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`SCIENCE & TECHNOLOGY COMMUNITY- BASED FARM ON GRACILARIA PRODUCTION IN LA UNION (PHILIPPINES)

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ABSTRACT

This paper presents the outcomes of farming Gracilaria (Rhodophyta) using the net module as improved culture technology adopted by coastal communities of Rosario, La Union thru the Science and Technology Community Based Farm. Generally, the objective of the project is to upscale the application of S&T intervention in Gracilaria farming through community-based approach. Cooperators were capacitated with skills trainings on Gracilaria culture method using net modules, farm management, proper harvesting, drying technology using the helio house solar dryer, packaging, and formulation of value added products from Gracilaria. Results revealed that the technology has significantly doubled the production of Gracilaria from 6,000 kg/ha/yr to 28,480 kg/ha/yr. The technology has improved the quality of dried Gracilaria. Moreover, increased awareness on the economic benefits of Graciaria has resulted to active participation of the coastal communities in promoting Gracilaria farming technology in La

Union. Increase in Gracilaria production could be attributed to the S and T intervention adopted by the cooperators thru the community-based strategy. Thus, Gracilaria farming technology using the net module is recommended to increase production and provide source of additional income and potential livelihood to coastal communities.

Keywords: community-based, farm management, Gracilaria, net module, post harvest

INTRODUCTION

Seaweeds are marine macro algae that are economically important as direct source of food, medicine, fertilizer, fodder, and good sources of phycocolloids. Annual global seaweed production was reported by FAO at 1.4M dry tons per annum, majority consisting of agarophytes and carrageenophytes with Gracilaria sharing 5% of the global annual production. According to the 2006 FAO analysis, seaweed based value chains generated a range of products with annual production value estimated at 5.5-7B USD per annum (Neish, 2008). Tropical seaweed production was used as raw material for making the red algal galactan (RAG) hydrocolloids known as agar and carageenan from the most commonly cultivated red algal galactan seaweeds (RAGS) such as the *Kapphaphycus cottonii*, *Eucheuma spinosum* and *Gracilaria* as sources of kappa carrageenan, iota carrageenan and agar respectively. Global market growth was projected to double based on the requirement for red algal galactan seaweeds raw materials especially agar and kappa carrageenean (SEAPlant.net) in the Philippines and Indonesia from 2007-2012. Among the tropical countries, the Philippines ranked second contributing 35.2% of the total exported seaweeds with a volume of 170,564 tons from 2002-2006, a period characterized by tight supplies of Kappaphycus and adequate supplies of Eucheuma and Gracilaria. Estimates of seaweed production reported for the Philippines in 2007 were about 70,000 tons dry but mostly from Kapphaphycus with the largest trading flows from the Philippines to Hongkong and China. Prospects for seaweeds market globally continue to rise due to the increasing organic food market utilizing seaweed extracts in many food industries including other non-food applications.

In 1992, the Philippines ranked second, next to Japan, in terms world production of red seaweeds contributing 350,504 tons or almost 30% of the global production (FAO, 1992). In 2007, it contributed 10.13% of the 14.9M metric tons world production, next to China and Indonesia. Apparently, the Philippines is a major producer of raw material for carrageenan and also the leading producer of semi-refined carrageenan (MDA, 2011). In terms of export,

seaweeds were valued at USD99.44M or Php4.70B in 2009 (Philippine Fisheries Profile, 2009), next to tuna in terms of overall export. Recent statistics show that seaweed production at 383, 694.82 metric tons contributed more than half or 64.82% of the total aquaculture production during the second quarter of 2012 (Fisheries Situationer, 2012).

Gracilaria, an agar-agar bearing seaweed, is one of the three commercial species of seaweeds in the Philippines, along with Eucheuma and Gelidium. Gracilaria has been used as an important source of agar, a form of phycocolloid which has many important uses as food and numerous industrial applications. Locally, the agar from Gracilaria is utilized by gulaman food processors, refined agar users (such as the local pharmaceuticals, drug companies, hospitals, research institutions, and food and cosmetic manufacturers) and bacteriological grade users. The better quality agar is used in microbiological specimens while the food industry uses them as protective gels in canned meat and stabilizers in many products. They are also used in sizing of fabrics, waterproofing of paper and cloth and or clarifying agent in the manufacture of wines, beers, and coffee. Gracilaria has also been used as effective biofilters in recirculating systems for milkfish broodstocks and in brackishwater ponds (SEAFDEC, 2011). It has been reported that Gracilaria (together with Macrocystis and Sargassum) is a source of biofuel or methane production which is a new venture in the United States (Pelinggon and Tito, 2009). Recent published researches revealed that Gracilaria contain bioactive compounds with broad spectrum of biological activities such as antibacterial (Srikong *et al*, 2015; Widowati *et al*, 2014; Ramalingam and Amutha, 2013; Jeyanthi *et al*, 2013; Mendes et al., 2013), antifungal (Kolanjinathan and Saranraj, 204; Prabhahar *et al*, 2012), antioxidant (Widowati *et al*, 2014; Namvar *et al*, 2014;), anticancer (Moussavou *et al*, 2014; Patra and Muthuraman 2013; Sundara *et al*, 2012), and immunostimulant (Hamed *et al*, 2015; Maningas *et al*, 2013; Kumar, 2012). Based on the numerous uses of Gracilaria, increasing demand is projected in the local market which can be attributed to the discoveries on the new uses and emerging applications of seaweeds including Gracilaria. Statistics show that international demand for phycocolloids such as agar, alginate, and carrageenan has grown very rapidly. This growing demand for seaweeds including Gracilaria as raw materials needs to be addressed due to the large scale employment that it can generate for fisherfolks. Increased demand for Gracilaria supply is also projected due to the recent trend of agar uses which is now focused on soft gel rather than the traditional hard gel (Seaweed Industry Association of the Philippines, SIAP). At present, Gracilaria is basically harvested from wild stocks although farming technology has been commercially practiced in

other countries such as China, Taiwan, and Thailand. Intensification of harvesting wild stocks of Gracilaria could lead to depletion of stocks. Indiscriminate harvesting or overharvesting of Gracilaria in its natural habitats for several years may possibly cause extensive damage to the marine habitats and declining fish productivity.

With the increasing demand for Gracilaria and the threats to the wild stocks, management options must be done to ensure sustainable supply for this resource. Thus, STBF Gracilaria farming is promoted to answer this concern. Gracilaria culture shall not only become an alternate source of livelihood but also as an environment friendly aqua-farming technology for biomass supply to the seaweed industry. The technology can use family labor thus it is a low-cost, profitable venture and a potential source of supplemental income for marginal fishermen or small fisherfolks associations. Gracilaria farming does not only provide livelihood opportunity for marginal fishermen but at the same time conserve natural stocks and protects the coastal areas from illegal fishing. Fishing pressure is minimized or decreased in the municipal waters because fishermen are engaged in Gracilaria farming that can directly help them thru seaweed trading.

Harvesting wild or natural stocks of Gracilaria in the coastal waters of La Union, particularly in Rosario and Sto. Tomas, has been stimulated by the increasing demand for dried seaweeds by foreign processors and local market thru the information given by local traders. For many years, fisherfolks living along these areas seasonally gather the natural stocks of Gracilaria due to the economic benefits they derived from the activity. However, the tendency for the fisherfolks to overharvest the wild stocks is possible since no local regulation exist in terms of resource management. Current survey of Gracilaria trading in Rabon shows that semi-dried Gracilaria (sundried for two days), locally called “gulaman” or “kaw-kawayan” is sold by gatherers at P10 per kilo (pick-up price). This project was aimed to improve Gracilaria production through the community based STBF modality. Likewise, the project was aimed to enhance active participation among resource users of Gracilaria and empower them in promoting Gracilaria resource management and sustainability.

OBJECTIVES

General: To upscale the application of S&T interventions in Gracilaria farming through the community based approach

Specific:

1.To promote wider adoption/commercialization of Gracilaria farming technology through the community-based STBF;

2. To develop farmer's skills in Gracilaria farming;

3. To enhance active participation of the community LGUs and other cooperating agencies in promoting the application of the *Gracilaria* farming technology;

4. To promote *Gracilaria* as an alternative source of livelihood for the community.

MATERIALS AND METHODS

The technology uses simple and locally available materials and inputs. The materials used in Gracilaria culture technology includes polyethylene (P.E.) net (10 x 12), polyethylene (P.E.) ropes (# 16, # 14, # 8, #2), iron bars (steel posts) and styropore (as floaters). Most importantly, the raw materials, Gracilaria seedstocks in the form of cuttings or propagules, which are used in planting were taken from the naturally growing Gracilaria in the coastal area located adjacent the residence of the cooperators in barangay Rabon, Rosario, La Union, where the STCBF farm was established. The project was divided into two phases, the pre-implementation and implementation phase. The pre-implementation phase includes the identification of project site, identification of cooperators, and inception meeting while the implementation phase covers capability building (biology and culture of Gracilaria), culture and management, and capability building (post harvest and value adding). The implementation phase consisted of capability building among cooperators through the conduct of lectures and hands-on training on the biology and culture of Gracilaria, growth monitoring and farm management, post harvest techniques, and value adding. Technical experts were tapped to provide lectures on the biology and culture of Gracilaria, net module construction, growth monitoring and management of project. After acquiring knowledge and skills from the training, the cooperators constructed the net modules that were used in Gracilaria production. Before the harvesting month, another training was conducted to provide the cooperators with the knowledge and skills in post harvest processing of harvested Gracilaria. The scheme of Gracilaria production using the net module in the improved culture technology is discussed below.

Step 1. Net Module Construction. Net modules are made of polyethylene nets (PE # 10) with measurements of 12. 5 m in length, and 20 cm in width. A polyethylene rope (#16) is knitted inside each module. Ten net modules compose one set.

Step 2. Gathering of Gracilaria Seedstocks. Fresh Gracilaria thalli are collected from the coastal waters of barangay Rabon, Rosario, La Union and used as seedstocks.

Step 3. Insertion of Seedstocks in Net Modules. Each net module is stocked with 700 g of Gracilaria propagules or cuttings thru manual insertion of thalli into the meshes of the net module.

Step 4. Installation of Net Modules. Net modules are installed by set (10 net modules per set) at regular intervals and fixed with iron bars (sinkers). Modules are set in the farm site situated along the coastal shores adjacent the residents of cooperators for easier farm management and guarding.

Step 5. Growth Monitoring and Farm Management. Monitoring of growth is done on a monthly basis to check robustness of seaweeds. Growth & other water parameters (salinity, temperature) are also monitored to determine effects on growth. Farm management includes regular visitation and inspection of net modules whether they are properly anchored.

Step 6. Harvesting. Harvesting is done by cutting/pruning the Gracilaria thalli which vegetatively branched outside the net modules. Using a scissor, the Gracilaria outgrowths are carefully cut. In this manner, uncut seaweed thalli inside the net modules are left behind to allow continuous vegetative reproduction.

Step 7. Post Harvest. Harvested seaweeds are washed thoroughly with clean water. Epiphytes such as other algal species and unnecessary debris are also removed. Cleaned Gracilaria are dried using the MaConray solar dryer. The MaConray plastic absorbs heat faster than the conventional plastic sheet. Drying time for the seaweed is reduced and most importantly, the quality of dried seaweed is improved using the solar dryer compared to the poor quality as a result of the common practice of drying Gracilaria along the highway and exposing the Gracilaria from vehicular fumes and domestic wastes.

Step 8. Storage. Dried Gracilaria are packed in a clear plastic bag (100g/pack) and stored in a dry, clean place at room temperature.

Step 9. Trade and Marketing. Quality dried Gracilaria produced are linked to Gracilaria traders from neighboring provinces. There is also a demand for fresh Gracilaria from private companies and research institutions as they utilize Gracilaria as fodder or feed for their culture stocks such as sea urchins and abalones. Cooperators also market their products (dried Gracilaria and seaweed chips) in local and provincial agro-industrial trade fairs and exhibits.

Step10. Value Adding. Gracilaria has been used as an important source of agar, a form of phycocolloid which has many important uses as food and numerous industrial applications.

RESULTS AND DISCUSSIONS

Adoption of Gracilaria farming technology

Gracilaria farming technology using the modified culture medium (net module) was adopted by three coastal communities in Rosario, La Union thru the community based STBF. Modules were set in the farm site situated along the coastal shore adjacent the residents of cooperators for easier farm management especially in monitoring and guarding. Based on the first production cycle presented in Table 1, the total Gracilaria harvested (fresh) was 7,120 kg in the 0.50 hectare farm. Production of Gracilaria thru STCBF modality is presented in comparison with the natural production or Gracilaria produced in the wild (based on the survey before the project implementation as reported by Gracilaria traders) (Table 2). It can be noted that production of Gracilaria with STCBF was more than doubled using the net modules. Using the technology, Gracilaria thalli left inside the culture medium after pruning or harvesting served as unlimited source of seedstocks or propagules resulting to continuous vegetative growth of Gracilaria.

The technology was also able to improve the quality of Gracilaria for post harvest processing. Harvesting Gracilaria requires less effort in cleaning since the net modules are set off bottom. Small rocks, stones and other debris found at the sea substratum/floor are prevented from attaching to the Gracilaria thalli because the net modules were set in a suspended manner. With the technology, harvested Gracilaria are clean with few epiphytes thus, time spent in cleaning is much lesser compared to the wild Gracilaria that attaches its holdfast to any solid material found in the sea substratum, and exposed to small stones, rocks and other epiphytic algae.

Table 1. Production of *Gracilaria* using modified culture medium

	Units
Number of sets installed	178
Number of net modules/set	10
Total number of net modules installed	1,780
Total area planted (ha)	0.5
Gracilaria seedstocks(kg/net module)	0.7
Gracilaria seedstocks (kg/set)	7

Culture period (months)	5
Harvested Gracilaria (kg/set)	40
Total harvest/cycle (kg/0.5 ha)	7,120
Total harvest (kg/ha)	14,240

Table 2. Production of Gracilaria with STCBF (2014)

Natural Production (Produced in the wild, fresh weight)	Production from STCBF Gracilaria farming (fresh weight)	Increase
6,000 kg/ ha/year (based on 2012 survey from Gracilaria traders)	14,240 kg/ha/cycle or 28,480 kg/ha/year	22,480 kg/ha/yr

The technology allows easy handling and transporting of Gracilaria harvest. Freshly harvested Gracilaria are thoroughly washed with clean freshwater and sundried as soon as possible. They are spread thinly in a dryer to less than 10% moisture and stored in a clean cool and dry place. Transporting fresh Gracilaria is also very convenient because it does require water and aeration systems. Freshly harvested Gracilaria could be packed in clean sacks and transported either by land or sea. Much more convenient and easy to transport are the semi-dried forms because they can be packed in clean plastic bags or sacks that could be piled easily in a transport vehicle.

Development of Farmers Skills

The capacity building effort in this project is demonstrated by the enhancement of the human resource capabilities through the training of cooperators. The training activities include lectures and hands-on trainings which provided the cooperators the opportunity to learn the technology and the scheme of production for Gracilaria. The cooperators were trained on Gracilaria farming including important aspects in the biology of Gracilaria. Consultants with technical expertise on the biology and farming of Gracilaria were tapped and served as discussants providing the cooperators with relevant lectures and experiences in Gracilaria farming. Thru this activity, the cooperators, farmer leaders, and the local government representatives have acquired sufficient knowledge and information about the important economic utilization Gracilaria.

Cooperators have gained technical skills thru the hands-on training in module construction, insertion of Gracilaria thalli into the modules, and installation of modules in the project site, proper gathering of Gracilaria seed stocks for planting. The lectures and skills trainings conducted were considered enabling environment where the cooperators acquired the value of Gracilaria as a very important resource of their community including the benefits that accrue to their adoption of the technology. Before the project implementation, the community was not aware of the economic potentials of Gracilaria because they have been giving the resource to gatherers coming from the neighboring province for free to the extent of uprooting Gracilaria, a practice which can possibly destroy the natural stocks. The capacity and skills of the cooperators were the opportunities to effectively utilize the technology. Farmers' skills in farming Gracilaria using the improved technology were also facilitated which can be attributed to the project management staff (the implementers) that was able to establish trust and good working relationships with the cooperators including the local government leaders. According to Mulwa (2010), adequate staffing is an important factor in implementing community-based projects due to the need of integrating and building local management structures in order to have better prospects for effective project delivery. Thus, the knowledge and skills developed by the cooperators were results of synergistic interaction between cooperators and technical experts.

Community Participation in Promoting Gracilaria Farming Technology

Community participation is a mechanism in which local communities and outsiders come together, as participants, to achieve the objectives of community-based projects such as the STCBF on Gracilaria Production in La Union. The STBF modality was able to improve community participation and increased awareness of knowledge and capacities to improve cooperators ability to increase production of Gracilaria. Good governance of community leaders was also a factor in promoting participation and cooperation. The strong commitment and openness of community leaders supported the cooperators as evident by their active engagement with the cooperators in all activities of the project. According to Muro and Namusonge (2015), governance is good when it ensures that political, social and economic priorities of the communities who aspire for development change are considered. In this project, local governance is an important strategy providing framework to encourage participation, cooperation, and collaboration for the common good. As a result, the cooperators contributed their labor and community resources towards the achievement of the project objectives.

The capability building trainings not only provided knowledge and skills to cooperators but most importantly have raised community awareness on the economic value of Gracilaria. They have come to realize the benefits that this resource can offer to them. This has led to their active participation in Gracilaria farming. Thru the spirit of cooperation and team effort led by their farmer leaders, the farm inputs provided by the project (such as net modules, steel posts, ropes, floats) were utilized by the cooperators to produce quality Gracilaria harvest. The local government unit of Rosario also provided support in all activities during and even after the project implementation. According to Oino et al (2015), community acceptance and project ownership promote project support by all stakeholders in the project reducing community resistance in participation. Community support increases efficiency and participation increasing effectiveness as it helps to ensure that the project achieves its objectives and that benefits go to the intended groups. In this project, community empowerment allowed the fisherfolks to have access to productive resources most especially Gracilaria which enable them to increase their earnings. Community participation provided opportunities shared among the cooperators to establish new knowledge, improved understanding of the role of several stakeholders involved, and most importantly the development of appropriate technical skills necessary for the interventions in Gracilaria farming.

Gracilaria Farming as Source of Livelihood

Gracilaria culture technology is an environment friendly mariculture technology for biomass supply to the seaweed industry. The technology can use family labor thus it is a low-cost, profitable venture and a potential source of supplemental income for marginal fishermen or small fisherfolks associations. Gracilaria farming does not only provide livelihood opportunity for marginal fishermen but at the same time conserve natural stocks and protects the coastal areas from illegal fishing. Fishing pressure is minimized or decreased in the municipal waters because fishermen are engaged in Gracilaria farming that can directly help them thru seaweed trading. Livelihood trainings were conducted to enhance cooperators and other resource users on the potentials of Gracilaria farming as source of additional income for coastal communities. Thru the livelihood training, the participants did not only acquired skills in the preparation of different value-added products from Gracilaria, but at the same time provided motivation among the participants to utilize the skills learned in putting up a small business.

SOCIO-ECONOMIC ANALYSIS

Table 3 presents the cost and returns of Gracilaria farming using the modified culture media or net modules. Farming Gracilaria using the improved culture media (net modules) has a return of investment of 30% which indicates profitability. Profitability could be attributed to the increase in production of fresh Gracilaria, use of drying technology which resulted to better quality of dried Gracilaria produced. The quality of dried produced using the technology is clean and free from unwanted debris, thus the product commands a higher price. This can be possibly increased by the cooperators thru value adding of dried Gracilaria into different products that are nutritious. After the implementation of this project, the cooperators have organized and registered themselves into an association and initially engaged in small scale production of Gracilaria food products.

Table 3. Costs and Returns of Gracilaria farming technology

Particulars	Amount (Php)
Sales: 21,360 packs dried Gracilaria (100g/pack) @ Php 30.00 per pack	640,800.00
Materials	
Polyethylene (PE) nets	177,045.00
Polyethylene ropes	68,078.00
Posts (steel)	20,700.00
Floaters	16,960
Seedlings	6,230.00
Sub-Total	289,553.00
Operating Cost	
Module construction & installation	168,750.00
Fixed Cost	
MaConray solar dryer	5,000.00
Total Production Cost	491,635.30
Net Income (Sales-Total Production Cost)	149, 164.70
Return on Investment (%)	30.34

Conclusions and Recommendations

Project outcomes revealed that the organized cooperators from coastal communities have increased Gracilaria production from 6,000 kg/ha/yr to 28,480 kg/ha/yr thru the improved farming method. Production of good quality dried Gracilaria was increased thru skills and capability trainings as empowering tools that enable the community to enhance active participation and promoting gracilaria as additional source of income. The project has organized a cluster of Gracilaria producers in three coastal barangays with 31 cooperators. The technology using the modified culture medium for Gracilaria farming was successfully adopted by the coastal communities. Cooperators were capacitated through series of trainings and workshops on improved Gracilaria farming method, post-harvest handling; use and maintenance of helio-house solar dryer, and preparation of value-added products from Gracilaria. The coastal communities of Barangay Rabon, Bani & Damortis and the Local Government of Rosario, La Union have actively participated in promoting Gracilaria farming technology in the province of La Union. In conclusion, production of Gracilaria has significantly increased thru the application of science and technology intervention and community based coupled with institutional support from the academe, local government units. Likewise, the community-based STBF approach was able to recognize the resilience, capacities, skills and resources of the coastal people concerned, and build on these to promote wider adoption and commercialization of Gracilaria farming technology. Based on the conclusion derived from the project outcomes, the use of net modules as culture medium for Gracilaria farming is strongly recommended. Coastal communities must be encouraged to adopt commercialization of Gracilaria farming and sustain production of quality Gracilaria. Finally, cooperators must be encouraged to organize themselves into an association and engage in commercialization of value added products from Gracilaria.

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