Field testing of synthetic insecticides on fall armyworm (Spodoptera frugiperda J.E. Smith) in corn plant

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Abstract. Fall armyworm is a new pest in Indonesia that is currently of concern because of its widespread attack on corn production areas. FAW infestation in young plants will cause damage up to 90% and even corn plants can die. The study on the control of the fall armyworm (FAW) caused by Spodoptera frugiperda was conducted at the Bajeng Technology Research and Assessment Installation, Gowa, which took place from March-August 2020. The treatments were arranged in a randomized block design with 6 treatments repeated 4 times. The treatments consist of 4 synthetic insecticide treatments derived from 4 active ingredients (emamectin benzoate, spinoteram, carbofuran, chlorantraniliprole + tiamethoxam), one vegetable pesticide (nano pesticide; a.i. citronella, geraniol and citronellol) and one control treatment without pesticides. The treatment application was carried out 2 weeks after planting (WAP) then repeated every 2 weeks until the plants were 8 WAP. The treatment was carried out 2 times in the vegetative phase, 2 times in the generative phase. The plot area of each treatment is 5 x 5 m, the spacing is 70 x 20 cm. The results showed that the most effective insecticide to control FAW was Spinetoram followed by Emamectin Benzoate and Chlorantraniliprole. The average percentage of attacks in the spinetoram treatment was: 24.2% at 4 WAP, then 24.9% at 6 WAP, 29.1% and 37.1% at 10 WAP. The highest average yield was obtained in the insecticide treatment Spinetoram (10.7 t/ha) followed by Emamectin Benzoate (9.3 t/ha) and Chlorantraniliprole (8.9 t/ha), while the lowest yield was obtained in the control treatment (5.2 t/ha).

1. Introduction
Plant destruction organisms in corn is one of the important factors that need attention. As we know that corn plants can be damaged by many types of pests, both in the vegetative phase and in the generative phase. The types of pests found in the field on corn are: seed flies (Atherigona sp.), leaf eaters (Spodoptera litura, Mythimna separata), leaf rollers, stem borer (Ostrinia furnacalis), cob borer (Helicoverpa sp.), Aphis sp., and grasshoppers [1-3]. These pests damage the corn crop after it grows until before harvest.

Fall Armyworm (FAW), Spodoptera frugiperda J.E. Smith is one of the most destructive pests in the world. Assefa & Ayalew [4] and Bhavani et al (2019) [5] reported that FAW is a new pest on corn in Ethiopia and also in India, which is very destructive, so its management is recommended to apply the concept of integrated pest management (IPM). FAW can result in
significant yield loss if not handled properly [6]. This pest has several generations per year, its moths can fly up to 100 km in one night [7].

So far, the control carried out is the use of synthetic insecticides, however, it should be noted that the inappropriate use of synthetic pesticides can lead to the development of resistance, plant damage, risks to human health and the environment [8]. Pes et al. [9] suggested that clorantraniliprole and cyantraniliprole as seed treatments reduced the need for spraying plants against FAW.

Appropriate timing of insecticide application for effective pest control is very important, both in relation to the life cycle and timing of spraying (eg during the day) [10]. It was further stated that spraying on young and old plants, where the larvae were on the leaf buds and the larvae on the corn cobs was ineffective, as well as the application of insecticides carried out during the day was not effective, because the larvae damaged the plants from the evening and at night.

Farmers in Ethiopia and Kenya control FAW by mixing sand with the pesticide trichlorfon and applying it to young shoots, effectively controlling FAW pests [11]. Given the importance of these FAW pests, this study was conducted with the aim of knowing which pesticides are effective in controlling FAW pests in the field.

2. Materials and Methods
This research was conducted at the Bajeng Agricultural Technology Research and Assessment Installation, which took place from March to August 2020. The maize used was the high yielding variety of the Ministry of Agriculture HJ 21. The treatments were arranged in a randomized block design with 6 treatments and 4 replications. The treatments consisted of 4 synthetic insecticide treatments derived from 4 active ingredients (emamectin benzoate, spinoteram, carbofuran, clorantraniliprole + tiamethoxam), one vegetable pesticide (nano pesticide; a.i. citronellal, geraniol and citronellol) and one control treatment without pesticides. The first application of insecticide treatment was carried out 2 weeks after planting (WAP) then repeated every 2 weeks until the plants were 8 WAP. Twice the treatment in the vegetative stage, 2 times the treatment in the generative stage. The plot area of each treatment is 5 X 5 m, spacing of 70 X 20 cm, fertilizer was given according to the recommended dose of 300 kg Urea and 200 kg Phonska each per hectare, half dose of urea was given at 10 DAP, along with the entire dose of fertilizer Phonska. Half the dose of Urea fertilizer was given at 30 DAP.

The percentage of infected plants was determined randomly from 10 sample plants in each treatment plot.

Variable observed include:
- The percentage of leaf damage in the sample plants was determined based on the Davis scale as shown in Table 1 [12].
- Yields.
Table 1. Visual rating scales for leaf damage assessment

| Scale | Description |
|-------|-------------|
| 0     | No visible leaf damage |
| 1     | Only pinhole damage on leaves |
| 2     | Pinhole and shot hole damage to the leaf |
| 3     | Small elongated lesions (5–10 mm) on 1–3 leaves |
| 4     | Midsized lesions (10–30 mm) on 4–7 leaves |
| 5     | Large elongated lesions (>30 mm) or small portions have eaten on 3–5 leaves |
| 6     | Elongated lesions (>30 mm) and large portions have eaten on 3–5 leaves |
| 7     | Elongated lesions (>30 cm) and 50% of leaf eaten |
| 8     | Elongated lesions (30 cm) and large portions have eaten on 70% of leaves |
| 9     | Most leaves with long lesions and complete defoliation observed |

The rating scale is then transformed to the percentage of incidence formula as follows:

\[
P = \frac{\sum(n \times v)}{ZN} \times 100\%
\]

Notes :
- \(P\) = Percentage of attacks (%)
- \(n\) = Number of affected plants in each category
- \(v\) = Scale value for each affected plant
- \(Z\) = The highest scale value
- \(N\) = Number of plants observed in each incidence.

3. Results and Discussion

The germination of HJ21 variety was quite good, 5 days after planting the germination reaches almost 100%, and plant growth is also quite good until harvest. FAW incidence was found at 1 WAP. Prior to the first insecticide application, FAW incidence were observed first at 2 WAP. The percentage of incidence in all treatments was between 14.3 – 15.9% (Figure 1). FAW incidence continue to increase from the vegetative to the generative stage. Observation at 4 WAP, the average percentage of incidence in the spinetoram treatment was 24.2%, then at 6 WAP 24.9%, at 8 WST 29.1% and at 10 MST 37.1% (Figures 2, 3, 4 & 5). While in control, the increase in FAW incidence began to be seen at 4 WAP and continued to increase until the last observation at WAP.

The results of statistical analysis on the percentage of FAW incidence at 4 WAP for all treatments were significantly different from the control (Figure 2). While the results of statistical analysis on observations 6 WAP, 8 WAP and 10 WAP, for the 3 treatments, namely Spinetoram, Emamectin Benzoate, Chlorantraniliprole, showed significant differences with the Carbofuran and Citronellal treatments. These three treatments were also significantly different from the control (Figures 3, 4 & 5). Desmukh et al. [12] reported that the insecticide that was effective in suppressing FAW in India was emamectin benzoate which showed the highest acute toxicity, followed by chlorantraniliprole and spinetoram.
Figure 1. Effect of synthetic insecticides on the percentage of FAW incidence at 2 WAP before application of insecticides.

Figure 2. Effect of synthetic insecticides on the percentage of FAW incidence at 4 WAP.
Figure 3. Effect of synthetic insecticides on the percentage of FAW incidence at 6 WAP

Figure 4. Effect of synthetic insecticides on the percentage of FAW incidence at 8 WAP
Insecticide applications are effective when sprayed at locations where larvae feed and shelter [13]. Similar results were reported by Belay et al. [14] that the insecticides thiodicarb, acephate, spinetoram or spinosad are effective in controlling FAW in the field. Zhao et al. [15-16] reported, of the 8 types of insecticides tested against FAW, emamectin benzoate, spinetoram, chlorantraniliprole, chlorfenapyr, and lufenuron showed higher toxicity against these pests, while lambda-cyhalothrin and azadirachtin showed lower toxicity. Furthermore, it was proposed by Belay et al. [14], despite differences in the rate of lethal activity, most of the tested insecticides were effective in controlling FAW. This may have been due to the regular search for pests and the rotational or combined use of insecticides, which may have helped delay the development of resistance and, thus, maintain the FAW population susceptible to these insecticides.

The results of observations on yields showed that the highest yield was obtained in the Spinetoram treatment with an average of 10.7 t/ha, while the lowest yield was obtained in the control treatment with an average of 5.2 t/ha (Figure 6).
Figure 6. The average yield (t/ha) on each treatment

Figure 6 shows that the highest yield was obtained in the Spinetoram treatment with an average of 10.7 t/ha, but statistically the yield was not significantly different from that obtained in the Emamectin Benzoate, Chlorantraniliprole, and Carbofuran treatments. However, the results obtained in all pesticide treatments were significantly different from the results obtained in the control treatment (5.2 t/ha).

4. Conclusion

From the results of this study it can be concluded:

- The best control method for FAW is application of synthetic insecticides. Insecticides that are effective in suppressing WFH was Spinetoram (37.1%), followed by Chlorantraniliprole (38.5%) and Emamectin Benzoate (39.1%), both in the vegetative phase and in the generative phase.
- Spinetoram insecticide can reduce yield loss due to FAW. The highest yield was obtained in the Spinetoram treatment, which was 10.7 t/ha, while the lowest yield was obtained in the Control treatment, which was 5.2 t/ha.

References

[1] Arshad A Munawar A Ahmad F and Mastoi M I, Jan. 2019. Varietal susceptibility of local and hybrid maize against Atherigona soccata (Diptera: Muscidae) under field conditions J. Entomol. Zool. Stud. 7: 36–41.
[2] Kalshoven L. 1981. Pests of Crops in Indonesia Jakarta: PT. Ichtiar Baru-Van Hoeve.
[3] CABI. 2019. Invasive Species Compendium.
[4] Assefa F and Ayalew D, Jan. 2019. Status and control measures of fall armyworm (Spodoptera frugiperda) infestations in maize fields in Ethiopia: A review Cogent Food Agric. 5(1):1641902.
[5] Bhavani B, Chandra Sekhar V, Kishore Varma P, Bharatha Lakshmi M J P and S B. 2019. Morphological and molecular identification of an invasive insect pest, fall army worm, Spodoptera frugiperda occurring on sugarcane in Andhra Pradesh, India J. Entomol. Zool. Stud. 7(4):12–18.

[6] Baudron F Zaman-Allah M A Chaipa I Chari N and Chinwada P. 2019. Understanding the factors influencing fall armyworm (Spodoptera frugiperda J.E. Smith) damage in African smallholder maize fields and quantifying its impact on yield. A case study in Eastern Zimbabwe Crop Prot. 120: 141–150.

[7] FAO. 2018. Integrated Management of Fall Armyworm on Maize. A Guide for Farmer Field Schools in Africa.

[8] Abou Togola, Silvestro Meseka, Abebe Menkir B B-A and Ousmane Boukar, Manuele Tam and R D. 2018. Measurement of Pesticide Residues from Chemical Control of the Invasive Spodoptera frugiperda (Lepidoptera: Noctuidae) in a Maize Experimental Field in Mokwa, Nigeria Int. J. Environ. Res. Public Heal. 15 (849): 1–11.

[9] Pes M P et al., Apr. 2020. Translocation of chlorantraniliprole and cyantraniliprole applied to corn as seed treatment and foliar spraying to control Spodoptera frugiperda (Lepidoptera: Noctuidae) PLoS One 15 (4): e0229151.

[10] Day, Roger; Abrahams, Phil; Bateman, Melanie; Beale, Tim; Clotey, Victor; Cock, Matthew; Colmenarez, Yelitza; Corniani, Natalia; Early, Regan; Godwin, Julien; Gomez, Jose; Moreno, Pablo Gonzalez; Murphy, Sean T.; Oppong-Mensah, Birgitta; Phiri, Noah; Pra A. 2017. Fall Armyworm: Impacts and Implications for Africa Out looks Pest Manag. 28 (5):196–201.

[11] Kumela T et al., Jan. 2019. Farmers’ knowledge, perceptions, and management practices of the new invasive pest, fall armyworm (Spodoptera frugiperda) in Ethiopia and Kenya Int. J. Pest Manag. 65 (1): 1–9.

[12] Deshmukh S Pavithra H B Kalleshwaraswamy C M Shivanna B K Maruthi M S and Mota-Sanchez D, Jul. 2020. Field Efficacy of Insecticides for Management of Invasive Fall Armyworm, Spodoptera frugiperda (J. E. Smith) (Lepidoptera: Noctuidae) on Maize in India Florida Entomol. 103 (2): 221–227.

[13] Pitre H. 1986. Chemical control of the fall armyworm (Lepidoptera: Noctuidae). Florida Entomol. 69 (3): 570–578.

[14] Difabachew K. belay R M huckaba and J E F. 2012. Susceptibility of the fall armyworm, Spodoptera frugiperda (Lepidoptera: Noctuidae), AT SANTA ISABEL, PUERTO RICO, TO DIFFERENT INSECTICIDES Florida Entomol. 95 (2): 476–478.

[15] Guo, J., Qi, J., He, K., Wu, J., Bai, S., Zhang, T., Zhao, J., & Wang Z, Jan. 2019. The Asian corn borer Ostrinia furnacalis feeding increases the direct and indirect defence of mid-whorl stage commercial maize in the field Plant Biotechnol. J. 17 (1): 88–102.

[16] Zhao, Y. X., Huang, J. M., Ni, H., Guo, D., Yang, F. X., Wang, X., Wu, S. F., & Gao C F. 2020. Susceptibility of fall armyworm, Spodoptera frugiperda (J.E.Smith), to eight insecticides in China, with special reference to lambda-cyhalothrin. Pestic. Biochem. Physiol. 168: 104623.