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THE EFFECTS OF NATURAL PESTICIDES USAGE AND NATURAL ENEMIES ON SEVERAL CORN VARIETIES AGAINST *SPODOPTERA FRUGIPERDA*

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Abstract

The attack of "Spodoptera frugiperda" on maize has the potential to disrupt the availability of maize production in Indonesia, particularly in North Sulawesi, where it spread to additional districts of corn planting centers. Observations were made on nine maize varieties (Manado Kuning, Bissi 2, Pertiwi 3, JH 37, Bissi 18, Pioner P 37, Twinn 20, Bissi 228, and Nasa 29) and on the types and populations of pests and natural enemies on farms, which were sprayed with biopesticides, to determine the resistance, the number of eggs laid and the egg laying period; and logs the types of "S. frugiperda" egg parasitoid. The results showed that the Manado Kuning, Pioner P 37 and Nasa 29 corn varieties were the three most abundant varieties in terms of the number of egg groups laid by "S. frugiperda", where each had five. The Bissi 2 and Pertiwi 3 maize varieties had the least with only one egg group each. The earliest time for oviposition occurred at five days of age on the Pioner P 37, Bissi 228, and Nasa 29 varieties, while the latest time occurred on the Bissi 2 variety at 17 days of age. It was determined that the Bissi 2 variety may become the main plant choice, while the Pioner P 37 and Nasa 29 can be used as bait plants. The type of parasitoids obtained were "Telenomus sp." and "Trichogramma sp.", where "Telenomus sp." was obtained more than "Trichogramma sp." Both can be used as a natural insecticide.

Key words: *corn, fall armyworm, oviposition, varieties, parasitoids*

INTRODUCTION

Corn (*Zea mays* L.) is a type of food plant from the grass family which is classified as a grain crop. In Indonesia, this type of zea plant can be used as a staple food substitute for rice and various kinds of processed foods. Corn is the second food need after rice. To support the need for corn as food, and a staple for the animal feed industry, it is necessary to guarantee the availability of good quality corn, because corn is one of the plant commodities that has an important role in fulfilling human food needs, besides that it is widely used as a basic ingredient for making animal feed, parts of the corn plant can also be used as animal feed such as leaves, stems, husks and cob; so it is an opportunity to develop maize cultivation so that maize production increases. Corn is a seasonal product that is easily damaged, for that it is necessary to apply the right post-harvest technology so that the corn commodity remains available throughout the year, is not easily damaged and is more resistant to storage [20]. Corn has a large production potential and the prospect of its use is also good as a food and feed ingredient. In its marketing activities, there are still some obstacles, namely the availability of products throughout the year and quality that meets the requirements [21]. Therefore, post-harvest handling is important so that the corn does not become damaged and lost. To get quality corn, proper harvest and post-harvest handling is very necessary considering the main problems often faced by farmers are the high yield loss at harvest and post-harvest handling that has not been optimal.

Corn plants grow in the lowlands to high up to 1,200 meters above the sea level, require clay soil media, sandy loam, volcanic soil, fertile, loose, rich in organic matter, requires at least 8 hours of sunlight per day, air temperature 20-33^0 Celsius, rainfall medium, soil pH 5.5-7 with good drainage.

Pests and Diseases of Corn Plants

One of the obstacles in cultivating corn is the presence of pests or plant-disturbing organisms, which interfere with corn productivity, namely armyworm (*Spodoptera frugiperda*) or Grayak caterpillar. The part of the corn plant that is attacked by this pest is the young stem, the stem will break and eventually the corn plant will die. *Agrotis sp.* attacks at night and during the day. This caterpillar control can be done by spraying using the appropriate insecticide and using the recommended dose.

According to Nonci *et al*. (2019) [13], the symptoms of *S. frugiperda* attack can be seen on the young leaves that are still curled with bite holes and dirt. The presence of fall armyworm (FAW) eggs on the leaves and sometimes on the stems, as well as FAW larvae which are characterized by an inverted Y on the head and four dots forming a square on the penultimate segment.

The attack of *Spodoptera frugiperda* (Smith: *Lepidoptera*, *Noctuidae*) on maize has become an important issue because it has the potential to disrupt the availability of maize or maize production in Indonesia. Since April 2019, *S. frugiperda* has been declared or published as a new pest in Indonesia [6], and it attacked maize plantations in West Sumatra Province. It has since quickly attacked and damaged many maize crops in other Indonesian regions, including the North Sulawesi Province.

The corn armyworm *S. frugiperda* is an invasive insect that has become a pest on maize in Indonesia. This insect comes from America and has spread in various countries. In early 2019, this pest was found in corn plants in the Sumatra area [6]. This pest attacks the growing point of the plant which can result in the failure of the formation of young shoots/leaves of plants. *S. frugiperda* larvae have high feeding ability. Larvae will enter the plant and actively feed there, so if the population is still small it will be difficult to detect. Imago is a strong aviator and has a high cruising range [2]. *S. frugiperda* is polyphagous, some of its main hosts are food crops from the Graminae group such as corn, rice, wheat, sorghum, and sugar cane, so the existence and development of its population needs to be watched out for. The losses caused by this pest attack on maize in African and European countries are between 8.3 to 20.6 million tons per year with an economic loss value of between US$ 2.5-6.2 billion per year [5].

The larval species of the Lepidoptera group, namely *S. frugiperda* on sweet hybrid maize in Petir Village, Dramaga District, Bogor Regency. Damage to corn plants caused by *S. frugiperda* was about 60%. The growth phase of the attacked corn plants starts at a young age (vegetative) to the flowering phase (generative). *S. frugiperda* larvae were found on the shoots of plants. Infected plant shoots when the leaves have not fully opened (buds) appear hollow and there is a lot of larval faeces. If the leaves are open, you will see a lot of damaged leaf parts, with holes from the larvae. The larvae usually settle on plant shoots [8].

The emergence of *S. frugiperda* has become a topic of discussion for many parties, from the scientific community to corn farmers. This pest causes severe anxiety because it damages corn plants, especially if the attack occurs at an early age (< 2 weeks) because it causes the death of the corn plants. It also spreads very quickly. According to Meilin, *et al*. (2020) [11], the attack percentage of *S. frugiperda* reaches 93.45% during the vegetative phase of maize. Particularly in North Sulawesi, the attack percentage of *S. frugiperda* in the region reached around 30% to 70%, with a low to severe intensity [10]. As a result, it greatly depressed the psychological condition of corn farmers; moreover, the information on approaches to control and prevent these pests is still very limited.

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In North Sulawesi Province, the presence of *S. frugiperda* was found at the end of July 2019, three months after the pest attacked West Sumatran corn plants. The pest attack started on sweet corn plants (*Zea mays* var. saccharata) in Tomohon City; then, in the short time until October 2019, it spread to various corn planting centers in North Sulawesi Province, although in this early period (July – October 2019), attacks occurred in spots and the infestation did not spread evenly. Next, with the expansion of corn planting in November 2019, *S. frugiperda* attacks expanded with a relatively high population and attack rate. The attack pattern was no longer in the form of spots but occurred evenly in one planting area, which resulted in a severe level of damage and even caused the death of corn plants.

It was difficult to control this pest in many places because various control techniques showed low success rates. In addition, the use of synthetic pesticides (insecticides) was not successful, even though treatments were repeated at intervals from 2-3 days. This situation continued until June 2020 because no registered insecticides effectively controlled *S. frugiperda*, so various insecticides were used by trial and error. This situation was a big problem for corn farmers until several registered insecticides were found to have a satisfactory efficacy for *S. frugiperda*. However, the use of insecticides in pest management is not recommended because of their adverse side effects. In addition to the basic consequences, such as environmental pollution and contamination of corn products with hazardous materials, eventually, pests become resistant to pesticides; in addition, the choice of other insecticides with active ingredients and different ways of working will be very limited.

For this reason, it is imperative to develop environmentally friendly pest control approaches so that the use of pesticides may be avoided. Controlling pests by optimizing the management of plant cultivation and the use of natural enemies needs to be carried out and developed [18].

Entomopathogenic fungi have the potential to be used as one of the biological agents for pest control in food crops. The results indicated that *M. rileyi* was easily propagated in bulk on agar medium and had high virulence against *S. frugiperda* [8].

The oviposition (eggs laying) by adult *S. frugiperda* insects begins to occur as soon as corn plants appear on the soil surface. The younger a corn plant is infested, the greater the chance of damage with a high attack intensity. Nonci *et al*. (2019) [13], states that infestations that occur in corn plants when the young leaves are still rolling cause a production loss of 15-73% if around 55-100% of the plant population is being attacked. Furthermore, the same research states that losses due to *S. frugiperda* attacks varied and depended on the age of the affected corn plants. In addition, the yield loss also depends on the variety and plant cultivation techniques used.

The information above is very important in terms of efforts to implement agricultural controls. It is important to test the preference of maize varieties to see their resistance and susceptibility. Resistant varieties can be the best choice when selecting varieties to be planted, while susceptible varieties can be considered as bait plants.

S. frugiperda are transboundary destroyers with the ability to fly up to 100 km in one night, which allows a rapid increase in the population in new areas because of the lack of natural enemies [13]. However, biodiversity due to the presence of rich varieties of parasitoids, entomopathogenic fungi, and local predators has the ability to become an effective natural enemy for *S. frugiperda* pests. To obtain information about the possibility of local egg parasitoids capable of parasitizing *S. frugiperda* eggs, it is necessary to collect egg groups in preference tests to further maintain and inventory their species.

Corn pests are known to attack in all phases of plant growth, both vegetative and generative. The purpose of this study was to determine the type of pests and natural enemies on corn plants. This study aims to determine the population of pests and natural enemies in corn plants, and the benefits that can be taken are as information material about the composition of pests and natural enemies in corn planting areas, as a reference for environmentally friendly pest control for the community, especially farmers in suppressing corn pest populations. The results of the research that have been carried out show that there are five types of pests that have been found in the field, namely, grasshoppers, *Epilachna sp, Nezara viridula* and *Spodoptera litura*. Grasshoppers are pests that always appear during observation, while *Epilachna sp*, is a pest that rarely appears during observations. Natural enemies found during observations were *Oxyopes sp, Coccinella sp, Praying Mantis, Diplocodes sp*. The natural enemy that often appears when observing *Oxyopes sp,* while the natural enemy that rarely appears is the praying mantis. The largest pest population is grasshoppers for the largest natural enemy population is *Oxyopes sp*. [7].

Many natural enemies control the armyworm population in field. *Peribae orbata* (Tachinidae) is a larval parasite of caterpillars armyak in Laguna, Philippines. The role of the larval parasite important in the field, because in Sarawak, Kalimantan, parasitization levels can be reach 40%. Another parasite that has been identified is *Palexorista lucaqus* (Wlk), *Pseudogonia rufifrons, Apanteles sp., Chelonus sp*., and *Cuphocera varia* and there are still some larval parasites others from the families *Braconidae* and *Icheumonidae*. *Telemonus sp*. and *Tetrastichus schoenobii* were found as egg parasites. In South Sulawesi, the fungus *Nomuraea rileyi* is found (Far.) Sanson and polyhidrosis nuclear virus attack larvae. This natural enemy mainly plays a role in suppressing the population so that no pest explosion and reduce population when it occurs explosion. However, due to the time lag and effectiveness low during the population explosion, the results are not satisfactory so that additional efforts such as pesticides are needed.

Armyworm (*Spodoptera sp*.), is a polyphagous pest. These pests, among others, attack corn plants. The leaves of the plant can be eaten up until only the bones remain. The distribution of armyworms starts from Southern Europe, Africa, India, China, Indonesia, Australia, Pacific countries to America. This caterpillar is found in Java, Indonesia up to an altitude of 1,800 m. The explosion of the armyworm population can suddenly appear and also quickly disappear. Often a population explosion lasts for only one generation, followed by a population decline in the next generation. From observations made every time there is a population explosion due to climate change, especially dry periods followed by high rainfall and humidity and accompanied by abundant food. Often a population explosion is preceded by unfavorable conditions for the development of parasites and predators. Eggs are laid in clusters on leaves and covered with light brown hairs. A female *Spodoptera sp*. lay about 1,500 eggs, each group there are 50-400 grains. The egg stage lasts 3-5 days. The ability to lay eggs is increased by the habit of cannibalism among female larvae. This cannibalism compensates for poor food quality and is an important factor in population dynamics. The young larvae, temporarily stay where the eggs are laid and attack in groups. During the day, the larvae hide in the soil and are active at night, except for *S. exempta* which is also active during the day. The color patterns of the larvae differ depending on their behavior. In crowded conditions, namely the gregarious phase, dark in color, the larvae are active. In the solitary phase, the color is lighter and passive. The larvae can reach a length of (4-4.5) cm. Larval stage obtained after 13-18 days. Pupae are formed in the soil with a stadium length of about 9 days. Development from egg to adult in *Spodoptera sp*. shorter, i.e. 29-31 days. Adult insects are short-lived, can mate several times and lay eggs for 2-6 days [7].

The use of resistant varieties to control pests is a cheap and easy way, it can also be combined with other ways, but have not found varieties that have high resistance to the main pests of corn. There are three ways that might be developed today in Indonesia, namely technical culture, biology, and insecticides. Research results from Balittan Maros, Indonesia, for several years show that corn planted earlier at the start of the rainy season will be less susceptible to pests, especially stem borers [4].

Pest and disease control can be done mechanically, technically and chemically. Mechanically is by catching pests that attack the plants or dispose of diseases parts of plants that are attacked by pests, or control of the technical culture between the air humidity regulation, the protective arrangement and the intensity of sunlight. Chemical control using insecticides and functionalities. Recommendation usage of insecticides and fungicides in the cultivation of medicinal plants are avoided, because the chemical residues can affect the medicinal compounds in the plant, so it is necessary to use biopesticide than chemical insecticides and fungicides.

In general, biopesticides are defined as a pesticide whose base material is derived from plants and microbes. With advances in the field of chemistry and the development of analytical tools, many chemical compounds derived from plants have been isolated and identified even synthesized. The content of plant compounds can show various kinds of biological activity on insects such as inhibition/rejection of feeding, spanking rejection activities, growth and development inhibitory activities, and death effect, therefore the bioactive can be used to control of plant pest organism (PPO). This study aimed to determine the effectiveness of various biological agents, consisting of biological and microbial pesticides as biopesticide, also obtain bait plants to protect the main crop from *S. frugiperda* attacks.

MATERIALS AND METHODS

Preference test

This research was conducted in Paniki Bawah Village, Mapanget District, Manado City between December 2020 to January 2021. The method, does not use a special design because it is carried out based on primary data, namely direct observation data at the research location, with observation intervals every two days, and the number of plants observed is 63 plants per plot. The condition of the research location is made to resemble the conditions in the field, to estimate the yield when planted by farmers. In this study, observations were made on the types and populations of pests and natural enemies on corn farms, which were sprayed with biopesticides. Each treatment plot measured 3 x 4 meters with a spacing of 80 x 20 cm. There were 3 rows of plants, and in each row, there were 21 plants; thus, there were 63 plants per plot. By taking a sample of 10%, 7 plants were used from the 63 total plants. The types of corn varieties used as treatments were Manado Kuning, Bissi 2, Pertiwi 3, JH 37, Bissi 18, Pioner P 37, Twinn 20, Bissi 228, and Nasa 29. The varieties chosen were based on the varieties used by farmers in addition to the varieties available in the corn planting location. Observation of egg laying (oviposition) started from day 3 after corn was planted until day 21 after corn was planted at an observation interval of 2 days. Based on the observation results, the number of egg groups laid and the oviposition period differed and depended on the type of corn plant. Furthermore, the eggs were collected and maintained in the laboratory.

The oviposition evaluations were stopped when the corn plants reached the age of 21 days. This was done in accordance with the goal of this research, which was to analyse *S. frugiperda* oviposition preferences and its most destructive impacts on relatively young corn plants during the early stage of their growth (0-21 days old). According to Maharani *et al*. (2019) [9], this pest attacks the growth point of plants, which results in the failure of the formation of young shoots/leaves and causes the death of corn plants. Mamahit *et al*. (2020)[10] stated that corn plants are very vulnerable to attacks by pests during an early age (0-21 days old). Beyond the first 21 days, corn plants can recover from pest attacks through normal cultivation processes.

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Parasitoid inventory

The identification process was then carried out at the Laboratory of Biological Agents (LBA), Kalasey, Manado. Each group of eggs found during observation was kept in a test tube until they hatched. The identification process of the parasitoids was carried out using a microscope to determine the type of parasitoid that emerged from each group of eggs. To support the results obtained in the laboratory, *S. frugiperda* eggs were also collected from several corn planting centers in several locations, including North Minahasa Regency, Minahasa Regency, Bolaang Mongondow Regency and Tomohon City.

RESULTS AND DISCUSSIONS

Number of eggs laid

The results of the observations on the number of eggs laid on the corn plants at 3 days of age (observation 1) until 21 days of age (observation 10) are presented in Table 1. The oviposition process began to occur at the age of 5 days (observation 2), and the final oviposition occurred when the plants were 17 days old (8th observation). The number of eggs laid varied from 5 groups of eggs to 1 group of eggs, and all maize varieties were laid by *S. frugiperda*.

Table 1.Data on the oviposition of *S. frugiperda*

Corn Variety	Total Replication	Mean Replication	Mean Treatment
Manado Kuning	5	1.67	0.17
Nasa 29	5	1.67	0.17
Pioner P 37	5	1.67	0.17
Bissi 228	4	1.33	0.13
Bissi 18	2	0.67	0.07
JH 37	2	0.67	0.07
Twinn 20	2	0.67	0.07
Bissi 2	1	0.33	0.03
Pertiwi 3	1	0.33	0.03

Source: Personal observation results.

Table 1 shows that the Manado Kuning, Nasa 29 and Pioner P 37, varieties experienced the most egg laying during the observation process, with five groups of eggs laid. Meanwhile, the other three varieties experienced egg laying between four and two groups (Bissi 224 with four egg groups, and Bissi 18, JH 37, and Twinn 20 each with two egg groups). The Bissi 2 and Pertiwi 3 varieties experienced the lowest egg laying number, with only one egg found on each.

The Bissi 228, Nasa 29, and Pioner P 37 varieties experienced the fastest egg laying by *S. frugiperda* due to the physical and chemical support of these maize varieties compared to the other six varieties. In addition, the speed at which the maize plants appeared on the soil surface and the physical growth speed of the maize were factors. The longest varieties chosen for laying eggs after appearing on the ground was Bissi 2, with a difference of about 12 days. The difference in egg laying time is quite long, indicating that Bissi 228, Nasa 29, and Pioner P 37 are preferred by *S. frugiperda*. The sooner *S. frugiperda* lays eggs on corn plants, the earlier the *S. frugiperda* larvae will attack it. The younger the corn plants are that are infested/attacked by *S. frugiperda* larvae, the more severe the damage to the corn plants will be.

Death can even occur because the larvae of *S. frugiperda* can reach and eat up to the growth point of corn plants. This is in accordance with the statement by Sharanabasappa et. al. (2018) [17] and CABI (2019)[2], which stated that *S. frugiperda* attacks growing points and can thwart young leaves and plant shoot formation.

That plants are chosen by insects because of their physical and chemical properties [15]. In addition, according to Borror *et al*. (1992)[1], insect eggs are generally laid in conditions where they get protection as young insects.

The choice of oviposition for all varieties may also be due to *S. frugiperda*, which has a wide variety of plant hosts. Clark *et al*. (2007) [3]

and Purwanto and Agustono (2010) [14], stated that *S. frugiperda* pests are polyphagous and found in many countries. However, there were differences in the level of preference; there were very liked, liked and disliked corn varieties, which could be seen from the different number of groups of eggs laid, as shown in Table 2.

Table 2. The preference level for oviposition of *S. frugiperda*

Preference level	Number of eggs	Varieties
Very liked	5 groups	Manado Kuning, Nasa 29, Pioner P 37
Liked	Groups of 2 – 4	Bissi 18. JH 37, Twinn 20, Bissi 228
Disliked	One group only	Bissi 2, Pertiwi 3

Source: Personal observation results.

As shown in Table 2, the Manado Kuning, Nasa 29 and Pioner P 37 varieties were the most favored varieties ("very liked" preference level) for the *S. frugiperda* egg laying process. They had five egg groups, while the Bissi 2 and Pertiwi 3 varieties were the least preferred varieties ("disliked" preference level) with only one group of eggs.
As the most preferred, the Manado Kuning, Pioner P 37 and Nasa 29 varieties seemed to have more attractive support for *S. frugiperda* to lay their eggs. This support involved the appearance of the plant, such as having an adequate leaf condition and nutrient content. The instincts of *S. frugiperda* adult females favored these factors because they guarantee the availability of food for larvae that will hatch. This was not the case for the Bissi 228, JH 37, Bissi 18, and Twinn 20 varieties; this was especially true for the Bissi 2 and Pertiwi 3 varieties, which only experienced one group of egg laying.
Each adult female insect of *S. frugiperda* will choose the type and condition of a plant that can ensure the health of newly hatched larvae because they must be provided with sufficient and suitable food for growth in the form of fresh young leaves. Mello da Silva *et al*. (2016) [12] and Sharanabasappa *et al*. (2018) [17] stated that early instar larvae of *S. frugiperda* usually live on young corn leaves, which was confirmed by the statement of Nonci *et al*. (2019) [13] that the favorite place for *S. frugiperda* larvae to live and grow is on the young leaves of corn.

Natural enemy type and population density

The results of the study on egg laying time by *S. frugiperda* are given in Table 3.

Table 3. Data on the oviposition time by *S. frugiperda*

Corn Variety	Plant age (days)									
	3	5	7	9	11	13	15	17	19	21
Manado Kuning	-	-	v***	v	v	-	-	-	-	-
Bissi 2	-	-	-	-	-	-	-	v	-	-
Pertiwi 3	-	-	v	-	-	-	-	-	-	-
JH 37	-	-	-	v	v	-	-	-	-	-
Bissi 18	-	-	-	v	v	-	-	-	-	-
Pioner P 37	-	V	v**	v	-	v	-	-	-	-
Twinn 20	-	-	v	v	-	-	-	-	-	-
Bissi 228	-	V	-	v***	-	-	-	-	-	-
Nasa 29	-	V	v**	v	v	-	-	-	-	-

Source: Personal observation results.

Table 3 shows that oviposition by *S. frugiperda* began at the age of 5 days and ended at the age of 17 days. There was no oviposition in all treatment varieties during the first observation (3 days old), while the earliest oviposition by *S. frugiperda* occurred at the age of 5 days for the Pioner P 37, Bissi 228, and Nasa 29 varieties. Then, at the age of 7 days, egg laying occurred on the varieties of Manado Kuning, Pertiwi 3, Pioner P 37, Twinn 20, and Nasa 29. At 9 days of age, egg laying occurred in seven of the nine varieties tested, namely, the Manado Kuning, JH 37, Bissi 18, Pioner P 37, Twin 20, Bissi 228 and

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Nasa 29 varieties. At the age of 11 days, eggs were laid on the Manado Kuning, JH 37, Bissi 18, and Nasa 29 varieties. At the age of 13 days, egg laying only occurred on the Pioner P 37 variety, and at the age of 15 days, there was no egg laying on all varieties of maize tested. Meanwhile, at the age of 17 days, the oviposition occurred only on the Bissi 2 variety. At the ages of 19 and 21 days, the oviposition process ceased.

The Pioner P 37, Bissi 228 and Nasa 29 varieties had the earliest oviposition time by *S. frugiperda* compared to that for the other six varieties. Bissi 2 had the longest oviposition time, and the time difference between the earliest oviposition on the Pioner P 37, Bissi 228 and Nasa 29 varieties and the latest oviposition on the Bissi 2 variety was 12 days long. This considerable difference in oviposition indicates that the physical and chemical support of the Pioner P 37, Bissi 228 and Nasa 29 maize varieties were preferred by *S. frugiperda* compared to those for the Bissi 2 variety. Other differences in oviposition time may be due to the speed at which corn plants appear on the soil surface and the physical growth rate of corn after it appears on the soil surface. These factors are important because *S. frugiperda* will not lay eggs on corn that has not yet appeared on the soil surface. Differences in growth delay are possible if the time difference lasts only 1-2 days. This is because the seeds of each variety used as treatment may differ in several ways, such as the water content and depth at planting, so these two things may cause differences in the growth of each corn variety planted.

The data obtained on oviposition time for each variety are important because the sooner the oviposition of *S. frugiperda* on corn plants occurs, the earlier the *S. frugiperda* larvae will attack it. The younger the corn plant is when it is infested by *S. frugiperda* larvae the more severe the damage to the corn crop. Even death may occur because the *S. frugiperda* larvae can reach and eat up to the growth point of the corn plant. This is in accordance with the statement of Sharanabasappa et al. (2018) [17] and CABI (2019) [2] that S. frugiperda attacks growing points and can thwart young leaves and plant shoot formation.

Inventory of egg parasitoids

Parasitoids are insects that are smaller or at least the same size as their host, live on the host throughout their lifetime and slowly eat the host until the host dies. Depending on the stage of the insect it attacks, there are three types of parasitoids, namely, egg parasitoids, larval parasitoids and pupae [16]. Research on egg parasitoids was carried out to complement this study after a preference test was conducted. A total of 27 groups of eggs found during observations were collected and reared by putting each group of eggs into a measuring cup. Egg group maintenance was also carried out by taking samples of egg groups from several areas in addition to the research location, such as Manado City, Bolaang Mongondow Regency, North Minahasa Regency, Minahasa Regency, and Tomohon City. The maintenance and inventory process lasted for one month and started on the same day.

From the results of the egg parasitoids inventory, two parasitoids were obtained, namely, *Telenomus sp.* (Figure 1) and *Trichogramma sp.* (Figure 2).

Based on observation, *Telenomus sp.* had several distinctive physical characteristics, such as a black body colour, wings that were slightly larger than the forewings, angled antennae consisting of 10-11 segments, and a tarsi with 5 segments. *Telenomus sp.* is larger than *Trichogramma sp.*, which has the distinctive physical characteristics of a clear yellowish body colour, antennae consisting of 6 segments, and a tarsi with 3 segments. *Trichogramma sp.* also has hairy wing edges and short hairs at the tip of the antennae. The observation results are in accordance with the statement of [1].

The level of parasitizing was very different among the areas, with the highest level of 85% in Manado and the lowest level of 5% in Bolaang Mongondow Regency.

In the city of Manado, from the average number of 27 egg groups of *S. frugiperda*, there were 23 egg groups parasitized that consisted of 17 *Telenomus sp*. and 6 *Trichogramma sp*. parasitoids. In Minahasa Regency, from 26 groups of *S. frugiperda* eggs, 12 groups were parasitized that consisted of 9 *Telenomus sp*. and 3 *Trichogramma sp*. parasitoids.

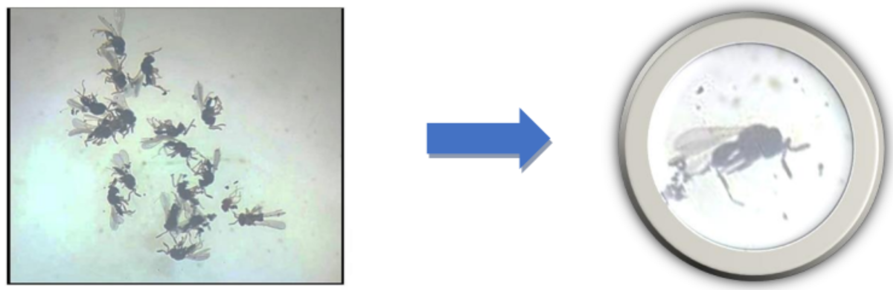

Fig. 1. Image of *Telenomus sp*.
Source: Personal observation results

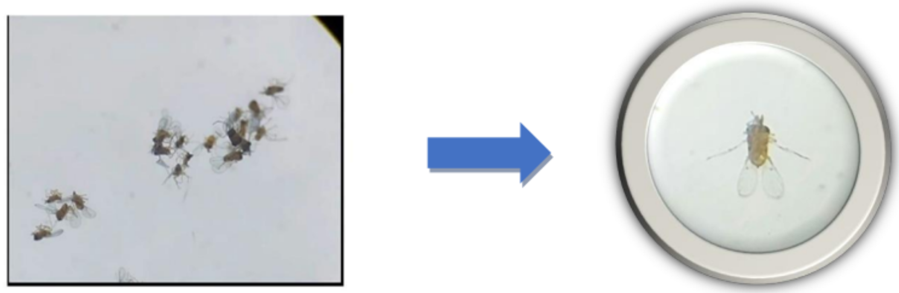

Fig. 2. Image of *Trichogramma sp*.
Source: Personal observation results

Table 4. Number of *S. frugiperda* egg groups, types of parasitoids, and parasite level

Region of Origin	No. of Egg Groups	Frugiperda Larvae	Type of parasitoid			Percentage of parasites
			a	b	c	
Manado	27	4	17	6	23	85%
Minahasa Regency	26	14	9	3	12	46%
North Minahasa Regency	59	48	7	4	11	19%
Tomohon	32	30	1	1	2	6%
Bolaang Mongondow	37	35	2	0	2	5%

Notes: a = *Telenomus sp*.
b = *Trichogramma sp*.
c = Sum
Source: Personal observation results.

Furthermore, from North Minahasa Regency, 59 groups of *S. frugiperda* eggs were obtained, and as many as 11 groups of eggs were parasitized that consisted of 7 *Telenomus sp*. and 4 *Trichogramma sp*. parasitoids. From Tomohon City, 32 groups of *S. frugiperda* eggs were obtained, but only two groups of eggs were parasitized and consisted of one *Telenomus* and one *Trichogramma*. From Bolaang Mongondow Regency, 37 groups of *S. frugiperda* eggs were obtained, and only two groups of eggs were parasitized, all of which consisted of *Telenomus sp*. and not *Trichogramma sp*.

These results are in accordance with Shylesha *et al*. (2018)[18], who reported finding a natural enemy complex of *S. frugiperda*, namely, the egg parasitoid *Telenomus sp.* (Hymenoptera: Platygastridae) and *Trichogramma sp*. (Hymenoptera: Trichogrammatidae).

The egg parasitoid type *Telenomus sp*. was found in five study areas that were the source of the egg group of *S. frugiperda*, while *Trichogramma sp*. was not found in Bolaang Mongondow Regency. This indicates that there were sufficient egg parasitoids naturally. According to Sembel (2010)[16], parasitoids are insects that are small or as large as the host that parasitize and kill the host. Its role is very dominant in suppressing the development of plant pest populations. A parasite attack can weaken the host and can eventually kill it because the parasitoid eats or sucks the body fluids of the host [19].

It is known that there are two types of parasitoids capable of parasitizing *S. frugiperda* eggs. This means that naturally, there are two types of parasitoids that play a role in controlling *S. frugiperda* populations by eating or making *S. frugiperda* eggs their hosts. These two types of parasitoids are effective natural enemies against *S. frugiperda* eggs [16].

CONCLUSIONS

Several conclusions based on the research of the preference of *S. frugiperda* on several maize varieties are:

(i)The Bissi 2 variety may become the main plant choice, because it only gets one group of eggs and has the longest oviposition period, while Pioner P 37 and Nasa 29, as the varieties with the most abundant number of egg groups laid and shortest oviposition period, can be used as bait plants.

(ii)The highest number of eggs laid by *S. frugiperda* was found on Manado Kuning, Pioner P 37 and Nasa 29 maize varieties, each with five groups of eggs, while the lowest number of eggs was found on Bissi 2 and Pertiwi 3 varieties, with only one egg group.

(iii)The earliest egg laying time by *S. frugiperda* occurred on Pioner P 37, Bissi 228, and Nasa 29 varieties at five days of age, while the latest oviposition occurred on Bissi 2 corn variety at 17 days of age.

(iv)The type of egg parasitoid found in the egg group of *S. frugiperda* was *Telenomus sp*. and *Trichogramma sp*., and both can be used as parasitoids against *S. frugiperda*.

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