



# Education and Training on the Production of Organic Fertilizers and Biopesticides for Cocoa Farmers in Pulukan Village, Jembrana, to boost organic cocoa production

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## A B S T R A C T

Pulukan Village, located in the Jembrana Regency of Bali, is one of the primary communities that produce organic cocoa. The huge demand for organic cocoa beans has not been satisfied due to the poor production per hectare. One of the causes is that cocoa farmers in the village have trouble obtaining the recommended volumes of organic fertilizers and biopesticides. To raise the yield of organic cocoa, this service is provided to farmers to enhance their knowledge and ability to create organic fertilizers and biopesticides from local components. The activities are implemented through counselling and training on producing organic fertilizers and biopesticides, followed by support in applying organic fertilizers and biopesticides. Participants in training and mentoring are encouraged to work together and learn concurrently. The implementation of the counselling on the production of organic fertilizers and biopesticides was excellent, as indicated by the fact that 93.33 per cent of participants said they comprehended the material presented very well, and 100 percent said it was fascinating and very beneficial. Participants could produce excellent organic fertilizers and biopesticides due to training activities involving direct practice. As a result of training in plots, organic fertilizers, and biopesticides can improve farmers' ability to directly implement fertilizing methods and disease pest management in organic cocoa farming. Applying organic fertilizers and biopesticides in the plot revealed that cocoa trees treated with organic fertilizers and biopesticides had greater growth and fewer disease-causing insect infestations than control trees. This motivated the service volunteers to implement the plot's best practices on their organic cocoa crops.

## 1. INTRODUCTION

### 1.1. Research Background

Pulukan Village, located in the Pekutatan District of Jembrana, is 26 kilometres from the Jembrana Regency seat and 80 kilometres from Denpasar. In 2021, Pulukan Village will have a total population of 4,767, composed of 2,379 men and 2,379 women, with an area of 3,548 acres. Based on the land use classification, the area of Pulukan Village is dominated by its designation as plantation land, which encompasses 2,982 ha, or 84.05 percent of the village territory, and cocoa is the predominant plantation product, covering 1,040 ha [1]. Due to the favourable topographical conditions for cocoa cultivation and production,

this community is one of the primary producers of organic cocoa in the Jembrana Regency.

Generally, cocoa planting in Pulukan Village is conducted organically. According to Widiastuti [2], the development of organic cocoa cultivation in Jembrana Regency, including in Pulukan Village, is due to the high demand of organic cocoa exporters and chocolate producers with raw materials for organic cocoa beans (chocolate = processed cocoa beans) from within and outside the country, such as France, Japan, Belgium, England, and various other nations, so that the profits obtained by organic cocoa farmers are significantly higher than cocoa non-organic farmers. For this reason, cocoa farmers are eager to participate in the organic cocoa certification program. However, despite obtaining the organic certificate, cocoa farmers cannot appropriately implement the organic cocoa farming method / Good Agricultural Practices (GAP). Thus, farmers' organic cocoa



production is still relatively low, ranging from 465 to 720 kg of dry beans per hectare per year, despite the production potential being 2,000 kg of dry seeds per hectare per year.

## 1.2. Research Background

Cacao (*Theobroma cacao* L.) is an important plantation product for the national economy, and Indonesia is currently the third largest cocoa producer in the world [4] behind Côte d'Ivoire and Ghana. Cacao is a raw ingredient in the agro-industry, particularly in the food and beverage, cosmetics, and medicines industries. Chocolate is the processed cocoa fruit favoured by consumers because it tastes nice, can be offered in a range of goods, and has significant health benefits such as reducing the risk of heart disease and enhancing relaxation and memory [5-6].

For Bali, cocoa is a critical regional plantation product with a significant economic value and an export commodity. The average annual Bali cocoa production during the last three years (2018-2020) has been 4,974 tons [7], while the average annual national cocoa production over the same period has been 238,000 tons [4]. Bali's cocoa production is among the world's finest fermented cocoa beans, according to the 2017 Cocoa Excellence Award, and has been certified as premium quality chocolate with a distinctively aromatic flavour (Fine Flavor Cocoa). With this predicate, exporters and chocolate manufacturers from France, Japan, Belgium, the United Kingdom, and other nations are willing to wait to acquire fermented cocoa from Bali [2].

The greatest barrier to cocoa growing on smallholder plantations in Bali is the extremely low average yield per hectare. The low productivity is attributable to cocoa farming typically being carried out on the arid ground by relying on irrigation from rainfall and inconsistent and imbalanced garden care [8-9]. In addition, cocoa farming in Bali is typically conducted organically to suit buyers' high demand for organic cocoa, so Subak Abian is competing to join the organic cocoa certification program. However, after obtaining the organic certification, farmers did not apply the organic cocoa cultivation method properly and correctly / Good Agricultural Practices (GAP), especially fertilization (the right type, dosage, time, place, and method), citing the difficulty of obtaining large amounts of organic fertilizer as recommended for cocoa, which is 15 tons per hectare per year [3], and also requiring a great deal of labour in transportation and application. With this kind of farming, cocoa is nutrient-deficient, and its yield is low.

Education and training on producing organic fertilizers and biopesticides from local materials are among the most promising strategies for resolving issues in organic cocoa farming so that farmers can easily access organic fertilizers and veggie insecticides. Through decomposition or fermentation, organic fertilizers are produced from residual organic matter from plants, animals, and natural organic waste. Biological processes interpret material with the aid of microorganisms (fungi, bacteria, or mold) and macroorganisms (earthworms) [10]. The advantage of organic fertilizer is that it enhances the concentration of organic matter and nutrients in the soil and improves the soil's physical, chemical, and biological properties [11]. Compared to chemical fertilizers, organic fertilizers have a greater variety of microelements. Organic fertilizers will sustain soil microbes, hence increasing soil fertility [12-13].

In addition to being environmentally benign, biopesticides used to manufacture organic cocoa plantations are inexpensive because not all of the ingredients are purchased but rather occur

naturally in the surroundings of organic cocoa farmers. In this service activity, local ingredients of Bali Spice herb (Bali Space botanical Pesticide) with a composition of tubers containing insect repellent and antimicrobial chemicals [14] are used to create vegetable pesticides for organic cocoa.

## 2. METHODS

As many as fifty organic cocoa farmers participated in the activity, which was carried out through counselling, training, and help in producing organic fertilizers and biopesticides. It included a detailed description of the procedures for conducting activities, strategies for producing organic matter and biopesticides, the necessary supplies, equipment, specifications, and photo/video simulations. Combining counselling activities with interactive conversations and debates with participants enables participants to comprehend and accept technological breakthroughs in producing organic fertilizers and biopesticides. The training was conducted one week after the counselling through direct practice by demonstrating how to create organic fertilizers and biopesticides utilizing local products. Dry goat manure, animal feed residue, fodder scraps and weeds, rice hulls, urea, and sugar are used to make organic fertilizer. At the same time, the ingredients for biopesticides include onion (*Allium ascalonicum*), garlic (*Allium sativum*), chilli (*Capsicum frutescens*), galangal (*Alpinia galanga*), kencur (*Kaempferia galanga*), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), lemongrass (*Aleiria mollucana*), chives (*Cymbopogon citratus*) (*Cinnamomum burwanii*). Participants were allowed to work independently and in groups during the training to enhance their abilities. Then, support is provided for applying organic fertilizers and biopesticides on the plot, i.e., fertilizing suitably with organic fertilizers from training and conducting pest control with biopesticides training outcomes correctly and adequately. Throughout the four months from May to August 2022, participants were asked to evaluate the impact of the application of organic fertilizers and biopesticides on the Plot compared to the control. Assistance in plotting aims to facilitate technology transfer (Technology Transfer) from the service team to participants, while participants are actively and creatively invited to work together (working with the community) to solve problems through the Problem-Based Learning (PBL) approach and learning by doing (LbD).

## 3. RESULTS AND DISCUSSION

Counseling on how to make, how to apply, and the benefits of organic fertilizers and biopesticides for soil and plant fertility is conducted to increase the understanding of organic cocoa farmers about the significance of organic fertilizers and biopesticides in organic cultivation and to increase their knowledge so that they can make organic fertilizers and biopesticides independently using local ingredients so that on the one hand, the needs of organic matter and biopesticides can be met. The evaluation findings demonstrated that the counselling participants participated in the counselling event with great zeal (Figure 1), resulting in their excellent comprehension of the offered material. This is demonstrated according to the results of the analysis of the questionnaire distributed during the counselling, 93.33 percent of the 30 respondents who filled out the questionnaire said they

understood the content presented very well, while the remaining 6.77 percent said they understood it well. In addition, one hundred percent of respondents indicated that the offered material was extremely interesting and valuable.

Training in producing organic manure is conducted using the fermentation process of composting. A preset mixture of dry goat manure, chopped leftover animal feed, chopped weeds and dadanan, rice husk, urea, and sugar is combined until

homogeneous, and water is added until wet. The biomass stack measures 3 m long, 1 m broad, and 1 m high (Figure 2). The organic raw materials are organized in one or more piles, each of which stands independently, with a 0.5 m gap between each pile. To keep the biomass pile warm, tarpaulin is placed over it and tied with raffia string. Once per week, the biomass mound is stirred.



**Fig. 1.** The participants enthusiastically followed the counseling exercise on how to create, utilize, and reap the benefits of organic fertilizers and biopesticides in organic cocoa farming.

Stirring is a necessary treatment in the composting process, with the goals of homogenizing the compost's maturity, dispersing excessive heat (reducing the temperature), infusing fresh air into the pile, equally distributing water, and aiding in the breakdown of the material into minute particles. With a shovel or hoe, the organic matter is stirred to mature and become uniform. To monitor the composting process following the requirements, biomass piles are routinely checked by monitoring the temperature of the biomass and visually examining the presence of moisture on the inside of the tarpaulin and changes in the colour of the biomass. The composting process is terminated when the compost has reached maturity, as evidenced by the compost's brown-black colour, the temperature near to the ambient temperature, and crumbly structure. The expected result of the composting process used as a criterion in training on making organic fertilizer through composting is that the color of the biomass is dark brown or close to the color of the soil, the temperature of the biomass is close to the ambient temperature, the structure of the biomass is crumbly or soft, C/N 15, pH is close to neutral, organic matter content > 5%, there are no pathogenic microorganisms, and composted organic fertilizer is suitable as a soil amendment.

The attendees took the instruction very seriously and passionately. The training results demonstrated that the created organic fertilizer met the criteria for a high-quality organic

fertilizer. The organic fertilizer obtained from the training was then applied to a demonstration plot while demonstrating proper fertilization techniques. Throughout the training and application in the demonstration plot, participants were encouraged to collaborate and work while learning, including watching and evaluating the success of adding biological fertilizers to the organic cocoa crop. Observations revealed that cocoa trees supplied with organic fertilizers grew more than the control trees (not fertilized with organic fertilizers). The attendees took the course very seriously and with great enthusiasm.

The training results demonstrated that the created organic fertilizer met the criteria for a high-quality organic fertilizer. The organic fertilizer obtained from the training was then applied to a demonstration plot while demonstrating proper fertilization techniques. Throughout the training and application in the demonstration plot, participants were encouraged to collaborate and work while learning, including watching and evaluating the success of adding biological fertilizers to the organic cocoa crop. Observations revealed that cocoa plants nourished with organic fertilizers saw superior development compared to the control trees (not fertilized with organic fertilizers).



**Fig. 2.** Preparing composting sites (A), mixing chemicals (B), obtaining ready-to-apply organic fertilizers (C), and applying organic fertilizers to a plot (D) are all components of organic fertilizer-making instruction (D).

From the collecting of materials to the application of training result on the plot, participants participated in the implementation of manufacturing biopesticides with a great deal of vigour and seriousness. The production of biopesticides begins with a list of materials, followed by mixing and hammering/blending until smooth. Once smooth, water is added and swirled until thoroughly blended. After that, the mixture is filtered with gauze. The filtered liquid is placed in sealed jerry cans for two to three days. The biopesticide can then be sprayed with 250 ml of biopesticide liquid dissolved once again in 1 litre of water. If the resulting biopesticide is to be stored for over six months, 1 litre

of 25% alcohol per 50 litres of biopesticide must be added. The resulting Bali Seasoning Vegetable Biopesticides can control pest and disease attacks through unique working mechanisms, such as damaging the development of insect pest eggs, larvae, and pupae, disrupting insect communication, inhibiting the reproduction of female insects, blocking the ability to consume insects, repelling insects, and inhibiting the development of disease pathogens [14]. Observations revealed that spraying the plot with biopesticides learned in training was highly efficient at controlling organic cocoa disease bugs (Figure 3).



**Fig. 3.** Ingredients for the production of biopesticides (A), stirring after finely ground and mixed with water (B), filtration with gauze (C), spraying biopesticides from training by farmers in Plot (D), young leaves of cocoa that were previously heavily attacked (E) grow healthy and free of pest disease attacks after spraying with biopesticides (F).

#### 4. CONCLUSION

Organic cocoa farmers gladly embraced the execution of advice on producing organic fertilizers and biopesticides. 93.33 per cent

of participants reported that they comprehended the material presented very well, and 100 percent reported that it was highly engaging and valuable. Instruction in producing organic fertilizers and biopesticides through hands-on practice; participants are encouraged to collaborate and work while

learning to create organic fertilizers and biopesticides proficiently. Using organic fertilizers and biopesticides can boost farmers' ability to directly implement fertilization methods and disease pest management in organic cocoa cultivation due to training in the field through the mentoring process. Observation and evaluation of the effect of fertilization and spraying biopesticides by Demplot demonstrated that cocoa trees given organic fertilizers and sprayed with biopesticides had superior growth and fewer disease pest attacks than cocoa trees not fertilized with organic fertilizers and not sprayed with biopesticides (control).

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