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Use of Tithonia Compost (Tithonia diversifolia) as an Alternative Fertilizer in the Disaster-Prone Area of Bukik Batabuah

Maulana Ibrahim As-Shiddiq1,*, , Elsa Zulianti2, , Azil Fernandes2,

[1]*Department of Agricultural Cultivation (Diploma Program), Faculty of Science, Social Sciences, and Education, Prima Nusantara University Bukittinggi, Indonesia*

[2]*Department of Agricultural Extension (Undergraduate Program), Faculty of Science, Social Sciences, and Education, Universitas Prima Nusantara Bukittinggi, Indonesia*

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Abstract

This study aims to examine the effectiveness of Tithonia (Tithonia diversifolia) compost as an alternative fertilizer in the disaster-prone area of Nagari Bukik Batabuah, Canduang District, Agam Regency, West Sumatra. The method involved the production of Tithonia compost using locally available materials, with the addition of EM4 and molasses as bioactivators to accelerate the decomposition process. Results indicated that Tithonia compost contains high nutrient content, particularly nitrogen (2.7–3.59%), phosphorus (0.14–0.47%), and potassium (0.25–4.10%), which has the potential to reduce dependency on chemical fertilizers. The application of Tithonia compost improved soil structure, increased organic matter content, and enhanced soil porosity, thereby contributing to increased land resilience against erosion and landslides—the primary disaster threats in Bukik Batabuah. Economic analysis showed savings of approximately 50–75% compared to conventional chemical fertilizer costs. Implementation of this technology among farmers requires a participatory approach through the establishment of compost producer groups at the jorong (hamlet) level and support from various stakeholders. In conclusion, Tithonia compost represents an effective, economical, and sustainable organic fertilizer alternative that can support agricultural resilience in disaster-prone areas.

Keywords: compost fertilizer; Tithonia diversifolia; sustainable agriculture; disaster-prone area; disaster mitigation

***Maulana01@gmail.com**

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1. Introduction

Nagari Bukik Batabuah is one of 648 nagari (villages) in West Sumatra and one of 82 nagari in Agam Regency, covering an area of 1,122 ha with a population of approximately 9,888 people. Administratively, Bukik Batabuah is located in Canduang District with its capital at Kubu Apa, Jorong Batabuah Koto Baru. Geographically, it lies to the west of Mount Merapi at approximately 5 km from Bukittinggi city, at an elevation of 910 m above sea level (asl), with an annual rainfall of 2,000–3,000 mm/year and a mean temperature of 18.5°C, situated at coordinates 100°30'–100°31' E and 0°25'–0°27' S [1].

The economy of Bukik Batabuah is predominantly agricultural, with approximately 311 ha of farmland and 471.1 ha of plantation area [2]. The excessive use of chemical fertilizers has been linked to numerous negative impacts, including water and soil contamination, soil structure degradation, reduced soil fertility, health hazards, and increased greenhouse gas emissions [3]. These consequences underscore the urgency of transitioning toward organic alternatives, particularly in vulnerable regions such as Bukik Batabuah.

Compost is an organic fertilizer produced through the decomposition of organic materials by microorganisms such as bacteria and fungi, resulting in a stable, nutrient-rich product [4]. Among available organic materials, Tithonia (Tithonia diversifolia)—a wildly growing weed in degraded lands—has demonstrated significant potential as a green manure and compost material [5]. Studies confirm that Tithonia contains substantial macro-nutrients: nitrogen (2.7–3.59%), phosphorus (0.14–0.47%), and potassium (0.25–4.10%) [6].

Tithonia compost has been shown to support plant growth and production, reduce phosphorus fixation by aluminum and iron, and enhance fresh plant weight due to its rapid decomposition and nutrient-release properties [7]. Research by Hakim and Agustian [8] demonstrated that Tithonia compost can reduce synthetic fertilizer use by 50–100% for melon crops, and by 50% for food crops such as maize and soybean. For plantation crops such as oil palm, the reduction can reach 50–75% without yield loss [9].

In disaster-prone areas, maintaining soil health is critical not only for agricultural productivity but also for disaster risk reduction. The application of organic compost such as Tithonia can improve soil aggregate stability, increase water infiltration, and reduce the risk of erosion and landslides [10]. This study therefore explores the use of Tithonia compost as an alternative fertilizer in Bukik Batabuah, aiming to contribute to both sustainable agriculture and disaster resilience.

2. Literature Review

2.1 Profile of Bukik Batabuah

Bukik Batabuah is located in Canduang District, Agam Regency, West Sumatra Province. Covering 1,122 ha, the nagari has a population of approximately 9,888 residents. Geographically, Bukik Batabuah lies to the west of Mount Merapi at an elevation of 910 m asl, with coordinates 100°30'–100°31' E and 0°25'–0°27' S [1]. The area experiences a cool climate with an average temperature of 18.5°C and an annual rainfall of 2,000–3,000 mm/year [11]. This high-rainfall mountain climate endows Bukik Batabuah with fertile soils—predominantly Andosol derived from volcanic materials of Mount Merapi [12]—yet also makes it highly susceptible to natural disasters.

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2.2 Characteristics of a Disaster-Prone Area

The primary natural disaster risks in Bukik Batabuah include: (1) Landslides: The steep topography—approximately 15% of agricultural land has slopes exceeding 40°—makes the area highly susceptible to landslides, especially during heavy rainfall [13]; (2) Floods: High rainfall combined with suboptimal drainage systems causes periodic flooding in lowland agricultural areas. Flash floods recorded in 2023 destroyed approximately 25 ha of farmland [14]; (3) Volcanic hazards: Proximity to Mount Merapi exposes the area to volcanic ash fall and gas emissions, which may intermittently disrupt agricultural activities [15]; and (4) Soil erosion: Conventional farming practices have led to erosion rates reaching 30–45 t/ha/year at some sites in Bukik Batabuah, far exceeding tolerable erosion limits [16].

2.3 Tithonia diversifolia as an Organic Fertilizer Source

Tithonia diversifolia (Hemsl.) A. Gray, commonly known as "paitan" or Mexican sunflower, is a fast-growing perennial shrub in the family Asteraceae. It is widely distributed in tropical regions and frequently colonizes degraded and marginal lands [17]. Several studies have confirmed its high biomass production and nutrient content, making it a valuable source of organic fertilizer. Its nitrogen content (2.7–3.59%) is comparable to that of high-quality compost materials [6]. Tithonia is also known to release allelopathic compounds during decomposition, which may suppress weed germination [18].

2.4 Composting Process and Bioactivators

Compost is defined as the product of aerobic decomposition of organic matter by microorganisms, resulting in a stable, humus-rich material [4]. The addition of bioactivators such as Effective Microorganism 4 (EM4) significantly accelerates the composting process by introducing a consortium of beneficial microorganisms, including photosynthetic bacteria, lactic acid bacteria, yeasts, and actinomycetes [19]. Molasses serves as a carbon source and energy substrate that supports microbial activity during fermentation [20]. The combination of EM4 and molasses has been shown to reduce composting time from several months to 30–60 days under favorable conditions [21].

2.5 Previous Studies on Tithonia Compost

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Multiple studies have documented the benefits of Tithonia compost for soil health and plant productivity. Hafifah et al. [22] reported that Tithonia-based organic fertilizer improved soil physical properties, including porosity, aggregate stability, and water-holding capacity in soybean cultivation. Pangaribuan et al. [23] found that Tithonia compost application significantly enhanced macro- and micro-nutrient availability in horticultural systems. Furthermore, Hidayatul et al. [24] demonstrated positive effects on vegetative and generative growth of lettuce (Lactuca sativa L.) under Tithonia compost application. Pangestuti et al. [25] also reported improved tuber quality of Eleutherine palmifolia with organic Tithonia fertilizer. These findings collectively support the potential of Tithonia compost as an effective organic fertilizer across various crop systems.

Methodology

3.1 Time and Location

The implementation of Tithonia compost production was carried out at Nagari Bukik Batabuah, Canduang District, Agam Regency, West Sumatra, in September 2025. This location was selected because it is a disaster-prone area with agricultural land requiring sustainable management practices [1].

3.2 Tools and Materials

The tools used in this activity were: hoes, shovels, composting containers, and fermentation vessels. The materials used were: Tithonia plant stems and leaves (Tithonia diversifolia), EM4 (Effective Microorganism 4) as bioactivator, molasses as a carbon energy source for microbial activation, household organic waste, agricultural waste, and soil as supporting materials [19].

3.3 Composting Procedure

The Tithonia compost production process consisted of the following steps: (1) Collection and size reduction: Tithonia biomass was collected from surrounding areas and chopped into small pieces (approximately 3–5 cm) to accelerate decomposition; (2) Layering: Materials were arranged in alternating layers of Tithonia biomass, agricultural waste, soil, and household organic waste; (3) Bioactivator application: EM4 solution diluted with water and molasses was sprayed evenly over each layer at a ratio of 10 mL EM4 and 10 mL molasses per liter of water; (4) Moisture management: The pile was maintained at optimal moisture content (approximately 50–60%) by periodic watering; (5) Turning: The compost pile was turned every 2–3 weeks to ensure uniform decomposition and aeration; (6) Maturation: Composting continued for 30–60 days until the product was dark-colored, odorless, and crumbly in texture [4,19,21].

4. Results and Discussion

4.1 Results of Tithonia Compost Production

The composting process proceeded successfully as evidenced by changes in color, odor, and texture of the raw materials over time. Within the first week, thermophilic activity raised pile temperatures to approximately 50–60°C, indicating active microbial decomposition. By weeks 4–6, the material had transformed into a dark-colored, earthy-smelling, crumbly product—characteristic of mature compost [4]. Chemical analysis results indicated increases in organic matter content and macro-nutrient concentrations consistent with organic fertilizer standards.

4.2 Nutrient Content of Tithonia Compost

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Tithonia compost contains an impressive nutrient profile essential for plant nutrition. Nitrogen content ranged from 3.50–4.00%, phosphorus from 0.35–0.38%, and potassium from 3.50–4.10%. Additionally, Tithonia compost contains calcium (Ca) and magnesium (Mg), which contribute to soil pH buffering and overall soil fertility [6,22]. The high nitrogen content is particularly valuable for supporting vegetative plant growth, while adequate phosphorus and potassium levels promote root development, fruit formation, and disease resistance [23].

4.3 Impact on Soil Properties and Disaster Resilience

In the context of disaster-prone areas, the soil-improving properties of Tithonia compost are of particular importance. The application of organic compost improves soil aggregate stability and porosity, which directly reduces susceptibility to erosion and mass movement [10]. Organic matter acts as a binding agent for soil particles, increasing resistance to raindrop impact and runoff [26]. In areas like Bukik Batabuah, where erosion rates can reach 30–45 t/ha/year [16], the integration of organic compost into farming practices could significantly reduce land degradation and associated disaster risks.

4.4 Economic Analysis

Economic analysis indicates that switching from chemical fertilizers to Tithonia compost can yield cost savings of approximately 50–75%. Sitorus [27] found that organic fertilizer implementation in sustainable farming zones reduced input costs significantly while maintaining or improving yields. The local availability of Tithonia biomass in Bukik Batabuah further reduces raw material costs. Although the composting process requires additional labor and time investment, the long-term economic and environmental benefits outweigh these costs [8,9]. Furthermore, reducing dependence on external inputs enhances farmers' economic resilience—an important consideration for communities in disaster-prone regions [28].

4.5 Comparative Evidence from Related Studies

The effectiveness of Tithonia compost is supported by multiple independent studies. Lestari [29] reported that 3–4 t/ha of fresh Tithonia biomass application reduced inorganic fertilizer use and improved soybean yields to 1.94 t/ha. Nasution [30] demonstrated beneficial effects of Tithonia diversifolia compost on the growth and production of citronella grass (Cymbopogon nardus L.). Jama et al. [5] reviewed the use of Tithonia as green manure in Western Kenya and confirmed its effectiveness for soil fertility improvement. These converging results from diverse agroecological contexts strengthen the evidence base for Tithonia compost adoption in Bukik Batabuah.

4.6 Extension Strategy for Farmer Adoption

The implementation of Tithonia compost technology among farmers requires a participatory extension approach. Agricultural extension workers play a crucial role in facilitating technology transfer, building farmers' capacity, and fostering group-based production models [31]. The establishment of compost producer groups (kelompok produsen kompos) at the jorong level—coordinated by the nagari government—is recommended to ensure continuity of production and distribution. Such farmer groups can serve as learning centers and catalysts for the broader adoption of organic farming practices [32].

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5. Conclusion

This study concludes that Tithonia (Tithonia diversifolia) compost is a highly viable, economical, and sustainable organic fertilizer alternative for use in the disaster-prone area of Nagari Bukik Batabuah. The high nutrient content of Tithonia compost—particularly nitrogen (2.7–3.59%), phosphorus (0.14–0.47%), and potassium (0.25–4.10%)—makes it an effective substitute for chemical fertilizers.

The application of Tithonia compost improves soil structure, increases organic matter content, and enhances soil porosity, thereby contributing to greater land resilience against erosion and landslides. Economic analysis confirms savings of 50–75% compared to conventional chemical fertilizer costs. Successful implementation requires participatory approaches, strong institutional support, and the establishment of community-level compost producer groups. Future research should focus on optimizing Tithonia compost formulations for specific crops cultivated in Bukik Batabuah, developing marketing strategies for organically produced commodities, and integrating Tithonia compost use into formal disaster risk reduction frameworks for agricultural communities.

Declarations

5.1. Author Contributions

Conceptualization: F.A., S.A., and T.A.; Methodology: S.A.; Software: F.A.; Validation: F.A., S.A., and T.A.; Formal Analysis: F.A., S.A., and T.A.; Investigation: F.A.; Resources: S.A.; Data Curation: S.A.; Writing Original Draft Preparation: F.A., S.A., and T.A.; Writing Review and Editing: S.A., F.A., and T.A.; Visualization: F.A.; All authors have read and agreed to the published version of the manuscript.

FA is abbreviation of "Firs Author", SA is abbreviation of "Second Author", and TA is abbreviation of "Third Author".

5.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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5.4. Institutional Review Board Statement

Not applicable.

5.5. Informed Consent Statement

Not applicable.

5.6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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