Journal of Agriculture and Sustainability
ISSN 2201-4357
Volume 12, Number 2, 2019, 185-201

INFINITY PRESS
www.infinitypress.info

Assessing the Impact of Neem on Fall Armyworm Damage to Maize Crops: A Field-Based Study in Nabdam District, UER, Ghana

Zibrim Shaiba, Bright Amoore, Ibrahim Amoore, and Elisha Renne*

Department of Afroamerican Studies
University of Michigan
Ann Arbor, MI 48109-1045 USA

* Corresponding author: erenne@umich.edu

Assessing the Impact of Neem on Fall Armyworm Damage to Maize Crops: A Field-Based Study in Nabdam District, UER, Ghana

ABSTRACT

This paper examines the effectiveness of neem as a biopesticide (using both oil and seed cake) obtained from the neem tree (*Azadirachta indica*) for controlling fall armyworm infestations in maize crops in Nabdam District, Upper East Region, Ghana. In July 2018, a demonstration maize field plot, with the monitoring of fall armyworm damage carried out before and after neem treatments. After two weeks, no fall army worms were seen in the section treated with neem oil spray, while they were found in the neem cake and control sections. In September 2018, maize yields were weighed. Although heavy rains affected the yield, a slightly greater yield was seen in the neem-oil sprayed section. The results of this field application of neem biopesticides is also considered in terms of practicality, effectiveness, cost, and environmental and health issues. The paper concludes with a discussion of the importance of farmer education for effective fall army worm monitoring and neem biopesticide use. Since registered neem oil products are currently being manufactured by the Nabdam Neem Company in Nangodi, the district headquarters, their availability for the study of neem effectiveness in countering FAW damage in northeastern Ghana is particularly appropriate.

KEY WORDS: fall army worm, neem biopesticide, farmer education, northeastern Ghana

INTRODUCTION

In 2017, farmers in Nabdam District, a mainly agricultural area in northeastern Ghana began to see a new insect pest, the fall army worm, on maize planted in May and June of that year. The fall armyworm (*Spodoptera frugiperda*; Lepidoptera: Noctuidae) is known as *nzur*, which means worm in Nabt, the local language. This worm was first seen in Africa in 2016; according to Niassey and Sevgan Subramanian (2018), it started "in the São Tomé and Príncipe Islands and Nigeria, in just two years it spread to over 38 African countries." In Ghana, it was first reported in the Yilo Krobo District of the Eastern Region in 2016. The federal government, along with assistance from USAID, has developed programs to help farmers in confronting this growing problem (Tamakloe 2018).

This study considers the effectiveness of the biopesticide derived from neem seeds (both oil and seed cake) obtained from the neem tree (*Azadirachta indica*), which grows throughout Nabdam District and elsewhere in Ghana. Since neem oil products (oil and seed cake) are currently being manufactured by the Nabdam Neem Company in Nangodi, the district headquarters, their availability for the study of neem effectiveness in countering FAW damage in northern Ghana is particularly appropriate.

This paper begins with a discussion of the fall armyworm, its habits, and its consequences for maize crop yields in Ghana. A brief literature review of studies of neem-based pesticides and their application to fall armyworm infestations follows. These materials and field methods were used to develop a study for assessing neem effectiveness as a biopesticide in a demonstration plot in Zogabre area of Nabdam District (from July to September 2018). The results of this field application of neem biopesticides is then considered from a number of perspectives: practicality, effectiveness, cost, as well as environmental and health issues. This paper concludes with a discussion of the importance of farmer education for effective fall army worm monitoring and neem biopesticide use.

Background on Fall Armyworm Infestations

The fall army worm has affected maize crops in many parts of the world. In the US, agricultural and university extension service personnel have provided recommendations for addressing FAW problems. For example, they provide detailed descriptions of the damage caused by the FAW and have stressed the importance of regular monitoring for FAW control (Bressin 2003). The fall army worm has also affected the maize crops of smallholder farmers in central and south America. The UN Food and Agricultural Organization has described some of these farmers' practices as possible strategies for FAW control in Africa:

> Smallholder maize farmers…apply ash, sand, or soil into the whorls and report significant control of FAW larvae with these applications. Other farmers report using soap solutions or local botanical mixtures (including, but not exclusively using extracts from neem trees) with good control success (FAO 2017: 4).

The FAO has also noted steps taken by African governments, including Ghana, to provide farmers with chemical means to control the fall army worm:

> A number of countries in the region have already begun significant programmes of providing pesticides to farmers, often as the main response to FAW infestation. The Government of Zambia, for instance, allocated $3m to smallholder maize farmers in 2017 for pesticides, including provision for replanting 90,000 hectares affected. Government of Ghana provided $4m as an emergency measure to procure plant protection products (FAO 2017: 3).

These efforts have also been described in several articles published in the Ghanaian newspaper, the *Daily Graphic* (Asare-Boadu 2018; Dapatem 2018; Fugu 2018; Ngnenbe 2018). While chemical pesticides have been distributed to some farmers, others have not received them or have had unsuccessful results (Fugu 2018). This latter situation

underscores the importance of training farmers in the effective use of chemical pesticides, e.g., spraying directly into the maize whorl. However, chemical pesticides are expensive, may be dangerous for farmers administering them without protective equipment, and may not provide a sustainable source of control. Thus:

> The Deputy Director of the Plant Protection and Regulatory Services Directorate of the Ministry of Food and Agriculture (MoFA), Dr Ebenezer Aboagye, who stated this in Accra on Monday, said the use of chemicals could not effectively deal with the threat the pests posed to crops (Ngnenbe, 2018).

The possible use of biopesticides such as neem oil, powdered seed cake or leaf infusions have been discussed and investigated in several studies.

Studies of Neem-Based Pesticides for Control of Fall Army Worm

The many uses of products derived from the neem tree (*Azadirachta indica*), which include its leaves, seeds, seed oil, seed cake, and bark, are well-known in India (Schmutterer 1995). While there are numerous neem trees in Nangodi, a result of a British colonial tree-planting initiative which brought seeds from India in the 1950s, their use has been limited to leaves for anti-malarial teas although a few neem oil projects were initiated in the early 2000s by institutions in southern Ghana (Forster and Moser 2000: 60-61). However, with the growing interest in neem as biopesticide, the use of neem products, mainly those derived from neem seeds (both oil and seed cake) have been expanded. Nonetheless, as Forster and Moser (2000: 5) note, one of "the main problems hindering greater acceptance of neem by farmers include poor dissemination of neem-related knowledge…" In their *Status Report on Global Neem Usage*, they provide extensive information on neem oil use as a biopesticide (Forster and Moser 2000: 23), which includes its effects on insect pests: as "a repellent and inhibition of feeding, a metamorphosis-inhibitor, impairing fitness and reproductive ability, and an egg-laying deterrent.

More specific studies of the use of neem-based pesticides for controlling fall army worm damage include a study of the use of an aqueous solution of ground neem seed

cake and of leaves (Silva et al. 2015); it was found that the neem seed cake more effectively controlled FAW infestations. Montes-Molina et al. (2008: 772) also discussed the use of an aqueous solution of neem leaves and found that it reduced the damage done to maize crops, compared with untreated maize. The effectiveness of neem seed oil in an aqueous solution is discussed by Campos et al (2016), although not specifically addressing fall army worm infestation. This study focused on controlling fall army worm damage of maize crops using neem-based biopesticides.

MATERIALS AND METHODS

In this study, we examined the effectiveness of a locally available neem oil- and neem seed cake-based pesticides on maize plants in Nangodi, Nabdam District, of the Upper East Region of Ghana. A demonstration plot of 1.0352 acres was delineated on one maize field in the Zogabre section of Nabdam District in July 2018.

Table 1. Kparibire Gbea Farm, Zogabre, Nabdam District: Plot Descriptions, GPS Coordinates, July 2018

Plot description	Location	Area of plot
Neem oil sprayed area	N 10° 48′ 46.5″ W 008° 41′ 01.9″	0.4531 acres
Neem cake watered area	N 10° 48′ 46.6″ W 000° 41′ 02.0″	0.2962 acres
Control area	N 10° 48′ 46.3″ W 000° 41′ 02.4″	0.2859 acres
TOTAL PLOT	N 10° 48′ 48.1″ W 000° 41′ 00.7″	1.0352 acres

On 14 July 2018, the plot was divided into three parts (see Table 1). After delineating these plots, the study began with an assessment of initial fall armyworm damage, which was done on 15 July 2018 by examining 20 consecutive maize plants in rows in each of the three different plot areas. This was done in the early morning or in the late afternoon since the fall army worm "is usually most active in the morning or late afternoon" (Bessin 2003).

On 15 July 2018, in two of the three demarcated areas, maize plants were either sprayed with a neem oil-soap-water solution or were treated at the base of the maize plants with an aqueous solution of neem cake powder (Fig. 1). The control patch was left untreated. The neem oil/seed cake treatments were only done once.

RESULTS

Assessment of Fall Army Worm in Neem Demonstration Plot

After the initial visual evaluation of fall army worm damage and the neem biopesticide treatments on 15 July 2018, the evaluation of plants that had larvae or feces present was repeated twice in late July 2018 (Fig. 2a, b; Table 2). No further evaluations for the presence of larvae or feces were carried out after maize cobs had developed silk.

Table 2. Assessment of Fall Army Worm in Neem Demonstration Plot, Nangodi, UER, July 2018

18 July 2018[1]

Plot	No. of maize plants	FAW damage	FAW seen	FAW seen/No. of plot plants
Control	75	14	13	17.3%
Neem cake liquid	136	13	3	2.20%
Neem oil spray	92	15	11	12.0%

25 July 2018[2]

Plot	No. of maize plants	FAW damage	FAW seen	FAW seen/No. of plot plants
Control	75	21	20	26.7%
Neem cake liquid	36	24	20	14.7%
Neem oil spray	92	10	0	0.0

[1] Inspected 4 days after 1st application of neem seed cake powder, aqueous solution, or oil spray (on 14 July 2018).

[2] Inspected 11 days after 1st application of neem seed cake powder, aqueous solution, or oil spray (on 28 July 2018).

Yield Assessment

On 22 September 2018, an evaluation of maize yields in each of the three delineated plot areas was made. This evaluation was accomplished by counting the number of plants in a 6 m by 6 m section in each treatment and control area, then weigh the maize cobs produced (Fig. 3). The activity lasted for two days and the objective was done to ensure proper yield analysis results (Table 3).

Table 3. Assessment of Yield in Neem Demonstration Plot, Nangodi, UER, 22 September 2018

Plot section	No. of maize plants[3]	Maize grain weight	Area in plot section
Control	97	3.6 kg	0.2589 acres
Neem seed cake liquid	120	4.8 kg	0.2692 acres
Need oil	156	6.0 kg	0.4261 acres

[3] The number of maize plants were counted in 6m x 6m areas of each sub-section regardless of whether they had maize cobs on them or not.

The relatively low number of maize plants at harvest and low grain weight per plot was due to the excessive rainfall in July-September 2018, with approximately 2,088mm of rain recorded. Part of the neem demonstration plot was flooded, leading to considerable variation in terms of sections with well-developed cobs and under-developed cobs in different sections, which did not reflect biopesticide treatment. The rainy weather also impeded FAW inspection and the final crop yield assessment.

Despite the rain which affected the assessment of the impact of neem biopesticides on FAW infestation and presence in maize plants, it appears that the neem-oil based spray was most effective against damage by *S. frugiperda* larvae (Table 2). In the area treated with neem-oil biopesticide spray, the initial visual evaluation of fall army worms seen in five consecutive rows of plants found 11 larvae present. One week later, none of

the plants had larvae present, although larvae were seen in all of the other sections. This finding suggests that the neem oil-soap aqueous solution sprayed directly into the maize whorl early in maize cob development was the most effective means of preventing FAW damage.

However, when the yield assessment was conducted 22 September 2018, the findings were inconclusive as the extreme rainfall affected sections of the demonstration plot differently. While it was found that the neem-oil sprayed plot had the highest yield, there were more plants counted in the 6m x 6m harvest area as compared with the other sections, possibly explaining the somewhat greater grain yield. (Table 3). This finding underscores the difficulties of conducting field-based as opposed to laboratory-controlled studies of the effects of neem biopesticides (Silva et al. 2015).

When Field Officer Zibrim Shaiba, one of this article's co-authors, met with local farmers during the harvest of maize cobs on 20-21 September 2018, he discussed the use of a neem oil-soap solution for the control of the FAW. During this meeting, farmers were told about what had transpired during the neem biopesticide demonstration plot under study. He also discussed the importance of neem biopesticide, particularly for food crops with regard to human health and for the environment. As part of this activity, farmers were asked to walk through the various sections of the trial plot in order to observe and evaluate the results of the different treatments given to the plot sections. Farmers were then asked to raise their preferred treatment; the majority chose the neem oil-soap spray treatment plot as their first choice. This meeting of Field Officer Shaiba with farmers which informed them about the benefits of using a neem oil biopesticide spray reflects one of the FAO's recommendations for informing smallholder farmers about managing FAW damage in their maize fields (FAO 2017: 4). More specifically, his presentation underscored FAO point about the importance of "look[ing] for longer-term solutions:"

> [Farmers] should also recognize that insecticide applications are costly, may not work, and probably kill off the natural enemies of FAW. Although they may receive

insecticides free this year, and maybe next, it is doubtful if they'll still be receiving them many years in the future. Unfortunately, FAW is in Africa to stay (FAO 2017: 5).

FIELD-BASED NEEM APPLICATION ISSUES

Because neem oil and neem seed cake are being produced in Nangodi, access for their use in biopesticide applications in Nangodi and elsewhere in the Upper East Region are easily available. There are two issues that may affect farmers use of neem oil biopesticides. The first is that it is not subsidized for use by the Ghana Ministry of Food and Agriculture (MoFA), although it compares in price with Nomax,[1] which is sold in a popular agricultural supplies store in Bolgatanga for 8 Gh₵ for a 15-liter spray container, while a comparable amount of neem oil- liquid soap combination is sold for 10 Gh₵. The second issue concerns the preparation of the
aqueous neem biopesticide solution for spraying. Once the neem oil is mixed with liquid soap and water, it has a very short "shelf life" so that the spray container (referred to as a knapsack) of 15 liters is best used the day it is mixed. The Nabdam Neem Company has addressed this problem by selling the requisite amount of neem oil and liquid soap that can be added to the 14 liters of water to fill the knapsack. The Nabdam District officials and agricultural officers are assisting farmers in the proper preparation of neem oil spray.

Health Issues: Synthetic Pesticides and Farmers' Health

[1] Nomex® is a registered trademark of E.I. DuPont de Nemours and Co., with the active ingredient, permethrin.

Aside from its local production, the lack of side-effects for humans from using neem oil spray is another benefit of its use (Campos et al. 2016: 2; Forster and Moser 2000). This situation compares with the use of chemical pesticides. In 2017, one woman said that people using

chemical pesticides to kill fall army worms on maize plants "burnt" their skin when the pesticide touched their faces, legs, and arms. Another, a man, said that some maize plants died when farmers applied too much insecticide (Interview: Ibrahim Amoore, 18 July 2017, Nangodi). The unavailability of protective materials and the misuse of chemical pesticides reflects farmers' lack of experience in using them. It also reflects the need to educate farmers about the benefits of using of neem biopesticides to protect their maize fields, as well as other vegetable crops (Ikeura et al. 2013), from the fall army worm.

CONCLUSION

This small field study of the use of neem-based biopesticide spray suggests that farmers, when informed of its benefits, will use it on their maize crops to prevent damage from the fall army worm. As has been discussed, there are obstacles to farmers obtaining access to this product which is not subsidized by the government and has only recently been available in agricultural supply stores. The short-shelf life of the active compound in neem oil, azadirachtin, when mixed with liquid soap and water also presents a challenge although training sessions with farmers can address this concern.

It is not always easy to change established ways of dealing with insect pests which affect farmers' crops, especially for smallholder farmers who depend on crops such as maize for food as well as income. Yet the authors of the 2017 FAO report on ways to address the damage caused by the fall army worm in West Africa acknowledge the need for just this sort of rethinking. Probst et al. (2012: 56), in their case study innovative practices used in cabbage farming in urban West Africa, suggest some practices which could apply to the use of neem biopesticides as well:

> In order to tip the system to an alternative state, an intervention will ideally (i) promote alternative technologies (e.g., biopesticides) that are as competitive as possible in inherent attributes and marketing; (ii) stimulate market demand [by] attempting to make the 'invisible' attribute of vegetable safety more visible;…and (v) improve farmers' access to knowledge education, with a focus on raising risk awareness regarding current strategies of pesticide use (Probst et al. 2012: 56).

The trial neem pesticide plot in Nabdam District, Upper East Region, Ghana and the accompanying educational training sessions of local farmers is a step in this direction. The next step involves further farmer education about the use and benefits of neem oil pesticides and its improved marketing in Nabdam District and elsewhere in the UER and in the coming years.

REFERENCES

Asare-Boadu, Kwame. 2018. FAO supports MoFA in fight against fall armyworm threat. *Daily Graphic* (12 January), https://www.graphic.com.gh/news/general-news/fao-supports-mofa-in-fight-against-fall-armyworm-threat.html, accessed 24 October 2018.

Bessin, Ric. 2003. Fall armyworm in corn, ENTFACT-110. University of Kentucky Cooperative Extension Service.

Buhari, Safina. 2018. 'How neem bio-pesticide can tackle deadly tomato disease'. *Daily Trust* (6 May), https://www.dailytrust.com.ng/how-neem-bio-pesticide-can-tackle-deadly-tomato-disease.html, accessed 25 Oct 2018.

Campos, E., J. Oliveira, M. Pascoli, R. de Lima, and L. Fraceto. 2016. Neem oil and crop protection: From now to the future. *Frontiers in Plant Science* 7: 1494-1501.

Dapatem, Donald Ato. 2018. "Fall army worms here to stay." *Daily Graphic* (23 January), https://www.graphic.com.gh/news/general-news/fall-armyworms-cannot-leave-ghana.html, accessed 24 Oct 2018

Food and Agricultural Organization (FAO). 2017. Sustainable Management of the Fall Armyworm in Africa, FAO Programme for Action (6 October)), www.fao.org/3/a-bt417e.pdf. accessed 4 July 2018.

Förster, Peter, and Gerald Moser. 2000. Status Report on Global Neem Usage. Eschborn, Germany: GTZ.

Fugu, Mohammed. 2018. Fall Army Worms resurface in parts of Northern Region. *Daily Graphic* (20 July), https://www.graphic.com.gh/news/general-news/fall-army-worms-resurface-in-parts-of-northern-region.html, accessed 24 October 2018.

Ikeura, H., A. Sakura, and M. Tamaki. 2013. Repellent effect of neem against the cabbage armyworm on leaf vegetables. *Journal of Agriculture and Sustainability* 4: 1-15.

Montes-Molina, J.A., M.L. Luna-Guido, N. Espinoza-Paz, B. Govaerts, F.A. Gutierrez-Miceli, and L. Dendooven. 2008. Are extracts of neem (Azadirachta indica A. Juss. (L.)) and Gliricidia sepium (Jacquin) an alternative to control pests on maize (Zea mays L.)? *Crop Protection* 27: 763-724.

Ngnenbe, Timothy. 2018. Agric experts explore ways to fight Fall Army Worms. *Daily Graphic* (15 May), https://www.graphic.com.gh/news/general-news/agric-experts-explore-ways-to-fight-fall-army-worms.html, accessed 24 Oct 2018

Niassey, Saliou, and Sevgan Subramanian. 2018. Exploring the best tactics to combat fall armyworm outbreaks in Africa. *The Conversation* (7 May), https://theconversation.com/exploring-the-best-tactics-to-combat-fall-armyworm-outbreaks-in-africa-95451, accessed 28 June 2018.

Probst L. A. Adoukounou, A. Amankwah, A. Diarra, C. Vogl, and M. Hauser. 2012. Understanding change at farm level to facilitate innovation towards sustainable plant protection: A case study at cabbage production sites in urban West Africa. *International Journal of Agricultural Sustainability* 10(1): 40-60.

Schmutterer, H., ed. 1995. *The Neem Tree*. Weinheim: VCH Verlagsgesellschaft mbH.

Silva, M.S., S.M.F. Broglio, R.C.P. Trindade, E.S. Ferrreira, I.B. Gomes, and L.B. Micheletti. 2015. Toxicity and application of neem in fall armyworm. *Comunicata Scientiae* 6(3): 359-64.

Tamakloe, Shiela. 2018. Fall armyworm causes Africa to lose over $13bn. *JoyBusiness* (11 April), https://www.myjoyonline.com/business/2018/April-11th/fall-armyworm-causes-africa-to-lose-over-13bn.php, accessed 28 June 2018.

FIGURES

Fig. 1. Men pouring neem seed cake solution on the base of maize plants in section of demonstration plot (15 July 2018).

Fig. 2a. Maize plants in demonstration plot with fall army worm damage.

Fig. 2b. Fall army worm after neem oil spraying of maize plants in demonstration plot.

Fig. 3. Monitoring the growth of the maize crop in the control section of demonstration plot.