ISSN 2664-4142 (Print) & ISSN 2664-6749 (Online)
South Asian Research Journal of Pharmaceutical Sciences
Abbreviated Key Title: South Asian Res J Pharm Sci

| Volume-7 | Issue-4 | Jul-Aug 2025 | **DOI: https://doi.org/10.36346/sarjps.2025.v07i04.004**

Review Article

Review of the Herbicidal and Pesticidal Properties of the Tropical Legume Tree *Gliricidia sepium*

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Article History
Received: 12.06.2025
Accepted: 16.08.2025
Published: 19.08.2025

Abstract: *Gliricidia sepium* (Jacq.) Kunth ex Walp is a legume tree species categorized as a versatile plant due to its multi uses in many areas including agro-forestry, agriculture, animal husbandry, and pharmaceuticals. This paper presents the results of research on the herbicidal and pesticidal efficacies of gliricidia plant. The data were compiled by searching papers covering the relevance subjects that have been published in English that can be accessed through Google search engine. There were 36 papers that met the inclusion criteria consisting of 11 papers revealed herbicidal properties, 6 papers reporting nematicidal properties, and 19 papers presenting insecticidal properties of plant extract or residues of *G. sepium.* In addition to reporting its efficacy, several articles have reported the existence of the type and nature (stability) of the phytochemicals contained in this plant extract. Overall, gliricidia plant is rich in phytochemicals which are toxic to various living organisms, from microbes, plants to animals. It was also revealed the physical and organoleptic properties of this plant extract remained stable in storages for 2-3 years. Thus, it can be concluded that *G. sepium* has the potential to be developed as a commercial herbicide and pesticide.

Keywords: Gamal, Gliricidia Plant, *Gliricidia Sepium*, Herbicidal Properties, Insecticidal Properties, Pesticidal Properties.

1. INTRODUCTION

Gliricidia sepium (Jacq.) Kunth ex Walp is the tropical forage belongs to family of Fabaceae (alt. Leguminosae), native to dry Pacific Coast of Central America that has been long cultivated and naturalized in tropical Mexico, Central America and northern South America up to 1500 m altitude. Now this species of legume tree, which in the past was commonly used as fodder, has spread to other tropical regions of the world and planted for various purposes (Wiersumn *et al*., 1992). The benefits of the plant with the popular name gliricidia are incredibly diverse, ranging from animal husbandry, agriculture, forestry, pests and diseases, to pharmaceuticals. Therefore it's not an exaggeration if *Gliricidia sepium* is called a versatile plant (Rojas-Sandoval, 2022).

Studies in the agroforestry sector, for one example, revealed that when Gliricidia was intercropped with maize, the yield of maize tended to increase. The gliricidia had a positive effect on soil organic matter, particulate matter and Nitrogen (N) (Beedy *et al.,* 2010). The application of gliricidia green manure on maize farming has confirmed that the organic material of gliricidia can increase shoot dry weight and N accumulation of maize (Diouf *et al.,* 2017).

A study carried out in Indonesia showed that the application of the mixture of sago pulp waste and *Gliricidia sepium* pruning increased the cumulative amount of mineral N in the soil, which in turn improved maize growth (Putinella *et al*., 2022). The benefits of the Gliricidia plant in soil enrichment, in the field of agroforestry studies, have even been summarized by Alamu *et al.,* (2023) in their review work (Alamu *et al*., 2023).

Second aspect that has been studied from this plant which in Indonesia is called gamal is its metabolites content. Phytochemicals screening done by Eluyode and Alabi (2007) indicated that roots, barks, and leaves of this plant contained

secondary metabolites including tannins, phlobatannins alkaloids, saponnins, and flavonoids. While in its seeds, in addition to those five substances, there were identified glycosides and sterols (Eluyode and Alabi, 2007). The presence of alkaloids and saponins in the bark and leaves of the Gliricidia plant was confirmed by other researchers (Cruz and Cui-Lim, 2016). Phytochemicals screening carried out using MALDI Mass Spectrometry Imaging found that Gliricidia plant leaf extract containing polyphenols, tannins, dan flavonoids (Pereira *et al*., 2022).

The next aspect that most extensively studied from *Gliricidia sepium* plant was the medicinal properties potency of its secondary metabolites. The efficacy test against bacteria revealed that the crude extract of this plant leaves showed anti-bacterial properties against both Gram (+ve) and (-ve) pathogenic bacteria (Nazli *et al.,* 2011; Cherian and Thambi, 2019). There are at least four strains of bacteria that are known greatly affected by the gliricidia plant extract, namely: *Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae* and *Staphylococcus aureus* (Martínez *et al.,* 2021). Apart from its antimicrobial properties, the secondary metabolites of the gliricidia plant have been shown to have various other medicinal properties including cytotoxic activity, anti-inflammatory activity, antioxidant activity, thrombolytic, anti-sickling activity, wound healing, mosquitocidal activity, and anthelmintic activity (Awafaey *et al*., 2023).

This work focuses on gathering the results of research on the potential of the *Gliricidia sepium* plant as a source of herbicides and pesticides that have been carried out in various countries where these plants are cultivated. The main objective of this review work is to present the hard work of researchers in an effort to find alternative natural ingredients from the Gliricidia plant which can be developed into effective and safe herbicides and pesticides. Not to show off research results based on the greatness of the researchers and the sophistication of the equipment and methods used.

2. METHODOLOGY

2.1. Search Strategy

Relevant literature searches were all done online using the Google search engine. The targeted database is not limited based on its reputation, but rather the open access nature of the database in question. All open access databases that allow the full text to be downloaded are used in searches, including PubMed, Science Direct, Web of Science, Semantic Scholar, PLOS ONE, MDPI, JSTOR, Zendy, Zenodo, SCI, and Research Gate. The keyword used was as follows "*Gliricidia sepium*" AND "pesticidal properties" AND "herbicidal properties" AND other words related to herbicides and pesticides such as "allelophatic properties", "insecticidal properties", "larvicidal properties" and nematicidal properties".

2.2. Inclusion Criteria

All papers presenting the results of a study on the effect of the active ingredients contained in the gliricidia plant on weeds, pests and human diseases were included in our search. The main paper inclusion criteria are published in English, or other languages but the abstract is written in English. The country where the research is conducted and the institution where the researcher is affiliated are not taken into consideration. The year of publication of the work is also not used as a criterion for data compilation in this review.

3. RESULT AND DISCUSSION

3.1 Herbicide Properties

There are 11 papers published in the last 30 years covering the results of studies on the effect of plant residues or plant extracts of *Gliricidia sepium* on the growth performance of weeds or other crops. The context of research, types of preparations, methods of application, and the effects observed compiled from these studies are presented in Table 1.

Table 1: Allelopathic properties and herbicide potential of *Gliricidia sepium*

Context	Preparation	Application	Herbicidal effects observed	Reference
Allelophaty for controlling weeds	Leaf mulches from which extracts were screened to identify allelopathic substances	The mulch applied to the *Sorghum vulgare* grown fields	Weeds effectively controlled, Sorghum yield improved	Ramamoorthy and Paliwal (1993)
Allelopathic effects on crops growth	Green manure	The green manure incorporated to soil substratum of grown cowpea, rice and maize	Gliricidia negatively affected the growth parameters of grown crops	Gunasekara and Jayakody (1998)
Allelopathic effects on seed germination	Aqueous leaf extract and pulverized leaf tissue	The leaf extracts and pulverized leaf tissues applied to seedling of corn (*Zea mays* L.) and	Gliricidia extract inhibited germination, radicle and plumule lengths, root and shoot growth, chlorophyll content, photosynthesis and nutrient uptake in both crops	Oyun. (2006)

		bean (*Vigna sinensis* L.)		
Herbicidal efficacy on seed germination	Aqueous suspension (5%) of the ethyl alcohol and petroleum extract of the plant leaves	Extracts applied in vitro to maize (*Zea mays* L.), cowpea (*Vigna unguiculata*), and okra (*Okra* spp.)	In contact the extract inhibit the seed germination and shoot growth of maize and cowpea, but no inhibitory effect on the germination and shoot growth of okra.	Owokotomo and Afuye 2007.
Allelopathic effect on crops growth	Crude methanol extract of plant leaves fractionated using n-hexane solvent and characterized for allelopathic compounds	The fractionated extract applied to grown lettuce (*Lactuca sativa*)	The n-hexane soluble fraction of the extract inhibited the growth of lettuce (*Lactuca sativa*) radicles.	Takemura *et al.*, 2013
Allelopathic effects test in laboratory and nursery	Fresh leaves extract and shredded leaves	Leaf extract applied in laboratory, while shredded leaves applied in nursery experiment against corn (Zea mays)	Both laboratory and nursery test exhibit the prepared extracts and shredded leaves affect the germination survival, early shoot and root growth, and biomass of corn.	Manee and Rodriguez, 2014
Allelopathic potentiality for controlling weeds	Incorporartion of fresh leaf *Gliricidia sepium* and *Cassia siamea*	Fresh leaf incorporation applied in the aman rice farm	Weed control efficiency of fresh leaf of *G. sepium* at 10 t per ha give similar results to herbicide treatment Pretilachlor 1 L a.i. per ha.	Nasir *et al*., 2016
Herbicidal potentials for controlling weeds	Aqueous extracts of the leaves and barks	The extract applied to seedling growth of *Bidens pilosa* L (Asteraceae) weeds	Both leaf and bark extract inhibited germination and radicle length, and retarded the plumule length.	Janet., 2016
Herbicidal potential for controlling weeds	Aqueous extract of leachates of petals that characterized for allelopathic compounds	The extract applied to weed *Alternanthera tenella*. Colla seeds	Germination and seedling growth of *A. tenella* was inhibited siginificantly	Kamble and Pawar, 2018
Herbicidal potential for controlling weeds	Mulch of the plant tree branches	The mulch of gliricidia plant branches applied in a corn field	The mulch of gliricidia branches caused a reduction in weed growth, and increased growth and yield in the corn.	Santos *et al*., 2020.
Allelopathic potentiality for controlling weeds	Foliar biomass prepared as green manure	The manure applied to maize (*Zea may*s L.) and bean (*Phaseolus vulgaris* L.) in laboratory and green house	The plant residues of Gliricidia showed depressive effects particularly on radicle elongation, root and shoot growth of tested crop species	Kaboneka *et al*., 2020

Factors that make the legume tree plant of *Gliricidia sepium* potentials to have herbicidal properties are the presence of allelopathic phytochemicals. As reported by Ramamoorthy and Paliwal (1993) in the crude extract of gliricidia plant there were dozens of toxic compounds found namely gallic acid, protocatechuic acid, p-hydroxybenzoic acid, gentisic acid, t3-resorcyclic acid, vanillic acid, syringic acid, p-coumaric acid, m-coumaric acid, o-coumaric acid, ferulic acid, sinapinic acid (trans and cis forms), coumarin, and myricetin (Ramamoorthy and Paliwal, 1993). The presence of coumarin as suggested by Takemura *et al*., (2013) is the main factor for the allelopathic nature of the gliricidia plant extract. The allelopathic properties of the gliricidia plant extract which are associated with the presence of gallic acid and coumarin derivatives were strengthened by Kamble and Pawar (2018) through their study which revealed the inhibitory effect of this plant extract on the weed *Alternanthera tenella* Colla. GC-MS analysis they did found there were phenolics (gallic acid), hydrocoumarin, 3-(2-hydroxyphenyl) propionic acid, diphenyl ether and hydroxybiphenyl in the leachates of petals extract of *Gliricidia sepium*.

3.2 Pesticide Properties

There are two groups of pests that have received the most attention from researchers in testing the pesticide properties of the *Gliricidia sepium* plant we found in this review, namely nematodes and arthropods—mainly insects.

The Nematicidal Properties

There are six papers published in the last 15 years that contain the results of testing the nematicidal properties of gliricidia plant extracts that we have collected. The research findings reported in those five papers can be outlined as follows in Table 2.

Table 2: Nematicidal properties of plant extract of *Gricidia sepium*

Extract Preparation	Targeted pest	Treatment	Effects observed	References
Plant leaf and root extracts followed by phytochemical analysis	*Meloidogyne incognita*, a nematode infecting okra	Nine-day old okra seedling in greenhouse inoculated with 3,000 fresh eggs of *M. incognita* and 5ml of each of the extracts was added simultaneously around the roots of the seedling.	Nematode population, galling, and nematode reproduction rate reduced, while fruit weight of okra enhanced	Adekunle and Akinlua (2007)
Leaves methanol extract	Livestock gastrointestinal nematodes	Egg hatch inhibition assay of the extract compared to standard nematicide (levamisole 2 mg/mL)	The extract showed a dose-dependent response in inhibition of eggs hatching with a LD_{50} value of 394.96 Î¼g/mL	Pérez-Pérez *et al.*, 2014
Coumarin derivative of 2H-chromen-2-one isolated from acetonic extract of leaves through silica gel columns	*Cooperia punctata,* a cattle parasitic nematode	Eggs of the *C. punctata* were treated with the extract and then assessed for the egg hatching rate and embryo development inhibition of its.	Extract fraction of 2H-chromen-2-one, effectively inhibited both egg hatching and embryo development of *C. punctata* with an EC_{50} value of 0.024 ± 0.082 mg mL-1.	Son-de Fernex *et al.,* 2017
Ethanolic extracts of the plant for which the anthelmintic substances determined using UHPLC-Q/Orbitrap/MS/MS	*Haemonchus contortus,* sheep gastrointestinal nematodes .	The larvae and eggs of the nematode were treated with the extract and assessed for exsheathment and egg hatching rates of its	Application of *G. sepium* extract led to inhibition rate of exsheathment and egg hatching inhibition rate up to 91.2% and 99.5% respectively	Romero *et al.,* 2020
Ethanol extract of *G. sepium* leaves	*Ascaridia galli*, a parasitic nematode in the digestive tract of poultry	The plant extracts given to galli worms in vitro	At concentration of 5% the extract showed anthelmintic properties against *Ascaridia galli* almost the same as standard piperazine nematicide	Sandy *et al.,* 2023
The plant leaves of *G. sepium* were prepared to be forage feed and leaf powder	Sheep gastrointestinal nematodes (*Haemonchus contortus*, *Trichostrongylus* sp, *Oesophagostomum* sp., Cooperia sp)	The forage and leaf powder were given to sheep to be compared to standard nematicide albendazole	Sheep treated with fresh leaves and leaf powder of *G. sepium* showed decreased number of nematode eggs in their feces.	Sawitri *et al*., 2023

There are several metabolites in *Gliricidia sepium* which are strongly suspected to be toxic to nematodes (nematicidal properties). Adekunle and Akinlua (2007) suspects that the inhibition properties of G. sepium against nematodes are due to the presence of metabolites such as phenolic compound and carboxylic acid and aromatic amide. Next, it is known that *G. sepium* contains coumarin and its derivatives (Ramamoorthy and Paliwal, 1993; Takemura *et al.,* 2013), while according to the findings of Son-de Fernex *et al*., (2017) one of the coumarin derivatives 2h-chromen-2-one has been revealed to have a very significant inhibitory effect on nematode *Cooperia punctata*. Apart from that, the anthelmintic properties of G. sepium can also be related to the presence of glycosylated flavonoids, methoxyphenols, phenylpropanoids, anthraquinone glycosides, amino acids and glycosylated phenolic acids in its extracts (Romero *et al*., 2020).

The Insecticidal Properties

We have collected 19 articles published in the last 25 years (1998-2022) containing research results on the insecticidal properties of *Gliridia sepium* (Jacg.) Walp plant extracts. Six of the 16 articles, presented earliest in Table 3, are original research articles of my colleagues and I.

Table 3: Insecticidal properties of plant extract of *Gricidia sepium*

Extract Preparation	Targeted pest	Treatment	Effects observed	References
Flavonoid-rich fraction of ethanol and water extract	*Planococcus citri* Risso., the coffee mealybugs	Mealybugs fed consecutively with flavonoid fractions of aqueous and methanolic extracts of gamal plant leaves.	Both aqueous and methanol extracts the plant leaves were toxic and lethal to the (*Planococcus citri* Risso.). with an LC_{50} values of 0.033% for water extract and 0.039% for methanol extract	Nukmal *et al*., 2017
Water and methanol extract of leaves extract	*Paracoccus marginatus,* the papaya mealybugs	Mealybugs fed with young fruits of papaya that previously soaked in aqueous and methanolic extracts of gamal for 10 minutes	The aqueous and methanol plant extracts are lethal to P. marginatus with LD_{50} values of 0.063% and 0.09% respectively.	Pratami *et al*, 2018
Water extract formulation of leaf powder from four cultivars of G. sepium namely: Bandar Lampung (BL); Pringsewu (PR); North Lampung (LU); and West Lampung (LB)	*Paracoccus marginatus, (*Hemiptera: Pseudococcidae), the papaya mealybugs	Water extract formulation of gamal leaf powder from four different cultivars given to the mealybugs.	Crude leaf extracts of LU, PR, LB, and BL cultivars lethal to *Paracoccus marginatu* with LC_{50}-72 values of 0.033%, 0.090%, 0.184% and 1.818% respectively, and the mortality rate up to 86.7%.	Nukmal *et al*., 2019
Water and methanol extracts of leaves that have been stored for 2 -3 years	*Pseudococcus longispinus***,** mealybugs infecting rose apple	Two types of extract prepared, namely water and methanol were tested for their physical and organoleptic and pH.	Compared to fresh extract, G. sepeium extract which has been stored for 2 - 3 years does not experience a significant change in toxicity against mealybugs. The organoleptic and physical properties of the extract also remained stable	Nukmal *et al*., 2022
Crude water extract at the concentration of 0.11%.	S*olenopsis* sp., red ants mutualistic symbiont of mealybugs	Symbionic ants of the mealybugs treated with crude water extract	The *G. sepium* extract showed anti-feed ant and lethal effect on red ants. The lethal effect of the extract similar to a synthetic insecticide Regent 50 SC.	Sari *et al*., 2019
Crude ethanol extracts of dry leaves, fresh leaves, dry petioles, and stem bark	Mosquito larvae of *Anopheles stephansi*, *Aedes aegypti* and *Culex quinquefasciatu*	The extracts of *Gliricidia sepium* were used to treat he late third instar larvae of Anopheles stephansi, Aedes aegypti and Culex quinquefasciatus.	All the plant extracts are toxic to the larvae of the three mosquito species, causing 100% mortality at a dosage of less than 16,000 ppm.	Sharma *et al*., 1998
Various concentrations (50-250 ppm) of plant extract of *G. sepium* ext	Eggs, 3rd instar larvae, and pupae of *Anopheles stephensi (An. stephensi)*	Early third instar larvae of *Anopheles stephensi* were exposed to various	The G. sepium xtracts exhibited 100% egg hatching inhibiton, 96.0% larvae mortality; and	Krishnappa *et al*., 2012

		concentrations the extract.	91.10% pupae mortality in *Anopheles stephensi*	
Petroleum ether, hexane, acetone, methanol and water extracts of leaves	4th instar larvae of *Culex quinquefasciatus*	The extracts of Gliricidia sepium leaves were assayed for toxicity against 4 th instar larvae of C.quinquefasciatus and then purified by column chromatography	The 8,11,14- eicosatrienoic acid fraction of the extract showed larvicidal activity against *Culex quinquefasciatus* with LC_{50} value of 0.011 mg/ml and LC_{90} of 0.060 mg/ml	Thomas *et al*., 2014
Petroleum ether crude extract of the leaves *Gliricidia sepium*	4th instar larvae of Anopheles mosquitoes	Petroleum ether crude extract of the leaves of *G. sepium* exposed to the fourth instar larvae of Anopheles mosquitoes and non targeted organisms.	The extract at 200 ppm cause lethality with LC_{50} was 70.68 ppm/6 hrs.	Mathew *et al.,* 2015
Ethanol, acetone, and iso-propanol extract of leaves *Gliricidia sepium*	3rd instar larvae of *Aedes aegypti*	*G. Sepium* leaves extracts of different solvent exposed to *Aedes aegypti* larvae.	The ethanol extract was found to inhibit the growth of *A. aegypti* larvae and was the most effective than other solvent	Krishnaveni *et al*., 2015
Methanol and hexane extracts of *Gliricidia sepium* flowers and seeds of *Annona squamosa*	2nd, 3rd, and 4th instar larvae of *Aedes aegypti*	The metabolites from aromatic phytoextracts were exposed to dengue vector: *Aedes aegypti*.	Methanol extract of *G. sepium* showed LC_{50} of 38.01ppm, 45.65 ppm, 60.25 ppm against 2nd, 3rd, and 4th instar larvae	Goyal *et al.,* 2019
Aqueous extract of G.sepium leaves that were isolated for its essential oil	4th instar larvae of household mosquitoes	The mosquitoes of fourth instar larvae were treated with 5 different concentrations of aqueous extract.	Volatile oil from *G. sepium* leaves caused mortility of mosquito larvae up to 45% in 24 h	Umadevi A and Jaleel, 2020
Juice extract prepared through chopping and grinding the leaves of Madre de Cacao and screened for its phytochemicals	Mosquito larvae of *Aedes aegypti*	Different extract formulations of the plant exposed to different instar stage of mosquito larvae.	100% *G.sepium* formulation highly effective in killing mosquito larvae	De Leon *et al*., 2021
The leaves were pounded using mortar and pestle and was diluted to various quantities	Mosquito wrigglers (larvae) of unknown species	Some concentrations of Madre de Cacao and Guava leaves use as repellent.	100% concentration of *G. sepium* leaves extract effectively reduced number of mosquito larvae	Sasan *et al.,* 2021
Petroleum ether, ethyl acetate and methanol extracts of leaves	3rd instar larvae of *Helicoverpa armigera*	Different solvent extracts of *Gliricidia sepium* fed to third instar larvae of *H. armigera*	Methanol, ethyl acetate, and petroleum ether extracts at 1000 ppm exhibited as significant antifeedant activity by 62.38%, 46.67%, and 40.37% respectively	Jose and Sujatha, 2017
Ethanol extract of the leaves	Tick of *Rhipicephalus (Boophilus) annulatus* collected from infested animals,	Different dilutions of the extracts such as 50, 60, 70, 80, 90 and 100 mg/mL were tested using adult immersion test (AIT)	Ethanol extract of *G. sepium* exhibit a relatively low toxicity effect on the ticks with a mortality rate of 4-12 per cent, and did not affect the hatching of eggs laid by treated females.	Ravindran *et al.*, 2017

Extract juice of *G. sepium* and Andrographis paniculata leaves added with coco milk	Lice and ticks infecting dogs	Three preparations of the extract juice used in the three trials against the lice and ticks,	The formulation consisted of 2 cups of madre *G. sepium*, 2 cups of *A. paniculata*, and 2 cups coco milk is the most effective to make lice and tick fall off the treated dogs	Torres, 2018
Hexane, chloroform and ethanol extract of *Gliricidia sepium* leaves	Granary weevil of *Sitophilus granarius* (Linn.) (Coleoptera: Curculionidae)		The ethanol extracts more effective than the other solvents, with repellent activity of 93.7% and the insecticidal activity of 69.8% in 72hrs against *S. granarius.*	Dharani *et al*., 2021
Leaves extracts of *G. sepium* that were screened for its bioactive compounds	Aphis fabae, black bean aphids infecting string beans (*Phaseolus vulgaris*)	Plant leaves extracts was prepared using microwave assisted extraction and exposed to black bean aphids in string beans	The effectiveness of *G. sepium* on *A. fabae* mortality was comparable to the commercially available pesticide	Maulion *et al*., 2021

Based on the research results presented in Table 3, it is highly feasible to suggest that the *Gliricidia sepium* plant has the potential to be used as a natural insecticide. The majority of pesticide efficacy tests accompanied by phytochemical screening reveal that there are many secondary metabolites of these plants that are toxic. The secondary metabolites of *G. sepium* that are thought to contribute greatly to the mortality of mealy bugs are flavonoids. Nukmal *et al*., (2017) by using the TLC method revealed that there were 7 out of 42 fractions of aqueous extract of this legume plant leaves identified as flavonoids.

Next, the metabolite constituent that has revealed to show a strong larvicidal activity against *Culex quinquefasciatus* mosquito is 8, 11, 14- eicosatrienoic acid a substance belongs to fatty acid group (Thomas *et al*., 2014). Whereas metabolites that are suspected of having larvicidal effect against *Aedes aegypti* mosquito include: sterols, flavonoids, alkaloids, saponins, glycosides, tannins, triterpene (Krishnaveni *et al*., 2015; De Leon *et al*., 2021). In addition, G. sepium is also known to contain essential oils. As has been revealed by Umadevi and Jaleel (2020) that volatile oil from this plant exhibited a lethal effect on the larvae of household mosquitoes. Not only toxic against mosquitoes, bioactive compounds of alkaloids, flavonoids, tannins and phenols also found to have insecticidal effects against black bean aphids (*Aphis fabae*) (Maulion *et al*., 2021).

Another aspect that makes this tropical forage *Gliricidia sepium* feasible to develop as a source of natural pesticides is the stability of the physical and organoleptic properties of the plant extract. Our study showed that the physical stability and bioactivity of methanol extract and aqueous extract of G. sepium leaves could last for 3 years of storage (Nukmal *et al*., 2022).

4. CONCLUSION

Gliricidia sepium (Jacq.) Kunth ex Walp is rich in phytochemicals which are toxic to various living organisms, from bacteria, plants to animals. The results of testing the efficacy of the extract or mulch/pulp of this plant against various living organisms prove that this Leguminosae group of plants has both herbicidal and pesticide properties. In addition, the long-lasting stability of the physical and organoleptic properties of this plant extract makes this tropical forage the potential to be developed as a commercial herbicide and pesticide.

Compliance with Ethical Standards

Acknowledgments

All authors would like to thank all colleagues in the Department of Biology, Faculty of Mathematics and Sciences, University of Lampung for their supports in sharing information regarding relevant articles for this review article.

Disclosure of Conflict of Interest: The authors declare no conflict of interest.

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