

EFFECTS OF THE ESSENTIAL OILS OF MAHOGANY (*Khaya senegalensis*) A. JUSS. AND NEEM (*Azadiracta indica*) A. JUSS. ON COWPEA FOR THE CONTROL OF POD SUCKING BUGS COMPLEX (*CLAVIGRALLA spp*) IN BAUCHI, NIGERIA.

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ABSTRACT

Field studies were conducted at the Teaching and Research Farm of Abubakar Tafawa Balewa University Bauchi, during the cropping seasons of 2005 and 2006. The objectives of the experiments were to compare the effects of essential oils of neem (*Azadiracta indica* A. Juss.) and mahogany (*Khaya senegalensis* A. Juss.) seeds with a synthetic insecticide (Cymbush + Dimethoate (Cymbush super ED) and their application frequency in the control of Pod sucking bugs complex (*Clavigralla spp*). Each of the insecticide was applied twice (one at bud initiation and the other at 50% flowering), thrice (one at bud initiation, 50% flowering and 50% podding) and four times (consisting of one spray at bud initiation, 50% flowering, full flowering and 50% podding) respectively. Factorial experiment was laid out in randomized complete block design (RCBD), an untreated control was included. Each treatment was replicated four times. Results in both seasons revealed that, all the essential oil treatments were significantly ($p \leq 0.05$) better than the control in reducing the population of and damage by Pod sucking bugs complex on cowpea. Similarly, the neem oil performed better than the mahogany oil in controlling the insect pests, but the two were less effective than the synthetic insecticide. A significantly ($p \leq 0.05$) higher reduction occurred in the population of and damage to cowpea by the insect pests with 3 to 4 applications. The interaction between insecticide type and application frequency was found to be significant on the population of and pod damage by Pod sucking bugs complex at 3DAA and 7DAA in 2006 cropping season. The grain yield obtained in both seasons showed that, the two essential oils were significantly ($P= 0.05$) better than the control check. However, the synthetic insecticide produced significantly ($p \leq 0.05$) higher cowpea grain yield than the other treatments. It is therefore suggested that, farmers be encouraged to use mahogany oil applied at bud initiation, flowering and 50% podding stages in reducing the population and damage of the Pod sucking bugs complex for a significant increase in cowpea grain yield relative to control. Thus, this could play a role in the integrated management of the target pests in the study area. **KEYWORDS:** Essential oils, Application Frequency, Pod sucking bugs complex and *Vigna unguiculata* (L.) Walp.

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp., is a grain legume grown mainly in the savanna regions of the tropics and subtropics in Africa, Asia, and South America. Cowpea value is rated high for its high protein content, and ability to tolerate drought. It is also an important cash crop that makes up part of the export commodities for the countries cultivating it. About 2.4 million metric tonnes is produced in Nigeria from a total of about 5 million ha of land, and about 80-90 % of this is produced in the Northern part of the country (FAO, 2004). This represents about 60 % of the world's total production (Ansari and Singh, 1984).

In spite of all its derivable benefits, cowpea production is constrained by many factors which may vary to some extent according to agro-ecological zones. Every growth stage of cowpea has at least one major insect pest. Aphids (*Aphis craccivora*) attack cowpea especially in the seedling stage, flower thrips (*Megalurothrips sjostedti*) at flowering, pod borer (*Maruca vitrata*) at flowering and pod formation and a complex of pod sucking bugs at podding, while the cowpea weevil (*Callosobruchus*

maculatus) during seed storage (Allen *et al.*, 1996). Thus, the objective of the present study is to evaluate the effects of some essential oils on the population and damage by *Clavigralla tomentosicollis* in Bauchi, Northern Guinea Savannah ecology of Nigeria.

MATERIALS AND METHODS

Field studies were conducted at the Teaching and Research Farm of Abubakar Tafawa Balewa University Bauchi, in the northern guinea savanna during the cropping seasons of 2005 and 2006. The total experimental area measured 1034m², with 48 plots each measuring 4m x 3m. The net plots size was 220x225cm (4.95m²). Plots and replications were separated by 1m and 2m, respectively. Cowpea variety ('NGVU-05-25' (Reg. no. CV-261, PI 632848), originally tested as IT90K-277-2) was used as planting material which was purchased from the International Institute for Tropical Agriculture (IITA), Kano station (NCGRB 2005). The insecticide, Cymbush super ED contains Cypermethrin and Dimethoate, an oil based insecticide marketed in a container, was purchased from Jubaili Agrotech, Gunduwawa District, Hadejia road, Kano.

Moreover, as reported by Lale (1992), the seeds and fruits of the essential oils appeared to be the commonest and perhaps the most important sources of natural chemicals for the management of insect pests. Matured pods of neem and mahogany after dropping from the tree were picked after which the seeds were removed. The seeds were then dried in the sun to reduce its moisture level. These were grounded thereafter with manual blender (mortar and pestle) and then water was added (10ml/kg of seed power) to form a paste. The paste was then kneaded with hands and the oil pressed out. This was then filtered with a sieve (mesh size 5 x 0.5m) to remove particles and the oil was then transferred into plastic bottles and stored for usage in the field. The procedure followed for the extraction of both neem and mahogany oils was described by Stoll (1988). The experiment was laid out in a randomized complete block design with four replications. The treatments consisted of three insecticides (Viz:- Cymbush ED, neem and mahogany oils) and three (3) application frequencies (Viz:- two, three and four) as shown below:

A₂ = Two sprays; one at bud initiation and the other at 50% podding.

A₃ = Three sprays; one at bud initiation, 50% flowering and 50% podding.

A₄ = Four sprays; consisting of one spray each at bud initiation, 50% flowering, full flowering and 50% podding respectively.

The insecticide treatments were applied with a four battery operated electrodyn sprayer (imperial chemical industries PLC, England) which sprays 60µm, diameter droplets that are attracted to the nearest earth object. The cowpea variety (IT90K-277-2) is susceptible to major cowpea pests with an average yield of 1172

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{a}{b} \times \frac{10,000\text{ha}}{1,000\text{kg}}$$

Where: a = Plot yield (g)
 b = Net plot size (4.95m²)

All the data obtained were analyzed using analysis of variance (ANOVA), while all the numerical data with low counts or zero values were transformed to $\sqrt{n+1}$. The transformed data were subjected to analysis of variance, and Students Newman's Keuls (SNK) test was used to distinguish significant differences between treatment means at 5% level of probability.

RESULTS

As presented in Table 1, the two essential oils were significantly ($p \leq 0.05$) the same in reducing the population of Pod sucking bugs at all days after application in 2005. However, both the essential oils differed significantly ($p \leq 0.05$) at 1 and 7DAA in 2006, with mahogany oil performing better than the neem oil. All the insecticidal treatments were not as effective as the Cymbush ED, but were significantly ($p \leq 0.05$) better than the control in both years.

kg/ha (NCGRB 2005). The seeds were sown after the field was harrowed and ridged on 23rd day of June, 2005 and 25th July, 2006. The sowing was made at a spacing of 20cm within rows and 75cm apart between rows. Four seeds were sown per hole at a depth of about 3cm which were later thinned to two stands per hole. In each year, germination started after four days. All the missing spots were replanted after seven days. There were five rows per plot (75x20cm) which were weeded twice i.e two weeks after emergence and the other at an interval of another two weeks. The population of Pod sucking bugs complex (*Clavigralla tomentosicollis*, *Clavigralla schadabi* and *Anoplecnomis curvipes*) were counted on the leaves and pods of plants every net plot in a treatment at 16.00 - 18.00 hrs in the afternoon and 7.00 - 8.00am when many of the bugs were either feeding or mating. Counts were made at 1, 3 and 7 days respectively (Ivbijaro and Bolaji, 1990). While the damage made by Pod sucking bugs was assessed on pods that were shriveled or showing a pod space in the case of a matured pod, (Ivbijaro and Bolaji, 1990). Harvesting of fully dried pods for the experiment conducted during the seasons of 2005 and 2006. During the harvesting, all the pods in each plot were harvested and placed in separate polythene bags. The bags were then labeled according to the treatments and weights of harvested pods were recorded. The pods from the net plot were separately threshed, winnowed and grain weights recorded accordingly. Yield data were converted to kilogram per hectare before analysis of variance. The grain yields of all the harvested pods were calculated using the following formula.

In respect of the frequency of application, the differences among the three sprays (2, 3 and 4) were not significant at 3DAA in 2005 (Table 1), but significantly ($p \leq 0.05$) differed from each other at 7DAA. However, 3 and 4 application frequencies were significantly ($p \leq 0.05$) the same only at 7DAA in 2005. Similarly, the difference between three and four applications was not significant at 1 and 3DAA in 2006, but all the two performed significantly ($p \leq 0.05$) better than 2 applications in both years. Significantly ($p \leq 0.05$) lower populations of Pod sucking bugs were recorded in four applications of the insecticidal types at 7DAA in 2006.

In 2005, both mahogany and neem oils were statistically same in reducing number of pod damage by Pod sucking bugs at all days after applications, but were not as effective as Cymbush ED.

The control plots recorded significantly ($p \leq 0.05$) higher number of damaged pods than all the other treatments. In 2006, the two essential oils had significantly ($p \leq 0.05$) lower number of damaged pods than the control, but the two were statistically same at 1, 3 and 7DAA (Table 2). The Cymbush ED performed significantly ($p \leq 0.05$) better than the two essential oils.

In both cropping seasons, there were significant ($p \leq 0.05$) differences among all the application frequencies, where four applications significantly ($p \leq 0.05$) reduced number of pod damage by *Clavigralla* than the 2 and 3 at all the days after applications (Table 2).

In table 3, the two essential oils did not significantly ($p \leq 0.05$) differ at 3 and 4AFR in reducing pod damage at 3DAA, but were not as effective as the Cymbush super ED. A similar non-significance was observed between the two essential oils at 7DAA and 4AFR, while the 2 applications of Cymbush ED performed statistically the same level of control with that of the 4AFR of the essential oils. However, the higher application regimes of the Cymbush ED recorded the least number of pod damage by pod sucking bugs. The untreated check performed statistically the least control on cowpea pods at all applications.

The effects of the insecticide type and the application frequency on grain yield of cowpea in both years are presented in Table 4. Results in 2005 show that the mahogany oil recorded a significantly ($p \leq 0.05$) lower (1434.30 kg ha⁻¹) grain yield compared to that of neem oil (1643.10 kg ha⁻¹), and the two were significantly ($p \leq 0.05$) better than the control (497.40 kg ha⁻¹), but lower than that of the Cymbush ED. In 2006, the grain yield in mahogany was higher but not significantly ($p \leq 0.05$) different from that of neem oil. These two performed significantly ($p \leq 0.05$) better than the control (123.4 kg ha⁻¹). A significantly ($p \leq 0.05$) higher grain yield was recorded in the Cymbush ED insecticide, (1017.8 kg ha⁻¹) than all the others in 2006.

In both cropping seasons, there were significant ($p \leq 0.05$) differences in grain yields among the three application frequencies, with four applications having the highest and the lowest recorded with two application.

DISCUSSION

There was significant ($p \leq 0.05$) difference among the treatments as regards the population of Pod sucking bugs, in which the differences among the treatments were significant ($p \leq 0.05$) only in 2006, with mahogany oil proving superior to neem oil treated plots. This might be due to changes and/or differences in the weather conditions among the two cropping seasons, as well as the slow but steady action of the mahogany oil.

More so, on pod damage, the two essential oils recorded similar effect in reducing damage in both seasons. In a similar finding, the

effectiveness of mahogany wood ash in the control of maize weevil was reported by Yusuf, (1997). Works carried out in a laboratory to determine the efficacy of some botanicals against *L. trifoli* on cotton revealed that neem oil, neem seed kernel extracts and longifolia oil caused high mortality on the larva of *L. trifoli* at 24 hours after application. Similarly, Oparaeke *et al.* (2006c) reported that all the plant extracts, *Zingiber officinale* (Ginger), *Capsicum annum* (Pepper), *Piper guineense*, *Afromomum melegueta* (Roscoe), *Xylopi aethiopica* (Dunal) A. significantly ($p \leq 0.05$) reduced the number of legume pod borer larvae and pod sucking bugs compared with the untreated control.

The result of this study clearly shows the dependence of the insecticidal activities on application frequency of the essential oils. The reduction in the number of damaged cowpea pods could probably be attributed to the increase in the frequency of application, which had probably increased the potency of the essential oils. It also indicated that the insecticidal activity of the two essential oils increases with frequent sprayings at certain time intervals. This corroborates the findings of several authors, like Afun, *et al.* (1991) who reported that three sprays at bud formation, flowering and podding stages provided adequate protection of cowpea in the absence of pre-flowering insect pests, while calendar schedules recorded lower infestation and/or damage but did not differ between them. This indicated that the total insect kill was not necessarily for optimum cowpea grain yields. However, much earlier Mishra (1984) reported that, application rates for natural products have not been standardized although both volumetric and gravimetric methods are reported in the literature; with a considerable variation in the rates of plant powders which found to be effective against stored product coleopterans.

On the effect of the interaction between the two essential oils and application frequency, the result shows that both essential oils were significantly ($p \leq 0.05$) the same at all the applications frequencies, but the 3 and 4 AFRs were superior than the 2 AFR at 3DAA in 2006. However, the synthetic insecticide was significantly ($p \leq 0.05$) more effective in reducing pod damage by pod sucking bugs complex, than the other treatments even at 2AFR. The control check recorded the highest pod damage by pod sucking bugs complex at 3DAA in 2006 (Table 3). This had demonstrated the potential of mahogany and neem oils to control Pod sucking bugs complex on cowpea plants, compared with the control. According to Oparaeke *et al.* (2006) that all the tested plant extracts significantly ($p \leq 0.05$) reduced the number of legume pod borer larvae by 33-29.3% and pod sucking bugs by 5.6 -21.8% compared to untreated check during the three cropping seasons.

Moreover, Oparaeke (2006a) reported that higher rate (20%) and more frequent applications (4 to 6 weekly applications) could significantly reduce the population of the target pests, protect pods from damage and result in higher grain yields compared with lower extract rate (5%w/v) at all the application schedules. Similarly, the effect of neem extract in reducing thrips incidence in treated plants was reported (Tanzubil, 1991).

Moreover, mahogany oil at all the application frequencies was found to be significantly ($p \leq 0.05$) the same with that of neem oil at 4AFR and effectively better than the 3 and 2AFRs respectively at 7DAA in 2006. The synthetic insecticide at 2AFR was also found to be significantly ($p \leq 0.05$) the same with both essential oils at 4AFR, while statistically better than the two oils at 3 and 4AFRs respectively. It was also reported that garlic bulb extract at 20% with six (6) applications was superior to 50% rate with 2 applications, and was not significantly different from the synthetic insecticide treatment in the control of *Maruca vitrata*. More so, 20% extract with six (6) weekly applications caused significant reduction in Pod sucking bugs population and were superior to 50% extract at all spraying schedules Oparaeke *et al.* (2005b).

The present investigation shows that cowpea grain yield was significantly influenced by insecticide type and application frequency. Mahogany oil recorded (1434.30kg/ha) significantly lower yield compared to neem oil (1643.10kg/ha) in 2005, indicating the superiority of neem oil over mahogany oil. However, a reverse situation was observed with a non significant influence of the two essential oils on grain yield. This indicates the compatibility of mahogany oil to neem in the control of pod sucking bugs complex and therefore, the present study had indicated the insecticidal potential of mahogany along with neem in the management of pod sucking bugs complex as they all performed significantly better than the control check, but not as effective as the synthetic Cymbush ED in increasing the grain yields of cowpea.

In respect of the application frequencies, the four applications have proved to be better than all others. Next to this was the three application frequency, while the two applications remained least effective. This corresponds to the earlier work reported by Oparaeke (2006c) that, there was a significant ($p \leq 0.05$) increase in yields assessed, where the three plant extracts (neem seed, breadfruit, and fermented cassava) gave higher grain yields and better quality grains compared to the other plant extracts, but were all inferior to that recorded in the synthetic insecticide treatments.

CONCLUSION

Results of the findings revealed that the application of mahogany oil three to four times could greatly reduce the number and pod damage on cowpea plant by Pod sucking bugs complex apart from neem oil for subsequent increase in grain yields and hence, could serve as an alternative to neem oil. However, the two oils were not as effective as Cymbush super ED in the management of Pod sucking bugs complex on cowpea in the study area.

RECOMMENDATIONS

It is therefore suggested that, since the performance of mahogany oil was statistically similar to neem oil, resource poor farmers could also be encouraged to use mahogany oil in the control of the Pod sucking bugs complex for a significant increase in cowpea grain yield relative to control. However, further studies could be conducted to find out more on the compounds responsible for the insecticidal activity of mahogany oil and the right dosage of its application; this could play a vital role in the integrated management of the target pests in Bauchi. Also assessment of the essential oils for control of *Megalurothrips sjostedti* and *Aphis craccivora* could be an area of research in the future.

Table 1. Effects of insecticide type and application frequency on the population of pod sucking bugs complex on cowpea during the 2005 and 2006 cropping seasons

Treatments Insecticide Type	2005			2006		
	1DAA	3DAA	7DAA	1DAA	3DAA	7DAA
Mahogany oil	1.00(1.35) ^b	0.94(1.34) ^b	1.14(1.41) ^b	0.61(1.22) ^c	1.33(1.46) ^b	1.11(1.39) ^c
Neem oil	1.06(1.39) ^b	1.00(1.36) ^b	1.25(1.42) ^b	0.89(1.32) ^b	1.31(1.44) ^b	1.39(1.47) ^b
Cymbush ED	0.22(1.09) ^c	0.17(1.07) ^c	0.42(1.16) ^c	0.22(1.09) ^d	0.22(1.09) ^c	0.28(1.11) ^d
Control	8.33(2.96) ^a	9.17(3.09) ^a	7.50(2.85) ^a	4.75(2.36) ^a	6.25(2.66) ^a	5.42(2.56) ^a
SE±	(0.08)	(0.09)	(0.08)	(0.06)	(0.06)	(0.06)
Application Frequency						
Two	2.98(1.82) ^a	2.94(1.75)	2.83(1.80) ^a	1.83(1.57) ^a	2.73(1.81) ^a	2.39(1.74) ^a
Three	2.56(1.67) ^b	2.81(1.71)	2.44(1.67) ^b	1.58(1.48) ^b	2.10(1.61) ^b	1.98(1.59) ^b
Four	2.42(1.61) ^b	2.71(1.68)	2.46(1.67) ^b	1.44(1.44) ^b	2.00(1.57) ^b	1.77(1.53) ^c
SE±	(0.09)	(0.09)	(0.07)	(0.05)	(0.05)	(0.05)

Means in parentheses followed by same letters within same column are not significantly different at $P \leq 0.05$ according to SNK test

Figures in parentheses are means of square root transformation. DAA = Days after treatment application.

Table 2. Effects of insecticide type and application frequency on pod damage by pod sucking bugs complex on cowpea during the 2005 and 2006 cropping seasons.

Treatments Insecticide Type	2005			2006		
	1DAA	3DAA	7DAA	1DAA	3DAA	7DAA
Mahogany oil	28.94(5.35) ^b	32.89(5.60) ^b	26.08(5.11) ^b	20.50(4.58) ^b	20.44(4.59) ^b	23.86(4.94) ^b
Neem oil	26.53(5.13) ^b	33.03(5.59) ^b	25.33(5.04) ^b	20.06(4.51) ^b	18.67(4.60) ^b	24.39(5.01) ^b
Cymbush ED	15.75(4.04) ^c	22.58(4.71) ^c	17.06(4.19) ^c	14.78(3.86) ^c	09.06(3.04) ^c	13.64(3.70) ^c
Control	49.58(7.02) ^a	55.58(7.28) ^a	47.67(6.91) ^a	35.08(5.97) ^a	34.17(5.92) ^a	38.58(6.27) ^a
SE±	(0.17)	(0.27)	(0.15)	(0.13)	(0.10)	(0.11)
Application Frequency						
Two	33.79(5.73) ^a	40.90(6.23) ^a	31.21(5.54) ^a	24.92(4.99) ^a	23.50(4.85) ^a	28.19(5.33) ^a
Three	29.67(5.35) ^b	35.69(5.78) ^b	29.56(5.37) ^b	22.38(4.71) ^b	19.83(4.44) ^b	25.38(5.03) ^b
Four	27.15(5.08) ^c	31.48(5.38) ^c	26.33(5.03) ^c	20.52(4.47) ^c	18.42(4.20) ^c	21.79(4.57) ^c
SE±	(0.15)	(0.23)	(0.13)	(0.12)	(0.08)	(0.09)

Means in parentheses followed by same letters within same column are not significantly different at $P \leq 0.05$ according to SNK test

Figures in parentheses are means of square root transformation.

DAA = Days after treatment application.

Table 3. Effects of interaction between insecticide type and application frequency on number of pod damage by Pod sucking bugs complex at 3DAA and 7DAA on cowpea during the 2006 cropping season.

Treatments	Frequency of application		
	2AFR	3AFR	4AFR
3DAA			
Mahogany oil	22.58(4.83)b	19.50(4.50)c	19.25(4.46)c
Neem oil	24.33(4.98)b	15.58(4.04)c	16.08(4.09)c
Cymbush ED	12.92(3.67)d	10.08(3.28)e	04.17(2.15)f
Control	34.17(5.92)a	34.17(5.92)a	34.17(5.92)a
LS		*	
SE±		(0.16)	
7DAA			
Mahogany oil	28.17(5.36)b	24.00(4.96)c	19.42(4.49)d
Neem oil	27.50(5.32)b	24.25(5.00)c	21.42(4.70)d
Cymbush ED ED	18.50(4.38)d	14.67(3.89)e	07.75(2.83)f
Control	38.58(6.27)a	38.58(6.27)a	38.58(6.27)a
LS		*	
SE±		(0.18)	

Means in parentheses followed by the same letters within and across column are not significantly different at $p \leq 0.05$ according to SNK test.

Figures in parentheses are means of square root transformation.

LS = Level of Significant AFR = Application Frequency

*= Level of Significant at 5% level DAA = Days After Application

Table 4. Effects of insecticide type and application frequency against *Maruca vitrata* and Pod sucking bugs complex on cowpea grain yield during the 2005 and 2006 cropping seasons.

Treatments	Grain Yield (kg ha ⁻¹)	
	2005	2006
Insecticide Type		
Mahogany oil	1434.3(3.141)c	748.4(2.866)b
Neem oil	1643.1(3.188)b	710.9(2.842)b
Cymbush ED	2388.6(3.371)a	1017.8(3.004)a
Control	497.4(2.685)d	123.4(2.078)c
SE±	(0.03)	(0.03)
Application Frequency		
Two	1205.7(3.021)c	570.3(2.656)c
Three	1497.3(3.106)b	666.1(2.705)b
Four	1770.3(3.262)a	713.9(2.732)a
SE±	(0.03)	(0.02)

Means in parentheses followed by the same letters within same column are not significantly different at $p < 0.05$ according to SNK test.

Figures in parentheses are means of square root transformation.

REFERENCES

- Afun, J. V. K.; Jackai, L. E. N. and Hodgson, C. J. (1991). Calendar and monitored insecticide application for the control of cowpea pests. *Crop Protection*, **10**: 363 - 369.
- Allen, D.J.; Ampofo, J.K.O. and Wortmann, C.S. (1996). **Pests, Diseases and Nutritional Disorders of the Common Bean in Africa: A Field Guide**. Cali, Colombia: International Centre for Tropical Agriculture; Wageningen, The Netherlands: Technical Centre for Agricultural and Rural Cooperation, 1996. 132p. (CIAT Publication; NO. 260).
- Ansari, A. K. and Singh, I. J. (1984). Agronomic aspect of cowpea production in North Western Nigeria. In: Programme and Abstracts. *World Cowpea Research Conference*, IITA, Ibadan, Nigeria, 4th - 9th November 1984. 84pp.
- FAO, (2004). FAOSTAT, Agricultural Database, <http://www.fao.org>.
- Ivbijaro, M. F. and Bolaji, O. O. (1990). Effects of Cypermethrin + Dimethoate and extracts of *Piper guineense* and *Azadiracta indica* on the pests and yield of cowpea, *Vigna unguiculata*. *Journal of Agricultural Science, Cambridge*. **115**: 227 - 231.

- Lale, N. E. S. (1992). A laboratory study of the comparative toxicity of products from four species on cowpea bruchid and maize weevils in air tight storage facilities. *Samaru Journal of Agricultural Research*. **11**: 79 – 84.
- Mishra, R.C. (1984). Effect of mixing the menthe powders with the giving oil-in-water Emulsion Dip to the chickpea on pulse beetle, *Callosobruchus chinensis* Linn. *Bulletin of Grain Technology*. **22**: 19 – 19.
- NCGRB. (2005). Crop varieties released and registered in Nigeria. National Center for Genetic Resources and Biotechnology, Federal Ministry of Science and Technology, Moor Plantation, Ibadan, Nigeria. 268-269.
- Oparaeke, A.M.; Dike, M.C, and Amatobi. C.I. (2005). Effect of application of different concentrations and appropriate schedules of aqueous garlic (*Allium sativum* L.) bulb extract against *Clavigravilla tomentosicollis* on cowpea, *Vigna unguiculata* (L.) Walp. ISSN 0323-5408 print/ISSN 1477-2906 online © 2006, Taylor and Francis. DOI: 10.1080/03235400383941. *Achives of Phytopathology and Plant Protection* **38**:1 – 6pp.
- Oparaeke, A.M.; Dike, M.C.; and Amatobi, C.I. (2006) Field evaluation of extracts of five Nigerian spices for control of post-flowering insect pests of cowpea, *Vigna unguiculata* (L.) Walp. *Plant Protection Science*, **41**(1): 14 – 20.
- Oparaeke, A.M. (2006a). Bio-potential of different rates and application schedules of *Xylopi aethiopica* (Dunal) A. Rich extracts for control of *Maruca* pod borer and spink bug on cowpea plants. *Journal of Plant Sciences*. **1**(2): 126 – 131.
- Oparaeke, A.M. (2006b). Pesticidal activity of three rates and spraying frequencies of extracts of *Xylopi aethiopica* (Dunal) A. Rich for reducing thrips infestation on cowpea flowers. *Journal of Plant Sciences*. **1**(2): 119 – 125.
- Stoll, G. (1988). **Natural crop protection based on local farm resource in the tropics and sub-tropics**. 3rd edition, Weikerssheim, Germany, Margraf publishers, Scientific books. 188pp.
- Tanzubil, P.B. (1991). Control of some insect pests of cowpea (*Vigna unguiculata*) with neem (*Azadiracta indica* A. Juss.) in northern Ghana. *Tropical Pest Management*. **37**(3): 216-217.
- Yusuf, S. R. (1997). Laboratory Evaluation of Five Plant Products for the Control of *Sitophilus zeamais* (Motsch.) (Coleoptera:Curculionidae) in Stored Maize. Unpublished M.Sc. Thesis, Abubakar Tafawa Balewa University, Bauchi, Nigeria. 57pp.