Full Length Research Paper

Post-harvest bruchid richness and residual activity of pirimiphos-methyl on *Callosobruchus maculatus* F. infested pigeon pea (*Cajanus cajan* L. Millsp.) in storage

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The residual activity of actellic dust (pirimiphos-methyl) on *Callosobruchus maculatus* F. and the field-to-store bruchid richness of pigeon pea grains were studied at Nsukka, Nigeria. Results of the bruchid richness study showed that there was no emergence or infestation of bruchids from both the treated and untreated grains six months post harvest. Assessment of the residual activity of pirimiphos-methyl on *C. maculatus* six months post treatment revealed that although *C. maculatus* could not be controlled completely, its developmental potential and extent of grain damage were drastically reduced, which showed the continued activity of the pesticide six months post treatment. Incremental doses of actellic dust produced residual effects which significantly (P<0.05) reduced the number of F_1-emergence, adult bruchid emergence, total mortality count, grain weight loss and grain damage. Half-dose of pirimiphos methyl was not as effective as its full dose in controlling *C. maculatus* infestations under comparable residual level and grain post harvest storage period. Pigeon pea varieties differed significantly (P<0.05) in their grain susceptibilities to *C. maculatus* as assessed by the quantity of damaged grains, grain weight loss, mean developmental days of insects (MDD) and adult emergence of the pest; the characteristics which allowed the varieties be classified as moderately resistant to the bruchid attack. Residual effect of pirimiphos-methyl when combined with the varieties did not result in any significant effect on *C. maculatus* or grain damage by them.

Key words: Field-to-store pest, pirimiphos-methyl, bruchid richness, residual activity, pigeon pea.

INTRODUCTION

Members of the family leguminoseae are amongst the largest plant families worldwide. They have a large economic value as their grains contain large amount of protein that are useful in food and fodder productions. Pigeon pea (*Cajanus cajan* L. Millsp) is a legume of semi-arid tropics. It is cultivated in more than 25 tropical and sub-tropical countries of the world (Reddy et al., 1993). Pigeon pea is a major source of protein in areas where it is cultivated.

In the field, as well as in the storage, bruchids especially *Callosobruchus maculatus* (F.) damage crops and other pulses (Dongre et al., 1993). The pest generates exceedingly high levels of infestation even when they pass only one or two generations on the host plant. The larvae of the bruchid feed on the pulse seed contents reducing their degree of usefulness and making them unfit either for planting or for human consumption (Ali et al., 2004).

Some physical and chemical characteristics of legume pods and seeds have been identified as influencing resistance to insects. Some of these plant characteristics include pod thickness and hardness, seed coat thickness and hardness as well as the chemical compositions of seeds (Fatunla and Baaru, 1983; Caswell, 1975; Silim Nady, 1998). However, there is paucity of literature on the level and mode of attack of bruchids on pigeon pea in the field prior to harvest and storage by this pest. Both Silim Nahdy (1995) and Ajayi et al. (1995) separately con-

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tented that there is relatively few published accounts of this pest to pigeon pea. Furthermore, there is no information available on the residual effects of storage insecticides on the bruchid infestations on stored pigeon pea grains.

To add to the knowledge of the biodiversity of this pest and to ensure food security, an investigation was conducted to ascertain the bruchid infestation of freshly harvested grains of this crop. Also, the residual activity of a conventional storage insecticide, actellic 2% dust, on the bruchid, *C. maculatus* infestation was evaluated.

MATERIALS AND METHODS

The study was conducted at the Teaching and Research laboratory of the Department of Crop Science, University of Nigeria, Nsukka, Nigeria. Nsukka is located at latitude 06^0 52^1 N and longitude 07^0 24^1 E and at an altitude of 447.26 m above mean sea level. Two experiments were conducted. The first experiment was to assess the bruchid richness of freshly harvested pigeon pea grains while the second was to evaluate the residual effects of actellic dust (pirimiphos-methyl) on bruchid infestation six months post treatment on stored grains.

Application of treatments

Cylindrical plastic containers of about 6.5 cm depth and 11.5 cm diameter were used. The open end of the plastic containers was covered with muslin cloth held in place with a rubber band. Three ventilation holes were made on the curved surface of every container. The holes were later covered with fine muslin cloth stuck firmly to the container with an "evostick" gum.

Treatments comprised factorial combinations of grains of six pigeon pea genotypes and three doses of actellic 2% dust® (pirimiphos-methyl). A 30 g grain sample of the six pigeon pea genotypes was used. The genotypes were ICPL87, ICPL 85063, ICP 7120, ICPL 161, ICPL 87119, obtained from the Institute for Agricultural Research (IAR) and International Crops Research Institute for Semi-Arid Tropics (ICRISAT) breeding programme and Nsukka local were used. The three doses of actellic dust used were 0.0, 0.5 and 1.0 g. Treatments were replicated three times and were laid out in a Completely Randomized Design (CRD) on a laboratory bench. The 0.0 g treatment which was used as a control was to allow for the emergence of any field-to-store pest within the period. Treatments of 0.5 and 1.0 g were the recommended half- and full-doses of actellic dust, respectively, for the control of bruchids.on stored grains.

The pigeon pea grain and the appropriate doses of the pesticide were weighed out into the plastic containers according to the schedules. Both the grains and the chemicals were thoroughly admixed to ensure complete cover of the grains by the chemical.

In the first experiment, the grains were monitored for six months from 11th April, 2006 to 12th October, 2006 for any infestation and damage by bruchids. The second experiment commenced 13th October, 2006 with the introduction of 10 freshly emerged *C. maculatus* adults in all the treatments. Both sexes of the bruchids were selected in a 1:1 ratio of 5 females to 5 males. The insects were allowed to oviposit for two weeks and later removed. This experiment was monitored for another six months and terminated on 14th April, 2007.

Data collection

The following parameters were scheduled to be collected from the first experiment if available:

i.   Days to first bruchid emergence.
ii. Identification of emerged bruchids
iii. Daily counts of F_1 emergence of adult bruchids.
iv. Total number of bruchids (dead and alive) at the end of the study.
v.   Total number of damaged seeds (perforations caused by bruchids).
vi. Percentage loss in grain weight (after adjustment for moisture content) and susceptibility rating of damaged seeds according to Khare and Johari (1984).

The following parameters were assessed in the second phase of this experiment:

i.   Daily oviposition count on 20 sampled seeds from the 4th day to the 14th day of oviposition.
ii. Days to first adult emergence (F_1 generation).
iii. Daily count and removal of emerged adult insects up to 45 days after infestation (DAI).
iv. Daily counts of dead insects up to 45 DAI.
v.   Susceptibility index (SI) calculated after Howe (1971) as modified by Dobie (1977) using the formular S.I. = log F/ D x 100, where F= total number of F_1 progeny emergence; D = mean development period (days), estimated as the time from the middle of oviposition period to the 50% emergence of the F_1 progeny.

The values of the susceptibility indices were used to rank genotype susceptibility to the bruchids into five categories according to Mensah (1986) as follows:

i.   Genotypes with values from 0.0-2.5 were considered resistant genotypes (R).
ii. Genotypes with values from 2.6-5.0 were considered moderately resistant (MR).
iii. Genotypes with values from 5.1-7.5 were considered moderately susceptible (MS).
iv. Genotypes with values from 7.6-10.0 were considered susceptible (S).
v.   Genotypes with values greater than 10.0 were considered highly susceptible (HS).
vi. The total number of insects (dead or alive) at the end of the experiment within each treatment were also counted and recorded.
vii. Weight loss (%) and ranking of susceptibility was done according to Khare and Johari (1984), as described above.

Statistical analysis

Because some of the insect counts were not normally distributed, these counts were first of all subjected to square root transformation before analysis of variance was carried out on them according to the procedure outlined by Obi (2002). All the data obtained were analyzed using GENSTAT (3) discovery edition package for statistical analysis. Detection of differences among treatment means for significant effects was done using F-LSD.

RESULTS

There was no infestation on the untreated grains until

Table 1. Main effect of actellic residual dose on the susceptibility indices of *Callosobruchus maculatus* six months after treatment.

Actellic dose	Oviposition count	F_1 count	MDD	Adult emergence (days)	Mortality count	Damaged grains (No)	Damaged grains (%)	Grain loss	Grain loss (%)
Zero	38.6	21.3	31.8	54.7	292	274.0	78.0	12.61	42.0
Half	27.7	13.9	31.7	46.2	186	195.0	54.5	10.81	36.0
Full	26.2	7.9	31.8	28.3	170	182.0	50.5	11.25	37.5
Mean	30.8	13.9	31.8	43.1	216	217.0	61.0	11.56	38.5
F-LSD$_{(0.05)}$	-	3.5	-	3.9	35.5	30.4	8.2	0.74	2.5

Table 2. Main effect of Pigeon pea variety on the susceptibility indices of *Callosobruchus maculatus* six month actellic treatment.

Variety	Oviposition count	F_1 count	MDD	Adult emergence	Mortality count	Dangerous No.	Damaged Grain (%)	Grain loss (g)	Grain loss (%)	S.I
ICPL 87	32.3	13.3	31.33	40.0	221.0	239.0	69.6	12.47	41.5	3.56
ICPL 85063	37.0	14.1	28.44	35.4	286.0	284.0	79.2	12.70	42.3	4.04
ICP 7120	25.7	15.1	26.11	49.0	170.0	186.0	50.6	10.71	35.7	4.52
ICPL 161	19.7	8.2	35.11	33.0	150.0	202.0	49.5	9.76	32.5	2.60
ICPL 87119	32.0	18.7	32.67	49.2	302.0	246.0	63.8	12.87	42.8	3.89
Nsukka local	22.3	14.1	36.89	51.8	169.0	147.0	53.4	10.83	36.1	3.12
Mean	30.8	13.9	31.76	43.1	216.0	217.0	61.0	11.56	38.5	3.62
F-LSD$^{(0.05)}$	NS	NS	0.56	5.6	50.3	43.0	NS	1.04	NS	NS

S.I= Susceptibility index.

adult bruchids were introduced after six months of storage (no table was presented as zero infestations were recorded in all the treatments and data were therefore not analyzed). However, seven days after bruchid infestation, egg counts and mean developmental days of insects (MDD) decreased with increasing doses of actellic dust but their differences were not significant compared to where no actellic was applied (Table 1). All cases where actellic dust was applied had significantly less (P<0.05) number in F_1 generation, adult emergence, mortality count, damaged grains, loss in grain weight than where no actellic was applied. Where full dose of actellic was applied significantly depressed (P<0.05) the above parameter than where only half dose was applied.

Differences in oviposition count, F_1 count, percentage of grains damaged and percentage loss of grain weight amongst the varieties did not attain any statistical significance (Table 2). However, there was an evident trend of lower oviposition count, F_1 count, damaged grain, grain weight loss amongst varieties ICPL 161 and ICP 7120, respectively. On the other hand, the differences in the MDD, adult emergence, mortality count, grain damage and grain loss (%) were significant (P<0.05) amongst the varieties. On the test varieties, MDD ranged from 26 days on ICP 7120 to 37 days in Nsukka local, while adult emergence ranged from 33 in ICPL 161 to 52 in Nsukka local. The mortality count was highest in ICPL 87119 (302) and least in ICPL 161 (150). The cumulative quantity of damaged grains was between 147 (Nsukka

local) and 246 (ICPL 87119). Grains of ICPL 87119 also had the highest loss in weight of 13 g while ICP 161 had the least loss in weight of 10 g.

Combination of chemical treatment and variety generally did not produce any significant effect. However, ICPL 7120 admixed with half actellic dose appeared to produce less oviposition count, F_1 count ,MDD, mortality count, damaged grains (both in number and in per cent) and loss in grain weight (both in number and in per cent).

DISCUSSION

Evidence from this result showed that threshed grains of pigeon pea varieties stored for six months did not reveal any incipient bruchid infestation or post harvest insect attack up to six months post storage. This overrules any field-to-store infestation with post harvest stored pigeon pea unlike in cowpea (*Vigna unguiculata* L. Walp). In low-resource farms, the bruchid, *C. maculatus* infestations on cowpea is reported to start in the field and continue in storage (Taylor, 1981). In such fields, gravid females deposit eggs on the surface of cowpea pods still hanging on the plant and the emerging larvae later would find their way through the pod wall to the seeds. Caswell (1984) has documented loss of cowpea grains due this pest during traditional post harvest storage in Nigeria. Pods stored for 8 months had 50% of the grain damaged by bruchids, but when stored as grain, 82% of the grain had

one or more holes. The lack of field-to-store infestations on pigeon pea stored for 6 months in this study primarily was attributed to the thick and tougher pod-wall that is always associated with this crop compared with those of cowpea. Generally, pigeon pea has tougher and thicker pod walls than cowpea which in most cases do not dehisce. Akingbohungbe (1976) had earlier attributed pod-wall thickness to be responsible for reduced bruchid adult emergence from resistsance cowpea with this trait. Owusu-Akyaw (1987) found a significant correlation between pod-wall toughness measured by penetrometer and cowpea pod resistance. Consequently, the post harvest storage losses to bruchids usually encountered in pigeon pea should not be attributed to field-to-store infestation but to re-infestations or cross-infestations in the store. The difficulty in surmounting pod-wall barriers by bruchids therefore accounts for the recorded no field-to-store infestation of the pest in this study.

Result also showed the continued residual effective-ness of actellic dust on bruchid development and damage six months later. Reductions in emerging number of F1 generation, adult emergence, mortality count, damaged grains and grain loss lent credence to this continued potency of the insecticide residue even six months after treatment. The surprisingly higher bruchid population amongst the untreated obviously would result to bruchid mortality in this treatment being more than that of the treated grains with fewer infestations. Also, since emergence holes (damaged grain number) represents insects that have developed and left the seed, mated and laid additional eggs, increase in emergence holes (as in untreated lots) should linearly correlate with increase in F_1 count, adult emergence, mortality population, loss of pigeon pea grain and vice versa for the treated samples. This was also evident in the result of this study. Furthermore, half-dose of actellic as a residual treatment was not as effective as its full dose. This is because the half-life of the active ingredient (a.i.) in the half-dose would normally be shorter and therefore wane down faster than the half-life of the a.i. in the full dose. This relative susceptibility/resistance of the different varieties under prolonged storage to bruchid attack was also evident from the result. Except for ICPL 161 which showed some promise in reducing oviposition, F_1 count, adult emergence, mortality count, damaged grains and loss of grain weight, other varieties showed considerable susceptibilities toward these traits. And based on Mensah (1986) classification, all these varieties were classified as being moderately resistant when exposed to prolonged storage; which implied that it had some resistant traits to C. maculatus. However, owing to the relatively high MDD values recorded with ICPL 161, the susceptibility index of the variety was the least (2.60).

That the combination of residual insecticide treatment and moderate resistant variety did not produce any significant effect amongst all the assessed parameters

was expected. The potency of the doses within six months after treatment was not strong enough to achieve the desired effect even at full dose. However, with a full resistant variety and/or fresh insecticide application an additive or synergistic effect may have resulted. Jackai and Adalla (1997) demonstrared that with a susceptible Vita 7 cowpea variety, half dose of freshly applied Apron plus (2.5 g/kg seed) did not reduce aphid infestation after 2 weeks. But on aphid-resistant cultivar, IT 8455-2246, they showed a marked reduction in the number of aphids even with a half dose. Tough and thick pod-wall structure therefore holds a strong promise in selecting physical traits with a strong promise for pigeon pea resistance against bruchids. When clothed with this structure, the chances of field-to-store infestations would be reduced if not completely eliminated. Furthermore, actellic dust when applied especially at full dose was capable of ensuring bruchid-free infestation on pigeon pea up to 6 months after application and reducing the developmental potential of the pest under prolonged storage of the pulse.

Conclusion

Treatments of stored grains with synthetic chemicals to reduce post-harvest losses by bruchids have been reported to have some economic, health and environ-mental implications. The development of varieties combining both seed and pod resistance to bruchids is a paramount approach to achieving a desirable, durable and high level of bruchid resistance that will likely be both environmentally and economically sustainable. Results of this research revealed that pigeon pea grains freshly harvested from the field does not carry field-to-store bruchids to the store. This demonstrates that infestations found associated with grains in the store was due to cross or re-infestations in the store. This result was attributed to the thick pod coat of the pulse which makes larval penetration to the seeds a little bit difficult. After introducing C. maculatus to assess the residual effect of actellic dust (pirimiphos-methyl) on the control and development of the pest, the result showed that the insecticide had some activities on the pest up to six months post treatment. Incremental doses of the insecticide also produced residual effects which reduced number of F_1 emergence, adult bruchid emergence, total motality count, grain weight loss and damaged grains. Half-dose of the pesticide was less effective compared to its full dose implying positive residual effect on the pest. Insect development, mortality and grain damage varied significantly amongst the various pigeon pea varieties.

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