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Corn Pests and Evaluation of the Implementation of Integrated Pest Management in West Sumatra, Indonesia

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***Abstract*—Indonesia is one of the maize-producing countries in the world. However, Indonesia's production is below the world average. One of the problems that can reduce productivity is pests. In addition, although corn is grown globally in Indonesia, it is usually not grown under the Integrated Pest Management (IPM) program. Therefore, this study aims to obtain pest information on maize and evaluate the application of IPM in West Sumatra. The study was conducted centra production of maize in West Sumatra from May 2019 to August 2020. The method used purposive random sampling. The results showed differences in the population density of pests on centra production of maize in West Sumatra. The highest percentage of pest attacks on cornfields was Pasaman Regency (41%), while the lowest pest attack was in Solok Regency (19%). The difference in population density of pests caused the influence of climate, varieties of maize, altitude, weather conditions at the time of pest observation, and the application of IPM. Several types of pests found were Beetles (Chrysomelidae), Aphids (Aphididae), Seed Flies (Muscidae), Grasshopper Oxya Chinensis (Acrididae), Fall Armyworm *Spodoptera frugiperda* (Noctuidae), and Corn Planthoppers (Delphacidae). The most common pest found attacking maize in West Sumatra were *S. frugiperda*. Then the study results also showed that not all corn farmers in West Sumatra applied IPM in their corn cultivation. IPM is needed to manage corn pests, so there is no economic loss.**

***Keywords*—Fall armyworm; integrated pest management; Indonesia; pest; zea mays.**

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I. INTRODUCTION

Indonesia is one of the maize-producing countries in the world. Indonesia maize production was 24.95 million tons of dry shells in 2020. However, Indonesia's production is below the world average. West Sumatra is one of the maize-producing provinces in Indonesia, with production is 939,465.95 tons in 2020, or 59,465 tons less than the production target of 995,201 tons. Several districts in West Sumatra that are maize production centers are West Pasaman, Padang Pariaman, and Solok Regency [1].

Corn is grown globally and is one of the most important cereal crops in the world. Corn is not only an essential nutrient for humans but also the basic element of animal feed and raw materials for manufacturing many industrial products. These products include corn syrup, corn starch, corn oil, and maltodextrin, as well as products of the fermentation and distillation industry [2].

One of the problems that can reduce productivity is insect pests which often cause yield loss. Maize cultivation is still vulnerable to pests and diseases, and maize is one of the plants that pests can attack during its growth period, from seedling to generative [3]. In addition, the limited knowledge possessed by farmers in overcoming pests and diseases impacts corn productivity and can even cause losses for farmers. Climate directly affects the bioecology of insect pests, such as drastic climate changes that can disrupt the insect breeding process (reduce or increase). The indirect effect of climate change can affect the environment that supports insect life, such as the availability of plants as food and a source of nutrition for insect pests. Thus, climate change will directly or indirectly affect the life of insect pests so that their role in a tropic will be different.

Climate change is the leading cause of the diversity of arthropods, the geographic distribution of pests, pest biotypes, interactions between plants and herbivores, natural enemies, species extinction, and plant protection efficacy and

technology [4]. Then climate suitability is also an environmental requirement for a pest to settle in a companion permanently [5], [6]. Due to climate change, there is an explosion in the population of certain insect pests or the extinction of a pest insect [7].

The most widely cultivated maize crops are sweet maize and fodder maize. The dynamics of the main pests and diseases in sweet maize and fodder maize are strongly influenced by the stage of plant growth, and disease growth also increases with plant growth. The corn growth phase can be divided into five, but not all types of pests attack every phase or all phases of growth. For example, the stem borer *Ostrinia francais* attacks every phase of plant growth [8].

About 70 insects attack corn plants in Indonesia, but only a few causes economic losses. Pests commonly found are *Atherigona* sp., *Peregrinus maydis*, *Ostrinia furnacalis*, *Helicoverpa armigera*, *Spodoptera litura*, *Aphids* sp., *Locusta* sp. [9]–[12], *Spodoptera frugiperda* [3], [13]–[19]. Then [20] reported four maize pests in Tarakan City, North Kalimantan Province. However, information about maize pests in West Sumatra is still limited. Although maize is grown globally in Indonesia, it is usually not grown under the Integrated Pest Management (IPM) program. Therefore, this study aims to explore the pests that attack maize and evaluate the application of IPM in West Sumatra.

II. Materials and Method

A. Material

This study was conducted from May 2019 to August 2020 in centra production of maize, West Sumatra, Indonesia. The three selected regency are West Pasaman, Padang Pariaman, and Solok Regency. Two sub-districts represent each regency (Figure 1).

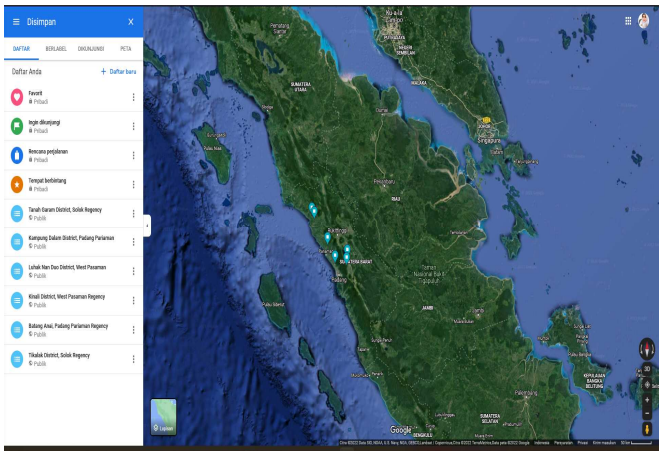

Fig. 1 Map of locations for studies pest exploration and evaluation of IPM in West Sumatra, Indonesia.

B. Method

The tools used in this study were tweezers, a hand counter, dropper pipette, a microcentrifuge tube, container box, petri dish, face shield, mask, binocular microscope, Sony HX-300 digital camera, tissue, crab plastic, label paper, and other tools. Then the material used in this study is 96% alcohol. The method in this research is a survey method. Plant sampling was done by purposive random sampling. The selected corn area has a minimum area of 1 hectare. The intensity of pest sampling was carried out four times, namely 20, 40, 60, and 80 Days After Planting (DAP). The pest samples were put into a microcentrifuge tube containing 96% alcohol.

Furthermore, all samples of pests found in the field were brought to the Insect Bioecology laboratory, Faculty of Agriculture, Andalas University, for identification. The identification process is carried out at the family level. Identification of insect pests uses several kinds of literature, such as Introduction to Insect Lessons [21], The Pests of Crops in Indonesia [22], and online identification keys [23].

C. Data Analysis

All pest data obtained in the field were made in qualitative and quantitative forms. The pest population was processed using Microsoft Excel, Pivot Table, and Minitab 16. The data was processed to determine the population of pest attack corn plants in three districts in West Sumatra. In addition, the data (questionnaire) is also displayed descriptively. The evaluation data on the implementation of Integrated Pest Control in the three districts in West Sumatra were obtained through interviews and direct questionnaires to corn farmers in the three districts.

III. Results and Discussion

The results showed differences in the population density of maize pests in centra production of maize in West Sumatra, Indonesia. It shows the percentage of pest attacks on cornfields (Figure 2).

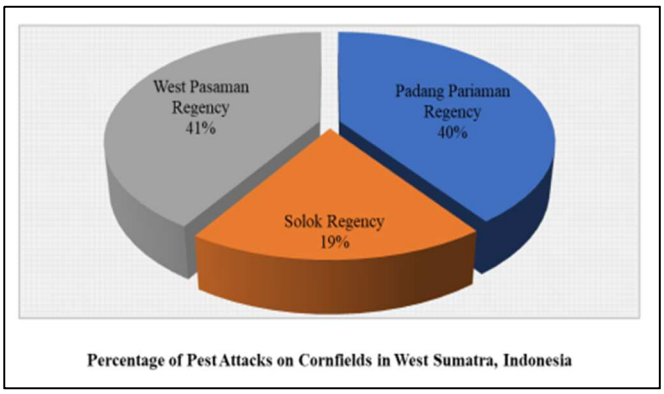

Fig. 2 Percentage of Pest Attacks on Cornfields in West Sumatra, Indonesia

The highest percentage of pest attacks on cornfields in West Sumatra was Pasaman Regency (41%), while the lowest pest attack was found in corn plantations in Solok Regency (19%) (Figure 2). The differences in maize pest populations in the three maize center districts in West Sumatra are thought to be due to the influence of climate, maize varieties planted, altitude, and time and weather conditions at the time of pest observation (rain or heat).

The effect of rain on insect pests can be direct or indirect. Rain can directly affect the population density of insect pests of corn. If the intensity of the rain is significant, it can cause insect pests to be carried away by rainwater and even die. Direct effects, for example, rain, can cause insect pests to fall, be carried away by rainwater, and even die. Indirect influence, rain can affect the humidity of the air and soil to inhibit or interfere with the life of insect pests. In addition to rain, wind can also affect insects on corn cultivation land. There are

differences in pest populations found in several production centers in West Sumatra (Table 1).

TABLE I
PEST POPULATION OF MAIZE PRODUCTION CENTER IN WEST SUMATRA, INDONESIA

Centra Production of maize in West Sumatra (Regency)	Observation time (Days After Planting)				Population (Individual)
	20	**40**	**60**	**80**	
Padang Pariaman	316	340	329	417	**1402**
Pasaman Barat	403	444	128	460	**1435**
Solok	113	142	174	232	**661**

The highest pest attack was found in corn plantations in West Pasaman Regency (1435 individuals), while the lowest pest attack was found in corn plantations in Solok Regency (661 individuals) (Table 1). In terms of observation time, the observation of maize pests in West Pasaman Regency is held from October to January. Then the observation of pests in Padang Pariaman Regency was conducted from April to June, and Solok Regency from December to July. In addition to the observation time, differences in pest populations on maize in West Sumatra were caused by varieties. Farmers in Padang Pariaman Regency grow maize variety P32 with fodder maize. Then the farmers in Pasaman Barat Regency grow corn of the NK 212 variety, and the type of corn is feed corn. In contrast to corn farmers, Padang Pariaman Regency uses the Pioneer 32 variety (feed corn), while Solok Regency uses the JH 27 variety with hybrid corn. Based on the study results, corn variety NK 212 was more susceptible to pests, while variety JH 27 was resistant. The JH 27 variety is a hybrid variety used by PT. CNM in Solok Regency. It is suspected that the JH 27 variety has a large stem morphological growth and a thick and hard bark so that insect pests do not like it so that this variety is resistant to pests in the field. In older plants, the plant tissue is getting harder so that pests fewer favor pests to carry out their lives.

According to Gill and Garg [24], the advantages of using resistant varieties are practical and economically profitable, specific control targets, cumulative and persistent control effectiveness, compatibility with other components of Integrated Pest Control, and limited negative impact on the environment. Sari et al. [25] also said that using pest-resistant maize varieties is an easy, inexpensive, and environmentally friendly way to control pests. One important indicator of a superior crop variety is the resistance to biotic stresses [26]. 17 West Sumatra brown and black rice tested, 7 genotypes were resistant, and 2 were moderately resistant assays to brown planthopper (*Nilaparvata lugens* Stal.) in West Sumatra [27].

This study's results also showed that altitude affects the population of pests that attack corn in West Sumatra, Indonesia. West Pasaman Regency and Padang Pariaman Regency has an altitude of less than (<) 200 meters above sea level), while Solok Regency has an altitude greater than (>) 700 meter above sea level. It can be seen from the population of pests that attack corn plants in West Pasaman and Padang Pariaman Regency, which are relatively the same. The number of pests found at all research sites can be seen in more detail (Figure 3).

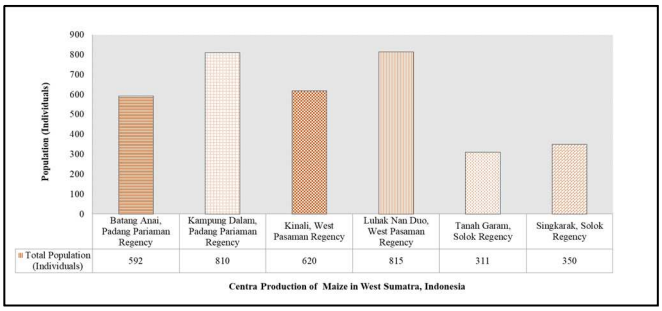

Fig. 3 Total pests found in corn production centers in West Sumatra, Indonesia

The highest pest population was in Luhak Nan Duo District, West Pasaman Regency (815 individuals), and the lowest pest population was in Singkarak District, Solok Regency (350 individuals). In contrast to the number of pest populations that attack maize in Solok District (Tanah Garam District and Singkarak District), the number of pests obtained is lower than in West Pasaman and Padang Pariaman Regency. It means that maize grown in the lowlands and medium lands is more susceptible to pest attack than maize grown in the highlands. This is presumably because the landscapes dominated by hills and forests limit the spread of pests from one place to another.

According to Subekti [28], the distribution of insects is limited by suitable geological and ecological factors, resulting in differences in the diversity of insect species. This difference is caused by differences in climate, season, altitude, type of food, and river flows. The research results of Maulana, Dadi, and Sopyan [29] showed that the diversity of insect species in the protected forest area of Karangkamulyan, Ciamis Regency, was influenced such as the ability to spread, habitat selection, air temperature conditions, soil moisture, light, rainfall, vegetation, and food availability.

Several types of pests found in maize plantations in West Sumatra are Beetles (Chrysomelidae), Aphids (Aphididae), Seed Flies (Muscidae), Grasshopper Oxya Chinensis (Acrididae), Fall Armyworm *Spodoptera frugiperda* (Noctuidae), and Corn Planthoppers (Delphacidae) (Figure 4).

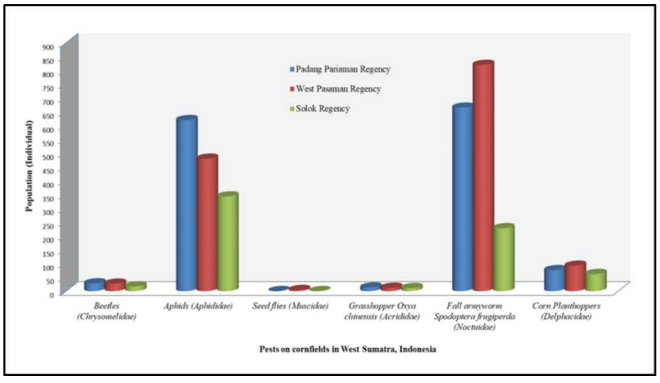

Fig. 4 Pests on cornfields in West Sumatra, Indonesia

The most common pests found attacking maize of centra production in West Sumatra were the fall armyworm *S. frugiperda* (Noctuidae) (1713 individuals), while the fewest pests found were seed flies (Muscidae) (4 individuals) (Figure 4). This pest is a new pest in maize plantations in West

Sumatra. It can also be seen that *S. frugiperda* can attack maize at all altitudes, both lowlands (West Pasaman and Padang Pariaman Regency) and highlands (Solok Regency).

Fall armyworm *S. frugiperda* is a pest native to the tropics and subtropics in America. It was first reported in West Africa from Nigeria and the island of São Tomé and Principe in 2016 [30] and in almost all sub-Saharan African countries [31]–[36]. Then *S. frugiperda* disperse to India and Yemen in 2018, in Karnataka India [30], [32], [37]–[39].

Pest distribution and climatic suitability models have indicated that the environmental requirements for this pest to establish itself permanently are present in large parts of Africa, Asia, and some parts of Europe [5], [6]. The pest's distribution has reached the southern fringes of the Sahara, and several states in India [40], [41] as well as Myanmar, Yemen, Sri Lanka, and Thailand [6], [30], [37]. Indeed, it is likely to spread further north to Europe and other countries in Asia.

In Indonesia, this pest is invasive to corn plants and was discovered in early 2019 [42]. In early 2019, also reported maize in several districts in West Sumatra were attacked by *S. frugiperda* pests, such as maize in West Pasaman, Padang Pariaman, Solok Regency, and several other areas [43]. Farmers fear this new pest attack because the damage caused by this pest is very high [3], [18]. *S. frugiperda* was also found in Bandung [15], Lampung [14], and Bengkulu [16].

S. frugiperda is new invasive pest in West Pasaman. It feeds on the growing point of maize crop so that buds of maize look cut and leave their feces like sawdust. Further damage due to *S. frugiperda* in the generative phase can be seen at the end of maize cobs, even sometimes can be found in larvae or pupae *S. frugiperda* [18]. The attack rate of *S. frugiperda* in the West Pasaman Regency was high. The *S. frugiperda* pest attacked several maize varieties in West Pasaman, varieties Pioneer 32, Pertiwi, Bisi 18, NK 7328, and NK 212 with attack percentages ranging from 6.0 – 96.0% [17].

Besides *S. frugiperda*, other pests that are often encountered in West Sumatra are Corn Planthoppers (Delphacidae) and Aphids (Aphididae) (In Figure 4). Corn Planthoppers and Aphids are presumably due to the spacing used by farmers in cultivation. Farmers generally use a distance of 70 cm x 15 cm, and the number of seeds is two seeds per planting hole to produce more maize. Spacing is one of the crucial components in controlling maize pests.

Stenocranus pacificus (Hemiptera: Delphacidae) is a corn planthopper in West Sumatra [12]. Then Sari et al. [25] research showed that aphids (Hemiptera: Aphididae) attack hybrid maize in Solok Regency, West Sumatra. Two species that attack hybrid maize are *Rhopalosiphum maidis* Fitch and *Myzus persicae*. The low population of aphids that attack hybrid corn plants is due to several factors, such as corn varieties, cropping patterns, and cultivation practices carried out by local farmers.

Proper spacing can be seen as necessary to obtain uniform plant growth, even distribution of nutrients, the effectiveness of land use, facilitate maintenance, and suppress the development of pests and diseases. Sembel [44] revealed that spacing settings influence the physical environment of the plant itself. Planting at a very close distance can reduce the space for the plant to grow, increase competition for food nutrients, disrupt the root process, create more fabulous shade and create a microclimate that affects plant growth and development. Plants with poor growth are usually susceptible to pests and diseases.

In addition to the factors above (the influence of climate, maize varieties planted, altitude, weather), the differences in population and types of pests on centra production of maize, West Sumatra are also thought to be caused by the application of Integrated Pest Management (IPM). Based on the results of interviews and questionnaires with farmers in three regencies of maize production centers in West Sumatra that not all maize farmers in West Sumatra apply IPM, such as the use of pest-resistant varieties, sanitation, pest monitoring, and observation, fertilization according to the recommended dose of the Ministry of Agriculture, and time and type of pest control technique.

Corn farmers in Solok Regency tend to apply IPM in controlling pests and diseases of the corn they plant. Pest monitoring and observation measures are carried out at least once a week to avoid losses by pests and diseases of corn. The use of synthetic pesticides (chemicals) is carried out when the maize pest population is high in the field. However, it differs from farmers in West Pasaman and Padang Pariaman Regency. After the corn seeds are planted, the corn is left alone until fertilization, so many weeds grow in the corn cultivation area. As a result, the number of plants attacked by pests in West Pasaman and Padang Pariaman Regency is higher than in Solok Regency (Figure 5).

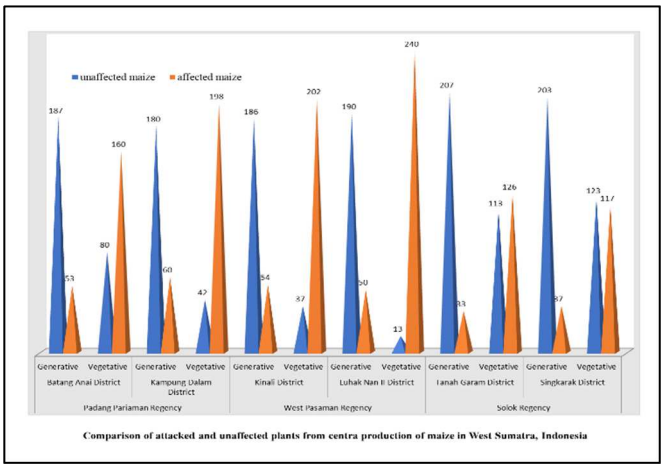

Fig. 5 Comparison of attacked and unaffected from centra production of maize in West Sumatra, Indonesia

The highest number of plants attacked by pests occurred in the vegetative phase in three maize production centers in West Sumatra (Figure 5). This is thought to be due to the relatively young age of corn (less than 35 days) [18]. The vegetative phase is the most vulnerable to *S. frugiperda* attack on corn plants. Corn in West Pasaman Regency was severely attacked by *S. frugiperda* with insect percentage up to 100.0%, and 1-2 medium or large larvae were found in each of maize.

Sanitation or cleaning is essential in cultivating corn because many insect pests can survive on crop residues [24]. Maize farmers in Solok Regency carried out sanitation on plants aged 14 DAP and 35 DAP simultaneously as fertilization, while in Batang Anai, Kampung Dalam, Luhak Nan II, and the farmers of Kinali district did not do sanitation. According to Sembel [44], weed removal is essential for

healthy plant growth and necessary to keep weeds from becoming a place for insects to live to lay eggs or obtain food sources or just as temporary shelter. Food is a source of nutrition used by insects to live and develop. If food is available of suitable quality and sufficient quantity, the insect population will increase rapidly. Conversely, if food is lacking, the insect population will also decrease.

Farmers in West Pasaman Regency and Padang Pariaman Regency also rely on synthetic pesticides (chemicals) by mixing two or three trademarks to control pests. Synthetic pesticide application time is generally a day before the second fertilization. Then after the second fertilization, the corn is left alone until it is harvest time-one of the factors causing farmers in Padang Pariaman and Pasaman Regency to rely on chemical pesticides. These farmers have side jobs, such as trading, motorcycle taxis, and even village officials, so farming is no longer the main job to support their family needs. The effects of using these pesticides can be seen from the presence of natural enemies (predators, parasitoids, and insect pathogens). However, this paper does not discuss the negative impact of synthetic pesticide application on natural enemies.

Based on the results of interviews with corn farmers in West Pasaman and Padang Pariaman Regency, it turns out that the profile of corn farmers in the two districts has an average age between 40-60 years, while the education level of farmers is still relatively low, namely Elementary School and Junior High School. Most farmers have low education, so most farmers, in dealing with pest and disease problems, take practical steps by spraying synthetic pesticides (chemicals) without thinking about the adverse effects it causes. In addition, farming skills are generally acquired through heredity. Most of the workers involved in corn cultivation come from their family members, which are around 2-3 people. According to Zulaiha, Suprapto, and Apriyanto [46], reducing pesticides will reduce environmental pollution and reduce the cost of maintaining corn plants.

IV. Conclusion

This study concludes that differences in the population density of pests on centra production of maize in West Sumatra. The highest pest attacks on cornfields were West Pasaman Regency (41%), while the lowest pest attack was found in Solok Regency (19%). The difference in population density of pests that attack maize is caused by the influence of climate, varieties of maize, altitude, weather conditions at the time of pest observation, and the application of IPM. Several types of pests found were Beetles (Chrysomelidae), Aphids (Aphididae), Seed Flies (Muscidae), Grasshopper *Oxya chinensis* (Acrididae), Fall Armyworm *Spodoptera frugiperda* (Noctuidae), and Corn Planthoppers (Delphacidae). The most common pests found attacking maize in West Sumatra were *S. frugiperda*. Then the results of the study also showed that not all corn farmers in West Sumatra applied IPM in their corn cultivation. IPM is needed to manage corn pests so that there is no economic loss.

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