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Field evaluation of mineral oils for insect pests management and yield of cowpea (*Vigna Unguiculata)* (L) walp in Abraka, Southern Nigeria

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ABSTRACT

Mineral oils have been successfully used as insecticides to control insect pests on several crops such as cotton in many parts of the world. Such work is yet to be reported in Nigeria. This study assayed the effectiveness of three mineral oils - premium motor spirit (PMS), dual purpose kerosene (DPK) and automotive gas oil (AGO) at 0.4% concentration in the management of four major insect pests of cowpea, namely the cowpea aphid, Aphis craccivora Koch, legume bud thrips, Megalurothrips sjostedti Tryb, legume pod borer, Maruca vitrata Fab. and pod sucking bugs. It also assessed influence of pests control on cowpea yield. The field trials were carried out during the early and late seasons on a public land about half kilometre to Campus 2 of Delta State University, Abraka, Southern Nigeria. The results indicated that all the tested mineral oils effectively controlled M. sjostedti damage in the early season. Similarly, AGO controlled M. vitrata and pod sucking bugs. DPK equally controlled coreid bugs. In the late season, A. craccivora and coreid bugs were reduced by all the mineral oils. In the early season, grain yields were high as follows: 1,342.90 kg ha^{-1}, 963.30kg ha^{-1}, 836.70 kg ha^{-1} and 917.80kg ha^{-1} for DPK, PMS, AGO and control respectively. In the late season, yields were 763.30kg ha^{-1}, 634.60kg ha^{-1}, 578.00kg ha^{-1} and 375.00kg ha^{-1} for AGO, PMS, DPK and control respectively. Grain yields were significantly higher ($P<0.05$) in the early than late season. Delay and reduced flowering were observed in the field. Elimination of these factors could improve the use of mineral oils in the cultivation of cowpea. The information given here can be used to strengthen the integrated pest management programme in the control of cowpea insect pests.

Key words: Cowpea, insect pests, mineral oils, early/late, Abraka, Southern Nigeria.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is a major food crop cultivated in the tropics and sub-tropics for its dry grains as source of cheap plant protein [1] for man in many African countries. Cowpea protein is becoming an alternative to meat, fish and egg protein which have gone out of the poor man's reach because of its high cost. Cowpea protein has been referred to as “poor man's meat [2]. The crop is also rich in minerals, fats, oils and vitamins. Because of its value to man and livestock used as fodder crop [3] its demand in recent times has increased.

The crop is intensively and extensively grown in the Sudan savanna zone of Northern Nigeria and bulk production in Africa is obtained from this agro-ecological zone [4]. Though cultivated mainly in the drier regions of Northern Nigeria, cowpea has rapidly found its cultivation in Southern Nigeria and is now being grown in the West and East [5-6].

Important and promising as a "crop of hope" to man, efforts to increase yields are being countered and thwarted by certain biotic factors which are largely responsible for low yields in African countries [7]. The activities of insect pests and diseases have been clearly identified as biotic agents which contribute largely to cowpea low yield [8-9]. Insects of various orders attack and damage the crops in the field, at all growth stages [10]. These include the cowpea aphid, *Aphis craccivora*, Koch, flower bud thrips, *Megalurothrips sjostedti* Tromb, the legume pod borer, *Maruca vitrata* Fab, and a complex of pod sucking bugs among which are *Clavigralla tomentosicollis* Stal, *Anoplocnemis curvipes* Fab, *Aspavia armegera* L and *Nezera viridula* Fab [7]. Without their control, reasonable yield is not obtained from cowpea farms [11-12]. The application of synthetic insecticides, have been the main weapon for control and a number of them are effective [13-14] and increase in yield, several folds have been recorded [15]. Though the use of insecticides against pests is encouraging, their use have deleterious effect on crops, users, consumers, non target organisms and the environment generally [1]. This seems to suggest that chemicals should be discarded for other control alternatives. However, the warning is that total abandonment of pesticides would worsen the already declined food situation [16] and recommendation is that, their use should be minimised. To achieve this, control measures to compliment insecticide usage should be sourced for. Host plant resistance (HPR) and insecticides of plant origin are fast becoming component of integrated pest management. Mineral oils (refined petroleum products) have been successfully used to control insect pests of several crops in many parts of the world [17-19]. In Nigeria, information on the use of mineral oils in insect pest control is at present lacking. This work evaluates three mineral oils - premium motor spirit (PMS), dual purpose kerosene (DPK) and automotive gas oil (AGO) for the control of major field insect pests of cowpea and influence on yield during the early and late cropping seasons in Abraka, Southern Nigeria.

MATERIALS AND METHODS

The field study was conducted during the early and late planting seasons of 2005, on a public land, half a kilometre to Campus 2, Delta State University Abraka, Ethiope East Local Government Area. The land was measured out and was manually prepared with hoes and shovels in both seasons. Experimental plot size for the study was 5m x 3m and in-between the plots was 1.5m. The cowpea seeds planted was Ife brown (obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Planting during the early season took place on the 14th of June, 2005 and late season planting took place on the 29th of September, 2005. Three seeds were planted per hole and planting space of 60cm x 30cm was adopted [20]. Seeds which did not germinate after 4 days were replaced. Thinning to 2 plants per stand was carried out 10 days after planting (DAP). Each plot consisted of 6 rows of 36 plants. The chemicals applied on the crops were mineral oils (non-conventional chemicals) and a conventional chemical – cypermethrin for comparison purposes. After a concentration study of each mineral oil from 0.1 - 0.5 percent on one month old cowpea plants, 0.4 concentration for each mineral oil was chosen as non-toxic and best suitable for the crop. Chemical application commenced when the field crops were 25 DAP and was done weekly for 5 times. Throughout, the farm was kept weed free.

The experiment was a randomised complete block design consisting of 5 treatments and 3 replicates. The treatments were plots sprayed with:

(1) Premium motor spirit (PMS)
(2) Dual purpose kerosene (DPK)
(3) Automotive gas oil (AGO)
(4) Cypermethrin and
(5) Plots without chemical treatment

The effect of chemical application on four notorious insect pests of cowpea was observed.

Insect observations and data collection

Aphis craccivora: *A. craccivora* infestation was assessed weekly from the 2 central rows of each plot, between 8 and 10 a.m., beginning from 26 DAP. Twenty cowpea stands in the two middle rows were randomly selected and tagged. Each was observed for aphid infestation and the colony size was visually scored on a scale of 10 points (Table 1). The mean score was then calculated. Six observations were made.

Megalurothrips sjostedti: Damage to cowpea was determined when the plants were 30 DAP. From the two middle rows of each plot, twenty cowpea stands were randomly selected, tagged and were observed between 8 and 10 a.m. at 5 days' intervals. Damage to each stand was visually rated based on known symptoms of *M. sjostedti* such as drying/browning of stipules/leaves, bud abscission, etc on a scale of 1-9 points (Table 2). The mean score in each plot was then calculated. Four observations were made.

Maruca vitrata: Damage to cowpea by *M. vitrata* was assessed from flowers in the two outer rows of each plot beginning from 45 DAP.

Table 1. Scale for rating aphid infestation on cowpea

Rating	Number of aphids	Appearance
0	0	no infestation
1	1-4	a few individual aphids
3	5-20	a few isolated colonies
5	21-100	several small colonies
7	101-500	large isolated colonies
9	>50	large continuous colonies

Source: Litsinger *et al*. [21]

Table 2. Scale for rating flower bud thrips infestation on cowpea

Rating	Appearance
1	no browning/drying (i.e scaling) of stipules, leaf or flower buds; no bud abscission
3	initiation of browning of stipules, leaf or flower buds; no bud abscission
5	distinct browning/drying of stipules and leaf or flower buds; some bud abscission
7	serious bud abscission accompanied by browning/drying of stipules and buds; non elongation of peduncles
9	very severe bud abscission, heavy browning, drying of stipules and buds; distinct non-elongation of (most or all) peduncles.

After Jackai and Singh [22]

Table 3: Scale for rating *Maruca vitrata* damage to cowpea

Pod load (PL)		Pod damage (PD)	
Rating	Degree of podding	Rating	%
1 3	most (<60% peduncles bare (i.e. no pods) 31-50% peduncles bare	1 2 3	0-10 11-20 21-30
5	16-30% peduncles bare	4 5 6	31-40 41-50 51-60
7	Up to 15% peduncles bare	7 8	61-70 71-80
9	Occasional bare beduncles	9	81-100

After Jackai and Singh [22]

Twenty flowers were randomly opened and examined on the spot for *Maruca* larva/damage between 3 and 5 p.m. at the intervals of 6 days. Also, the number of *M. sjostedti* an insect which fed on pollen was counted when each flower was opened. Mean score for both insects was then calculated.

Pod Sucking bugs: Damage to cowpea by pod sucking bugs was determined weekly from the two middle rows of each plot at 45 DAP, between 8 and 10.00 a.m. The number of PSBs that rested on the plants was counted and recorded. All adults and those beyond the nymphal stage were counted since they do similar damage. The mean for PSBs in each of the plots was then calculated.

Yield and yield related components

Yield data

From the 2 central rows of each plot, the pods at 65DAP were harvested and kept in black polythene bags according to treatments. They were sundried for 2 weeks and shelled with hands. With a Tripple Beam Balance (Haus model) the grains were weighed and the weight recorded. The yield per plot was extrapolated to kg ha^{-1}. One hundred seeds were hand-picked from the grains in each bag (plot), weighed and the weight recorded.

Pod load and pod damage:

From the 2 central rows of each plot, pod load and pod damage by *Maruca* were rated visually on a scale of 1-9 points (Table 3). The damage index were the presence of frass and holes on pods and sticking of pods.

Pod evaluation index (IPe): This was assessed with the formula - PL x (9-PD) where PL was pod load and PD was pod damage [22].

Number of pods per plant: Assessment was made when plants were 60DAP. From the two middle rows, one metre ruler length of cowpea was marked with 2 sticks. All the pods and their stands that fell within this range were then counted and number of cowpea pods was then divided by the number of stands.

Pod and seed damage: Pod and seed damage due to pod sucking bugs were determined in the laboratory. From the 2 middle rows of each plot, matured pods were harvested into medium size bags according to plot number. These pods were sundried for one week. From each bag, twenty

pods were then hand-picked randomly. Each pod was measured with a flexible thread to determine its length. With hand, each was carefully opened and the seeds per pod, aborted seeds per pod, wrinkled seeds per pod and seeds with feeding lesions per pod were observed, recorded and the mean calculated.

Data for insect observation, yield and yield related components were subjected to analysis of variance (ANOVA) and significant means were separated by Fisher's Least Significant Difference Test (LSD), at 5% level of significance.

RESULTS

The effect of mineral oils and cypermethrin application for the control of major insect pests on cowpea in the early and late season experiments at Abraka is given in Table 4.

All the major insect pests were observed in the study area during the early season experiment. The mineral oils treatment did not significantly ($P > 0.05$) reduce the population of *A. craccivora* when compared to control. Also, the treatments were not significantly different. All the treatments significantly ($P < 0.05$) reduced the damage to cowpea by *M. sjostedti*. There was no significant difference among the treatments. With respect to flower bud thrips, the population from chemically treated cowpea was not significantly different from the control. The CPM was slightly more effective in suppressing the thrip population than the other treatments. There was no significant difference among the mineral oils treatments.

All the treatments did not significantly reduce *Maruca* damage and PSB population when compared with the control and no significant difference among the mineral oils treatments.

For *M. vitrata*, the treatments did not significantly reduce *Maruca* damage when compared with the control and no significant difference among the mineral oils treatments. However, AGO, was slightly more effective in reducing *Maruca* damage than PMS and DPK. Furthermore, CPM had the least *Maruca* damage. The DPK and AGO treatments were slightly more effective in suppressing the PSB population than PMS and CPM treatments.

In the late season experiment, all the major insect pests were recorded on the crop, in the study area. The mineral oils treatments did not significantly ($P>0.05$) reduce *A. craccivora* population and *M. vitrata* damage to cowpea when compared to control. Moreover, the mineral oils treatments were similar in their effect on *A. craccivora* population. The CPM treatment, however, significantly ($P < 0.05$) reduced the aphid population and *Maruca* damage when compared to control but was not significantly more effective in reducing aphid population and *Maruca* than the mineral oils. All treatments were not significantly different from the control in thrips control, although this (control) slightly had higher cowpea damage. Apart from AGO, the CPM was not significantly more effective in reducing *Maruca* damage, when compared with other mineral oil treatments.

PSBs were not encountered in the study area - an unusual situation in the late planting season.
The seasonal effect of the application of mineral oils on major insect pests of cowpea is presented in table 5. *A. craccivora* population was not significantly different in the two seasons. However, early season population was slightly higher than late season population. *M. sjostedti* damage to flower buds in both seasons was similar, though early season damage was slightly higher. For flower bud thrips, the population was significantly ($P < 0.05$) higher in the late

season when compared with early season population. On *M. vitrata* damage to flowers, it was more in the late season and significantly higher than early season damage. There was no significant difference in the population of PSB in the two seasons. However, early season population was more in number.

Yield and yield related components from cowpea under application of mineral oils during the early and late seasons at Abraka.

The effect of mineral oils and cypermethrin on cowpea yield and yield related components in the early and late seasons in Abraka is presented in table 6.

Insecticide protected plots did not significantly (P>0.05) increase yields when compared with plots without insecticide protection during the early season. Yields from CPM, DPK and PMS treated plots produced slightly more yields than control plots and AGO plots. Yields were highest in CPM treated plots and least in AGO treated plots. With regards to 100 seed weight, all the treatments were at par except AGO - treated plots where seeds were significantly higher than DPK -treated plots. All the yield related components were not significantly different from the control (Table 6).

In the late season, the mineral oils protected plots did not significantly (P > 0.05) increase yield when compared with the control (Table 6). However, with cypermethrin, the yields were significantly (P < 0.05) higher compared with control and mineral oil protected plots. Yields were moreover slightly higher in mineral oils protected plots than the control. Except for pod damage and wrinkled seeds/pod, all yield related components from chemically treated plots showed significant difference compared to control (Table 6).

The seasonal effect on yield and yield related components from cowpea under the application of mineral oils and cypermethrin in the early and late seasons in Abraka is presented in table 7.

Early season grain yields were significantly (P < 0.05) higher than late season. On 100 seeds weight, late season seeds weighed significantly (P <0.05) higher than early season seeds. With number of pods per plant, early plants had pods more which were significantly higher than late season. For pod length, both seasons were not significantly different. The number of seeds per pod, was more in the early season and significantly (P < 0.05) higher than pods compared with late season. Also, pod load was higher significantly in the early season than late season. With pod damage, damage was significantly (P <0.05) higher in the late season than early. For pod evaluation index, early season cowpea had significantly higher Ipe. value than late season. Aborted seeds were significantly (P < 0.05) higher in the early season than late season while in the case of wrinkled seeds, late season recorded significantly higher number than the early season. For seeds with feeding lesions, there was no significant difference between early and late season data.

Table 4: Effect of mineral oils and cypermethrin application on cowpea major insect pests in the early and late seasons at Abraka

	Treatments	*Aphis craccivora* (rating)**	*Megalurothrips sjostedti* (rating)	Flower bud thrips* (actual counting)	*Maruca vitrata** (actual counting)	PSB** (actual counting)
Early season	CONTROL	1.61	1.33	0.04	0.03	0.00
	PMS	1.89	1.00	0.05	0.04	0.11
	DPK	2.44	1.00	0.06	0.03	0.00
	AGO	1.78	1.00	0.05	0.01	0.00
	CPM	1.89	1.00	0.00	0.00	0.11
	LSD(0.05)	NS	0.29	NS	NS	NS
Late season	CONTROL	2.22	1.00	4.46	0.09	0.00
	PMS	2.06	1.00	4.16	0.10	0.00
	DPK	1.61	1.00	3.43	0.15	0.00
	AGO	1.72	1.00	3.38	0.26	0.00
	CPM	1.50	1.00	2.06	0.03	0.00
	LSD(0.05)	0.65	NS	1.43	0.19	NS

PMS - Premium motor spirit, DPK - Dual purpose kerosene, AGO - Automotive gas oil
CPM - Cypermethrin, N.S - Not significant
** Means of 20 flowers*
*** Number per 2-middle rows*

Table 5: The seasonal effect of the application of mineral oils on the major insect pests of cowpea at Abraka

Treatments	*Aphis craccivora* (rating)	*Megalurothrips sjostedti* (rating)	Flower bud thrips* (actual counting)	*Maruca vitrata** (actual counting)	PSB** (actual counting)
Early	1.92	1.07	0.04	0.02	0.04
Late	1.82	1.00	3.48	0.12	0.00
LSD (0.05)	NS	NS	0.45	0.06	NS

** Means of 20 flowers*
*** Number per 2 middle rows*
NS-Not significant

Table 6: Effect of mineral oils and cypermethrin on yield and yield related components from cowpea in the early and late seasons in Abraka

	Treatments	Dry Grain yield (kg ha^{-1})	100 seeds wt(g)	Number of pods/ plant (approx)	Pod length (cm)	Number of seeds/pod	Pod load	Pod damage	Pod evaluation index	Aborted seeds/pod	Wrinkled seeds/pod	Seeds with feeding lesions
Early season	CONTROL	917.80	13.47	5.61	13.52	12.55	8.33	1.67	61.33	3.08	0.15	0.07
	PMS	963.30	13.33	10.06	13.31	12.55	9.00	1.33	69.00	3.12	0.32	0.25
	DPK	1342.90	13.60	9.96	13.36	13.03	9.00	1.00	72.00	2.93	0.28	0.42
	AGO	836.70	12.87	6.88	13.27	11.90	8.67	1.33	66.33	2.80	0.35	0.03
	CPM	1413.00	13.37	9.52	13.42	12.97	9.00	1.33	69.00	2.82	0.30	0.02
	LSD (0.05)	NS	0.73	NS	NS	NS	NS	NS	NS	NS	NS	NS
Late season	CONTROL	378.30	11.77	2.94	12.21	8.80	3.33	5.00	20.33	0.13	0.50	0.13
	PMS	634.60	17.87	8.06	12.67	10.15	6.33	3.00	38.33	0.07	0.70	0.20
	DPK	578.00	18.63	7.96	13.65	11.07	4.67	5.00	21.67	0.07	1.08	0.13
	AGO	763.30	16.83	4.88	12.29	11.28	6.67	3.00	41.67	0.02	0.60	0.07
	CPM	1482.60	11.77	7.53	13.02	11.05	9.00	2.00	63.00	0.23	0.63	0.00
	LSD (0.05)	388.45	4.29	3.76	1.24	2.12	4.01	NS	36.02	0.18	NS	0.10

PMS - Premium motor spirit, DPK- Dual purpose kerosene, AGO - Automotive gas oil, CPM - Cypermethrin, N.S - Not significant

Table 7: The effect of early and late season on yield and yield related components from cowpea under mineral oils application at Abraka

Season	Dry Grain yield (kg ha^{-1})	100 seeds wt(g)	Number of pods/ plant (approx)	Pod length (cm)	Number of seeds/pod	Pod load	Pod damage	Pod evaluation index	Aborted seeds/pod	Wrinkled seeds/pod	Seeds with feeding lesions
Early	1094.70	13.33	8.41	13.37	12.60	8.80	1.33	67.53	2.95	0.28	0.14
Late	767.40	16.36	6.27	12.97	10.47	6.00	3.60	37.00	0.10	0.70	0.11
LSD(0.05)	216.42	1.31	1.68	NS	0.81	1.13	1.36	11.11	0.33	0.24	NS

PMS - Premium motor spirit, DPK- Dual purpose kerosene, AGO - Automotive gas oil CPM - Cypermethrin, N.S - Not significant

DISCUSSION

Najar *et al*. [23-24] reported the effectiveness of mineral oils against the cotton aphid, *Aphis gossyppi* Gover. Similarly, work using petroleum spray oils to control the damage of insect pests on crops have been documented [17-19]. Reports from Israel also showed that many insect pests on crops have been subdued using petroleum sprays as contact insecticide (Emosairue, personal communication).

During the early season in the study area, the mineral oils were not effective in aphid control. Aphids rarely fly and are not highly mobile. Therefore, insecticidal sprays should have touched and killed them or made them sluggish. Possibly, the time the insecticide was applied was inappropriate or a washing away of insecticides occurred. Furthermore, the mineral oils (PMS, DPK and AGO) may have very short residual life as they are readily volatile. For *M. sjostedti* damage, the data have shown that mineral oils were effective tools against the activities of thrips on cowpea. This report is consistent with previous work of the efficacy of petroleum spray oils against field insect species. In terms of population of thrips, the results revealed that the insecticide was not effective. It could be that a population pressure of the insect occurred after insecticide application had stopped. The results have given support to the effectiveness of CPM against flower thrips insects. The legume pod borer, *Maruca vitrata* was effectively controlled by AGO and since the least damage was recorded in cypermethrin treated plots, it shows that CPM was superior to mineral oils in thrip control. DPK and AGO performed better in suppressing the coreid bugs than PMS and CPM.

In the late season, *A. craccivora, M. sjostedti* damage, flower bud thrips population and *Maruca vitrata* damage were not affected by mineral. Probably, the insecticides were less effective because of rain effect, due to a washing away of the chemicals. However, the study indicated the control effect of CPM on aphid, thrip population and *M. vitrata* as has been reported by early cowpea researchers [25] [15]. The non appearance of PSBs in all the treatments was unusual, since the general trend of PSB population in the late season is that of abundant occurrence [26-27]. It could be that mineral oils as insecticide have very strong pungent and repellent property against PSB.

The seasonal effect, indicated that *A. craccivora* population, *M. sjostedti* damage and population of coreid bugs were significantly higher in the early season than late season. This being so in the early season, presents a rather difficult explanation, judging from the past that the area had not received cowpea cultivation for several years and more so rains were heavier in the early season. Most probably, a washing of the chemical occurred and could not affect these insects. Second, alternative host plants (wild plants) such as some like *Centrocema pubiscens, Puereria spp*., which could have harboured the insects were close to the farm and they (insects) easily migrated to the cowpea field. For the higher population of flower bud thrips and *Maruca* damage, in the late season, this possibly could be due to population pressure of the insects which may have resulted from early planting insect population.

Under mineral oils application, grain yields were high in the early season in the study area. Cypermethrin treated plots (for comparison purposes) had the highest yields (1413.00kg ha^{-1}), followed by DPK (1342.90 kg ha^{-1}), PMS (963.30 kg ha^{-1}) and AGO (836.70kg ha^{-1}). The yields compared favourably with yields from some other parts of Nigeria – Bauchi [28-29] and Calabar [30]. Yields from the control plots (917.80 kg ha^{-1}) were equally high. The high yields from all the plots may be due to light insect load on the crop during this period and high nutrients absorbed from the soil resulting in optimum plant development. Apart from the

one hundred seed weight and seeds with feeding lesions, all other yield related components were not statistically different in values.

In the late season, yields from mineral oils application were high; cypermethrin had the highest yield (1482.60kg ha^{-1}) followed by AGO (763.30 kg ha^{-1}), PMS (634.60kg ha^{-1}) and DPK (578.00kg ha^{-1}). The control had poor yield (378.30kg ha^{-1}) as expected in unprotected plots. The yields in mineral oils were lower than CPM probably because of the delay and less flowering effect on cowpea by mineral oils. Most of the yield related components from the unprotected plots performed poorly when compared with components from protected plots. This was probably due to exposure to insect pest damage. The seasonal effect (early and late seasons compared) showed that grain yields in the two seasons - early yields (1094.70kg ha^{-1}) and - late yields (767.00kg ha^{-1}) were quite high and compare favourably with grain yield from Mokwa and Bida, Nigeria [31]. The data obtained give support to the incorporation of mineral oils into cowpea production, once the constraints (toxicity issues and flowering delay) are resolved. Grain weight in the late season was better than early grain weight. Apart from aborted seeds per pod, and seeds with feeding lesions, all other yield related components had values which favoured cowpea production in the early season when compared with late season production.

It is hoped that this preliminary work on the efficacy of mineral oils in cowpea insect pest management could form baseline for further research.

CONCLUSION

The control of cowpea insect pests and moderate grain yield recorded in the study area indicate that mineral oils can be reliable non-conventional insecticides (at 0.4 percent) for cowpea growers. If the delay and reduction in flowering are removed, mineral oils could form new components in the overall management of cowpea pests in Nigeria.

REFERENCES

[1] Alabi, O.Y., Odebiyi, J.A. and Jackai, L.E.N, *International Journal of Pest Management*, **2003,** 49 (4), 287-291
[2] Aykroyd, W.R. and Doughty, *J. Legumes in Human Nutrition*. FAO. Nutrition Studies 19, FAO, Rome, **1982.**
[3] Rachie, K.O. Introduction. P. xxi xxviii. In: S.R. Singh and K.O. Rachie (eds). Cowpea research, production and utilization. Wiley New York, **1985**
[4] Singh, S. R. and Rachie, K.O. Cowpea Research and Utilization (New York: John Wiley and Sons), **1985,** P. 460
[5] Ejiga, N.O., *Savannah Dec*., **1979**, 8 (2), 70-83
[6] FOS Annual Abstract of statistics, Lagos, Nigeria, **1995.**
[7] Olatunde, J.A. Odebiyi, Chiang, H.S. and Jackai, L.E.N. *Insect Sci. Applic*., **1991**, 12 (4), 455-461
[8] Taylor, T.A., *Grower Producer,* **1964,** *3* (2)
[9] Booker, R.H. *Bulletin of Entomological Research*, **1965**, 55, 663-672.
[10] Jackai, L.E,N., Roberts, J.M.F. and Singh, S.R. *Crop Protection*, **1988**, 7: 384-390.
[11] Matteson, P.C. *Trop. Pest Manage*, **1982**, 28, 372-380.
[12] Jackai, L.E.N. and Singh, S.R. New foloiar insecticides for the control of cowpea pests. In: Proc. 1986 Br. *Crop Prot*. Conf-Pests diseases, **1986**, 761-768

[13] Ayoade, K.A. *International Institute of tropical Agriculture*, Ibadan, Nigeria., **1975**, pp. 44-51
[14] Jackai, L. E. N. The use of neem in controlling cowpea pests, IITA Research No 7. September, 1993, **1993**
[15] Jackai, L.E.N. and Daoust, R.A. *Annual Review of Entomology* **1986**, 31, 95 119
[16] Stern V. M. Economic threshholds. *A. Rev. Entomol*. **1973**, 18. 259-280.
[17] Mensah, R. K., Frerot, B. and AL Dabel, F. *International Journal of Pest Management* 51, **2005a,** (2) 111 -119.
[18] Mensah, R. K., Liang, W., Gibb, D., Coates, R. and Johnson, D. *International Journal of Pest Management*, **2005b,** 51 (1) 63-70.
[19] ALdabel, F., Mensah, R. K. and Frerot, B. *International Journal of Pest Management* (In press), **2007**
[20] Remison, S.U. Cowpea agronomy works at National Cereals Research Institute. Paper presented at the 1st National meeting. On development of package. Recommendations for legume crops at N.C.R.I, Ibadan, 7-8 February, **1978e**
[21] Litsinger, J.A., Quirino, C.B., Lumaban, M.D. and Bandong, J.P. Grain Legume Pest Complex of Three Phillipine Rice-Based Cropping System. Cropping Program, IRRI. Los Banos. Philippines, 39, **1977**.
[22] Jackai, L.E.N. and Singh, S.R. *Tropical Grain Legume Bulletin*, **1988**, *35*: 2-18.
[23] Najar, R. A. J., Walter, G. H. and Mensah, R. K. *Pest Management Science* **2007a**, 63; 586-595.
[24] Najar, R. A. J., Walter, G. H. and Mensah, R. K. *Pest Management Science* **2007b** 63; 596-607.
[25] Karungi, J., Adipala, E., Ogenga-latigo, M.W., Kyamanywa, S. and Oyobo, N. *Crop Prot*. **2000** 19, 231-136.
[26] Dina, S. O. *J. Agric, Camb*. **1982,** 99. 471-478
[27] IITA Annual Report for 1982. Ibadan, Nigeria **1983**.
[28] Degri, M. M. and Hadi, H. M. *ESN Occasional Publication*, **2000,** 32 (113-118)
[29] IITA Annual Report for 1986, Ibadan, Nigeria, **1986**.
[30] Emosairue, S. O., Eze, D. E. and Okore, I. K. *Journal of Applied Chemistry and Agricultural Resource* **1994**, 1 (1), 6-11.
[31] Afun, J.V.K., Jackai, L.E.N. and Hodgson, C.J. *Crop Protection*, **1991**, 10: 363-370.