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Assessing three biopesticides effectiveness on the Fall Armyworm (*Spodoptera frugiperda*) in maize production

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Abstract

In Burkina Faso, current pest control relies on synthetic chemical pesticides, which could negatively impact the environment and develop some resistances when used excessively. This study used three biopesticides (Neem oil, Bio k16 and Biopoder) to examine their effectiveness on fall armyworm (FAW) control in maize crop. The study was conducted in the central region of Burkina Faso using a randomized Fisher block design with 5 treatments in 4 replicates. The applied treatments were: T0 (control), T1 (Neem oil), T2 (Bio K16), T3 (Biopoder) and T4 (Emacot 019EC). The efficiency of these biopesticides in controlling FAW was compared with that of the Emacot 019EC in maize crop. The results showed that the biopesticides significantly reduced the infestation rate, the live larvae density and the number of corncob damaged. However, Emacot 019C was the most effective pesticide. Among the three biopesticides, neem oil was the most effective followed by Bio K 16 and Biopoder respectively. This study needs to be deepened in other sites and in taking into account the economic aspect.

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Introduction

Fall armyworm (*Spodoptera frugiperda*, J. E.Smith), is a major agricultural pest native of the tropical and sub-tropical regions of the Americas (Bateman *et al.*, 2018). According to Prasanna *et al.* (2018), FAW moths have both a migratory habit and a more localized dispersal habit, which can migrate over 500 km before oviposition. It was identified as a polyphagous insect and can potentially feed on over 100 species of plants specially the Poaceae family (CABI, 2018a). It causes damage to economically important cultivated crops such as some cereals, roots and vegetables (Pogue, 2002). According to Roel *et al.* (2010), its damage is based on the leaves and ears, which reduces plant development and consequently grain yield. In Africa, FAW was first reported in 2016 and has since become a serious threat to cereals specially to maize production (Aniwanou *et al.*, 2021) where the loss due to this pest (FAW) mainly in flowering period was reported up to 20-34% (Lima *et al.*, 2010 ; Polanczyk and Fiuza, 2000). In 2016, this pest damaged more than 38,000 ha of maize production in northern Benin (Goergen *et al.*, 2016). Nowadays, it is detected in over 40 African countries (Rwomushana *et al.*, 2018) and this expansion is due to host plants availability and certain environmental conditions (FAO, 2018).

In Burkina Faso, FAW appeared in 2017, and since, it has spread to all regions. It is a real danger for agricultural sector as it affected food security. In 2019 production campaign, its infestation rate was 81.32% in the Centre-east, 80.27% in Centre-south, 39% in the Centre-north including Koulpélogo (with a rate of 99.13%, i.e. 685.77 ha out of 691.72 ha), Kouritenga (88.74%, i.e. 382.5 ha out of 431 ha), and Boulgou (73.73%, i.e. 1,506.75 ha out of 2,043.50 ha) (MAAH, 2018). Nationally, maize was the most affected with 3,152.45 ha, followed by sorghum 376.45 ha, millet 89 ha and rice 47.87 ha. In the country, FAW control is mainly achieved using synthetic insecticides. However, it develops resistance to this synthetic chemical very quickly (Munoz *et al.*, 2013) making its control very difficult in some areas. In addition, these synthetic pesticides are proven to be toxic, polluting, carcinogenic and non-specific for their targets (Riba and Silvy, 1989). They accumulate in the environment and cause soil and water pollution (Gangné *et al.*, 1999). Therefore, there is a need to look for alternative control methods that could be more effective and environmentally friendly. Biopesticides based on plant or microbial were considered. Among them, *Azadirachta indica* A. Juss, a tree with natural insecticidal properties harmless to humans, animals, fungi, and bacteria (Vallet, 2006), could be used. Also, other biopesticides based on bacteria (Bacillus thuringiensis) or viruses (Baculovirus) were shown to be effective against caterpillars. This study will then evaluate the effectiveness of these biopesticides in FAW control in maize crop.

Material and method

Study site description

The study has been led out in the Central plateau of Burkina Faso (Fig. 1), at 12°15’ - 12°29’ N and 1°41’- 1°24’ W. This area belongs to the northern Sudanian zone (Guinko,1984) with a mean rainfall of 933mm.

Experimental design and applied treatments

The experiment used a randomized Fischer block design with five (5) treatments in three replicates. The applied treatments are: T0 (control), T1 (Neem oil), T2 (Bio K16), T3 (Biopoder) and T4 (Emacot 019EC). The efficacy of the three biopesticides (Neem oil, Bio K16 and Biopoder) in managing FAW was compared with that of the Emacot 019EC (chemical pesticide) in maize crop.

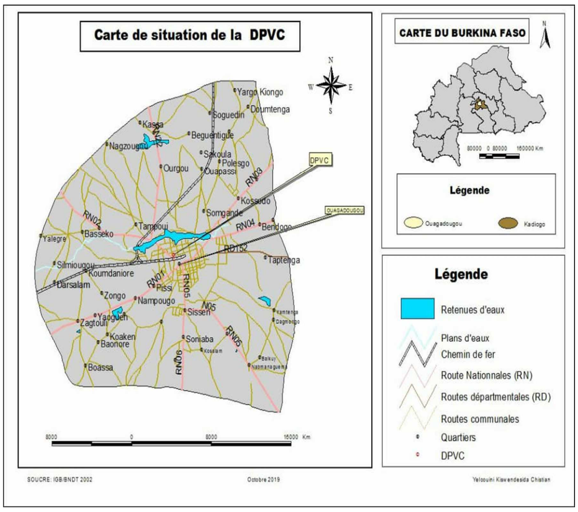

Fig. 1. Study site location.

Husbandry practices

The experimental area was ploughed with tractor and harrowed manually before planting. Basal applications of organic fertilizer at 20 t/ha were applied. The plots size was 5m x 2m.

The sowing density was 0.8m between lines and 0.4m between seed hills. Three seeds were sown but two plants were left per seed hill. Two weeks and one month after sowing, 200kg/ha of mineral fertilizer (NPK) and 100kg/ha of urea (46% N) were applied respectively in single dose. Field data collection consisted of the following operations:

Assessment of infestation rate

Observations consisted of counting the number of plants in each microplot with larval damage in the last three leaves of the top. Thus, the rate of infestation by *Spodoptera frugiperda* has been determined for each plots.

Assessment of larvae density

Larvae were counted on infested plants and corncob in the plot. The operation consisted of counting the number of live larvae on infested plants on the 3rd, 6th, 9th and 12th days after pesticide application. The number of *Spodoptera frugiperda larvae* present in the plot were then counted.

Yield assessment

Corncob weight and grain moisture content at 15% were considered in grain yield assessment. The following formula as been used :

$$\text{Grain yield (t/ha)} = \text{Corncob total weight} \times \frac{\text{Grain weight}}{\text{Corncob weight}} \times \frac{100 - \text{relative humidity}}{85} \times \frac{10}{\text{Area}} \quad (1)$$

Assessment of the relative agronomic efficiency (RAE)

The REA was used to compare treatments themselves. Emacot 019 EC is considered as the reference with an efficiency of 100%. The RAE of the other treatments were calculated in reference to the recommended treatment, using the following formula:

$$\text{RAE} = \frac{\text{Yield of treated plot - Control yield}}{\text{Reference yield - Control yield}} \times 100 \quad (2)$$

Statistical analysis

Data collected were subjected to an analysis of variances (ANOVA) with XLSTAT Pro 7.5.2 software. Means comparison was done using the Newman-Keuls test at the probability of 5%. Graphics were built using Excel version 2013 software.

Results

Effect of biopesticides on FAW control

The results showed that the applied treatments had high significant ($p<0.001$) effects on the infestation rate (Fig. 2), larvae density (Fig. 3) and on the corncob damaged (Fig. 4). Among these applied treatments, the three graphes showed a best response of the Emacot 019EC (chemical pesticide) in FAW control. But regarding the three biopesticides, neem oil was the best in reduction of the infestation rate, of larvae density and of corncob damaged. It was followed by Bio K16. The T0 treatment was the most presenting FAW damaged.

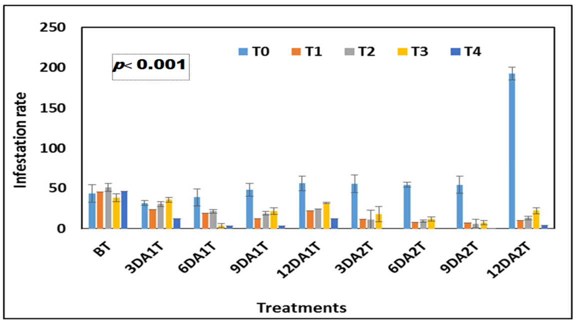

Fig. 2. Infestation rate as affected by treatments. T0 : control ; T1 : Neem oil ; T2 : Bio K16 ; T3 : Biopoder ; T4 : Emacot 019EC ; BT : before treatments ; DA1T : day after 1st treatment ; DA2T : day after 2nd treatment.

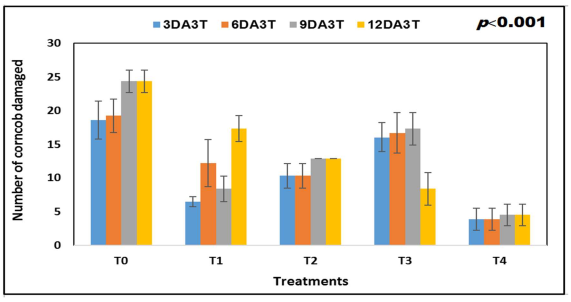

Fig. 3. Density of larvae as affected by treatments. T0 : control ; T1 : Neem oil ; T2 : Bio K16 ; T3 : Biopoder ; T4 : Emacot 019EC ; BT : before treatments ; DA1T : day after 1st treatment ; DA2T : day after 2nd treatment ; DA3T : day after 3rd treatment.

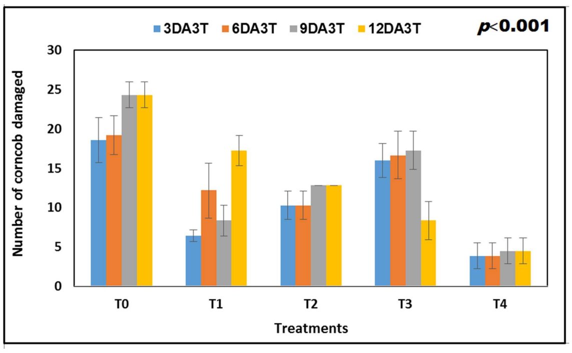

Fig. 4. Number of corncob damaged according to treatments.

To : control ; T1 : Neem oil ; T2 : Bio K16 ; T3 : Biopoder ; T4 : Emacot 019EC ; DA3T : day after 3rd treatment. The bars are errors bars.

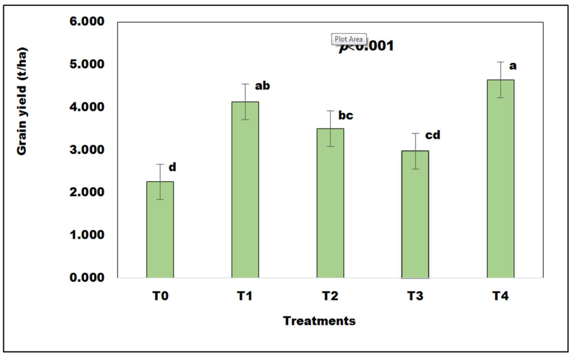

Fig. 4. Grain yield as affected by treatments.

To : control ; T1 : Neem oil ; T2 : Bio K16 ; T3 : Biopoder ; T4 : Emacot 019EC ; the barre represent errors barres ; the graph presenting the same letters are not significantly different.

The results also demonstrated that the Emacot 019EC and the biopesticides were only efficient during the 9 first days after their application. The second application on the 12th day, was able to control the infestation rate, larvae density and corncob damaged during 9 days again. This study further indicated that the Emacot 019EC and the biopesticides were able to control FAW only 9 days after their application.

Effect of biopesticides on maize yield and on the relative agronomic efficiency

The damaged caused by the fall armyworm affected hugely maize yield (Fig. 4) and the relative agronomic efficiency (Fig. 5). The efficiency of the Emacot 019EC in FAW control contributed to improve significantly ($p<0.05$) maize yield compared to the biopesticides.

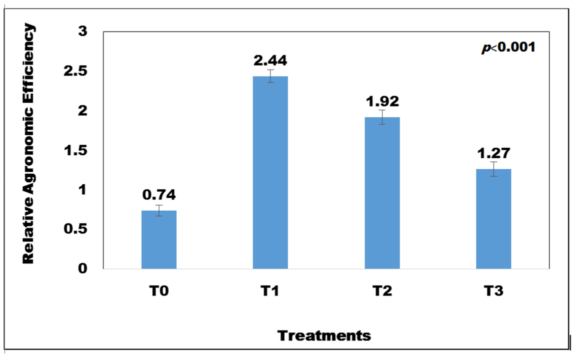

Fig. 5. Relative agronomic efficiency according to treatments.

To : control ; T1 : Neem oil ; T2 : Bio K16 ; T3 : Biopoder ; T4 : Emacot 19EC.

Among the biopesticides used in this study, neem oil was the most contributing maize yield improvement. Its improvement was 8% and 16% compared to that of the Bio K16 and Biopoder respectively. Regardless of the RAE, this neem oil contributed to the increase of 12% and 32% compared to that of Bio K16 and Biopoder respectively. The study underscored therefore the efficiency of neem oil in FAW control and in improving maize yield and RAE compared to the other biopesticides. Bio K16 was the second pesticide proved to be efficient.

Discussion

The study showed that the applied biopesticides significantly reduced the infestation rate and the larvae density of FAW compared to the control (To). These results highlighted therefore the sensitivity of FAW larvae to biopesticides. They (Neem oil, Bio k16 and Biopoder) could be used to effectively control FAW (Sisay *et al.*, 2019). The efficiency of these biopesticides could be linked to the fact that maize plant was quick to the uptake of the substances from these biopesticides, which confered an effective systemic action. The results are consistent with those of Babendreier *et al.* (2020) who reported also a positive effect of biopesticides on pests control.

Comparing the effects of the three biopesticides (Neem oil, Bio k16 and Biopoder) to those of Emacot 019EC, the study revealed that Emacot 19EC was the most effective. Among the 3 biopesticides, neem oil was more effective than the two others (Bio k16 and

Biopoder), with a relative agronomic efficiency of 2.44%. This difference in efficiencies could be explained by the amount and the capability of the active substance of a biopesticide to react quickly. Neem oil was sought to have an impact on pest larvae. Some findings such as those of Ferreira *et al.* (2013) and Ouedraogo (2018) reported this. They found that neem oil was highly effective on *Spodoptera frugiperda* larvae. Similar results were also reported by Silva *et al.* (2015) and Prasanna *et al.* (2018) who noted that using neem oil can kill FAW larvae up to 80%. The use of Azadirachtin induces disorders in the feeding and in the hormonal cycle of FAW, preventing its normal development and growth (Vallet, 2006). According to this author, the use of neem as biopesticide is very effective in agriculture. Plots where Bio k16 was applied showed its effectiveness in the control of FAll armyworms. *Bacillus thuringiensis* is the active ingredient of Bio k16. It induces apoptosis, prevent larvae development and lead to their death (Dougoud *et al.*, 2019; Akhtar *et al.*, 2008). Other authors such as Magalhaes (2015) indicated that *Serovar thuringiensis* has very toxic strains on *Spodoptera frugiperda* and *Spodoptera littoralis*.

The damaged caused by the fall armyworm affected hugely maize yield and the relative agronomic efficiency. However, this damage was more pronounced in the control plots (where no insecticide was applied) and in plots where biopoder was applied. Meaning that the Biopoder was the least effective among the three applied biopesticides. This inefficiency of this Biopoder in FAW management could be explained by an insufficient amount of elements that are enclosed in this biopoder.

Conclusion

In Burkina Faso, current pest control relies on synthetic chemical pesticides, which could negatively impact the environment and develop some resistances when used excessively. This study showed that using some biopesticides could be an alternative to this negative practice. Among the three applied biopesticides, neem oil was the best in reduction FAW infestation rate, larvae density and corncob damaged. It was followed by Bio K16. Regardless of the relative agronomic efficiency and grain yield of maize, this neem oil contributed to their improvement compared to that of Bio K16 and Biopoder. The study underscored therefore the efficiency of neem oil in fall armyworm control and could be recommanded to farmers.

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