I. INTRODUCTION

A. Background

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a dangerous transboundary insect, cosmopolitan, polyphagous, voracious, and invasive pest. This species is native to the tropics and sub-tropics of America (FAO, 2018a). In America, adult FAW moths are extremely migratory, capable of moving up to 1,500-2,000 km per year in quest of warmer temperatures and 500 km in a single season in search of oviposition locations (FAO & CABI, 2019). *S. frugiperda* then raced over 44 nations in SubSaharan Africa during the next two years and was discovered in India in July 2018 and quickly spread to other Asian countries such as Thailand, Indonesia, Vietnam (Sisay, Tefera, Wakgari, Ayalew, & Mendesil, 2019). *S. frugiperda* has a wide host range and feeds in high numbers on the leaves, stems, and reproductive portions of over 350 plant species (27 families). FAW causes significant harm to economically important cultivated grasses such as maize, rice, and wheat resulting in symptoms such as loss of photosynthetic area, structural damage in the whorl, lodging, and decreased reproduction (Montezano *et al*., 2018).

Corn is the preferred host of FAW which can result in significant yield losses if not managed properly. FAW outbreaks in corn could result in yield losses of up to 70% (Nboyine *et al*., 2020). Depending on the crop season and hybrid used, this species could reduce maize yields by up to 57% in Brazil and other South American countries (FAO, 2019). The FAW was discovered in West Sumatra, Indonesia, in early 2019. Its invasion of new habitats may have a negative influence not just on maize output but also on local biodiversity, and other native pests, and the economic damage was estimated to be around US$ 1 billion (FAO & CABI, 2019). At a severe attack rate on corn, the larval population could reach 10 individuals per plant. The same thing was also explained by Nadrawati, Ginting, & Zarkani, (2019) that the FAW pest has also attacked maize plants in Bengkulu, in the vegetative and the generative phase. Simanjuntak, sumiartha, yuliadhi, &

supartha, (2022) reported that the maximum percentage of *S. frugiperda* outbreaks in sweet corn was 43% in Bali.

It was estimated that 30 - 40% of crop loss occurs between preharvest and postharvest. Approximately 1.8 billion people worked in agriculture, with the majority of them using approximately 5.6 billion pounds of synthetic pesticides (FAO, 2018b). Only 0.1% of active ingredients reached the target pests, while 99.9% leaked into the surrounding environment leading to water pollution, soil contamination, lost biodiversity, elimination of key species, and increased pest resistance (Kumar *et al*., 2019). However, the efficiency of this control strategy was hampered by larval activity inside the maize whorl, making it insecticidal sprays difficult to reach the target. The widespread use of synthetic pesticides has been linked to adverse impacts on the environment and nontarget creatures, as well as the fast evolution of insecticide resistance (Sisay, Simiyu *et al*., 2019).

The identification of 54 biopesticides that have been registered in various countries for the management of *Spodoptera* spp. or lepidoptera, in general (Abrahams *et al*., 2017). Botanical insecticides are highly evaluated to tackle *S. frugiperda* at a low economic threshold in most countries (Molina-Ochoa, Carpenter, Heinrichs, & Foster, 2003) and (Kravchuk *et al*., 2019). Leaf extracts of *T.vogelii* are applied as pesticides to kill larvae which are widely used as a chemical insecticide showing a significant decrease in insect and pest activity (Stevenson *et al*., 2012). Tama, Nelly, Djamaan, a, & Candra Lina, (2020) clearly stated that nanoemulsion extract from *T. vogelii* against the II instar larvae of *C. pavonana* at a concentration of 0.5% and 0.25% were 100% and 90% respectively. The fruit of *P. aduncum* contains dillapiole as an active ingredient which is at least 64.4% responsible for biological activities (Karsidi, Rustam, Hennie Laoh, & Pembimbing, 2013). The same thing was reported by Erlina, Lina, Reflinaldon, Djamaan, & Arneti, (2020) that the *P. aduncum* nanoemulsion at a concentration of 0.5% caused 85.33% mortality of larvae *C. pavonana* with LC95 was 0.76% and extended the duration of larval development from instar II to instar IV 2.34 days. The mortality of *S. frugiperda* in trials with *P. aduncum* ethyl acetate extract at a concentration of 10 mg/ml was greater than 50% (Lucena *et al*., 2017). *P. aduncum*'s active ingredient has a negative influence on mortality, the rate of

consumption, and growth causing a decrease in the efficiency of utilization of food, and digestibility (Syahroni & Prijono, 2013).

The utilization of botanical insecticides still contains many weaknesses. Famers are not able to accept a slower rate of control, a lower efficacy, shorter persistence, low physicochemical stability, and greater susceptibility to adverse environmental conditions compared to conventional pesticides. Lina, Dadang, Manuwoto, & Syahbirin, (2015) also mentioned some problems found in botanical insecticides which were easily degraded by heat and easily broken down by the sun. According to Silva *et al*., (2014) synergisms can generate a new excellent commercial bioinsecticide formulation, boosting organic farmers, and the efficacy of the bio-combi products to overcome the specific inadequacies of each product. The use of botanical pesticides from two or more types of plant extracts can lessen reliance on a single type of plant. The combination of two extracts with nanoemulsion technology formed nano-size particles that easier fit into the target which is possible to give a promising prospect to control FAW. For this reason, the research was done entitled "**Joint action of *Tephrosia vogelii* and *Piper aduncum* based nanoemulsion as an alternative control against *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)**".

B. Objectives

The objectives of the research were to determine the insecticidal activity of nanoformulations form the mixtures *T. vogelii* and *P. aduncum* extracts based on mortality, larval development time, and to study the physiological effects of synergistic mixture by assimilation of insect food on S. frugiperda.

C. Goals

The results of the research were expected to give information about the efficiencyaz of nanoformulation from the mixture of *T. vogelii* and *P. aduncum* extracts as an alternative control of *S. frugiperda.*