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Impact of rates and frequency of Formulated neem seed oil (F-NSO) on *Riptortus dentipes* Fab. Hemiptera: Coreidae damage of improved pigeonpea in Owerri, rainforest Zone, of Southeastern, Nigeria

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Abstract
Research on *Riptortus dentipes* Fab., Hemiptera: Coreidae) was carried out at the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri Imo, State, during 2009, and 2010 planting seasons. Their damage on pod/seed was studied under control with formulated neem seed oil (F-NSO) and synthetic pyrethroid (SPY) (cypermethrin) at different rates and spraying frequencies. The experiment was laid out in 3 x 5 factorial comprising three rates of F-NSO: 4.2 L ha^{-1}, 8.3 L ha^{-1}, 12.5 L ha^{-1} with untreated control (0L ha^{-1}), and SPY (1.5L ha^{-1}) as checks and three intervals of application namely : once a week, once in two weeks, and once in three weeks. Results showed that application of F-NSO at the highest dose of 12.5L ha^{-1} and at four regime spraying intervals of once a week significantly ($p<0.05$) resulted to reduced pod/seed damage and better pod/seed quality observed irrespective of the planting seasons. July planting season witnessed low pod/seed damage with enhanced seed quality (percentage wholesome seeds) when compared with May planting season. Therefore, in the humid environment of Owerri South-eastern, Nigeria, application of 12.5 L ha^{-1} of F-NSO once a week and at four spraying intervals especially during July planting season should be incorporated into pigeonpea Integrated Pest Management (IPM) Programmes.

Keywords: Early maturing pigeonpea, *Riptortus dentipes*, damage, neem seed oil, frequency, rates

1. Introduction
Pigeonpea (*Cajanus cajan* (L.) Millsp) belongs to the genus *Cajanus*, subtribe *cajanae*, tribe phaseoleae and family fabaceae [1]. Many species of closely related genus Atylosia successfully cross with pigeonpea [2]. All the evidence gathered to date points to Peninsular India as the place where pigeonpea originated [3]. It is believed that pigeonpea moved from India, its primary center of origin and diversity to Eastern Africa over 1,000 years ago [2] with Kenya as the world's second largest producer of pigeonpea from an estimated area of 100,000 hectares annually [4]. Pigeonpea production in Africa contributes 9.3% of the world production, which is very little compared to the 74% contribution from India alone [5].

Pigeonpea is an important grain legume of rain fed Agriculture in the semi-arid tropics and other tropical countries use it in a variety of ways [6]. The dry seed is dehulled and the split cotyledons called dhal are cooked to make thick soup primarily for mixing with rice. In India sprouted seeds are consumed and the flour or the split seeds are used for making soup. In Africa and Central America whole dry seeds without the seed coat are cooked alone or mixed with meat and used as food while in Southeastern Nigeria whole dry seeds with seed coat are cooked and mixed with yam, dry cocoyam chips (achicha) or with maize/sorghum flour [7].

There are problems from unfavourable edaphic factors, and production systems with low and variable plant populations of pigeonpea coupled with moisture stress during fruiting and seed development [8]. Most importantly damage by insect pests such as pod sucking bugs (*Riptortus dentipes* Fab, *Nezara viridula* L *Clavigralla tomentosicollis* Stal., *Clavigralla. shaddabi* Dolling,.etc), podborers (*Helicoverpa armigera* Hubner, *Maruca vitrata* Fab. etc), and insect vectors such as whiteflies, aphids, thrips, etc have seriously been reported to be the major constraints to the production efforts [9, 7]. Out of all these pests, *R. dentipes* possess the greatest threat to pigeonpea production in Imo State as its population appears at all the different time of the cropping seasons [7, 10]. More than 200 insect species have been reported feeding on pigeonpea at various stages of its growth [11]. In a survey carried out by [7], in pigeonpea growing areas in Nigeria between February 2007 and 2008, *R. dentipes* were identified in Imo state as the most pod damaging pests compared with all other states [12]. In his research on cowpea reported pod sucking bugs complex namely: *C. tomentosicollis*, *A. curvipes*, *Mirperus jaculus* as major insect pests that decimate cowpea at podding stage.

Thus, farmers in their efforts to combat pest problems in pigeonpea farms resort to indiscriminate application of synthetic pesticides. Synthetic pesticides can present danger to environment, consumers, bystanders, or workers during mixing, or during and after application. Insecticides are sold in open markets by business men who have no knowledge of toxicological consequences of pesticides to man and the environment.

In Southeastern Nigeria, the problems caused by pesticides have become a serious concern to farmers and the general public. It is now obvious that synthetic insecticides have detrimental effects on man and his environment such as

effects on immune system of animal [33]), disruption of endocrine gland [13], and structural deformities of the reproductive tract [14]. Also problems such as respiratory problems, memory disorders, cancer, miscarriages, birth defects, land, and water and air pollution can occur [15]. With these problems, the cry by farmers and consumers is for an alternative and effective pest control strategy, hence the interest in the study of alternative plant derived insecticide for effective pest control in pigeonpea farms in Owerri South-eastern, Nigeria.

Plant derived insecticides can be an appropriate pest control alternative to synthetic insecticides in pigeonpea farms. The most current of the organic pesticides (botanical insecticides) are those derived from seeds of neem tree, *Azadirachta indica* A. Juss. Neem seeds are easily available in Southeastern Nigeria, and the oil extracts can be prepared by farmers and safely applied. The neem oil extracts are relatively safe to humans, to non-target organisms, to beneficial organisms, and to the environment in general when compared with the synthetic pesticides. The oil formulation leaves no residues hence cause no contamination or pollution [16]. To meet the protein requirement of the teeming Nigerian population, there is need to embark on increased production of these grain legumes.

Available information on the use of neem oil for pest control has concentrated on crude formulation of the extract which fails to achieve the desired purpose. Industrial processing and formulation of neem seed oil are available but information on the appropriate rate and effective spraying intervals required for the formulated neem seed oil (F-NSO) to control the targeted pests of pigeonpea in Owerri rainforest zone of South-eastern Nigeria is lacking. Hence the objective of this research was to determine the optimum dosage and intervals of application of formulated neem seed oil (F-NSO) required to control *R. dentipes* on early maturing pigeonpea cultivar in humid environment of Owerri, South-eastern, Nigeria.

2. Materials and Methods

Field research was carried out in the Teaching and Research Farms, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Imo State Nigeria. Experiments were established in the months of May and July, 2009 and repeated same periods in 2010. The research fields were located in the rain forest belt, longitude 7° 12′ E and latitude 5° 27′ N of equator. Plates 1,2 show the map of Nigeria, and the location of the research field in Owerri, Imo State.

Plate 1: Map of Nigeria showing location of Imo State (arrowed)

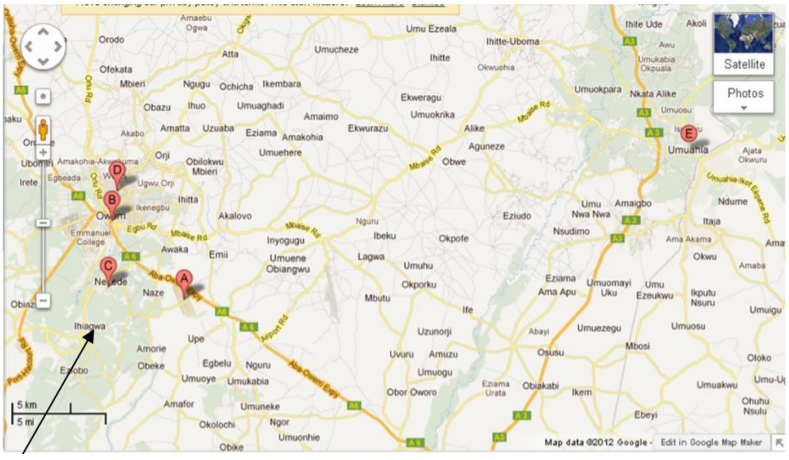


Plate 2: Map showing Ihiagwa in Owerri Imo State where Federal University of Technology Owerri, is located (arrowed)

2.1 Variety of Pigeonpea used
An improved pigeonpea cultivar, ICRISAT pigeonpea lines (ICPL) 84023 was used for the research and was procured from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) India. The cultivar matures within 3 to 4 months as against our local cultivar that takes up to 8 to 9 months before maturity.

2.2 Land Preparation
An area measuring 40.0 m by 15.0 m (600.0 m^2) was cleared and mapped out at the beginning of May 2009, and repeated May and July 2010 cropping seasons. There were three replications with 3.0 m pathways between replications and each replication comprised of 15 plots of size 2.4 m by 2.0 m and separated by 1.0 m pathways between plots. There were five ridges per plot and each ridge contained twelve plants. Within row planting spacing was 0.2 m and 0.4 m between ridges. Three seeds were planted per hole and later thinned down to one plant per stand two weeks after planting (WAP) to give a plant population of 60 plants per plot and 125,000 plants per hectare.

Cultural practices
Weeding was done manually with the use of hand hoe at two and six weeks after planting

2.4 Source of neem Seed oil used.
Industrially formulated neem seed oil (F-NSO) from neem tree *Azadirachta indica* A. Juss by National Research Institute for Chemical Technology (NARICT), Zaria Road, Kaduna was used in all the spraying trials at recommended rate of one litre (1) in 200 litres of water per hectare.

2.5 Treatments allocation
There were 5 treatments comprising three rates of formulated neem seed oil (F-NSO), 2 ml (4.2L in 840 litres of water ha^{-1}), 4 ml (8.3L in 840 litres of water ha^{-1}), 6 ml (12.5L in 840 litres of water ha^{-1}), untreated plot (0L ha^{-1}) and synthetic pyrethroid (Cyperforce (cypermethrin 30 gl^{-1} +dimethoate 250 gl^{-1} EC) at 0.72 ml (1.5L in 840 litres of water ha^{-1}) as checks) with 3 intervals of application namely (once in a week, once in two weeks, and once in three weeks).

2.6 Experimental design and spraying schedules
The experimental design was a 3 x 5 **factorial** laid out in Randomized Complete Block Design (RCBD) with three replications. The 15 treatments were allocated at random within each block. Spraying was carried out weekly starting from flower bud initiation till pods maturity using hand operated knapsack sprayer. At spraying time SPY and the different rates of F-NSO were diluted with a constant water volume of one (1) litre of clean water and later converted to hectare basis as described above.

2.7 Pest sampling, collection and identification
Data on *R. dentipes* count started from the flower bud initiation using four (4) plants selected at random from each three middle ridges giving a total of 12 sampled plants per plot till pod maturity. *R. dentipes*, were also collected with sweep net and preserved in the Crop Science Departmental Laboratory with 95% ethyl ethanol and identified with preserved samples from the Department of Crop Science and Technology, Federal University of Technology, Owerri.

2.8 Assessment of pods and seeds damage by insect pests
At maturity the pigeonpea pods were harvested and threshed manually. The pods and seeds were examined for insect damage and incidence of damage assessed as the proportion of pods and seeds shriveled, twisted, and constricted. Pod/Seed damage indices (Sdi), were determined by sorting pod/seed lot from each plot into seeds with no feeding damage (wholesome pods/seeds), pods/seeds severely shrunken to small sizes (shriveled), and mild shrinkles. The proportions of each category from 100 pods/seeds selected at random from each plot were counted, and expressed as percentage of the total weight of pods /seeds assessed, as shown below:

$$\text{Pod/seed damage (\%)} = \frac{\text{No. of damaged pods/seeds}}{\text{Total No. of pods/seeds examined}} \text{ x } \frac{100}{1}$$

2.8 Statistical Analysis
All data collected were subjected to analysis of variance using [17]. Data on *R. dentipes* counts and pod/seed damage were subjected to square root transformation before analysis of variance was carried out, while treatment means were separated by the use of Least Significant Difference at 5% level of significance as described by [18].

3. Results
Table 1 presents the result of the effects of F-NSO and spraying schedule on percentage pod and seed damage by *R. dentipes.* During May 2009, 2010 and July 2010 planting seasons, percentage pods and seeds shriveled by *R. dentipes* as well as percentage wholesome pods and seeds were significantly (P<0.05) influenced by different rates of neem seed oil. With regards to application intervals, percentage pods/seeds shriveled by *R. dentipes* were equally significant (P<0.05) in both planting seasons.
Plots of pigeonpea that received neem seed oil treatment recorded low percentage pods shriveled by *R. dentipes* but were inferior to pigeonpea plots sprayed with SPY. Similarly percentage wholesome pods and seeds were also higher than the control plots. Plates 3 a,b,c,and d show the nature of damaged pods/seeds by *R. dentipes* (plate 3) and normal pods/seeds. Spraying at once a week, recorded the least percentage pods shriveled and greater portion of wholesome pods and seeds. In May 2009, *R. dentipes* damage was low but high in May 2010
Similarly, in May 2009 result shows the interaction between rates of neem seed oil and frequency of application was significant P<0.05) with respect to reduction in percentage seeds shriveled and wholesome seeds while in May 2010 and July 2010, there were no significant interaction (P>0.05) effects for rates of F-NSO and spraying schedules with respect to percentage pods/seeds shriveled and percentage wholesome pods/seeds (Table 1). The lowest percentage pods and seeds damages were recorded during July planting compared with May 2009 and 2010 planting periods. The unprotected plots recorded greater percentage pods and seeds damage with the lowest percentage wholesome pods and seeds, compared with protected plots. However, plots sprayed with synthetic pyrethroid (SPY) were much better protected than plots sprayed with neem seed oil (F-NSO) and untreated (control) plots.
Generally, the greatest damage coupled with low percentage wholesome pods and seeds occurred in unprotected plots while in protected plots the damage were high as the rates of

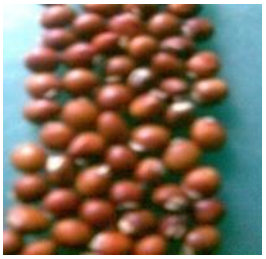
formulated neem seed oil (F-NSO) decreased. Synthetic chemical (SPY) gave the lowest percentage pods and seeds damage compared with unprotected plots and plots sprayed with F-NSO. Application of neem seed oil at weekly intervals recorded the least percentage pod damage and the highest percentage wholesome pods and seeds compared with other application frequencies.

Pods and seeds damaged by podsucking bugs e.g *R.dentipes*

(a) Shriveled pods caused by *R.dentipes*

(b) Wholesome pods (undamaged pods)

(c) Shriveled seeds



(d) Wholesome seeds (undamaged seeds)

Plates 3

Plate 4: *Riptortus dentipes* Fab mmating in pigeonpea farm

Table 1: Effect of different rates of formulated neem seed oil (F-NSO) and frequency of application on the *R. dentipes* damage of early maturing pigeonpea cultivar at different planting seasons in Owerri

	May 2009				May 2010				July 2010			
Rates of Neem oil	**% pods shriveled**	**% seeds shriveled**	**% whole some**	**% whole some**	**% pods shriveled**	**% seeds shriveled**	**% whole some**	**% whole some**	**% pods shriveled**	**% seeds shriveled**	**% whole some**	**% whole some**
(NO)	**by *by R. dentipes***	***by R. dentipes***	**pods**	**seeds**	**by *by R. dentipes***	***by R. dentipes***	**pods**	**seeds**	**by *by R. dentipes***	***by R. dentipes***	**pods**	**seeds**
0 ml (0l ha^{-1})	80.80	89.30	2.90	0.70	51.70	85.91	3.40	8.20	36.48	49.00	59.22	45.70
2 ml (4.2l ha^{-1})	73.20	84.70	16.26	9.52	36.20	72.00	27.90	26.00	29.56	47.00	68.56	52.90
4 ml (8.3l ha^{-1})	65.50	76.40	28.24	21.14	33.90	66.90	36.10	31.43	27.22	44.60	71.00	53.60
6 ml (12.5l ha^{-1})	55.60	60.40	40.40	37.93	28.10	52.10	45.90	47.60	24.23	38.60	74.44	58.30
SPY(1.5l ha^{-1})	42.60	37.69	55.73	62.20	17.00	34.60	71.40	65.30	18.11	27.30	81.56	73.80
LSD 0.05	12.20	8.66	12.90	8.23	6.61	11.73	8.88	12.06	5.27	7.90	5.16	6.92
Frequency (F)												
Once a week	57.80	63.96	36.59	33.10	29.60	56.30	44.60	42.50	24.96	32.90	73.60	67.10
Once in 2 wks	64.00	67.80	28.38	28.00	32.60	60.90	37.50	37.17	26.47	36.60	71.80	63.40
Once in 3 wks	68.80	77.73	19.20	17.40	37.90	69.10	28.80	28.10	29.27	54.70	68.13	40.70
LSD 0.05	N.S	6.71	9.99	6.38	5.12	9.08	6.88	9.34	4.09	6.12	3.99	5.36
interaction												
(NO × F.)	N.S	15.00	N.S	14.26	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

4. Discussion

There was increased population of *R. dentipes* at podding stage of pigeonpea. This finding agreed with [10] Dialoke *et al*., 2014a who reported high incidence of *R. dentipes* on pigeonpea pods in Owerri. The presence of many pods often longer on the plants than the flowers must have attracted greater population of *R. dentipes* at the pigeonpea podding phase**.** Also *R. dentipes* population before spraying F-NSO was high on pigeonpea pods but after spraying especially when sprayed at a high dose of 6 ml per litre of water reduced their population, while the population fluctuates in untreated pigeonpea plots in relation to days after spraying. This clearly demonstrated the efficacy of active ingredient, Azadirachtin in neem seed which must have exerted repellent and antifeedant action against *R. dentipes* after spraying. [19] Working on pigeonpea also recorded ecdysteroid depletion when neem extracts were applied. The synthetic pyrethroid controlled *R. dentipes* on the pods better than the F-NSO probably because of its contact poison activity [20]. Reported that application of dimethoate significantly controlled population of pod sucking bugs.

Moreover, the insecticidal activity of azadirachtin has been

demonstrated against numerous insect pests [21, 22, 23 24, 25, 10, 26] and its various mode of action can include disruption of feeding, reproduction or development [27, 28].

The F-NSO and SPY when sprayed on the pods at once a week proved better control strategy but for economic reasons spraying at once in 2 weeks seem to be a more reasonable control of the pest when compared to spraying once in 3 weeks [29]. From this study, attempts to control pod and seed damage caused by *R. dentipes* in Imo state proved effective as synthetic pyrethroid and different rates of neem seed oil sprayed on pigeonpea plants significantly at $P<0.05$ influenced percentage pod and seed shriveled by *R.dentipes*. Also as a repellent neem prevents insects from initiating feeding and as a feeding deterrent, it causes insect to stop feeding either immediately after the first taste (due to the presence of deterrent taste factors) or at some point soon after ingesting the food (due to secondary hormonal or physiological effects of the deterrent substance [30]. As a growth regulator neem is thought to disrupt normal development interfering with chitin synthesis [30, 31, 32]. They also maintained that the susceptibility to the various effects of neem differs from species to species.

This study therefore, revealed that neem seed oil could be adjudged effective in the management of *R. dentipes*, though less effective compared with the synthetic pyrethroid [33]. However, because of problems to humans and environment associated with synthetic chemicals, the use of formulated neem seed oil could be advocated. The low pod and seed shriveled in neem sprayed plots could be due to presence of active ingredients, Azadirachtin in neem seed oil with its bitter taste which might have deterred *R. dentipes* from feeding (sucking sap from flowers and young pods) and thus increased the percentage wholesome pods/seeds quality). On the other hand, synthetic insecticide is a contact insecticide and could have caused quick mortality to *R. dentipes* in contact with the spraying liquids hence the efficacy was higher than spraying with F-NSO..

The percentage pod and seed shriveled which was more in May 2009, followed by 2010 and least during July 2010 planting time could be due to changes in climatic conditions prevalent during the planting seasons. Throughout the planting times, control of *R. dentipes* at application intervals of once a week had the least values of percentage shriveled pod and seed than application intervals of once in two or three weeks. This implies that application of the insecticides at once in three weeks could not have effective control of *R. dentipes* during the podding phase of the early maturing pigeonpea. This could be due to the short residual activity of Azadirachtin and synthetic pyrethroid which probably made the spray liquids not to stay effectively on the plants longer than three weeks.

5. Conclusion and Recommendation

On daily basis, farmers and the general public are exposed to toxic chemicals through indiscriminate use of synthetic pesticides. The use of neem seed oil will provide an alternative plant derived pesticides to synthetic pesticides which will help protect farmers, soil, and environment from the toxic effect of chemical pesticides.

Application of different rates of formulated neem seed oil (F-NSO) and at higher dosage of 12.5 L ha^{-1} of water at intervals of once a week consistently controlled the population of *R.dentipes* and gave the best protection to the pigeonpea pods and seeds against damage especially when early maturing pigeonpea is planted and sprayed with F-NSO in July. Even though synthetic pyrethroids (SPY) performed much better than F-NSO in controlling *R. dentipes*, the use of F.NSO is highly recommended to farmers in view of the toxic nature of synthetic pesticides on human health and environment.

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