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Superworm (*Zophobas morio*) breeding for papaya stem waste management

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ABSTRACT

Boyolangu District is a famous papaya-producing area and the largest in Tulungagung Regency. The local papaya farming community is active in farming. They succeeded in producing approximately 10 tons of papaya in 2020. This number has decreased by more than half from the previous year in 2019. This is inseparable from the impact of the COVID-19 pandemic. In addition, the community complaint about a large amount of papaya stem waste after harvest. Waste management is a separate problem for farmers. Not to mention the added problem of the low price of papaya per kilogram. Therefore, a community service program aims to overcome the target community's problems with superworm (Zophobas morio) breeding education and training. The activity conducted by the team of the Faculty of Agriculture, University of Kadiri empowering the papaya farming community in Boyolangu District, Tulungagung Regency to manage papaya stem waste as an alternative feed for superworm breeding. Farmers were invited to breed superworm as their additional income and improve the standard of living of the family. This activity mainly focused on the introduction and training of superworm breeding. The activity was beneficial for the social, economic, and environmental life of the target community.

Kata Kunci
Batang pepaya
Budidaya
Pakan
Pengolahan limbah
Ulat Jerman

Budidaya ulat jerman (Zophobas morio) sebagai upaya pengelolaan limbah batang pepaya. Kecamatan Boyolangu merupakan wilayah yang terkenal sebagai produsen papaya terbesar di Kabupaten Tulungagung. Komunitas petani pepaya setempat cukup aktif dalam budidaya. Mereka berhasil memproduksi sekitar 10 ton pepaya pada tahun 2020. Jumlah ini menurun lebih dari separuhnya dari produksi tahun sebelumnya pada 2019. Fakta ini tidak dapat dipisahkan dari dampak pandemi COVID-19. Lebih dari itu, komunitas mengeluhkan bertumpuknya limbah batang papaya pascapanen. Pengelolaan limbah menjadi permasalahan bagi petani setempat. Belum lagi, mereka dihadapkan pada permasalahan rendahnya harga jual per kilogram papaya. Oleh karena itu, sebuah program pengabdian masyarakat ditujukan untuk mengatasi permasalahan komunitas sasaran melalui edukasi dan pelatihan budidaya ulat jerman (*Zophobas morio*). Kegiatan ini diprakarsai dan dilakukan oleh tim pengabdian masyarakat dari Faculty Pertanian Universitas Kadiri yang memberdayakan komunitas papaya di Kecamatan Boyolangu Kabupaten Tulungagung dalam pengelolaan limbah batang pepaya dan memanfaatkannya sebagai pakan alternatif dalam budidaya ulat jerman. Petani diajak untuk melakukan budidaya ulat jerman ini sebagai tambahan pendapatan dan peningkatan kesejahteraan keluarga. Aktivitas ini berfokus utama pada pengenalan dan pelatihan budidaya ulat jerman. Kegiatan bermanfaat bagi kehidupan sosial, ekonomi, dan lingkungan dari komunitas sasaran.

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INTRODUCTION

The economic turmoil that occurred due to the Covid-19 pandemic that hit countries in the world, became a historical moment, especially for people in Indonesia (Lisanty, 2021). The impact of the Covid-19 pandemic on the economy of the Indonesian people was enormous, which among other things resulted in a decline of around 60% in household consumption or people's purchasing power, prolonged uncertainty, resulting weak investment, business stoppages, and economic slowdown which caused commodity prices to fall and Indonesia exports to several countries also stopped too (Lisanty, Andajani, et al., 2021; Susilawati et al., 2020).

The bad impact of the pandemic has also been felt by the papaya farming community in Tulungagung Regency. According to BPS Provinsi Jawa Timur (2021), Boyolangu District is the largest papaya production centre in Tulungagung Regency and it experienced a decrease in production in 2020. The production in 2019 was 18,846 kg, while 2020 production was less than half of 2019, by 9,895 kg. This became the first reason for the Kadiri University Community Service Team to visit and stay in touch with farmers in that location. When visited, the local papaya farming community welcomed the team warmly and explained some of the production problems they faced.

Apart from the weakening of activities during and after the pandemic, farmers complained about the low selling price of papaya, which has resulted in reduced income and the economy of farmer households. This was the reason for their shift from cultivating papaya to other commodities, such as chilies and tubers. More than that, farmers also experience difficulties in managing the waste of papaya stems after harvest. Unlike the stems of annual crops which can be burned immediately after harvest, papaya stems are generally stacked first in the field and allowed to dry so that they can be easily burned, destroyed, or thrown away. They proposed that there was a technology for treating papaya stem waste so that it would not pile up on the land after harvest. This is of course their aim so that the land can be used again immediately after harvest.

The team held a meeting to discuss these matters. The team initiated a program which may address the main problems of the target community as well as the SDG's goals. For instance, handling papaya production waste is a step in ensuring sustainable production patterns of papaya and a way of promoting sustainable agriculture; the introduction and implementation of superworm breeding strengthen the means of implementation and revitalize the global partnership for sustainable development, and finally this new business as a concrete form of efforts to end the poverty of target communities. Therefore, the program focuses to manage papaya stem waste by using it as an alternative feed in superworm (*Zophobas morio*) breeding. This solution is not only intended for waste management at partner locations but also as the introduction of new businesses to improve the welfare of the targeted community and their families. Although not a common main feed for superworm, plant stems such as papaya have the potential to be used as alternative feeds in superworm breeding. Superworm eats any type of feed even including plastic (Jiang et al., 2021; Luo et al., 2021; Yang et al., 2020). The astonishing thing about this animal is that it can survive without eating even for up to three weeks (Kuan et al., 2022). Of course, superworm can live well when given organic feed intake (van Broekhoven et al., 2015), especially feed with fibre above 5% (Li et al., 2016). Papaya stems as superworm feed are believed to provide not only fibre but also produce quality superworms, given the presence of antibacterial content in papaya stems (Handayani et al., 2020; Nirmala et al., 2022; Watung et al., 2020).

This article describes the program being implemented, the purpose of implementation, and the results of its implementation. The program aims to overcome the target community's problems with superworm cultivation education and training. The main results of this program are hoped to increase the knowledge, skills, and income of papaya farmers in Boyolangu District through the introduction, training, and mentoring of superworm breeding as a new business alternative for the community. In addition, the program also supports the Community Food Security Program launched by the Regional Government following the potential of each region, increases the role of farmers in Indonesia's agricultural development, and strengthens farmers' income in the post-pandemic period. The results of the provision of training and mentoring are expected to affect the development and application of science and technology. In this case, promoting sustainable agriculture of papaya farming, as one of the Sustainable Development Goals (SDGs), as well as other SDGs of protecting, restoring, and promoting sustainable use of terrestrial ecosystem where the activity is conducted.

METHOD

The implementation of this program began with field observations and continued with joint discussions between the community service team, village officials and the local papaya farming community. This community is a collection of papaya farmers in Boyolangu District who form associations as a means for them to establish communication, share information, and collaborate on production and marketing. The number of community members reaches 80 farmers, but active members until December 2022 number is around 20 people. Targeted farmers are papaya farmers in the community who are willing or registered to participate in the activity program, totaling 15 participants. Figure 1 illustrates a papaya plantation owned by one member of the local community. The community service team is a combination of 2 lecturers and 4 students who have been assigned by the Kadiri University's Research and Community Service Institute. The team has a background in agriculture, particularly agribusiness and agrotechnology. Waste management is a theme of service activities that is often implemented by several team members and has become part of the team's specialization. Previously the team managed household waste to produce fertilizer (Lisanty, Hadiyanti, et al., 2021), liquid organic fertilizer (Junaidi et al., 2022; Lisanty & Junaidi, 2021), as well as reuse and recycle activities to make it into useful goods (Mariyono et al., 2022; Probojati et al., 2022).

Figure 1. Papaya Plantation Owned by A Farmer in the Community in Boyolangu District

Coordination is carried out after an agreement has been reached between the target community and the community service team. The agreement is related to the schedule for implementing the superworm breeding training program during January 2023, for 4 times every Sunday. Furthermore, the team collected data on farmers as training participants, as well as submitting SOPs or rules that must be obeyed by participants. Socialization from the team needs to be done for the smooth running of training activities. Several things were conveyed to farmers as training participants, including a) training materials, b) training materials, and c) tools and equipment.

On the day of the program, particularly in the first meeting/first week, participants filled out a questionnaire containing questions related to cultivation techniques, cultivation benefits, and future product prospects. In the first meeting, the team shared information and theory related to superworm breeding. In the second meeting, the participants were trained on how to start the breeding, any equipment and materials, feed alternative, treatment, pest and diseases, and all related to the breeding techniques. In the third meeting, participants learnt and practised their first box of superworm breeding (approximately a population of 50 adult superworms). In the last week's meeting, the team handed in the participants the second questionnaire. Almost the same questions were asked back to the participants after attending the training to measure the participants' knowledge as an indicator of the success of the activity. Evaluation and monitoring were carried out through assistance in the implementation and practice of cultivation activities by training participants from February to March 2023. More details regarding the stages, activities, and indicators of program success are presented in Table 1.

Table 1. Phases, Activity, and Success Indicators of Program Implementation

No	Phase	Activities	Success Indicator
1	Preparation	Coordination Socialization Material, Tool, and Equipment Preparation Schedule and Location Agreement	Completing permits, training materials, tools and equipment, as well as the required supporting documents.
2	Implementation	Knowledge Identification Training and Demonstration of Breeding technique	Knowledge data. Training is implemented.
3	Evaluation and Monitoring	Questionnaire filling before and after training Assistance for the breeder from breeding activities to product marketing	Participants' knowledge increases (see a score increase) after training. Participants practice superworm breeding by utilizing papaya stems as a feed alternative.

RESULTS AND DISCUSSION

Preparation Phase

In the initial phase (preparation), the team coordinated with the participants to prepare the tools and materials needed for training. Some materials such as papaya stems and carpentry tools for superworm nests such as hammers, nails, and saws were prepared by the participants collectively. Meanwhile, the main materials for breeding, starting from superworm eggs, larvae, cocoons, and darkling beetles, were prepared by the team. The various phases of the superworm metamorphosis were deliberately presented so that participants understand the life phases of this animal. The superworm life cycle is indeed longer than the yellow mealworm (*Tenebrio molitor*). Its age can reach 1 year and will only become a cocoon if separated from other larvae. In crowded conditions in the nest, superworm tend to not pupate and stay in the larvae phase until death (Kim et al., 2015).

Implementation Phase

At the initial meeting (first training), the team distributed questionnaires to participants containing 20 questions about superworm farming, breeding, benefits, and prospects. Furthermore, training was continued by making shelves and nest boxes which took about 3 hours. The team showed an example of a superworm nest box made of wood, measuring 50x100 cm. One nest box can contain 800 to a maximum of 1000 beetles or superworm larvae. Participants may adjust the size of the box according to the needs and availability of land, considering that size. Boxes with dense populations are not suitable for superworm growth in the larval or other stages. According to research, yellow mealworms seemed to be more suitable for farming at high larval density compared to superworm (Zaelor & Kitthawee, 2018). Interesting questions from participants related to determining harvest needs. The team explained the parable of harvest needs, for example harvesting every 15 days, then during the 90-day production period 24 boxes are needed. This is based on the consideration of 90 days divided by 15 days and then multiplied by 4 boxes per harvest. Once all the boxes have been harvested, the cycle repeats.

The box for the beetles can be made slightly smaller (by 2-5 cm on each side) than the box for the larvae with the same number of beetle populations as the larvae. The height of the larvae (or beetle) boxes can range from 12-15 cm. The base or bottom of the box can be made of plywood. In order not to take up too much space, nest boxes can be arranged vertically on shelves with about 16-20 cm between boxes for air circulation. An example of boxes of nests made together by the team and participants is shown in Figure 2 and the rack arrangement (shelves) is shown in Figure 5. The box frame was not only nailed but also resealed with duct tape to keep it secure.

Figure 2. Several tools and equipment for the training

The team suggests placing the shelves in a safe place in the room. Both larvae and superworm beetles are a favourite food for several household animals such as ants, rats, and geckos. Security from ants can be done by smearing oil on the pillars supporting the rack. Mousetraps can be placed in several locations around the shelf. Plastic gauze as a cover for nest boxes can also be a solution so that geckos do not prey on beetles or superworm larvae. Additional information was provided by the team to the participants regarding the use of banana stem fronds on the sides of the nest box to maintain moisture and heat absorption around the box.

Figure 3. The Superworm Beetles and Larvae are eating Papaya Stem

In the second meeting, training was started with a description of various feeds for superworm. Generally, superworm breeders feed pollards for superworm beetles and larvae (Rohman et al., 2022). Pollard is a by-product of the agricultural industry from milling wheat. The team suggested pollards should still be used as feed plus the utilization of papaya stem waste. The feeding of the pollard and papaya stem is adjusted to the number of colonies in the nest. Such a combination of feed will provide sufficient nutrition for superworms (Harsanyi et al., 2020). Ideally, with a loading box size of up to 1000 larvae or beetles, up to 400 grams of papaya stem pieces can be given per feeding time. Figure 3 shows both beetles and larvae which immediately eat papaya stem pieces that are in their nests.

Some of the participants asked about giving this animal a drink. Superworms do not drink water like large animals or humans. The drinking medium is in the form of feed that contains a lot of water, such as slices of carrot, unripe papaya, watermelon, or melon, which are only a small amount compared to the main feed earlier. The provision of additional feed which contains a lot of water must be adjusted to the needs and not excessive, ideally only given once in a while. Feed is considered finished when the colour looks black or when the superworms are no longer surrounding it. There are times when the feed provided is immediately used up without remainder by their colony, but there are other times when they will leave the feed when they are full. This means that the breeder must remove the feed from the nest and replace it with other feed at the next feeding time. Figure 4a shows the leftover uneaten feed of the papaya stem.

(a) (b)

Figure 4. (a) Feed Residue; (b) Superworm Manure

Of course, with the provision of food, these creatures will produce excrement, as shown in Figure 4b. If it is considered that there is enough excrement, the breeder should reduce it by sifting the excrement or manure from the superworm larvae or bettle. Once separated, about 200-300 grams of manure can be returned to the nest box along with the superworm larvae or beetles. This treatment is necessary so that the superworm does not feel foreign and still feels that the box is its habitat. Meanwhile, the manure that is no longer used can be collected in sacks or any media because of its extraordinary benefits as an organic fertilizer medium for various plants (Kosewska et al., 2022; Porzuc et al., 2022). The team also explained to the participants that these animals were interesting because even styrofoam could be occasionally given as feed and would not affect the superworm's health status (Zielińska et al., 2021).

The team distributed 50 larvae to each participant so they could practice breeding for 1 week until the next meeting. This was intended so that each participant can ask questions related to technical cultivation because of their own experience and were more confident about starting a superworm cultivation entrepreneur. Questions asked by participants in the third week of the training related to postharvest processing. Participants stated that they were quite satisfied with very simple cultivation and found no difficulties in its implementation. They were more focused on harvesting, marketing, post-harvest processing, and so on.

The team responded to participants' questions regarding harvesting and marketing. As exemplified in the training, each superworm nest box can contain 500 larvae, which at harvest can produce a minimum of 10 kg of larvae ready for marketing. The team advised participants to have at least 10 nest boxes, where a single harvest after 3 months of treatment will give a sizable yield. The estimated selling price per kilogram of superworm larvae was currently around IDR 40,000. Breeders can cooperate with several big superworm entrepreneurs, such as those in East Java and West Java, to deposit their harvested fresh larvae. Apart from selling fresh produce, superworms can also be sold in processed form. Superworm larvae can be oven-dried and sold in batch sizes to local animal markets as feed for a variety of animals, including poultry (Hopley, 2016). Overseas even superworms are consumed not only by animals but also by humans preceded by the roasting process (Żołnierczyk & Szumny, 2021). Apart from that, blanching treatments can also be carried out, which occurs during the roasting process of the superworm. According to Cacchiarelli et al. (2022), blanching treatments may increase the hygienic quality of superworm larvae, because the process has reduced loads of microbes and bacteria inside or attached to the larvae.

Evaluation and Monitoring Phase

The last week of the training was evaluating the participants' knowledge and skills. Therefore, the team distributed questions related to the training materials which consisted of questions regarding the life cycle of the superworm, making boxes of nests and shelves, feeding and drinking, treating and controlling pests, harvesting and postharvest processes, and marketing the products. The results of this evaluation show an increase in participant scores compared to before the training, as shown in Table 2.

Table 2. Participants' Evaluation Results Before and After The Training

NO	Question Topic	Participants' Average Test Score	
		Before Training	After Training
1	Superworm Life Cycle	45.00	85.00
2	The Making of Nests and Shelves	40.00	90.00
3	Feeding and Drinking	60.00	90.00
4	Treating and Controlling Pests	60.00	85.00
5	Harvest and Postharvest Process	50.00	80.00
6	Marketing Product	40.00	95.00
	Average Overall Score	**49.17**	**87.50**

Figure 5. Boxes of Nests and Shelves Made by a Trainee

In addition to evaluating the results of the training, the team also monitored the implementation of the results of the training in the initial efforts made by most of the trainees in superworm breeding. Figure 5 depicts the pride of a participant who succeeded in making nests' shelves and the first larvae colony to start superworm breeding. The trainee in the picture and her family committed to breed more than 10,000 larvae and hence built a large vertical shelf as a new home of the larvae. The team regularly communicates and answers trainees' questions through social media groups and telephones, even after the training process ends. This is the team commitment so that the training participants apply their knowledge and skills and can generate additional income to increase household welfare. Moreover, the team monitored the papaya cultivation process and ensured that the participants continued to manage their papaya cultivation waste (papaya stem) for superworm breeding for the sustainability of both businesses.

CONCLUSION

This project aimed to utilize papaya stem waste and increase farmers' income through the introduction and training of superworm breeding. The implementation of training was conducted four times including the introduction and theory of superworm breeding, the practice, the evaluation, and monitoring. The trainees' knowledge of superworm breeding significantly increased after the training. The trainees also implemented their knowledge and skills in superworm breeding. The activity was proven to be beneficial for the social, economic, and environmental life of the trainees and hopefully to the targeted community.

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