

Livestock Manure-Based Organic Fertilizer: Farmer Knowledge, Product Quality, and Spinach Growth Response

Andri Kusmayadi^{1*}, Ghaling Achmad Abdul Ghonisyah¹, Yusuf Sumaryana¹,
Yanti Yanti²

¹Universitas Perjuangan Tasikmalaya, Tasikmalaya, West Java, Indonesia

²Universitas Mayasari Bakti, Tasikmalaya, West Java, Indonesia

*Correspondence email: andrikusmayadi@unper.ac.id

ARTICLE INFO

Article history:

Received : 20 June 2025

Accepted : 30 July 2025

Available : 31 July 2025

Keywords:

Farmer knowledge; fermentation;
livestock manure; organic
fertilizer; spinach.

ABSTRACT

Livestock manure from poultry, sheep, and cattle in rural Indonesia is often left unprocessed and pollutes the environment, although it is a potential nutrient source for horticultural crops. This study aimed to examine the effect of participatory training on farmers' knowledge of manure processing, to evaluate the maturity of the fermented organic fertilizer produced, and to observe the growth response of spinach to its application. A quantitative descriptive study with a one-group pretest-posttest design was conducted in Sukanagalih Village, Tasikmalaya Regency, involving 28 livestock keepers and farmers. Data were collected using a knowledge test, a skill observation checklist, organoleptic and pH-temperature measurements of the fertilizer, observations of spinach growth up to 21 days after planting, and a questionnaire, and were analyzed using descriptive statistics and the normalized gain (N-gain) score. The mean knowledge score increased from 53.75% to 87.75%, with an N-gain of 0.74 (high category), and the greatest gain was in fertilizer production techniques. After training, 80% of respondents were able to produce the fertilizer independently. The 14-day fermentation produced a mature fertilizer that was blackish brown, crumbly, free of pungent odor, and had a pH of 6.5-7.2. Its application made the soil more friable and supported spinach growth compared with the control, and 70% of respondents intended to continue production. Participatory training effectively improves farmers' knowledge of manure processing, and on-farm fermentation of mixed livestock manure produces a mature organic fertilizer suitable for spinach, supporting integrated crop-livestock farming.



By Authors

This work is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

1. INTRODUCTION

The livestock and agricultural sectors are closely interlinked and play an important role in supporting food security and the economy of rural communities (Gustiani & Fahmi, 2022). In Sukanagalih Village, Rajapolah District, Tasikmalaya Regency, poultry, sheep, and cattle farming have developed considerably. However, these activities generate livestock manure that has not been used optimally. The manure is generally discarded or simply piled up around the pens, which causes unpleasant odors, increases fly populations, and has the potential to pollute soil and water.

At the same time, the need for organic fertilizer is increasing, particularly for horticultural crops such as spinach (*Amaranthus* sp.), which is widely cultivated in the area. Continuous long-term use of chemical fertilizers is known to reduce soil fertility, damage soil structure, and have negative effects on the environment (Faradiba et al., 2023). Livestock manure contains organic matter and plant nutrients such as nitrogen (N), phosphorus (P), and potassium (K) (Indrayani et al., 2025), and through fermentation or composting it can be converted into a valuable fertilizer that is safe for the environment (Dewi et al., 2025). Its use can reduce pollution while increasing the economic value of farm waste (Maghfuri, 2023).

Several studies have processed livestock waste into organic fertilizer at the farmer-group level (Dewi et al., 2025; Indrayani et al., 2025; Mufida et al., 2025). However, these reports tend to describe the implementation of activities, while changes in farmers' knowledge, the quality of the fertilizer they produce, and the response of crops to that fertilizer are rarely measured together within one study. In Sukanagalih Village, farmers' knowledge and skills in manure processing are still limited, and the quality of farmer-made fertilizer from mixed poultry, sheep, and cattle manure has not been assessed. This study therefore addressed three research questions: (1) to what extent does participatory training improve farmers' knowledge of manure processing; (2) does on-farm fermentation of mixed livestock manure produce a mature organic fertilizer; and (3) how does spinach respond to the application of this fertilizer? Accordingly, the study aimed to measure knowledge improvement using the normalized gain score, to evaluate the maturity characteristics of the fertilizer, and to observe spinach growth after application. The novelty of this study lies in its integrated assessment of the knowledge, product, and crop dimensions of manure processing in a smallholder integrated crop-livestock setting.

2. LITERATURE REVIEW

Livestock manure is one of the most widely available organic resources in rural areas. Bhunia et al. (2021) reviewed the agronomic efficiency of animal-derived organic fertilizers and their effects on soil biology and fertility, showing that manure-based fertilizers can serve both as a nutrient source and as a soil conditioner. In Indonesia, livestock waste has been processed into organic fertilizer to reduce planting costs (Indrayani et al., 2025) and into bokashi to strengthen the independence of farmer groups (Mufida et al., 2025), and various organic wastes have been converted into useful products to support sustainable agriculture (Dewi et al., 2025).

The quality of organic fertilizer is largely determined by the processing method. Fermentation with microbial activators accelerates the decomposition of organic matter and produces a stable product. Nufus et al. (2025) studied the fermentation process in producing a multinutrient fertilizer from organic waste, while Ariny and Nisa (2024) reviewed compost quality parameters obtained with different activators. Physical indicators such as color, odor, texture, temperature, and pH are commonly used as practical indicators of maturity, which makes them suitable for assessing fertilizer produced by farmers who lack access to laboratory analysis.

The application of organic fertilizer affects both soil and plants. Organic fertilizer has been reported to improve plant growth and soil quality (Zebua et al., 2025), improve soil structure and stability (Mendrofa & Gulo, 2024), and support soil microorganisms that play a role in soil health (Dohare et al., 2025). The availability of macronutrients and organic carbon in agricultural soils is closely related to soil chemical properties (Andira et al., 2022; Gobel et al., 2025). The effectiveness of organic, inorganic, and biological fertilizers on crop productivity has been compared (Lestari et al., 2024), and nutrient management has been shown to affect mineral accumulation in spinach (Das et al., 2025). Spinach growth also depends on environmental factors such as light intensity (Saputri et al., 2025).

The adoption of a new farming technology depends on how well farmers understand and practice it. Sustainable social innovation that involves communities from planning to evaluation can strengthen ownership and resilience (Jareh, 2025), and using waste as an input for other production activities is in line with the zero waste concept (Yuliardani et al., 2024). Learning gains from an intervention can be assessed with the normalized gain, which expresses the actual improvement relative to the maximum possible improvement and therefore allows groups with different initial scores to be compared (Hake, 1998). Based on these studies, participatory training was

expected to improve farmers' knowledge, fermentation of mixed manure was expected to produce a mature fertilizer, and its application was expected to support spinach growth.

3. METHODS

Research design and location. This study used a quantitative descriptive approach. Changes in knowledge were measured using a one-group pretest-posttest pre-experimental design, fertilizer quality was evaluated through observation and measurement, and the response of spinach was assessed by comparing fertilized and unfertilized plots. The study was conducted in Sukanagalih Village, Rajapolah District, Tasikmalaya Regency, West Java.

Population and sample. The population consisted of livestock keepers and farmers who are members of the Megar Bebek Cihateup group. A total of 28 respondents were selected purposively based on their involvement in livestock and/or crop farming and their willingness to take part in all stages of the study.

Variables and instruments. The intervention was participatory training on processing livestock manure into organic fertilizer, consisting of extension, hands-on practice, and mentoring. The observed variables were (1) knowledge, measured with a test covering four aspects (understanding of livestock manure waste, fertilizer production techniques, benefits of organic fertilizer, and environmental impacts of livestock waste) administered before and after the training; (2) skill, assessed with an observation checklist of the fertilizer-making procedure; (3) fertilizer characteristics, namely color, odor, and texture assessed organoleptically, pH measured with a pH meter, and temperature measured with a thermometer; (4) spinach growth, namely plant height and number of leaves; and (5) respondents' intention to continue production, assessed with a questionnaire.

Fertilizer production. The materials were livestock manure from poultry, sheep, and cattle, EM4 as an activator, rice bran, and water. The tools were fermentation drums, shovels, tarpaulins, and temperature and pH meters. The manure was collected and sorted, mixed with rice bran and the activator, and moistened with water to a moisture content of approximately 60%. The mixture was fermented for 14 days with periodic turning, and changes in color, temperature, pH, and odor were recorded as indicators of maturity.

Spinach trial. The fertilizer was applied to spinach beds at a rate of approximately 1-2 kg/m², while control beds received no fertilizer. Plant height and number of leaves were observed up to 21 days after planting (DAP), together with the general condition of the plants and soil.

Data analysis. The data were analyzed using descriptive statistics (means and percentages). Knowledge improvement was expressed as the difference between post-test and pre-test scores in percentage points and as the normalized gain, $g = (\text{post-test} - \text{pre-test}) / (100 - \text{pre-test})$, categorized as high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), or low ($g < 0.30$) (Hake, 1998). Fertilizer characteristics were compared with general standards for mature organic fertilizer, and spinach growth was compared between the fertilized and control treatments.

4. RESULTS AND DISCUSSION

Twenty-eight respondents completed all stages of the study. Their knowledge scores before and after the training are presented in Table 1.

Table 1. Respondents' Knowledge Scores before and after Training

Knowledge aspect	Pre-test (%)	Post-test (%)	Gain (pp)	N-gain (category)
Understanding of livestock manure waste	52	86	34	0.71 (high)
Fertilizer production techniques	48	88	40	0.77 (high)
Benefits of organic fertilizer	60	90	30	0.75 (high)
Environmental impacts of livestock waste	55	87	32	0.71 (high)
Mean	53.75	87.75	34.00	0.74 (high)

Note: pp = percentage points; N-gain category according to Hake (1998)

The mean knowledge score increased from 53.75% to 87.75%, a gain of 34 percentage points with an N-gain of 0.74, which falls in the high category. All four aspects reached the high category. The largest absolute gain occurred in fertilizer production techniques (40 percentage points; N-gain 0.77), which also had the lowest pre-test score. In contrast, the benefits of organic fertilizer had the highest pre-test score and the smallest absolute gain (30 percentage points), but its N-gain (0.75) was still high. This pattern indicates that respondents were already aware of the benefits of organic fertilizer before the training, whereas their main knowledge gap was procedural, namely how to produce the fertilizer. Hands-on practice in the participatory approach directly addressed this gap, which is consistent with the finding that 80% of respondents were able to produce the fertilizer independently after the training.

The fermentation lasted 14 days, and its success was indicated by a change in color to blackish brown, a crumbly texture, and the absence of a pungent odor (Marpaung & Simangunsong, 2025). The characteristics of the fertilizer produced are presented in Table 2.

Table 2. Characteristics of the Organic Fertilizer Produced

Parameter	Result	General Standard
Color	Blackish brown	Dark brown
Odor	Not pungent	Odorless
Texture	Crumbly	Crumbly
pH	6.5-7.2	6-8
Final temperature (°C)	28-30	Close to ambient

The fertilizer was blackish brown, crumbly, free of pungent odor, and had a neutral pH, and its final temperature had returned to near-ambient levels. These characteristics indicate that fermentation proceeded well and that the fertilizer had matured, consistent with general standards for organic fertilizer suitable for horticultural crops. The optimal fermentation was supported by the use of an activator and periodic turning. This result shows that a mixture of poultry, sheep, and cattle manure can be processed by farmers into a mature fertilizer with simple on-farm equipment.

The growth of spinach in the fertilized and control treatments at 21 DAP is presented in Table 3.

Table 3. Spinach Growth at 21 Days after Planting

Parameter (21 DAP)	Control	Organic fertilizer
Plant height (cm)	12-18	18-25
Number of leaves	6-8	8-11

Note: DAP = days after planting

Spinach that received organic fertilizer showed higher plant height and number of leaves than the control (Table 3), indicating that the manure-based fertilizer was able to supply sufficient nutrients for spinach growth. Field observations also showed that the fertilized soil had a looser structure than the control soil, which supports root development so that water and nutrients can be absorbed more effectively. These results are in line with reports that organic fertilizer improves plant growth and soil quality (Zebua et al., 2025) and that livestock manure, which is rich in organic matter, nitrogen, phosphorus, and potassium, is beneficial for plants (Mufida et al., 2025).

The effectiveness of the fertilizer can be explained in terms of nutrient availability and soil dynamics (Bhunja et al., 2021). Organic matter plays an important role in increasing the cation exchange capacity (CEC) of the soil, so that nutrients such as N, P, and K become more available and are less easily leached (Andira et al., 2022; Gobel et al., 2025). This contributes to more efficient nutrient uptake by spinach during the vegetative growth phase (Das et al., 2025). The improvement in soil structure also increases aeration and the

activity of soil microorganisms involved in the further decomposition of organic matter (Dohare et al., 2025).

The fermentation process generates beneficial microorganisms such as decomposer bacteria (Nufus et al., 2025). These microorganisms not only help the fertilizer mature but also remain active after application, accelerating the mineralization of organic matter into plant-available nutrients (Ariny & Nisa, 2024). Compared with inorganic fertilizers, organic fertilizer made from livestock manure has the advantage of maintaining the balance of the soil ecosystem (Lestari et al., 2024). Although plant responses to organic fertilizer tend to be more gradual, its long-term effects are more sustainable (Mendrofa & Gulo, 2024), which is important for horticultural crops such as spinach that require fertile and stable soil conditions (Saputri et al., 2025).

From a farming-system perspective, the results demonstrate the integration of livestock and crop production, in which livestock waste becomes an input for crop production, in line with the *zero waste* concept (Yuliardani et al., 2024). A total of 70% of respondents stated their intention to continue fertilizer production independently. Active participation at every stage of the study is likely to have strengthened respondents' sense of ownership (Jareh, 2025). Respondents also identified two obstacles: the fermentation period, which some considered too long, and variation in the quality of the manure, which may affect fertilizer quality.

This study has several limitations. The one-group design without a control group means that the knowledge gain cannot be attributed entirely to the training. Knowledge scores were analyzed at the aspect level, so inferential testing of individual scores was not performed. Fertilizer quality was assessed using physical indicators without laboratory analysis of nutrient content, and spinach growth was observed only up to 21 DAP. Future studies should use a controlled design, analyze the N, P, K, and C-organic content of the fertilizer, and conduct replicated field trials until harvest.

5. CONCLUSION

Participatory training effectively improved farmers' knowledge of processing livestock manure into organic fertilizer, with the greatest improvement in procedural knowledge of fertilizer production, and enabled most farmers to produce the fertilizer independently. On-farm fermentation of mixed poultry, sheep, and cattle manure with a microbial activator produced a mature organic fertilizer that met general quality standards, and its application supported spinach growth and improved soil friability. These findings indicate that farmer-produced manure-based fertilizer can link

livestock and crop production in an environmentally friendly integrated farming system. Further research should employ controlled designs, laboratory nutrient analysis, and replicated field trials through to harvest to strengthen the evidence on fertilizer quality and crop response.

6. REFERENCES

- Andira, U., Killa, Y. M., & Kapoe, S. K. K. L. (2022). Analisis sifat kimia tanah pada lahan pertanian di Kelurahan Kawangu Kecamatan Pandawai Kabupaten Sumba Timur. *Jurnal Agro Indragiri*, 7(2), 22–26. <https://doi.org/10.32520/jai.v7i2.2133>
- Ariny, M., & Nisa, S. Q. Z. (2024). Tinjauan terhadap parameter dan kualitas kompos organik perusahaan galangan kapal dengan penggunaan aktivator PROMI dan coenzymes. *Botani: Publikasi Ilmu Tanaman dan Agribisnis*, 1(2), 15–27. <https://doi.org/10.62951/botani.v1i2.40>
- Bhunja, S., Bhowmik, A., Mallick, R., & Mukherjee, J. (2021). Agronomic efficiency of animal-derived organic fertilizers and their effects on biology and fertility of soil: A review. *Agronomy*, 11(5), 823. <https://doi.org/10.3390/agronomy11050823>
- Das, P., Biswas, P., Akter, M., Hossen, M. Z., & Alam, M. S. (2025). Bioaccumulation of minerals and trace elements in spinach (*Spinacia oleracea* L.) grown under different nutrient management and their implications for human health. *Journal of Trace Elements and Minerals*, 14, 100270. <https://doi.org/10.1016/j.jtemin.2025.100270>
- Dewi, M., Mustari, E., & Rahmawati, N. (2025). Teknologi pengolahan limbah organik menjadi produk bermanfaat guna menunjang pertanian berkelanjutan di Desa Argo Mulyo daerah penyangga Ibu Kota Nusantara. *JOMPA ABDI: Jurnal Pengabdian Masyarakat*, 4(4), 96–101. <https://doi.org/10.57218/jompaabdi.v4i4.2194>
- Dohare, K. S., Lahagu, M. P., & Waruwu, P. N. K. (2025). Peran mikroorganisme tanah dalam meningkatkan kesehatan tanah dan hasil pertanian organik. *Hidroponik: Jurnal Ilmu Pertanian dan Teknologi dalam Ilmu Tanaman*, 2(1), 166–178. <https://doi.org/10.62951/hidroponik.v2i1.253>
- Faradiba, A. A., Dwi, E. Y., & Sa'id, I. (2023). Impact of urea fertiliser on rice (*Oryza sativa* L) plant tissue in food production. *Jurnal Agricultural Science*, 18(2), 55–60.
- Gobel, S. S., Nurmi, & Ilahude, Z. (2025). Analisis kadar hara makro (N, P, K), C-organik pada lahan sawah dan tegalan di Desa Dutohe Kecamatan Kabila. *Jurnal Lahan Pertanian Tropis*, 4(1), 203–209.
- Gustiani, E., & Fahmi, T. (2022). Peran sektor peternakan mendukung ketahanan pangan di era new normal melalui penerapan teknologi

- reproduksi pada sapi potong di Kabupaten Majalengka. *Prosiding Seminar Nasional Hasil Penelitian Agribisnis VI*, 6(1), 70-76.
- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64-74. <https://doi.org/10.1119/1.18809>
- Indrayani, N., Jennatan, A. F., Lestari, E. D., Ardelia, A., Amanda, S. A. A., Sofia, S., Rahayu, S. U. T., Azizah, N. A., Rahmah, M., Rofahati, M., Attok, M. K., Nadiroh, U., Firmansha, F., Khasanah, S. N. F. H., Muchlis, K. R., & Firmansyah, D. D. (2025). Pemanfaatan limbah ternak sebagai pupuk organik untuk membantu meminimalisir biaya operasional tanam di Desa Mrawan Kecamatan Tapen Kabupaten Bondowoso. *Manfaat: Jurnal Pengabdian pada Masyarakat Indonesia*, 2(3), 1-9. <https://doi.org/10.62951/manfaat.v2i3.429>
- Jareh, A. (2025). Sustainable social innovation as a solution for systemic change and resilience. *Sustainability*, 17(4), 1583. <https://doi.org/10.3390/su17041583>
- Lestari, C. A., Setiawan, A., Putri, A. M., Muqoddam, Khairunnisa, F. D., Rahmadi, R., & Rochman, F. (2024). Efektivitas pemberian pupuk organik, anorganik, dan hayati terhadap produktivitas tanaman padi (*Oryza sativa* L.). *Planta Simbiosa*, 6(2), 169-179.
- Maghfuri, A. (2023). Strategi pemanfaatan limbah pertanian untuk peningkatan nilai ekonomi dan lingkungan di Kabupaten Cilacap. *Jurnal Inovasi Daerah*, 2(2), 144-156. <https://doi.org/10.56655/jid.v2i2.125>
- Marpaung, S. M., & Simangunsong, T. (2025). Application of agricultural waste-based fermented feed to increase the daily weight of Etawa crossbred goats (PE). *Jurnal Teknologi dan Ilmu Pertanian*, 3(1), 11-17. <https://doi.org/10.54209/tip.v3i01.376>
- Mendrofa, M. T., & Gulo, D. (2024). Pengaruh pupuk organik terhadap perbaikan struktur dan stabilitas tanah. *PENARIK: Jurnal Ilmu Pertanian dan Perikanan*, 1(1), 105-110.
- Mufida, I., Muhtiwati, S., Firmansyah, D. A., Berliana, A. P., Auni, N. L., Amin, A. S., Qoyyimah, U., Meilani, N. A., Hersa M., M. R., Muhtiwati, S., Umami, Z., Prayogi, D. A., & Priadi, E. (2025). Optimalisasi pemanfaatan limbah ternak melalui pembuatan pupuk organik bokashi untuk meningkatkan kemandirian kelompok tani. *Welfare: Jurnal Pengabdian Masyarakat*, 3(3), 561-566. <https://doi.org/10.30762/welfare.v3i3.2758>
- Nufus, W. Q., Nuraini, A. S., Suprianti, L., Perwitasari, D. S., Wahyudi, B., & Husodo, A. S. (2025). Kajian proses fermentasi pada pembuatan pupuk multinutrient berbahan limbah baglog jamur tiram putih dan kotoran

- kelelawar. *Jurnal Penelitian Pertanian Terapan*, 25(4), 33-47.
<https://doi.org/10.25181/jppt.v25i3.3560>
- Saputri, A., Prayogo, M. S., & Ni'mah, F. (2025). Pengaruh intensitas cahaya terhadap laju fotosintesis pada tanaman bayam (*Amaranthus* sp.). *Flora: Jurnal Kajian Ilmu Pertanian dan Perkebunan*, 2(2), 1-13.
<https://doi.org/10.62951/flora.v2i2.312>
- Yuliardani, W. I., Supomo, & Santoso, C. K. (2024). Implementasi metode zero waste dalam meminimalisasi limbah makanan pada dapur produksi di Hotel G Suites Surabaya. *Journal of Accounting, Management, and Financial (JAMFI)*, 1(2), 106-114.
- Zebua, T., Gulo, S. M., & Gulo, S. S. (2025). Pengaruh pupuk organik terhadap pertumbuhan tanaman dan kualitas tanah. *Flora: Jurnal Kajian Ilmu Pertanian dan Perkebunan*, 2(1), 208-213.
<https://doi.org/10.62951/flora.v2i1.268>