The use of several maize varieties by farmers and the infestation of *Spodoptera frugiperda* (Noctuidae: Lepidoptera)

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**Abstract.** The use of plant varieties can affect the presence and extent of pest attacks. Resistant varieties will cause a lower attack rate compared to susceptible varieties. It is not yet known which varieties of maize are resistant to Fall armyworm (*S. frugiperda*) (FAW) in the field, because this pest is an invasive pest and entered Indonesia one year ago. Research has been carried out to study the distribution, population, and level of *S. frugiperda* attack on maize varieties planted by farmers in the field. The research was conducted at the first location this pest was reported in West Pasaman district, West Sumatra, Indonesia. Survey on farmers’ corn with a sampling method: purposive random sampling. Samples were taken from different varieties of corn and showed signs of *S. frugiperda* attack. Observations were made on the varieties planted by farmers, symptoms, larvae population, and *S. frugiperda* attack rate. The results of the observations were that several trademarks of maize varieties grown by farmers were: Pioneer 32, Pertiwi, Bisi 18, NK7328, and NK212. The symptoms of this pest attack were the same for all varieties of maize, while the attack rate was significantly different at the 5% level. The attack rate ranged from 6.0 to 96.0%. The lowest attack percentage was on variety Bisi18, and the highest was on variety NK212. The population of *S. frugiperda* larvae was found in all varieties of maize with an average of 0.70 larvae per stem.

1. **Introduction**

Fall armyworm *Spodoptera frugiperda* is a pest that attacks maize plants. This pest has been reported in the Americas to cause serious damage to maize. Yield loss in maize in the US due to Fall armyworms is known to attack many crops; maize, cotton, rice, sorghum, and others. In Brazil and the United States, *S. frugiperda* is a major pest [1]. Fall armyworm larvae can cause a 34 to 38% yield loss. If an attack occurs and it is too late to start overcoming it in the early phase then the attack can reach 100% [2].

Efforts to control the fall armyworm attacks are always being pursued. In the United States, Fall armyworm is a major pest of maize. Many technologies have been studied to control these pests. In the USA, the researcher has studied the control of *S. frugiperda* using sterile insect techniques [3]. Research for control using natural enemies in America has also been observed by Hay-Roe (2016), to the known distribution pattern of *S. frugiperda* parasitoid in maize in Florida. In September 2017, the level of attack of this pest was also reported on the African continent, especially in Egypt [5]. Fatoreto et al. (2017) [6] in Brazil has conducted research using *Bacillus thuriengiensis* to FAW control. Fotso et al. (2019) [7] has also conducted a case study in Cameroon Africa on damage and distribution as well as farmers’ responses to this pest. Nagoshi and Meagher (2004) [8] have also observed the behavior and spread of FAW in two types of hosts in Florida, USA.

In Indonesia, the first reported attack of *S. frugiperda* occurred in West Pasaman Regency, West Sumatra province in March 2019 [13]. Several studies to control this pest have been carried out in West Sumatera. Maharani et. al (2019) [9] observed the presence of Fall armyworm at different altitudes. It has been more than a year since this pest has entered Indonesia, it is suspected that the attack has spread to many locations [13] [14]. Population control efforts are needed to reduce the level of attack. There
are not yet recommended control techniques for Fall armyworm in Indonesia, such as technical culture or recommended varieties of maize and pesticide. Farmers still use the varieties they usually grow for several reasons, such as easy access and high production. However, it is not yet known the level of damage to the varieties planted by farmers due to the Fall armyworm attack. This also happened in the West Pasaman area, the case of Fall armyworm attacks with different populations and levels of attacks was expected to affect the attack. For this reason, research has been carried out to know the level of damage to maize plants due to Fall armyworm attacks, and study the relationship between population and the level of damage.

2. Material and Methods
2.1. Study sites
The study was conducted in West Pasaman, West Sumatra Province from July to September 2020, at 11 locations (Figure 1).

![Figure 1. Observation location in West Pasaman district, West Sumatra Province](image)

2.2. Identification of symptoms and levels of S. litura attacks on maize in the field
Observations of the types of varieties planted by farmers in West Pasaman district. Symptoms of fall armyworm attacks were observed in the vegetative phase at all sample locations. The attack rate was observed in a sample plot with a size of $1 \times 1 \, \text{m}^2$. Observations of all plants with damage to the leaves and stems were counted as affected plants. Larval populations were observed and counted for each symptomatic maize stalk. The percentage of attack is calculated based on the affected plants divided by the total plants observed:

$$P = \frac{n}{N} \times 100\%$$

P = Percentage of attack
n = Plants attacked
N = The total plant observed

2.3. Data analysis
Data were tabulated in Microsoft Excel program to get the value of population and mean per clump from each variety. The data were analyzed by ANOVA, if significantly different, then continued with the LSD test at the 5% level. To study the correlation between population and attack rates, regression analysis was performed. The correlation model is determined by the R-value. The value closest to 1 or equal to 1 indicates the population correlation model.

3. Result
3.1. Symptoms of a Fall armyworm attack on maize plants
Field observations found that corn plants were attacked by FAW larvae showed visible symptoms on the leaves and stems (Figure 2)
Figure 2. Maize plants affected by FAW with visible symptoms on leaves and stems.

In Figure 2, it can be seen that the symptoms of FAW attacks are easily recognized in the field, maize leaves look torn and broken. On the top leaves, there are traces of dry larvae droppings like sawdust. In the affected maize stalks, larvae are often found. Larvae with the morphological characteristics of *S. frugiperda*, which are visible on the anterior look like the letter Y, and there are spots posteriorly (Figure 3).

![Figure 3. Morphology of *S. frugiperda* larvae](image)

Larvae with morphological characteristics, the anterior part of the old instar larval phase will be characterized. Larvae are found at the base of the leaves or shoots. On the symptomatic stem, 1 or 2 larvae were found. However, in symptomatic plants (Figure 1), larvae are sometimes not found.

3.2. Percentage of *S. frugiperda* larvae attack several varieties of maize

The results of the observation of the percentage of attacks *S. frugiperda* in all varieties grown by farmers in the field was significantly different from the LSD test at the 5% level. (P = 0.000) (Figure 4)
The highest percentage of attacks occurred in NK212, with an average of 96%, which was significantly different from other varieties. This pest attack occurs in all varieties planted by farmers. In variety NK7328, the attack percentage reached 57%, not significantly different from Pioneer32 varieties, but significantly different from Pertiwi and Bisi18. The percentage of attacks on the Pertiwi variety was 9%, not significantly different from Bisi18 with only a 6% attack percentage.

3.3. The population of S. frugiperda larvae in several varieties of maize

The results of observing the larval population in the sample plots varied from only 1 larva to 32 larvae as high. The results of the analysis of variance (ANOVA) showed that the larva population in each variety was significantly different from the LSD test at the 5% level (P = 0.000) (Table 1).

### Table 1. The average population of S. frugiperda larvae

| Variety   | Average larva population/plot (± sd) | Larvae/stem |
|-----------|--------------------------------------|-------------|
| NK212     | 32.00 ± 11.81 a                       | 1.60        |
| NK7328    | 18.60 ± 2.07 b                        | 0.93        |
| Pioneer32 | 15.60 ± 6.43 b                        | 0.78        |
| Pertiwi   | 2.40 ± 1.52 c                         | 0.12        |
| Bisi18    | 1.60 ± 1.14 c                         | 0.08        |

The average population of larvae in the Bisi 18 variety was 1.60 per plot or 0.08 larvae/plant, not significantly different from Pertiwi varieties, but significantly different from other varieties. The larva population in the Pioneer32 variety was 15.6 larvae, not significantly different from NK7328, and significantly different from NK212. The highest average population per stem in variety NK212 was 32 larvae per plot.

3.4. Correlation of larval population and attack percentage

The results of the regression analysis of larval populations with the percentage of attacks on maize were polynomial models. The R² value is 0.9945 (Table 2).

### Table 2. Correlation of larval populations with the attack rate of S frugiperda in several varieties of maize plants

| Models     | Formula                        | R² value |
|------------|--------------------------------|----------|
| Exponential| $y = 1.7371e^{0.0342x}$        | 0.9396   |
| Linear     | $y = 0.3312x - 0.9312$         | 0.9885   |
| Logarithmic| $y = 9.4825\ln(x) - 17.55$    | 0.8786   |
| Polynomial | $y = 0.001x^2 + 0.2394x + 0.1417$ | 0.9945   |
Analysis of the correlation description between larvae population and *S. frugiperda* attack rate was carried out by regression analysis. Of the 4 regression models, the most depicting form of the model is polynomial (Figure 5). The formula is: \( y = 0.001x^2 + 0.2394x + 0.1417 \) with a value of \( R^2 = 0.9945 \). This means that the percentage of attack (y) is influenced by the number of larvae (x).

**Figure 5.** Regression model for the relationship between larvae populations and the percentage of FAW attacks

4. Discussion

West Pasaman Regency is the area where *S. frugiperda* attacks were found in West Sumatra and Indonesia. Farmers plant several types of maize for their agricultural business. The use of these varieties is carried out for reasons of high production. Five varieties of maize grown by farmers, namely; Pioneer, Pertiwi, Bisi 18, NK212, and NK7328. All varieties found in the field were attacked by *S. frugiperda*. Almost every corn crop in the field shows damage. These pests can be classified as polyphagous pests. According to Nonci, et al. (2019) [10], *S. frugiperda* can attack 80 types of crops including, maize, rice, sorghum, cotton, and others. At the observation site in West Pasaman, maize is planted on oil palm plantations. In the vicinity of the maize plantation, there are also rice fields. Fall armyworm is polyphagous that can live and reproduce in all planting conditions.

Most of the maize plants attacked by *S. frugiperda* are in the vegetative phase. Symptoms of attack are very easy to recognize, the affected leaves are torn and broken. In a severe attack, the maize plant grows as if it was cut off. Maize is the main host for *S. frugiperda*. The results of the observations of Baros et al. (2010) [11], these pests can also live and be attracted to other plants such as cotton. As the results of observations at the maize planting location in West Pasaman, farmers planted various varieties of maize. All maize varieties found in the field were attacked by *S. frugiperda*. The feeding preferences of *S. frugiperda* in various varieties of maize appear to be different. Variety NK212 was the most preferred because it found a high population and attack percentage compared to other varieties. Likewise, the NK7328 and Pioneer varieties were attacked and the larvae population was also higher compared to Bisi18.
In nature, insects have a host preference. The high population and level of damage caused by *S. frugiperda* indicate that this insect likes its host. Observations by Campos et al. (2012) feeding preferences of *S. frugiperda* on varieties of cotton plants are also different. Please explain in a brief and compare to the maize. Research to evaluate the attractiveness and non-preference for feeding of newly hatched fall armyworm larvae on the cotton plant parts and different varieties. There are differences in the response of *S. frugiperda* larvae to different varieties of cotton.

The level of compatibility of pests with their hosts will affect the development and growth of their populations. The population will increase if the host plant is preferred and its feeding capacity increases. When the population increases, the level of damage will also increase. This can be seen in varieties with high larval population levels and high levels of damage. This relationship can be described by the Polynomial model ($R = -0.9945$), where the level of damage is determined by many terms. There is an increase in damage with increasing population to certain conditions which will be influenced by many things. In maize varieties with high attack rates, high *S. frugiperda* populations were also found.

5. Conclusion

In the field (West Pasaman) found 5 varieties of maize grown by farmers, namely NK212, NK7328, Pioneer, Pertiwi, and Bisi18. All of these maize varieties were attacked by *S. frugiperda*, the highest was NK212 96% and the lowest was Bisi 18 with an average of 6%. The largest larval population was also found in variety NK212. The model of the correlation between damage and larval populations is a polynomial form, defined by many tribes.

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References

[1] Blanco, C. A., W. Chiaraavalle, M. Dalla-Rizza, J. R. Farias, M. F. GarciaDegano, G. Gastaminza, D. Mota-Sanchez, M. G. Murua, C. Omoto, B. K. Peralisi, et al. 2016. Current situation of pests targeted by Bt crops in Latin America. Current Opinion in Insect Science. 15: 131–138.

[2] Avila, C. J., P. E. Degrande, and S. A. Gomez. 1997. Insetos pragas: reconhecimento, comportamento, danos e controle. Milho: Informacoes Tecnicas 5.

[3] Carpenter, JE. Hidrayani, N. Nelly, and BG Mullinix, 1997. Effect of substerilizing doses radiation on sperm precedence Fall Armyworm (Lepidoptera; Noctuidae). Journal of Economic Entomology, Vol. 90 issues 2: 444-448.

[4] Hay-Roe, M. M., Meagher, R. L., Nagoshi, R. N., & Newman, Y. 2016. Distributional patterns of fall armyworm parasitoids in a cornfield and a pasture field in Florida. Biological control. 96: 48-56.

[5] Heinrichs E.A., J Sidhu, R. Muniappan, A. Fayad, A. Adiga, A. Marathe, J. McNitt, 2017. Pest Risk Assessment of the Fall Armyworm, *Spodoptera frugiperda* in Egypt. Feed the Future, The U.S Governments Global Hunger and Food Security Initiative. Innovation Lab For Integrated Pest Management.

[6] Fatoretto, JC. A P. Michel, M C. Filho, and N. Silva, 2017 Adaptive Potential of Fall Armyworm (Lepidoptera: Noctuidae) Limits Bt Trait Durability in Brazil. Journal of Integrated Pest Management. 8(1): 17; 1–10

[7] Fotso Kuate A, Hanna R, Doumsotp Fotio ARP, Abang AF, Nanga SN, Ngatat S. 2019. *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Cameroon: A case study on its distribution, damage, pesticide use, genetic differentiation, and host plants. *PLoS ONE* 14 (4): e0215749. https://doi.org/ 10.1371/journal. pone.0215749

[8] Nagoshi R.N and R.L Meagher, 2004. Behavior and distribution of the two Fall armyworm host strain in Florida. Florida entomologist. 87(4): 440-449.

[9] Maharani, Y. VK Dewi, LT Puspasari, L Rizkie. Y Hidayat, D Dono, 2019. Cases of Fall Army Worm *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae) Attack on Maize in Bandung, Garut and Sumedang District, West Java. CROPSAVER-Journal of Plant Protection. 2(1), 38-46. (Indonesian)
[10] Nonci N, Kalqutny SH, Mursam H, Muis A, Azrai M, Aqil M. 2019. Pengenalan Fall Armyworm (Spodoptera frugiperda J.E Smith): Hama Baru pada Tanaman Jagung di Indonesia. Maros: Balai Penelitian Tanaman Serealia. Badan Penelitian dan Pengembangan Pertanian. Kementerian Pertanian, Jakarta. (Indonesian)

[11] Barros, E.; Torres, J.B.; Ruberson, J.R.; Oliveira, M.D. 2010. Development of Spodoptera frugiperda on different hosts and damage to reproductive structures in cotton. Entomologia Experimentalis et Applicata. 137(3): 237-245.

[12] Campos, Zeneide & Boiça-Júnior, Arlindo & Filho, Walter & Campos, Ostenildo & Campos, Alcebíades. 2012. The feeding preferences of Spodoptera frugiperda (J. E. SMITH) (Lepidoptera: Noctuidae) on cotton plant varieties. Acta Scientiarum. Agronomy. 34:125-130. 10.4025/actasciagron. v34i2.11577.

[13] BBPOPT, 2019. Spodoptera frugiperda invasive pest in Indonesia (Result of verification BBPOPT April-June 2019 Periode). https://bbpopt.id/index.php/2019/07/15/ Hama invasive-Spodoptera-frugiperda-di-Indonesia-hasil-verifikasi-bbpopt-period-April-June-2019/ (Indonesian)

[14] Hutasoit RT, Kalqutny SH, Widiarta IN. 2020. Spatial distribution pattern, bionomic, and demographic parameters of a new invasive species of armyworm Spodoptera frugiperda (Lepidoptera; Noctuidae) in maize of South Sumatra, Indonesia. Biodiversitas 21: 3576-3582.