Indian Journal of Entomology Online published Ref. No. e24013 DoI. No.: 10.55446/IJE.2024.2013

HOST PREFERENCE AND DEVELOPMENTAL DYNAMICS OF FALL ARMYWORM *SPODOPTERA FRUGIPERDA* (J E SMITH)

Lutfi Afifah[1*], Vania Utami Hidayah[1], Vani Nur Oktaviany Subagyo[2] and Tatang Surjana[1]

[1]Agrotechnology Department, Faculty of Agriculture, Universitas Singaperbangsa Karawang, Jl. HS. Ronggo Waluyo, Puseurjaya, Telukjambe Timur, Karawang, Jawa Barat 41361, Indonesia
[2]Research Center in Applied Zoology, National Research and Innovation Agency Cibinong Science Center, Jl. Raya Jakarta-Bogor, Cibinong, Bogor, West Java, Indonesia
*Email: lutfiafifah@staff.unsika.ac.id (corresponding author): ORCID ID 0000-0002-2387-0565

ABSTRACT

The invasive fall army worm *Spodoptera frugiperda* (J E Smith) is a major global agricultural pest, originally from tropical and subtropical America, now affecting over 80 plant species across Africa, Asia, and beyond. This study examines its host preferences and developmental dynamics, focusing on four host plants: *Zea mays* L., *Glycine max* L., *Carica papaya* L., and *Brassica oleraceae* var. *acephala* L. Using a complete randomized design, mortality and developmental rates of larvae were evaluated. These results revealed that *C. papaya* and *B. oleraceae* leaves resulted in maximum larval mortality (80 and 65%, respectively). This can be attributed to the presence of secondary metabolites like tannins, terpenoids, flavonoids, and alkaloids, which exhibit toxic and antifeedant properties. This study highlights the armyworm's ability to adapt to alternative hosts like *G. max* and *B. oleraceae*, even surviving on *C. papaya* leaves, typically used as a botanical pesticide.

Key words: *Spodoptera frugiperda*, invasive pest, alternative hosts, development rates, feeding behaviour, mortality rates, *Zea mays*, *Glycine max*, *Carica papaya*, *Brassica oleraceae* var. *acephala*, non-choice test, lifecycle

Spodoptera frugiperda (J E Smith) commonly known as fall army worm, is an invasive pest. Originally native to tropical and subtropical America, this pest has rapidly spread to various regions, including Africa and Asia, affecting over 80 plant species; first reports of its presence outside the Americas emerged in 2016, with confirmed sightings in Nigeria and Togo (Rwomushana, 2022). By 2019, it had been identified in several countries, including Myanmar, India, Sri Lanka, China, Japan, Korea, and Indonesia (Ariani et al., 2021). In Indonesia, reports of *S. frugiperda* infestations emerged in 2019, affecting maize in Karo Regency, North Sumatra Province, and East Lampung Regency, Lampung Province (Trisyono et al., 2019)2019 in the District of East and Central Lampung to identify the attacking Spodoptera species, and to observe and determine the damages. Based on the morphological characteristics, the "Y" inverted shape on the head capsule and the patterns of black spots on the abdominal segments (square and trapezoidal forms. Subsequent infestations were observed in Petir Village, Dramaga District, Bogor Regency, and Tulo Village, Sigi Regency (Lubis et al., 2020) (Arfan et al., 2020). The pest's preferred host is maize, but it is known to infest a wide range of plants, making it a polyphagous insect (Arfan et al., 2020). Climate change can influence its migration patterns and host plant preferences, potentially leading to increased spread and impact (Subiono, 2020) (Diyasti and Amalia, 2021). Effective management strategies, such as crop rotation, are essential to disrupt the pest's life cycle and minimize its impact on crops (Afifah et al., 2023). Research into the biological responses of *S. frugiperda* to various host plants is crucial for identifying suitable host plant varieties and developing effective control strategies. This knowledge can help mitigate the economic and agricultural losses caused by this destructive pest.

MATERIALS AND METHODS

The study utilized an experimental method employing a complete randomized design with four treatments: corn leaves (*Zea mays*), soybean leaves (*Glycine max*), papaya leaves (*Carica papaya* L.), and kale leaves (*Brassica oleraceae var. acephala*). *S. frugiperda* caterpillars were provided with distinct feeds corresponding to each treatment. Each treatment was replicated five times, resulting in 20 experimental units, with one sample of *S. frugiperda* larvae per experimental unit. *S. frugiperda* larvae are housed in rearing boxes until they undergo pupation. Throughout the larval development phase, baby corn serves as the primary feed. Sawdust is utilized at the bottom of the rearing box to maintain moisture levels, a crucial aspect in light of *S. frugiperda* excretion. To prevent cannibalism among larvae, the population density within the rearing box is carefully managed. Larvae are nurtured until they reach the pupal stage within the maintenance box. Subsequently, the formed pupa is transferred to a larger maintenance box. Adults receive a diet of honey dissolved in water at a concentration of 10%. Egg harvesting is conducted at 24 hr intervals using a fine brush. The larvae used are of second instar, with feeding carried out once a day in the morning, as much as 1 g/ day. The foliar feed of various types of host plants is changed daily. Feeding is carried out until the larva turns into a pupa. Each experiment was conducted using a petri dish. The mortality rate of larvae is directly linked to their survival during specific feedings. Determining the mortality rate involved monitoring and counting deceased larvae until the completion of the last instar (instar 6). Following Khamid and Siriyah (2018), the mortality of larvae can be assessed using the method by (Afifah et al., 2023). The design used was a factorial completely randomized design (CRD), with ANOVA. p=0.05) to find out which treatment giving the highest results; which were further tested with DMRT test.

RESULTS AND DISCUSSION

The average accumulation of larval mortality of *S. frugiperda* was observed across four host plants. The mortality rates were significantly different between the host plants, with papaya and kale leaves showing the highest rates of larval mortality. Papaya leaves display a substantially higher mortality rate of 80.00%. Similarly, kale leaves also show a significantly elevated mortality rate of 65.00% (Table 1; Fig. 1). Papaya and kale leaves standing out as particularly influential in inducing higher mortality rates compared to corn and soybean leaves. Suroto et al. (2021) highlighted that the elevated mortality rate observed in *S. frugiperda* results from the larvae's reluctance to consume the provided leaf feed. This aversion is attributed to challenging leaf morphology and secondary metabolite compounds acting as allelochemicals, imparting a repellent effect that hinders growth and survival. In this study, *S. frugiperda* was deprived of the opportunity to select its preferred food, necessitating a non-choice test where armyworms were compelled to feed on the provided diet. This test assesses the resistance of the tested variety to *S. frugiperda* viability. Building on this, Hariani et al. (2011) emphasized the necessity for pests to adapt to

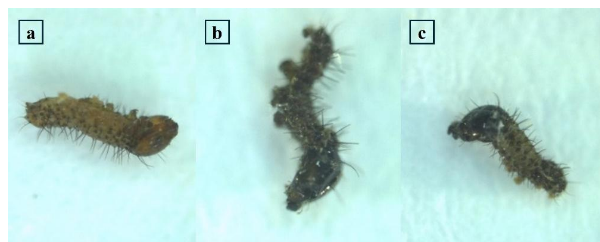

Fig. 1. Mortality of *S. frugiperda* larvae: day 5 after experiment in some host plants

Table 1. Larva mortality rate, larval duration, % of larvae into pupae and pupae into imago of *S. frugiperda*, and residual feed weight in four host plants

Treatment	Larval mortality (%)	% of larvae become pupa (%)	Pupa to imago (%)	Residual feed weight (g)
Corn leaf	0.00b	100.00a	95.00a	14.94 a
Soybean leaves	10.00b	90.00a	70.00a	14.76 a
Papaya leaves	80.00a	35.00b	35.00b	6.37 b
Kale leaves	65.00a	20.00b	20.00b	12.91 a

Larval duration

Treatment	Length of instar (Days)					
	Instar 2	Instar 3	Instar 4	Instar 5	Instar 6	Total
Corn leaf	2.84 a	3.60 a	3.36 a	2.62 a	2.50 a	14.92
Soybean leaves	2.70 ab	3.56 a	3.50 a	2.42 a	2.58 a	14.76
Papaya leaves	2.24 b	2.32 b	2.18 b	1.78 a	1.98 a	10.50
Kale leaves	2.30 b	3.52 a	3.76 a	2.58 a	2.52 a	14.68

Mean followed by same letter in each column showed no real difference in the LSD (Least Significant Different) follow-up test level of (α=5).

nutritional content and proportions variations, including proteins, carbohydrates, and various other elements in their food, which directly impact their growth and reproduction. *S. frugiperda* exhibits reduced feeding activity when exposed to papaya leaf extracts due to the presence of toxic metabolites in the leaves.

Studies have shown that papaya leaves contain compounds such as tannins, terpenoids, flavonoids, and alkaloids (Arif et al., 2022). These compounds have been found to have toxic effects on *S. frugiperda* larvae, leading to reduced feeding activity and even mortality (Van Den Berg & Du Plessis, 2022). Additionally, the extracts of both Indonesian and Thailand papaya cultivars have demonstrated significant antifeedant activity against *S. frugiperda* larvae, inhibiting their feeding behavior when exposed to concentrations of 40% and 50% (Rahayu et al., 2022). Therefore, the bioactive compounds present in papaya leaves act as a natural deterrent against *S. frugiperda*, making them less likely to consume the leaves. Table 1 displays the average highest percentages produced by the papaya plant treatment. This aligns with Juleha et al. (2022) assertion regarding using papaya leaves as a vegetable insecticide. The rationale behind this lies in the presence of papain compounds in papaya leaves, acting as contact toxins that can infiltrate the insect body through natural openings (Julaeha et al., 2022). Moreover, these papain compounds function as stomach toxins, entering through the insect's mouth apparatus. The fluid penetrating the insect esophagus and progressing into the digestive tract targets the nervous system, disrupting pest activities, including feeding disturbances.

Results indicated that papaya leaves and kale leaves show lower transformation with 35.00% for both larvae-to-pupa and pupa-to-imago stages for papaya leaves, and 20.00% for both stages in kale leaves (Table 1). *S. frugiperda* struggles to survive on papaya and kale leaves due to their unsuitability as host plants (Dono et al., 2023) Papaya leaves did not support larval development into adults, resulting in low transformation rates (Mumpuni and Sholichudin, 2022). The nutritional indices of papaya leaves were likely inadequate for the successful development of *S. frugiperda*, leading to poor survival rates (Afifah et al., 2023). Similarly, kale leaves may lack essential nutrients or contain compounds that are not conducive to the growth and development of *S. frugiperda* larvae, resulting in low transformation percentages (Lestari et al., 2022). These findings suggest that the nutritional quality and suitability of the host plant play a crucial role in the survival and development of *S. frugiperda* larvae into adults, highlighting the importance of plant species in influencing pest population dynamics. Ecdysteroids and juvenile hormones (JH) are two types of hormones that play a role in the regulation of insect development, including in the processes of moulting and metamorphosis. Both hormones work together to regulate the life cycle of insects. Ecdysteroids, like ecdyson, are hormones that regulate the moulting process (skin replacement) in insects. Ecdyson stimulates moulting by triggering the production of enzymes necessary for the formation of a new cuticle (outer shell). Juvenile hormones, on the other hand, are hormones that play a role in maintaining the juvenile state or immature phase in insects (Khalid et al., 2021). JH plays a key role in preventing moulting that would take insects to the next stage in their life cycle. When the concentration of JH is high, the insect will remain in the juvenile phase, and moulting will not occur (Muramatsu et al., 2020). The relationship between ecdysteroids and juvenile hormones is very dynamic. During the moulting phase, the concentration of ecdysteroids increases, triggering the moulting process, while the concentration of juvenile hormones decreases. Once moulting is complete, the concentration of juvenile hormones increases again, helping to control development and maintain the juvenile state until the insect is ready for the next moulting. Thus, ecdysteroids and juvenile hormones work in pairs and coordinate to regulate the life cycle and insect development (Pangestika et al., 2023). Based on this, it can be concluded that the presence of excessive juvenile hormone content in the pupa can cause the pupa to fail to become an imago. The performance of juvenile hormones can be minimized when the protein content in the feed is sufficient for the formation of cells and tissues of the insect body so that it can achieve further growth. This is in line with the statement of Hidayanti and Asri (2019) which states that one of the ingredients such as protein plays a role in the formation of hormones.

Statistical analysis showed significant differences among the treatments, with papaya leaves resulting in the lowest residual feed weight, indicating the highest consumption by the larvae (Table 1). In contrast, corn, soybean, and kale leaves had higher residual feed weights, with no significant difference among them. The residual feed weight data reveal notable differences in the feeding behavior of *S. frugiperda* larvae across the four host plants. The significantly lower residual feed weight on papaya leaves (6.37 g) compared to the other plants suggests a higher larval consumption rate. This could be attributed to the lower presence of deterrent secondary metabolites or higher nutritional value in papaya leaves, making them more palatable to the larvae. Interestingly, despite the high consumption rate of papaya leaves, previous results showed that papaya leaves also resulted in the highest larval mortality rate (80%) (Table 1). This paradoxical finding implies that while the larvae prefer papaya leaves, the toxic secondary metabolites present in the leaves, such as tannins, terpenoids, flavonoids, and alkaloids, eventually lead to higher mortality (Danar et al., 2020). This highlights the potential of papaya as a botanical pesticide, effectively attracting and then eliminating the pest. On the other hand, *Z. mays*, *G. max*, and *B. olleracea* leaves exhibited higher residual feed weights, indicating lower consumption by the larvae. This could be due to higher concentrations of antifeedant compounds or lower palatability. The lack of significant differences among these three plants suggests that they are equally less preferred by the larvae compared to papaya leaves. These findings underscore the importance of host plant selection in the management of *S. frugiperda.* Utilizing plants like *C. papaya*, which the larvae find palatable yet ultimately toxic, could be an effective strategy in integrated pest management (IPM) programs. The data also suggest that increased surveillance and targeted interventions on preferred host plants are crucial for controlling the spread and impact of this invasive pest.

Corn leaf treatment exhibits the longest average length of life for each instar, totalling 14.92 days. Soybean leaves follow closely, with an overall duration of 14.76 days (Table 1). In contrast, papaya and kale leaves display shorter average lengths of life, with papaya leaves having the briefest life span at 10.50 days. In the papaya plant leaves treatment, larvae consume fewer plant parts and leave a substantial amount of feed compared to other treatments. This observation aligns with (Subiono, 2020), suggesting that the accelerated duration of larval development to adulthood indicates that the provided feed may not be preferred or that the consumed feed lacks nutritional content suitable for the optimal growth and development of *S. frugiperda* larvae. Afifah et al. (2023) noted that variations influence the life cycle length in the duration of larval stadia and imago, which are affected by host suitability, type of feed, and the quality and quantity of host plants. The difference in larval development, characterized by the transition from instar 2 to instar 6, is determined by the action of three crucial hormones in insect development: juvenile hormone, protoracicotropic hormone (PTTH), and ecdyson hormone Afifah et al., (2023). Juvenile hormones are maintained in high concentrations to preserve juvenile (larval) structures during moulting, while PTTH stimulates the production of ecdysone hormones, initiating the moulting process. The speed of the degradation of juvenile hormones by the juvenile esterase enzyme is influenced by ambient temperature, impacting the development duration of *S. frugiperda* larvae. Faster degradation leads to a shorter time for the larva to complete its larval phase and transition into the pupal phase. If the concentration of juvenile hormone is very low, the insect undergoes metamorphosis to the next stage (pupa or imago).

In conclusion, the research on the feeding preferences and developmental responses of *S. frugiperda* highlights its significant threat to agricultural crops, particularly corn, but also extends to other crops like soybeans, kale, and papaya. The study employed a systematic experimental approach to assess the host suitability of various plants, revealing stark differences in mortality rates, developmental times, and residual feed weights among different host plants. The pest exhibited high mortality rates on papaya (80%) and kale leaves (65%) (Table 1). *S. frugiperda*'s ability to thrive on a papaya leaf diet, despite the botanical pesticide compounds present. Maize leaves exhibited the highest average percentage of larval to pupae development (100%), while kale leaves showed the lowest (20%). Maize leaves had the highest average percentage of pupa to imago development (95%), whereas kale leaves possessed the lowest (20%). The findings emphasize the importance of robust surveillance and pest management strategies due to the pest's adaptability and the wide range of potential hosts it can exploit.

ACKNOWLEDGEMENTS

The authors acknowledge the National Research and Innovation Agency (BRIN) for providing the facilities and resources essential for conducting this research. The generous support and opportunity granted by BRIN have significantly contributed to the advancement of scientific knowledge in the field of agricultural pest management.

FINANCIAL SUPPORT

The research project acquired no external financial assistance.

AUTHOR CONTRIBUTION STATEMENT

Vania Utami contributed to the conception and

design of the research project and conducted the experiments. Lutfi Afifah, Vani Nur Oktaviany Subagyo and Tatang Surjana provided guidance and supervision throughout the research process, including experimental design, data interpretation, and manuscript revision. All authors contributed to the critical review and editing of the manuscript and approved the final version for publication.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES

Afifah L, Oktaviani S, Surjana T, Irfan B, Priyo Prabowo D, Bagus Widiawan A. 2023. The biological response of *Spodoptera frugiperda* larvae in several different types of host plants. IOP Conference Series: Earth and Environmental Science 1133(1): 012041.

Arfan If'all, Jumardin Noer, H Sumarni. 2020. Population and attack level of *Spodoptera frugiperda* on maize plants in Tulo Village Sigi Regency. Jurnal Agrotech 10(2): 66-68.

Ariani D, Supeno B, Haryanto H. 2021. Host preference test of *Spodoptera frugiperda* pest on several food crops. Prosisiding Saintek 3 (November 2020). pp. 229-236.

Arif R, Ramadhan M, Nasrudin D. 2022. Effect of *Carica papaya* leaf extract on mortality and growth of *Spodoptera frugiperda* larvae. Agriekstensia (Malang) 21(2): 123-129.

Danar D, Yusuf H T S, Widayani N. 2020. The toxicity of neem (*Azadirachta indica*) citronella (*Cymbopogon nardus*) castor (*Ricinus communis*) and clove (*Syzygium aromaticum*) oil against *Spodoptera frugiferda*. CROPSAVER - Journal of Plant Protection 3(1): 22-30.

Diyasti F, Amalia. 2021. The role of climate change on the emergence of new pests. Agroscript: Journal of Applied Agricultural Sciences 3(1): 57-69.

Dono D, Wulansari R, Hidayat Y. 2023. Biology of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on several types of plant feed: Potency as a pest on various plants. Preprints 2023, 2023030482

Hidayanti Y, Asri M. T. 2019. Growth of *Spodoptera litura* (Lepidoptera: Noctuidae) on natural and artificial feeds with different protein sources. LenteraBio 8(1): 44-49.

Khalid M Z, Ahmad S, Ngegba P M, Zhong G. 2021. Role of endocrine system in the regulation of female insect reproduction. Biology 10(7): 614.

Lestari Y A, Verawaty M, Herlinda S. 2022. Development of *Spodoptera frugiperda* fed on young maize plant's fresh leaves inoculated with endophytic fungi from South Sumatra Indonesia. Biodiversitas 23(10): 5056–5063.

Lubis A, Anwar R, Soekarno B P, Istiaji B, Sartiami D, Irmansyah, Herawati D. 2020. Attack of corn armyworm (*Spodoptera frugiperda*) on maize crops in Petir village Daramaga Subdistrict Bogor Regency and its potential control using *Metarizhium rileyi*. Jurnal Pusat Inovasi Masyarkat 2(6): 931–939.

Mumpuni R P, Sholichudin A. 2022. The efficacy of several types of organic pesticides against mortality of armyworm (*Spodoptera frugiperda*). Advances in Science and Technology 112: 113-118.

Muramatsu M, Tsuji T, Tanaka S, Shiotsuki T, Jouraku A, Miura K, Vea I M, Minakuchi C. 2020. Sex-specific expression profiles of ecdysteroid biosynthesis and ecdysone response genes in extreme sexual dimorphism of the mealybug *Planococcus kraunhiae* (Kuwana). PloS One 15(4): e0231451.

Pangestika W, Himawan T, Widjayanti T. 2023. Development of breeding methods of *Crocidolomia pavonana* F. (Lepidoptera: Pyralidae) with artificial feeding based on green sprout. Jurnal Hama Dan Penyakit Tumbuhan 11(2): 70-75.

Rahayu S E, Leksono A S, Gama Z P, Tarno H. 2022. The bio-insecticidal activity of papaya (*Carica papaya* L.) leaves extract against *Spodoptera litura* Fabr. (Lepidoptera: Noctuidae) larval growth. Indian Journal of Agricultural Research of Agricultural Research 56(6): 741-745.

Rwomushana I. 2022. *Spodoptera frugiperda* (fall armyworm). CABI Compendium.

Subiono T. 2020. Preferences of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in several feed sources. Jurnal Agroteknologi Tropika Lembap 2(2): 130-134.

Trisyono Y A, Suputa Aryuwandari V E F, Hartaman M, Jumari. 2019. Occurrence of heavy infestation by the fall armyworm *Spodoptera frugiperda* a new Alien Invasive Pest in Corn Lampung Indonesia. Jurnal Perlindungan Tanaman Indonesia 23(1): 156-160.

Van Den Berg J, Du Plessis H. 2022. Chemical control and insecticide resistance in *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Journal of Economic Entomology 115(6): 1761-1771.

(Manuscript Received: February, 2024; Revised: June, 2024;
Accepted: June, 2024; Online Published: June, 2024)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e24013