cost-effectiveness analysis of the various planting techniques found that the Bamboo quadrat had the most affordable cost per survival rate and that the Sugarcane pot had the most expensive cost per survival rate. Selection of a planting technique for restoring seagrass, however, is based on budget and ideal survival rate.

In growth rate, the leaf length of seagrass cultivated with the Sugarcane pot and Bamboo quadrat method was the longest, while the shortest leaf length was in the control group. This is due to the Sugarcane pot, which supplied more nutrients to the seagrass from biodegradable sugarcane fiber. This conclusion is consistent with the research conducted by Prasert Thongnui, which confirmed that seagrass cultivated in pots had the longest leaves. Statistical analysis, though, showed that there were no differences in the growth rates among the various planting methods ($p \leq 0.05$).

Soil quality analysis conducted prior to and after planting indicated that Site 1 was made up of sandy soil, whereas Sites 2 and 3 comprised a sandy loam structure. The pH level and organic matter content in the soil were found not to vary significantly statistically prior to and after planting ($p > 0.05$). However, the N, P, and K levels of nutrients rose after planting, as revealed by the work of Jirayawadee Suriya-Phan (2019) that seagrass raises the concentration of nitrogen and phosphorus in the soil.

The development of a natural anchoring-based seagrass planting technique resulted in a significant increase in survival rate ($p \leq 0.05$), though there was no significant difference in growth rate between techniques. There was no alteration in soil quality except for increased N, P, and K after planting. Ultimately, planting method selection must be done considering budget limitations and desired survival rates.

Acknowledgements

Special thanks to Walailak University for consultation and advice on environmental studies, Ban Modtanoi Community Enterprise Group, Kantang District, Trang Province, for support and data, and Teacher Apasri Chumchuen and Sirikwan Nuphuti for advice and data collection. We also thank Princess Chulabhorn Science High School, Trang, for support in carrying out this study.

Citations

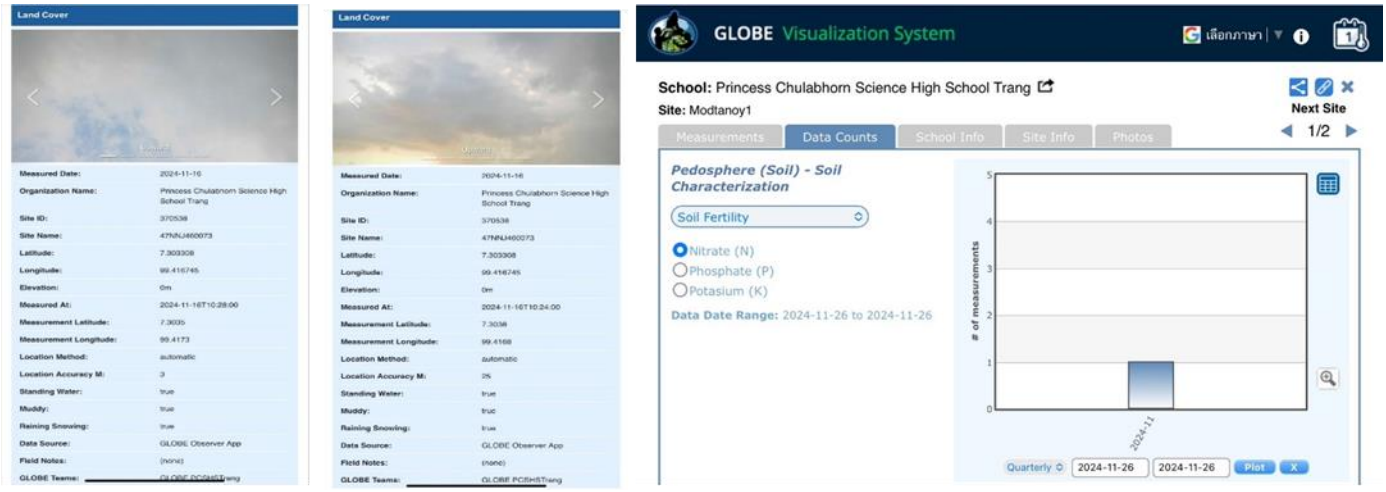
Edward JK Patterson et al. (January 2019). Seagrass restoration in Gulf of Mannar, Tamil Nadu, Southeast India: a viable management tool. https://shorturl.at/5MtFP

January Wegoro et al. (5 November 2022). Seagrass restoration in a high-energy environment in the Western Indian Ocean. https://www.sciencedirect.com/science/article/abs/pii/S0272771422003778

Katie M. Watson et al. (29 November 2023). Using transplantation to restore seagrass meadows in a protected South African lagoon. https://pubmed.ncbi.nlm.nih.gov/38047028/

Parichat Boonaek. (9 March 2024). 'Disappearing seagrass' degradation Impact on the ecosystem. https://www.bangkokbiznews.com/environment/1116955#google_vignette

GLOBE's databases



Badges

I MAKE AN IMPACT

Seagrass decline is a local issue linked to global challenges like biodiversity loss and climate change. Our research aimed to improve restoration methods, addressing the inefficiency of traditional techniques. We developed a new method that significantly increased seagrass survival rates. Locally, this method provides a scalable solution for coastal communities, enhancing coastal protection and supporting marine biodiversity. Globally, it contributes to blue carbon sequestration and helps combat climate change. Our findings were shared with the community, leading to actions that improve conservation efforts, demonstrating how local issues can drive positive global impact.

I AM A DATA SCIENTIST

In the past, Mod Tanoi Beach in Thailand had abundant seagrass meadows, but today, these ecosystems have drastically declined. This research employs a data-driven approach to investigate and restore seagrass populations, integrating GLOBE database records with field-collected data. We analyze soil quality parameters such as pH, organic matter content, and nutrient levels before and after planting activities. Statistical analysis, including ANOVA, is applied to assess the correlation between previous anchoring techniques and seagrass survival and growth rates. Our quantitative findings reveal the limitations of earlier methods and guide the development of more effective innovations, ensuring sustainable seagrass conservation in the future.

I AM A COLLABORATOR

Successful seagrass restoration needs interdisciplinary collaboration. This project unites marine biologists, environmental scientists, coastal communities, and policymakers to create sustainable solutions. We enjoy intimate cooperation with the coastal communities of Mod Tanoi Village, combining their folk wisdom with scientific innovation. Through nurturing the partnerships' growth, we aim to build long-term seagrass restoration solutions benefiting marine ecosystems and coastal livelihoods.

Appendix with raw data

Table 8 shows the soil texture, pH, and organic matter content before and after planting for each technique and location.

Techniques		Soil Texture	pH		Oraganic Matter	
			before	after	before	after
Site 1	Bamboo Quadrat	Sand	8.6	8.5	1.54	1.05
	Bamboo Quadrat	Sand	8.7	8.4	1.46	1.02
	Bamboo Quadrat	Sand	8.6	8.6	1.44	0.97
	Average	Sand	8.6	8.5	1.48	1.01
	Sugarcane pot	Sand	8.6	8.4	1.63	1.26
	Sugarcane pot	Sand	8.5	8.5	1.55	1.30
	Sugarcane pot	Sand	8.6	8.4	1.59	1.22
	Average	Sand	8.6	8.4	1.59	1.26
	Sugarcane pot and Bamboo quadrant	Sand	8.5	8.6	1.5	1.13
	Sugarcane pot and Bamboo quadrant	Sand	8.4	8.6	1.46	1.09
	Sugarcane pot and Bamboo quadrant	Sand	8.4	8.5	1.61	1.24
	Average	Sand	8.4	8.6	1.52	1.15
	Traditional Wooden Stake Anchoring	Sand	8.4	8.6	1.34	0.91
	Traditional Wooden Stake Anchoring	Sand	8.4	8.5	1.39	0.95
	Traditional Wooden Stake Anchoring	Sand	8.4	8.7	1.33	0.88
	Average	Sand	8.4	8.6	1.35	0.91
	Control group	Sand	8.5	8.5	1.74	1.42
	Control group	Sand	8.4	8.6	1.68	1.37
	Control group	Sand	8.3	8.5	1.64	1.39
	Average	Sand	8.4	8.5	1.69	1.39

Techniques		Soil Texture	pH		Oraganic Matter	
			before	after	before	after
Site 2	Bamboo Quadrat	Loamy Sand	8.6	8.5	3.12	2.49
	Bamboo Quadrat	Loamy Sand	8.6	8.5	3.27	2.56
	Bamboo Quadrat	Loamy Sand	8.5	8.7	3.11	2.74
	Average	Loamy Sand	8.6	8.6	3.17	2.60
	Sugarcane pot	Loamy Sand	8.5	8.5	3.23	3.1
	Sugarcane pot	Loamy Sand	8.6	8.6	3.41	3.02
	Sugarcane pot	Loamy Sand	8.5	8.6	3.56	3.14
	Average	Loamy Sand	8.5	8.6	3.40	3.09
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5	8.6	2.98	2.56
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5	8.5	3.04	2.64
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5	8.6	3.10	2.44
	Average	Loamy Sand	8.5	8.6	3.04	2.55
	Traditional Wooden Stake Anchoring	Loamy Sand	8.6	8.5	3.38	2.95
	Traditional Wooden Stake Anchoring	Loamy Sand	8.5	8.6	3.45	3.01
	Traditional Wooden Stake Anchoring	Loamy Sand	8.6	8.5	3.47	3.18
	Average	Loamy Sand	8.6	8.5	3.43	3.05
	Control group	Loamy Sand	8.5	8.5	3.13	2.98
	Control group	Loamy Sand	8.6	8.6	2.99	2.85
	Control group	Loamy Sand	8.4	8.6	3.09	3.12
	Average	Loamy Sand	8.5	8.6	3.07	2.98
Site 3	Bamboo Quadrat	Loamy Sand	8.6	8.5	4.27	3.87
	Bamboo Quadrat	Loamy Sand	8.6	8.7	4.09	3.56
	Bamboo Quadrat	Loamy Sand	8.5	8.4	3.87	3.21
	Average	Loamy Sand	8.6	8.5	4.08	3.55
	Sugarcane pot	Loamy Sand	8.6	8.4	3.91	3.53
	Sugarcane pot	Loamy Sand	8.5	8.5	4.21	3.67
	Sugarcane pot	Loamy Sand	8.5	8.4	4.16	3.74
	Average	Loamy Sand	8.5	8.4	4.09	3.65
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5	8.4	4.43	4.01
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.5	8.4	4.49	3.87
	Sugarcane pot and Bamboo quadrant	Loamy Sand	8.4	8.4	4.25	3.89
	Average	Loamy Sand	8.5	8.4	4.39	3.92
	Traditional Wooden Stake Anchoring	Loamy Sand	8.5	8.6	3.97	3.84
	Traditional Wooden Stake Anchoring	Loamy Sand	8.5	8.5	5.41	5.2
	Traditional Wooden Stake Anchoring	Loamy Sand	8.6	8.6	4.42	4.28
	Average	Loamy Sand	8.5	8.6	4.60	4.44
	Control group	Loamy Sand	8.5	8.6	4.36	4.35
	Control group	Loamy Sand	8.5	8.4	4.81	4.59
	Control group	Loamy Sand	8.6	8.7	4.73	4.5
	Average	Loamy Sand	8.5	8.6	4.63	4.48

Table 9 shows content soil nutrients before and after planting for each technique and location.

Techniques		N		P		K	
		before	after	before	after	before	after
Site 1	Bamboo Quadrat	trace	trace	low	low	trace	trace
	Bamboo Quadrat	trace	trace	trace	trace	trace	low
	Bamboo Quadrat	trace	trace	low	low	trace	low
	Average	trace	trace	low	low	trace	low
	Sugarcane pot	low	low	trace	low	trace	low
	Sugarcane pot	trace	trace	trace	low	low	trace
	Sugarcane pot	trace	low	low	low	low	low
	Average	trace	low	trace	low	low	low
	Sugarcane pot and Bamboo quadrant	low	low	low	low	low	low
	Sugarcane pot and Bamboo quadrant	trace	low	trace	low	low	low
	Sugarcane pot and Bamboo quadrant	trace	trace	trace	low	low	trace
	Average	trace	low	trace	low	low	low
	Traditional Wooden Stake Anchoring	trace	trace	trace	trace	low	low
	Traditional Wooden Stake Anchoring	trace	trace	low	low	trace	trace
	Traditional Wooden Stake Anchoring	trace	trace	low	low	low	low
	Average	trace	trace	low	low	low	low
	Control group	trace	trace	trace	trace	trace	trace
	Control group	low	trace	low	trace	trace	low
	Control group	trace	trace	trace	trace	low	trace
	Average	trace	trace	trace	trace	trace	trace
Site 2	Bamboo Quadrat	trace	trace	trace	trace	low	medium
	Bamboo Quadrat	trace	trace	trace	trace	low	medium
	Bamboo Quadrat	low	trace	trace	low	low	low
	Average	trace	trace	trace	trace	low	medium
	Sugarcane pot	trace	trace	low	low	low	low
	Sugarcane pot	low	low	medium	medium	trace	low
	Sugarcane pot	trace	low	low	low	trace	medium
	Average	trace	low	low	low	trace	low
	Sugarcane pot and Bamboo quadrant	trace	trace	trace	low	low	trace
	Sugarcane pot and Bamboo quadrant	trace	low	low	low	low	low
	Sugarcane pot and Bamboo quadrant	low	low	trace	low	low	low
	Average	trace	low	trace	low	low	low
	Traditional Wooden Stake Anchoring	trace	low	trace	low	trace	low
	Traditional Wooden Stake Anchoring	low	medium	trace	trace	trace	trace
	Traditional Wooden Stake Anchoring	low	medium	low	low	trace	trace
	Average	low	medium	trace	low	trace	trace
	Control group	low	low	trace	low	low	medium
	Control group	trace	low	low	low	low	low
	Control group	trace	trace	low	medium	trace	low
	Average	trace	low	low	low	low	low

Techniques		N		P		K	
		before	after	before	after	before	after
Site 3	Bamboo Quadrat	low	low	low	low	trace	low
	Bamboo Quadrat	trace	low	trace	medium	trace	trace
	Bamboo Quadrat	low	low	trace	low	low	low
	Average	low	low	trace	low	trace	low
	Sugarcane pot	low	medium	medium	low	medium	low
	Sugarcane pot	low	low	low	low	low	medium
	Sugarcane pot	medium	medium	low	low	low	medium
	Average	low	medium	low	low	low	medium
	Sugarcane pot and Bamboo quadrant	low	medium	trace	low	low	low
	Sugarcane pot and Bamboo quadrant	trace	low	low	medium	low	medium
	Sugarcane pot and Bamboo quadrant	low	low	low	medium	low	trace
	Average	low	low	low	medium	low	low
	Traditional Wooden Stake Anchoring	trace	trace	trace	trace	trace	trace
	Traditional Wooden Stake Anchoring	trace	low	low	low	trace	trace
	Traditional Wooden Stake Anchoring	low	low	trace	low	trace	low
	Average	trace	low	trace	low	trace	trace
	Control group	low	medium	low	low	low	low
	Control group	low	low	low	low	trace	trace
	Control group	low	low	low	trace	low	low
	Average	low	low	low	low	low	low

Figure 5 shows Condition of seagrass in Koh Libong, Trang Province