INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–6–987–993
http://www.ijab.org

Pre-harvest Spray of Neem (*Azadirachta indica* A. Juss) Seed Products and Pirimiphos-methyl as a Method of Reducing Field Infestation of Cowpeas by Storage Bruchids in the Nigerian Sudan Savanna

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ABSTRACT

The efficacy of neem seed oil (NSO) applied in water at the rate of 20 ml/l and aqueous neem seed extract (ANSE) applied at the rate of 50 g/l, in reducing field infestation of cowpeas by storage bruchids was compared with that of pirimiphos-methyl (PMM) (Actellic 25 EC®) applied at the recommended rate of 2 ml/l to plants in 16 m^2 experimental plots in Maiduguri, northeastern Nigeria in the cropping seasons of 2001 and 2002. Insecticides were applied twice, thrice or four times at weekly intervals to mature cowpea (var. IT89KD-374-57) pods. The results show that in the 2002 cropping season, two, three or four sprays of NSO or ANSE significantly reduced the number of eggs laid by bruchids on cowpea pods. In both cropping seasons, two sprays of any of the insecticides significantly reduced the percentage of pods bearing bruchid eggs and/or the number of exit holes of F_1 adult bruchids on pods in the 2001 season. In plots that received two sprays of the insecticides in 2002, PMM reduced the number of eggs laid on threshed cowpea seeds significantly more than ANSE. In the same year, significantly fewer adult bruchids emerged from seeds obtained from PMM-treated pods that received two sprays than those from ANSE-treated pods that received a similar number of sprays of the 977 adult bruchids that emerged from shelled cowpea seeds in the 2001 cropping season, 28.6, 24.0, 29.6 and 17.7% emerged from seeds obtained from unsprayed pods and pods sprayed with NSO, ANSE and PMM, respectively; 28.6, 20.2, 21.2 and 30.1% emerged from cowpea seeds obtained from unsprayed pods and pods sprayed twice, thrice and four times, respectively. Of this number of adult bruchids, 28.2, 40.9, 28.0 and 2.8% were *Callosobruchus rhodesianus*, *C. maculatus*, *Bruchidius atrolineatus* and *C. chinensis*. Of the 1727 adult bruchids that emerged in the 2002 cropping season, comparable figures were 30.8, 26.1, 30.2 and 12.9% for unsprayed pods and pods sprayed with NSO, ANSE and PMM, respectively; 30.8, 22.3, 25.5 and 21.4% for unsprayed pods and pods sprayed twice, thrice and four times, respectively. Of this number, 16.3, 29.5, 7.5 46.7 were *C. rhodesianus*, *C. maculatus*, *B. atrolineatus* and *C. chinensis*, respectively.

Key Words: Field infestation; Bruchidae; Pre-harvest spray; Biopesticides; Neem (*Azadirachta indica*); Insecticide

INTRODUCTION

Species of Bruchidae are serious field-to-store pests of pulses in tropical Africa and Asia and the level of field infestation is a major factor that influences the bionomics of these bruchids in storage (Ajayi & Lale, 2001). For instance, cowpeas and pigeon peas harvested at the recommended harvest periods were found to be significantly infested with bruchid eggs (Olubayo & Port, 1997; Silim Nahdy *et al*., 1998). The different species which have been recorded on field-infested cowpea seeds in tropical Africa belong to the genus *Callosobruchus* and include *C. chinensis* (L.), *C. maculatus* (F.) and *C. rhodesianus* (Pic.) (Olubayo & Port, 1997; Ofuya, 2001). Another bruchid, *Bruchidius atrolineatus* (Pic.) damages cowpea seeds in the field but is usually unable to establish damaging populations in storage (Booker, 1967), and is thus often out-competed in the store in Nigeria by *C. maculatus* which is reported to be the principal post-harvest pest of cowpeas (Jackai & Daoust, 1986).

Techniques that have been developed for the management of these bruchids in stored cowpea have been mostly post-harvest, a major component of which involves the protection of shelled cowpea seeds with both synthetic insecticides and phytochemicals obtainable from locally-available species of plants (Caswell & Akibu, 1980; Ivbijaro & Agbaje, 1986; Don-Pedro, 1989; Rahman, 1990). Three products from neem (*Azadirachta indica* A. Juss), comprising aqueous neem seed extract (ANSE), neem seed oil (NSO) and neem seed powder (NSP) are among the most widely reported phytochemicals employed for pest management in developing countries (Lale, 1995; 2002) of these, NSO and NSP have been used extensively for the control of *C. maculatus* infesting cowpeas especially in storage in Nigeria (Ivbijaro, 1983; Lale & Abdulrahman, 1999; Lale & Mustapha, 2000). Products from neem have also been used extensively for the protection of growing crops from infestation by various field pests (Jackai *et al*., 1992; Przybyszewski, 1993; Emosairue & Ukeh, 1996; Emosairue & Ubana, 1998; Hassan, 1999; Anaso & Lale, 2001a, b). Reports on the use of any of these products for interventions against infestation by bruchids at the pre-harvest stage are very scarce in the literature. However, reports on the pre-harvest application of some synthetic insecticides to reduce field-infestation of maize by two field-to-store pests, *Sitotroga cerealella* (Olivier) and *Sitophilus oryzae* (L.), suggest that intervention at this level may adversely affect the bionomics of these pests in storage (Sharma, 1995).

It is therefore reasonable to suggest that legume crops sprayed in the field against pre-harvest pests may incidentally suffer lower bruchid infestation than the unprotected crop (Ofuya, 2001). It may even be more beneficial to specifically spray growing cowpea in the field at the pod ripening stage when bruchids commence infestation. The level of bruchid control during this period may depend on the type of insecticide and crop growth stage during last application but none of these has been investigated sufficiently in the cowpea-growing savanna zones of Nigeria. In this study, the efficacy of pre-harvest spray of two products from neem (NSO & ANSE) and pirimiphos-methyl (PMM) to reduce field infestation of cowpeas by storage bruchids was investigated in the Nigerian Sudan savanna.

MATERIALS AND METHODS

Extraction and formulation of neem seed oil. Mature, fallen neem seeds were gathered from a neem plantation in Maiduguri, Nigeria. These were washed, sun-dried, decorticated and pulverized into fine powder using manually operated mill. One kg of the pulverized neem seed was weighed into a 5-litre plastic bowl and pre-boiled water was added, a little at a time, and mixed into the powder. This procedure was repeated until a dough-like material was formed. The oil was pressed out manually into a collecting container.

Twenty millilitres of the oil were dissolved in a litre of water in which 1 g of toilet soap has previously been dissolved to make the oil more miscible with water. This formed the neem seed oil (NSO) formulation.

Preparation of aqueous neem seed extract formulation. Neem seeds that received similar preliminary treatments described in the preceding section, were ground into relatively coarse powder and 50 g of these were soaked in 1 litre of water. The mixture was stirred vigorously and allowed to stand overnight and thereafter filtered through double folds of muslin cloth to obtain the filtrate containing the extract. This filtrate formed the aqueous neem seed extract (ANSE) formulation.

Field trial and experimental design. The two neem seed formulations (NSO and ANSE) and a recommended dosage (2 ml/l) of pirimiphos-methyl (Actellic 25 EC®) (PMM) were used for the study. Three seeds of cowpea (var. IT89KD-374-57) obtained from the Lake Chad Research Institute, Maiduguri, Nigeria, were sown per stand at a spacing of 60 cm x 60 cm in experimental plots measuring 4 m x 4 m each.

The three insecticides (NSO, ANSE & PMM) formed the main plot treatments and the number of sprays (0, 2, 3 & 4) formed the sub-plot treatments. The experiment was set up as a randomized complete block design with three replications. The trial was conducted during the cropping season of 2001 and repeated during the cropping season of 2002 in Maiduguri, northeastern Nigeria.

Each plot was sprayed twice, thrice or four times with each of the insecticides using a CP15 Knapsack sprayer. Spraying commenced at the pod ripening stage when bruchids commence egg-laying. NSO was applied at the rate of 20 ml/l and ANSE was applied as filtrate obtained from soaking neem powder in water at the rate of 50 g/l to plants in experimental plots. These were compared with the recommended dosage of pirimiphos-methyl (Actellic 25 EC®) (PMM) applied at the rate of 2 ml/l and unsprayed plots. Each group of plants was sprayed to run-off with the specified insecticides according to the method of Jackai *et al*. (1992).

Each experimental plot received an application of 40 kg/ha of P_2O_5 as single superphosphate by side placement. Fields were weeded twice according to the package of cropping recommendations for the study area (BOSADP, 1993). Dry pods were harvested one week after the last spray (that is 5 weeks after pod ripening commenced) and put into labelled polythene bags.

Laboratory aspect of the work. Forty-five pods were picked randomly from the batch of cowpea pods harvested from each plot and the eggs laid on them by storage bruchids and exit holes of F_1 adult bruchids were counted. Thereafter these pods were returned to the batches from which they were picked. The entire pods harvested from each plot for each of the three insecticides were shelled together. Eighty grammes of seeds were taken from each batch and eggs and exit holes of F_1 adult bruchids on shelled seeds were counted.

Thereafter these 80 g batches of seeds were put into 500 mL Kilner jars and covered with muslin cloths held in place by lids. These were stored under laboratory conditions (24-30^{o}C & d 26-58% r. h.) for 4 weeks to allow bruchids developing within the seeds to emerge for identification. Second generation adult bruchids that emerged were counted and the different species of Bruchidae that emerged were identified using the keys provided by Haines (1991). The identities of the species were eventually confirmed at the Insect Museum of the Institute for Agricultural Research/Ahmadu Bello University, Zaria, Nigeria. The grain yield per hectare was estimated from the yield obtained from the 16 m^2 plots used for the experiment.

Data analysis. Data obtained were subjected to two-way ANOVA and differences between means were determined using the technique of Least Significant Difference (LSD) at the 5% level of probability. The numbers of the various species of Bruchidae that emerged from stored cowpea seeds were expressed as percentages of the total number of bruchids according to species, insecticides and number of sprays.

RESULTS

Table I shows that in the 2001 and 2002 cropping seasons, two sprays of NSO and ANSE significantly reduced infestation of cowpea pods with bruchid eggs relative to the levels of infestation on unsprayed pods. It also shows that in both cropping seasons' pods from plots that were sprayed twice or thrice were infested to a significantly lesser extent with bruchid eggs than pods from unsprayed plots. In 2002, PMM protected cowpea pods from infestation with eggs significantly more than NSO (Table I). In the same season, spraying of cowpea pods twice with any of the insecticides also reduced the percentage of pods infested with eggs significantly; four sprays of NSO and ANSE and three sprays of PMM also reduced the percentage of cowpea pods infested with bruchid eggs significantly (Table II).

Two sprays of ANSE and PMM reduced the number of exit holes of F_1 adult bruchids by 47.6 and 74.8%, respectively in the 2001 cropping whereas two sprays of NSO reduced exit holes of F_1 adult bruchids by 42.8% in the 2002 cropping season (Table III). In both seasons, pods that were protected with two or three sprays of the insecticides bore significantly lower numbers of exit holes of adult bruchids and in 2001 and ANSE-treated pods bore significantly higher numbers of exit holes than NSO-treated pods (Table III). In 2001, only four sprays of NSO provided significant protection of shelled seeds against the development of F_1 adult bruchids as indicated by the number of exit holes and in the 2002 season, seeds from NSO-treated or PMM-treated pods were infested significantly less with bruchid than seeds from ANSE-treated pods (Table IV). Table IV also shows that two or four sprays of the insecticides significantly reduced the number of F_1 adult bruchids that emerged from seeds obtained from pods treated with these numbers of sprays relative to the numbers of adult bruchids that emerged from seeds from unsprayed pods.

Application of insecticide and number of sprays did not have any significant effect on the numbers of eggs laid on shelled seeds obtained from treated pods in the 2001 season (Table V). In 2002, however, two sprays of PMM reduced egg-laying by bruchids significantly more than two sprays of ANSE. Spraying cowpea pods with PMM significantly reduced egg-laying on shelled seeds relative to the number of eggs laid on shelled seeds obtained from pods that were treated with NSO or ANSE, and two sprays or four sprays significantly reduced egg-laying on shelled

Table I. Mean number of eggs laid by bruchids in the field on cowpea pods that were protected with neem seed oil (nso), aqueous neem seed extract (anse) and pirimiphos-methyl (pmm

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	9.7	3.7	7.3	7.3	7.0
ANSE	11.0	4.7	5.0	6.7	6.8
PMM	7.7	3.7	6.3	4.7	5.3
Mean	9.1	4.0	6.2	6.2	
SED = 1.2, LSD (> 0.05) (Insecticide); SED = 1.4, LSD (0.05) = 2.9 (Number of applications); SED 2.4, LSD (0.05) = 5.0 (Interaction)					
			2002		
NSO	22.7	9.7	12.7	16.0	15.3
ANSE	15.7	8.7	12.3	11.0	11.9
PMM	12.7	7.7	11.0	10.3	10.4
Mean	17.0	8.7	12.0	12.4	
SED = 1.2, LSD (0.05) = 2.4 (Insecticide); SED = 1.4, LSD (0.05) = 2.8 (Number of applications); SED = 2.4, LSD (0.05) = 4.9 (Interaction)					

Table II. Mean percentage of cowpea pods protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) that were infested with bruchid eggs in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	17.0	7.4	9.6	13.3	11.9
ANSE	15.6	8.9	10.4	14.1	12.2
PMM	14.1	6.7	8.9	9.6	9.8
Mean	15.6	7.7	9.6	12.3	
SED = 2.0, LSD (> 0.05) (Insecticide); SED = 2.3, LSD (0.05) = 4.7 (Number of applications); SED = 3.9, LSD (0.05) = 8.1 (Interaction)					
			2002		
NSO	15.6	9.6	10.4	11.1	11.7
ANSE	14.8	10.4	11.9	11.1	12.0
PMM	12.6	8.2	8.9	9.6	9.8
Mean	14.3	9.4	10.4	10.6	
SED = 0.8, LSD (0.05) = 1.6 (Insecticide); SED = 0.8, LSD (0.05) = 1.7 (Number of applications); SED = 1.6, LSD (0.05) = 3.3 (Interaction)					

Table III. Mean number of exit holes of F_1 adult bruchids on cowpea pods protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) that were infested with bruchid eggs in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	10.3	8.0	6.3	10.0	8.7
ANSE	21.0	11.0	6.3	10.3	12.2
PMM	14.7	3.7	8.0	12.0	9.6
Mean	15.3	7.6	6.9	10.8	
SED = 1.6, LSD (0.05) = 3.4 (Insecticide); SED = 1.9, LSD (0.05) = 3.9 (Number of applications); SED = 3.3, LSD (0.05) = 6.8 (Interaction					
			2002		
NSO	18.7	10.7	10.7	13.3	13.3
ANSE	17.0	13.3	14.0	12.3	14.2
PMM	14.3	11.3	11.7	13.0	12.6
Mean	16.7	11.8	12.1	12.9	
SED = 1.9, LSD (> 0.05) (Insecticide); SED = 2.1, LSD (0.05) = 4.4 (Number of applications); SED = 3.7, LSD (0.05) = 7.7 (Interaction)					

Table IV. Mean number of exit holes of F_1 adult bruchids on cowpea seeds that were protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) that were infested with bruchid eggs in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	9.0	7.7	7.0	2.7	6.6
ANSE	6.3	4.3	5.0	5.3	5.3
PMM	6.3	3.0	4.3	6.0	4.9
Mean	7.2	5.0	5.4	4.7	
SED = 1.2, LSD (> 0.05) (Insecticide); SED = 1.4, LSD (> 0.05) (Number of applications); SED = 2.4, LSD (0.05) = 5.1 (Interaction)					
			2002		
NSO	17.0	12.0	16.3	12.3	14.4
ANSE	23.0	19.3	22.3	15.3	20.0
PMM	18.7	9.3	18.3	12.3	14.7
Mean	19.6	13.6	19.0	13.3	
SED = 2.5, LSD (0.05) = 5.2 (Insecticide); SED = 2.9, LSD (0.05) = 6.0 (Number of applications); SED = 5.0, LSD (> 0.05) (Interaction)					

Table V. Mean number of eggs laid by F_1 storage bruchids on cowpea seeds that were protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	45.7	29.3	31.7	26.3	33.3
ANSE	45.0	34.0	24.0	45.0	37.0
PMM	28.3	15.3	21.7	26.3	22.9
Mean	39.7	26.2	25.8	32.6	
SED = 8.3, LSD (> 0.05) (Insecticide); SED = 9.6, LSD (> 0.05) (Number of applications); SED = 16.7, LSD (> 0.05) (Interaction)					
			2002		
NSO	73.0	45.0	61.7	55.7	58.8
ANSE	78.3	75.0	62.7	51.7	66.9
PMM	55.0	19.3	32.3	28.7	33.8
Mean	68.8	46.4	52.2	45.3	
SED = 8.4, LSD (0.05) = 17.5 (Insecticide); SED = 9.7, LSD (0.05) = 20.2 (Number of applications); SED 16.8, LSD (0.05) = 34.9 (Interaction)					

seeds when compared to the number of eggs on shelled seeds obtained from unprotected pods (Table V). The effect of combining insecticide application with number of sprays on the number of F_2 adult bruchids that emerged after 4-week storage from shelled seeds produced a trend similar to that observed for number of eggs on shelled seeds in both 2001 and 2002 cropping seasons (Table VI).

Characterization of the 977 F_2 adult bruchids that emerged from shelled seeds in 2001 shows that 28.6, 24.0, 29.6 and 17.7% emerged from seeds obtained from unsprayed pods and pods sprayed with NSO, ANSE and PMM, respectively. In 2002, of the 1727 F_2 adult bruchids that emerged 30.8, 26.1, 30.2 and 12.9% emerged from unsprayed pods and pods sprayed with NSO, ANSE and PMM, respectively (Table VII). Distribution according to number of sprays shows that in 2001, 28.6, 20.2, 21.2 and 30.1% of the bruchids emerged from unsprayed pods and pods sprayed twice, thrice or four times with insecticides, respectively. Comparable figures for 2002 were 30.8, 22.3, 25.5 and 21.4% for unsprayed pods and pods sprayed twice, thrice and four times with insecticides, respectively (Table VIII). During the cropping season of 2001, 28.2, 40.9, 28.0 and 2.8% of the adult bruchids that emerged were *C. rhodesianus*, *C. maculatus*, *B. atrolineatus* and *C. chinensis*, respectively; and in 2002, 16.3, 29.5, 7.5 and 46.7% of the adult bruchids that emerged from shelled cowpeas were *C. rhodesianus*, *C. maculatus*, *B. atrolineatus* and *C. chinensis*, respectively (Tables VII, VIII).

Table VI. Mean number of F_2 adult storage bruchids that emerged after a 4-week storage period from cowpea seeds that were protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	35.7	25.0	29.7	24.3	28.7
ANSE	39.3	31.3	23.7	41.0	33.8
PMM	20.3	10.0	16.7	33.3	20.1
Mean	31.8	22.1	23.3	32.9	
SED = 8.5, LSD (> 0.05) (Insecticide); SED = 9.8, LSD (> 0.05) (Number of applications); SED = 17.0, LSD (> 0.05) (Interaction)					
			2002		
NSO	68.0	38.3	59.0	53.0	54.6
ANSE	64.7	71.0	58.0	36.7	57.6
PMM	50.0	20.7	29.7	27.7	32.0
Mean	60.9	43.3	48.9	39.1	
SED = 7.8, LSD (0.05) = 16.2 (Insecticide); SED = 9.0, LSD (0.05) = 18.7 (Number of applications); SED = 15.6, LSD (0.05) = 32.3 (Interaction)					

Table VII. Distribution of F_2 adult bruchids that emerged after a 4-week storage period from field-infested cowpea seeds that were protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) according to insecticide and species

	Species of Bruchidae					
Insecticide	***C. rhodesianus***	***C. maculatus***	***B. atrolineatus***	***C. chinensis***	**Pest total**	**Pest %**
			2001			
Control	74	135	65	5	279	28.6
NSO	60	94	74	6	234	24.0
ANSE	97	104	82	9	289	29.6
PMM	50	67	53	7	173	17.7
Species total	276	400	274	27	977	
Species %	28.2	40.9	28.0	2.8		
			2002			
Control	94	205	47	186	532	30.8
NSO	69	91	29	261	450	26.1
ANSE	76	141	29	276	522	30.2
PMM	42	72	25	84	223	12.9
Species total	281	509	130	807	1727	
Species %	16.3	29.5	7.5	46.7		

Table VIII. Distribution of F_2 adult bruchids that emerged after a 4-week storage period from field-infested cowpea seeds that were protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) according to number of insecticide applications and species

	Species of Bruchidae					
No. of insecticide applications	***C. rhodesianus***	***C. maculatus***	***B. atrolineatus***	***C. chinensis***	**Pest total**	**Pest %**
			2001			
Control	74	135	65	5	279	28.6
2	54	76	61	6	197	20.2
3	71	72	56	8	207	21.2
4	77	117	92	8	294	30.1
Species total	276	400	274	27	977	
Species %	28.2	40.9	28.0	2.8		
			2002			
Control	94	205	47	186	532	30.8
2	75	94	20	196	385	22.3
3	62	127	34	218	441	25.5
4	50	83	29	207	369	21.4
Species total	281	509	130	807	1727	
Species %	16.3	29.5	7.5	46.7		

With only an occasional exception (that is the difference between two and three sprays of ANSE in 2001), application of insecticides and number of sprays did not significantly affect grain yield of cowpea in both cropping seasons (Table IX).

DISCUSSION

The study has shown that for most of the parameters measured, two sprays of any of the two botanicals (NSO & ANSE) and the synthetic insecticide (PMM) were quite effective in providing protection to cowpea pods against field infestation by storage bruchids. Specifically, two-spray applications of these insecticides significantly reduced the number of eggs laid on cowpea pods by bruchids as well as the percentage of pods infested with bruchid eggs in the field. This number of sprays also reduced the number of

Table IX. Mean grain yield (kg/ha) of cowpea that was protected with neem seed oil (NSO), aqueous neem seed extract (ANSE) and pirimiphos-methyl (PMM) against bruchid infestation in the field

	Number of applications				
Insecticide	**0**	**2**	**3**	**4**	**Mean**
			2001		
NSO	944.4	1111.1	861.1	944.4	965.3
ANSE	1983.3	1222.2	638.9	888.9	958.3
PMM	1083.3	986.1	763.9	833.3	916.7
Mean	1037.0	1106.5	754.6	888.9	
SED = 126.0, LSD (> 0.05) (Insecticide); SED = 145.5, LSD (0.05) = 301.8 (Number of applications); SED = 252.1, LSD (0.05) = 522.8 (Interaction)					
			2002		
NSO	622.2	883.3	879.2	1002.8	846.9
ANSE	877.8	836.1	877.8	750.0	835.4
PMM	763.9	1022.2	1013.9	661.1	865.3
Mean	754.6	913.9	923.6	804.6	
SED = 123.2, LSD (> 0.05) (Insecticide); SED = 142.2, LSD (> 0.05) (Number of applications); SED = 246.4, LSD (> 0.05) (Interaction)					

eggs on shelled cowpeas and the number of adult bruchids that emerged from seeds obtained from insecticide-protected pods.

These observations are significant for a number of reasons. First, low field infestations will adversely affect the bionomics of the bruchids in storage. Dick and Credland (1984, 1986) have shown that the number of adult *C. maculatus* which can emerge from cowpea seeds depends amongst other things on the number of eggs initially present. The number of egg-laying female bruchids that are initially present is also an important consideration in the bionomics of species of Bruchidae (Haines, 1991). Second, pre-harvest intervention with two sprays of the insecticides is likely to be more economical when compared to the weekly sprays recommended for protection against such pests as flea beetles, *Podagrica* species, *Sylepta derogata* (F.) and *Helicoverpa armigera* (Hübner) infesting okra in the same agroecology (Anaso & Lale, 2001a, b). Third, the farmers have been provided with important options in terms of insecticides. Although PMM tended to be more effective with respect to some of the parameters than the botanicals, it is more expensive and not readily available. Besides, the role of insecticides in pest management systems is now open to question especially in the developing economies, due to decreased tolerance of chemical residues in foodstuff and the increased incidence of insecticide resistance (Banks *et al*., 1990; Longstaff, 1994). It is therefore, essential that stored products protection in developing countries of tropical Africa and Asia be much more dependent on a range of alternative non-chemical pest control measures (Ofuya, 2001). Furthermore, neem products are less likely to have harmful side-effects on natural enemies of storage bruchids under field situations. Schmutterer (1990) reported that because of the relatively weak contact effect in insects and the peculiar mode of action, neem-based pesticides have proved in most cases to be relatively harmless to important natural enemies of pests. Farmers' choice of any of the two neem products is likely to be influenced by the physical characteristics of the formulations. Aqueous neem seed extract is unstable and must be used immediately after preparation whereas NSO can be stored after extraction for long periods of time, sometimes even years, without loss of efficacy (Anaso & Lale, 2001a, b; Lale, 2002).

The species of Bruchidae (*C. rhodesianus*, *C. maculatus*, *C. chinensis* & *B. atrolineatus*) that emerged from field-infested cowpeas in the present study are identical with those that emerged from field-infested cowpeas in parts of East and West Africa in previous studies (Prevett, 1961; Caswell, 1970, 1984; Wanui, 1984; Olubayo & Port, 1997). However, in 2001, *C. maculatus* was the most dominant species but in 2002, *C. chinensis* was the most dominant bruchid. The reason for this observation is not known but it may not be completely unconnected with changes in the relative lengths of the wet and dry seasons during the two years when the trials were conducted. Although this aspect was not investigated, it is probable that in 2002 when *C. chinensis* predominated the bruchid population, the harmattan (cool, dry wind) characterized by relatively low temperatures and low relative humidity may have set in earlier and this species which is favoured by these conditions may have out-competed *C. maculatus*. Haines (1991) reported that the optimum temperatures for oviposition and development of *C. chinensis* and *C. maculatus* are 23^{o}C and 30-35^{o}C, respectively. *C. maculatus* is, however, the major species of Bruchidae infesting cowpeas in the stores in Nigeria. The high temperatures which often exist in the store possibly enable *C. maculatus* to smother out *C. chinensis* and other bruchids in cowpeas in subsequent generations. Under the conditions prevailing in the store, *C. maculatus* was reported to have out-competed *C. subinnotatus* (Pic.) on Bambara groundnuts (*Vigna subterranea* (L.) Verdcourt) (Lale & Vidal, 2001).

The results have also shown that, with an occasional exception, the application of insecticides beginning at the commencement of pod ripening did not adversely affect grain yield of cowpea. Pre-harvest spray of NSO and ANSE may therefore be a practical method that can be used by farmers to reduce field infestation of cowpeas by bruchids. Neem trees predominate the forest plantations of many northern States in the savanna regions of Nigeria because they are used to provide shade and to modify the microclimate of this otherwise open grassland. Farmers can collect seeds from these plantations and from them obtain insecticides as needed, at little or no extraneous cost (Jackai *et al.,* 1992). These could then be used in combination with existing levels of cowpea pod resistance and other cultural tactics such as optimal harvest (Kabeh & Lale, unpublished data) to obtain better levels of protection against field infestation by bruchids.

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(Received 10 June 2003; Accepted 10 May 2004)