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Eco-Friendly Fertilizer Shower Spreader from Maggot Waste: An Innovative Solution for Sustainable Agriculture in Rural Areas

Penyebar Pupuk Ramah Lingkungan Berbasis Limbah Maggot: Inovasi untuk Pertanian Berkelanjutan di Daerah Perdesaan

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Abstract*. This study presents an innovative granular fertilizer spreader made from maggot waste, designed as an appropriate technology to improve agricultural efficiency and sustainability in Karyasari Village. The development process, using a participatory approach and a descriptive-qualitative method, aimed to address the common challenge of organic fertilizer distribution, especially for farmers with large fields but limited physical capacity due to age or health issues. The tool leverages nutrient-rich maggot residue, or frass, to ensure more uniform and efficient fertilizer application across vast agricultural lands. By utilizing frass, the tool not only provides an environmentally friendly solution by reducing the use of chemical fertilizers but also supports sustainable farming practices. Field trials conducted in the village revealed significant positive impacts. The innovation reduced the time to harvest by up to two weeks and increased crop yields by 20–30%, demonstrating its effectiveness in improving both agricultural productivity and efficiency. Additionally, this tool offers economic benefits, as it minimizes reliance on expensive chemical fertilizers, which are often financially burdensome for farmers in rural areas. Beyond its practical application in farming, the tool contributes to ecological benefits by promoting the use of local organic waste, such as maggot frass, as a resource. This process not only supports the sustainability of agriculture but also empowers rural communities by reducing waste and creating a more circular and resilient farming system. The findings highlight the potential of integrating appropriate technology with local organic waste as a strategic and effective approach for fostering sustainable agriculture in rural areas, ultimately contributing to both economic and environmental development. This innovation demonstrates how technology can serve as a key driver of rural empowerment and sustainable agricultural practices.*

Abtrak

Penelitian ini memperkenalkan penyebar pupuk granula inovatif yang berbasis limbah maggot, dirancang sebagai teknologi tepat guna untuk meningkatkan efisiensi dan keberlanjutan pertanian di Desa Karyasari. Proses pengembangan alat ini menggunakan pendekatan partisipatif dan metode deskriptif-kualitatif, bertujuan untuk mengatasi tantangan distribusi pupuk organik, terutama bagi petani dengan lahan luas namun memiliki keterbatasan fisik karena faktor usia atau kesehatan. Alat ini memanfaatkan residu maggot yang kaya nutrisi atau frass untuk memastikan aplikasi pupuk yang lebih merata dan efisien di lahan pertanian yang luas. Dengan memanfaatkan frass, alat ini tidak hanya memberikan solusi ramah lingkungan dengan mengurangi penggunaan

pupuk kimia, tetapi juga mendukung praktik pertanian berkelanjutan. Uji coba lapangan yang dilakukan di desa menunjukkan dampak positif yang signifikan. Inovasi ini mempercepat waktu panen hingga dua minggu dan meningkatkan hasil panen sebesar 20-30%, membuktikan efektivitasnya dalam meningkatkan produktivitas dan efisiensi pertanian. Selain itu, alat ini memberikan manfaat ekonomi dengan mengurangi ketergantungan pada pupuk kimia yang mahal, yang seringkali membebani petani di daerah pedesaan. Selain aplikasinya dalam pertanian, alat ini juga memberikan manfaat ekologis dengan mempromosikan penggunaan limbah organik lokal, seperti frass maggot, sebagai sumber daya. Proses ini tidak hanya mendukung keberlanjutan pertanian tetapi juga memberdayakan komunitas pedesaan dengan mengurangi limbah dan menciptakan sistem pertanian yang lebih sirkular dan tahan banting. Temuan ini menunjukkan potensi integrasi teknologi tepat guna dengan limbah organik lokal sebagai pendekatan strategis dan efektif untuk mendorong pertanian berkelanjutan di daerah pedesaan, yang pada gilirannya berkontribusi pada pengembangan ekonomi dan lingkungan. Inovasi ini menunjukkan bagaimana teknologi dapat menjadi pendorong utama dalam pemberdayaan pedesaan dan praktik pertanian berkelanjutan.

Kata Kunci : Teknologi Tepat Guna, Pupuk Frass, Limbah Maggot, Pertanian Organik, Pertanian Berkelanjutan

1. BACKGROUND

Indonesia, as an agrarian country, relies heavily on the agricultural sector as the backbone of the rural economy. However, agricultural productivity in many regions remains suboptimal, mainly due to the manual distribution of fertilizers, excessive use of chemical fertilizers, and the low utilization of organic fertilizers. According to the 2019 Agricultural Census by Statistics Indonesia (BPS), fertilizer use among rice farmers in Indonesia is still dominated by inorganic fertilizers, accounting for approximately 86.41%, while the use of organic fertilizers stands at only 0.07%, and the combined use of organic and inorganic fertilizers at 13.5%. This indicates that organic fertilizers are scarcely used, reflecting the low adoption of environmentally friendly fertilization practices.

One potential source of organic fertilizer is the residue from maggot waste (larvae of the Black Soldier Fly). Maggots are capable of processing organic waste into nutrient-rich solid fertilizer, commonly known as *kasgot*. Studies have shown that *kasgot* meets the quality standards for organic fertilizer (NPK content > 2%, organic carbon levels between 6–7%) and can significantly improve crop yields. On a national scale, the consumption of organic fertilizers has increased over the years. BPS data reports that organic fertilizer consumption reached 88,148 tons in 2020, while the national demand exceeds 500,000 tons annually. This means that the fulfillment of organic fertilizer needs remains very limited. In reality, the potential for local raw materials such as agricultural waste, livestock manure, and maggot residue is substantial.

Nevertheless, the use of organic fertilizer continues to face challenges due to conventional and inefficient spreading methods. Most rural farmers do not have access to appropriate technologies that allow for the even and labor-efficient application of solid fertilizers. To address this issue, an innovative granular fertilizer spreader called the Fertilizer Shower was developed. This tool is designed to help farmers apply solid fertilizer made from maggot waste more efficiently, evenly, and with less physical effort. With the introduction of

this tool, it is expected that the use of organic fertilizers will shift from a marginal share (around 0.07%) to a more central role in village-based agricultural systems. Beyond its technical benefits, this innovation aligns with the principles of the circular economy and sustainable agriculture. Maggot waste, which was previously underutilized, can become a productive resource reducing environmental pollution while increasing the affordability and accessibility of fertilizers for farmers.

2. THEORETICAL STUDY

Appropriate technology is a type of technology designed to suit the needs, environmental conditions, and capabilities of the local community. In the context of rural agriculture, this technology aims to improve the efficiency of farmers' work without relying on high-cost or complex equipment (Sutrisno, 2020). The maggot-based granular fertilizer spreader tool falls under the category of appropriate technology, as it is designed with considerations for ease of use, low cost, and the potential to enhance agricultural yields. Fertilization is a crucial aspect of crop cultivation, as it serves to provide essential nutrients needed for optimal plant growth. Efficiency in fertilizer distribution is key to increasing productivity. The manual system commonly used by village farmers tends to result in uneven distribution and requires significant physical labor (Supriyadi & Rahardjo, 2019). Therefore, a fertilizer spreading tool is needed to ensure even application across agricultural land while minimizing labor intensity.

Organic fertilizer is derived from natural materials such as plant waste, animal manure, or decomposed organisms. One type of organic fertilizer with high added value is *kasgot* a solid fertilizer produced from the decomposition of organic waste by *Black Soldier Fly* (BSF) larvae, also known as maggots. Research by Nugroho et al. (2021) shows that *kasgot* contains essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as organic carbon content that meets organic fertilizer standards. Additionally, *kasgot* has a granular texture that makes it suitable for distribution using mechanical tools. In the design of agricultural tools, ergonomic aspects are vital to ensure that the tools are user-friendly, particularly in terms of body posture, lifting load, and motion mechanics. According to Widodo (2018), ergonomic tools can improve productivity and reduce farmer fatigue. The *Fertilizer Shower* fertilizer spreader is designed to be operated by hand or push mechanism, offering a lightweight and efficient solution for evenly distributing granular fertilizer. The utilization of organic waste into fertilizer by maggots supports the concept of the circular economy an economic system that maximizes resource use and minimizes waste. According to the Ellen MacArthur Foundation (2013), implementing a circular economy in agriculture can reduce

dependency on chemical inputs, extend the life cycle of organic matter, and enhance the sustainability of food systems. The innovation of this fertilizer spreader supports environmentally friendly farming practices and brings rural communities closer to the principles of sustainability.

3. RESEARCH METHODS

This community service activity employs a Participatory Action Research (PAR) approach combined with a descriptive-qualitative method**.** This approach was chosen because it involves the active participation of village officials and residents as the primary subjects, and it aims to describe the actual conditions and needs of the village based on the results of field observations**,** interviews**,** and documentation**.**

Time and Place

This research was conducted during July 2025 at several locations in Karyasari Village. The design and fabrication stage of the granular fertilizer spreader tool was carried out at the Student Community Service (KKM) Post of Group 48, which was equipped with the necessary tools and materials for assembling a simple prototype based on appropriate technology.v Meanwhile, the organic waste processing using maggot and fertilizer application trials were conducted in Karyasari Village, Sukaresmi Subdistrict, Pandeglang Regency, Banten Province. This location was chosen due to its high agricultural potential and the presence of community-based maggot cultivation already being practiced independently by local residents. Tool testing was conducted directly on farmers' fields, with horticultural crops such as mustard greens and water spinach serving as test subjects.

Target Audience

a Farmers and Farmer Groups in Rural Areas

Farmers are the primary target of this tool innovation, especially those who manage land manually and have limited access to agricultural technology. With this maggot-based fertilizer spreader, fertilization in community agricultural areas is expected to become more efficient and evenly distributed. Additionally, farmer groups as village-level farmer organizations can act as agents of technological dissemination, broadening the benefits and accelerating the adoption of appropriate technology in local agriculture.

b Village Goverments and Agricultural Departements

Village governments play a strategic role in supporting local innovations based on community needs. This study aims to support village food security programs,

environmentally friendly agricultural development, and community economic empowerment. Agricultural departments, both at the district and provincial levels, can also utilize the results of this research as a reference for the development of simple farming technologies, farmer training programs, and integration into agricultural aid programs for rural communities.

c Academics and Researchers

This innovation also targets academics and researchers interested in sustainable agriculture, waste management, and appropriate technology. This journal contributes to the scientific literature that explores the integration of simple technology and organic waste utilization. Through an interdisciplinary approach, this research can serve as a reference for further studies, student theses, or community service programs based on village potential.

d MSMEs and Social Enterpreneurs in the Agricultural Sector

The maggot-based fertilizer spreader also presents a business opportunity for micro, small, and medium enterprises (MSMEs) and social entrepreneurs operating in agriculture or waste processing. The simple production of this tool can be developed locally using easily sourced materials, thereby creating new economic value in rural areas. In addition to addressing farmers' needs, this innovation also supports entrepreneurship based on innovation and environmental sustainability.

Mandi Fertilizer Processing

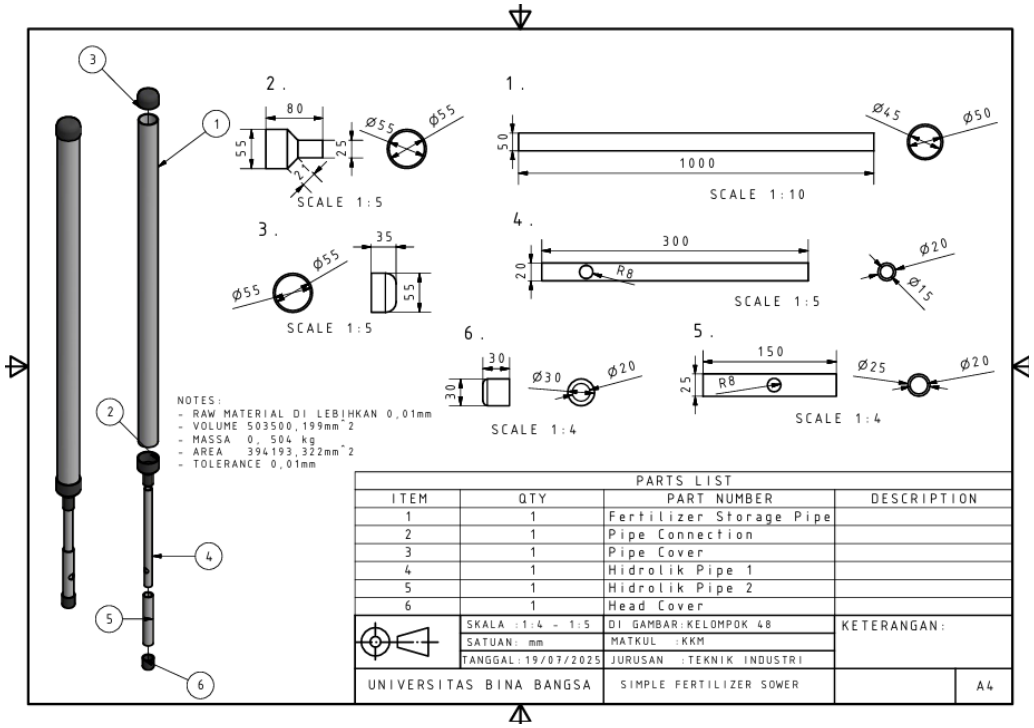

Figure 1. 2D Fertilizer Shower

The process of making the tool began with designing using 2D and 3D modeling software to determine the shape, capacity, and fertilizer spreading mechanism. The main materials used in the construction were PVC pipes, locking iron rods, and pipe caps. The tool was designed as a manual system so that it could be operated in narrow fields without requiring electrical power or fuel. The fertilizer distribution mechanism is gravity-based, with the addition of a simple spring to ensure smooth release of the fertilizer granules. This tool was tested on local farmland in Karyasari Village, with evaluation parameters including the spreading coverage area (in square meters), work time efficiency, and user comfort based on ergonomic testing. The trials were conducted repeatedly to obtain consistent and measurable results.

Figure 2. Assembly Process

Figure 3. Fertilizer Shower Product

4. RESULTS AND DISCUSSION

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Figure 4. Providing Tools to Village Farmers

Figure 5. Providing Tools to Village Farmers

The simple fertilizer spreader tool was developed based on the specific needs of the residents in Karyasari Village, identified through direct observation. The findings revealed that most villagers are farmers who are already familiar with fertilization practices, and many of them manage relatively large agricultural plots. As a result, fertilization requires significant labor, incurs relatively high costs, and is often time-inefficient. This simple tool was designed as a solution to these challenges by simplifying the fertilization process, making it faster and more efficient. This aligns with the findings of Waslah et al. (2021), who stated that the use of fertilizer spreaders can reduce labor burdens and improve application outcomes. Once the tool was constructed, it was demonstrated to local residents to explain its construction process,

benefits, and working mechanism. The demonstration utilized recycled materials such as PVC pipes (used as fertilizer containers), outlets, flow valves, and repurposed inner tire rubber. These materials formed the main structure of the tool. This design aims to assist farmers in improving the efficiency of their fertilization processes (Nasrullah et al., 2023). The tool is very easy to operate fertilizer is dispensed simply by applying downward pressure, with the quantity released depending on how long the tool is pressed. This function is particularly beneficial for elderly farmers, as it simplifies the fertilization task and ensures a more uniform distribution of fertilizer. According to Utomo et al. (2021), fertilizer spreader tools help reduce the risk of lower back injuries in elderly farmers and ensure better distribution through evenly spaced outlet holes.

Utilization of Maggot Organic Waste (Fertilizer)

Figure 12. Maggot Organic Waste

The fertilizer spreader developed by KKM students in Karyasari Village is a simple yet appropriate technology innovation designed to support environmentally friendly farming practices. One of the main advantages of this tool is its ability to evenly distribute organic fertilizer derived from maggot wast produced by local farmers through maggot cultivation. As documented in the image above, maggot farming generates organic residue known as *frass* (maggot droppings), which is rich in essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K).

This waste product has often been underutilized, even though it holds great potential as a natural organic fertilizer that can improve soil structure, increase land fertility, and reduce dependence on chemical fertilizers.

Using the simple fertilizer spreader, *frass* can be applied more efficiently and uniformly across farmlands and plantations. This technology is particularly helpful for farmers with large areas of land, as well as for elderly farmers who face physical challenges with manual fertilization. The results from using maggot-based fertilizer have shown significant improvements. Several farmers in Karyasari Village reported that vegetable crops such as chili, tomatoes, and water spinach grew more robustly, were more resistant to pests, and displayed better color and size. These crops even showed a 20–30% increase in productivity compared to previous yields. For fruit and staple crops like bananas and cassava, the use of maggot fertilizer helped accelerate harvest times by up to two weeks and increased the overall weight of the produce. Economically, using maggot fertilizer helps farmers reduce production costs, as they are no longer fully reliant on chemical fertilizers, whose prices can fluctuate unpredictably. Environmentally, recycling maggot waste into fertilizer reduces pollution and supports sustainable agriculture practices. Thus, the integration of maggot cultivation, waste processing into fertilizer, and the use of a dedicated spreading tool has created an efficient local eco-cycle that benefits Karyasari Village both ecologically and economically.

5. CONCLUSION AND SUGGESTIONS

The utilization of maggot waste as organic fertilizer and the use of the fertilizer spreader tool developed by KKM students in Karyasari Village demonstrate an effective, low-cost, and environmentally friendly *appropriate technology* approach. This process not only reduces organic waste but also enhances agricultural yields in a sustainable manner. The presence of this tool improves farmers' work efficiency, especially in achieving more even and faster fertilizer distribution, while also creating positive economic impacts by reducing reliance on chemical fertilizers. Thus, this innovation strengthens the cycle of sustainable agriculture at the village level. To enhance the impact of the fertilizer spreader innovation and the utilization of maggot waste as organic fertilizer, it is recommended that regular training sessions be provided to farmers on proper maggot cultivation techniques and the optimal use of the tool. The village government and relevant institutions are also expected to facilitate the mass production of this tool to reach more farmers and expand its benefits. Additionally, collaboration with educational institutions or agricultural agencies is necessary to develop more efficient versions of the tool that remain simple and cost-effective. Periodic monitoring and evaluation should be conducted to assess the long-term effectiveness of the tool and fertilizer on soil fertility and crop yields.

Finally, education on the importance of sustainable agriculture and circular economy practices should be strengthened, enabling the community to integrate organic waste utilization into their daily eco-friendly farming routines.

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