Status of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) as a Pest of Maize Based on the Relationship Between Infestation Area and Rainfall in West Sumatra, Indonesia

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Abstract. *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), commonly known as the Fall Armyworm (FAW), is an invasive pest that causes significant damage to maize crops across tropical regions. This study aimed to examine the status of FAW as a maize pest in West Sumatra, Indonesia, focusing on the relationship between infestation area and rainfall. Monthly rainfall data were obtained from the Meteorology, Climatology, and Geophysics Agency of Indonesia (BMKG). Data on maize damage caused by FAW were collected from the Provincial Agriculture Service of West Sumatra, while population data were acquired through field surveys in major maize production areas. The data were analysed using correlation approaches to determine the relationship between FAW infestation intensity and monthly rainfall levels. The results revealed that FAW infestations occurred in almost all observation sites, with varying levels of damage; however, no significant correlation was found between rainfall and infestation area. This finding indicates that climatic factors, particularly rainfall, are not the main determinants of FAW outbreak dynamics in West Sumatra. Other factors, such as host plant availability, cropping patterns, and pest management practices, will likely play a more decisive role in influencing infestation intensity. These results provide important insights into the current status of FAW in West Sumatra and serve as a foundation for developing more effective and sustainable control strategies that account for complex agronomic and ecological factors.

1 Introduction

Maize (*Zea mays* L.) plays a crucial role in Indonesia's economy and food security. As the second most important staple crop after rice, maize serves as an alternative carbohydrate source for human consumption and a key component in the animal feed industry, supporting the national livestock sector. The Indonesian government continues promoting maize production to reduce import dependency and achieve national food sovereignty. However, efforts to increase productivity face serious challenges from various plant pests. One of the

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most destructive threats in recent years is the invasion of the Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), which has emerged as a highly damaging pest.

Spodoptera frugiperda is a moth native to tropical and subtropical regions of the Americas. It is highly voracious and polyphagous, attacking more than 353 plant species across 76 families, with a preference for crops in the Poaceae family such as maize, sorghum, rice, and wheat. Since 2016, this pest has spread rapidly worldwide, first appearing in Africa, then the Middle East, and eventually Asia. The first confirmed report of FAW in Indonesia was made in early 2019 in the Pasaman Barat District, West Sumatra Province [1,2]. Its spread was swift and massive, soon covering almost all major maize-producing regions in Indonesia, from Sumatra and Java to Kalimantan and East Nusa Tenggara. This rapid expansion was facilitated by the strong flight capacity of adult moths, which can travel up to 100 km in a single night with the assistance of wind, enabling the quick colonisation of new areas..

The economic impact of FAW infestations is substantial. Reports from various invaded countries indicate potential maize yield losses ranging from 15% to 73% [1]. Globally, the annual economic loss caused by FAW in Africa alone is estimated at several billion US dollars [2]. The larval stage is the most destructive phase of FAW. During the vegetative stage of maize, young larvae attack the whorl leaves, causing typical symptoms such as rows of perforated leaves and larval frass deposits. Severe damage to the growing point can inhibit plant development or even kill young plants. At the generative stage, larger larvae bore into maize ears and feed on developing kernels. This directly reduces yield quantity and compromises quality, as kernel damage facilitates secondary infection by pathogenic fungi such as *Aspergillus flavus* and *Fusarium spp.*, which may produce harmful mycotoxins. Given FAW's status as a newly invasive and highly destructive pest, a comprehensive understanding of its bioecology and the factors influencing its population dynamics in new environments is urgently needed. Such knowledge forms the foundation for designing and implementing effective, efficient, and sustainable management strategies.

Long-term studies analyzing the relationship between FAW population dynamics and climatic factors, particularly rainfall, remain limited. Insects, including FAW, are strongly influenced by abiotic environmental conditions. Climatic factors, such as temperature, humidity, and rainfall, affect multiple biological aspects, including egg development rate, larval survival, life cycle duration, adult fecundity, and migration behaviour. Rainfall, in particular, may have complex dual effects. Heavy rain can be a natural physical mortality factor by washing away eggs and early-instar larvae from leaves. In contrast, high humidity following rainfall may create favorable conditions for pest development or promote entomopathogenic fungi that act as natural enemies. No studies have specifically linked FAW infestation data with long-term historical rainfall data in West Sumatra. Existing research has generally been descriptive, providing only snapshot assessments of infestation levels in specific cropping seasons or locations.

This study holds intense urgency, given that West Sumatra is a major maize production center in Indonesia and the initial entry point of FAW invasion [3,4]. Examining rainfall fluctuations over the past five years concerning FAW infestations provides valuable scientific insights. Such information can be the basis for developing predictive models and early warning systems [5]. These systems would enable stakeholders—from farmers to agricultural agencies—to implement more anticipatory, targeted, and timely control measures, particularly ahead of seasons with predicted high infestation risks [6]. Ultimately, this will help minimize potential economic losses from future FAW outbreaks [7]. The present study, therefore, aimed to analyze the relationship between FAW infestation levels and rainfall data in West Sumatra over the past five years, filling an existing knowledge gap and providing a strong scientific foundation for improved, climate-adaptive pest management strategies.

2 Materials and Method

2.1 FAW Infestation in West Sumatra

The occurrence and status of *S. frugiperda* infestation in West Sumatra were assessed based on the affected area recorded over the past five years. Secondary data were obtained from reports of FAW infestation levels provided by the West Sumatra Provincial Agricultural Service. Infestation levels in maize fields were routinely observed and reported by pest monitoring officers. Observations were conducted across all districts in the province.

During the current 2025 cropping season, the infestation level of *S. frugiperda* in three central maize-producing districts of West Sumatra (Pasaman Barat, Limapuluh Kota, and Padang Pariaman) was monitored during the vegetative growth stage. Field observations were carried out at three sites, with five sampling plots at each site. Each sampling plot consisted of a 1 m × 1 m maize stand, arranged diagonally across the field. Direct observations were made on maize plants to record infestation symptoms and the presence of larvae on damaged plants.

2.2 Rainfall Fluctuations in West Sumatra

Rainfall fluctuation data for the last five years were obtained from the Meteorology, Climatology, and Geophysics Agency of Indonesia (BMKG). Monthly rainfall data were collected from BMKG stations in West Sumatra for 2020–2024.

2.3 Data Analysis

To examine the relationship between FAW infestation and rainfall, data were analyzed using STAT 8.0 software. Linear, exponential, and logarithmic regression analyses were conducted to determine the coefficient of determination (R^2) and the regression equation. Infestation symptoms and population dynamics were described using figures and tables.

3 Results and Discussion

3.1 FAW Infestation in West Sumatra Over the Last Five Years

The average area of maize fields infested by FAW in West Sumatra during the five-year observation period is presented in Figure 1.

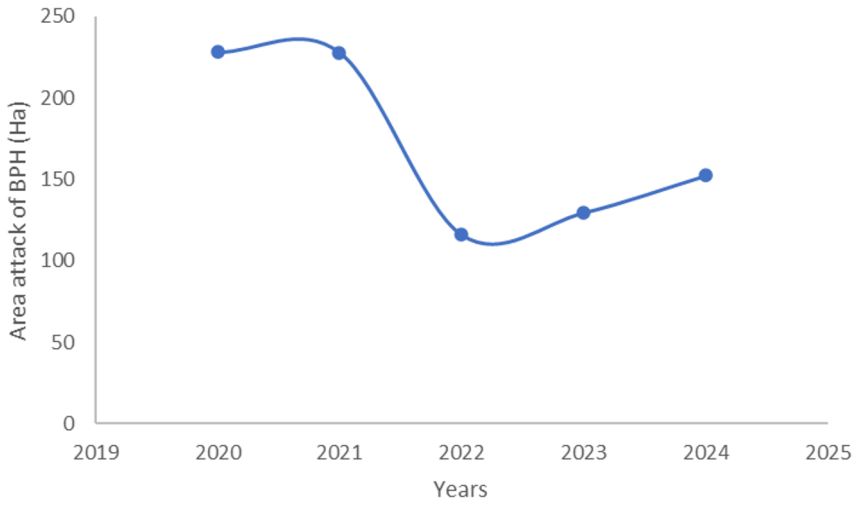


Fig. 1. Area of FAW Infestation on Maize in West Sumatra.

As shown in Figure 1, the highest infestation was recorded at approximately 220–230 ha. This indicates that during its initial invasion, FAW exhibited a high population density and rapid spread, consistent with FAO (2020) [8], which reported that FAW, as an invasive pest, is capable of causing extensive damage to maize crops within a short period. A significant decline was observed in 2022, with the infested area reduced to around 115 ha. This reduction may be attributed to farmers' adaptive management practices, including using insecticides, tolerant maize varieties, or improved crop management through Integrated Pest Management (IPM) strategies [17]. Subsequently, between 2023 and 2024, the infested area gradually increased, reaching approximately 150 ha. This resurgence suggests that FAW has persisted in the ecosystem, potentially due to insecticide resistance, the use of alternative host plants, or favourable climatic conditions that support its life cycle [9].

FAW-induced damage was detected in all maize-growing areas. In Pasaman Barat, infestations were found across many maize production sites. Pasaman, Luhak Nan Duo, and Kinali sub-districts, the primary maize production centres in Pasaman Barat, continued to exhibit high levels of FAW infestation. Luhak Nan Duo was the first location where FAW was initially reported, while the Pasaman sub-district recorded a higher infestation percentage than the other two sites. Previous research in Pasaman Barat also reported that FAW infestation occurred in nearly all maize fields. Similarly, in Padang Pariaman, FAW infestations were observed across all three monitoring sites, with the infestation level in Padang Pariaman being higher than in Pasaman Barat.

During the 2025 cropping season, FAW infestations remained widespread. The highest infestation levels were recorded in Limapuluh Kota District compared to the other two districts, Pasaman Barat and Padang Pariaman. Within the sample locations in Limapuluh Kota, the Luhak sub-district exhibited a higher infestation rate than the other two sites. Moreover, FAW larvae were still present in nearly all observation sites across the three districts in West Sumatra. The presence of FAW larvae has also been documented across almost all maize-growing regions in various locations throughout Indonesia. The highest larval population density was recorded in the Limapuluh Kota District compared to the other observation sites (Figure 2).

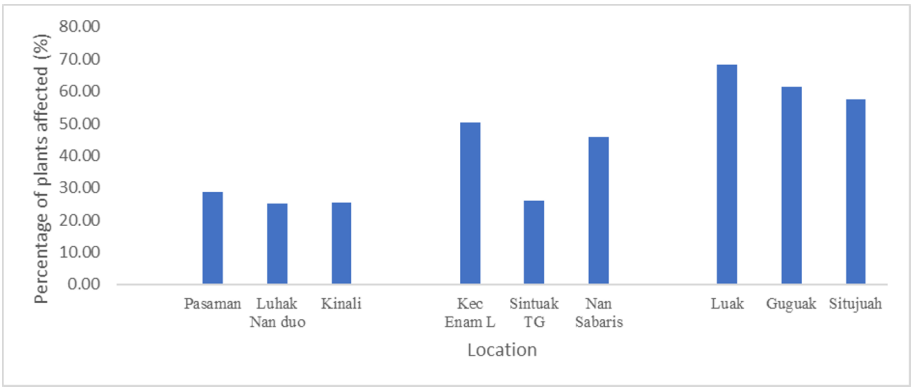


Fig. 2. Percentage of Maize Plants Infested by FAW in Several Locations, Three Districts of West Sumatra.

FAW larvae in maize fields strongly influenced the percentage of infested plants, almost always detected in every sampling plot. Regardless of maize type or variety, FAW larvae were consistently found. Larval populations within sampling plots varied, primarily depending on the stage of crop growth. The percentage of infested plants across the three observation sites ranged from 25.07% to 68.28%.

Larvae were most frequently observed on maize plants during the vegetative stage, where symptoms of infestation were more apparent (Figure 3).

Fig. 3. FAW larvae and symptoms of infestation on maize plants.

As shown in Figure 3, *Spodoptera frugiperda* (FAW) infestation on maize can be identified through the characteristic symptoms it causes. Damaged plants typically exhibit torn or shredded leaves, often accompanied by larval frass deposited on the plant surface. Larvae are frequently found within the affected parts of the plant, with an average of one larva per stalk. Interestingly, in some maize plants that show visible damage, FAW larvae are not always present. However, symptomatic plants consistently display frass residues, which, when dried, appear as sawdust-like particles.

3.2 Rainfall fluctuations

Over the past five years, rainfall data in West Sumatra revealed no consistent pattern. Monthly fluctuations occurred throughout the year, as illustrated in the following figure (Figure 4).

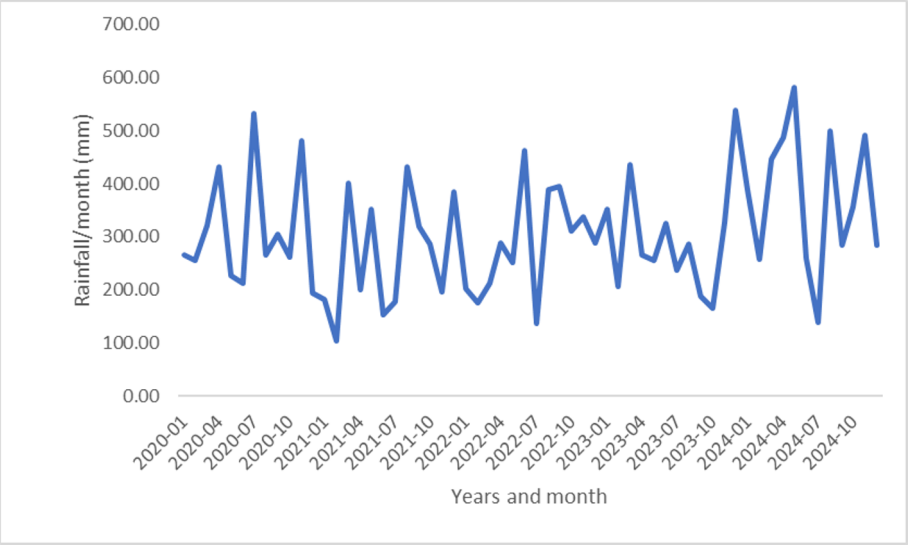


Fig. 4. Rainfall fluctuations over five years in West Sumatra.

As shown in Figure 4, rainfall in West Sumatra exhibited considerable fluctuations. The highest average monthly rainfall reached 500 mm, while the lowest was 135.65 mm. This variability makes it difficult to determine clear periods of heavy rainfall or drought. Consequently, there is no separation between wet and dry months, and seasonal rainfall patterns appear relatively moderate. Such conditions are assumed to influence the presence and persistence of insect pests in the field. The continuous occurrence of *Spodoptera frugiperda* (FAW) populations is likely driven by multiple factors beyond rainfall alone.

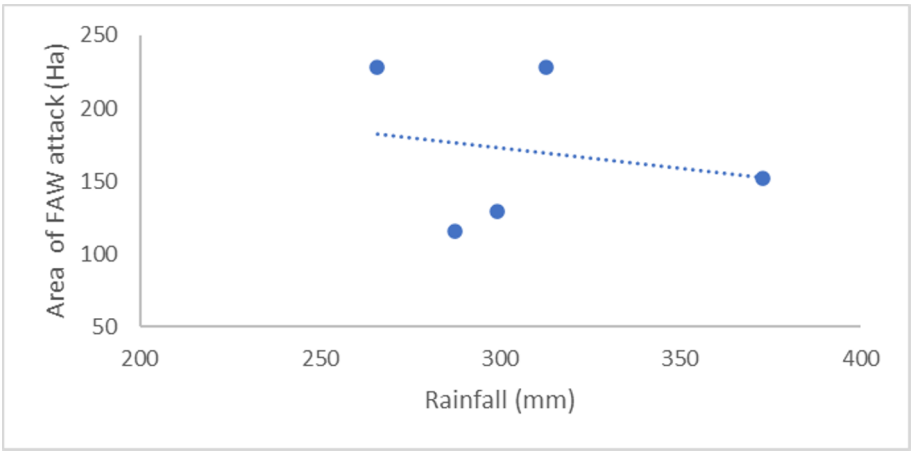
Rainfall fluctuations in West Sumatra do not allow for a clear distinction between wet and dry months. This pattern is typical of humid tropical regions, where monthly rainfall variability is high due to local and global climatic drivers, such as the Asian monsoon and the El Niño–Southern Oscillation (ENSO) [10].

Moderate rainfall conditions are expected to affect pest population dynamics in the field. Rainfall is closely linked to microhabitat moisture availability and host plant conditions, which can influence insect abundance and activity. Several studies have shown that increased rainfall may reduce specific pest populations by washing away eggs or larvae from plant surfaces [11]. On the other hand, sufficient but not excessive rain can promote vegetative growth of host plants, thereby providing more abundant food resources for pests.

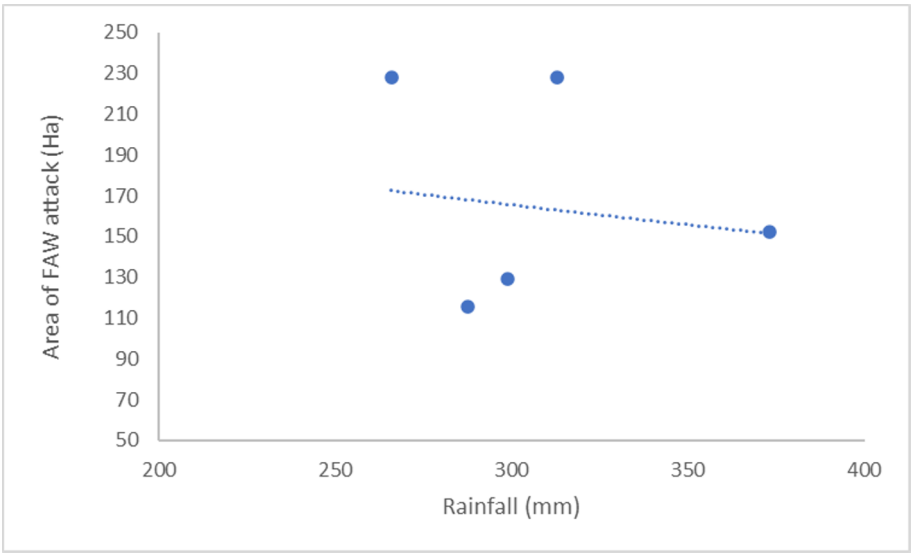
In the case of *Spodoptera frugiperda*, its distribution and infestation intensity in tropical regions are not always directly correlated with rainfall, but are more strongly associated with the continuous availability of host plants throughout the year [12]. In West Sumatra, fluctuating rainfall without prolonged dry periods is likely to support the persistence of FAW populations throughout the year, although infestation intensity may still fluctuate in response to environmental dynamics.

3.3 Correlation between infestation area and rainfall

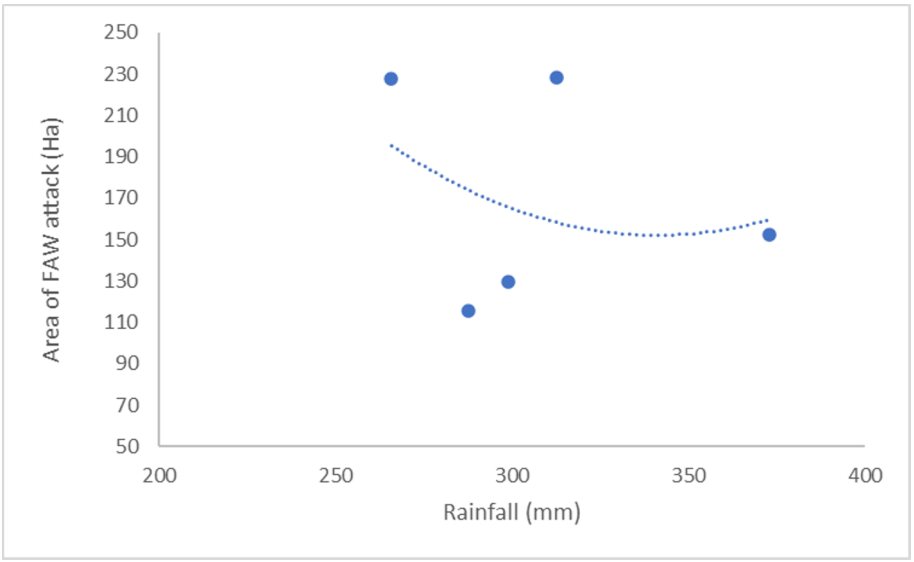
The correlation analysis between rainfall and FAW infestation area in West Sumatra revealed differences across several regression models, including linear, polynomial, and logarithmic relationships (Figure 5).



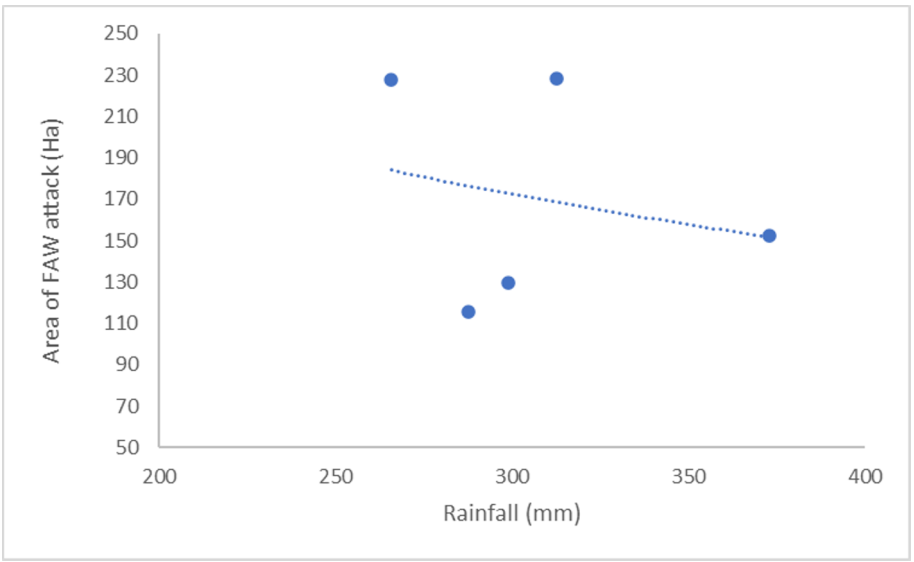
a. linear



b. Eksponensial



c. Polynomial



d. Logaritmik

Fig. 5. Correlation model between the extent of FAW infestation and rainfall in West Sumatra.

As shown in Figure 5, there is no correlation between rainfall and the extent of FAW infestation. The R^2 value indicates the strength of the relationship. The regression equation describing the relationship between rainfall and infestation extent, along with the corresponding R^2 value, is presented in Table 1.

Table 1. Correlation between FAW infestation and rainfall fluctuations.

No	Formula	R^2 value	Model
1	$y = -0,2829x + 257,74$	0.0448	Linear
2	$y = 237,97e^{-0,001x}$	0,0464	Eksponential
3	$y = 0,0076x^2 - 5,2119x + 1041,5$	0,0796	Polynomial
4	$y = -95,26\ln(x) + 715,79$	0.0497	Logaritmic

Based on Figure 5 and Table 1, the relationship between rainfall and the infestation area of *Spodoptera frugiperda* (FAW) in West Sumatra did not show a strong correlation. This is indicated by the very low coefficients of determination (R^2) across all regression models, including linear ($R^2 = 0.0448$), exponential ($R^2 = 0.0464$), polynomial ($R^2 = 0.0796$), and logarithmic ($R^2 = 0.0497$). These values are far below 0.5, which is generally considered the minimum threshold for a meaningful relationship. Consequently, rainfall fluctuations cannot be used to predict the intensity of FAW infestation.

Several biological and ecological factors can explain this phenomenon. Biologically, FAW is an invasive pest with a high adaptability to diverse environmental conditions, including variations in rainfall. Previous studies have indicated that while humidity and precipitation may influence oviposition activity and larval survival, these factors are not the primary determinants of pest population dynamics [13][14].

Ecologically, FAW infestation is more strongly influenced by the availability of host plants, particularly maize continuously cultivated without planting breaks (overlapping cropping). Such conditions provide a favourable habitat for the pest throughout the year, allowing FAW populations to remain stable despite variations in rainfall [12]. Therefore, agronomic factors shape Infestation patterns more than single climatic variables. It isn't easy to distinguish between dry and wet seasons in tropical regions, such as West Sumatra, where rainfall remains relatively high throughout the year. The irregular and unpredictable rainfall patterns result in no clear periods that significantly constrain FAW populations. Consequently, in tropical environments, FAW populations tend to be more stable compared to subtropical regions, where winter acts as a natural limiting factor.

Rainfall can influence herbivorous insect populations by theoretically affecting microhabitat humidity and host plant development [15]. However, the present findings indicate that rainfall is not significantly correlated with the area of FAW infestation under local conditions in West Sumatra. This highlights the need to consider other factors, such as cropping patterns, the availability of resistant varieties, and agroecosystem management, in developing sustainable FAW control strategies.

4 Conclusion

Spodoptera frugiperda was first detected in West Sumatra in 2019, infesting maize crops across multiple locations. This pest continues to be present in all maize-growing areas. Observations in major maize-producing regions, namely Pasaman Barat, Limapuluh Kota, and Padang Pariaman, showed that infested plants ranged from 25.07% to 68.28%. The symptoms of infestation are easily identifiable in the field. The extent of infestation fluctuated over time but was not influenced by rainfall. Although rainfall in West Sumatra is variable, it does not exhibit distinct extremes between dry and wet seasons.

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