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Comparative Efficacy of Neem Seed Extract with Carbofuran in the Management of African Rice Gall Midge, *Orseolia oryzivora* Harris and Gagne (Diptera: Cecidomyppdae)

E. O. Ogah[1*] and E. N. Ogbodo[2]

[1]Department of Crop Production and Landscape Management, Ebonyi State University, PMB 053 Abakaliki Nigeria
[2]Department Soil Science and Environmental Management, Ebonyi State University, PMB 053 Abakaliki Nigeria
*E-mail of the corresponding author: emmamarg2005@yahoo.com

Abstract
African rice gall midge (AfRGM) *Orseolia oryzivora* Harris and Gagné is one of the major insect pests of rice in Africa. The dominant pest control strategy in the tropical rice over the past few decades has been in the use of synthetic insecticide. Unfortunately synthetic insecticides have not given the desired results in the management of African rice gall midge, in addition to the side effects of synthetic insecticides on the environment. In order to alleviate the growing public concerns regarding the effects of synthetic pesticides on human health and environmental impact, much attention has been given to botanicals pesticides in the recent decades. Consequently, this study was conducted to determine the efficacy of neem seed extracts in the management of AfRGM compare to carbofuran during 2006/ 2007 farming seasons at two eco-sites in Nigeria. Moreover the effect of the treatments on grain yields was carried out to determine its efficiency. Results showed that the plots treated with neem seed kernel extracts significantly ($P < 0.001$) reduced AfRGM damage compared to untreated check, and was not statistically different from those plots treated with synthetic pesticide across the levels and seasons. The highest infestation was recorded in the untreated control plots throughout the experimental periods. There was also significant ($P < 0.05$) increase in number of productive tillers in the treated plots, which significantly increased rice grain yield than in the control plots. The results therefore suggest that the application of neem seed extracts could serve as a suitable alternative to synthetic insecticides in the management of AfRGM. More so the extract has the potential to increase rice grain yield without the disruption of the agro-ecosystem.
Keyword: Plant extract, Carbofuran, *Orseolia oryzivora* control, grain yields

1. Introduction

African rice gall midge (AfRGM), *Orseolia oryzivora* Harris and Gagné (Diptera: Cecidomyiidae) is an indigenous insect pest of rice in Africa. Its infestation is one of the major constraints in achieving the yield potentials of a wide range of rice varieties that are susceptible to the rice gall midge (Ogah *et al.*, 2005 and Nwilene *et al.*, 2006). Although rice is grown virtually in all agro ecological zones of Nigeria, the production is still far below the potentials and domestic needs (Akinbile *et al*., 2007; AfricaRice, 2008). One of the major reasons for the low yield of rice in Nigeria is depredation by insect pests (AfricaRice 2007). Of all the insect pests of rice, African rice gall midge is the most economic important insect pests of rice in the recent time (Ogah *et al.*, 2010, Ogah, 2011).

For farmers and researchers alike reducing the numbers of these pests is therefore a priority. In the past, emphasis has been on the use of synthetic insecticides for the control of AfRGM; however, insecticides have not given the desired results. In addition, insecticides are not eco-friendly for sustainable production of rice (Derbalah *et al*., 2012). More so, insecticides are generally not affordable to African peasant farmers and most rice farmers have limited access to capital, and improved technologies (Nwilene *et al.,* 2008). Development and implementation of an alternative appropriate pest management approach in rice cultivation is therefore an absolute necessity. Hence in order to alleviate growing public concerns regarding the effects of synthetic pesticides on human health and environmental impact much attention has been given to botanicals pesticides in the recent decades. Plants produce a diversity of biologically active substances that affect the growth and development of other organisms and can provide protection against the herbivores to influence their feeding, settling, oviposition, growth and development, fecundity, and /or fertility (Omoloye , 2010). Botanicals are considered environmentally friendly; besides, this method does not only reduce application of synthetic insecticides, but also reduce the cost of pest management, which is an important factor for farmers in developing countries (Khorram *et al*., 2011). Moreover, resistance by pests and vectors against these bio-insecticides has not been reported and likely to be difficult (Regnault-Roger, 1997). Use of these natural compounds in place of conventional insecticides can reduce environmental pollution, preserve non-target organisms and avert insecticide induced pest resurgence.

Botanical pesticides are seldom as effective as chemicals in their wild-type form. The efficacies of botanicals have been largely demonstrated in insect management and have been advocated for use by resource poor farmers (Oparaeke and Kuhiep 2006; Sathyaseelan *et al.,* 2008; Khorram *et al.,* 2011; Mulungu *et al*., 2011). Neem products, chilies, tobacco products and wood ashes are among the reported botanicals with insecticidal activities (Anon. 2000). However some of these botanicals like neem seed extracts have not been fully evaluated especially under field conditions in Nigeria, despite the fact that it has been widely studied in Asian countries. Neem plant presents a great number of compounds (limonoids) with insecticides properties which can effectively reduce the population of several insect pests (Dhuyo and Soomro 2007, Sagheer *et al*., 2008). The use of neem products for the management of insect pest has been demonstrated with variable success (Bhanukiran & Panwar, 2000). The fact that azadirachtin is selective towards phytophagous insects with minimal toxicity to beneficial insects increases its potential value to pest management (Naumann and Isman 1996).

More so, the interest in the use of botanical pesticides is on the increase in the recent years particularly in cropping system where the use of natural enemies are being emphasized as a major component of integrated pest management (Rausell *et al*., 2000). Therefore the use of selective botanical pesticides that aid in managing the AfRGM without harming these natural enemies may be needed.

Consequently, this study was conducted to assess the efficacy of neem seed kernel extracts (NSKE) as an alternative to synthetic insecticide in the management of African rice gall midge in Nigeria.

2. Materials and Methods

The experiments were conducted at Africa Rice Centre (WARDA) Research Farm at Ogidiga in Abakaliki (06^o 17' N, 08^o 04' E and 104.40 masl), southeastern Nigeria and Edozhigi in Bida (09^o45'N, 06^o07'E and 51 masl), Northcentral Nigeria during 2006 and 2007 farming seasons under rain fed low land conditions.

2.1 Experimental design

The experiments were laid out as split-plot experiment in a randomized complete block design with three replications. A susceptible and improved rice variety ITA 306 (FARO 37) used for the experiments served as the main plot treatments while the application of crude neem seed kernel extracts (NSKE), Carbofuran and untreated control plots constituted the subplots. Rice seeds were soaked with 1kg of powdered neem kernel per 1 l of water overnight which was later seeded the following day. Thereafter a neem seed kernel extract at 2% was prepared by soaking 1kg of seed powder in 2 l of hot water for 24 hrs. The resultant mixture was filtered and filled up with water to obtain 2% concentration. Liquid soap at 0.1% of soap was added as emulsifier and the extracts were applied at 2 %, 4 % and 6 % NSKE concentrations per 15 litres (full knapsack sprayer) at 2 weeks interval starting from 10 days after transplanting till early booting stage of the rice. It was sprayed to the runoff point at each application. Three weeks old rice seedlings were transplanted in rows into 20 m^2 plots. Two seedlings were transplanted per hill at 20 x 20 cm plant spacing.

Carbonfuran 3 G at 0.75, 1.5 and 2.25 kg a. i. ha^{-1} were applied by broadcasting at 10, 30 and 50 days after transplanting (DAT), while the control plots did not receive either of the pesticides. Earth bunds were used to demarcate both the main-plots and sub-plots respectively to avoid lateral pesticides drift. All treated and untreated control plots received basal fertilizer application at the rate of 40 kg urea, 40 kg,P_2O_5 and 40 kg K_2O per ha. Thereafter, nitrogen fertilizer in form of urea was applied in two splits doses; 25 % top dressing four weeks after transplanting and 25 % top dressing at panicle initiation to all the plots. Weeding was done at three weeks interval.

2.2 Data collection

Data on Percentage field infestation of *O. oryzivora* was assessed using twenty hills randomly selected from each plot at 42 and 63 days after transplanting. The 20 hills were randomly selected at set intervals along parallel transects through the crops, while leaving the border rows. Grain yield was recorded from each plot. All plants on each plot were harvested, dried and threshed and the grains were weighed at 14% moisture content; the weights were converted in terms of tons per ha before comparisons were made between the treatments.

Statistical analysis

All the data collected were subjected to analyses of variance (ANOVA) using SAS (2003). Damage percentages were subjected to arsine transformation before analyses of variance were carried out on them. Significant differences between treatments were determined by student-Newman-Keuls (SNK) test at 5% probability level.

3. Results

Results showed that the two pesticides (NSKE and carbofuran) significantly ($P<0.01$) reduced AfRGM damage compared to untreated check (Table 1), and also significantly ($P<0.05$) increased grain yield above the yield of check throughout the experimental periods and sites. Increasing the level of all tested treatments reduced the percentage tiller infestation of AfRGM which differed significantly from the control plots. The results showed that the most effective concentration that recorded the least infestation level was on plots treated with 6 % concentration of NSKE followed by those treated with 4 % concentration of NSKE, while the control plots had the highest level of tiller infestation. However plots treated with 6 % concentration did not differ from those treated with 4 % concentration, but both differed from plots treated with 0 and 2 % concentration. On the other hand, plots treated with carbofuran rates had the similar trends. The least tiller infestation was recorded on plots treated with 1.5 kg a. i. ha^{-1}, followed by plots that had 2.25 kg a. i. ha^{-1} while the control plots had the highest tiller infestation. Similarly, plots treated with 1.5 kg a. i. ha^{-1} were not statistically differed from plots that received 2.25 kg a. i. ha^{-1} but both differed from 0.75 kg a. i. ha^{-1} and the control plots across the sites.

There was no significant difference on percentage tiller infestation levels between the two pesticides at the three levels of application even though plots treated with Carbofuran recorded the least percentage tiller infestation throughout the experimental periods and sites. At 42 DAT the application of the pesticides did not show any significant difference from that of the untreated control plot. However, the application at the maximum tillering stages onward reduced tiller infestation significantly compared to that of the untreated control plots with the least mean infestation recorded for carbofuran and NSKE respectively during 2006 and 2007 farming seasons at both sites at 63 DAT.

NSKE at 6 % concentration and carbofuran at 1.5 kg a. i. ha^{-1} gave the least tiller infestation and were the most effective treatments in the management of AfRGM in the field.

The results of the investigation took the same trend on the percentage tiller infestation of AfRGM throughout the experimental years and sites. However the incidences were more in 2006 than in 2007 farming season.

Table 2 indicated that NSKE was effective in reducing the percentage tiller infestation of AfRGM with a resultant increase in grain yield. At concentration as low as 2% there was significant difference on total grain yield from the control plots. However the highest grain yield was recorded on plots treated with 4 % concentration which differed from plots treated with 2 % and the control plots. Plots treated with neem, seed extracts generally produced significantly ($P<0.05$) higher grain yields than those treated with carbofuran rates at all the levels of the treatment and untreated control for two farming seasons and sites respectively. In terms of grain yield the order was neem extracts (t ha^{-1}) > Carbofuran (t ha^{-1}) > Control (t ha^{-1}). The results showed that there were yield gains as a result of the treatments. Plots treated with neem seed extract gave the highest yield return throughout the period of the experiment with 61% and 79.7% yield gain on plots treated with 4 % concentration for 2006 and 2007 respectively, which significantly differed from other treatments. Plots treated with Carbofuran at 1.5 kg a. i. ha^{-1} gave yield return of 56.7% and 78.6% for 2006 and 2007 respectively, which also differed from the untreated control plots. On the other hand, yield loss was highest in untreated control plots than the treated plots (neem seed extract and Carbofuran).

4. Discussion

The results of the present studies implied that NSKE was effective in reducing the percentage tiller infestation of AfRGM at concentration as low as 2 %. The results of this study also revealed that the plots treated with carbofuran were not significantly different from plots treated with neem extracts at all levels in the management of African rice gall midge. These results were in line with the findings of Prasad *et al.*, (2004) and Bora *et al.* (2004) who reported that Neem products are used for the control of yellow rice stem borer. Nwilene *et al.* (2008) have also reported the use of neem derivative in the management of pests of several field crops and stored products. The botanicals provide alternative means of insect (Mochiah *et al.,* 2011).However in Africa there have been more investigations in using plant products on post harvest pests than field pests. Neem oil and neem cake were found to be highly effective in reducing rice tungro virus transmission by the green leafhopper, *Nephottettix virescens* (Stool 2000). Similarly Amaugo and Emosairu, (2005) have reported that the application of neem seed kernel extract at 5% concentration on rice gave significant control of yellow rice stem borer by reducing damage and increasing the yield. The effectiveness of the extract may also be attributed to the admixture of 0.1 % soluble soap (as an emulsifier) to the extracts enhances uniform distribution of the spray liquid and its persistency on the surface of leaves and other plant parts.

Neem seed kernel extract has been reported as an antifeedant and insect growth regulator against many insect pests (Mordue and Blackwell, 1993). The growth regulatory effect is the most important physiological effect of neem on insects. It is because of this property that neem has emerged as a source of insecticides. On the other hand, the antifeedant activity and inhibition of hormone and enzyme activity have been attributed to the tetranortriterpenoid, azadirachtin (Nathen *et al,* 2004; Nathen *et al.,* 2005a, b).

The high level of tiller infestation recorded in untreated control plots implicates African rice gall midge as serious insect pest of rice in Nigeria whose effective control would improve rice production and yield. Although total control of African rice gall midge may not be achieved through neem application alone, their use could still guarantee reasonable levels of protection to a growing crop. Application of botanicals could greatly reduce the large-scale use of synthetic insecticides with a sustainable rice yield.

The abundance of none target pests and natural enemies observed on neem seed extracts treated and untreated plots indicates that this biopesticide is nontoxic to beneficial insects, and might be compatible with biological control currently emphasized in desirable crops such as rice that often cover large hectares. Similar results have been reported by Dhuyo and Soomro (2007) in their study on efficacy of plant extracts against yellow rice stem borer. According to them maximum number of different predators were found in neem extract treated plot.

The significantly higher grain yield produced on the treated plots than un-treated control showed that plant extracts controlled African rice gall midge as efficiently as chemical pesticides. Similarly the higher yield return recorded in plots treated with neem extracts indicated that neem did not only serve as biopesticide, rather it increased the fertility of the soil as well. Similar results have been reported by earlier researchers (Amaugo and Emosairue 2003; Dhuyo and Soomro 2007). According to them, NSKE showed some superiority over other plant extracts in terms of stem borer control and influencing grain yield.

Conclusion

The insecticidal activities of NSKE against AfRGM indicated its potentials as anatural sources of insecticide for the control of AfRGM. Although in this experiment it was impossible to completely prevent African rice gall midge damage through the pesticide application, the results obtained amply demonstrate the adverse effect of the NSKE on the incidence of African rice gall midge and yield implications. The results indicated substantial yield increases on treated plots against the control plots. Moreover NSKE could be integrated in any IPM package for rice especially where the emphasis is on the environment, food safety, and increased sustainable rice cultivation in addition to replacement of dangerous chemicals in our farming systems. Therefore, it is be concluded that neem extract can be a suitable alternate to synthetic pesticide for the management of African rice gall midge, and since it is available and easy to prepare, if adopted by resource poor farmers will bring about sustainable rice production in Nigeria without disrupting agro-ecosystem.

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Table 1: Comparative effect of NSKE and carbofuran on mean ± (SE) percentage tiller infestation of rice by AfRGM

Pesticides	% Concentration (ppm)	% tiller inf.			
Ogidiga		2006		2007	
		42	63	42	63
Neem	2	4.95±0.83b	6.58±1.48b	4.60±1.81c	8.53±2.10b
	4	4.65±0.75b	5.69±0.55a	4.25±1.23b	5.67±1.11a
	6	4.90±0.90b	5.35±2.53a	4.26±1.55b	11.72±1.94c
Carbofuran	.75 Kg a. i. ha^{-1}	4.23±.79b	6.29±0.75b	1.63±0.85a	4.82±1.75b
	1.5 Kg a. i. ha^{-1}	2.31±1.21a	4.60±1.90a	0.38±0.33a	2.90±2.1a
	2.25 Kg a. i. ha^{-1}	3.25±0.15a	6.71±1.25b	0.00±0.00a	2.92±1.45a
Control	0	14.71±1.75c	32.45±3.62c	13.15±4.01d	25.09±3.64d
	Edozhigi 2006			2007	
Neem	2	8.29±2.34b	11.72±3.02c	6.67±3.62b	8.26±3.89b
	4	7.95±2.63b	9.52±2.65b	8.26±4.60c	11.39±4.43c
	6	8.12±2.41c	10.62±2.72b	7.47±3.90b	9.41±4.13bc
Carbofuran	.75 Kg a. i. ha^{-1}	5.05±3.00b	10.74±5.01b	6.31±4.08b	8.05±3.82b
	1.5 Kg a. i. ha^{-1}	2.65±0.93a	5.32±1.0a	2.31±0.91a	5.02±1.41a
	2.25 Kg a. i. ha^{-1}	3.74±0.38a	6.51±0.91a	3.64±1.05a	6.69±0.74a
Control	0	14.69±2.39d	37.01±4.52d	14.73±4.42d	31.87±5.04d

Mean ± SE within a column followed by the same letter are not significantly different at P> 0.05, Student-Newman-Keuls (SNK) test

Pesticides	**% Concentration (ppm)**	**% tiller inf**	
	Ogidiga		
		2006	2007
Neem	2	3.1b	3.5b
	4	4.3c	4.7c
	6	4.5c	4.9d
Carbofuran	.75 Kg a. i. ha^{-1}	3.3b	3.7b
	1.5 Kg a. i. ha^{-1}	4.8c	5.0d
	2.25 Kg a. i. ha^{-1}	4.7c	4.7c
Control	0	2.7a	2.9a
	Edozhigi	**2006**	**2007**
Neem	2	3.0b	3.3b
	4	3.9b	4.3c
	6	4.4c	4.7c
Carbofuran	.75 Kg a. i. ha^{-1}	3.4b	3.6b
	1.5 Kg a. i. ha^{-1}	4.9c	4.5c
	2.25 Kg a. i. ha^{-1}	4.6c	5.1d
Control	0	2.5a	2.8a

Mean ± SE within a column followed by the same letter are not significantly different at P> 0.05, Student-Newman-Keuls (SNK) test