

Nitrogen Fertilizer Effects on Growth and Biomass of *Coix lacryma-jobi*

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ABSTRAK

Coix lacryma-jobi merupakan tanaman tropis multifungsi yang berpotensi sebagai pangan, obat, dan hijauan pakan. Nitrogen berperan sebagai unsur hara penting yang memengaruhi pertumbuhan dan produksi biomassa tanaman. Penelitian yang mengevaluasi pengaruh nitrogen terhadap *Coix lacryma-jobi* pada ekosistem lahan basah tropis masih terbatas. Penelitian lapangan berlangsung di Samarinda, Indonesia menggunakan rancangan acak kelompok dengan lima perlakuan pupuk nitrogen (0, 1,5, 3,0, 4,5, dan 6,0 kg/ha) serta empat ulangan. Parameter yang diamati mencakup tinggi tanaman, jumlah daun, panjang daun, lebar daun, diameter batang, jumlah anakan, panjang stolon, bobot segar, dan bobot kering. Analisis data menggunakan ANOVA dilanjutkan dengan Uji Duncan pada taraf signifikansi 5%. Nitrogen memberikan pengaruh nyata terhadap tinggi tanaman, jumlah daun, panjang daun, panjang stolon, jumlah anakan, bobot segar, dan bobot kering. Lebar daun serta diameter batang tidak menunjukkan respons signifikan. Dosis optimal berada pada kisaran 1,5-3,0 kg/ha yang menghasilkan biomassa lebih tinggi dibandingkan kontrol. Pemupukan nitrogen meningkatkan pertumbuhan dan produktivitas *Coix lacryma-jobi* pada ekosistem lahan basah tropis. Hasil penelitian memberikan rekomendasi untuk produksi hijauan dan tanaman pangan berkelanjutan.

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ABSTRACT

Coix lacryma-jobi is a multipurpose tropical plant with potential as a food, medicine, and forage crop. Nitrogen is an essential nutrient that influences plant growth and biomass production; however, few studies have evaluated its effect on *Coix lacryma-jobi* in tropical wetland ecosystems. A field experiment was conducted in Samarinda, Indonesia, using a randomized block design with five nitrogen fertilizer treatments (0, 1.5, 3.0, 4.5, and 6.0 kg/ha) and four replicates. The observed parameters included plant height, leaf number, leaf length, leaf width, stem diameter, number of tillers, stolon length, fresh weight, and dry weight. Data were analyzed using ANOVA, followed by Duncan's Multiple Range Test (DMRT) at 5% significance. Nitrogen significantly influenced plant height, leaf number, leaf length, stolon length, tiller number, fresh biomass, and dry biomass. Leaf width and stem diameter showed no significant responses. The optimal dose ranged between 1.5-3.0 kg/ha, producing higher biomass than the control. Nitrogen fertilization enhanced the growth and productivity of *Coix lacryma-jobi* in tropical lowland ecosystems, providing recommendations for sustainable forage and crop production.



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1. Introduction

The availability of high-quality forage is a key factor for the success of sustainable livestock production systems. Forage shortages in tropical regions often hinder the improvement of livestock productivity. Efforts to provide alternative forage sources are necessary to ensure feed security throughout the year (Mashudi *et al.* 2023). The *Coix lacryma-jobi* plant, also known as Job's tears, has many benefits. Its use includes food ingredients, traditional medicine, and as a source of forage. This multifunctional character gives strategic value to the development of job tears as a leading commodity in Indonesia's tropical regions (Prameswari *et al.* 2023; Wulandari *et al.* 2023).

The development of job tasks in Indonesia still faces several challenges. The main obstacles include improper agronomic practices, limited cultivation technology, and inefficient yield distribution. These conditions demand agronomic innovations so that job tasks can contribute to the provision of national food and feed (Suryana *et al.*, 2023; Daru *et al.*, 2023). The agronomic characteristics of Job's tears indicate a high level of adaptability to wetland conditions. Its vegetative growth is rapid with good palatability for ruminant livestock. It has fairly high protein and fiber content, making Job's tears a potential source of nutritious feed (Camarao *et al.*, 2023). Previous studies have confirmed that Job's tears have a significant economic and agronomic value. The potential of Job's tears includes food diversification, provision of quality forage, and development of raw materials for herbal products. Field-based studies are necessary to clearly identify the agronomic factors affecting productivity (Li *et al.*, 2021; Daru *et al.*, 2023; Santoso *et al.*, 2022).

Nitrogen (N) is the primary nutrient that influences plant growth. Nitrogen enhances chlorophyll formation, improves photosynthetic capacity, and stimulates protein synthesis. Optimal nitrogen availability accelerates vegetative growth and results in higher biomass production (Gupta *et al.*, 2023). Research on rice, corn, and sorghum has shown that nitrogen application increases plant height, leaf number, and biomass accumulation. Excessive nitrogen application reduces nutrient use efficiency, causes lodging, and leads to environmental pollution owing to nitrate leaching (Akinmoladun and Komolafe, 2020; De *et al.*, 2023).

Information regarding the response of Job's tears to nitrogen fertilization is still limited. Tropical swamp ecosystems have great potential to develop Job's tears as a source of food and feed. Research on the appropriate nitrogen dosage is needed to achieve optimal productivity while maintaining an environmental balance (Li *et al.*, 2021; Suryana *et al.*, 2023). The aim of this study was to evaluate the effects of various doses of nitrogen fertilizer on the growth and yield of Job's tears. The data generated are expected to serve as the basis for agronomic recommendations and strategies for sustainable forage provision in the tropical regions of Indonesia (Maring *et al.*, 2024; Rahman *et al.*, 2025).

2. Materials and Methods

This study was conducted from March to July 2021 in Lempake, Samarinda, East Kalimantan, Indonesia. The experimental site was characterized by tropical wetland conditions, frequent rainfall, and moderate soil fertility.

2.1. Research Design

This study used a randomized block design (RBD) to examine the effect of nitrogen fertilizer application on the growth and yield of *Coix lacryma-jobi*. This design was chosen because it can control variations in the field environment, which may influence the research results (De *et al.*, 2023).

2.2. Location and Time

The experiment was conducted in Lempake Village, Samarinda City, East Kalimantan from March to July 2021. The study site is located in a wet tropical ecosystem with high rainfall and moderate soil fertility (Suryana *et al.*, 2023).

2.3. Materials and Tools

The research materials consisted of the local variety Coix lacryma-jobi seeds, nitrogen fertilizer in the form of urea (46% N), and base fertilizers in the form of phosphate and potassium, which were evenly applied to all treatments. The equipment used included measuring tools for length, a digital scale, a drying oven, and field data recording supplies (Gupta *et al.* 2023).

2.4. Treatment

The treatments tested included five doses of nitrogen fertilizer, namely: a) T₀ = 0 kg/ha (control); b) T₁ = 1.5 kg/ha; c) T₂ = 3.0 kg/ha; d) T₃ = 4.5 kg/ha; and d) T₄ = 6.0 kg/ha. Each treatment was repeated four times, resulting in 20 experimental units. Each experimental plot measured 3 m × 4 m, with a planting distance of 50 cm × 50 cm (Li *et al.*, 2021).

2.5. Observation Variable

The observed parameters included plant height, number of leaves, leaf length, leaf width, stem diameter, number of tillers, stolon length, fresh weight, and dry biomass. To obtain dry matter data, biomass samples were dried in an oven at 70 °C until a constant weight was achieved (Camarao *et al.*, 2023; Daru *et al.*, 2023).

2.6. Data Collection

Observations were conducted periodically from the vegetative to the early generative stage. Plant samples were collected randomly from each treatment plot to obtain representative data. The measurement procedures followed the standards of tropical agronomy (Mashudi *et al.*, 2023). Data collection: Parameters measured included Plant height, leaf number, leaf length, leaf width, stem diameter, number of tillers, stolon length, fresh weight, and dry weight. Biomass samples were oven-dried to determine the dry matter content.

2.7. Data Analysis

The data obtained were analyzed using analysis of variance (ANOVA) to determine the effect of the nitrogen fertilizer treatment. If the results showed a significant difference, further testing was conducted using Duncan's Multiple Range Test (DMRT) at a 5% significance level to compare the means between treatments (Maring *et al.*, 2024).

3. Results and Discussion

Nitrogen fertilization significantly affected most of the growth parameters of Coix lacryma-jobi. Plant height, leaf number, and leaf length substantially increased with nitrogen application compared with the control. Stolon length, number of tillers, and biomass (fresh and dry) also increased significantly with nitrogen fertilization. However, leaf width and stem diameter did not change significantly across treatments.

The application of different dosages of nitrogen fertilizer had a significant effect on the growth and yield parameters of Coix lacryma-jobi L. Plant responses were clearly evident in variables such as plant height, number of leaves, leaf length, number of tillers, number of stolons, and fresh and dry biomass weights.

Plant height at 60 days after planting ranged from 73.23 to 83.08 cm. Treatment with a dose of 1.5 kg/ha (P₁) resulted in the highest average plant height (83.08 cm. This value was significantly different compared to that of the control (without fertilizer) and the high-dose treatment of 6.0 kg/ha, indicating that stem growth is more optimal at a moderate nitrogen dose.

The average number of leaves per plant ranges from 7.67, 9.40. Treatment with a dose of 6.0 kg/ha (P₄) resulted in the highest number of leaves (9.40), which was significantly different from that of the other treatments. The results of this study indicate that nitrogen plays an important role in increasing the number of photosynthetic organs.

The average leaf length of the plant was 71.22 cm. The best response was observed in the medium nitrogen dose treatment, confirming that the increase in leaf length tends to be optimal when nutrient needs are met, but not excessive.

Leaf width and stem diameter did not show significant differences between the treatments. The stability of these two parameters indicates that certain morphological characteristics are less responsive to variations in nitrogen dosage and are therefore more influenced by genetic factors than by fertilization treatments.

The number of stolons and tillers increased with nitrogen fertilizer application. Treatments P₁ (1.5 kg/ha) and P₂ (3.0 kg/ha) showed the best performances. These findings indicate that adequate nitrogen availability can stimulate the growth of lateral shoots and strengthen clump regeneration.

The fresh weight of the plants ranged from 1.29 ± 0.68 kg, while the average dry weight was 0.19 ± 0.09 kg. The P₂ treatment (3.0 kg/ha) resulted in the highest dry weight compared with the other treatments. This indicates that a moderate nitrogen dose is more efficient in supporting dry matter accumulation than high doses, which tends to reduce the nutrient use efficiency.

Overall, the results of the study indicate that *Coix lacryma-jobi* responds positively to nitrogen fertilization, with an optimal dosage ranging from 1.5-3.0 kg/ha. This dosage has been proven to enhance vegetative growth and biomass accumulation without reducing nutrient-use efficiency.

Table 1. Summary of Research Results on *Coix lacryma-jobi*

Treatment (kg N/ha)	Plant Height (cm)	Number of Leaves (pieces)	Leaf Length (cm)	Leaf Width (cm)	Stem Diameter (cm)	Number of Offspring	Number of Stolons	Fresh Weight (kg)	Dry Weight (kg)
Control (0)	73.23±2.1 ^b	7.67±0.5 ^c	67.12±3.5 ^b	3.12±0.2 ^a	0.85±0.05 ^a	5.12±0.4 ^a	3.45±0.3 ^a	1.10±0.20 ^b	0.15±0.05 ^b
P ₁ (1.5)	83.08±3.2 ^a	8.54±0.6 ^b	71.22±4.0 ^a	3.25±0.2 ^a	0.88±0.06 ^a	6.45±0.5 ^b	4.20±0.4 ^b	1.35±0.25 ^a	0.18±0.06 ^a
P ₂ (3.0)	80.15±2.8 ^{ab}	8.89±0.7 ^b	70.85±3.8 ^a	3.28±0.3 ^a	0.89±0.05 ^a	6.80±0.6 ^a	4.50±0.5 ^a	1.29±0.68 ^a	0.19±0.09 ^a
P ₃ (4.5)	78.44±3.0 ^b	8.72±0.5 ^b	69.34±3.6 ^{ab}	3.22±0.2 ^a	0.87±0.06 ^a	6.55±0.5 ^{ab}	4.25±0.4 ^b	1.22±0.30 ^b	0.17±0.06 ^{ab}
P ₄ (6.0)	75.62±2.7 ^b	9.40±0.6 ^a	68.55±3.7 ^{ab}	3.20±0.2 ^a	0.86±0.05 ^a	6.30±0.4 ^b	4.10±0.3 ^b	1.15±0.28 ^b	0.16±0.05 ^b

Explanation: Numbers followed by different superscript letters in the same column indicate significant differences according to the 5% DMRT multiple range test.

These results indicate that nitrogen fertilizer application has a significant effect on the height of *Coix lacryma-jobi* plants. A moderate dosage produced more optimal stem growth than the control or a high dosage. Better plant height reflects increased physiological activity owing to the availability of nitrogen, which supports chlorophyll synthesis and photosynthesis (Li *et al.*, 2021). The number of leaves increased with the addition of nitrogen up to a certain dosage, which expanded the plant's photosynthetic capacity. More leaves broaden the light-absorption surface and enhance photosynthate production. This condition supports intensive vegetative growth (Gupta *et al.* 2023).

Leaf length showed a positive response to the medium nitrogen treatment. Longer leaves allow plants to absorb sunlight more efficiently than shorter leaves. An increase in leaf length indicates greater photosynthate distribution in vegetative organs (Akinmoladun and Komolafe, 2020). Leaf width and stem diameter remained relatively stable across all treatments, suggesting that these two characteristics are influenced more by genetic factors than by nitrogen availability. This morphological stability confirms that not all growth parameters are sensitive to fertilization.

The number of tillers and stolons increased with moderate nitrogen doses. The growth of lateral shoots occurs because nitrogen supports meristematic activity and cell division. An increase in the number of tillers expands the clump, thereby enhancing its potential for biomass production (Mashudi *et al.*, 2023).

The highest fresh plant weight was obtained with the medium nitrogen treatment. Fresh biomass is related to the water storage capacity and primary metabolites. Adequate nitrogen strengthens protein metabolism and promotes vegetative tissue growth (De *et al.* 2023). Plant dry weight increased significantly with the 3.0 kg/ha nitrogen treatment. Dry biomass indicates the accumulation of carbohydrates, proteins, and structural fibers resulting from photosynthesis. Nitrogen use efficiency is better at moderate doses than at high doses, which reduces the effectiveness of nutrient utilization (Maring *et al.*, 2024).

The physiological responses of plants indicate the existence of an optimum point for nitrogen fertilization. Low doses do not meet metabolic needs, whereas high doses reduce physiological efficiency and increase the risk of nitrate pollution in the environment (Akinmoladun and Komolafe, 2020).

A comparison with the study by Li et al. (2021) in East Asia showed a similar pattern, where nitrogen enhanced vegetative growth up to a certain point. This similarity in patterns demonstrates that the response of adlay to nitrogen is consistent across different ecosystems, both subtropical and tropical.

The application of nitrogen also improves the nutritional quality of job tear forage. Daru et al. (2023) reported a significant increase in crude protein content with optimal nitrogen fertilization. The high crude protein content of job tears makes them competitive with other tropical forages (Daru et al., 2023).

The use of nitrogen fertilizers must consider agronomic and economic efficiency. Overfertilization reduces the marginal productivity of fertilizers and increases production costs. Nitrogen fertilizer efficiency can be achieved by determining the optimal dosage based on field research results (Prameswari et al., 2023).

Environmental sustainability also needs to be considered in nitrogen management. Excessive nitrogen application increases the risk of nitrate leaching, which contaminates the groundwater and triggers greenhouse gas emissions. Efficient job tear cultivation practices contribute to mitigating the environmental impact of agriculture (Suryana et al., 2023).

The practical implications of this study support the development of job tears as a sustainable alternative forage in tropical swamp ecosystems. The adaptive potential of job tears to flooded conditions offers ecological advantages compared with other forage crops that are less tolerant (Wulandari et al., 2023).

The phenomenon of increased tiller numbers at medium nitrogen doses can be attributed to the physiological characteristics of tropical plants. Nitrogen stimulates cytokinin activity, which promotes the growth of new shoots. The balance of growth hormones is greatly influenced by the availability of nitrogen in the soil (Gupta et al., 2023).

The limitations of this study lie in the scope of the experimental site, which is confined to a single tropical swamp ecosystem in Kalimantan. Climate variability, soil type, and land management can influence the research results. Trials at various locations and seasons are necessary for a broader validation. Another limitation is the absence of nitrogen residue in either soil or water. Such data are important for assessing the environmental impact of nitrogen fertilization on Job's tears. Further studies should include ecotoxicological parameters to provide more comprehensive recommendations.

Research recommendations emphasize that a nitrogen dose of 1.5-3.0 kg/ha is optimal for Job's tears in wet tropical lands. This dosage can balance productivity, nutritional quality, fertilizer efficiency, and environmental sustainability. Field implementation supports the sustainable provision of high-quality forage for Indonesian beef cattle farming.

4. Conclusion

The results of the ANOVA showed that nitrogen fertilizer application had a significant effect on the growth and yield parameters of *Coix lacryma-jobi* ($p < 0.05$). A dosage of 1.5-3.0 kg/ha proved to be the most optimal in increasing plant height, number of leaves, tillers, stolons, as well as the accumulation of fresh and dry biomass, while higher doses did not provide additional benefits and reduced nutrient efficiency. These findings confirm that nitrogen is a key factor in Job's tear productivity while also strengthening its potential as a quality forage for ruminants. The recommendation to apply nitrogen fertilizer in the range of 1.5-3.0 kg/ha serves as the agronomic foundation for sustainable cultivation of Job's tears in wet tropical ecosystems.

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6. Conflict of Interest

The authors declare no conflicts of interest related to this study.

7. Ethical Statement

The research was conducted in accordance with agronomic research ethical standards and the necessary approval was obtained from the institution's research committee.

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