CHAPTER I. INTRODUCTION

A. Background

In agroecological systems, weeds are a critical concern that requires stringent management due to the potential harm they may cause. Weed infestation can directly impact crop development by competing with crops for essential resources such as water, nutrients, and light, often resulting in a considerable reduction in crop growth and substantial yield losses. Moreover, weeds often act as a secondary host for phytopathogens, including insects and pathogens that can infect to crops, lead to compromising crop yield, quality, and market value (Alluri & Saha, 2024; Rasul *et al*., 2024).

Study showed that weeds are the leading cause of global crop losses, accounting for 34% of total potential losses, higher than those caused by animal pests (18%) or pathogens (16%) (Oerke, 2006). On average, weeds reduce global plant productivity by 31.5%, resulting in economic losses of approximately 32 billion USD annually. This significant impact is further exacerbated by the emergence of 380 herbicide-resistant weed biotypes, driven by the frequent use of herbicides, highlighting the need for innovative weed management strategies to address ecological and regulatory challenges (Kubiak *et al*., 2022). Additionally, weeds alone reduce crop yields by an average of 28%, a figure comparable to the 27% loss observed when combined with environmental changes, emphasizing their critical role in limiting agricultural productivity, especially under increasingly variable environmental conditions (Vilà *et al*., 2021).

In addition to directly affecting crops and reducing the yield and quality of agricultural products, various weeds indirectly interact with crops by releasing secondary metabolites, known as allelochemicals, into the environment. This phenomenon called allelopathy, refers to the positive or negative effects that one plant has on others through the releases of allelochemicals (Semmar, 2024; Song *et al*., 2024). Allelochemicals can originate from ungerminated seeds, germinating seeds, or the roots of seedlings, and are released through processes such as exudation, volatilization, leaching, frost damage, or the decay of plant tissues and organs. After plant death, allelochemicals may also enter the soil through the decomposition of plant residues (Arora *et al*., 2024). Depending on the type and species of plants, allelopathy often leads to reduced germination rates, inhibited seedling growth, and suppressed root and shoot development in neighboring plants (Hussain *et al*., 2020; Imad *et al*., 2021; M'barek *et al*., 2018). Allelopathic effects of some weeds have demonstrated reduction in respiration of germinating soybeans, cell division, nitrogenase enzyme activity, and cell membrane integrity (Chaniago, 2004).Furthermore, the effects of allelopathy are not limited to living weeds; residues such as stems and leaves left in the soil after weeding can continue to negatively impact crop germination and development (El-Masry *et al*., 2019; Fujii *et al*., 2004; Rashid *et al*., 2010).

There are three common groups of weeds that frequently exhibit allelopathic properties are the Poaceae (grasses), Cyperaceae (sedges), and various broadleaf species. The Poaceae family, also known as grasses, includes species such as *Eleusine indica* and *Echinochloa colona*, which are known for their robust growth and competitive nature (Deng *et al*., 2020; Rao, 2021). The *Cyperaceae* family, or sedges, includes species like *Cyperus iria* and *Kyllinga brevifolia*, which thrive in moist conditions and can produce allelochemicals that inhibit the growth of neighboring plants (Chopra *et al*., 2017; Kawabata *et al*., 1994). Broadleaf weeds, such as *Mimosa pudica* and *Sphagneticola trilobata*, are characterized by their wide leaves and diverse growth habits, often releasing compounds that affect the germination and development of crops (Hernández-Aro *et al*., 2016; Perera *et al*., 2023).

Efforts to understand allelopathy effect and allelochemicals, their release into the environment, their effects on neighboring plants, and their impact on soil are of great interest to researchers in the field of allelopathy. Additionally, applying this knowledge to manage natural and agricultural ecosystems is a key focus for scientists engaged in allelopathic research worldwide (Jose & Shaji, 2020). The sandwich method is a bioassay technique that allows for the assessment of allelopathic activity by placing plant material between layers of agar, thereby facilitating the detection of inhibitory effects on seed germination and seedling growth this method helped to detect the allelopathy potential of the test subject in the short time and accurately (Fujii *et al*., 2003). Complementary to this, pot experiments and field experiment provide a more realistic soil-based environment to observe the allelopathic interactions under conditions that closely mimic natural growing situations (Khatri *et al*., 2024; Tian *et al*., 2022).

Various plant species are used to test allelopathic potential, including crop plants, weeds, and model species, to evaluate their sensitivity to allelochemicals. Among these, *Lactuca sativa* (lettuce) is one of the most commonly used test plants in allelopathy studies. Its widespread use is attributed to its high sensitivity to a broad range of allelochemicals, rapid germination, and consistent growth patterns, making it an ideal bioindicator for assessing the effects of inhibitory substances on seed germination and seedling development (Hussain *et al*., 2020; Mukaromah *et al*., 2017; Rashid *et al*., 2010; Rehman *et al*., 2019; Zohra *et al*., 2019). Other species, such as *Lepidium sativum* (garden cress), *Zea mays* (maize) and *Brassica juncea* (mustard greens) are also employed in specific cases (Iqbal & Fry, 2012; Kupcinskiene *et al*., 2024; Ma *et al*., 2022; Nuaman, 2023; Rehman *et al*., 2019). However, the prominence of *Lactuca sativa* in allelopathic research underscores its reliability in providing reproducible and measurable responses, facilitating the comparison of allelopathic effects across different studies (Hussain *et al*., 2020; Tantiado & Saylo, 2012).

In Indonesia, several weed species pose significant challenges to agriculture. *Kyllinga brevifolia* is known for its adaptability and presence in agricultural areas, particularly in regions like Malang (Rodiyati & Nakagoshi, 2003). *Eleusine indica*, commonly found in Indonesian oil palm plantations, has developed resistance to glyphosate herbicide, complicating its management (Kurniadie *et al*., 2023). *Sphagneticola trilobata* is recognized as a noxious weed in agricultural lands and along roadsides, further disrupting farming activities (Handayani *et al*., 2021). Although several studies have investigated the allelopathy of *Eleusine indica, Kyllinga brevifolia* and *Sphagneticola trilobata* (Kawabata *et al*., 1994; Perera *et al*., 2023; Rahardiyan *et al*., 2019), the understanding of their allelopathic effects remains fragmented and needs further consolidation.

In many agricultural practices, weed removal is often conducted through physical means, either manually or with the use of machinery (Woyessa, 2022).

These methods typically leave behind substantial amounts of weed residues, which are either left to decompose in place or gathered and deposited in designated areas. While this approach is effective in clearing fields, it may unintentionally lead to adverse effects on the soil environment. Unlike crop residues that generally decompose relatively quickly, weed residues, particularly from species with fibrous or lignified tissues tend to break down more slowly (Vazquez et al., 2003). During this prolonged decomposition process, allelochemicals stored within plant tissues, especially in the stems and leaves, can be gradually released into the soil. These compounds may alter soil chemical properties and negatively impact the germination and growth of nearby or subsequent crops (Zohaib et al., 2016).

Although organic mulches are biodegradable and widely used, their decomposition may temporarily deplete soil mineral nitrogen and release phytotoxins that inhibit not only weed growth but also that of crop plants (Bond & Grundy, 2001). Despite the widespread use of physical weed control and organic mulching, the ecological consequences of poorly managed weed residues remain underexplored. Given the aggressive nature and widespread presence of *E. indica*, *K. brevifolia* and *S. trilobata*, it is crucial to evaluate their allelopathic potential systematically. Comprehensive studies that examine and compare their effects under controlled conditions are essential to better understand how these weed residues influence crop performance and to inform more sustainable residue management strategies in agroecosystems.

Given this context, the study "Allelopathic effects of plant litter from *Eleusine indica* (L.) Gaertn, *Kyllinga brevifolia* Rottb. and *Sphagneticola trilobata* (L.) Pruski on the germination and growth of lettuce (*Lactuca sativa* L.)" aims to address this knowledge gap. By employing sandwich method and pot experiments, this research offers a dual approach to understanding the allelopathic dynamics of these weeds. The findings from this study are expected to significantly contribute to the body of knowledge on weed-crop interactions and provide practical insights for developing effective weed management strategies in agricultural systems.

B. Novelty

This research offers a novel perspective by systematically evaluating the allelopathic effects of decomposing weed residues from three weed: *Eleusine indica*, *Kyllinga brevifolia* and *Sphagneticola trilobata* on the germination and growth of *Lactuca sativa* under controlled laboratory and pot conditions. While allelopathy has been studied in various contexts, few investigations focus on the lingering effects of weed litter post-harvest or weed clearance, particularly within tropical agricultural systems. To compare multiple weed species using a standardized bioassay with lettuce as a sensitive indicator plant and bridging the gap between theoretical allelopathic knowledge and practical implications in residue management, this research contributes understanding to the field of weed ecology and sustainable agriculture.

C. Identify the problem of the research

1. There is a lack of comparative studies assessing their allelopathic potential under controlled conditions.

2. The effects of weed residues from common tropical weeds in the soil such as *Eleusine indica*, *Kyllinga brevifolia* and *Sphagneticola trilobata* are underexplored.

E. Objectives of the research

1. To evaluate the allelopathic effects of weed residues (*Eleusine indica*, *Kyllinga brevifolia* and *Sphagneticola trilobata*) on seed germination and early growth of *Lactuca sativa*.

2. To compare the strength of allelopathic effects among the three weed species under both agar-based (sandwich) and soil-based (pot) experimental conditions.

3. To determine the dose-dependent responses of lettuce to varying concentrations of weed litter in order to simulate realistic field residue levels.

4. To provide insights into the potential ecological risks posed by unmanaged weed residues in agricultural systems and inform more sustainable weed and residue management practices.

F. Benefits of the research

This study can be used as a baseline and a source of information in further research on the allelopathy potential of the weed. Understand the impact of allelopathy from the weed to the crop in the cultivation progress. Take advantage of the allelopathy ability of some weed species to apply it in practice as a natural herbicide.