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Utilization of Sulfur and Zinc Fertilizers Combined with Local Compost in Farmer-Livestock Groups of Satwa Winangun, Tangkas Village, Klungkung Regency, Bali

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A B S T R A C T

Farmer-Livestock Group Satwa Winangun in Tangkas Village, Klungkung Regency, faces challenges in improving agricultural productivity and soil health due to excessive use of chemical fertilizers. This Community Service Program (CSP) aimed to introduce and implement the utilization of sulfur and zinc fertilizers combined with locally produced compost as environmentally friendly and sustainable alternatives. The program was conducted through training sessions, field demonstrations, and intensive mentoring for farmers. The results indicated significant improvements in soil fertility, plant growth, and production cost efficiency. Sulfur and zinc fertilizers enhanced soil structure and nutrient uptake, while local compost derived from village organic waste reduced waste and improved soil quality. Farmers began adopting these methods independently and demonstrated strong enthusiasm for sustainable agricultural practices. Overall, this program successfully empowered the farmer group through appropriate technology and the use of local resources. Beyond increasing agricultural yields, the activities also strengthened environmental awareness and encouraged farmer self-reliance in managing land productively and sustainably.

Contribution to Sustainable Development Goals (SDGs):
SDG 2: Zero Hunger
SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

1. INTRODUCTION

1.1. Situation Analysis

Tangkas Village, located in Klungkung District, Klungkung Regency, Bali Province, serves as the partner site for this community service program. With an area of 2.78 km², the village possesses considerable agricultural and livestock potential but faces challenges in waste management and improving community welfare. The leading partner in this activity is the Satwa Winangun Farmer-Livestock Group, comprising 25 members engaged in organic fertiliser production and Bali cattle breeding. The group's office is strategically located at the Bali Cattle Breeding Centre on Jalan Raya Tangkas, approximately 5 km from Semarapura city center and 35 km from Denpasar. Established in 2005 by I Ketut Darmawan, S.Pt., and I Nengah Sudarma, the group is officially registered with the Department of Animal Husbandry. According to the 2019 village profile, Tangkas has a population of 3,333 (834 households), with

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relatively low educational levels, dominated by primary and secondary school graduates. The main occupations include farming and cattle raising, followed by self-employment, services, and civil service. Most members of the Satwa Winangun group are tenant farmers and cattle breeders, while a small portion work as sand laborers.

Agriculture and livestock play a strategic role in improving rural welfare. One of the main challenges faced by farmers and livestock breeders is the practical, environmentally friendly use of fertilizers to increase agricultural productivity. Excessive use of chemical fertilizers often leads to land degradation and long-term reductions in soil fertility (1). The Satwa Winangun group is active in crop cultivation and livestock farming but continues to face challenges in optimizing fertilizer use.

To address these issues, the utilization of sulfur (S) and zinc (Zn)-based fertilizers, combined with locally produced compost, offers a sustainable solution. Sulfur and zinc play important roles in improving soil fertility and plant health, while local compost reduces reliance on chemical fertilizers and effectively utilizes organic waste. This community service program aims to educate farmers on the benefits and applications of sulfur and zinc fertilizers, train them in the production and use of local compost as an alternative organic fertilizer, and raise awareness of sustainable agricultural practices to maintain ecosystem balance.

Geographically, Tangkas Village has untapped potential, including rice fields, dryland farming areas, and grasslands that serve as both cattle feed and sources of organic fertilizer. However, the Satwa Winangun group has not yet produced high-quality organic fertilizer. Manure applied to group fields is often in raw form, creating unpleasant odors (1). Although members have used organic fertilizer in farming systems, management remains conventional, and no one has yet developed it into a primary source of income. Therefore, traditional practices should be modernized by empowering farmers to acquire skills in compost production from cattle manure and in organic vegetable cultivation, thereby increasing yield quantity and quality, as well as economic value.

Compound NPK fertilizers containing sulfur (S) and zinc (Zn) provide essential macro and micronutrients for plant growth. Sulfur contributes to amino acid and protein formation and supports photosynthesis, while zinc plays a role in enzyme synthesis, hormone regulation, and enhancing plant tolerance to environmental stress. The use of these fertilizers can improve agricultural productivity by enhancing soil quality and supporting optimal plant growth. The introduction of NPK fertilizers enriched with sulfur and zinc needs to be disseminated to farmers to encourage their adoption in cultivation practices (2)(3).

Organic fertilizers are rich in nutrients, and organic residues can also be used as animal feed. Crop residues, including fruit peels, contain cell wall components that are important energy sources for ruminants (4)(5)(6). However, anti-nutritional factors can be reduced through fermentation, which breaks down complex compounds into simpler forms with the help of microbes (7). Fermentation using banana corm extract and coconut water has been shown to improve crude protein and fiber content (8) significantly.

Compost is an organic product derived from the decomposition or fermentation of organic waste. Materials used include organic residues, pruned leaves and branches, and livestock manure. Compost application improves soil physical and chemical properties (9) and enhances plant growth (10)(11)(12)(13) (14). Through this community service program, farmers are expected to process organic waste into compost, thereby adding value and generating economic benefits while reducing dependence on chemical fertilizers.

1.2. Objectives and Expected Benefits

1.2.1. Objectives

The primary objective of this program is to enhance farmers' capacity to use environmentally friendly fertilisers and to strengthen their competitiveness in marketing agricultural products. This activity aligns with the Key Performance Indicators (KPI) in community service, particularly in improving community welfare through science and technology. The focus of this program is on community empowerment through continuous training and mentoring in agricultural production and marketing, intending to deliver tangible, sustainable impacts for the people of Tangkas Village.

Based on the problem formulation, the specific objectives of this activity are as follows:
1. To introduce information on sulfur and zinc fertilizers, which are increasingly applied to improve productivity and quality of various crop commodities.
2. To empower farmer groups to increase the added value of organic waste by processing it into organic fertilizer products.
3. To strengthen the partner group through training in business management and marketing of high-quality organic fertilizer products.

1.2.2. Expected Benefits

The expected outcomes of this program include:
1. Improved knowledge and application of sulfur- and zinc-based fertilizers to enhance the productivity of various crop commodities.
2. Increased skills among group members in producing organic fertilizer from organic waste, along with greater awareness of the added value and economic potential of environmentally friendly organic fertilizer products.
3. Enhanced community knowledge in business management and marketing of organic fertilizer.

2. METHODS

2.1. Place and Time of Implementation

The community service program was conducted at the Satwa Winangun Livestock Farmers Group, located in Tangkas Village, Klungkung District, Klungkung Regency, Bali Province. The site is situated at an altitude of approximately 100 meters above sea level. The program was carried out from April to November 2025.

2.2. Methodology

The Participatory Action and Learning System (PALS) method was employed in this community service activity at the Satwa Winangun Livestock Farmers Group in Tangkas Village, Klungkung District. This method aims to position the partner group as the central subject of the program through various approaches such as education, training, extension, coaching, and mentoring (14). The PALS method was implemented in several

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stages: (1) awareness, (2) capacity, (3) scaffolding, and (4) institutionalization (15,16,17).

The stages of the PALS method are described as follows:

1) Awareness Phase: This initial stage aimed to raise awareness among the target group about the application of nanotechnology fertilisers and the importance of processing agricultural waste into organic fertiliser with economic value, while simultaneously reducing environmental impacts. The approach used in this phase involved both personal and institutional engagement through focus group discussions (FGDs), enabling participants to gain a comprehensive understanding of the benefits of waste utilisation.
2) Capacitance Phase: This stage involved the partner group's active participation in managing and developing their organic fertiliser enterprise. Programs agreed upon with the partners were implemented through training, discussions, Q&A sessions, technology transfer for organic fertiliser production, and practical exercises in business management and marketing.
3) Scaffolding Phase: This stage consisted of continuous mentoring for the partner group during program implementation. Monitoring was conducted by the Community Service Institute of Warmadewa University, while evaluation was carried out by comparing indicators of success before and after program implementation. The review also analyzed shortcomings and challenges encountered during the process and identified solutions to ensure the program was effective, optimal, and synergistic.

2.3. Implementation of Activities

To ensure the smooth execution of the fieldwork plan, the following procedures were established, as illustrated in Figure 1. The stages of program implementation are explained as follows:

1) Site Assessment: Conducting initial visits and approaches with the local subak abian farmer group, followed by the selection of participants (target members) to be involved in the educational activities.
2) Interviews and Problem Identification: Exploring the challenges faced by participants while simultaneously conducting socialization and planning the program activities. The team provided participants with prepared materials.
3) Utilization of Available Tools and Materials: Empowering the use of existing resources to produce organic fertilizer (biofertilizer) through the application of appropriate technological packages.
4) Practical Knowledge and Technology Transfer: Introducing and applying nanotechnology fertilizers, along with the production of certified organic fertilizer products, validated through laboratory analysis.
5) Final Evaluation: Assessing the overall implementation of the program, from site assessment to the improvement of farmers' skills, competencies, and product value-added, which contributes to increased economic income for the partner group. The program concluded with the preparation and publication of outputs in targeted media or journals.

3. RESULT AND DISCUSSION

3.1. Result

This Community Service Program (CSP) was carried out at the Satwa Winangun Farmers and Livestock Group, Tangkas Village, Klungkung Regency, to increase agricultural and livestock productivity by utilizing sulfur and zinc fertilizers, as well as locally produced compost. The activity was motivated by the poor soil quality and farmers' limited access to expensive chemical fertilizers, requiring a solution based on local resources that is more economical and sustainable.

The program was implemented in several stages: socialization of the benefits of sulfur and zinc fertilizers, training in the production of local compost from organic waste, and direct assistance in applying the fertilizers to agricultural land and livestock pens. Farmers and breeders were actively involved in every stage, ensuring effective transfer of knowledge and skills. Monitoring was carried out periodically to evaluate the progress of agricultural yields and livestock health.

Figure 1. Documentation during material delivery, practice of local compost production, and handover of materials and tools at the CSP location of Satwa Winangun Farmers and Livestock Group, Tangkas Village, Klungkung, Bali

The results of the activity showed significant improvements in soil fertility and plant growth, especially in vegetable crops and animal feed. Sulfur and zinc fertilizers proved effective in improving soil structure and enhancing nutrient absorption. Meanwhile, locally produced compost from agricultural waste and livestock manure significantly reduced production costs and minimized organic waste in the surrounding environment (22).

The enthusiasm and participation of the farmers' group members were very high. They felt supported by the availability of cheaper, more accessible fertilizer alternatives. Some farmers

even began producing compost independently and selling it as an additional product. This activity also strengthened solidarity among group members in maintaining the sustainability of environmentally friendly agricultural practices.

Figure 2. Training and handover of compost-making materials at Satwa Winangun Farmers Group, Tangkas Village, Klungkung, Bali.

Overall, this CSP activity successfully provided tangible impacts on improving productivity and sustainability of farming and livestock businesses in Tangkas Village. It is expected that similar activities can be replicated in other villages with similar characteristics. Furthermore, continued support is needed in the form of intensive training, strengthening of farmer group institutions, and integration with local government programs to expand its benefits.

3.2. Delivery of Technology and Innovation Products to the Community

The CSP activities carried out at the Satwa Winangun Farmers and Livestock Group, Tangkas Village, Klungkung Regency, not only focused on increasing the capacity of farmers and breeders but also emphasized the aspect of delivery, namely the direct dissemination of technology and innovation products to the community. Delivery is essential to ensure that the research and development results of the CSP team are truly applied and deliver real benefits in the field.

The technology products delivered included formulations of sulfur- and zinc-based fertilizers designed to improve soil fertility and plant nutrient absorption efficiency. In addition, innovations in locally produced compost made from organic waste from the surrounding environment were introduced as environmentally friendly and economical alternatives. Both products were packaged in user-friendly forms, accompanied by technical guidelines and practical training modules.

The delivery process was carried out through several strategic stages: (1) technology socialization to target groups, (2) intensive training and field demonstrations, (3) distribution of fertilizer and compost starter kits, and (4) direct assistance in applying the technology to agricultural land and livestock farming. This approach was designed so that the community not only received the products but also understood the scientific principles behind them and could develop them independently according to local needs.

Community response to the application of this technology was very positive. Farmers and breeders showed strong enthusiasm for participating in training and for directly testing the products provided. Some group members even began producing compost independently and turning it into an additional product for sale, demonstrating that the innovations delivered had been successfully adopted and sustainably utilized.

With the delivery of technology and innovative products, CSP activities not only served as an educational medium but also served as a bridge between the academic world and the community's real needs. This success highlights the importance of synergy between technological development and appropriate delivery strategies so that innovations can truly address local challenges and directly improve community welfare.

3.3. Technology and Innovation Products

To support improvements in productivity and efficiency in farming and livestock businesses at the Satwa Winangun Farmers and Livestock Group, Tangkas Village, Klungkung Regency, this CSP activity adopted a delivery approach for technology and innovation products divided into two main categories: Hard Technology and Soft Technology. These two approaches were designed to complement each other, so that the community not only received physical products but also gained understanding and skills to manage them independently and sustainably.

3.3.1. Hard Technology

Complex Technology refers to physical products and tools delivered directly to the community because of technological

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innovation. In this activity, the forms of complex technology delivered included Sulfur and Zinc Fertilizer Formulation, Locally Produced Compost, and the Technology Starter Kit.

Delivery of complex technology was carried out through direct distribution, field demonstrations, and joint practice at agricultural and livestock sites. This aimed to enable the community to adapt the technology to their local conditions immediately.

3.3.2. Soft Technology

Soft Technology encompasses knowledge, skills, and management systems delivered to the community to support the optimal use of complex technology. In this activity, the software delivered included: (a) Training and Education: Intensive training activities covering materials on the benefits of sulfur and zinc for plants, compost production techniques, as well as fertilization and livestock management based on natural nutrition; (b) Practical Modules and Guidelines: The CSP team prepared and distributed printed and digital modules containing technical steps, illustrations, and local case studies, enabling farmers to learn independently; (c) Assistance and Monitoring: Conducted periodically by the implementation team to ensure that the applied technology runs according to procedures and delivers the expected results. This assistance also serves as a consultation space for farmers to share challenges and their local innovations; (d) Strengthening Farmer Group Institutions: Through group discussions and networking facilitation, farmer groups were encouraged to establish collective management systems for compost production and distribution, thereby creating independence and sustainability of the business.

With the combination of hard and soft technologies, the delivery of technology and innovative products in this CSP activity was not only a transfer of tools but also of knowledge and a creative culture. The community became active subjects in the process of change, and the technology delivered truly became part of a locally effective solution.

3.4. Application of Technology and Innovation to the Community (Relevance and Community Participation)

The application of technology and innovation in this CSP activity was designed contextually and participatively to address local needs and truly encourage active community involvement. This approach ensured that the technology delivered was not only theoretical but also practical and directly impactful in improving the quality of farming and livestock businesses.

3.4.1. Relevance

The relevance of applied technology was very high to the conditions and challenges faced by the Satwa Winangun Farmers and Livestock Group. Agricultural land experiencing fertility degradation, the high cost of chemical fertilizers, and the underutilization of organic waste were the main background for choosing sulfur and zinc fertilizers and locally produced compost as solutions. This technology was not only suitable for the agroecosystem characteristics of Tangkas Village but also easy to apply with the resources available in the surrounding environment. Thus, the innovations delivered had high utility value and long-term sustainability potential.

3.4.2. Community Participation

Community participation in this activity was very active and positive. From the initial stage of socialization to training and technology application, members of the farmers' group showed high enthusiasm and involvement. They were not only beneficiaries but also acted as implementers and developers of technology in the field. Group discussions, hands-on practice, and joint evaluations became interactive spaces that strengthened the sense of ownership of the innovations delivered. Some members even initiated independent compost production and shared knowledge with other farmers in nearby villages, showing that participation had evolved into a collective movement that expanded the impact of CSP activities.

3.5. Impact (Usefulness and Productivity)

The CSP activities carried out at the Satwa Winangun Farmers and Livestock Group, Tangkas Village, had a tangible impact on increasing the usefulness of technology and the productivity of local farming and livestock businesses. This impact was not only short-term but also opened opportunities for sustainability and independent development of local innovations.

3.5.1. Usefulness

The use of sulfur and zinc fertilizers and locally produced compost provided direct benefits to farmers and breeders. Agricultural land that was previously less fertile showed improvements in structure and nutrient content, leading to healthier, more uniform plant growth. Local compost also helped reduce dependence on chemical fertilizers while addressing unmanaged organic waste (23). Beyond agronomic benefits, this activity also provides social benefits, including increased knowledge, skills, and community confidence in managing local resources productively.

3.5.2. Productivity

In terms of productivity, yields of vegetable commodities and animal feed increased when tested with innovative fertilizers and compost. Breeders also reported improvements in feed quality and livestock health, resulting in better growth and optimal livestock weight. Some group members began developing compost businesses as economic ventures, demonstrating that CSP activities not only improved agricultural productivity but also opened new economic opportunities through local innovation. Overall, the activity succeeded in creating a more efficient, independent, and sustainable agricultural and livestock ecosystem. The resulting impact demonstrated that appropriate, participatory technology approaches could address local challenges with relevant, far-reaching solutions.

3.6. Outputs Achieved

The Community Service Program (CSP) carried out at the Satwa Winangun Farmers and Livestock Group in Tangkas Village produced significant and sustainable outputs. These outputs reflected the program's success in transforming academic innovations into real solutions that directly impacted the community.

4. CONCLUSION AND RECOMMENDATIONS

4.1. Conclusion

Based on the implementation of the Community Partnership Program (CSP) with the Satwa Winangun Livestock Farmers Group in Tangkas Village, Klungkung Regency, Bali, the following conclusions can be drawn:

1. The application of sulfur and zinc fertilizers contributed significantly to sustainable agricultural practices by enhancing plant growth, improving the nutritional quality of agricultural outputs, and rehabilitating soil structures in previously less fertile areas.
2. The development of locally produced compost from village-based organic waste proved effective as an environmentally friendly, economically viable, and community-driven alternative to conventional organic fertilizers.
3. The program strengthened capacity building among farmer group members, particularly in fertilizer processing, balanced fertilization techniques, and the use of local resources to enhance agricultural productivity.
4. There was a notable increase in environmental awareness and community empowerment, particularly in waste management and the conversion of organic materials into valuable resources.
5. The partnership between the CSP implementation team and the farmer group was characterized by active participation, transparent communication, and collective commitment, reflecting a successful model of collaborative rural development.

4.2. Recommendations

To ensure sustainability and scalability of the program outcomes, the following recommendations are proposed:

1. The livestock farmer group should consistently integrate sulfur, zinc, and locally produced compost into feed crop cultivation as part of sustainable farming practices.
2. Advanced training programs are recommended to further enhance capacity building, focusing on fertiliser formulation, appropriate application techniques, and monitoring impacts on livestock productivity.
3. Local government and relevant agencies should provide policy support and facilitation, including access to raw materials, production equipment, and market linkages, thereby strengthening institutional frameworks for community empowerment.
4. Institutional strengthening of the farmer group is essential, encompassing systematic documentation of activities, establishment of organic fertilizer business units, and development of external partnerships to foster resilience and sustainability.
5. Replication of the program across other farmer groups in Klungkung Regency could serve as a strategic pathway to advancing food security and promoting a locally rooted, integrated livestock-based economy.

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