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2 Outbreaks of a new invasive pest, the fall armyworm (*Spodoptera frugiperda*) in South Sumatra, Indonesia

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Abstract. *Spodoptera frugiperda* is polyphagous besides attacking maize, it can attack other plant species from various families. Information about the attack and population of *S. frugiperda* in various maize production centers in Indonesia is still limited. This study aimed to find out the population and attack of *S. frugiperda* in South Sumatra. Surveys were carried out from the lowlands to the highlands of South Sumatra, such as Palembang City, Pagar Alam City, Lahat City, Ogan Ilir District, Prabumulih City, Muara Enim District, Banyuasin District. The mean percentage severity of *S. frugiperda* in South Sumatra reached 34.75%, and its percentage of mean incidence reached 78%. The highest larvae density was found in Pagaralam City with an average of 0.29 larvae/100 plants, while the lowest was found in Muara Enim District (0.08 larvae/100 plants). The population density of larvae began to occur at the age of 3 to 5 weeks, after that the larvae were not found in maize fields. We found that outbreaks of *S. frugiperda* have occurred in the South Sumatra.

2 Introduction

Fall armyworm (FAW) (*Spodoptera frugiperda*) is a new invasive maize pest in Indonesia. This insect pest comes from the Americas [1,2]. Then, the FAW spreads to other continents, such as Africa in 2016 [3], Europe in 2017 [4], Asia in 2018 [5]. In Asia this pest was first discovered in India [6]. The FAW first entered Indonesia on March 26, 2019 in West Sumatra [7]. Currently, the FAW has spread to other provinces and islands in Indonesia, including South Sumatra [8], West Java [9], Lampung [10], Bengkulu [11], Bali [12].

This pest is polyphagous besides attacking maize, it can attack other plant species from various families, such as paddy, sugar cane, cotton, and ornamental plants [13]. This pest is able to attack about 76 plant families in Brazil [14]. The FAW attacks both hybrid maize and local varieties in Bengkulu, Indonesia [11]. The larvae of *S. frugiperda* can eat voraciously on leaves, stems, flowers, growing points, fruits [12], and whole parts of maize to bald [11]. Information about the attack and population of *S. frugiperda* in various maize production centers in Indonesia is still limited, even in South Sumatra it



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does not yet exist. Based on this reason, a study of the population and its attacks in South Sumatra needs to be carried out. This study aimed to find out the population and attack of *S. frugiperda* in South Sumatra.

2. Materials and method

2.1. Survey sites

The locations for the *S. frugiperda* survey were carried out from the lowlands to the highlands of South Sumatra, such as Palembang City, Pagar Alam City, Lahat City, Ogan Ilir District, Prabumulih City, Muara Enim District, Banyuasin District (Figure 1 and Table 1) which were conducted from January to June 2021. Observation of population density and *S. frugiperda* attack was carried out directly using a scouting system. This scouting system was used because the survey area was large and in many locations [15]. The observed sample area for each location ranged from 1 to 3 ha, while the age of the selected maize ranged from 3 to 6 weeks. The calculation of the percentage of infested plant (incidence of damage) and severity (intensity of attack) caused by *S. frugiperda* larvae were scouted using a “W” pattern approach [16]. The total sample was observed as many as 10 consecutive plants at five different spots along a W-shape design so that the total number of the observed plants was 50 plants per a field [15]. The percentage of severity distinguished by severity of pin holes, shot-holes, lesions, tattering and dead hearts was calculated using a rating scale for scoring of damage severity on whorl-stage plants [16]. The percentage of plants infested termed as incidence was measured by calculating the total of infested plants divided by the total plants observed and multiplied by 100% [17]. The percentage of severity was calculated by dividing the sum of score (excluding score 1) by the number of plants damaged. The rating scale of damage severity scored from 1 to 5 was used as follows: 1) no damage; 2) > 0 – 10% leaf damage or < 5 mm diameter or only the leaf cuticle destruction; 3) >10 – 25% leaf damage with presence chewed areas > 5 mm, funnel leaves uninjured; 4) > 25 – 50% leaf damage with presence chewed areas > 1 cm, the funnel less severe; and 5) > 50% leaf damage, plant stunting and funnel damaged severely [16].

Table 1. The occurrence locations of *Spodoptera frugiperda* attack in South Sumatra, Indonesia

District/City	Suvei date	Altitude (m)	Coordinate	Farmer samples
Pagaralam City	30/05/2021	790.0	4°01'28"S 103°13'58"E	5
Lahat District	31/05/2021	732.0	3°57'26"S 103°14'05"E	3
Muara Enim District	17/06/2021	36.3	3°13'35"S 104°29'3"E	4
Prabumulih City	17/06/2021	44.9	3°24'05"S 104°16'24"E	2
Ogan Ilir District	23/05/2021	33.9	3°13'23"S 104°38'27"E	16
Banyuasin District	16/06/2021	28.1	2°41'32"S 104°44'52"E	12
Palembang City	14/05/2021	32.0	2°55'07"S 104°16'02"E	2

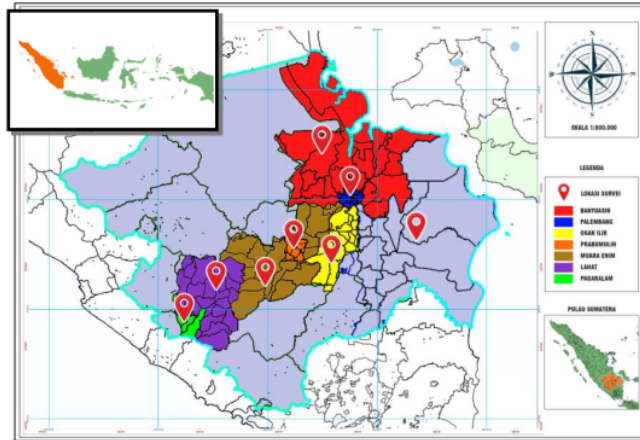


Figure 1. Survey sites in South Sumatra: Banyuwasin District, Palembang City, Ogan Ilir District, Prabumulih City, Muara Enim District, Lahat City, Pagar Alam City

2.2. Observation of *Spodoptera frugiperda* population during one maize growing season

Observation of egg and larvae populations of *S. frugiperda* during one growing season of maize were scouted using the W-shape design. The location chosen was in the central district of maize production, namely Ogan Ilir District. The maize was grown following the customs of local farmers. The selected location is one that did not use synthetic insecticides (No Pesticide), the other two areas used synthetic insecticides (Conventional A and B). The selection of the three types of location was based on variations in the habits of local farmers. Sampling of eggs and larvae of *S. frugiperda* was carried out from the maize was 2, 3, 4, 5, 6, 7, 8, and 9 weeks after planting. Observation of the population density of eggs and larvae of *S. frugiperda* was carried out in the morning starting from 06.00 to 09.00 a.m. because after 09.00 a.m. the larvae hid in the midrib of maize leaves.

2.3. Data Analysis

Average of the percentage of infested plant (incidence) and severity (on a scale of 1 to 5) per district or city was displayed in graphical picture. Data on population density of eggs and larvae were also displayed in graphical picture.

3. Results and Discussions

3.1. Symptoms of *Spodoptera frugiperda* attack

The presence of *S. frugiperda* and symptoms of its attack on host plants were characterized by the presence of eggs, larvae or even pupae or adult stages could be found. Eggs (Figure 2) were generally laid on the lower leaf surface near the leaf base but sometimes were also laid on the upper leaf surface. The newly hatched larvae (Figure 2) were still clustered and entering the second instar the larvae began to live solitary. The second to sixth instars (the last instar) behaved cannibally because of that, they lived solitary (Figure 2), i.e. on one leaf or one fruit, generally only one larva was found. The 5th or 6th instar larvae were found to have distinctive characteristics, namely in the head there was an inverted Y-like pattern, in the 8th (posterior) abdominal segment there were 4 black dots (pinacula) forming a rectangular position, there was a pale yellow dorsal line and dark yellow subdorsal, and there was a broad band of yellow along the lower abdomen (Figure 2). The pupae could be found on the soil surface

around the maize stalks (Figure 2), and adults were most easily found in the morning between 06.00 a.m. and 08.00 a.m. in the leaf sheath (Figure 2). Based on the morphological characteristics, the larvae were *S. frugiperda*. The morphology of the larvae from this survey was identical or the same as the morphology of the larvae of *S. frugiperda* illustrated [7] and [18].

The symptoms of *S. frugiperda* larvae attack could be found on leaves (Figure 3), leaf curls (Figure 3), stems (Figure 3), flowers (Figure 3), and fruit cobs (Figure 3). The symptoms of the attack of *S. frugiperda* larvae on the leaves were in the form of holes that were already drilled, around these there were traces of frass similar to sawdust. Stems and leaves that were still curled form drilling holes. Symptoms of *S. frugiperda* larvae attack are identical to those of *S. frugiperda* found by [7] and [11].

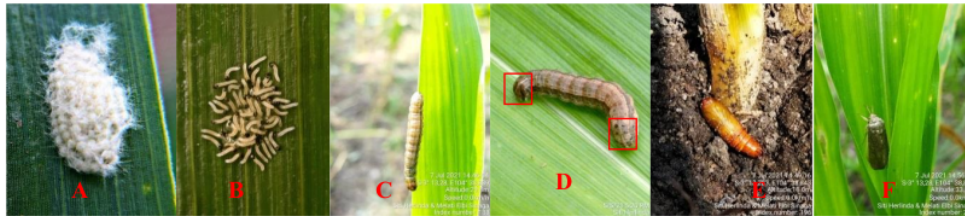


Figure 2. *Spodoptera frugiperda*: egg mass (A), eggs hatch (B), solitary mature larvae (C), larvae with inverted Y-shape head and 4 black pinacula, (D), pupae (E), and adult (F)



Figure 3. Symptoms of *Spodoptera frugiperda* larvae attack: leaf bored (A), leaf whorl bored (B), stem bored (C), maize flowers eaten (D), and maize cob bored by larvae (E)

3.2. Population and damage caused by *Spodoptera frugiperda* in maize

The surveys conducted in 7 district/cities (Palembang City, Pagar Alam City, Lahat City, Ogan Ilir District, Prabumulih City, Muara Enim District, Banyuasin District) showed that *S. frugiperda* underwent outbreaks in South Sumatra. The percentage of mean incidence of *S. frugiperda* was 22.00% in Palembang City, 60.25% in Pagar Alam City, 44% in Lahat City, 59.51% in Ogan Ilir District, 66% in Prabumulih City, 78% in Muara Enim District, and 31.86% in Banyuasin District (Figure 4). The mean percentage severity of *S. frugiperda* was 5.75% in Palembang City, 27.94% in Pagar Alam City, 25.50% in Lahat City, 23.09% in Ogan Ilir District, 20.00% in Prabumulih City, 34.75% in Muara Enim District, and 11.28%

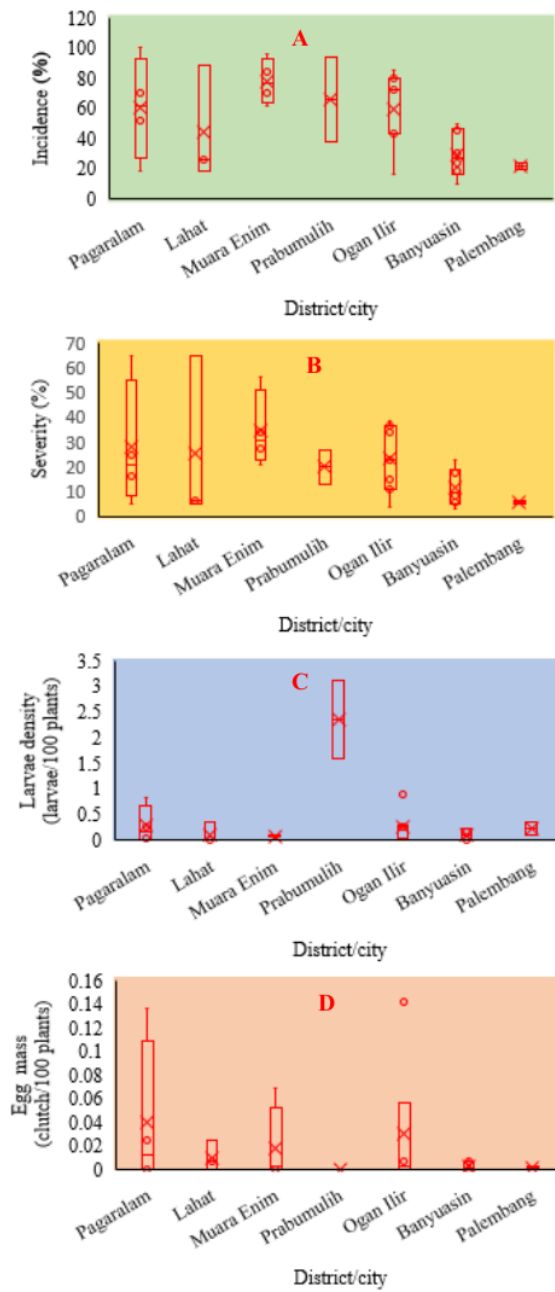


Figure 4. *Spodoptera frugiperda* incidence (A), severity (B), larvae density (C), and egg mass (D)

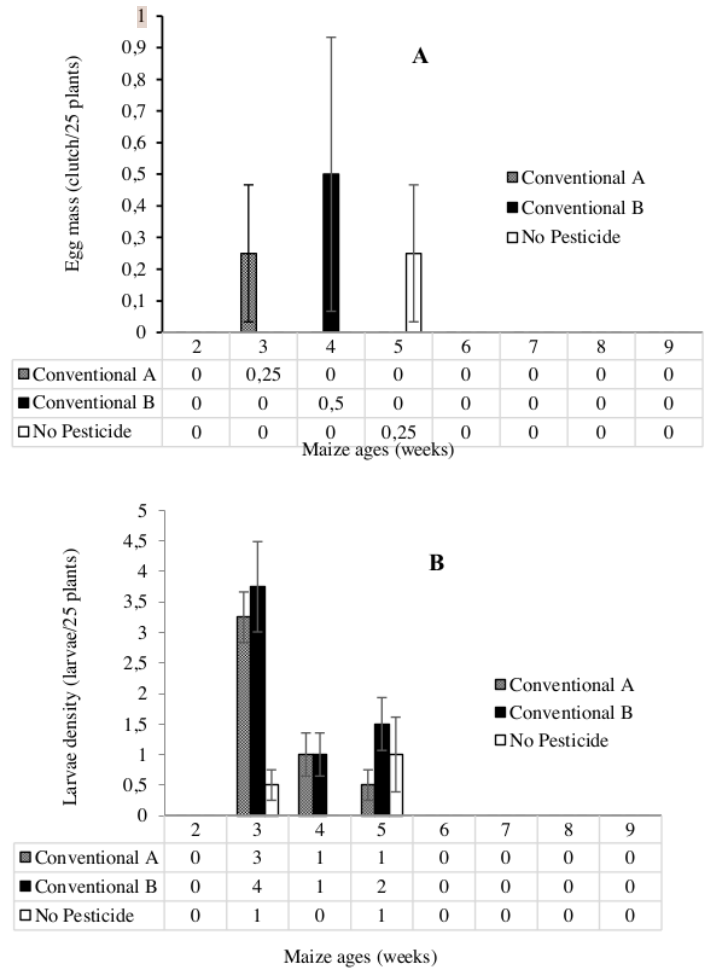


Figure 5. *Spodoptera frugiperda* egg mass (A) and larvae density (B) during a maize season

in Banyuasin District (Figure 4). The highest larva density was found in Pagaralam City with an average of 0.29 larva/100 plants, while the lowest was found in Muara Enim District (0.08 larva/100 plants) (Figure 4). The highest density population of egg mass was found in Pagaralam City (0.04 clutch/100 plants), while the lowest was in Prabumulih where *S. frugiperda* eggs were not found (Figure 4). There is a tendency for high population density of larvae and eggs resulting in high percentage severity and incidence of *S. frugiperda*. The results of the study [16] show that the higher the location is, the more severe the attack of *S. frugiperda* it will get. In contrast [12] in the highlands (> 500 m below sea level) there is no attack but in the lowland the FAW attack is very high. The survey data did not show a consistent influence of the height of the survey location with the percentage severity and incidence of *S. frugiperda*. Based on the direct observations in the field, whether the attack was severe or slight, it was affected by the extent of monoculture maize beds. Maize that is monocultured with >

10 hectares of fields tends to be more severely affected than the one surrounded by plantation crops, such as oil palm or rubber.

The results of observations of the egg population of *S. frugiperda* in the three locations of maize fields found the eggs only on the third day in location of Conventional B of 0.25 clutch/25 plants, on the fourth day they were found in Conventional B of 0.5 clutch/25 plants, on the fifth day they were found in no pesticide field of 0.25 clutch/25 plants (Figure 5). The population density of larvae began to occur at the age of 3 weeks to 5 weeks, after that the larvae were not found in maize fields. The highest population density was in Conventional B. Spraying of synthetic insecticides could not suppress the population of FAW eggs and larvae, the impact was an increase in the population of eggs and larvae of the FAW, while in the no pesticide location, parasitized eggs and many spiders were often found. Several research results show that maize fields that are not sprayed with synthetic insecticides tend to have low egg and larva populations of *S. frugiperda* due to the work of natural enemies [19], [20]. To overcome the outbreaks of *S. frugiperda*, we recommend to explore the natural enemies from South Sumatra for controlling this pest.

4. Conclusions

The mean percentage severity of *S. frugiperda* in South Sumatra reached 34.75%, and its percentage of mean incidence reached 78%. The highest larvae density was found in Pagaram City with an average of 0.29 larvae/100 plants, while the lowest was found in Muara Enim District (0.08 larvae/100 plants). The population density of larvae began to occur at the age of 3 weeks to 5 weeks, after that the larvae were not found in maize fields. We found that outbreaks of *S. frugiperda* have occurred in the South Sumatra.

Acknowledgment

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