JURNAL AGROEKOTEKNOLOGI TERAPAN
Applied Agroecotechnology Journal
Agroteknologi Universitas Sam Ratulangi e_ISSN:2797-0647

Effectiveness of Ketapang Leaf Extract (*Terminalia Cattapa* L.) As a Bioherbicide Against The Growth of Purple Nutsedge (*Cyperus Rotundus* L.)

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Manuscript received: 29 May 2026
Revision accepted: 7 June 2026

Abstract. Purple nutsedge (Cyperus rotundus L.) is one of the most problematic weeds in agricultural land due to its high adaptability and strong competition with cultivated plants for water, nutrients, light, and growing space. The intensive use of synthetic herbicides can lead to environmental pollution and residue accumulation in soil and crops, highlighting the need for environmentally friendly alternatives. Ketapang leaves (Terminalia catappa L.) contain allelochemical compounds with potential bioherbicidal properties. This study aimed to evaluate the effectiveness of ketapang leaf extract in suppressing the growth of purple nutsedge. A non-factorial Completely Randomized Design was employed with five treatments: distilled water (control), and ketapang leaf extract concentrations of 5%, 20%, 35%, and 50%, each replicated four times. Observed parameters included plant height, number of leaves, plant dry weight, phytotoxicity, and root length. Data were analyzed using analysis of variance at the 5% significance level, followed by the Least Significant Difference test when treatment effects were significant. The results showed that ketapang leaf extract significantly affected plant height, number of leaves, plant dry weight, and root length, but had no significant effect on phytotoxicity. Medium to high extract concentrations (20–50%) provided stronger growth inhibition than lower concentrations. The findings indicate that ketapang leaf extract has promising potential as a plant-based bioherbicide for controlling purple nutsedge growth in a more sustainable manner.

Keywords: bioherbicide, ketapang leaf extract, purple nutsedge, weed growth.

INTRODUCTION

The excessive use of synthetic herbicides by farmers in Indonesia has become an important issue because it can leave residues in soil and crops and may endanger both farmers and consumers. Therefore, environmentally friendly alternatives are needed to reduce dependence on synthetic herbicides. One potential solution is the utilization of botanical herbicides derived from plants containing allelopathic compounds. However, farmers' knowledge regarding the potential of secondary metabolites found in plants around agricultural land is still limited, causing weed control to rely mainly on chemical herbicides and mechanical methods. In fact, several studies have shown that plants and weeds contain allelochemicals that can suppress the growth of pests, fungi, bacteria, nematodes, and other weeds harmful to agricultural productivity (Tampubolon et al., 2018).

One plant with considerable potential as a natural herbicide source is ketapang or Terminalia catappa, commonly known as tropical almond. This plant belongs to the Combretaceae family and has high adaptability to various

environmental conditions, allowing it to grow in both lowland and highland areas (Batubara, 2020). In Indonesia, ketapang is generally used only as a shade tree in public areas, parks, and office yards (Ikaromah et al., 2023). Nevertheless, ketapang possesses significant ecological and economic value because several parts of the plant contain bioactive compounds that can be utilized in health, environmental, and agricultural sectors. In particular, ketapang leaves are known to contain natural antibacterial compounds and have the potential to be developed as bioherbicides.

Ketapang leaves contain various secondary metabolites, including flavonoids, alkaloids, tannins, saponins, terpenoids, steroids, quinones, and resins, which play an important role in inhibiting the growth of other plants through allelopathic mechanisms. These compounds can interfere with root growth, nutrient absorption, and cell metabolism of target weeds. Previous studies demonstrated that ketapang leaf extract effectively inhibited the growth of nut grass or *Cyperus rotundus*, with the optimal concentration reported at 35% (Pratama et al., 2024).

Weeds are one of the major obstacles in agricultural cultivation because they compete with crops for water, nutrients, and sunlight. Some dominant weeds, such as alang-alang (*Imperata cylindrica*), bayam duri (*Amaranthus spinosus*), and nut grass (*Cyperus rotundus*), belong to the C4 plant group, which is known for its strong adaptability and competitiveness (Najib et al., 2025). In addition to competition, weeds can also produce allelochemicals that inhibit the growth of surrounding plants. Nut grass, for example, contains terpenoids, flavonoids, tannins, and phenolic compounds that may influence plant physiological processes (Prabhu et al., 2022). Although allelochemicals at low concentrations may stimulate plant growth and increase resistance to abiotic stress, excessive concentrations can significantly inhibit crop development (Kristiana, 2019).

Considering the negative impacts of synthetic herbicides and the increasing demand for sustainable agriculture, the use of botanical herbicides derived from ketapang leaves represents a promising alternative for weed management. Botanical herbicides are considered safer because they are biodegradable, environmentally friendly, and relatively harmless to human health (Budi et al., 2023). Therefore, the utilization of ketapang leaf extract as a bioherbicide is expected to provide an effective, economical, and sustainable solution for controlling weeds, particularly nut grass, in modern agricultural systems.

RESEARCH METHODOLOGY

This research was conducted from November to December 2025 at the Rooftop Greenhouse of the Agroecology Laboratory, Faculty of Agriculture, Sultan Ageng Tirtayasa University, Pakupatan Campus, Serang, Banten. The tools used in this research included a blender, Erlenmeyer flask, pipette, measuring cup, analytical balance, ruler, filter paper, polybags, knife, oven, seedling tray, Buchner funnel, and label paper. The materials used were purple nutsedge (*Cyperus rotundus* L.) as the test plant, ketapang leaves (*Terminalia catappa* L.) as the source of bioherbicide extract, distilled water as the control and solvent, and soil as the planting medium.

This study used a non-factorial Completely Randomized Design (CRD) consisting of five treatments and four replications, resulting in 20 experimental units. The treatments were K = distilled water (control), P1 = 5% ketapang leaf extract, P2 = 20% ketapang leaf extract, P3 = 35% ketapang leaf extract, and P4 = 50% ketapang leaf extract. The observed parameters were plant height, number of leaves, plant dry weight, phytotoxicity, and root length. Purple nutsedge tubers

were planted in polybags and maintained until 14 days after planting. Ketapang leaves were extracted by maceration using distilled water for 24 hours, then filtered and diluted according to the treatment concentrations. The extract was applied by pouring 100 ml of solution to the root zone twice, namely in the first and second week after planting.

DATA ANALYSIS

Data were analyzed using analysis of variance (ANOVA) at the 5% level, and significant results were further tested using the Least Significant Difference (LSD) test at the 5% level.

RESULTS AND DISCUSSION

PLANT HEIGHT

Based on the analysis of variance, ketapang leaf extract significantly affected the plant height of purple nutsedge at 27 and 30 days after planting (DAP), while no significant effect was observed at 18, 21, and 24 DAP. This result indicates that the inhibitory effect of ketapang leaf extract on plant height did not appear clearly during the early observation period. The response became more evident at the later observation stages, especially after the plants had received repeated extract application.

Table 1. Average plant height (cm) due to the effect of ketapang leaf extract bioherbicide

Treatment	Plant age (DAP)				
	18 DAP	21 DAP	24 DAP	27 DAP	30 DAP
K	22.62	22.92	23.32	24.62c	24.92b
5%	20.52	21.10	21.62	22.62bc	23.20b
20%	18.77	19.12	19.67	20.70abc	21.05ab
35%	17.45	18.30	18.50	18.45ab	19.30ab
50%	14.07	14.17	14.55	15.12a	15.22a
Average	18.69	19.12	19.53	20.30	20.74

Note: Values followed by the same lowercase letter within the same column are not significantly different according to the LSD test at the 5% level.

The LSD test showed that the 50% concentration suppressed plant height more strongly than the control and the lower concentration that differed significantly from it. This indicates that ketapang leaf extract at 50% provided greater pressure on the vegetative growth of purple nutsedge at 27 and 30 DAP. However, the effect of this concentration should still be interpreted based on the significant differences among treatments, because the response of plant height was also shown by other concentrations at the later observation stages.

The reduction in plant height may be related to the secondary metabolites contained in ketapang leaf extract. Wahdaningsih and Najini (2024) reported that ketapang leaves contain alkaloids, flavonoids, saponins, phenols, and terpenoids, while Fitriani et al. (2024) found that ketapang leaf extract contains alkaloids, flavonoids, tannins, saponins, steroids, and terpenoids. These compounds may act as allelochemicals that interfere with plant physiological processes. Laksamana et al. (2025) explained that allelochemicals can inhibit plant growth by disrupting cell structure, cell elongation, enzymatic activity, and nutrient uptake. These disturbances may limit vegetative development and reduce plant height.

NUMBER OF LEAVES

Based on the analysis of variance, ketapang leaf extract significantly affected the number of leaves only at 30 DAP. The treatment did not significantly affect leaf number at 18, 21, 24, and 27 DAP. This result shows that the response of leaf formation appeared later than the early

growth observations. Leaf formation is a gradual vegetative process that depends on growing point activity, cell division, leaf tissue expansion, and assimilate availability.

Table 2. Average number of leaves due to the effect of ketapang leaf extract bioherbicide

Treatment	Plant age (DAP)				
	18 DAP	21 DAP	24 DAP	27 DAP	30 DAP
K	5.25	5.25	5.25	5.25	5.25a
5%	5.75	5.75	5.75	5.75	5.75ab
20%	6.50	6.50	6.50	6.75	7.25b
35%	6.00	6.00	6.00	6.00	6.00ab
50%	4.50	4.50	4.50	4.50	4.50a
Average	5.60	5.60	5.60	5.65	5.75

Note: Values followed by the same lowercase letter within the same column are not significantly different according to the LSD test at the 5% level.

At 30 DAP, the 50% concentration produced a lower number of leaves than the 20% concentration, but it did not show a clear difference compared with the control. This result indicates that leaf number did not decrease consistently with increasing extract concentration. The response of this parameter may vary because leaf number reflects both the formation of new leaves and the ability of the plant to maintain vegetative organs that had already developed before the inhibitory effect became visible.

This pattern is supported by Danong et al. (2024), who reported that the effectiveness of plant extracts may differ among growth parameters, since the effective concentration for plant height, number of leaves, leaf area, leaf damage, and weed mortality was not always the same. Pratama et al. (2024) also reported that ketapang leaf extract affected several growth parameters of purple nutsedge, including leaf number. These findings support the interpretation that leaf number has a specific physiological response to ketapang leaf extract exposure and does not always follow a simple concentration-dependent pattern.

PLANT DRY WEIGHT

Based on the analysis of variance, ketapang leaf extract significantly affected the dry weight of purple nutsedge. Dry weight represents the final accumulation of plant biomass after water content has been removed from plant tissues. Therefore, this parameter reflects the cumulative effect of ketapang leaf extract on plant growth, tissue formation, and biomass production during the experimental period.

Table 3. Average plant dry weight (g) due to the effect of ketapang leaf extract bioherbicide

Treatment	Total
K	0.94b
5%	0.89b
20%	0.75b
35%	0.68ab
50%	0.42a
Average	0.74

Note: Values followed by the same lowercase letter are not significantly different according to the LSD test at the 5% level.

The LSD test showed that the 50% concentration suppressed dry weight more strongly than the control, 5%, and 20% concentrations, while its effect was comparable with the 35% concentration. This result indicates that dry matter reduction became clearer at higher extract concentrations. The 50% concentration limited biomass formation more strongly than the control and lower concentrations, while the 35% concentration had already shown a comparable inhibitory response.

The lower dry weight may be related to the disruption of physiological processes involved in biomass accumulation. Dry matter formation depends on photosynthetic activity, assimilate utilization, cell formation, and tissue development. When allelochemical compounds interfere with these processes, the plant cannot efficiently convert growth resources into new biomass. Andriyani and Guntoro (2025) reported that increasing the concentration of *Eucalyptus pellita* leaf extract suppressed the growth of target weeds. Sofiyah et al. (2025) also showed that higher doses of bioherbicide were more effective in suppressing weed growth. These findings support the role of botanical bioherbicides in reducing dry matter accumulation through growth inhibition.

PHYTOTOXICITY

Based on the analysis of variance, ketapang leaf extract did not significantly affect the phytotoxicity of purple nutsedge. This result indicates that the application of ketapang leaf extract at 5%, 20%, 35%, and 50% did not produce clear differences in visible injury symptoms compared with the control. Since phytotoxicity was assessed visually, this parameter represents external symptoms such as leaf discoloration, wilting, drying, and tissue damage.

Table 4. Average phytotoxicity score due to the effect of ketapang leaf extract bioherbicide

Treatment	Total
K	1.00
5%	1.50
20%	1.50
35%	1.25
50%	1.50
Average	1.35

Note: The treatment effect was not significant based on analysis of variance at the 5% level; therefore, mean separation using the LSD test was not performed.

The absence of a significant effect on phytotoxicity may occur because botanical bioherbicides do not always produce visible injury symptoms at the same time as growth inhibition. Allelochemical compounds may first affect internal physiological processes before external symptoms become clearly visible. Motmainna et al. (2023) explained that the activity of allelopathic compounds may vary in strength depending on the target plant. Alanaz et al. (2023) also reported that weed responses to plant extracts can differ depending on extract type, weed species, and concentration.

Therefore, the nonsignificant phytotoxicity result does not indicate that ketapang leaf extract had no inhibitory effect. In this study, the inhibitory response was more clearly reflected in growth parameters, such as plant height, dry weight, and root length. Jalilian et al. (2025) reported that plant extracts containing allelochemicals can reduce weed biomass, leaf greenness, and stomatal conductance. Kostina-Bednarz et al. (2023) and Islam et al. (2024) also

stated that natural bioherbicides can suppress weed growth through physiological interference, not only through visible injury symptoms.

ROOT LENGTH

Based on the analysis of variance, ketapang leaf extract significantly affected the root length of purple nutsedge. Root length is an important parameter because roots directly interact with the growing medium and the applied extract solution. Therefore, root tissues can respond directly to allelochemical compounds released into the medium.

Table 5. Average root length (cm) due to the effect of ketapang leaf extract bioherbicide.

Treatment	Total
K	17.20b
5%	15.05ab
20%	14.35ab
35%	12.00a
50%	11.12a
Average	13.94

Note: Values followed by the same lowercase letter are not significantly different according to the LSD test at the 5% level.

The LSD test showed that the 35% and 50% concentrations significantly suppressed root length compared with the control. The 5% and 20% concentrations showed an intermediate response because their effects were still comparable with the control but also overlapped with the higher concentrations. This indicates that root growth began to respond to ketapang leaf extract at lower concentrations, while clearer suppression appeared at 35% and 50%.

This response may be related to the application method, in which the extract was applied to the root zone. When allelochemical compounds enter the growing medium and come into direct contact with roots, growth processes at the root tip may be disturbed. The root tip is an active region for cell division and elongation, so disruption in this area can limit root extension. Hasanah et al. (2019) explained that reduced root length can occur because allelochemicals interfere with cell division and elongation. Susilo et al. (2026) also stated that bioherbicidal candidate compounds may inhibit root growth in target plants. When root growth is inhibited, the ability of purple nutsedge to absorb water and nutrients may decrease, which can reduce overall weed growth.

CONCLUSION AND RECOMMENDATIONS

Ketapang leaf extract (*Terminalia catappa* L.) showed potential as a plant-based bioherbicide for suppressing the growth of purple nutsedge (*Cyperus rotundus* L.). The extract significantly affected plant height at 27 and 30 days after planting, number of leaves at 30 days after planting, plant dry weight, and root length, but did not significantly affect phytotoxicity. The 50% concentration showed a clearer inhibitory response in most growth parameters, especially plant height, number of leaves, and plant dry weight, while the 35% concentration showed a comparable effect to the 50% concentration on root length. Therefore, ketapang leaf extract can be considered a promising plant-based bioherbicide for controlling purple nutsedge growth. Further studies are recommended to re-evaluate the 50% concentration and include the 35% concentration as a

comparison, using more uniform planting materials, more replications, and a longer observation period to obtain stronger statistical results. Field-scale testing is also needed to evaluate the consistency and practical effectiveness of ketapang leaf extract under cultivation conditions.

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