RESEARCH PAPER

Infestation of *Helicoverpa armigera* (Hubner) and *Ostrinia furnacalis* Guenee on three tropical altitude variations

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ABSTRACT

Pest infestation is a major problem in corn cultivation because it causes a decrease in crop productivity or even crop failure. This study aimed to evaluate the level of crop damage caused by *Helicoverpa armigera* and *Ostrinia furnacalis* in three tropical altitude variations. Ten hybrid corns from cross-breeding strains and three commercial hybrid corn varieties were evaluated at three locations with different altitudes, classified as lowland (30 masl), midland (600 masl), and highland (1000 masl). The evaluation was carried out on the level of crop damage and plant resistance. The results showed that the highest percentage of *H. armigera* attack on hybrid corn was 75% at Caps 17B x Caps 23 (moderately susceptible) at the lowland and the lowest was 8% at Caps 2 x Caps 17A (resistant). The percentage of *H. armigera* attack was 100% at Caps 15 x Caps 22 (very susceptible) and the lowest was the evaluation of Caps 5 x Caps 17B was 58% (susceptible) at the midland. Meanwhile, the highest attack percentage was 92% on the Caps 17A x Caps 17B, Caps 17A x Caps 22, and Caps 5 x Caps 22 hybrids (very susceptible), while the lowest was 67% on the Caps 3 x Caps 17B and Secada hybrids (moderately susceptible) at the highland. *O. furnacalis* attack showed that all hybrid corns were classified as resistant except for Caps 5 x Caps 22 and Paragon was moderately resistant with a percentage attack of 25% at lowland. At the midland, Caps 5 x Caps 17B hybrid corn was classified as very susceptible with an attack of 92%, while Caps 15 x Caps 22 was classified as resistant with an attack percentage of 8%. At an altitude of 1000 masl, Caps 17A x Caps 17B, Caps 3 x Caps 17A, and Caps 5 x Caps 17B were moderately resistant with an attack percentage of 33% and other hybrids were resistant with an attack percentage of 8%.

Key words: corn, pests, elevation, hybrid

INTRODUCTION

Corn is a cereal plant as a source of carbohydrates and staple food for some Indonesian people, such as in East Nusa Tenggara and Maluku. Moreover, it is also used as animal feed, so the demand for corn grain continues to increase. Lately, domestic corn production in Indonesia could not fulfill national needs, especially for the food and feed industry sector, so the government was trying to encourage farmers to continue cultivating corn (Susmawati & Muda, 2014).

The efforts to increase corn production were often constrained by pests. Some kinds of pests that are common in corn fields are corn stem borer *O.*

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furnacalis (Lepidoptera: Pyralidae), corn borer *H. armigera* (Lepidoptera: Noctuidae), *Spodoptera litura* (Lepidoptera: Noctuidae) and *Mythimna separata* (Lepidoptera: Noctuidae), *Rhopalosiphum maidis* Fitch (Hemiptera: Aphididae), rats (Kalshoven, 1981; Blumenschein et al*.,* 1988; Swastika et al*.,* 2004), and fall armyworms or *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) which classified as an invasive pest in Indonesia (Maharani, 2019; Trisyono *et al.,* 2019). In this study, we focus on *H. armigera* and *O. furnacalis* which economically could cause heavy losses.

H. armigera is an important pest of corn in the world, including Indonesia (Karim et al*.,* 2013, Sarwono et al*.,* 2003). This pest infestation reduced the quality and quantity of corn cobs. Losses due to the pests were more than US\$ 2 billion per year in Asia, Europe, Africa, and Australia (Tay et al*.,* 2013). In Indonesia, *H. armigera* attack resulted in corn yield loss reaching 80% (Tenrirawe, 2011).

On the other hand, *O. furnacalis* were also reported as an important pest on corn in Indonesia, the Philippines, Cambodia, Vietnam, China, Thailand, Malaysia, and Papua New Guinea (Nonci, 2004). Loss

of maize yields caused by this pest in the Philippines reaches 20–80% (Bato et al., 1983), while in Taiwan, yield losses reach 95% (Nafus & Schreiner, 1991). In Sulawesi, the intensity of *O. furnacalis* attacks ranged from 1.19–14.54% meanwhile in Central Java 1.61–8.89% (Kementan, 2013), while in Bogor it could reach 52% (Heryana, 2013). Nonci & Baco (1987) reported that *O. furnacalis* attack before four weeks after a plant could cause total damage to the plants, while attacks on plants aged six weeks (female flowers have not been fertilized) could cause crop failure.

An increase in temperature affects the distribution, survival, and reproduction of insects, environmental conditions in the tropics are generally characterized by climatic characteristics at each altitude above sea level. These differences in climatic characteristics, types, distribution, behavior, and destructive power of insects are also different (Karenina, 2021). So far, studies on the destructive ability of these pests in the tropics are limited. This is because the pest control recommended to the public is still general for all environmental conditions, so the effectiveness of pest control varies greatly between environmental conditions. This study aims to evaluate the level of crop damage caused by *H. armigera* and *O. furnacalis* at three tropical altitude variations.

MATERIALS AND METHODS

Research Site. The research was carried out from October 2021 to February 2022, in three different locations with different altitudes. The lowland (30 meters Above Sea Level/masl) was in Kandang Mas Village, Kampung Melayu District, Bengkulu City; the midland (600 masl) was in Taba Mulan Village, Merigi District, Kepahiang Regency; and the highland (1000 masl) was in Sambirejo Village, Selupu Rejang sub-district, Rejang Lebong district, the planting area for each location was 500 m².

Research Design. This study used a Randomized Block Design, with the treatment of corn lines including Ten hybrids from crosses breeding strain corn of promising lines (Caps 2 x Caps 17A, Caps 3 x Caps 17A, Caps 3 x Caps 17B, Caps 5 x Caps 22, Caps 5 x Caps 17B, Caps 15 x Caps 22, Caps 17B x Caps 23, Caps 17A x Caps 17B, Caps 17A x Caps 22, Caps 22 x Caps 23) and three commercial hybrid varieties for comparison they were Bonanza, Secada (PT. East West Seed Indonesia), and Paragon (PT. Agri Makmur Pertiwi). The number of plants was fourty per variety with three replications and the number of sample plants for each treatment unit

was twelve plants.

Land Preparation and Seed Planting. Land preparation was carried out by clearing the land of existing vegetation, the soil was processed by hoe, and then experimental plots were made. The size of each experimental plot was 1.5 × 5 m with a 50 cm distance between plots and a 100 cm distance between plots. Planting was done by placing one seed in a hole. The planting distance was 75 × 25 cm so each plot contained 40 plants. Urea, SP-36, and KCl fertilizer doses were 50 kg/ha, 50 kg/ha and 25 kg/ha, respectively. The mixture of Urea, SP-36, and KCl fertilizer was put in an array 5 cm deep with a distance of 7 cm from the planting hole, then the array was covered with soil.

Percentage Attacks of *O. furnacalis* and *H. armigera*. Observation of *O. furnacalis* infestation was carried out in the generative phase by calculating the percentage of attacks on corn stalks using the formula:

$$P = \left(\frac{n}{N}\right) \times 100\%$$

Description:
P = Damage percentage (%);
n = Number of stems attacked by pest;
N = Total number plant observed.

Corn Damage Percentage. The percentage of damage to the corn cobs was calculated at harvest time using the formula:

$$X = \left(\frac{y}{Z}\right) \times 100\%$$

Description:
X = Percentage of ear damage (%);
y = Number of damaged corn cobs;
Z = Total number of cobs observed.

The cob damage was observed during harvest by counting the former corn cob borer attack or base on the presence of cob borer larvae on corn cob.

The level of resistance of corn to *O. furnacalis* and *H. armigera* attack was based the following scores:
Score 1: 0–20%   = resistant
Score 2: 21–40% = moderately resistant
Score 3: 41–60% = susceptible
Score 4: 61–80% = moderately susceptible
Score 5: >80%   = very susceptible

Data analysis. The data obtained were analyzed using analysis of variance (ANOVA) and Duncan test at the level of 5%.

RESULTS AND DISCUSSION

The symptoms of *H. armigera* attack were visible at the tip of the cob. The silks were cut off and there was a gnawing mark at the tip of the cob. The larvae feed on the developing corn kernels and gnaw the tips of the cobs (Figure 1). The result showed that the highest percentage of *H. armigera* attack reached 83% on Caps 17B x Caps 23 at lowland (30 masl), although it was not significantly different from hybrid corn and two commercial hybrid varieties (Paragon and Secada), but significantly different with the hybrid corn on Caps 2 x Caps 17A and Bonanza variety (Table 1).

The difference in the level of resistance was influenced by biophysical and biochemical factors which involved in plants interrelationship with insects. Biophysical factors such as morphology, anatomy, and plant color affect the resistance of a variety. Plants become more favored by insects, depending on how big the role of each factor influence resistance of plant or a combination of the three factors above. At the midland (600 masl), the highest attack percentage reached 100% at Caps 15 x Caps 22, although it was not significantly different from hybrid corns cross-breeding strain, and the three commercial hybrid varieties (Bonanza, Paragon, and, Scada), but significantly different from hybrid corn on Caps 5 x Caps 17B (Table 1). At highland (1000 masl), the highest attack percentage was 92% on the hybrid corns of Caps 17A x Caps 17B, Caps 17A x Caps 22, and Caps 5 x Caps 22 but was not significantly different from all hybrid corn and the three commercial hybrid varieties (Bonanza, Paragon and Scada) (Table 1).

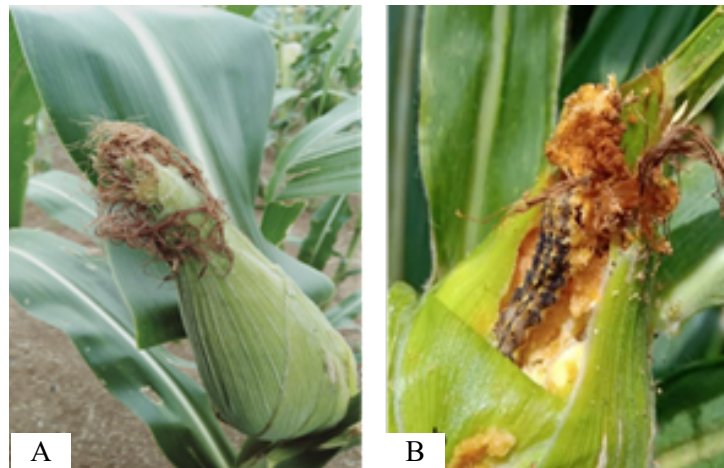The morphological and physiological conditions

Figure 1. Symptoms of *H. armigera* attack. A. Silk clipped; B. Corn cob borer larvae).

Table 1. Attack of *H. armigera* on hybrid corn in various altitude

No	Hybrid Varieties	Attack of *H. armigera* (%)		
		Lowland	Midland	Highland
1	Caps 2 x Caps 17A	8 a	92 bc	83 a
2	Caps 3 x Caps 17B	33 ab	92 bc	75 a
3	Caps 3 x Caps 17A	67 ab	83 abc	83 a
4	Caps 5 x Caps 22	75 ab	83 abc	92 a
5	Caps 5 x Caps 17B	67 ab	58 a	83 a
6	Caps 15 x Caps 22	42 ab	100 c	83 a
7	Caps 17A x Caps 17B	58 ab	83 abc	92 a
8	Caps 17A x Caps 22	58 ab	83 abc	92 a
9	Caps 17B x Caps 23	83 b	67 ab	67 a
10	Caps 22 x Caps 23	25 ab	83 abc	83 a
11	Bonanza	17 a	92 bc	75 a
12	Paragon	42 ab	75 abc	75 a
13	Secada	67 ab	92 bc	67 a

of each plant variety are generally different so they can affect the attack of *H. armigera.* The plants that grow corn silk earlier will be infected with more eggs of *O. nubilalis*. The *O. nubilalis* prefers corn plants with silk that have grown out of the cob. The silk of Genjah Kertas and Kretek varieties appeared earlier than Harapan and Permadi varieties so these varieties were preferred by *O. nubilalis* (Juliastuti, 1978).

The symptoms of *O. furnacalis* attack were seen on the stem where there were holes and larval hoops (Figure 2). The result showed that the highest percentage of *O. furnacalis* attack reached 25% on Caps 5 x Caps 22 and Paragon at lowland, but it was not significantly different from all hybrid corn varieties, as well as the three commercial hybrid varieties (Bonanza, Paragon,

and Scada) (Table 2). At midland, the highest percentage of *O. furnacalis* attack on corn stalks was 92% at Caps 5 x Caps 17B and was significantly different from all hybrid corn and the three commercial hybrid varieties (Bonanza, Paragon, and Scada) (Table 2). Meanwhile, the highest percentage of *O. furnacalis* attack on hybrid corn reached 33% on Caps 5 x Caps 17B, Caps 3 x Caps 17A, Caps 17A x Caps 17B, Bonanza, but was not significantly different from all hybrid corn and the three commercial hybrid varieties (Bonanza, Paragon and Scada) at the highland (Table 2).

The highest attack rate of *O. furnacalis* on composite maize occurred in the Sukmaraga and Srikandi Kuning varieties was 25 %, and the lowest in the Srikandi Putih variety was 12.5 % (Subiadi & Sipi,
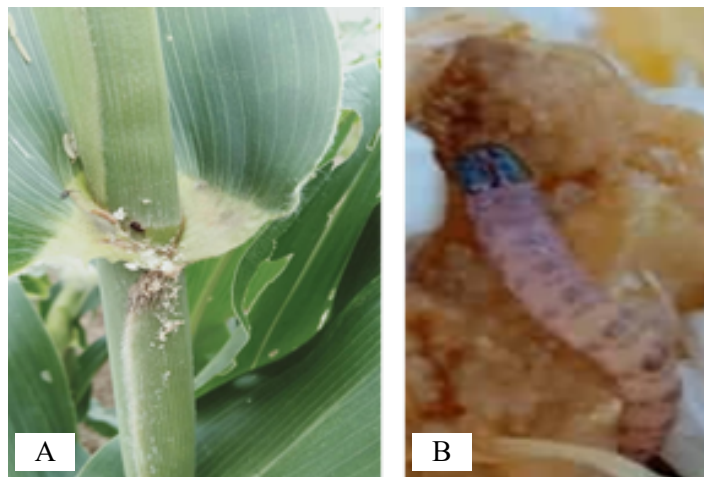
Figure 2. Symptoms of *O. furnacalis* attack. A. Boreholes on corn stalks; B. Larvae of *O. furnacalis*.

Table 2. Attack of *O. furnacalis* on hybrid corn in various altitude

No	Hybrid varieties	The attack of *O. furnacalis* (%)		
		Lowland	Midland	Highland
1	Caps 2 x Caps 17A	17 a	33 bcd	8 a
2	Caps 3 x Caps 17B	17 a	25 abcd	8 a
3	Caps 3 x Caps 17A	0 a	25 abcd	33 a
4	Caps 5 x Caps 22	25 a	25 abcd	8 a
5	Caps 5 x Caps 17B	0 a	92 e	33 a
6	Caps 15 x Caps 22	0 a	8 a	8 a
7	Caps 17A x Caps 22	17 a	33 bcd	17 a
8	Caps 17A x Caps 17B	17 a	50 d	33 a
9	Caps 17B x Caps 23	8 a	17 ab	17 a
10	Caps 22 x Caps 23	8 a	50 d	25 a
11	Bonanza	0 a	42 cd	33 a
12	Paragon	25 a	33 bcd	8 a
13	Secada	0 a	25 abcd	25 a

The numbers followed by the same letter in the same column do not show a significant difference based on the DMRT test at a 5% significance level.

2018). *O. furnacalis* attack on Bisma variety reached 98% in Bogor (Abdullah & Rauf, 2011). The damage intensity of *O. furnacalis* in Bonanza hybrid maize was 57.97%, with the highest larval population at 5.03 tail per stem (Patty, 2012). The number of larvae of *O. furnacalis* in the Sumo variety (forage corn) (2.11 tail) and the Bonanza variety (sweet corn) found as pests of *O. furnacalis* (0.77 tail) (Thamrin and Sudartik, 2019).

The resistance test through the tolerance mechanism was observed from the amount of damage to the hybrid corns from cross-breeding strain and the three commercial hybrid varieties. Each hybrid corn variety had a different attack level at each altitude. At the lowland and highland showed that hybrid corns from cross-breeding strains and commercial hybrid varieties were classified as resistant and moderately resistant to *O. nubilalis*. Meanwhile, in the midland, the resistance level of hybrid corns from cross-breeding strains and commercial hybrid varieties varied from resistant to very susceptible. This is thought to be due to differences in leaf tissue. Sodiq (2009) stated that larvae of *O. nubilalis* first live in a group of bulliform cells from leaves and bulliform cells in resistant varieties were smaller than bulliform cells of the susceptible one.

The hybrid corn of Caps 15 x Caps 22 showed the lowest *O. furnacalis* attack at all three locations and was classified as resistant. This was suspected to be influenced by biophysical and biochemical factors possessed by these plants. The tissue hardness of a plant greatly affects its tolerance to pest attacks. Strong plants have higher resistance. Varieties with denser vascular bundles are a barrier against attack by borer larvae. The varieties of Harapan and Permadi have more dense vascular bundles than the Genjah Kertas and Kretek, so these varieties were more resistant. In addition, biochemical factors such as Dimboa (2,4–dihydroxy–7–methoxy–(2H)–1,4–benzocaine–3 (4H)–one) which are naturally present in maize can caused high mortality of the first offspring of *Ostrinia nubilalis* larvae in corn (Sodiq, 2009).

The percentage of attacks by *H. armigera* and *O. furnacalis* was higher in the midland compared to the highland and lowland. This was influenced by environmental factors, one of factor was rainfall. Cumulative rainfall (October 2021–March 2022) in the area of Rejang Lebong and Bengkulu City (1501–2000 mm) was classified as normal with rainfall values between 85-115%. Meanwhile, the Kepahiyang area has less than average or below normal rainfall, which was less than 85% (BMKG, 2021). According to Kalshoven (1981), low environmental humidity

and warm temperatures were ideal conditions for the development of these two pests. In the Kepahiang, the average attack rate of *O. furnacalis* was high due to lower rainfall compared to Curup and Kandang mas which have normal rainfall.

According to Mavi & Tupper (2004), insect activity would be faster and more efficient at high temperatures but would reduce insect life. In some insects, high temperatures would inhibit metabolism or cause death, but insects that live in deserts could reduce their metabolic rate so that they could survive in areas with limited food and water (Speight et al., 2008).

Air temperature would affect the development, survival, and spread of insects (Koesmaryono, 1999). All insect species have a certain air temperature range in order to survive. This range would be different for each insect species. Insect development and activity would return to normal if the air temperature was in a suitable range (Mavi & Tupper, 2004). Rainfall has a direct effect on insects, by the pouring of raindrops on the insect's habitat, and an indirect effect on moisture and soil. The distribution of rain throughout the year also has a certain pattern that shows the short and short periods of months with a lot of rainfall (wet months) and periods of months with little rainfall (dry months). The population explosion of a pest was closely related to the periodicity of the distribution of the rain (Koesmaryono, 1999). High rainfall could result in the direct death of insects, or allow the development of insect pathogens (Mavi & Tupper, 2004).

CONCLUSION

The observation to plant damage due to the attack of *H. armigera* at lowland (30 masl) showed that Caps 17B x Caps 23 were moderately susceptible and Caps 2 x Caps 17A were resistant. While at midland (600 masl), the Caps 15 x Caps 22 were very susceptible and Caps 5 x Caps 17B were susceptible In the other hand, at highland (1000 masl), Caps 17A x Caps 17B, Caps 17A x Caps 22 and Caps 5 x Caps 22 were very susceptible, while Caps 3 x Caps 17B and Secada were moderately susceptible. The damage caused by *O. furnacalis* in all hybrid corn at the lowland were classified as resistant except for Caps 5 x Caps 22 and Paragon which moderately resistant, while at midland Caps 5 x Caps 17B were classified as very susceptible, and Caps 15 x Caps 22 were resistant. At the highland showed that Caps 17A x Caps 17B, Caps 3 x Caps 17A, Caps 5 x Caps 17B were moderately resistant and other hybrids were resistant.

AUTHORS' CONTRIBUTIONS

MZ and SS considered and planned the experiment. SG collecting data on the plant damage caused by Helicoverpa armigera (Hubner) and Ostrinia furnacalis Guenee. MZ performing analysis and interpreting the plant damage data. SG prepared the manuscript. The authors provided response and comments on the research flow, data analysis and interpretation as well as shape of the manuscript. All the authors have read and approved the final manuscript.

COMPETING INTEREST

I declare no competing interests regarding this publication.

REFERENCES

Abdullah T & Rauf A. 2011. Karakteristik populasi dan serangan penggerek jagung Asia, *Ostrinia furnacalis* (Lepidoptera: Pyralidae), dan hubungannya dengan kehilangan hasil [Population characteristics and plant damage caused by Asian corn borer, *Ostrinia furnacalis* (Lepidoptera: Pyralidae), and their relation to yield loss]. *Jurnal Fitomedika.* 7(3): 175–181.

Bato SM, Everett TR, & Malijan OO. 1983. Integrated Pest Management for Asian Corn Borer Control. *National Crop Protection Centre Series.* No. 9. 4p.

BMKG. 2021. *Buletin Prakiraan Musim Hujan 2021/2022 Provinsi Bengkulu [Forecast of the Rainy Season of Bengkulu Province 2021/2022].* https://bmkgbengkulu.id/wp-content/uploads/2021/09/PMH-2021.pdf

Heryana RTS. 2013. Penggerek Batang Jagung *Ostrinia furnacalis* Guenée (Lepidoptera: Crambidae): Tingkat Serangan di Wilayah Bogor dan Siklus Hidupnya di Laboratorium [Asiatic Corn Borer *Ostrinia furnacalis* Guenée (Lepidoptera: Crambidae): the Field Infestation in Bogor Area and its Life Cycle in the Laboratory]. *Skripsi.* Institut Pertanian Bogor. Bogor.

Juliastuti. 1978. Ketahanan Beberapa Varietas Jagung (Harapan, Permadi, Genjah Kertas, Kretek) terhadap Serangan Penggerek Jagung *Ostrinia nubilalis* Hubner [Resistance of Several Maize Varieties (Harapan, Permadi, Genjah Kertas, Kretek) to the Maize Borer *Ostrinia nubilalis* Hubner]. *Thesis.* Institut Pertanian Bogor. Bogor.

Kalshoven LGE. 1981. *The Pests of Crops in Indonesia.* Ichtiar Baru-Van Hoeve, Jakarta.

Karenina T. 2021. Metode analisis keanekaragaman serangga [Analysis method of insect biodiversity]. In: Herlinda S, Pujiastuti Y, Irsan C, Riyanto, Arsi, Anggraini E, Karenina T, Budiarti L, Rizkie L, & Octavia DM (Eds.). *Pengantar Ekologi Serangga [Introduction to Insect Ecology].* pp. 217−243. Unsri Press. Palembang.

Karim AI, Iswati R, & Zakaria F. 2013. Tingkat Serangan Hama Penggerek Tongkol (*Helicoverpa armigera* Hubner) pada Jagung Varietas Bisi-2 dan Lokal Motorokiki [Attack Level of Cob Border (*Helicoverpa armigera* Hubner) on Corn Bisi-2 and Motorokiki Varieties]. *Skripsi.* Universitas Negeri Gorontalo. Gorontalo.

Kementan. 2013. *Peta Sebaran OPT Utama Tanaman Jagung: Data Survey 26 Februari–01 Maret 2013 [Distribution Map of Main Pests of Maize: Survey Data 26 February–01 March 2013].* https://www.google.com/maps/d/u/0/viewer?mid=10r2VDnKqePmS1NRwHhfMyakwm-VE&hl=en_US&ll=0.674442064873294%2C121.45626066796872&z=8

Koesmaryono Y. 1999. *Hubungan Cuaca Iklim dengan Hama dan Penyakit Tanaman [Relationship between Climate and Pests and Diseases].* Kumpulan Makalah Pelatihan Dosen Perguruan Tinggi Negeri Indonesia Bagian Barat Bidang Agrometeorologi. IPB, Bogor.

Maharani Y, Dewi VK, Puspasari LT, Riskie L, Hidayat Y, & Dono D. 2019. Kasus serangan ulat grayak jagung *Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae) pada tanaman jagung di Kabupaten Bandung, Garut, dan Sumedang, Jawa Barat [Cases of fall army worm *Spodoptera frugiperda* J. E. Smith (Lepidoptera: Noctuidae) attack on maize in Bandung, Garut and Sumedang District, West Java]. *Cropsaver.* 2(1): 38−46.

https://doi.org/10.24198/cropsaver.v2i1.23013

Mavi HS & Tupper GJ. 2004. *Agrometeorology Principles and Applications of Climate Studies in Agriculture*. CRC Press, Boca Raton, Florida.

Nafus DM & Schreiner IH. 1991. Review of biology and control of the Asian corn borer, *Ostrinia furnacalis* (Lep: Pyralidae). *Trop. Pest Manag.* 37(1): 41−56. https://doi.org/10.1080/09670879109371535

Nonci N. 2004. Biologi dan musuh alami penggerek batang *Ostrinia furnacalis* Guenee (Lepidoptera: Pyralidae) pada tanaman jagung [Biology and natural enemies of corn stem borer *Ostrinia furnacalis* Guenee (Lepidoptera: Pyralidae) on corn]. *Jurnal Litbang Pertanian.* 23(1): 8−14.

Nonci N & Baco D. 1987. Pengaruh waktu infestasi dan jumlah larva *Ostrinia furnacalis* Guenee terhadap kerusakan pada tanaman jagung [Effect of time infestation and number of larvae of *Ostrinia furnacalis* Guenee on the damage of corn]. *Agrikam, Buletin Penelitian Pertanian Maros.* 2: 49–59.

Patty JA. 2012. Teknik pengendalian hama *Ostrinia furnacalis* pada tanaman jagung manis [Controlling technique of *Ostrinia furnacalis* on sweet corn]. *Jurnal Agroforestri* 7(1): 50–58.

Sarwono, Pikukuh B, Sukarno R, Korlina E, & Jumadi. 2003. Serangan ulat penggerek tongkol *Helicoverpa armigera* pada beberapa galur jagung [Attack of *Helicoverpa armigera* on corn]. *Agosains.* 5(2): 28–32.

Sodiq M. 2009. *Ketahanan Tanaman terhadap Hama* [*Plant Resistance to Pest*]. Universitas Pembangunan Nasional "VETERAN" Jawa Timur. Surabaya.

Speight MR, Hunter MD, & Watt AD. 2008. *Ecology of Insects: Concepts and Application*. 2nd Edition Wiley-Blackwell, New Jersey.

Subiadi & Sipi. S. 2018. Tingkat serangan hama penggerek batang jagung *Ostrinia furnacalis* Geunee (Lepidoptera: Crambidae) pada beberapa varietas jagung komposit [Level of attack of corn stem borer *Ostrinia furnacalis* Guenee (Lepidoptera: Crambidae) on some composite corn varieties]. *PANGAN.* 27(3): 179–186. https://doi.org/10.33964/jp.v27i3.383

Susmawati dan Muda W. 2014. *Hama dan Penyakit pada Tanaman Jagung dan Pengendaliannya*. Balai Besar Pelatihan Pertanian Binuang. Tapin, Kalimantan Selatan.

Blumenschein A, Manwan I, & Subandi. 1988. *National Coordinated Research Program: Corn*. Central Research Institute for Food Crops, Agency for Agricultural Research and Development, Bogor.

Swastika DKS, Kasim F, Sudana W, Hendayana R, Suhariyanto K, Gerpacio RV, & Pingali PL. 2004. *Maize in Indonesia: Production System, Constrains, and Research Priorities.* International Maize and Wheat Improvement Center (CIMMYT). Mexico City, D.F.

Thamrin NT & Sudartik E. 2019. Kepadatan populasi hama utama pada 2 varietas tanaman jagung di Kecamatan Malangke Kabupaten Luwu Utara [Population density of the main pests on 2 corn varieties in the Sub District of Malangke, District of Luwu Utara]. *Agrovital: Jurnal Ilmu Pertanian.* 5(2): 52−54.

Tay WT, Soria MF, Walsh T, Thomazoni D, Silvie P, Behere GT, Anderson C, & Downes S. 2013. A brave new world for an old world pest: *Helicoverpa armigera* (Lepidoptera: Noctuidae) in Brazil. *PLoS ONE.* 8(11): e80134. https://doi.org/10.1371/journal.pone.0080134

Tenrirawe A. 2011. Efektivitas virus patogen *HaNPV* terhadap hama penggerek tongkol jagung [Effectivity of entomopathogenic virus *HaNPV* to corn cob borer]. Seminar Nasional Serealia 2011. Available at http://balitsereal.litbang.pertanian.go.id/wp-content/uploads/2016/12/1hpros11.pdf. Accessed 03 April 2021.

Trisyono YA, Suputa, Aryuwandari VEF, Hartaman M, & Jumari. 2019. Occurrence of heavy infestation by the fall armyworm *Spodoptera frugiperda*, a new alien invasive pest, in corn in Lampung Indonesia. *Jurnal Perlindungan Tanaman Indonesia.* 23(1): 156–160. https://doi.org/10.22146/jpti.46455