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Harvest Time Modification, Neem Seed Products and Pirimiphos-Methyl as Methods of Reducing Field Infestation of Cowpeas by Storage Bruchids in the Nigerian Guinea Savannah

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Abstract: The efficacy of combining harvest time modifications at early (3 WAR), optimum (4 WAR) and late (5 WAR) harvests with two pre-harvest spray of Neem seed oil (NSO), Aqueous Neem Seed Extract (ANSE) and pirimiphos-methyl (PMM) at 20 ml L^{-1}, 50 g L^{-1} and 2 ml L^{-1} concentrations, respectively, during pod ripening and drying stages of cowpea (Var. IT 89KD-374-57) in 2004 and 2005 cropping season was evaluated in 16 m^2 experimental plots in Taraba State. Bruchids infestation generally increase with delayed harvest in both seasons, while significantly less bruchid eggs and F_1-adult exit holes were recorded on insecticides protected seeds. Identical bruchid species were recorded in this study as in other parts of West, East and Central Africa. The F_2-adults emergence within the 4 weeks storage period were 1116 in 2004, with 22.76, 29.57 and 47.67% for early, optimum and late harvests, respectively, while 9.08, 21.68, 28.05 and 41.22% were *C. chimensis*, *B. atrolineatus*, *C. rhodesianus* and *C. maculatus*; similar value for 2005 with 1167 F_2-adult emergence were, 18.56, 21.04 and 60.39% for harvest times and 78.87, 4.11, 6.50 and 10.52% for bruchid species. In both cropping seasons, larval parasitoids, *D. basalis* and *E. vuiletti* emergence maintained a 1:1 population ratio, without significant difference between species distribution.

Key words: Harvest time modification, neem seed products, cowpea bruchids, parasitoids

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp., form a cheap source of dietary phytoprotein with high nutritional proportion of the B-complex vitamins in the tropics, additionally cowpea constitute rich source of fodder for domestic animals (Bressani, 1985; Nwokolo, 1996). Nigeria is still the world's largest producer of the crop, accounting for 70% of world's cowpea production of over 30 million tonnes $year^{-1}$, with losses of 30% caused by storage bruchids estimated at over $30 m (IITA, 1989; Okoronkwo, 2001).

Planting and harvest time modification greatly affect pest population in cowpea production. Olubayo and Port (1997) recommended early harvest of cowpea as a check against incidence of storage bruchids. Cowpea infestation starts with females laying eggs on ripenning cowpea pods in the field (Silim Nahdy *et al*., 1999; Lale and Kabeh, 2004). At eclosion larvae burrow through the chorion directly into the seeds through the pod wall for pupation (Silim Nahdy *et al*., 1999). Growth, development and reproduction is optimitized at 30-35°C and 70% R.H, eggs hatch in 3-5 days, larval development, 8-16 days, 2 days-prepupal, 5 days-pupal, then adults emerge through exit holes, realized adult life is 8-16 days, but unmated females live much longer (Ivbijaro, 1990).

Being r-strategist, the proliferation and voracious capability of the cowpea bruchids ranked them as the must destructive insect pests in storage all over the tropics. They cause between 50-70% post harvests losses, a single larva consume between 4-11% of a cowpea seed (Silim Nahdy *et al*., 1999). Infested seeds have lower protein quality, increased non nutritional factors (uric and phytic acids, trypsin inhibitory activity and saponin content), weight loss, severe fungal contamination (mycotoxins). Produce become unfit for human consumption, lowering market value and germinability (Elhag, 2000).

Biological control of bruchids by conservation of indigenous parasitoids is feasible, for example, Braconids; *Apanteles flavipes*, Pteromalids, *Dinarmus basalis*, Eupelmids, *Eupelmus vuilleti* and *E. orientalis* or Trichogramatid egg parasitoids *Uscana lariophaga*, recorded between 80-97% reduction in bruchid population in comparison with the control (Sanon *et al*., 1998; Ofuya, 1999; Ndoutoume, 2002). Schmutterer and Singh (1995) listed 413 insect pest species sensitive to neem products. With reduced progeny production, various morphogenetic defects as well as mortalities of instars, as a function of concentration applied, but do not impair adult female longevity (Ivbijaro, 1990; Elhag, 2000). From the fore-going, the objective of this study was to evaluate effectiveness of harvest time modification, neem seed products and pirimiphos-methyl (PMM) on field infestation of cowpeas by storage bruchids.

MATERIALS AND METHODS

Pesticides Formulation

Matured fallen neem seeds, were collected, sun dried, decorticated and pulverized. One kilogram of the pulverized seed processed into a dough-like mass with pre-boiled water, from which oil is pressed out. 20 mL of the oil dissolved in 1 L of water and 1 g toilet soap added give the Neem Seed Oil (NSO) formulation. Similarly, 50 g of coarsely ground decorticated neem seeds were soaked in 1 L of water and 1 g toilet soap added. Using fine muslin cloth, the filtrate form the Aqueous Neem Seed Extract (ANSE) formulations. While Pirimiphos-methyl (Actellic 25EC® (PMM) at recommended rate of 2 ml L^{-1} were used.

Experimental Design and Field Lay-out

The experiment was conducted at the Teaching and Research Farm of College of Agriculture, Jalingo in 2004 and 2005 cropping seasons. An estimated 0.24 ha, experimental area was used. Laboratory experiment was in the Agricultural technology laboratory. While data on climate was from College of Education Meteorological Station.

Three seeds of cowpea (Var. IT89KD-374-57) were sown per stand at 60×60 cm spacing in 16 m^2 plots. Three harvest times, Early Harvest (EH), Optimum Harvest (OH) and Late Harvest (LH) i.e., 3, 4 and 5 Weeks After Ripening (WAR) form the main plot, while the insecticides, NSO, ANSE, PMM and the Control form the sub plot treatments. The plots were sprayed twice at pod ripening and drying stages. Each bunch of plant was sprayed to wetness with specified insecticides using CP_{15} knapsack sprayer (Jackai *et al*., 1992). The trial was laid out in RCBD, with 3 replications in 2004 and 2005 cropping seasons. Experimental plots received 40 kg ha^{-1} P_2O_4 as Single Super Phosphate (SSP) by side placement and weeded twice. Dry pods were harvested 3, 4 and 5 WAR into labeled polythene bags.

Laboratory Screening

Batches of picked pods per plant were threshed separately. Eighty gram of seeds from each batch placed in 500 mL kilner jars and covered with muslin cloth after eggs and exit holes of F_1-adults have been recorded. These kilner jars were held in the laboratory at 24-30°C and 26-58% RH, for 4 weeks. Emerged adults (F_2-generation) were counted daily categorized and identified at IAR-ABU Zaria and confirmed at The Natural History Museum (NHM) London. Data obtained were subjected to 2 way ANOVA and treatment means separated using LSD at 5% probability levels.

RESULTS

Fewer exit holes were recorded in early harvested cowpeas, with a direct proportional relationship between harvest time and F_1-adult emergence. The insecticidal effects actually reduced emergence of the F_1-adults, however there was no significant difference between protective effects of the insecticidal materials (Table 1). In 2005 cropping season, both harvest times and insecticides significantly reduce F_1-adult emergence, hence fewer exit holes in the stored cowpea seeds. The best protective effect was in early harvest with PMM and ANSE interactions, giving 3.33 and 4.00, respectively (Table 1).

The mean number of eggs laid on cowpea seeds harvested late is significantly higher than those of early and optimum harvest times. In same trend, insecticides treatment significantly protected the cowpea seeds, without significant difference between their effects. ANSE treated seeds, harvested late gave high infestation, while NSO treated seeds harvested early had least infestation. While PMM and ANSE treated seeds do not show definite trend with increasing harvest time (Table 2). In 2005, peak infestation was in the control treatment at late harvest. Early and optimum harvest times interacted favourably with the insecticides to reduce infestation of the cowpea seeds (Table 2).

In the 2004 cropping season, early and optimum harvests have lower emergence of F_2-adult bruchids, while PMM gave the best protection, which significantly differ from protective effect of ANSE (Table 3). In same respect, early and optimum harvest times significantly retard F_2-adult

Table 1: Mean number of exit holes of F_1-adult bruchids that emerged from 80 g cowpea seeds treated with insecticides and harvested at different times

		Insecticides			
Harvest time	Control	NSO	ANSE	PMM	Mean
2004					
EH	9.66	5.66	8.33	7.66	7.83
OH	11.33	6.66	8.00	7.66	8.41
LH	16.33	10.00	12.00	6.33	11.16
Mean	12.44	7.44	9.44	7.22	
SED = 1.448, LSD (0.05) = 3.0039 (Harvest time); SED = 1.6725, LSD (0.05) = 3.4687 (Insecticide); SED = 2.8969, LSD (0.05) = 6.0081 (Interaction)					
2005					
EH	7.66	6.66	4.00	3.33	5.41
OH	9.00	10.33	6.66	11.00	9.25
LH	13.00	9.66	6.33	11.33	10.08
Mean	9.88	8.88	5.66	8.55	

SED = 1.4385, LSD (0.05) = 2.9834 (Harvest time); SED = 1.661, LSD (0.05) = 3.4449 (Insecticide); SED = 2.8771, LSD (0.05) = 5.9671 (Interaction); EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest

Table 2: Mean number of eggs laid on 80 g of cowpea seeds treated with insecticides and harvested at different times

		Insecticides			
Harvest time	Control	NSO	ANSE	PMM	Mean
2004					
EH	39.33	24.66	27.66	33.33	31.25
OH	49.66	30.33	25.66	28.33	33.50
LH	60.33	43.33	52.66	32.00	47.08
Mean	49.77	32.77	35.33	31.22	
SED = 4.681, LSD (0.05) = 9.7083 (Harvest time); SED = 5.4052, LSD (0.05) = 11.2103 (Insecticide); SED = 9.3621, LSD (0.05) = 19.4169 (Interaction); EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest					
2005					
EH	23.33	20.66	16.66	19.66	20.08
OH	28.66	19.33	19.33	28.00	23.83
LH	74.33	62.33	56.00	67.00	64.91
Mean	42.11	34.11	30.66	38.22	

SED = 5.1716, LSD (0.05) = 10.7258 (Harvest time); SED = 5.9716, LSD (>0.05) (Insecticide); SED = 10.3432, LSD (0.05) = 21.4517 (Interaction), EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest

Table 3: Mean number of F_2-adult bruchids that emerged after 4 weeks storage period from 80 g of field infested cowpea seeds treated with insecticides and harvest at different times

		Insecticides			
Harvest time	Control	NSO	ANSE	PMM	Mean
2004					
EH	21.33	18.00	17.00	23.33	19.91
OH	39.00	21.66	23.00	26.00	27.41
LH	58.00	42.66	51.00	29.00	45.16
Mean	39.44	27.44	30.33	26.11	
SED = 4.4974, LSD (0.05) = 9.3276 (Harvest time); SED = 5.1932, LSD (0.05) = 10.7706 (Insecticide); SED = 8.9949, LSD (0.05) = 18.6554 (Interaction); EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest					
2005					
EH	21.66	9.66	15.66	18.33	18.83
OH	28.00	17.00	18.33	25.33	22.16
LH	71.33	59.00	50.33	58.33	59.75
Mean	40.33	31.88	28.11	34.00	

SED = 5.378, LSD (0.05) = 11.1539 (Harvest time); SED = 6.2099, LSD (>0.05) (Insecticide); SED = 10.756, LSD (0.05) = 22.3079 (Insecticide), EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest

Table 4: Distribution of F_2-adult bruchids that emerged after 4 weeks storage period from field infested cowpea seeds according to time of harvest and species

	Species of Bruchidae					
Harvest time	*C. rhodesianus*	*C. maculatus*	*B. atrolineatus*	*C. chinensis*	Pest total	Pest (%)
2004						
EH	73.00	95.00	62.00	24.00	254	22.76
OH	74.00	124.00	69.00	63.00	330	29.57
LH	166.00	241.00	111.00	14.00	532	47.67
Species total	313.00	460.00	242.00	101.00	1116	
Species (%)	28.05	41.22	21.68	9.05		
2005						
EH	14.00	08.00	05.00	190.00	217	18.56
OH	11.00	13.00	18.00	204.00	246	21.04
LH	51.00	102.00	25.00	528.00	706	60.39
Species total	76.00	123.00	48.00	922.00	1169	
Species (%)	6.50	10.52	4.11	78.87		

EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest

Table 5: Distribution of adult parasitoid that emerged after 4 weeks storage from field infested cowpeas according to harvest time and species

	Wasps species			
Harvest time	*D. basalis*	*E. vuilleti*	Wasps total	Wasps (%)
2004				
EH	0.00	0.00	0	0.00
OH	0.00	1.00	1	25.00
LH	2.00	1.00	3	75.00
Wasp total	2.00	2.00	4	
Wasp (%)	50.00	50.00		
2005				
EH	0.00	5.00	5	8.20
OH	2.00	9.00	11	18.03
LH	30.00	15.00	45	73.77
Wasp total	32.00	29.00	61	
Wasp (%)	52.46	47.54		

EH = Early Harvest; OH = Optimum Harvest; LH = Late Harvest

bruchids development in 2005 cropping season. Although both insecticides retard F_2-adult emergence, yet there was no significant difference (p>0.05) between their effects (Table 3).

Of the total F_2-bruchid (1116) that emerged in 2004 cropping season, 22.76, 29.57 and 47.67% were from early, optimum and late harvest, while 9.05, 21.68, 28.05 and 41.22% were *C. chinensis*, *B. atrolineatus*, *C. rhodesianus* and *C. maculatus*, respectively. In 2005, of the 1169 F_2-adult emergence, similar figures are 18.56, 21.04 and 60.39%, for harvest times and 4.11, 6.50, 10.52 and 78.87% for *B. atrolineatus*, *C. rhodesianus*, *C. maculatus* and *C. chinensis*, respectively (Table 4).

In 2004 cropping season, there was no larval parasitoids emergence in early harvest, except for optimum (25.0%) and late (75.0%) harvests. These parasitoids, *D. basalis* and *E. vuilleti*, maintain a 1:1 population ratio. However, in 2005, 8.20, 18.03 and 73.72% of these parasitoids emerged from early, optimum and late harvest, respectively, still without significant difference between species distribution (Table 5).

DISCUSSION

Two sprays of the insecticides were quite effective in protecting cowpeas against field infestation by bruchids (Kabeh and Lale, 2004). It is observed that PMM gave the best protection in 2004. This however was not the case in 2005, where ANSE performed even better than the synthetic. The reason for these is not clear, but Borikar and Pawar (1998), Ivbijaro (1990) and Ofuya (1999) both attributed this probably to selection pressure to the synthetic and also reported instances where botanicals performed much better than synthetics. The significance of the above observations are: (i) low field infestation, depressed bruchids bionomics in the stores (Borikar and Pawar, 1998), modulated by initial number of eggs and egg laying females; (ii) farmers have option to the synthetics, though effective, but are expensive, not readily available with decreased tolerance, high toxicities and increased resistance (Longstaff, 1994; Lale, 2002). As such for Stored Product Protection (SPP) in developing economies, neem products are most ideal, but farmers' choice is affected by formulation either as NSO (stable) or ANSE (Unstable) (Lale and Kabeh, 2004).

Insecticides spray significantly reduces level of field infestation of cowpea seeds in the Nigerian Guinea Savanna, it also eliminates damage by most pod borer, thereby regulates infestation of seeds by the bruchids as reported also by Jackai *et al.* (1992). In 2005 Cropping season at least twice the number of F_1-adult bruchids infests treated seeds harvested late. The implication of which is rapid population build up and subsequent economic loss to stored Cowpea in agreement with findings of Olubayo and Port (1997). However, several competing labour demand, uniformity of ripening and days to 50% ripening varies with Cowpea varieties, hence delay in harvest.

Identical species of Bruchidae were observed in this study as obtained in other parts of East and West Africa as reported by Olubayo and Port (1997). In 2004, *C. maculatus* population was dominant as against 2005, when *C. chinensis* excels. Reason for such behaviours is not known, however, changes in relative length of wet and dry seasons during the two years of this trial could be attributive. Also environmental conditions under which inter-specific competition occurs to a great extent modulate its outcome (Lale and Vidal, 2001). Furthermore, it is most probable that in 2004 cropping season, the low rain fall (126.4-178.4 mm) characterized by relatively low temperature (21.8-35.2°C) and low relative humidity (43.5-67.5%) may have set in earlier. In the related findings, Ofuya and Reichmuth (2002) reported that *C. chinensis* is favoured by such climatic depression. As climatic conditions in stores improve, *C. maculatus* out competes other bruchids in agreement with findings of Lale and Vidal (2001).

The parasitoids recorded in this study are larval parasitoid, depicting high infestation only in late harvested cowpeas. Although inter-specific competitors, yet maintained a 1:1 population ratio probably due to low population densities as against the consensus of Sanon *et al.* (1998), Ndoutoume *et al.* (2002). Where exploited these parasitoids had given substantial protection of cowpeas against bruchids infestation. It is therefore most recommended that effective protection of cowpeas against bruchids, must emphasized reduced field contamination as against post harvest interventions.

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