The potential for increasing the productivity of Indonesian silk farmers

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Abstract. Natural silk is one of the sources of livelihood for rural Indonesians. However, due to the Covid-19 pandemic, natural silk production has been affected. During the pandemic, the community implements health protocols such as keeping physical distance and physical contact. Meanwhile, the natural silk business is a labor-intensive business that involves a lot of labor, so a strategy is needed in order that silk farmers could continue running their productive business to meet the necessities of life. This paper aims to provide information on the potential for the economic increase of Indonesian silk farmers through sericulture technological applications. The research used desk study, descriptive qualitative, and quantitative methods with the study locations in Sulawesi, Gorontalo, and Java Provinces. The results of the study show that the technology input through the mulberry hybrid and silkworm hybrids can increase farmers' cocoon production by 21.4% - 36.4% with an increase of silk filament production by 75.4% - 358.8% per silkworm box. In addition, the use of mulberry hybrids and standard silkworm rearing room is also a potential for silk farmers to increase the number of silkworms raised with the same resource capital in the form of land ownership area and number of family labor. The application of sericulture technology is indispensable as one of the solutions in increasing the productivity of silk farmers in the pandemic era hence a sustainable socialization of technology is needed.

1. Introduction

Natural silk is one of the non-timber forest products in Indonesia. Silk is a textile fiber product that has various advantages over other textile fibers and has been recognized for centuries. The silk business provides opportunities for job creation and income for producers as well as the preservation of cultural heritage. Silk is the highest in demand fiber by the global community because silk textiles are synonymous with luxury, elegance, and splendor [1].

The main silk-producing countries in the world are China, India, Uzbekistan, Brazil, Japan, the Republic of Korea, Iran, and also several countries that are not major producers such as Malaysia, Kenya, Nigeria, Turkey, Romania, Bulgaria, Egypt, and several other countries including Indonesia. The main producers of silk, as well as the main suppliers of world silk, are the Asian countries, namely China (100000-170000) and India (23000-28000) tons/year for a period of 5 years from 2011-12 to 2015-16 [1].
The Covid-19 pandemic has had a tremendous impact on worldwide life [2] and has impacted almost every sector of the global economy [3], including the natural silk industry [4]. Indonesia has the opportunity to be in line with global silk-producing countries with several supporting factors such as: availability of quality silkworm seeds and feed [8] environment, market [9] culture and knowledge, and skills of farmers in sericulture.

Indonesian silk production tends to decrease over time due to several factors, including silkworm disease and limited quality silkworm seeds [5]. Currently, silk production of South Sulawesi is only about 2.5 tons/year [10]. This data shows a significant decrease (70%) because, before the Covid-19 pandemic, South Sulawesi silk production was 8 tons/year.

South Sulawesi is one of Indonesia's main silk centers, supplying over 80% of the country's silk needs [7]. Some people cultivate mulberry plants and silkworms from generation to generation in a traditional way and still apply the social culture of mutual cooperation between farmers. The Covid-19 pandemic demands the implementation of strict health regulations including limiting the social interactions. Meanwhile, farmers must continue to run a productive silk business to meet the needs of family life.

Based on the above circumstances, a strategy is needed so that silk farmers can remain productive during the Covid-19 pandemic while adhering government rules related to social restrictions by maximizing existing local resources to their full potential. This issue is the background behind efforts to examine the potential for increasing farmers' silk production through the application of sericulture technology in the form of hybrid mulberry and superior silkworms as well as standard cultivation rooms.

2. Material and methods
2.1. Material and locations
Observation of the silkworm cultivation room was carried out in South Sulawesi in 2019 in a pilot demonstration plot area at the location of silk farmers. Meanwhile, information on the production of mulberry and silkworms used data from trials that have been carried out in several natural silk development areas in Indonesia: Sulawesi (Soppeng), Java (Sukabumi, Pati, Garut) and Gorontalo (Bualemo). The following is map of the study locations (Figure 1).

![Figure 1. Map of the study locations](image)

2.2 Data collection
The data for cocoon and yarn production is done by re-analyzing the existing research data in percentage form. Some secondary data were collected through several media by literature studies. As for the trial data for silkworm cultivation, an experiment was conducted using a standard cultivation room in Soppeng Regency, South Sulawesi. The silkworm rearing house demonstration plots were made on a
small scale at the site of farmers who continue to cultivate mulberry and silkworms. The demonstration plot is expected to serve as a pilot and make it easier for surrounding farmers to access technology. The trial of the cultivation room is still a preliminary test scale and still needs to be observed further.

2.3. Data analysis
The cocoon and yarn production data were re-analyzed in the form of percentages to determine the increase in production by comparing production increase using commercial silkworm seeds and superior hybrids.

3. Results and discussion
To increase Indonesian silk production, several applications of domestic silk technology have been produced, including:

3.1. Mulberry plants from superior hybrid.
Three main components that support success in the silkworm cultivation plan are the amount of mulberry feed, labor, and maintenance facilities [11]. The following is the superior productivity of hybrid mulberry in Indonesia.

| Locations | Leaf production (ton/ha/thn) | Increased leaf production (%) | Protein content (%) |
|-----------|-----------------------------|-------------------------------|---------------------|
| Mulberry hybrids | | | |
| Java/Sukabumi (>500 m dpl) | | | |
| M.Cathayana (local) | 26.18 | 45 | 22.23 |
| M.SULI-01 (Superior hybrid) | 37.99 | 85 | 24.62 |
| M.AsI (hybrid) | 20.48 | 20.74 |
| Java/Sukabumi (>500 m dpl) | | | |
| M.Cathayana (local) | 10.00 | 96 | 14.20 |
| M.NI (hybrid) | 19.60 | 14.90 |
| M.Cathayana (local) | 10.00 | 88 | 14.20 |
| M.AsI (hybrid) | 18.80 | 14.70 |

Sources:[12,13,14] Data processed

Table 1 shows that the superior hybrid mulberry (SULI-01) has the potential to increase leaf production by 45% compared to local species (many cultivated by the community) and 85% compared to other hybrids (M.AsI). Thus the same area of land can provide optimal mulberry production through the adoption of technology, namely using cross-bred mulberry. Technology adoption is needed in order to increase farm productivity [15]. In order for this technology to be useful, farmers need to apply it in their farming business. Therefore, the adoption of technology and innovation is very important for farmers to increase the productivity of their silk farming. In addition, mulberry hybrid also contains higher leaf protein content (15-25%) than local mulberry (14-20%) while protein content positively affects silk filament production [17,18].

3.2. Hybrid silkworm seeds
One of the supporting factors for increasing the production of Indonesian silk growers is the availability of high-quality silkworm seeds. Productivity in question is the ability of farmers to produce targeted production by utilizing resources effectively and efficiently. So far, farmers have been using commercial seeds which apparently is starting to decline in quality. For this reason, several research results from the Bogor Forest Research and Development Center that show superiority in the production of cocoons and
filament need to be facilitated by the government so they can be commercialized and become a potential choice of silkworm seeds for silkworm rearing in Indonesia on a large scale. One of the superior hybrids that has been tested in multiple locations is PS 01. The following is the average production of cocoons and silk filament for superior silkworm seeds that have been tested in several potential silk development areas in Indonesia.

**Table 2. Increased cocoon production from using superior hybrid seeds (PS 01) compared to commercial silkworm seeds (C301)**

| Locations | Silkworm hybrids | Cocoon productions kg/boks | Increased cocoon production (%) | Filament productions kg/boks | Increased filament production (%) |
|-----------|------------------|-----------------------------|--------------------------------|----------------------------|---------------------------------|
| Pati      | C3 01            | 27.5                        | 36.4                           | 1.02                       | 358.8                           |
|           | PS 01            | 37.5                        |                                 | 4.68                       |                                 |
| Soppeng   | C3 01            | 27.5                        | 36.4                           | 1.02                       | 358.8                           |
|           | PS 01            | 37.5                        |                                 | 4.68                       |                                 |
| Sukabumi  | C3 01            | 30.0                        | 33.3                           | 2.28                       | 75.4                            |
|           | PS 01            | 40.0                        |                                 | 4.00                       |                                 |
| Bualaemo  | C3 01            | 35.0                        | 21.4                           | 2.80                       | 102.1                           |
|           | PS 01            | 42.5                        |                                 | 5.66                       |                                 |
| Garut     | C3 01            | 32.5                        | 23.1                           | 2.28                       | 75.4                            |
|           | PS 01            | 40.0                        |                                 | 4.00                       |                                 |

Source: [18] Data processed
Note: box = the size of the place of silkworm eggs, one box of 25,000 eggs

Table 2 shows that the cocoon production of superior hybrid seeds at 5 test locations namely Pati (Central Java), Soppeng (South Sulawesi), Sukabumi (West Java), Bualemo (Gorontalo) and Garut (West Java) was around 37.5 kg/box – 42.5 kg/box. Meanwhile, commercial seeds showed an average cocoon production of 27.5 kg/box – 35 kg/box. Table 2 also shows that the rearing of silkworms with superior cross seeds (PS 01) can increase cocoon production by an average of 21% - 36%. The highest increase in cocoon production (36%) was in the lowland areas, namely Pati and Soppeng (<400 m asl) therefore PS 01 silkworm seeds could be recommended for the lowlands.

The production comparison of superior and commercial hybrid silk filament can also be seen in Table 2, where the superior hybrid produced silk filament production of 4.5-6.6 kg/box while commercial silkworms produced silk filament of 1 to 2.8 kg/box. These data (Table 2) illustrate that the superior hybrid provides a significant increase in the average production of silk filament, which is 75%-358%/box. So that the silkworm PS 01 seeds can be developed for wide-scale use in the lowlands with an altitude of 100-200 m above sea level, and this is reinforced by the observation [18] that PS 01 provides higher silk filament production than the existing hybrid types. However, in the highlands this superior hybrid can also be used because it consistently provides higher production than commercial types [13].

A combination of excellent mulberry and superior silkworms has the potential to boost natural silk yield [18], as demonstrated. The combination of SULI's superior mulberry and PS 01 silkworm seeds can increase cocoon production by 39% of silkworm production in general, and produce 20% longer filaments than general production [19].

### 3.3. Standard silkworm rearing room

In addition to the types of silkworms and mulberry feed silkworms, the space where silkworms are grown in bulk can also affect the production of cocoons and silk filament. Silkworm rearing in the community is often found in South Sulawesi. Generally, the people of South Sulawesi rearing silkworms under the house (Figure 5) which is a tradition of owning a house on stilts. Under the stilt house, it is designed to be a silkworm rearing room. Utilization under the house from an economic point of view is
actually cost efficient because there is no need for a special building, only cement walls and floors are installed. Apart from being a rearing chamber, other family activities, such as cooking, and other household activities and for storing vehicles and garden tool, have the potential to be a nuisance to silkworm health [20].

Figure 2. Under house rearing silkworm (A) Standar room for rearing silkworm (B)

The recommended silkworm rearing room is a building that is separate from household activities, clean and meets the air cycle. The capacity of the rearing room also needs to be considered because it affects the health of the silkworm that are reared in bulk. The following is a brief description of the quality of the standard rearing room that has been observed in the initial experiment.

| Variable                  | Under house | Standar room rearing |
|---------------------------|-------------|----------------------|
| Temperature (°C)          | 25-29       | 23-27                |
| Humidity (%)              | 53-74       | 58-81                |
| Period of use (year)      | ± 10        | ± 30                 |
| Cocoon weight (gr)        | 0.97 -1.24  | 1.06 – 1.22          |
| Cocoon shell ratio (%)    | 15-16       | 15-18                |

Farmers have made special buildings for silkworm rearing, but they have not met the requirements such as air circulation and roofs that leak quickly. The silkworm rearing room was based on previous results and improved from the constraints farmers have faced. The silkworm rearing room building is separated from the domicile house and placed around the mulberry garden. The silkworm cultivation room is made of wood with a terraced roof model accompanied by a tool storage room and leaf storage. The side of the cultivation room is equipped with a window for regulating the air cycle (Figure 5).

Table 3 shows that the rearing of silkworms in the standard rearing room shows a cocoon shell ratio of 15-18% while that of rearing under the house is 15-16%. Air temperature conditions in the silkworm rearing standar ranged from 23-27°C with humidity ranging from 58-81% closer to the ideal conditions for sericulture business, namely temperatures ranging from 20-23°C and humidity ranging from 70-85% [21] compared to under house. In addition, the silkworm rearing standar also has a longer period of use than under the house. Although it is still a preliminary test, it provides an opportunity to increase silk productivity, especially during the pandemic. Appropriate technological innovation can increase productivity and increased added value [22].

Although natural silk technology has been widely publicized through various media and publications, it has yet to be fully implemented. Limited resources due to social restrictions such as the area of cultivated land, the number of workers, and the reduced volume of silkworms that are kept provide optimal production through the adoption and application of sericulture technology. To encourage national silk production, one of the steps is to implement the concept of participatory technology development. So that the existing technology involves the community to assess economic feasibility
through productivity and suitability with the environment and local culture according to the concept of appropriate technology [23].

Increasing the productivity of the Indonesian natural silk industry and the global silk industry has several impacts including empowering rural communities, increasing the income of farmers and business actors [24, 25] as well as maintaining the supply of industrial silk raw materials and providing employment for rural population [1].

4. Conclusion

The Covid-19 pandemic has had a real impact on the natural silk business, especially in the cultivation and marketing aspects. The use of independent silk rearing technology such as superior mulberry hybrids and superior silkworm hybrids has the potential to increase productivity and quality of natural silk products. The superior hybrid application of SULI mulberry and PS 01 silkworm has the potential to increase the average silkworm cocoon production by over 20% and silk filament production by 350% compared to existing hybrids with the same land area and limited workforce, so it needs to be widely disseminated in the area of natural silk development in Indonesia. The limitation of social interaction is the right momentum for the adoption and maximization of the use of domestic silk technology towards the independence of silk-based clothing products. Increasing productivity opens up opportunities to become a global silk-producing country, so it is necessary to make a real step in the form of technology development and innovation in a sustainable manner supported by government policies and the synergy of the parties.

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