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Evaluation of the Efficacy of Three Plant Crude Extracts for the Management of Major Insect Vectors on Different Okra Varieties in Ghana

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ABSTRACT

Background: Okra production is constrained by whiteflies and flea beetles attack and the associated respective *Okra yellow vein mosaic virus* [OYMV] and *Okra mosaic virus* [OMV] diseases. The predominant control of pests and diseases using synthetic agrochemicals poses health and environmental risks.

Methods: The efficacy of leaf extracts from Neem, Jathropha and Lemon grass as safer biopesticides in the control of whitefly and flea beetle populations was evaluated by insect count. The incidence and severity of OMV and OYVMV in the three okra varieties, *F1 Kirene, F1 Sahari* and *Asuntem*, were also assessed and confirmed by enzyme-linked immunosorbent assay (ELISA).

Result: Neem extract significantly ($p<0.05$) reduced the mean incidence (21.84%) of the viral diseases than Lemon grass extract (25.28%), Jathropha extract (25.44%) and the control (28.89%). *In vitro* confirmation using ELISA revealed that majority (86.67%) of the treatment combinations showed single infection of OMV while 13.33% was mixed-infection of OMV and OYVMV. In terms of yield levels, Neem extract treatment (144.81 kg/ha) yielded significantly higher than Jathropha extract (139.06 kg/ha), Lemon grass extract (115.75 kg/ha) and the Control (94.02 kg/ha).

Key words: Bio-pesticide, Insect vector, Low yield, Okra variety, Plant extract, Viral disease.

INTRODUCTION

The agriculture of okra (*Abelmoschus esculentus* L. Moench) provides livelihood security for many farmers in Ghana (Norman *et al.,* 2011). However, compared to agriculturally advanced countries where yields could be as high as 30 ton ha^{-1}, most areas of sub-Saharan Africa record averagely very low yields between 1.5 and 4.5 ton/ha (Anjorin *et al.,* 2013). The yield of okra in Ghana continues to decline due to the devastating attack of mainly flea beetle *Podagrica uniformis* and *Podagrica sjostedti* and whiteflies, *Bemisia tabaci* (Patil and Fauquet, 2011). Among the plant viruses of concern, *Okra yellow vein mosaic virus* (OYVMV) and *Okra mosaic virus* (OMV) are the most devastating (Echezona and Offordile, 2011; Asare-Bediako *et al.,* 2014). The flea beetle and whiteflies have been confirmed to respectively transmit the *Okra mosaic virus* and *Okra yellow vein mosaic virus* (Echezona and Offordile, 2011).

Synthetic pesticide control is becoming unattractive due to the associated harmful environmental effects and risks to human and animal health. Pest management approaches that are founded on minimal synthetic insecticides application are encouraged (Mochiah *et al.,* 2011; Singh *et al.,* 2025). In this regard, plant extracts as biopesticides are gaining wide use in crop protection. Plant extracts have been proven to be effective in the control of a wide range of pests and pathogens associated with plant diseases (Chakraborty, 2013; Hassan *et al.,* 2025). Besides, biopesticides have low toxicity to human and other animals and easily breakdown in the environment or metabolically. Moreover, biopesticides are easy to prepare, apply and integrate into any pest management strategy. In addition, availability, affordability and cost effectiveness justify the usage of biopesticides (Srivastava *et al.,* 2010; Bhandhari *et al.,* 2024).

The study evaluated the efficacy of three plant extracts: Neem (*Azadirachta indica)*, Physic nut (*Jatropha curcas)* and Lemon grass (*Citronella squinant*) compared to that of the chemical insecticide Akape ® on management of the populations of flea beetles and whiteflies, as well as the assessment of the associated incidence and severity of

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OMV and OYVMV diseases in three cultivated okra varieties under natural field situations.

MATERIALS AND METHODS

Plant species used, leaf extracts preparation and application

Extracts were prepared from neem, physic nut and lemon grass following the methods of Biswas (2013). Five treatments comprising the three plant extracts, Akape ® and control (no insecticide spray) were applied. Akape ® is a pesticide commonly used by farmers to control insect pests of okra. The doses of plant extracts and the pesticide used were based on Onunkun (2012). The crop was sprayed on both the adaxial and abaxial sides of the okra leaves at 15, 30, 45 and 60 days after sowing.

Experimental design and statistical analysis

Between July 2020 and March 2021, the field experiment was carried out at the Biotechnology and Nuclear Agriculture Research Institute (BNARI), Ghana. The field was divided into four blocks with five plots each and each plot had three sub plots. A randomized complete block design with four replications was used to plant the seeds of three different okra cultivars: *F1 Sahari* (FIS), *F1 Kirene* (FIK) and *Asuntem* (AST), a local variety. Two weeks following emergence, twenty seedlings per sub plot were reduced from the original four seeds per stand to one plant per stand. Five of the twenty plants in each sub plot were designated as experimental plants from which data was collected. Statsgraphics Centurion (version 16.1) and Microsoft Excel (2010 edition) were used to evaluate data on disease incidence and severity. Analysis of variance was performed on the quantitative data and Duncan's multiple range test was used to distinguish between means when significant differences were found (p-value<0.05).

Determination of flea beetle and whitefly populations

Data on insects was collected from five okra plants randomly selected from the middle rows. Five topmost fully expanded okra leaves were carefully examined weekly by observing both the abaxial and adaxial surfaces. Insects found on the surfaces were identified, counted manually and recorded. The insect count was carried out between 6.00 am and 8.00 am when the insects are known to be less active.

Estimation of disease incidence (DI) and symptom severity

In cases where the initiation of symptom development was observed, it was tracked and recorded for six consecutive weeks and considered as measure of disease incidence. Based on visual examination of symptoms and the procedure outlined by Karri and Acharyya (2012), the disease incidence within the okra field was estimated as follows:

$$\text{Disease incidence} = \frac{\text{Number of diseased plants}}{\text{Total number of plants per plot}} \times 100\%$$

Severity of symptoms was scored on a five-point scale (0-4), according to Ali *et al.* (2005).

Confirmation of virus infection by ELISA test

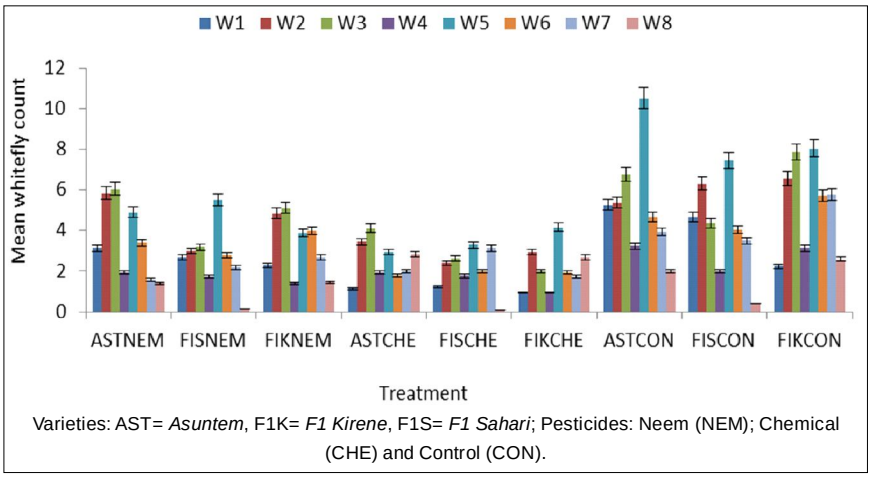
The ELISA kits were used for the detection of OMV and OYVMV following the protocol of the manufacturer except a slight modification of adding 2% skimmed milk to the wash to minimize non-specific binding. The double antibody sandwich ELISA (DAS-ELISA) test format used (Appiah *et al.,* 2020).

RESULTS AND DISCUSSION

Whitefly and Flea beetle vector population assessment

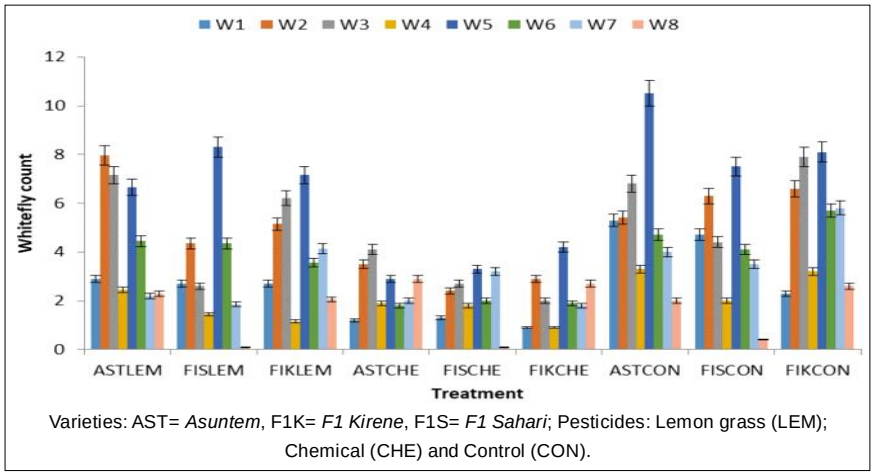
The effects of neem and lemon grass extracts as bio-pesticide for insect vector control are shown (Fig 1 and Fig 2). Mean whitefly numbers for the various treatments were significant in all varieties from week one to week 8. At week five, *Asuntem, F1 Sahari* and *F1 Kirene* had average whitefly counts of 10.5, 7.5 and 8.1 respectively. Neem performed comparatively better in terms of reduction in whitefly infestation (Fig 1). The highest average whitefly count for neem extract was 6.1 on *Asuntem* plants, followed by *F1 Kirene* with mean insect count of 5.1 at 3 weeks after planting (WAP). The lowest infestation (0.2) was found in *F1 Sahari* at 8 WAP. Extracts from neem have been identified as a strong anti-feedant and repellent, reducing growth and development and potentially delaying oviposition and preventing moulting. It has also been reported to effectively control whiteflies and aphids as well as over 200 other insect species (Mitchell *et al.,* 2004; Kumar *et al.,* 2005; Kumar and Poehling, 2006; Hemadri *et al.,* 2018).

Neem extract significantly outperformed Jatropha and Lemon grass extracts in suppressing insect populations. Nevertheless, the efficacy of Lemon grass for the control of cowpea weevil (*Callosobruchus maculatus*) (Uwamose and Okolugbo, 2016) and flea beetle (*Podagrica* spp.) (Ackah, 2013) have been reported. Extracts from Jatropha have also been used in the control of insect pests of stored grains (Gutierres *et al.,* 2012). The average whitefly count in the control plants was 5.2, 4.2 and 5.3 for *Asuntem, F1 Sahari* and *F1 Kirene* respectively. This is far lower than the numbers observed in okra by Khan *et al.* (2019) and Navneet and Tayde (2018). The three okra varieties used have medium to high density trichomes (Fig 3) and this may have resulted in the low whitefly numbers. According to Nausherwan *et al.* (2014) trichomes are known to effectively protect plant species from the adverse activities of major insect pests, particularly the sucking and chewing insect species. The effect of trichomes on whitefly abundance in okra has been reported (Chu *et al.,* 2000). However, the general declining trend recorded at weeks 6, 7 and 8 could be as result of plant senescence which has been found to reduce whitefly population on okra (Leite *et al.,* 2005). Similar trends were observed in the performance of the biopesticides on flea beetle count.



Varieties: AST= *Asuntem*, F1K= *F1 Kirene*, F1S= *F1 Sahari*; Pesticides: Neem (NEM); Chemical (CHE) and Control (CON).

Fig 1: Variation in whitefly abundance among three varieties of okra treated with aqueous neem plant extract.



Varieties: AST= *Asuntem*, F1K= *F1 Kirene*, F1S= *F1 Sahari*; Pesticides: Lemon grass (LEM); Chemical (CHE) and Control (CON).

Fig 2: Variation in whitefly abundance among three varieties of okra treated with aqueous lemon grass leaf extract.

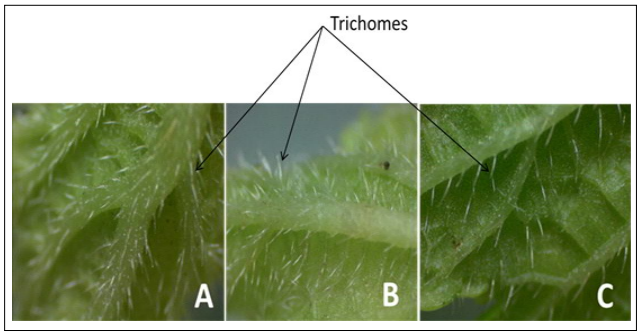


Fig 3: Trichomes observed on A. *F1 Sahari* B. *Asuntem* and C. *F1 Kirene* under the light microscope.

Effect of plant extract treatment on disease incidence

The effects of the leaf extracts on viral disease incidence on the three okra varieties are shown (Fig 4). Okra plants treated with the chemical and neem extract had a much lower disease incidence compared to the Jatropha and Lemon grass extract and the control. Disease incidence was relatively low in *F1 Kirene* plants irrespective of the treatment. This variety had previously been rated as highly susceptible (Boateng *et al.,* 2019), thus the low disease incidence could be attributed to biopesticides. The efficacy of biopesticides on the incidence of Okra mosaic virus and yield related parameters have been proven (Bhyan *et al.,* 2007). On the contrary, DI on variety *F1 Sahari* was generally high irrespective of the treatment. This could possibly be due to the extreme susceptibility of the variety as reported by Boateng *et al.* (2019). Disease incidence was low in *Asuntem* and *F1 Sahari* plants treated with Neem extract compared to those treated with Lemon and Jatropha extracts.

Plant extract treatment effect on disease symptom severity

The viral symptom severity scores for the three okra varieties are shown (Fig 5). Plants of variety *F1 Sahari* were most severely affected by the viral disease irrespective of the treatment. However, *F1 Kirene* was least affected showing mild symptoms. Paudel and Sanfaçon (2018) observed that in resistant/tolerant varieties even where they

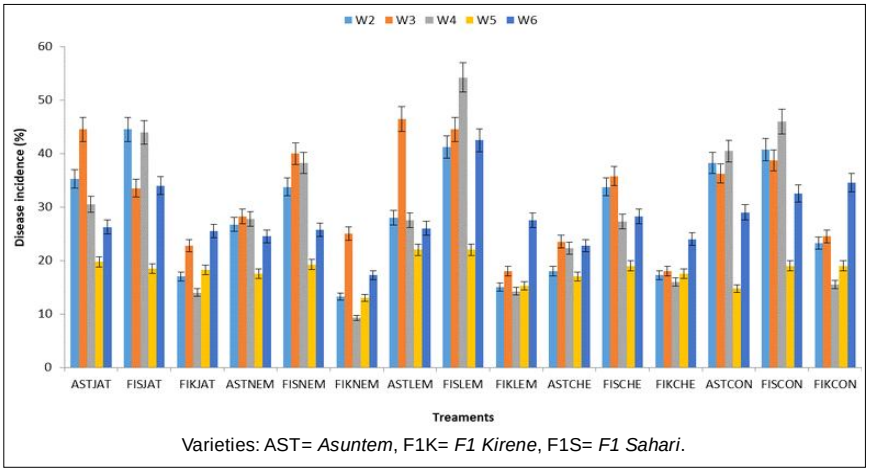
harboured significant virus load, plant growth and development was least affected. In which case visible symptoms turn out to be absent or mild, resulting in less damage to the host.

Confirmation of the presence of viruses by ELISA

Enzyme-linked immunosorbent assay (ELISA) successfully detected OMV and OYVMV confirming that the visual symptoms observed on the okra plants on the field were indeed due to the viral infection (Table 1). OMV was the most detected by ELISA. The highest positive absorbance of 0.252, indicating the highest virus titre, was recorded in neem extract treated *F1 Sahari* plants. The OYVMV infection incidence was generally low among the varieties irrespective of the treatment applied. The highest positive absorbance (0.525) was observed in *Asuntem* plants treated with neem extracts. The low incidence of OYVMV infection explains why mosaic symptoms were most prevalent on the field. Further more, the extent of co-infection of the two viruses (6.67%) among the varieties was low compared to a previous study (Appiah *et al.,* 2020).

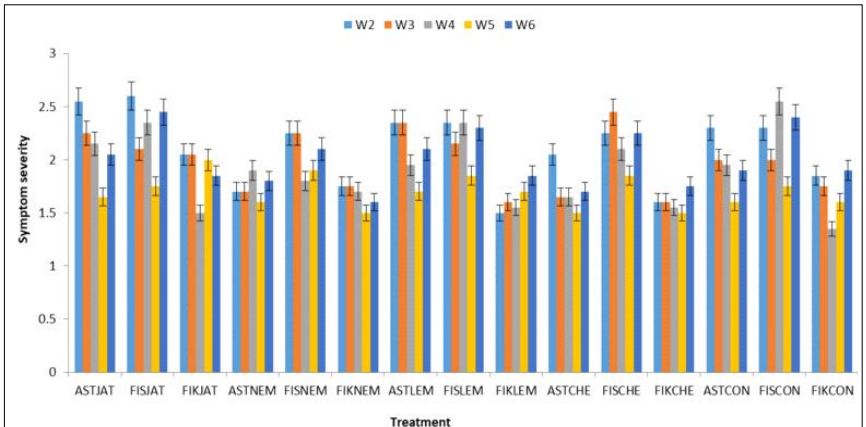
Influence of plant extract treatment on yield of okra varieties

The effect of the biopesticides on the total yield of the okra varieties is presented (Fig 6). The total yield for *Asuntem* and *F1 Sahari* were generally low, but the lowest yield was recorded in the control plants of *Asuntem*. Yield levels were significantly ($p<0.005$) highest in the chemically treated okra plants compared to all other treatments (Fig 6). In the control plants where no pesticides were applied, lowest yields were obtained. The yield of Jatropha extract treated *FI Sahari* plants was observed to be significantly higher than the control. Similarly, Neem extract treated *FI Kirene* and *FI Sahari* plants produced significantly higher yield levels than the control. In the variety *Asuntem*, comparing the control and biopesticide treatment, only Neem extract was



Varieties: AST= *Asuntem*, F1K= *F1 Kirene*, F1S= *F1 Sahari*.

Fig 4: Effect of different plant extracts; Jatropha (JAT), Neem (NEM) and Lemon grass (LEM); Chemical (CHE) and Control (CON) treatments on viral disease incidence of three okra varieties.



Varieties: AST= *Asuntem*, F1K= *F1 Kirene*, F1S= *F1 Sahari*.

Fig 5: Severity of viral disease symptoms in three okra varieties treated with aqueous leaf extracts of Jatropha (JAT), Neem (NEM) and Lemon grass (LEM); Chemical (CHE) and Control (CON).

Table 1: ELISA confirms the presence or absence of OMV and OYVMV in three okra varieties treated with pesticides in the field.

		OkMV			OYVMV		
Variety	Treatment	Absorbance @ 405 nm	Elisa reading (+/-)	% Infection	Absorbance @ 405 nm	Elisa reading (+/-)	% Infection
FIS	JAT	0.009	-		0.128	-	
	JAT	0.010	+	33	0.046	-	0
	JAT	0.001	-		0.108	-	
FIS	NEM	0.009	-		0.097	-	
	NEM	0.252	+	33	0.140	-	0
	NEM	0.003	-		0.099	-	
FIS	LEM	0.012	+		0.057	-	
	LEM	0.013	+	67	0.021	-	0
	LEM	0.007	-		0.076	-	
FIS	CHE	0.005	-		0.026	-	
	CHE	0.005	-	33	0.022	-	0
	CHE	0.234	+		0.078	-	
FIS	CON	0.245	+		0.292	+	
	CON	0.013	+	100	0.025	-	33
	CON	0.234	+		0.067	-	
FIK	JAT	0.007	-		0.057	-	
	JAT	0.011	+	67	0.025	-	0
	JAT	0.011	+		0.044	-	
FIK	NEM	0.009	-		0.059	-	
	NEM	0.010	+	33	0.042	-	0
	NEM	0.008	-		0.034	-	
FIK	LEM	0.008	-		0.031	-	
	LEM	0.007	-	0	0.028	-	0
	LEM	0.009	-		0.077	-	
FIK	CHE	0.008	-		0.017	-	
	CHE	0.005	-	0	0.025	-	0
	CHE	0007	-		0.024	-	
FIK	CON	0.004	-		0.152	+	
	CON	0.008	-	0	0.024	-	33
	CON	0.006	-		0.016	-	
AST	JAT	0.011	+		0.122	-	
	JAT	0.009	-	67	0.061	-	0
	JAT	0.011	+		0.050	-	
AST	NEM	0.005	-		0.351	+	
	NEM	0.007	-	0	0.525	+	67
	NEM	0.009	-		0.085	-	
AST	LEM	0.248	+		0.350	+	
	LEM	0.011	+	67	0.305	+	67
	LEM	0.226	+		0.094	-	
AST	CHE	0.011	+		0.012	-	
	CHE	0.235	+	33	0.031	-	0
	CHE	0.003	-		0.048	-	
AST	CON	0.006	-		0.059	-	
	CON	0.033	+	100	0.102	-	33
	CON	0.009	-		0.010	-	

Negative control= 0.005. Values are means are four tests. All values equal or greater than the negative control × 2 are positive (0.005×2 = 0.01). Varieties: AST= *Asuntem*, F1K= *F1 Kirene*, F1S= *F1 Sahari*; Pesticides: Jatropha (JAT), Neem (NEM) and Lemon grass (LEM); Chemical (CHE) and Control (CON).

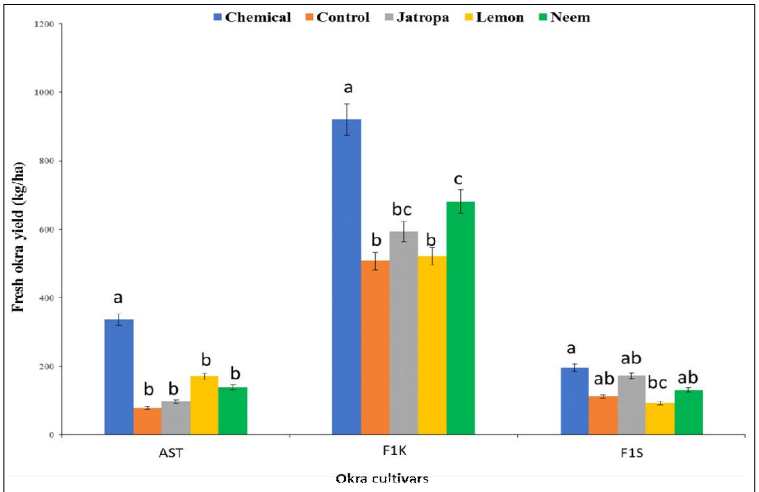


Fig 6: Effect of different pesticide treatments on the total yield of three okra varieties.

effective in producing a better yield. In *FI Kirene*, Jatropha and Lemon extract treatments were not effective except Neem. *F1 Kirene* performed best giving significantly ($p<0.005$) highest yields irrespective of the treatment it received. *F1 Kirene* had been rated as highly susceptible in a previous study (Boateng *et al.,* 2019), thus its high performance could be due to the effect of the pesticide treatment. The relatively low disease incidence and symptom severity throughout the study may have culminated in the high yield. The worst performing variety was *F1 Sahari.*

CONCLUSION

The study demonstrates that plant-based biopesticides, particularly neem leaf extract, offer a viable and environmentally safer alternative to synthetic insecticides for managing whiteflies, flea beetles, and their associated viral diseases in okra production. Neem extract consistently reduced pest pressure, lowered the incidence of OMV and OYVMV and significantly improved okra yield compared with Jatropha, lemon grass and the untreated control. The predominance of single OMV infections across treatments suggests that effective vector management can influence virus disease dynamics in the field. Overall, the findings support the integration of neem-based biopesticides into sustainable okra pest and disease management strategies in Ghana and similar agro-ecological environments.

Conflict of interest

The authors declare that they have no known financial or non-financial conflicts of interest that could have influenced the work reported in this paper. No funding agency or organization had any role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. All authors have reviewed and approved this declaration.

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