International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 05, Issue: 05 "September-October 2019"

A SUSTAINABLE APPROACH TO THE BIORATIONAL MANAGEMENT OF THE INVASIVE FALL ARMYWORM (*SPODOPTERA FRUGIPERDA*) (LEPIDOPTERA: NOCTUIDAE) IN TANZANIA.

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ABSTRACT

Fall armyworm is a food security threat in many African countries where its invasion into the continent is not only associated with crop yield losses but also the loss of biodiversity due to the unguided use of insecticides by many of the farming communities. The testing and adoption of a biorational pest management approach as part of integrated pest management is therefore of primary importance to enable the intensification of agriculture while maintaining health ecosystems. This study describes field trials on farmers' maize in Tanzania of three biorational products known to be effective against other Lepidopteran pests; abamectin (5%), Bacillus thuringiensis (Bt) var kurstaki (1.4%) plus abamectin (0.1%) and Metarhizium anisopliae (2%). The results showed that treating maize with any of the three biorational solutions reduced the damage caused by fall armyworm to less than 5%, in comparison to 25% damage seen in untreated maize. The reduction in damage resulted in final maize yields being 50 to 70% higher in the treated than the untreated crops. This study therefore demonstrates the effectiveness of this technology in managing fall armyworm for farmers in Tanzania and other African countries.

Keywords: Fall armyworm, biorational products, abamectin, *Bacillus thuringiensis*, *Metarhizium anisopliae*, Tanzania

INTRODUCTION

Fall armyworm (*Spodoptera frugiperda* (J.E. Smith)) is a Lepidopteran pest that feeds on over 350 host plant species, causing extensive economic damage to cultivated grasses such as maize, sorghum, rice, wheat and sugarcane as well as vegetable crops and cotton (Murua et al., 2008; Prassana et al., 2018). The insect is native to tropical and subtropical regions of the Americas but

ISSN: 2455-6939

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was detected as an invasive pest in Africa in 2016 where it has caused extensive damage and losses to crops (IITA, 2016; Goergen et al., 2016). In maize, grain yield decreases of up to 58% have been reported (Chimweta et al., 2019) and across Africa financial losses caused by this pest have been estimated to be between $2,481m and $6,187m (CABI, 2018).

To date the response of many farmers in Tanzania to a fall armyworm invasion has been to use chemical pesticides, use mixtures of soap and ashes or do nothing and allowing the rain to 'wash off' the insects. The latter notion of fall armyworm being controlled by rain arises from farmers' observations of the indigenous African armyworm (*Spodoptera exempta*) which can be washed off plants in heavy rain. However, due to the behaviour of fall armyworm and its tendency to live inside the maize whorl, this results in rain having little effect on fall armyworm survival.

While chemical pesticide use to manage this pest can sometimes be justified, its overuse and ineffective application can cause harm to beneficial invertebrates, cause increased pest numbers and result in negative impacts on human health. The use of biorational pesticides to manage fall armyworm has the potential to be efficacious against the pest but safe to natural enemies and the environment. A recent review (Bateman et al., 2018) reported that certain biopesticides were effective against FAW or related pests but that field trials in Africa were needed. In Tanzania biorational products are registered and successfully used to manage other invasive Lepidopteran pests such as *Tuta absoluta* (Chidege et al., 2016; Chidege et al., 2018).

This study describes field trials testing the efficacy of 3 biorational products, abamectin, *Bacillus thuringiensis kurstaki* and *Metarhizium anisopliae* in controlling fall armyworm on maize crops in Tanzania.

MATERIALS AND METHODS

Study area: The field trials were conducted from June 2017 to June 2018 on maize (*Zea mays*) in 3 wards in Tanzania; the Mwandeti ward of Arusha, the Lyamungo ward of Kilimanjaro and the Ifakara ward of Morogoro regions.

Experimental design and treatment combinations: Farmers' fields suitable for the studies were selected during the initial diagnostic survey by investigators guided by ward extension officers. Selection was made based on observations of plant damage and the presence of FAW larvae. Each farm was approximately 1 hectare in size.

Three biorational treatments were tested; Biotrine with an active ingredient of abamectin (5%), Antario with active ingredients *Bacillus thuringiensis* (Bt) *var kurstaki* (1.4%) plus abamectin (0.1%) and Recharge, *Metarhizium anisopliae* (2%). The abamectin and Bt plus abamectin treatments were applied to the foliage at rates of 1ml per litre of water and 1g per litre of water

ISSN: 2455-6939

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respectively and given in response to the appearance of leaf damage symptoms and the presence of 1st to 3nd instars larva in the maize. *Metarhizium anisopliae* was applied to the soil at sowing and again 4 weeks later.

In each region three farms were treated with each biopesticide and three farms were left untreated as controls. All control and treated farms were similar in the variety of maize used and irrigation and weed control practices.

Data collection and analysis

Each field was divided into five small plots and twenty plants were examined for damage symptoms to obtain 100 plants in total per farm, per region. Data on plant damage were collected by counting the number of plants with shot holes, windows or complete damage in samples of plants. Final yields were assessed by counting the number of 100kg bags of maize produced per farm in each location.

RESULTS AND DISCUSSION

Fall Armyworm Damage: There was a significant reduction in the number of plants showing signs of fall armyworm damage between the fields treated with the biorational products and the untreated controls (Figure 1).

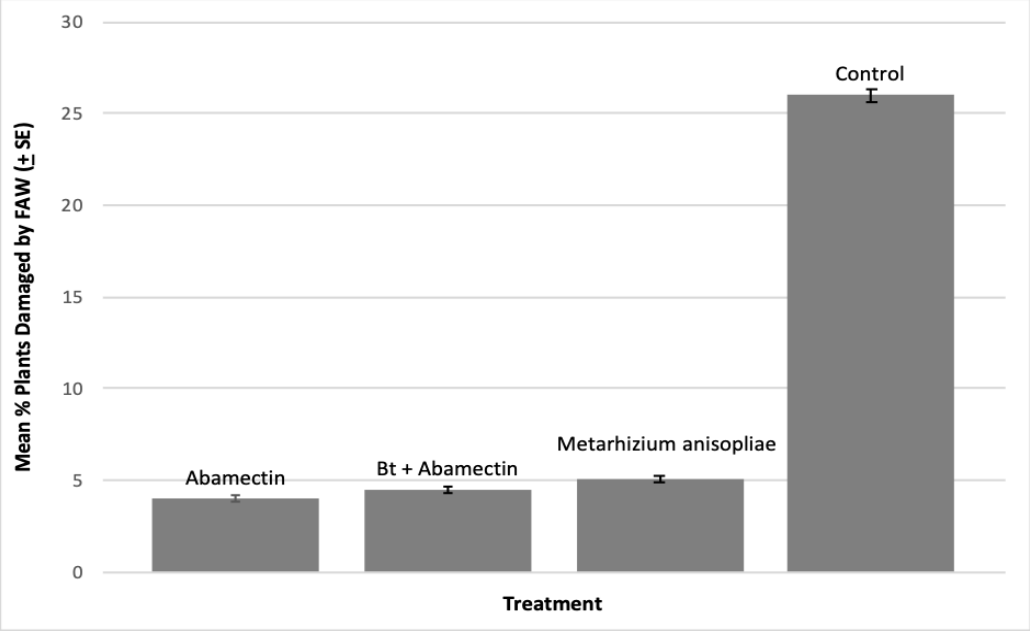

Figure 1: % Plants showing signs of fall armyworm damage under the biorational different treatments

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Maize plants treated with 5% abamectin suffered the least damage by fall armyworm with a mean of 4% of plants damaged. Application of Bt (1.4%) plus abamectin (0.1%) also resulted in significantly fewer plants showing signs of damage (4.5%) relative to the control group (26% of plants damaged). Bt and abamectin both cause death of the fall armyworm larvae by starvation; the Bt proteins binding to stomach receptors and the abamectin causing paralysis and feeding cessation.

The *Metarhizium anisopliae*-treated plants also performed well, with 5.1% of plants showing signs of damage. *Metarhizium* works by penetrating the cuticle of insect larvae and pupae in the soil, causing death. This serves to greatly reduce the number of fall armyworm adults emerging from the soil into the next generation.

No significant differences were found in this study between the different biorational products. The performance of the biorational products was consistent over the three wards where the trials took place (Figures 1-3).

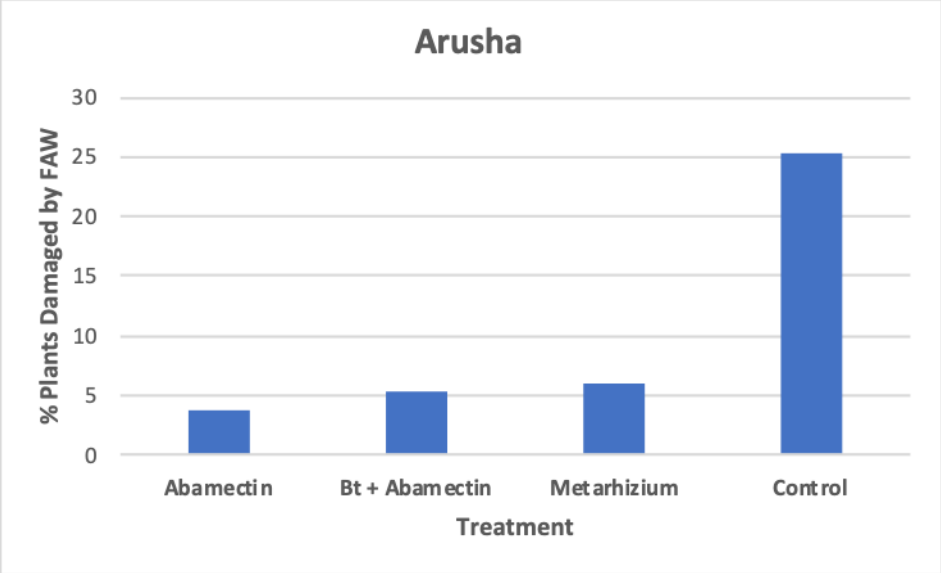

Figure 2: % Plants damaged by fall armyworm under different treatments in Arusha Ward

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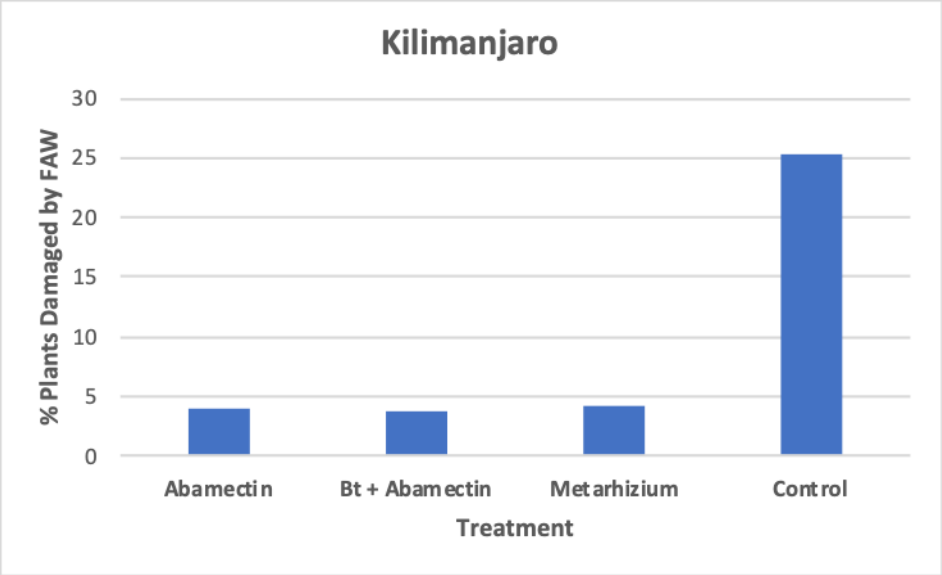

Figure 3: % Plants damaged by fall armyworm under different treatments in Kilimanjaro Ward

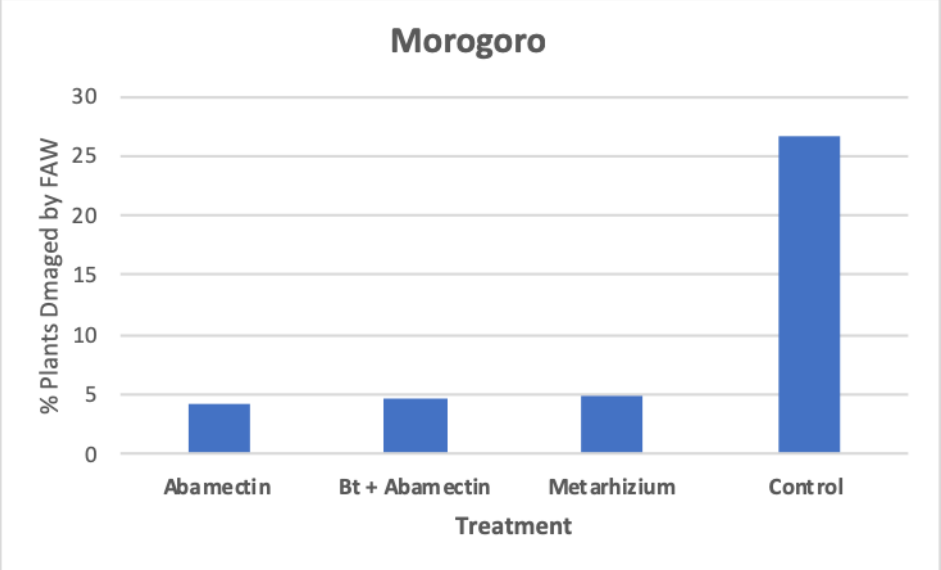

Figure 4: % Plants damaged by fall armyworm under different treatments in Morogoro Ward

Harvested Grain Yields: The differences in the levels of damage caused by fall armyworm between the treated and untreated maize resulted in significant differences in final yields (Table 1). In the Arusha, Kilimanjaro and Morogoro wards final maize yields were 70%, 60% and 52% higher respectively in fields treated with biorational products than the untreated fields in the

ISSN: 2455-6939

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same wards. This is an important finding as the relationship between foliar damage and final yields is often not linear but this study shows that the protection against fall armyworm that the biorational products conferred on the crop did translate into significant improvements in yields.

Table 1: Final maize yields in the treated and untreated fields in the different wards tested.

Area	Average Yields (Number of 100kg Bags) from Fields Treated with Biorational Products	Average Yields (Number of 100kg Bags) from Untreated Fields	% Increase in Yield between Treated and Untreated Fields
Arusha	11.33	6.67	70
Kilimanjaro	10.67	6.67	60
Morogoro	11.67	7.67	52

CONCLUSION

It is evident from this study that the biorational products abamectin (5%), *Bacillus thuringiensis* (Bt) *var kurstaki* (1.4%) plus abamectin (0.1%) and *Metarhizium anisopliae* (2%) are all capable of protecting maize plants from fall armyworm attack and that the reduced levels of damage resulted in significant increases in final yields. This effect was consistent across different geographical areas in Tanzania. Further work is needed to compare the cost-effectiveness of using biorationals versus chemical pesticides to manage fall armyworm but this study demonstrates that biorational products are a realistic option to effectively manage this serious pest. It is therefore recommended that farmers are made aware of this technology in Tanzania and other African countries affected by fall armyworm.

ACKNOWLEDGEMENTS

We are grateful to TPRI Administration for logistical support, Mr. Sanale of Mwandet-Arusha, Mr Ngeje of Ifakala- Morogogo and Mr. Olomi of Lyamungo-Machame, Kilimanjaro for allowing us to use their farms for this study.

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