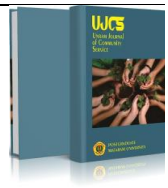
UJCS 6(1) (2025)

Unram Journal of Community Service

https://jurnalpasca.unram.ac.id/index.php/UJCS



Innovation of Silicon Fertilizer Based on Agricultural Waste to Address Fertilizer Scarcity in the Harapan Jaya Farmer Group, Pamekasan

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Received: January 9, 2025
Revised: March 13, 2025
Accepted: March 25, 2025
Published: March 31, 2025

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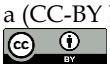
DOI: 10.29303/ujcs.v6i1.846



Abstract: The relatively high price of inorganic fertilizers means that members of the Harapan Jaya Farmer Group are unable to optimally meet their fertilizer needs. On the other hand, farmers have not been able to process their agricultural waste properly which is generally only by burning. This method is not environmentally friendly because it can pollute the air, lose its nitrogen content and kill soil organisms that are useful for plants. In fact, there is no return of crop residues to the land. This condition can cause soil fertility to decrease and requiring more fertilizer inputs. This additional input has an impact on increasing the cost of farming. To solve above problems, this community service program had been undertaken in April to November 2024 through counseling, training and mentoring to farmers who are members of the farmer group as the partner in this program. The focus of this program was mainly on the management of gramine crop waste such as rice and corn which absorb very high silicon element. The results of this service showed that the training participants were very enthusiastic in attending the counselling and could absorb the presented materials. Almost all participants were able to overcome the techniques or methods in the process of making silicon fertilizer during the training. In addition, they were also very interested in trying the fermented and well-designed fertilizer based on the respondent's assessment. However, applying fertilizer in the form of demo plots requires separate planning in the future because the process of making silicon fertilizer takes very long time.

Keywords: Farmer group; Silicon fertilizer; Agricultural waste.

Introduction

According to its use, the land area of Panaguan Village, Larangan Subdistrict, Pamekasan Regency is 202.25 ha, consisting of 140.00 ha of paddy fields, 39.10 ha of dry land, 0.00 ha of wet land, 9.45 ha of plantations, 13.70 ha of public facilities, 0.00 ha of forest. The 140.00 ha of paddy fields consist of 65.00 ha of technically irrigated rice fields which are currently no longer functioning because the river water source does not flow in the dry season and 75.00 ha of rainfed rice fields. In addition, the groundwater level is getting deeper due to the proliferation of boreholes for all purposes (Ministry of Home Affairs, 2018).

In line with the above conditions, the percentage of the total population based on their livelihood is dominated by farmers/farm labourers (Ministry of Home Affairs, 2018). Furthermore, according to the

How to Cite:
Sundahri, Azmi Saleh, Restiani Sih Harsanti, Indri Fariroh and Denna Eriani Munandar, Hudzaifah Musyaffa', Frisco Sendy Pramudya, Hadi Suwono, Henny Diana Wati, Fathoni Ilham Maulidi, Aulia Febrina Maharani (2025), Innovation of Silicon Fertilizer Based on Agricultural Waste to Address Fertilizer Scarcity in Harapan Jaya Farmer Group, Pamekasan, *Unram Journal of Community Service* 6(1), 1-8 https:/doi.org/

Panaguan Village profile, farmers/farm labourers make up 38.75% of the total population of 2,747 people (Sid.Kemedesa.go.id, 2024). The rest are civil servants 4.5%, farmers 4.1%, police 0.1%, self-employed 17.0%, unemployed 13.6%, housewives 13.6%, village officials 0.7%, and honorary employees 7.7%.

Based on the SDGS score, Panaguan Village is classified as low because it has a score of 48.14 although it is slightly higher than the national average score of 46.05. Panaguan Village's very low SDGS score is found in 4 Goals, namely: Villages Without Poverty at 15.65, Equitable Economic Growth at 23.82, Village Consumption and Production at 15.00, and Villages Caring for the Land Environment at 24.15 (Sid.Kemedesa.go.id, 2024).

SDGS Goals Village Consumption and Production has the lowest value. This shows that the level of production and purchasing power of the community is still very low, where most of them are farmers/farm labourers. Actually, to increase the production of their farms, institutionally, farmers form farmer groups, as a forum for exchanging information, knowledge and technology as well as farm business management. The farmer group has 49 active members with 10 administrators (Poktan Harapan Jaya, 2021). However, currently, Poktan Harapan Jaya members have several obstacles in fulfilling their needs for inorganic fertilizers and synthetic pesticides. This is because the price is relatively expensive, making it difficult for farmers to This is because the price is relatively expensive so it is difficult for farmers to afford it. This condition can reduce the productivity of their farming business. In addition, most of the land is rainfed, so productivity is even worse. This in turn leads to a decrease in farmers' income.

In addition, farmer partners in controlling pests and plant diseases are not fully environmentally friendly and do not guarantee consumer health. Meanwhile, costs for controlling pests and diseases occupy the highest portion compared to other production facilities. Besides that, inorganic fertilizers are sometimes difficult to obtain on the market. Another problem is that the Poktan members of this service partner have not been able to process their household waste and agricultural waste properly so that they pollute the surrounding environment due to the odor they cause and the smoke from their combustion which has the potential to contribute to global warming (Sid.Kemedesa.go.id, 2024).

The solution above problems, especially to process agricultural waste, particularly rice and corn waste. The plants can absorb relatively high amounts of silicon, especially the husk (Prayudo and Sundahri, 2022). This is very important if the waste is processed as a base material for silicon fertilizer, which is still rarely applied in Panaguan Village and villages throughout Indonesia. Whereas in developed countries, such as Japan, silicon fertilizer has been massively applied in their farms.

The problems faced by partners (Harapan Jaya Farmers Group) in Panaguan Village and have been agreed with the service implementers to be solved, namely: (1) Panaguan Village communities/farmers have not been fully able to process agricultural waste in accordance with SNI Organic Agriculture standards; (2) Panaguan Village farmers depends on the use of synthetic pesticides that have the potential to damage environmental sustainability and endanger the health of consumers and farmers who use them; (3) Low land productivity because in general Panaguan Village farmers' land is dry land or rainfed (4) Farmer's income is relatively low and vulnerable to production failure. To solve the above problems, it can be summarized in the following description where each problem faced by farmer group members is followed by the solution, the output and the benefits to be obtained, including:

1) Counseling, training and mentoring on environmentally friendly waste management into organic fertilizer integrated with the plan to establish a waste bank to process non-agricultural waste (Sekarningrum et al., 2017).
2) Counselling on organic farming system procedures in accordance with Indonesian national standards (Hoesain et al., 2020).
3) Counselling on the use of silicon fertilizer to reduce the use of synthetic pesticides.
4) Extension of the application of organic farming systems and production management and marketing of organic silicon fertilizer produced by partners as a form of business (Permana et al., 2020; Ebrilyani et al., 2023).

Method

In order to achieve the objectives of this community service program, it is necessary to conduct extension, training and mentoring to partner farmer groups. The activities include: (1) counselling on the management of processing agricultural waste into organic silicon fertilizer; (2) training and assistance in making and applying vegetable/organic silicon fertilizer, (3) counselling on organic farming systems in accordance with Indonesian national standards; and (4) counselling on production management and marketing of organic silicon fertilizer. Each of the extension, training and mentoring programs is explained in detail in the following description.

1) Counselling on the management of processing agricultural waste into organic fertilizer

This program involved farmers who are members of the Harapan Jaya Farmers Group and the community in general, especially community leaders, so that the objectives of this program could be achieved effectively. In addition to educate how to process agricultural waste, the program also sought the way to change the tradition of littering around their homes. Therefore, the involvement of community leaders as role models for the community was expected to enlighten the community about the impact of littering and how to process waste into fertilizer through the knowledge gained from the extension program. The number of participants in this extension program was 23 people including 2 students of the Agronomy Study Program, Faculty of Agriculture, University of Jember and a photographer/videographer. In this program, the partners provided the facilities and infrastructure as well as the venue.

In this extension program, farmers were also taught about the impact of using synthetic pesticides on the health of farmers, the environment and consumers. Materials on integrated pest management were also provided in this extension program in order to create a balance of ecosystems and environmental sustainability.

2) Training and assistance in making and applying silicon fertilizer

This training and mentoring program involved farmers who are members of the Harapan Jaya Farmer Group. The number of participants in this extension program was 23 people. In this program, partners were also willing to provide facilities and infrastructure as well as a place for training and mentoring extension.

Training and mentoring programs for farmer group members on how to make and apply organic silicon fertilizer and how to apply it to plants (Basuki et al., 2022). The program also introduced the potential of plants that have the potential as a basic ingredient for making organic silicon fertilizer. Schematically, the manufacture of vegetable silicon fertilizer derived from agricultural waste is summarized in the following diagram.

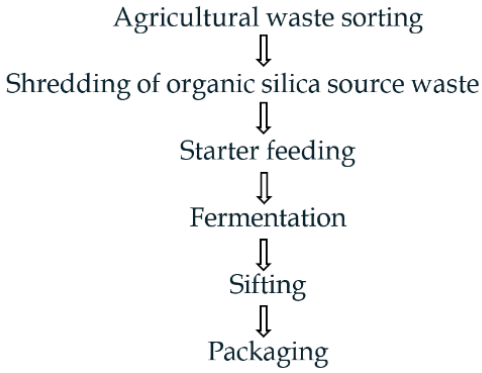


Figure 1. Schematic silicon fertilizer manufacture

3) Counselling on organic farming systems that comply with Indonesian national standards

This program also involved farmers who are members of the Harapan Jaya Farmers Group in Panaguan Village, which was a partner in this service. The number of participants was around 25 people. As in the previous program, partners were also willing to provide facilities and infrastructure as well as a place for extension. In this extension program, farmers were taught the material of the Indonesian national standard of organic agriculture which is a reference for the implementation of organic farming systems in Indonesia (Hasanah et al., 2023). Schematically, this program is illustrated in Figure 2.

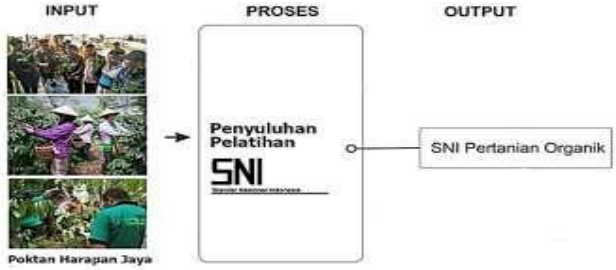


Figure 2. Organic farming system according to SNI

Through the above program, farmers were expected to have a sufficient basis of understanding to legally certify their farming business into national standard organic agricultural products so as to increase their economic value.

4) Extension and training on production management and marketing of organic silicon fertilizer

The organic silicon fertilizer production and marketing management extension program would aim to increase farmers' income if they pursued the silicon fertilizer business later. In this program, farmers who are members of the Harapan Jaya Farmer Group were trained on how to manage an organic silicon fertilizer production business especially how to package and market the organic

silicon fertilizer produced in the future.

Evaluation

The above programs were evaluated to determine their success in various ways such as: the number of active participants, participants' absorption of extension materials, participants' skills in training and the percentage of trainees who were interested in applying silicon fertilizer to their farming businesses and also the packaging that has been designed.

Sustainability Plan

To maintain the sustainability of the program that had been implemented, monitoring was carried out both directly and indirectly on the application of the results of the extension, training and mentoring that had been undertaken. This was certainly inseparable from efforts to advance the village community of origin. In addition, through the application of organic silicon fertilizer business carried out by farmers would automatically always provide or meet their own fertilizer needs for their farming business (Ramadhani et al., 2024). Thus, dependence on inorganic fertilizers was expected to be reduced step by step so that in the end it could encourage the creation of organic independent villages, especially in meeting the needs of fertilizers for their farming businesses and the needs of farmers in surrounding villages.

Result and Discussion

The first activity in the form of coordination with partners, namely the Harapan Jaya Farmer Group, Panaguan Village, Larangan District, Pamekasan Regency was had been undertaken on 27-29 May 2024; as indicated in the assignment letter from the Head of LP2M University of Jember number 04443/UN25.3.2/PM/2024 issued on 22 May 2024. The activities include: preparation of counselling and training, especially regarding the provision of materials and tools used in training. In this activity, a location survey was also carried out regarding the potential of agricultural waste which had a lot of silicon content. In general, the agricultural area in Panaguan Village is dry land. However, after the survey, it turns out that quite a lot of villagers grow rice. The farming activities are carried out mainly during the rainy season, namely in low-lying areas such as Sakaca Hamlet, which would be occupied by the extension and training program. Therefore, originally using corn waste, rice plant waste in the form of straw was an alternative to be used as a source or basic material for making silicon fertilizer. This was based on the results of research that had been done showing that straw contained a high amount of silicon, which was around 15-20%. However, based on the results of research also that rice husks contain much higher silicon. If the husk is burned, the silicon content in it can reach 90-98%. In the contrary to the Law on Environmental Protection and Management (PPLH) number 41 of 1999, burning agricultural waste is not justified because it can pollute the air and kill microbes in the soil, both beneficial and harmful microbes. Therefore, the practice of making silicon fertilizer was directed through a composting or fermentation process. Extension and training on the management of agricultural waste in the form of rice waste into silicon fertilizer had been conducted on 20-21 June 2024. The program had been carried out based on an assignment letter from the Head of LP2M University of Jember number 04906/UN25.3.2/PM/2024 issued on 7 June 2024. The event which was conducted in a hybrid manner (online and offline) attending by 23 (twenty- three) offline participants. The head and executive members of the service program attended in a hybrid manner, namely offline and online. While the chief executive attended offline because he was a native of Panaguan Village. While the implementing member of the service was present online because they were working on the task of preparing for accreditation of the Agronomy Study Program, Faculty of Agriculture, University of Jember, which could not be abandoned. Extension, training and mentoring activities are listed in Figure 3.

Figure 3. Extension and training on making silicon fertilizer

Most of the counselling and training participants came from Sakaca Hamlet, with 13 (thirteen) people. There were 2 (two) participants from other hamlets, namely Masaran Hamlet, 1 (one) from Sumber Hamlet, and 1 (one) from Alas Tenga Hamlet. The remaining 4 (four) people were PPLs (Field Agricultural Extension Workers) from Larangan subdistrict, 1 (one) official from Larangan subdistrict and 1 (one) person was the officer of Head of Panaguan Village. The core participants of the community empowerment program were the head and members of the Harapan Jaya Farmer Group and the field agricultural instructor of Larangan Sub-district. The field agricultural instructors were included in this

program because they are *agents of change in* the development of agricultural science and technology for farmers. They have a working area covering villages spread across the easternmost sub-district in Pamekasan District (bordering Sumenep District).

The material provided in the extension was in the form of organic waste management, especially agricultural waste that has the potential as silicon fertilizer material, the benefits of silicon fertilizer for monocotyledonous plants in tackling climate change (abiotic and biotic stress), as well as opportunities to produce silicon fertilizer for business and in order to meet their own needs. At the event, participants followed it with great enthusiasm. Each participant representative such as members of the Harapan Jaya Farmer Group, the officer of Head of Panaguan Village and field agricultural instructors of Larangan Subdistrict asked interesting and excellent questions in the discussion session. The moderator was the Head of Harapan Jaya Farmer Group who also serves as the Head of Private Senior High School of Miftahul Qulub Galis, Pamekasan.

The training program focused on how to make silicon fertilizer from agricultural waste such as rice straw. In the event, a chopping machine owned by the Harapan Jaya Farmer Group was used granting from a private university in Pamekasan several years ago. Actually, in this service program, a simple chopping machine would also be donated to speed up the fermentation process. However, because the partners already had the equipment, the plan was cancelled and instead provided transport money for the participants. Later during the training, the implementers used the equipment; on the other hand, found that it could not function properly. The results of chopping straw were large and difficult to cut, especially the leaves that had been lunged. However, the process was also assisted by the use of EM4 to accelerate composting but due to the large size, the fermentation process had not been completed until October (Figure 4). For this reason, the output of this activity in the form of silicon organic fertilizer based on agricultural waste has not been obtained until waiting for October 2024.

Figure 4. Straw cut with a large shredding machine

Overcoming the problems with the above tools, the implementer of this service program together with a field agricultural instructor disassembled the chopping machine. After disassembly, it turned out that there were problems with the shape, position and sharpness of the blades on both blades. Therefore, a set of chopping knives was taken to a workshop that was an expert in making disc-based knives and the both blades. Initially, the blades were to be replaced with steel from antique motorcycle discs. But after consultation, in terms of sharpness durability, the knife material had a longer durability than steel from discs. Disc steel only had the advantage of not rusting for a very long time. Therefore, in the end it was decided to keep the original blade material. The repair was done by refining and honing and positioning the blade close to the body of the chopping machine so that it had a scissor-like effect. Thus, after experimenting with the repaired and modified tool, the cutting results were so smooth that it could help shorten the composting process time. The improved chopping knife blade is shown in Figure 5.

Figure 5. Chopping machine knife blade that had been sharpened

The manufacture of silicon fertilizer was basically the same as the process of making organic fertilizer. The difference lies only in the materials used, namely using agricultural wastes that contain a lot of organic silicon. One of the common characteristics of plants that contained a lot of high silicon were plants that classified as monocots. The way to make it was by smoothing the plant waste so that the manufacturing process ran faster. To make agricultural waste-based silicon fertilizer, the following tools need to be prepared:

1. Cutting or chopping tools such as knives, machetes and the like.
2. A place to collect rubbish, which could be a bucket or something like that.
3. Stirring device.
4. The place to dissolve the waste with EM4 activator could be a bucket with small in the bottom and a lid.
5. Leachate collection bucket.

6. Gloves.

The materials that need to be provided in the manufacture of agricultural waste-based silicon fertilizer are as follows:

1. Agricultural waste from monocotyledonous plants such as: rice, sugarcane, elephant grass, bamboo, oil palm plants, reeds and so on.
2. EM4 (effective microorganism4) activator.
3. Molasses or brown/white sugar water or molasses.
4. Water.

The simple process of making silicon fertilizer is as follows:

1. Agricultural waste (straw) containing high silicon content was shredded; the smaller the size, the faster the decomposition process.
2. Leachate collection bucket was placed below where the waste was dissolved with EM4 activator.
3. The chopped rice straw was put into a bucket where the waste was dissolved with EM4 activator.
4. Molasses of approximately 250 cc was poured into the chopped straw.
5. EM4 activator was dissolved in water in a ratio of 1 : 50, then poured into the bucket where the chopped straw.
6. The mixture was stirred, then covered tightly; then stored in a shady place that was not exposed to rain.
7. Every 1 week stirred so that the composting process ran well.
8. The compost fertilizer would be ready for using usually at week 7-8.
9. The leachate collected at the bottom could be used as an organic silicon liquid fertilizer that was good for monocot plants such as rice, corn, sugarcane, oil palm and so on.

The production of silicon fertilizer until it was ready for use in this service program was very long even though it used microbial fermentation because the tools used were not sharp enough as explained above. In addition, the humidity of the fermentation room was too high which was very wet because one of the participants poured water in a volume exceeding its optimal size so that it could hamper the weathering process of the rice straw waste used. Therefore, to speed up the process dued to reporting and evaluation of activities, the organic silicon fertilizer that was originally designed to be solid organic fertilizer was converted into liquid organic fertilizer by means of a dissolving process as in the making of compost tea. Furthermore, the liquid silicon fertilizer was packaged in 500 ml packages (Figure 6).

Figure 6. Packaged organic silicon fertilizer

Overall, this service program had been carried out well in accordance with the planned program and based on the results of the evaluation that had been undertaken. About 85% of participants had understood the extension material provided and 95% of participants had mastered the skills taught in the training of making organic silicon fertilizer. During the counselling and training, the participants were also very active in asking weighty questions. Most of them were very interested in applying the fertilizer to their farms.

In addition, the evaluation of the results of the activity also assessed the packaging of the silicon fertilizer that had been made, where 78% of respondents rated the appearance of the packaging as very good and 21% as good (Figure 7a).

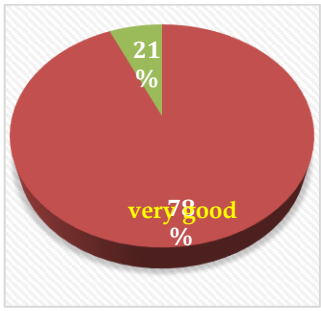


Figure 7a. Assessment of packaging appearance

A total of 86% of respondents gave a very good rating to the colour composition of the packaging. The remaining 14% of respondents rated the colour composition as good (Figure 7b).

Figure 7b. Assessment of packaging colour composition

As for the assessment of the packaging design, 93% of respondents rated it as excellent and 7% as good (Figure 7c).

Figure 7c. Assessment of packaging design

Conclusion

Based on the results of the service to farmers as members of the Harapan Jaya Farmer Group, it could be concluded that this activity program could generally be said to be successful where participants absorbed the extension material very well. In addition, almost all participants were able to carry out the process of making organic silicon fertilizer derived from agricultural waste, namely rice straw. They also tried to apply the fertilizer to their cultivated plants. However, due to time constraints, a demo plot on the application of the fertilizer produced needs to be provided in the next service program. For this reason, a laboratory analysis of the nutrient content of the fertilizer is necessary as the main requirement if the tested fertilizer is to be commercialised. This is because the Indonesian Ministry of Agriculture requires a minimum nitrogen content of 2% in fertilizer. To further increase the effectiveness of silicon fertilizer, it is also important to involve the use of microorganisms based on several researches by Andharesta and Sundahri (2024); Harsanti et al., (2024); Sundahri and Saputra (2025); Saputra et al., (2024); Sundahri et al., (2023) in future service programs as a mixture of silicon fertilizer produced when it is packaged where the packaging has been well designed as a form of pre-branding (Rahman et al., 2023) (Figure 6).

Acknowledgments

The implementers of this service program, the authors would like to express deepest gratitude to the head and members of the Harapan Jaya Farmer Group, the field agricultural instructors of Larangan Subdistrict who participated in the activities, Panaguan Village Officials and other parties involved directly or indirectly. Thanks a lot also to L2PM University of Jember for the financial support that had been provided through the Lecturer Grant to Serve in the Village of Origin with contract number 3569/UN25.3.1/LT/2024 dated on 20 March 2024.

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