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Establishment of seed cocoon area in Pugo, La Union, Philippines: A strategy for a viable sericulture industry

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Abstract

Sericulture is a promising business with multi-disciplinary programs that grow sustainably and give farmers a source of income. It involves mulberry cultivation, silkworm rearing for cocoon production, and raw silk production. The Philippine Sericulture industry has great expansion potential, particularly cocoon production. Seed cocoon production is vital in sericulture as it provides quality silkworm eggs for commercial purposes. The Pugo Sericulture Project was selected by the DMMMSU-Sericulture Research and Development Institute as a seed cocoon area. The project's goal is to showcase the effectiveness of the Pugo Sericulture Project to demonstrate a package of technologies on mulberry leaf production, silkworm rearing management, and seed cocoon production; adopt and implement the best practices in producing seed cocoons; and evaluate the productivity and profitability of seed cocoon production. Silkworm purelines (DMMMSU 100, DMMMSU 101 & DMMMSU 102) and F_1 hybrids (DMMMSU 201, DMMMSU 215, DMMMSU 216, DMMMSU 209 & DMMMSU 226) were reared and tested based on qualitative characters such as effective rearing rate, single cocoon weight, shell percentage, pupation rate, and hatching percentage; and quantitative characters like cocoon yield, number of cocoons per kilogram, filament length, fecundity, and the number of silkworm eggs per gram. Based on an eight-year rearing period, the farmer-cooperator produced a total of 327.35 kg of seed cocoons from 13.5 boxes of parental silkworm larvae reared, earning Php 49,489.00, with a net income of Php 5,552.47 and an average return on investment of 13.98%.

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Introduction

Sericulture is one of the ideal sectors for employment and income generation with various entrepreneurial opportunities starting from mulberry cultivation, silkworm rearing and cocoon production, silkworm seed or egg production, reeling, weaving, etc. The sericulture industry depends on the production of quality as well as quantity of silkworm seed produced from parental silkworm eggs.

Silkworm seed cocoon is referred to as the backbone of the sericulture industry. A sufficient and timely supply of quality seed cocoons defines the production of quality silk. As the quality of seed cocoons is one of the important factors in commercial egg production, parental cocoons should conform to qualitative standards like uniformity in size, shape, and color as per the characteristics of the particular silkworm breed. Effective rearing rate (ERR), and yield for 100 diseased free layings (dfls) must be high, the number of cocoons/kg should be 575-650 for bivoltine breeds and 1,000-1,100 for multivoltines. Pupation rate should be 85-90% (Rahmathulla, 2012). Silkworm eggs are very vital materials to produce silk. Good quality silkworm seed has to be free from diseases can produce more good eggs that hatch uniformly, and assure a stable cocoon. Seed cocoon forms the basic raw materials for the preparation of commercial seed cocoons, thus, superior character, vigor, and disease resistance are among the criteria in selecting quality seed cocoons crop (Narasimhanna, 1988).

At the DMMMSU-Sericulture Research and Development Institute, seed cocoons of bivoltine races are produced and maintained all throughout the year. These silkworm seeds serve as the sources of silkworm eggs for breeding and hybridization purposes to produce commercial silkworm hybrid eggs. These silkworm hybrids, in turn, are being distributed to various sericulture farmers or cocoon producers.

In recent years, however, a shortage of seed cocoons was experienced at the Institute. This prompted the need to evaluate and validate potential areas for seed cocoon production. The Training and Technical Services Division (TTSD) as the extension arm of the institute spearheaded the endeavor and intensified its implementation of the various extension modalities towards promoting sericulture in the province, particularly for the purpose of silkworm seed production.

Farmers having idle lands have been the target of the DMMMSU - SRDI to engage in sericulture activity. One must have at least ¼ hectare of land for a mulberry plantation area (to cater to at least 3,333 mulberry plants that can cater to three to four rearings per year). Meeting all these requirements, the Pugo Sericulture Project emerged as the first seed cocoon area of DMMMSU-SRDI. The evident willingness and commitment of the farmer also accounted for the sustainability of the project.

The project aimed to demonstrate and document the SRDI package of technologies on mulberry leaf production and silkworm rearing for seed cocoon production; adopt and implement appropriate technologies for quality seed cocoon production; and evaluate the productivity and profitability of sericulture seed cocoon production.

Materials and methods

The project was implemented by employing various technologies in mulberry production, silkworm rearing and cocoon production through effective extension strategies and interventions.

Pre-implementation phase

Orientation seminar

Prior to project implementation, farmer cooperators attended an orientation seminar to inform them of the Institute programs on sericulture and provide them with an overview of the different practices of general sericulture and other activities. As part of the orientation, the farmers were toured around the institute facilities and observed the different activities. The Farmer's profile was also documented based on his capacity to engage in sericulture and adopt various technologies.

The farmer/technology adopter

Mr. Geribert R. Garcia was considered by DMMMSU-SRDI as sericulture technology adopter due to his training on Four (4) months Diploma Course in Sericulture under the Department of Agrarian Reform Development Project (DARDP), a tie-up project of SRDI and DAR-funded by Dutch Government and served as technical staff of sericulture projects in La Union, specifically at Inabaan Norte, Rosario, La Union.

Area validation

After the orientation and with the farmer's eagerness to engage in sericulture, the project site was visited and evaluated as to its suitability for mulberry and cocoon production.

Soil samples were collected and submitted to SRDI's Soils Laboratory for analysis to determine the soil's physical characteristics like density and porosity. Soil analysis showed that the Pugo project's proposed mulberry plantation has a soil pH of 6.1, with a moisture content of 11.63% and organic matter of 1.05, categorized as heavy sandy loam which indicates that mulberry plants can thrive very well.

Partnership

After validation, a Memorandum of Agreement was forged between the farmer and DMMMSU-SRDI. The roles and obligations of each party were stipulated in the agreement.

Training

The DMMMSU-SRDI-Training Unit conducted and facilitated on-site trainings on mulberry sapling production, silkworm rearing, and seed cocoon production to equip the farmer-cooperator including his family members with the basic knowledge and skills. IEC materials such as techno-guides and flyers were provided to supplement the lectures and demos.

Technical support services

The construction materials for the rearing house were provided by farmer/technology adopter. On the other hand, farm inputs (fertilizers) and rearing materials (rearing trays, cocooning frames, bedding and cleaning nets, disinfectants and plastic mountages for cocoon spinning were provided by DMMMSU-SRDI .

DMMMSU-SRDI also provided silkworm eggs and larvae for silkworm rearing. The silkworm eggs were incubated by the Silkworm Egg Production and Distribution Unit, and then reared by the Fourth Instar Larvae Production and Distribution Unit from 1st to 3rd instar. At 3rd instar-2nd day, larvae were transported to the farmer's site for further rearing until cocoon harvesting.

In February 2009, the 3m x 6 m rearing house was constructed beside the farmer's house, away from the mulberry plantation. The rearing house could accommodate a minimum of 0.25 box of silkworm larvae.

Project establishment, implementation, and adoption of sericulture technologies

Mulberry plantation establishment, maintenance and leaf production

The mulberry area was thoroughly prepared. Following the standard procedures in mulberry cultivation, saplings from the SRDI sapling production area were dipped in fungicide solution for at least 10 minutes for disease prevention. The planting distance of 1.0 m x 0.5 m between rows and hills was employed. 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 the need arose.

Fertilization of inorganic fertilizer was conducted five (5) times after transplanting, 3-4 weeks after pruning, after 2nd leaf harvest, 3rd leaf harvest, after 4th leaf harvest, and after 5th leaf harvest. The application of composted silkworm waste as organic fertilizer was also done once a year. Both organic and inorganic fertilizer and application of fertilizer were done based on the recommended rate (12.59 g complete and 5.9 g urea) or soil analysis.

A unique feature of the manuring done at his farm is the application of composted silkworm waste from silkworm rearing, manuring the plant to utilize a lot of soil nutrients from the rich foliage, and fertilization of composted silkworm waste from silkworm bed cleaning was used to enrich the fertility of the plantation, to save money by minimizing buying of inorganic fertilizer and increase the water holding of the soil. Irrigation enables the full utilization of the heavy application of fertilizer and manure, the supply of requisite irrigation during dry spells, the crops were irrigated. Irrigation was implemented during summertime using a water pump. Sipping the water on the creek using a hose directly to the mulberry area and the rain, river, and tributaries are the main source of irrigation in the area. Weeding is also very essential as the weeds compete for nutrients and water with the mulberry plants. It was also done when the weed is taller than the mulberry plants. The Farmer Cooperator used manual cutting and a glass cutter. Nearly 70% of the silk protein produced by a silkworm is directly from the protein derived from the consumption of mulberry leaves (FAO, 1986). Pruning was done twice a year in July and November, maintaining a one-meter medium height per plant.

Silkworm rearing for seed cocoon production

The farmer followed the standard operating procedures and practices in silkworm rearing including feeding silkworms with plucked leaves during 3rd instar and branch feeding at 4th instar. Recommended frequency and time of feeding (5 AM, 10 AM, 3 PM, and 7 PM) was also followed with slight modification with additional feeding at 9-10 PM.

Assistance during silkworm rearing is provided especially during the onset of moulting and determining the time of feeding after moulting, also referred to as "resume feeding".

Fig. 1 illustrates the flow of silkworm seed cocoon production from parental silkworm egg up to commercial silk production.

Provision of marketing assistance and filature services

Seed cocoons produced on the farm are hauled back to the Institute and purchased by DMMMSU-SRDI at P350.00/kg.

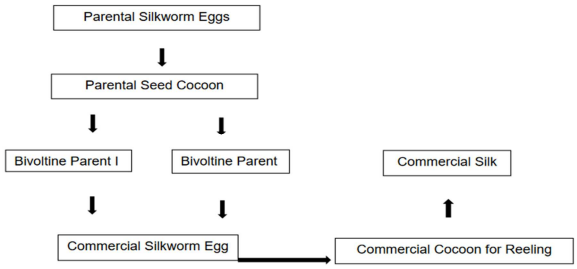

Fig. 1. Production of seed cocoons

Monitoring and evaluation

Quarterly monitoring and evaluation were conducted by the University Extension Office to determine the progress of project implementation and provide solutions to any problems identified. After each monitoring and evaluation, an exit conference was set to discuss the results of the monitoring and evaluation. Field visitation/consultations were also employed during the project implementation. Upon the request of the farmer or as the need arises, technical experts from the institute were sent to the project site to assist in the various activities in the field for mulberry maintenance, and/or in silkworm rearing, farming systems, and pest management. During field visitations, technology needs assessment was also being done in the area to determine whether such technologies fit climatic conditions, the resources of the farmer, and the goals in farming.

Results and discussion

Sericulture was first introduced in Duplas, Pugo, La Union in 2008. The Duplas area, with an initial land area of 1,744 sq. m. was planted with 5,000 mulberry saplings double row last September 2008. Due to natural calamities, the population was reduced to 3,400 mulberry plants. A year after another devastating typhoon crossed the area, a portion of which was washed out. In 2014, the expansion of a 150 m^2 mulberry area with 300 plants was established beside the house of Mr. Garcia.

The Pugo Seed Cocoon Area was established in a plain marginal area in Pugo, La Union. Sericulture practices did not compromise the agricultural lands used for rice, vegetables, and other food/animal production areas, since the area was previously planted with fruit trees, timber, and root crops.

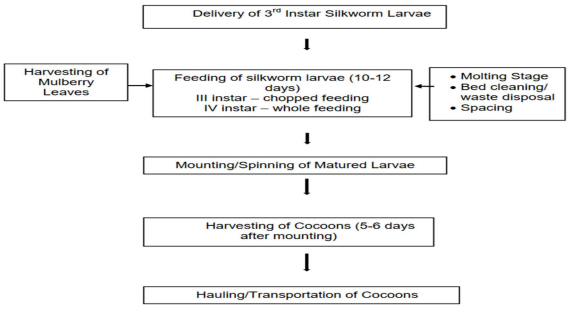

Fig. 2. Standard Operating Procedures on Late-Age Silkworm Rearing (Garcia, 2020)

Five to six (5-6) months after the mulberry establishment and management, silkworm rearing for seed cocoon production started. Young age rearing of silkworms was done at the Institute before the on-site rearing. Certain SOPs before rearing were employed including disinfection of the rearing house and implements with 3% calcium hypochlorite solution three (3) days before the delivery of the silkworms. On its third instar second feeding, silkworm larvae were delivered to Pugo Seed Cocoon Area for late-age rearing (Fig. 2).

Three (3) parental silkworm purelines DMMMSU 100, DMMMSU 101, and DMMMSU 102; and five (5) F_1 parental silkworm hybrids DMMMSU 201, DMMMSU 209, DMMMSU 215, DMMMSU 216, and DMMMSU 226 were reared on the entire duration of the project in the Pugo Seed Cocoon Area. These parental silkworm breeds will, later on, serve as materials for hybridization to produce silkworm hybrid eggs namely: DMMMSU 346, DMMMSU 406, DMMMSU 408, and DMMMSU 221 which are utilized for commercial cocoon production by various clienteles. These hybrids were recommended based on the result of the study National Cooperative Testing of Silkworm Hybrids (Abuan, 2003) in all types of climatological conditions in the Philippines and confirmed by (Madrid, 2013) were found to be adaptable both during wet and dry seasons in Bacnotan, La Union. These were the hybrids used by farmers/cocoon producers for commercial cocoon production that can increase cocoon yield box^{-1} by 18.55% to 24% (Bunnao, *et al.*, 1994). In addition, these hybrids also observed by Gapuz *et al.* (2011) produced well commercial cocoons valued from Php 3,990.00 to Php 12,390.00 with an ROI of 18-117% per annum in 2009.

The performance of these breeds varies from season and year indicating the degree of variability in genetic potential. Results of various economic parameters of these breeds revealed their genetic potential as well as their variability for economic traits. These breeds have immense potential as breeding materials as they displayed their good variability from economic traits (Table 2). These were recommended as good sources of quality seed cocoons.

Seed cocoon quality and technical and managerial efficiency are the important factors responsible for the production of quality seed (Samson, 1998). Thus, to ensure good seed cocoon quality, certain parameters were set (Table 1). Some specific traits or characteristics have to be met and the seed cocoons produced have to conform to be considered as quality seed cocoons. These include cocoon shape and color, larval marking, yield, cocoon shell percentage, number of cocoons per kg, effective rearing rate, pupation rate, and hatching percentage.

In the same manner, the quality of the seed cocoons produced in the area consequently would determine the effectiveness and efficiency of the Pugo Sericulture Project as a Seed Cocoon Area. Quality seed cocoons produced in the area also demonstrate its effective adoption of the various mulberry production and silkworm and cocoon production technologies extended by DMMMSU-SRDI.

The farmer's enthusiasm and dedication, coupled with the strong support services rendered by the assigned project in-charge and technical staff of DMMMSU-SRDI, the project was able to conduct silkworm rearing three (3) to six (6) times per year, for the period of eight (8) years. A total of 13.75 boxes (1 box = 28,000 larvae) of silkworm larvae were reared which consumed a total of 7,858.04 kilograms of mulberry leaves.

The cocoons produced by the farmer from the parental breeds DMMMSU 100, DMMMSU 101, DMMMSU 102, DMMMSU 216, DMMMSU 215, DMMMSU 201, DMMMSU 209, and DMMMSU 226 silkworm larvae reared are seen in the collected data on cocoon yield from the field for eight (8) years during the different seasons (Table 2).

Table 1. Varietal description of bivoltine purelines silkworm used in Pugo seed cocoon (Bunnao *et al.*, 1994 and Gapuz *et al.*, 1999), CY 2009-2016

Silkworm breed	Cocoon shape	Cocoon color	Larval marking	Yield box- (kg)	Cocoon shell (%)	No. of cocoons /kg	Effective rearing rate	Pupation rate	Hatching (%)
DMMMSU 100	Short Oval	Off- white	Plain	33.15	17.37	538	86.3	90.1	90.0
DMMMSU 101	Long Peanut	Off- white	Plain	31.60	19.25	549	92.0	91.2	91.0
DMMMSU 102	Big Oval	Off- white	Plain	28.11	19.32	560	90.8	89.8	91.3
DMMMSU 201	Oval	Off- white	Plain	21.45	19.01	502	88.30	90.6	90.61
DMMMSU 215	Oval	Off- white	Plain	27.98	17.79	515	89.0	90.8	90.0
DMMMSU 216	Oval	Off- white	Plain	22.97	17.28	520	91.8	89.9	90.8
DMMMSU 209	Long Peanut	Off- white	Plain	28.30	17.70	569	91.6	90.0	90.0
DMMMSU 226	Short Peanut	Off- white	With marking	24.27	17.92	602	93.0	90.0	90.3

Table 2. Quantitative and qualitative characters of seed cocoon, CY 2009- 2016

Silkworm Breed	Number of boxes reared	Cocoon yield box- (kg)	Number of cocoons /kg	Effective rearing rat (%)	Cocoons shell (%)	Pupation Rate (%)	Hatching (%)
DMMMSU 100	0.85	15.3	760.50	88.73	17.70	89.83	92.86
DMMMSU 101	2.6	35.25	760.07	90.20	18.12	89.82	91.84
DMMMSU 102	0.3	10.0	699.25	83.95	17.05	90.15	90.90
DMMMSU 201	1.65	36.25	754.88	89.46	17.90	92.86	91.08
DMMMSU 215	0.5	9.25	760.0	87.6	19.0	90.1	90.60
DMMMSU 216	6.4	170.70	708.04	88.82	18.62	91.31	94.12
DMMMSU 209	0.25	2.25	698.0	89.3	16.01	89.6	91.60
DMMMSU 226	0.85	21.50	809.17	88.12	18.34	91.52	92.28
Total	13.75	327.35	5,949.26	106.18	142.74	725.13	735.28
Average		27.02	743.74	88.27	17.84	17.84	91.91

Table 3. Productivity and profitability of seed Cocoon production in Pugo seed cocoon area

Year	No. of box reared	Cocoon yield (kg)	Price of Cocoon (Php)	Gross income (Php)	Production cost (Php)	Net income (Php)	ROI (%)
2009	1.45	52.75	140.00	7,385.00	4,725.33	2,659.67	56.29
2010	1.65	53.25	140.00	7,455.00	4,826.98	2,628.02	34.44
2011	2.30	48.75	140.00	6,825.00	5,505.06	1,319.94	5.81
2012	1.0	33.20	140.00* / 160.00** JM / AD	4,928.00	4,421.28	506.72	16.44
2013	1.0	25.50	160.00	4,080.00	4,763.91	(683.91)	(14.36)
2014	2.25	51.30	160.00	8,208.00	7,059.28	1,448.72	21.43
2015	2.35	37.80	160.00	6,048.00	6,534.28	(486.28)	(7.44)
2016	1.75	22.80	160.00***/ 200.00*** JJ/AD	4,560.00	6,400.41	(1,840.41)	(44.17)
Total	13.75	327.35		49,489.00	44,236.53	5,552.47	111.86 13.98

*January-March ***January-June **April-December ****August-December

Every rearing season the volume of silkworm eggs ranges from 0.25 box - 0.50 box per rearing. It was done in three (3) to six (6) rearings from January to December. The number of boxes reared has a minimal quantity because due rearing house can only accommodate 0.5 boxes of silkworm larvae. After all, the rearing of the Parental breed should be in minimal populations to avoid mixing of breeds and easier management. Each silkworm breed has a specific or distinct trait or characteristic. For example, DMMMSU 100 has a short oval cocoon shape while DMMMSU 101 has a long peanut-shaped cocoon. This characterization should also be strictly observed at the seed cocoon area to avoid mixing-up of breeds.

Based on the different cocoon parameters (Table 1), the specific characteristics observed and gathered from each breed indicated that the seed cocoons produced passed and conformed to the parameters (Table 2). The economic characters were assessed individually and were selected according to the usual selection for cocoon shape, and color, among others.

The number of boxes reared

Mr. Garcia opted to rear 0.25 box to 0.5 box per rearing season whereas reared 13.5 boxes of silkworm larvae DMMMSU 100 (0.85 box), DMMMSU 101 (2.6 boxes), DMMMSU 102 (0.3 box), DMMMSU 201 (1.55 boxes), DMMMSU 215 (0.5 box), DMMMSU 216 (6.4 boxes), DMMMSU 209 (0.25 box) and DMMMSU 226 (0.85 box).

Cocoon yield

Out of the breed (Pureline & F_1 hybrids) reared, the area produced an average yield of 27.02 kg, where DMMMSU 216 obtained 170.70 kg out of 6.4 boxes of silkworm larvae. Cocoon yield a very important character linked directly with the income of the farmer and positively correlated with survival rate, pupation rate, and cocoon weight. The expected yield of P1 seed cocoons during favourable seasons is more than 25 kg/ box however the unfavourable seasons the yield is expected more or less 18 kg.

Number of cocoons per kilogram

This signifies the size of the cocoons being produced. The greater number of cocoons per kilogram the smaller it is in size. Cocoon yield was calculated for every 10,000 brushed larvae by weight. The cocoon yield of all breeds of silkworm reared yielded 25.0 on average throughout the year and season. Thus, DMMMSU 209 produced the biggest cocoon with 698 cocoons/kilogram. However; DMMMSU 226 obtained the smallest cocoon size with 844.17 cocoons/ kilogram.

Effective rearing rate

Effective rearing rate was assessed at two levels, first in respect of the percentage of missing larvae during rearing and second in respect of the ratio of cocoons to the reared larvae. The highest effective rearing rate was seen in DMMMSU 101 with 90.20%.

In general, seed cocoon quality such as effective rearing rate and cocoon weight affect laying yield, and fecundity in silkworms (Krishna Reddy, 1987).

Cocoons shell percentage

The percentage of shell ratio varies with the breed of silkworm and the normal range is 65-84 % for the weight of cocoon shell and 12-20 % for the weight of whole fresh cocoons. DMMMSU 215 obtained the highest cocoon shell percentage of 19.0 %.

Pupation rate

The pupation rate has a positive correlation with the fecundity of silkworms. And ease the selection of made-for cocoon shell weight and shell ratio, pupal weight increases with the improvement of cocoon shell weight. Amongst the larvae reared, DMMMSU 201 produced the highest pupation rate of 92.86%.

Hatching percentage

This was indicated by the hatched silkworm larvae from the population. DMMMSU 216 obtained the highest hatching percentage of 94.12 %.

The laying yield or egg production, in general, is influenced by the parental seed crop standard cocoon yield by number and weight (Narayanan et al, 1904). This hybrid seed quality and quantity may be affected by the seed crop, particularly of the female parents. It is believed that hybrid seeds produced from high-yield seed crops are qualitatively superior and result in better progeny performance and cocoon yield compared to low-yielded seed crops.

Productivity and Profitability of Seed Cocoon Production

Table 3 depicts the productivity and profitability of seed cocoons. Mr. Garcia conducted three (3) to six (6) times silkworm rearing. He produced and harvested an encouraging average cocoon yield /box of 27.02 kg, considering the breakeven yield/box, it surpassed the standard yield /box of 20.0 kg. This implied that the productivity of pure lines has been consistently good. The higher cocoon yield was attributed to environmental factors during the rearing season and proper care and management of silkworms. The silkworm breeds raised were able to perform well when provided with enough quality mulberry leaves during feeding where the worm consumed 550-600 kg of mulberry leaves during late age. Considering the result obtained it can be said that the parental bivoltine rearing was properly implemented.

The crop performance resulted in an encouraging yield as well as good income in-between years although low production was observed in some periods due to disease incidence during larval and cocooning stages, caused by high temperature and humidity.

The performance of silkworm larvae reared by the farmer cooperator showed better cocoon production of 327.35 kg out of 13.5 boxes of parental silkworm larvae thus recording an average cocoon production of 27.02 kg with sales amounted to Php 5,974.63.

The overall production of cocoons has been fluctuating. The year 2010 recorded the highest peak of production of seed cocoons at 53.25 kg wherein the Farmer Cooperator reared 1.65 boxes of parental silkworm breed. In the year 2016, the project produced a total of 22.80 kg fresh cocoons from 1.75 boxes of parental silkworm larvae having sales of Php 4,560.00 with four (4) times rearing from January to September 2016. The first rearing (January) of the silkworm was from PTRI wherein showed from this year the lowest seed cocoon production. This was due to several factors such as the occurrence of disease during rearing, fluctuating environmental temperature and humidity, and low water supply to irrigate resulting in mulberry low leaf production.

In 2009 to March 2011 cocoon price was valued at Php 140.00 per kg but increased in April 2011 to July 2018 to Php 160.00 per kg, then another increase in August 2016 at Php 200.00 per kg was approved.

The project generated a total gross income of Php 49,489.00 from seed cocoons less production cost of Php 44,236.53 with a net income of Php 5,552.47 and an average return on investment of 13.98%. Whereas, during the year 2009 recorded the highest return on investment at 56.29%. The production cost includes the payments of direct materials, direct labor, and depreciation cut of production equipment including rearing house and implements

Conclusion

The project has evidently demonstrated its adoption of the various technologies generated by DMMMSU-SRDI through mulberry production and silkworm rearing activities. Also, the project has served its purpose as an effective area for quality seed cocoon production thereby providing support to DMMMSU-SRDI, particularly the Silkworm Egg Production and Distribution Unit. Seed cocoon production can be as productive and profitable as commercial cocoon production. In addition, seed cocoon areas contributed to the production of the needed parents for hybrid eggs used by the farmers to produce silkworm larvae for commercial cocoon production.

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