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MAIZE GROWTH RESPONSE TO VARIOUS TYPES AND DOSAGES OF ORGANIC MULCH IN THE DRYLANDS OF SOUTHEAST ACEH

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Abstract

Drylands face physical and chemical constraints that often limit maize growth. The use of organic mulch is a potential strategy to improve growing conditions and nutrient availability. This study aims to examine the growth response of maize to the application of various types and dosages of organic mulch in dryland. The research utilized a factorial Randomized Block Design (RBD) with two factors: mulch type (Chromolaena odorata, bamboo leaves, and rice husk) and mulch dosage (0, 15, 20, and 25 tons/ha). Parameters observed included plant height at 60 days after planting (DAP) and total plant fresh weight at harvest. The results indicated no significant interaction between mulch type and dosage for all parameters. However, mulch dosage had a highly significant effect on plant height, while both mulch type and dosage independently had a significant effect on plant fresh weight. The application of mulch at a dosage of 15 tons/ha was the effective minimum threshold for significantly increasing growth compared to the control. Bamboo leaf mulch provided the best response to biomass accumulation, achieving the highest average fresh weight (232.08 g). Increasing the dosage beyond 15 tons/ha showed a trend of non-proportional returns (diminishing returns). Consequently, the use of bamboo leaf mulch at a dosage of 15 tons/ha can be recommended to efficiently enhance maize productivity in dryland.

Keywords: Maize, Dryland, Organic Mulch, Plant Growth, Southeast Aceh

INTRODUCTION

Maize (Zea mays L.) is a strategic commodity that plays a vital role in maintaining national food security and economic stability. Beyond its function as a carbohydrate source, maize is a primary component of the livestock feed industry, resulting in a continuous increase in demand alongside the growth of the livestock sector (USDA, 2025). In the Aceh region, specifically Southeast Aceh, maize is a flagship commodity cultivated predominantly in drylands. However, maize productivity in these areas frequently fluctuates due to climate variability and soil quality degradation. Drylands face significant challenges, including low organic matter content and limited water retention capacity. Intensive agricultural practices without proper nutrient management have triggered soil structure degradation, a decrease in Cation Exchange Capacity (CEC), and disrupted soil microbial activity (Dinca et al., 2022; Ashitha & Rakhimol, 2021). These conditions are exacerbated by high evaporation rates and extreme soil temperature fluctuations, which ultimately inhibit vegetative growth and plant biomass formation (Anjum et al., 2019). One mitigation strategy to overcome the physical and chemical constraints of dryland soil is the application of organic mulch. Utilizing crop residues such as Siam weed (Chromolaena odorata), bamboo leaves, and rice husks is known to improve the microclimate at the soil surface. Mulch functions by suppressing evaporation rates, stabilizing soil temperature, and providing nutrient sources through a gradual decomposition process (Resdiar et al., 2019; Yahya et al., 2023). Siam weed is recognized for its high nitrogen content, bamboo leaves possess a dense structure favorable for water conservation, while rice husks are rich in silica and potassium, which enhance plant resilience (Hendrawan & Hardati, 2021; Rusdi et al., 2019; Murdhiani & Maharany, 2019).

Despite the widely acknowledged benefits of organic mulch, its effectiveness depends heavily on the type of material and the precision of its application dosage. Improper dosing risks causing nutrient immobilization or soil aeration disturbances. There is a critical need to synchronize nutrient release from various organic mulches with the physiological requirements of maize, particularly during the critical stages of vegetative growth and biomass formation at harvest (Lian et al., 2024). Based on these issues, this study aims to evaluate the influence of various types and dosages of organic mulch on plant height growth and the accumulation of plant fresh weight in dryland maize. The results of this study are expected to provide practical recommendations regarding the most effective mulch types and optimal dosages for increasing maize productivity while maintaining the sustainability of soil ecosystem functions.

LITERATURE REVIEW

Maize occupies a strategic position in national food security and the economy, serving as both a staple food and a primary raw material for the livestock feed industry. The increasing demand from the livestock sector, particularly poultry, has triggered a surge in maize requirements that often exceeds domestic production (USDA, 2025). In regions such as Southeast Aceh, maize is a flagship commodity for dryland agriculture. However, its productivity remains fluctuant due to climate variability and limited inputs. Therefore, sustainable land management strategies, such as the application of organic mulch, are essential to enhance water efficiency and nutrient availability. As a C4 plant, maize possesses high photosynthetic efficiency. Its growth is supported by a complex fibrous root system designed for optimal nutrient acquisition (Genesiska et al., 2020; Pioneer, 2023). Maize cultivation requires specific environmental conditions, including an ideal temperature of 26°C and a soil pH ranging from 5.5 to 7.5 (Ministry of Agriculture, 2022). Critical growth phases occur at V6–V8 (secondary root formation) and VT–R1 (reproductive stage), where water and nutrient deficiencies can have a fatal impact on final yields.

Conventional agricultural practices on drylands frequently trigger soil quality degradation. Monoculture systems utilizing chemical fertilizers reduce organic matter content and cation exchange capacity (CEC) (Dinca et al., 2022). Low organic matter leads to unstable soil aggregates and increases the risk of drought stress (Anjum et al., 2019). Furthermore, the accumulation of chemical residues can inhibit the activity of microorganisms essential for nutrient cycling (Ashitha & Rakhimol, 2021). Another major issue is the fluctuation of macronutrient availability (N, P, K) caused by high rates of leaching and evaporation in coarse-textured soils. Organic mulches, such as Siam weed (Chromolaena odorata), bamboo leaves, and rice husks, serve as soil covers that suppress evaporation, stabilize temperature, and control weeds (Resdiar et al., 2019). Chemically, mulch decomposition gradually releases nutrients and increases soil organic carbon content (Yahya et al., 2023). Biologically, mulch acts as an energy substrate for soil microbes, which accelerates nutrient mineralization (Ren et al., 2025).

Specifically, Siam weed possesses high nitrogen content (2.42%) and decomposes rapidly, making it highly effective in supporting early vegetative growth (Jamilah, 2005; Hendrawan & Hardati, 2021). Bamboo leaves, rich in potassium and flavonoids with a moderate decomposition rate, are capable of maintaining nutrient stability and moisture over the long term (Rusdi et al., 2019). Meanwhile, rice husks contain high levels of potassium and silica, which can strengthen soil structure and enhance plant resilience against environmental stress (Murdhiani & Maharany, 2019). Determining the optimal mulch dosage is crucial; insufficient doses are ineffective, while excessive applications risk causing nitrogen immobilization. Synchronizing nutrient release from mulch with the physiological needs of the plant during critical phases is key to achieving maximum maize productivity (Lian et al., 2024; Verma & Pradhan, 2024).

METHOD

Study Site and Time

This research was conducted in Simpang Empat Village, Lawe Bulan District, Southeast Aceh Regency, Aceh. Data analysis and observations were carried out until the plants reached the harvest phase (including vegetative observations at 60 days after planting/DAP).

Materials and Tools

The primary materials used in this study were Pioneer 32 variety maize seeds and three types of organic mulch: Siam weed (Chromolaena odorata), bamboo leaves, and rice husks. Basal fertilizers and other agricultural inputs were applied according to the recommended dosages.

Experimental Design

The study employed a Factorial Randomized Block Design (RBD) consisting of two treatment factors:

Factor I: Type of Organic Mulch (J)
J1: Siam weed mulch
J2: Bamboo leaf mulch
J3: Rice husk mulch
Factor II: Dosage of Organic Mulch (D)
D0: 0 tons/ha (Control)
D1: 15 tons/ha
D2: 20 tons/ha
D3: 25 tons/ha
From these two factors, 12 treatment combinations were obtained, each replicated 3 times.

Research Procedure

1. Land Preparation: The soil was tilled intensively and divided into experimental plots.
2. Planting: Maize seeds were planted with a spacing of 75 cm x 20 cm.
3. Mulch Application: Mulch was applied according to the treatment type and dosage immediately after planting, spread evenly over the soil surface to form a uniform layer.
4. Maintenance: Activities included replanting (penyulaman), supplementary fertilization, irrigation, and pest and disease control based on field conditions.

Observation Variables

The variables observed in this study included:

1. Plant Height (cm): Measured at 60 DAP from the base of the stem to the tip of the highest leaf.
2. Total Plant Fresh Weight (g): Weighed at harvest, encompassing all parts of the plant canopy above the soil surface.

Data Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA) at a 95% confidence level. If the results indicated a significant or highly significant effect, the analysis was followed by Duncan's Multiple Range Test (DMRT) at the 5% level to determine the differences between treatment means.

RESULTS AND DISCUSSION

1. Plant Height

Table 1. presents the observation data for plant height based on the type and dosage of organic mulch. The analysis indicates that there was no significant interaction between the two factors. Although the type of organic mulch did not exert a significant influence, variations in mulch dosage were shown to have a highly significant effect on plant height growth.

Table 1. Average Plant Height of Maize at 60 DAP Under Various Types and Dosages of Organic Mulch.

Treatment	**Plant Height at 60 DAP (cm)**				**Average**
	D0	D1	D2	D3	
J1	90.08	166.25	180.75	173.75	152.71
J2	113.50	182.50	174.17	168.67	159.71
J3	95.08	171.83	183.50	196.92	161.83
Average	99.56A	173.53B	179.47B	179.78B	

Note: J1: Siam weed; J2: bamboo leaves; J3: rice husk. D0: 0 ton ha^{-1}; D1: 15 ton ha^{-1}; D2: 20 ton ha^{-1}; D3: 25 ton ton ha^{-1}. Figures followed by the same uppercase/lowercase letters are not significantly different based on the Duncan Multiple Range Test (DMRT) at the 0.05 level.

Based on the data in Table 1, the application of mulch at a dosage of 15 tons/ha significantly increased plant height compared to the control. This finding suggests a specific mulch mass threshold is required to effectively modify the soil microenvironment, particularly through thermal insulation mechanisms and enhanced water retention capacity. At an optimal dosage, mulch forms a continuous protective layer capable of reducing temperature fluctuations and maintaining soil moisture stability, thereby stimulating vegetative growth and stem structural strengthening (Oematan et al., 2022; Syafrizal et al., 2024). However, it is important to note that increasing the dosage beyond the saturation point does not always result in a linear growth response. This "diminishing returns" phenomenon is presumably due to inhibited gas diffusion in the soil and the potential release of phytotoxic compounds during organic decomposition. Therefore, determining the mulch dosage must balance microclimate improvement against potential physical-biochemical soil constraints. Furthermore, the effectiveness of bamboo leaf mulch in enhancing plant height is closely linked to its ability to stabilize the microclimate at the soil surface. The dense physical structure of bamboo leaves is highly efficient in suppressing evaporation rates and temperature fluctuations, ensuring consistent water and nutrient availability for the roots (Shilpa et al., 2022; Choudhary et al., 2024; Ramadhani et al., 2024). From a physiological perspective, a moist and stable environment supports cell expansion and optimizes photosynthetic rates from the early growth stages. Ecologically, this mulch also provides a competitive advantage for the primary crop by suppressing weed growth, leading to greater availability of light and nutrients. In practice, selecting organic mulch types can serve as a key strategy to accelerate early plant growth while acting as a water conservation measure, particularly in drought-prone areas.

2. Plant Fresh Weight

Data regarding the influence of organic mulch types and dosages on maize fresh weight at harvest are summarized in Table 2. Statistical analysis showed no significant interaction between the mulch type and dosage factors. Nonetheless, each factor independently exerted a significant influence on the fresh weight of the maize plants. This indicates that both the selection of organic material and the determination of the applicat ion dosage play crucial, distinct roles in determining the accumulation of plant fresh biomass.

Table 2. Average Fresh Weight of Maize Plants at Harvest Under Various Types and Dosages of Organic Mulch.

Treatment	Plant Fresh Weight (g)				Average
	D0	D1	D2	D3	
J1	80.67	173.67	209.33	184.00	161.92a
J2	107.00	284.33	294.33	242.67	232.08b
J3	85.00	196.67	286.33	245.33	203.33ab
Average	90.89A	218.22B	263.33B	224.00B	

Note: J1: Siam weed; J2: bamboo leaves; J3: rice husk. D0: 0 ton ha^{-1}; D1: 15 ton ha^{-1}; D2: 20 ton ha^{-1}; D3: 25 ton ton ha^{-1}. Figures followed by the same uppercase/lowercase letters are not significantly different based on the Duncan Multiple Range Test (DMRT) at the 0.05 level.

Based on Table 2, the use of bamboo leaf mulch resulted in a higher total fresh weight accumulation at harvest compared to Siam weed or rice husk mulches. This increase in fresh weight reflects the cumulative result of efficient assimilation rates, tissue water retention capacity, and biomass distribution driven by soil microclimate stability. Bamboo leaves are thought to possess an optimal synergy between physical structure and decomposition rate, thereby improving the mineralization process of essential nutrients (N, P, K) that support both vegetative and reproductive phases. The capacity of bamboo leaves to maintain soil moisture and accelerate nutrient release is a key factor in achieving higher biomass accumulation (Usio et al., 2021). Therefore, selecting organic mulch types should consider the balance between the physical stability of the mulch layer and nutrient supply. Practically, bamboo leaf mulch is highly recommended as an organic input to increase biomass production, especially in regions where this organic material is locally available.

In addition to the type factor, Table 2 confirms that a minimum dosage of 15 tons/ha was sufficient to significantly increase plant fresh weight compared to the control. The effectiveness at this dosage indicates that the formation of an adequate mulch layer creates a more stable growth environment, allowing for more efficient photosynthesis and nutrient absorption throughout the plant cycle (Ali et al., 2024; Kucerik et al., 2024). However, the results show that increasing the dosage to the 20–25 tons/ha range did not provide a proportional yield increase, highlighting an optimal threshold for mulch utilization. This phenomenon underscores the necessity of cost-benefit analysis in agronomic practices. Excessive dosages not only increase procurement and labor costs but also risk negative effects such as phytotoxicity or alterations in soil physical properties. Consequently, the determination of the ideal dosage should aim for maximum productivity without resource wastage.

CONCLUSION

This study concludes that the application of organic mulch significantly enhances the vegetative growth and biomass accumulation of maize plants compared to the non-mulched treatment (control). While no interaction was found between the type and dosage of organic mulch regarding plant height and fresh weight, both factors exerted significant independent effects.

1. Optimal Dosage: A minimum dosage of 15 tons/ha serves as an effective threshold capable of significantly increasing plant height and fresh weight. Increasing the dosage beyond this level (20–25 tons/ha) does not result in proportional growth improvements (diminishing returns); thus, a dosage of 15 tons/ha is considered the most efficient from both agronomic and economic perspectives.
2. Superior Mulch Type: Bamboo leaf mulch (J2) yielded the best results for plant fresh weight accumulation compared to other types. This superiority is attributed to its dense leaf structure and optimal decomposition rate, which effectively maintains soil microclimate stability and accelerates nutrient mineralization (N, P, and K).
3. Supporting Mechanisms: Enhanced plant productivity is driven by the mulch's ability to suppress soil temperature fluctuations, reduce evaporation, and minimize weed competition, which physiologically supports optimal plant development.

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