CHAPTER I. INTRODUCTION

A. Background

Red chili pepper (*Capsicum annuum* L.) ís an impȯtant horticultural crop widely cultivated worldwide. It offers a range of spicy and sweet flavors depending on the variety. It is commonly used as both a vegetable and a spice in various dishes. Red chili pepper (RCP) has a high commercial value. It is grown throughout Indonesia, including West Sumatra (Rawung *et al.*, 2021; Rodríguez-Barajas *et al.*, 2023; Rodríguez &Velastequí, 2019).

According to data from BPS (Central Statistical Biro of Indonesia, 2023), chili production in Indonesia always fluctuates. The fluctuation could be seen from the national production from 2019 to 2023, i.e., 1.214; 1.264; 0,8; 1.017; and 1.159 million tons respectively. From 2019 to 2023, national productivity also generally declined, registering 9.10, 9.45, 8.37, 9.22, and 8.87 tons/ha, respectively. One of the factors that caused the fluctuation is pest attacks. Aphid is one of the pests that always attack red chili pepper plants. Cotton aphid (*Aphis gossypii* Glover) is one of the species causing a major threat to the productivity of red chili pepper plants.

Cotton aphid is a significant pest affecting chili crops (Daryanto *et al.*, 2018). It has a wide host range, which includes plant families like Fabaceae, Solanaceae, Cucurbitaceae, and Asteraceae (Nurhayati & Haryadi, 2022). The damage caused by this aphid can be direct or indirect. Directly, aphid sucks the plant sap, causing the plants not to grow well. Leaves show the symptom of curls. Indirectly, aphid secretes honeydew, a sugary liquid, that can coat the surface of the plant leaves, encouraging the growth of sooty mold on host plants. Sooty mold develops as a result of the interaction between honeydew and fungi (Daryanto *et al.*, 2018). The molds finally cover the surface of the leaves, leading to the disruption of the photosynthesis process (Nurhayati & Haryadi, 2022). Early growth stage infection can result in complete losses because of fruit setting and blossom dropping. Plants infected during the generative stage yield little, hard, and unmarketable fruits (Suwandi *et al.*, 2020). Aphid invasion can cause a 65% loss (Tobing *et al.*, 2023).

In controlling the aphid attacks, farmers commonly still rely on synthetic insecticides. Using synthetic insecticides causes so many problems, such as posing environmental risks. Pesticides contaminate soil and water, harm ecosystems, and reduce biodiversity by killing beneficial insects. They also affect non-target species and disrupt food chains, raising concerns about sustainability. In contrast, biological control, particularly using entomopathogenic fungi, offers a safer and more sustainable alternative for pest management.

Around 1.000 types of entomopathogenic fungi, including *Trichoderma* spp, *Trichoderma harzianum*, *Trichoderma viride*, *Metarhizium anisopliae*, and *Beauveria bassiana*, have shown effectiveness in controlling aphids (Baki & Erler, 2024; Erol *et al.*, 2020; Mukherjee & Ghosh, 2023; Nawaz *et al.*, 2022). The entomopathogenic fungi (EPF) *Trichoderma* spp., *B. bassiana*, and *M. anisopliae* share a similar mechanism for infecting aphids, involving adhesion, penetration, colonization, and dissemination. The infection begins with the attachment of fungal spores to the insect cuticle, mediated by hydrophobic interactions and surface proteins. Once adhered, these fungi produce hydrolytic enzymes such as chitinases, proteases, and lipases, coupled with mechanical pressure, to degrade the cuticle and penetrate the insect's body (Erol *et al.*, 2020; Shakeri & Foster, 2007; Xiong *et al.*, 2013; Yan *et al.*, 2011). Inside the hemocoel, they evade the host's immune defenses using immunosuppressive metabolites and proliferate by producing blastospores or hyphae that invade internal tissues. The fungi release toxins and enzymes, disrupting physiological processes and leading to the host's death through systemic infection and nutrient depletion (Guo *et al.*, 2020; Ortiz-Urquiza & Keyhani, 2013; Syazwan *et al.*, 2021).

There have been studies using entomopathogenic fungi. Baki & Erler (2024) assessed the pathogenicity of five indigenous *B. bassiana* isolates (BbFn-2, BbKm-2, BbSr-2, BbDs-4, and BbDm-2) against *A. gossypii* nymphs and adults at varying conidial concentrations (from 1×10^5 to 1×10^9 conidia/mL). The study found that after 10 days, the highest concentration, 1×10^9 conidia/mL, resulted in mortality rates ranging from 83.3% to 100%**,** indicating a strong pathogenic effect at higher conidial concentrations. Nawaz *et al.* (2022) demonstrated that *M. anisopliae* has potential for pest control. The combination treatments significantly enhanced aphid mortality compared to individual applications, with the flonicamid-*M. Anisopliae* mixture achieved the highest mortality rate (91.68%) within 72 hours at a concentration of 2.4 × 10^6 cfu/ml. These studies have demonstrated the great potential of EPF in the control of *A. gossypii*. According to Podder & Ghosh. (2019), *Trichoderma asperellum* demonstrated a high capacity as an entomopathogenic activity against *Anopheles* mosquitoes. The *Trichoderma asperellum* (TaspSKGN2) strain was the most virulent of the three isolates examined. It had the lowest LD_{50} (2.68 × 10^7 conidia/mL) and LT_{50} (12.33 h). Strong larvicidal activity was demonstrated by methanolic extracts, especially Fraction 8 (MF8) (LD_{50} = 0.059 mg/mL; LT_{50} = 8.57 h).

Entomopathogenic fungi (EPF), such as *Beauveria bassiana* and *Metarhizium anisopliae*, have been shown to enhance plant defense mechanisms by increasing salicylic acid (SA) levels and chlorophyll content. SA is a key signaling molecule in plant defense, activating systemic acquired resistance (SAR) pathways that bolster the plant's ability to resist pests like aphids. The application of EPF can induce systemic responses in plants, leading to elevated SA concentrations and improved chlorophyll content, which enhances photosynthetic efficiency and overall plant health. This synergistic effect not only strengthens the plant's resistance to aphids but also promotes growth and productivity. Recent studies have demonstrated that EPF-treated plants exhibit increased SA levels and chlorophyll content, correlating with enhanced aphid resistance. These findings underscore the potential of EPF as a biocontrol agent that simultaneously boosts plant immunity and suppresses pest populations. (Ahsan *et al.*, 2024; Beris *et al.*, 2025; Li et *al.*, Kaloshian, 2006).

The studies mentioned above have proven that *Trichoderma asperellum*, *Beauveria bassiana*, and *Metarhizium anisopliae* are effective in controlling insect pests. However, no detailed studies have reported the ability of each fungus to suppress *A. gossypii*. So, studies have been conducted on using three entomopathogenic fungi to control *A. gossypii* on red chili plants, entitled "The potency of three entomopathogenic fungi to control *Aphis gossypii* Glover *(Hemiptera: Aphididae* L.*)* causing damage to red chili pepper (*Capsicum annum* L*)".*

B. Objectives of the research

This study was aimed at evaluating the potential of three entomopathogenic fungi (*Trichoderma asperellum*, *Beauveria bassiana*, and *Metarhizium anisopliae*) as biological control agents against *Aphis gossypii* and their effects on chili growth. The specific objectives were to:

1. Identify the morphological characteristics of each fungal species.
2. Determine the most effective spore concentration (10^4 - 10^{10} conidia/mL) for controlling *A. gossypii* under greenhouse conditions.
3. Assess the effects of the optimal fungal spore concentrations on aphid suppression and chili plant growth compared to chemical and untreated controls.

C. Goals of the research

The results of the research can be used as a scientific basis for using entomopathogenic fungi to control insect pests and for further research on entomopathogenic fungi on other insects and crops, in different climatic areas. It can be used as a reference for research, teaching, and learning at educational institutions, a basis for applying and practicing agricultural production for farmers, and as a means of disseminating and transferring farming production techniques.

D. Hypothesis

Null hypothesis (H_0): There were no significant differences among treatments with *T. asperellum*, *B. bassiana*, *M. anisopliae*, and the control in terms of aphid mortality, reproductive suppression, and the physiological or growth parameters of chili plants (e.g., plant height, biomass, chlorophyll, and salicylic acid contents).

Alternative hypothesis (H_1): At least one of the entomopathogenic fungal treatments produces a statistically significant difference compared to the control in aphid mortality, reproduction, or plant physiological and growth parameters. This hypothesis framework was established to determine whether entomopathogenic fungi could effectively suppress *A. gossypii* populations while simultaneously enhancing chili plant growth and defense responses.