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Sericulture: A productive and profitable livelihood in a rural community in Northern Philippines

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Abstract

The best sericulture technologies were tested in Calungbuyan, Balaoan, La Union, Philippines by the Don Mariano Marcos Memorial State University Sericulture Research and Development Institute (DMMMSU-SRDI) to improve the socio-economic standing of marginal farmers, provide community members with gainful employment, and satisfy domestic and international costumers' demand for silk. The project applied various production strategies, such as plot sapling production, mulberry production in the lowland rain-fed area, and synchronized and sanitized silkworm rearing. The farmer cooperator reared 50 batches of silkworms consisting of 51.10 boxes of fourth-instar larvae from 2011 to 2020, which consumed approximately 27,898 kg of fresh mulberry leaves with a total production cost of PHP 149,640.63. With an average cocoon yield of 20.85 kg per box, the total yield of fresh cocoons was 1,065.60 kg which amounted to PHP 185,178.00. An average ROI of 20.36% was achieved with a total net income of PHP 35,537.38. Along with producing cocoons, additional income from fuel wood and mulberry saplings was obtained, with a total production cost of PHP 12,160.00 and an ROI of 72.70%. Sapling production, composting of seri-wastes, and utilization of clipped mulberry stems were examples of by-product development. Composted silkworm rearing wastes and litter are used as fertilizer for mulberry plantations and media for mushroom production. Family members and community people were hired by the project for a total of 134.01 and 341.71 man-days, respectively. The revenue generated from cocoon production was used to supplement basic requirements for the family, pay the farm workers, and buy medicines. A portion of the cash was used by the farmer to purchase agricultural equipment and more breeding animals to enhance outputs even more. These SRDI best practices have been proven to raise agricultural income and production.

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Introduction

In the Philippines, sericulture was introduced in the 1990s with the creation of the Sericulture Research and Development Institute, the national center for the silk industry. It has been providing year-round income to farmers and employment to community people (Obille, 2014). It is a viable agro-based industry for rural development predominantly shaping the economy. It is a promising employment-generating industry, especially in rural and semi-urban areas (Kapoor, 2020). It requires a relatively small start-up capital suitable to the economic level of marginal farmers.

It is highly suitable, particularly in La Union, Philippines which has a favorable climate for year-round production of mulberry and cocoons as well as the presence of a wide tract of under-utilized lands and hardworking community people. Operation is continuous, thereby offering year-round employment and a source of additional income to the people. Being a labor-intensive farming activity, it employs rural men, women, and out-of-school youth (FAO, 2001).

It is a waste-free industry utilizing all by-products into saleable items and usable material for households. Aside from cocoon production, the income of some sericulture farmers was further increased from sales of by-products such as mulberry saplings, cuttings, fruits and seeds, firewood, and novelty products (Almojuela *et al.*, 2016). Sericulture by-product utilization can be of value. The high protein content of mulberry leaves, silkworm pupa, and silkworm litter can be processed into feed for fish, pigs, and cattle; timber from mulberry trees is used as furniture and tool making, and unwanted pupae are used in soap and cosmetics; eaten as a source of protein (Greenhalgh, 1986). Effective utilization of wastes generated in the industry makes sericulture more viable and stable, creates more employment opportunities, and generates attractive income for Seri-entrepreneurs.

The DMMMSU-SRDI recognized its potential for the economic well-being of the farmer-cooperators. The project was a partnership between the Institute and the farmer. The farmer provided the land, labor, and capital while the Institute extended appropriate technologies and adequate support services. The support system which includes the administrative, financial, and technical support extended to Seri-farmer through the provision of needed materials was properly observed. Demo farms, field visits, and field days were used as delivery systems (Bacnat, 2011).

Aware of these benefits and opportunities the DMMMSU-SRDI extension program was focused on developing the rural areas through the establishment of sericulture demonstration sites and sericulture enterprises, which are either individually- owned, clustered, or cooperatives. Sustainable technologies were pilot-tested in Calungbuyan, Balaoan, La Union. Generally, the purpose of this study was to showcase sericulture technologies and their potential as a source of employment and livelihood for the family and community people. Specifically, the project sought to: a) demonstrate and document the sericulture package of technologies on mulberry leaf production and silkworm rearing/cocoon production; b) assess the productivity and profitability of the sericulture demo farm; and c) assess the employment generated of the family and community people.

Materials and methods

Information Dissemination

The Institute conducted information drives in various forms (print media, audiovisuals in various forums, symposiums, and other gatherings (exhibits) to disseminate the different sericulture technologies, products, and by-products. The project was made known to the farmers through a word-of-mouth introduction by the project leader and visitation of some project sites in the locality and at the Institute. This created awareness and enthusiasm for the farmer cooperators/family members to venture into the project.

Site visitation and validation

Once they signified their intention to be involved in the project, their project sites were visited and evaluated as to their suitability for mulberry and cocoon production.

During the validation of the proposed project, there were selection criteria employed such as a) farmer's interest and dedication to the project, b) suitability of the area for sericulture, c) absence of pollution, d) availability of farm tools and machines, e) availability of water source, f) readiness of workforce, g) willingness to share supplemental funds, and h) willing to adopt the package of technologies.

Farmers Dialogue/Orientation/MOA

Orientation of farmer members was conducted on-site in an informal meeting during field visitations where they were informed on the mechanics of the project and its operations. They were presented with a draft of a Memorandum of Agreement (MOA) to review and made aware of the terms and conditions of the project. The MOA serves as the binding document of the farmer and the Institute as a basis of payment for the products sold at the Institute.

The signing of the Memorandum of Agreement

When they qualified, they forged a Memorandum of Agreement as a binding document of what to do and what ought to be done as agreed by the two parties. The roles and obligations of each party were stipulated in the agreement.

Profiling of farmer-community

This benchmark information gathered from the farmer and other beneficiaries is an important document for future use to gauge if there are impacts or improvements in their quality of living after the project implementation.

Techno-demo on Sericulture Technologies

Several technologies were demonstrated in the project site through the years of conduct of the project including technologies on Sapling Production, Mulberry Establishment and Maintenance, Silkworm Rearing, and By-Product Development). Any innovations that improved production outputs were documented and recorded.

Nursery establishment/Sapling Production

Before the mulberry establishment, the farmer was encouraged to put up a nursery to reduce the cost of investment in planting materials. The Seri-farmer adopted sapling production following the package of technology on nursery bed preparation, planting of pre-incubated cuttings, watering and fertilization, and uprooting of saplings ready for planting.

Mulberry Plantation Establishment, Leaf Production and Maintenance

Mulberry plantation was established by a farmer's workforce with some SRDI extension staff demonstrating the SOPs like land preparation, planting distance, fertilization, etc. Before to field establishment, the area was thoroughly prepared and saplings were uprooted and dipped in fungicide solution for at least 10 minutes for disease prevention. The 1.5 m x 0.5 m between rows and hills respectively. Planting was done following the row system by dibbling, and pressing the soil near the base to prevent dehydration. It was followed by light watering and repeated a week after and or as needed. Fertilization was conducted one month after planting and a second dose was applied after six months following the rate based on soil analysis. Usually, farmers were given saplings at cost as initial planting materials for planting. Mulberry Leaf Production and Maintenance. Replanting of missing hills was done one month after the mulberry establishment with the same age as mulberry saplings. Mulberry plants were maintained by employing cultural management such as weeding to avoid competition in the absorption of nutrients, pruning of mulberry trees to allow new sprouts/shoots to come out for the production of new and more vigorous leaves suitable and enough for feeding silkworms during rearing; proper amount and the right time of fertilizer application to nourish the mulberry trees; irrigation to obtain the optimum efficiency of the applied fertilizer and for the mulberry trees to grow and maintain its vigorous and robust stand. Based on the result of soil analysis, the recommended rate of fertilizers was 300kg nitrogen, 60kg phosphorus, and 60kg potassium per hectare. Supplemental irrigation/watering was applied as the need arose especially during the summer months. Mulberry leaves were ready for silkworm-rearing activity 45-50 days after pruning.

Rearing House Construction

The design and size of the rearing house were patterned on the size of the mulberry plantation however; materials were based on the capacity of the farmers, availability of local materials, and loans spared by government, and non-government institutions. To ensure the construction of an ideal rearing house, technical experts in building construction were sent out to supervise and assist construction workers.

Late Age Silkworm Rearing

After four to six months from the mulberry establishment, the First on-farm training on silkworm rearing was done. One week before the scheduled silkworm rearing the rearing house and implements were disinfected thoroughly by spraying a 3% hypochlorite solution. Farmers were relieved with young-age silkworm rearing to give them time for other farming operations. Instead, the farmer was given 4th instar larvae and continued administering plucked leaves and branched feeding at the 5th instar. Recommended time of feeding (5 AM and 10 AM, 3 PM and 7 PM) was followed with slight modifications like additional feeding at 9-10 PM. Bed cleaning was done before settling for molt, after resuming feeding, and on the third day of the fifth instar, As part of the training, three trial rearing were conducted with close monitoring and supervision of the Training Officer, Project In-charge, and Subject Matter Specialist (SMS).

By-product Production

The main product of the enterprise is good quality cocoons for the production of raw silk for silk fabrics. During the conduct of activities in each production system, wastes generated were further processed into new products and by-products thathave useable values, Among these were: a) Cutting/sapling production – after each pruning schedule, mature cuttings for sapling production were selected, cut, and planted in nursery beds, cared for until maturity; b) Composting from silkworm wastes. Wastes generated after silkworm rearing were segregated removing dead worms then leaf leftovers and wastes were composted naturally at one side of the farm until ready for use; c) Unusable/leaf scraps as feed to animals. Just after rearing, unused leaves usually the leaf leaf-over were gathered to feed livestock; and d) pruned branches/twigs - after pruning stems not suited for sapling production were gathered and dried and used as firewood.

Technical Support Services

To equip the farmers' workers on the rigors of sericulture, the entrepreneurs sent staff for training on sapling production, mulberry production, and silkworm cocoon production and were instructed to train fellow workers who were not trained. That way, sharing what theyhad learned with others improved their knowledge and skills and farm performance. Some farmer cooperators, family members, and relatives were trained on product development as novelty items making Fruit processing and compost making were also demonstrated. To augment the lectures and demonstrations, techno-guides and flyers were distributed during training and field visitations. This included Mulberry Sapling Production, Mulberry Productions and Maintenance, and Silkworm Rearing. Upon request of the farmer, technical experts were sent to the project site to provide consultations and or assist in the implementation of the project in the field of mulberry and silkworm rearing, farming systems, and pest management. Technology Need Assessment was done every time there was a visit so that technologies being done in the area fit climatic conditions, resources of the farmer, and its goals in farming. Unique to the area was the use of organic farming practices in sericulture.

Provision of Material Support

Construction materials were availed through soft loans or grants from government agencies like the Department of Science and Technology (DOST), Senator Loren Legarda Fund, and PhilFIDA. The sole source of eggs was SRDI, in case of shortage; silkworm eggs from PTRI were sourced. For young age, silkworm eggs were incubated and reared at the 4^{th} instar larvae production and distribution unit.

As soon as 4th instar larvae were developed, they would be transported to farmer fields for late-age rearing untilharvesting. Fertilizers were provided at cost so bedding cleaning nets, and plastic mountages for mounting. The Institute formulated silkworm disinfectant and supplied the same to the farmer during silkworm rearing to prevent the occurrence of diseases.

Provision of marketing assistance and filature services

Cocoons produced on the farm were marketed at SRDI. This was priced according to weight and quality and paid through check one to two weeks upon delivery.

Monitoring and Evaluation

Monitoring and evaluation were carried out during field visitations. Monitoring is an integral component of project implementation. Quarterly monitoring and evaluation was conducted by the University Extension Office while monthly monitoring was done by the Institute to check the progress of project implementation and provide solutions to the problems as they arise. After each monitoring and evaluation, an exit conference was scheduled to discuss the results of the monitoring and evaluation. Productivity and income records of the farmers were documented across years and assessed whether there were improvements with the introduction of sericulture in the system and the introduction, transfer, and utilization of improved technologies complemented by the needed support systems. Crop yield income and inputs utilized with management intervention to mention the assistance extended were measured, accordingly. Generated employment records of the farmers were recorded across years and assessed whether there were improvements in employment created (man-days) for the family and the community people.

Data Gathering Procedures

Photo and process documentation were employed to document the project's activities and progress was regularly reported at the office. Travel and progress reports were always prepared and submitted to monitor and evaluate the projects. A desk review was undertaken by the extension worker/researcher for the collection of background literature, annual and monthly accomplishment reports, and other pertinent data and documents.

Records of inputs and outputs were maintained at the project site where a log book or record book was provided for the farmer to record all activities. Production records were maintained by the project in charge for use during analysis. Productivity measures included yields of mulberry leaves, cocoons, and by-products produced in the area while profitability measures include analysis of cost and returns using indicators such as net income and return on investment. Labor productivity includes the estimation of generated man-days and its corresponding value based on the current value of wages in each year.

Results and discussion

Farmer's Profile and Engagement

Description of the Farmer and Farm

Mr. Roberto H. Ancheta of Calungbuyan, Balaoan, La Union, is a 70-year-old, college graduate, and a retired bank employee. He is married to Mrs. Melinda N. Ancheta and they are blessed with two children. The family is religious (Iglesia Ni Cristo) and friendly and they are industrious andhardworking. He practiced multiple cropping systems and crop-animal integration. The Ancheta's Sericulture Project is located in Purok 1, Calungbuyan, Balaoan, La Union. It is a 3.14 hectares lowland rain-fed area. Along the creek and at the foot of the hill were planted with mulberry, the low-lying lots were devoted to the rice-corn-vegetables cropping system, some upland portions were planted with fruit trees along the peripheries and livestock production were set near the house and others as free ranged. The creek traversing the barangay was the source of water during the summer months. The Ancheta's farm was subdivided into five major crops: along the creek and at the foot of the hill was planted with mulberry (about 0.25ha), the low-lying lots (2.54ha) were devoted to the rice-corn cropping system, some upland portions were utilized for vegetable production (0.35ha) with fruit trees planted along the peripheries, the mushroom was cultured under the trees and livestock production were set near the house and others as free ranged.

Farmer's Adoption of Sericulture Technologies

Nursery Establishment/Sapling Production

The farmer produced his planting materials (saplings) by requesting incubated cuttings from the Institute. In June 2010, about 5,000 cuttings were provided and on-site sapling production technology was demonstrated. The activities on sapling production were followed by the farmer such as nursery bed preparation, planting of pre-incubated cuttings, watering and fertilization, and uprooting of saplings ready for planting (Fig. 1). To prevent weeds from growing, mulching the mulberry plants was done with either rice hay, rice hull, dried banana leaves, or dried leaves of trees just after planting (Fig. 2). This also conserved soil moisture for plant use. (Dacayanan *et al.*, 1996). Fungicide application, incubation, and soil sterilization were not adopted by the farmer. This implies that since the farmer knows more about his farm environment, he may find some of the components of sericulture technologies to be incompatible and disadvantageous to his farming practices. This finding supports Bonifacio (1994) when he found out that many technologies were not adopted by the farmers because of the inappropriateness of the technology to farmers' conditions. Contrary to Obille *et al.* (2002), the result showed the adoption of farmers' sericulture technology for sapling production was always adopted.

Fig. 1. Planting of pre-incubated cuttings.

Fig. 2. Mulching of planted pre incubated cuttings.

Fig. 3. Silkworm Rearing House.

Fig. 4. Feeding of fifth instar silkworm larvae.

Fig. 5. Cocoon harvest.

Mulberry Plantation Establishment

Before field establishment, the area was thoroughly prepared. Saplings were uprooted and dipped in fungicide solution for 10 minutes for disease prevention. The 1.5m x 0.5m plant distancing was followed between rows and hills, respectively. Planting was done following the row system by dibbling. In November 2010, a total of 3,333 mulberries were planted with the assistance of the SRDI technical team. The varieties planted were Batac, S54, and Alfonso along the dikes and periphery of his farm and in vacant lots of rain-fed lowland in his area. Replanting of missing hills was done one month after with the same age of mulberry planted. Watered the plants immediately after transplanting and repeated a week after or every 10 days and or as the need arises to prevent dehydration. To boost the growth of mulberry plants, fertilization was done one month after transplanting. The amount of fertilizer applied was based on the recommended rate of soil analysis which is 300kg of nitrogen, 60kg of phosphorous, and 60kg of potassium. The second dose was applied six months after transplanting or after the first leaf harvest. Six months after transplanting initial rearing was conducted.

In developing countries like the Philippines, the environmental condition is ideally suited for mulberry leaf production as the sole source of food for silkworms (*Bombyx mori* L.) for cocoon production (Jolly, 1987). Bagtang (2021) stated to start rearing, at least ¼ hectare of land area and a 16-square meter rearing house to feed ½ box of silkworm eggs are needed. During the training, the farmers even came up with the idea that those who have ¼ hectare of land or with larger landholding can grow mulberry trees and sell the leaves to those who want to rear silkworms but cannot provide the land requirement.

Mulberry Cultivation and Maintenance

In the second year of establishment, mulberry plants were maintained by employing cultural management such as weeding to avoid competition in the absorption of nutrients, pruning of mulberry trees to allow new sprouts/shoots to come out for the production of new and more vigorous leaves suitable and enough for feeding silkworm during rearing; proper amount and the right time of fertilizer application to nourish the mulberry trees; irrigation to obtain the optimum efficiency of the applied fertilizer and for the mulberry trees to grow and maintain its vigorous and robust stand. Supplemental irrigation/watering was applied as the need arose. Mulberry leaves were ready for silkworm-rearing activity 45-50 days after pruning. The maximization of quality mulberry leaf yield per unit area determines the productivity and profitability of sericulture. This could be achieved through various agronomic practices like irrigation, fertilizer application, and inter-cultivation (Jolly, 1987). Two methods of irrigation were used such as sprinkle and furrow (Supsup & Dacayanan, 1996).

Construction of Rearing House and Implements

While waiting for the mulberry plants to produce enough leaves for silkworm-rearing activity, the rearing house was constructed. A low-cost type of rearing house was adopted by the farmer. In 2010, a rearing house was made of indigenous materials (low-cost materials) like bamboo (Fig. 3). The flooring was filled with coarse sand and the sidings were covered with *sawali* and plastic mesh. In 2012, expansion of the rearing house was done to accommodate more silkworms to the rear. Another rearing house expansion was made in 2014, the farmer availed rearing materials through a soft loan from SRDI. At the end of the second quarter of 2018, he constructed a new rearing house to replace the damaged one caused by the typhoon. He availed financial assistance in terms of a soft loan the from Department of Science and Technology (DOST) amounting to 40,000.00 pesos to finance the establishment of a new rearing house whichhas a floor area of fifty-six square meters (56 m^2). The rearing house was made up of wood enclosed with *sawali* and nets, the flooring was cemented and he used galvanized iron (G.I.) sheets as roofing. Financial support and technical assistance were provided to the Seri farmer. This finding contradicts the study conducted by Gowda (1993), as cited by Almojuela (2018) who indicated that lack of rearing house was one of the constraints in the adoption of recommended technologies. Other constraints found for the non-adoption of recommended practices were lack of finance and awareness. This finding negates the finding of Afshan (1992) that the low adoption of silkworm rearing is attributed to the inadequate resources to build up rearing houses.

Disinfection of Rearing House and Implements

Before silkworm rearing, the farmer cleaned and disinfected the rearing house and rearing paraphernalia. All rearing facilities were put in for easy mobilization in the workplace. The farmer carried out late-age silkworm rearing operations like feeding at the proper time (four times and additional feeding at night, 9-10 PM), proper bed spacing, bed cleaning and waste removal, and silkworm disinfection. Waste removal and disposal were properly done as well as good sanitation and cleanliness in the workplace. Silkworm rearing of the farmer commenced in May 2011. On the first to third trial rearing, the silkworm-rearing activities were monitored and supervised by the project in charge, the training and documentation team, and the silkworm-rearing experts. The recommended technologies for rearing grown silkworms are disinfection of rearing house and implements, harvesting of mulberry leaves, storage/preservation of mulberry leaves, feeding of silkworm larvae, bed spreading/spacing, molting, bed cleaning, pest prevention control, spinning/mounting, harvesting, sorting of cocoons were adopted by the farmer. This supports the finding of Obille *et al.* (2002) that the adoption of the farmer to silkworm rearing for cocoon production was all adopted. Their finding showed that the farmers are knowledgeable enough about this technology. It also assumed that introduced silkworm-rearing practices were adopted and suited to the farmers' specific skills and capabilities.

Delivery of Silkworms

The farmer secured silkworm larvae from the Institute on specific dates/schedules. The worms were usually delivered at fourth-instar second day early morning using a delivery vehicle. The worms were transferred in a rearing rack lined with blue nets prepared by the farmer before the delivery. Likewise, the farmer already harvested leaves to feed the worms immediately.

Late-age Silkworm Rearing/Cocoon Production

At the fourth instar stage, the worms were fed four times a day at 5:00 AM, 10:00 AM, 3:00 PM, and 8:00 PM (Fig. 4). More leaves were given in the evening as the worms were nocturnal. At molt, feeding was stopped, dusted the worms with rice hull or pure lime, and waited until all wormshad molted. After molting, the worms were dusted with worm disinfectant and then transferred into another clean tray or rearing bed.

At the fifth instar, the worms were spaced further and fed with mulberry leaves in branches. The branches with leaves were alternately placed over the worms. When branches were piled up bed cleaning was done. Diseased worms were regularly monitored before feeding, removed from the bed, and discarded properly. Proper waste disposal is very important. Before disposing of the waste collect all dead and sick worms from the bedding and bury them in a pit. Collect all silkworm-rearing waste and put it in vacant spaces on the farm.

Six to seven days the worms were expected to spin their silk. Pick the matured worms and mount them to a rotary frame and plastic mountages that are placed in the rearing trays. The worms spun their silk strands after three days and then harvested cocoons on the sixth day.

The cocoons were sorted by separating the good and bad (reject) cocoons. Good cocoons were characterized as thick, and firm with no stains inside and outside the cocoon shell while unreelable cocoons were soft, malformed, double cocoons, and stained cocoons. Reject cocoons were soft or flimsy and inside stained. Good cocoons command a high price of 350.00 pesos while unreelable cocoons have a price of 60.00 pesos per kilogram.

Productivity of the Project

The productivity of the Calungbuyan Sericulture Project is summarized in Table 1. For 10 years of operation, the farmer cooperator conducted 50 batches of silkworm rearing. The total volume of silkworms reared was 51.10 boxes of fourth-instar silkworm larvae which consumed approximately 27,898 kg of fresh mulberry leaves. The farmer cooperator produced a total cocoon yield of 1,065.60 kg with an average cocoon yield per box of 20.85 kg slightly surpassing the standard yield of 20.0 kg box^{-1}. The project created employment for the family and community people with 134.01 man-days and 341.71 man-days, respectively.

Table 1. Productivity of Calungbuyan Sericulture Project (2011-2020).

Year/ Particulars	No. of Rearing	No. of boxes	Leaf Production/ Consumption (kg)	Cocoon Yield (kg)	Average Cocoon Yield (kg)
2011	4	3.0	1,658	61.0	20.33
2012	5	5.25	2,911	156.0	29.71
2013	4	5.25	2,835	124.85	23.78
2014	6	1.0	5,400	254.10	25.41
2015	8	6.35	3,429	145.60	22.93
2016	6	8.0	4,396	111.90	13.99
2017	7	6.5	3,624	85.65	13.18
2018	2	2.0	1,080	32.15	16.09
2019	5	4.0	2,160	74.75	18.69
2020	3	0.75	405	19.60	26.13
Total	50	51.10	27,898	1,065.60	
Average	5	5.11	2,789.8	106.56	20.85

For the first year of operation, the project conducted four batches of silkworm rearing and increased in the second year onwards. In 2015, the project had the highest number of rearing conducted with eight batches, and the lowest was two rearing in 2018. The average number of rearing conducted was five batches. The farmer cooperator slowed down his silkworm rearing/cocoon production activity due to his health condition (kidney failure). Consequently, on the third quarter of 2018, his health continued to deteriorate.

During the conduct of the first three trial rearing, the project reared three-way and four-way silkworm hybrids such as DMMMSU 346 & DMMMSU 406. However, it was observed that cocoon production was very low. Temporarily, the farmer-cooperator and the project in charge agreed upon that they requested silkworm larvae from the Philippine Textile Research Institute (PTRI) based at La Trinidad, Benguet. For three rearing from December 2011 to May 2012, the project ordered silkworm larvae from PTRI. However, in the third quarter of 2012, the project resumed rearing of DMMMSU silkworm hybrids until the third quarter of 2016. In 2016, it was observed that the cocoon production of DMMMSU silkworm hybrids deteriorated due to disease infection. To break the infestation of diseases, the farmer-cooperator again ordered silkworm larvae from PTRI from November 2016 to May 2017. Afterward, the project continued to rear DMMMSU silkworm hybrids.

For the first year of operation, the farmer cooperator reared two boxes of fourth-instar DMMMSU silkworm hybrids and one box of third-instar silkworms from PTRI. In the year 2014, had the highest volume reared with 10 boxes of silkworm larvae, while the lowest was three-fourth (0.75) box in 2020. The average volume of silkworms reared was 5.11 boxes in year 1.

The mulberry plantation produced enough mulberry leaves to feed the three boxes of silkworm larvae. For the first year of operation, the project harvested 1,658 kg of mulberry leaves which fed to the three boxes of silkworm larvae. The highest mulberry leaf consumption was recorded in 2014 with 5,400kg that fed 10 boxes of silkworm larvae. The lowest mulberry consumption was documented in 2020 with 405 ofkg mulberry leaves consumed by three-fourths of box silkworms. The average mulberry leaf consumption was 2,789.8 kg year^{-1}.

Mulberry is the sole food plant for the silkworm, *B. mori,* and hence its cultivation is an essential part of sericulture. For the development of the silk industry, the production of quality silkworm cocoons is a must. To achieve the production goal of good quality silkworm cocoon crop, certain factors play an important role, mulberry leaf (38.2%), climate (37.0%), rearing techniques (9.3%), silkworm race (4.2%), silkworm egg (3.1%) and other factors (8.2%) in producing good quality cocoons (Boraiah, 1986). Hence mulberry leaf quality, as well as quantity, is one of the basic prerequisites of sericulture and plays an essential role in successful silkworm cocoon crops (Singh *et al.*, 2018). Sericulture depends on the rearing of silkworms on mulberry leaves for this reason, silk production has a direct relationship with larval growth on mulberry. Leaves of superior quality enhance the chances of a good cocoon crop (Ravikumar, 1988). It has been established that cocoon quality contributes about 80% of the raw silk quality which is reflected by the mulberry leaves fed to the silkworm (Boraiah, 1986). Casagan, 2020 added that if the mulberry leaves that will be fed to the silkworms are of good quality, then they will also produce a good-quality cocoon. The mulberry plant is very important in producing cocoons. She added that about 1.2 to 1.5 kilometers of silk can be extracted from one cocoon regardless of size.

From the first year of operation, the farmer cooperator produced 61.0kg of fresh cocoons. From 2011, cocoon yield tremendously increased from 61kg to 254.10kg in 2014 which was recorded as the highest cocoon yield. Aside from an increase in cocoon production, a better quality of cocoons was produced. Additional feeding at night, ad libitum feeding and feeding systems such as leaf plucking and branch feeding mighthave improved the production. However, the lowest cocoon production was documented in 2020 with 19.60kg. Overall, the average cocoon yield per year was 106.56kg (Fig. 5).

In 2012, the highest cocoon yield per box was 29.71kg, while the lowest was 13.18kg for the year 2017. Low cocoon production might be caused by the occurrence of diseases such as grasserie and flacherie after the fourth molting stage and before the spinning stage. Thorough disinfection of rearing house and rearing implements was undertaken, practiced sanitized rearing and application of bed disinfectant before resuming feeding and before bed cleaning.

Profitability of the Project

The project had total gross sales of PHP 185,178.00, a total production cost of PHP 149,640.63 a total net income of PHP 35,537.38, and an average ROI of 20.36% (Table 2).

The project's income was found to be negative (-PHP 5,538.76) from cocoon production in 2011. It was observed that during the first year of operation, sales from cocoons were still low enough to cover the expenses during the mulberry establishment and maintenance however, it tremendously increased in the second year of operation onwards. The highest sales were obtained in 2014 with PHP 40,656.00. Since then, sales of cocoons gradually decreased due to the decreasing volume of silkworms reared by the farmer cooperator. The lowest cocoon sales were recorded in 2018 with PHP 6,430.00.

Table 2. Profitability of the Project (2011-2020).

Year/ Particulars	Cocoon Sales (PHP)	Production Cost (PHP)	Net Income (PHP)	ROI (%)
2011	8,540.00	14,078.76	(5,538.76)	(39.34)
2012	24,960.00	14,486.32	10,473.68	72.30
2013	19,976.00	15,111.70	4,864.30	32.19
2014	40,656.00	27,086.76	13,569.24	50.10
2015	23,296.00	16,482.95	6,813.05	41.33
2016	22,380.00	21,380.76	999.24	4.67
2017	17,130.00	16,401.07	728.93	4.44
2018	6,430.00	7,657.07	(1,227.07)	(16.02)
2019	14,950.00	11,332.07	3,617.93	31.93
2020	6,860.00	5,623.63	1,236.80	21.99
Total	185,178.00	149,640.63	38,537.38	203.59
Average	18,517.80	14,964.06	3,553.74	20.36

*_/Price of cocoons per kilogram-₱140.00 (2011) **_/Price of cocoons increased to ₱160.00/kg (2012)

***_/Price of cocoons increased to ₱200.00/kg (2016)

****_/Price of cocoons increased to ₱350.00/kg (2020)

Production cost consists of the cost of material inputs such as fertilizer, silkworm larvae, newspaper, laundry soap, chlorox, and bed disinfectant.

Labor costs in preparation for silkworm rearing such as cleaning and disinfection of rearing house and implements, and various silkworm rearing activities like harvesting of leaves, feeding of silkworm larvae, bed cleaning, picking and mounting of matured silkworm larvae, and harvesting of cocoons. And depreciation cost of rearing house and other rearing implements. The highest production cost was incurred in 2014 with PHP 27,086.76 and the lowest was in 2020 with PHP 5,623.19. The average production cost in year 1 was PHP 14,964.06. The farmer had the highest net income of PHP 13,569.24 in 2014, while the lowest (positive) in 2017 with PHP 728.93. This implied that sericulture farming provided additional income to the farmer and livelihood for community/rural people. During the first year of operation, it was observed that the net income was negative. Likewise, a negative net income was obtained in 2018 due to a lesser volume of silkworm reared as well as low cocoon yield. During the first year of operation, it was recorded that the return on investment (ROI) was negative at 39.34%. However, in the second year onwards ROI was already positive. The highest ROI of 50.10% was observed in 2014 and the lowest was documented in 2018 a negative ROI of 16.03%. With this fig., the farmer did not lose hope, he promised to continue the project because according to him sericulture is a high-value crop that has a fast return on income. According to Philippine Fiber and Development Authority (PhilFIDA), sericulture is a labor-intensive than other livelihood activities such as vegetable production, with a shorter period on the return of investment. The ROI in the sericulture for the first year may break even in the second year (19%) and in the third year onwards (64%). But such gain is only on cocoon production. However, if processed to silk there is added income (www.sunstar.com.ph).

By-Product Utilization and Commercialization (2011-2020)

The project has total gross sales of by-products amounting to PHP 21,000.00, a total production cost of PHP 12,160.00, a total net income of PHP 8,840.00, and an ROI of 72.70% (Table 3). The project started producing saplings in 2012 with 2000 pieces, another 2,000 pieces in 2013, and 400 and 200 pieces in 2014 and 2015, respectively for a total production of 4,600 saplings. The saplings were valued at PHP 1.0 each in 2012 and 2013 and PHP 2.50 in 2014 and 2015. The project has total sales of PHP 5,500.00, a net income of PHP 2,640.00, and an ROI of 92.31%.

Table 3. Production of Sericulture By-products CY 2011-2020.

Particular	Production	Unit	Unit Price (PHP)	Gross Sales (PHP)	Production Cost (PHP)	Net Income (PHP)	ROI (%)
Saplings							
2012	2,000	pc	1.00	2,000.00	1,040.00	960.00	92.31
2013	2,000	pc	1.00	2,000.00	1,060.00	940.00	88.68
2014	400	pc	2.50	1,000.00	510.00	490.00	96.08
2015	200	pc	2.50	500.00	250.00	250.00	100.00
Total	4,600			5,500.00	2,860.00	2,640.00	92.31
Firewood							
2012	75	bundle	10.00	750.00	450.00	300.00	66.67
2013	100	bundle	15.00	1,500.00	900.00	600.00	66.67
2014	150	bundle	20.00	3,000.00	1,800.00	1,200.00	66.67
2015	160	bundle	25.00	4,000.00	2,400.00	1,600.00	66.67
2016	200	bundle	25.00	5,000.00	3,000.00	2,000.00	66.67
2018	50	bundle	25.00	1,250.00	750.00	500.00	108.33
Total	735			15,500.00	9,300.00	6,200.00	66.67
Grand Total				21,000.00	12,160.00	8,840.00	
Average ROI (%)							72.70

In 2012 the project gathered 75 bundles of firewood valued at PHP 10.00 bundle^{-1}. 100 bundles in 2013 valued at PHP 15.00 bundle^{-1}, 150 bundles in 2014 valued at PHP 20.00 bundle^{-1}, 160 bundles (2015), 200 bundles (2016), and 50 bundles (2018) valued at PHP 25.00 bundle^{-1}, accordingly. It has a total sales amounted to PHP 15,500.00, with a net income of PHP 9,300.00 and an ROI of 66.67%.

Employment Generated by the Project (CY 2011-2020)

Sericulture being a labor-intensive industry offered employment to family members and rural people. The generated employment of the Calungbuyan sericulture project is shown in Table 4. The project created employment during mulberry establishment and maintenance and silkworm rearing for the family and the community people. For 10 years of operation, the family generated employment of 134.01 man-days. Likewise, the community/rural people rendered 341.71 man-days. The highest employment generated was recorded in 2014 with 92.20 man-days while the lowest was observed in 2020 with 6.53 man-days.

The sericulture project was family-managed and an additional labor force served as their part-time occupation with significant contribution to increasing farm output and maximizing the use of farm resources.

Table 4. Employment Generated of Calungbuyan Sericulture Project (2011-2020).

Year	Employment Generated (man-days)	
	Family	Community People
2011	8.9	31.4
2012	12.13	35.5
2013	11.78	39.65
2014	32.60	59.6
2015	14.35	45.23
2016	20.6	56.6
2017	19.0	39.65
2018	6.5	10.9
2019	6.4	18.4
2020	1.75	4.78
Total	134.01	341.71
Average	13.04	34.17

Conclusions

Mulberry farming maximizes the use of marginal lands as a productive endeavor. Sapling production, mulberry leaf production, silkworm rearing/cocoon production, and by-product utilization were adopted by the sericulture farmer. Sericulture business venture was a profitable livelihood thus, providing additional income for the family members and rural people. The revenue generated from cocoon production was used to augment basic family needs and wages of farm operations and maintain the health of the farmer cooperator by purchasing maintenance medicines and dialysis costs. A portion of the cash was used by the farmer to buy agricultural equipment and more breeding animals to enhance outputs even more. These SRDI best practices have been proven to raise agricultural income and production.

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Conflict of interest statement

The authors declare that there is no conflict of interest during the conduct of the project.

References

Afshan AI. 1992. Adoption of Improved Practices in Sericulture Extension. Department of Agriculture. Bangalore University, Karnataka, India.

Almojuela CM, Apilado LP, Madrid EH. 2016. Higher Productivity and Profit through the Utilization of Best Sericulture Technologies. An Agency-funded Research. DMMMSU-SRDI, Bacnotan, La Union. Presented to Commodity Review on Sericulture.

Almojuela CM. 2018. Case Study of Seri-Entrepreneurs in La Union. Unpublished MS Thesis, DMMMSU-NLUC, College of Graduate Studies, Bacnotan, La Union.

Bacnat MTL. 2011. Evaluation of the 2005-2008 Farmers-Led Extension Program in Ilocos Norte. Unpublished Master's Thesis, Mariano Marcos State University, Batac, Ilocos Norte.

Bagtang ET. 2021. Philippine Silk Production Gets Stronger in the North. Retrieved August 18, 2022, from https://ptri.dost.gov.ph/fabulous-at-50/9-transparency-seal/322-philippine-silk-production-gets-stronger-in-the-north.

Bonifacio M. 1994. Images of Agricultural Problems. Issues and Trends in Technology Transfer, PCARRD.

Boraiah G. 1986. Lectures on Sericulture. Suramya Publishers. Bangalore, India p. 98.

Cagasan E. 2020. Iloilo town shows potential for mulberry, silk production. Retrieved March 8, 2022, from https://www.pna.gov.ph/articles/1094289.

Dacayanan GP, Galiste JR, Libunao VM. 1996. Effects of Different Mulching Materials on the Leaf Yield of Mulberry under Rainfed Condition. Technical Report. DMMMSU-SRDI, Bacnotan, La Union.

Fiber Industry Development Authority (FIDA). 2002. The Philippine Silk Industry Profile. Fiber Industry Development Authority. ASIATRUST Bank, Annex Building, Quezon City, Philippines.

Food and Agriculture Organization. 2001. Current Uses of Mulberry. Food and Agriculture Organization. Retrieved July 15, 2017 from http://www.fao.org.

Greenhalgh P. 1986. The World Market for Silk. Report of the Tropical Development and Research Institute, London. College House, Wright's Lane.

Jolly MS. 1987. Appropriate Sericulture Techniques. International Center for Training and Research in Tropical Sericulture. Central Sericultural Research and Training Institute, Mysore, India.

Kapoor B. 2020. Sericulture as a Profit-Based Industry-A Review. Retrieved August 10, 2022 from https://www.researchgate.net/publication/344426430_Sericulture_as_a_Profit-Based_Industry-A_Review.

Obille PS. 2002. Factors Affecting the Level of Adoption, Productivity, and Income of SRDI-Assisted Sericulture Farmers. Agency-funded Research. DMMMSU-SRDI, Bacnotan, La Union. Paper Presented in Commodity Review.

Obille PS. 2014. Implementation of the Extension Programs of Sericulture Research and Development Institute. Dissertation in Doctor of Philosophy (Rural Development). Benguet State University, La Trinidad, Benguet, Philippines.

Singh M, Singh RK, Sao S. 2017. Comparative studies of Silk Worm species in Ambikapur District Surguja (C.G.). International Journal of Development Research **7(7),** 13642-13649.

Singh RK, Yadav P. 2017. Comparative study of two Silkworm species in Ambikapur, Surguja District, Chhattisgarh for Quality Cocoon Yield. World Journal of Pharmaceutical Research **7(11),** 1446-1455.