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Insecticidal Potential of Two Indigenious Plant Extracts and Synthetic Dust on Control of *Callosobruchus chinensis* (L) in Pigeon Pea Seeds

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Abstract
Synthetic pesticides have proven to be the most effective control agents against all pests of minor pulses. However, considering the drawbacks of pesticide residues in the seed quality, environmental pollution, and damage to natural enemies associated with synthetic pesticide use, integrated pest management schemes for pulses are being developed. The study evaluated the insecticidal potential of two indigenous plant extracts and synthetic dust on control of *callosobruchus chinensis* in pigeon pea seeds. Two botanicals: *Eugenia aromatic* and *Piper guineese,* were used in combination with synthetic dust at different treatment combinations for the control of *Callosobruchus chinensis.* The *Callosobruchus chinensis* used was derived from a colony originating from heavily invested pigeon pea seeds in the laboratory, while clean NSWCC-50 pigeon pea seeds were obtained from Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria. The botanical plant extracts were obtained from a herbal store in Owerri. They were oven- dried at 60°C for 48hrs and grounded to a powder form in an electric mill. The synthetic dust (pirimiphos-methyl and permethrin) were used at a fixed application rate of 0.lg, while the botanical were varied at 0.02, 0.04, 0.06, 0.08, 0.10 g/ 20 seeds. Both the synthetic dust and the plant extracts were used singly and in combination. The mortality of *Callosobruchus chinensis* was monitored within the time intervals of 12, 24, 48 and 72hrs. The result showed that a sub-lethal dose of pirimiphos-metyl produced 100% adult mortality of *Callosobruchus chinensis.* The study also revealed that there is great potential in reducing the rate of application of synthetic organic insecticides by mixing with a sub-lethal dose of insecticidal materials. It is however, recommended that to maintain the optimum quality of pigeon pea seeds in storage, all possible combinations of low dosages of both the insecticidal plant powders and synthetic organic dusts should be tested so that the best mix can be determined.

Keywords: Integrated pest management, storage pest, stored seeds, insecticidal plant, seed quality, synthetic powder

Introduction

Legumes occupy an important place in the nutrition of Nigerians because their edible seeds form a cheap source of protein in the diets. Food legumes have been described as "poor man's meat" because animal protein sources are seldom affordable by majority of the populace (Baiwa *et al*., 2006). Minor pulses are cultivated on a small scale by economically poor farming communities for subsistence food. Currently, these crops are under-utilized or neglected, although they are reasonable sources of protein and can increase food security in rural areas. Research and development is underway to improve the grain quality and increase the productivity of these crops, both of which are negatively impacted by insect pest damage, especially in storage (Boopathi *et al*., 2009). Pigeon pea is a perennial legume of Class; Equisetopsida, Subclass; Magnolidae, Superorder; Rosanae, Order; Fabales, Family; Leguminosae/Fabaceae- Papilionoideae, Genus; *Cajanus*, ranked 5th in the world and the second most important legumes after beans with total production of about 133,000.00 tons produced from over 249,000.00ha. Many pigeon pea attributes have contributed to its wide use in the semi-arid tropics of which the most important is its seeds (Karthikayen *et al.,* 2006). The grain is thus an important diet for resource poor farmers who consume mainly low- protein cereals and root crops. In addition, minor pulses (seeds of legume crops other than dry beans, dry fava beans/ broad beans, dry peas, chickpeas, cow peas, pigeon peas, Bambara beans, vetches, or lupins) are used in bakery products, bread, pasta, snack foods, baby food, sports food, soups and tortillas, and their flour can be added to frozen dough (Asif *et al*., 2013). In developing and less developed countries where people suffer from protein deficiency (Gahukar, 2014a). The per capita consumption of pulses is decreasing because of the increasing human population, fluctuating market prices, and low crop productivity (Akibod and Maredia, 2011).

Pigeon pea productivity is low due to poor agronomic control, drought stress and pest and diseases among others. This severely reduced storage life, thus limiting seed and food availability. Among bruchidea species, the genus c*allosobruchus* cause great damage to pigeon pea (Keneni *et al*., 2011). In Nigeria, *C. maculatus*, *C. chinensis*, and *C. theobromae* are the most common. Past records showed that *C. maculatus* and *C. chinensis* are the most common and deadly storage pest associated with pigeon pea seeds (Khan *et al*., 2015). However, of all the three pests, *C. chinensis* is the most deleterious. Very heavy pigeon pea seed damage has been reported in several studies across the globe. In India for example, seed damage is reported only in four months, if not protected (Kosar and Srivastava, 2016), while Dialoke *et al*. (2010) reported disease surveillance in three States of Imo, Abia, Enugu and Anambra, Nigeria and established high level of pest incidence and damage caused by insect pests among farmers . However, because of this heavy damage to pigeon pea in storage, several management options were recommended, this include; the use of synthetic and non-synthetic pesticides, bio-rational, physical and cultural practices. These recommendations have been met with various levels of usage and degree of successes (Lai and Jat, 2015). The modern pest options which are insecticides and fumigant though effective but not very much used because they are expensive and not affordable for farmers in developing countries. Most of the stored grains are for continuous consumption and not commercial purposes, so, the use of hazardous insecticides are totally unacceptable (Nayer and Pedigo, 2006).

Synthetic pesticides have proven to be the most effective control agents against all pests of major pulses, however, considering the drawbacks of pesticide residues in the grain, environmental pollution, and damage to natural enemies associated with synthetic pesticide use; integrated pest management schemes for pulses are being developed (Alice *et al.,* 2014). For example, economic thresholds are being developed for pests of green gram (Vigna radiata [L.] R. Wilczek) and black gram (Vigna mungo [L.] Hepper) to avoid unnecessary pesticide applications (Akibod and Maredia, 2011). The adoption of these integrated practices by farmers in resource-poor communities should improve food security in rural areas. However, the introduction of integrated pest management in controlling the storage pest has been studied by many researches (Ofuya and Akingbohungbe, 2007). Integrated pest management (IPM) combines different control measures both on the field and in storage to produce a cost-effective and practical régime (Stoddard *et al*., 2010). Singh *et al.* (2009) recommended intercropping green gram with corn, releasing the predator *Chrysoperla carnea* at 25,000 adults/ha and applying a mixture of NO at 0.2% + malathion at 0.05% and a second spraying of No at 0.2% + endosulfan at 0.007% as needed. Within the two season trials, this regime significantly reduced pest levels compared with a control for several pests, including for M. vitrata (8.9–23.9 vs 10.6–30.3%), L. boeticus (8.6–20.6 vs 9.6–25.6%), aphids (56.6–65.2 vs 62.5–66.4%), jassids (58.0–66.7 vs 62.2–71.4%), and whiteflies (57.8–62.0 vs 58.2–71.5%) (Singh *et al.*, 2011). In black gram, IPM programs include; seed treatment with *B. bassiana* followed by the application of profenophos, and this program lowered pest levels to 3.6 whiteflies/plant versus 5.9 whiteflies in the control, while *B. bassiana* seed treatment + P. fluorescens seed treatment reduced population levels to 2.5 jassids/plant versus 5.6 jassids in control and an imidacloprid seed treatment + profenophos spraying showed 2.0 thrips/plant versus 4.1 thrips in the control (Singh *et al*., 2014). Also, Ofuya and Akingbohugbe (2007) reported that an application rate of 0.4 g/20 g of *E. aromatic* and *P.guineese* powder was effective in the control of *C.maculatus* and *S. zeamais* as 100% adult mortality was recorded at 48 and 72 hrs of post-infestation. Sequel to these menace, this study evaluated the use of two indigenous plant extracts (*Piper guineense* fruit and *Eugenia aromatic)*, in combination with synthetic insecticides i.e. pirimiphos-methyl and permethrin in the control of *C. chinensis* in pigeon pea seeds.

Material and Methods

Experimental material and source

The study was carried out at the Crop production, Research laboratory of the University of Agriculture and Environmental Sciences, Umuagwo, Owerri. The *C. chinensis* used were derived from culture maintained in Kilner jars under ambient laboratory conditions 28± 2°C and 70 ± 2%, relative humidity. *C. chinensis* was maintained on pigeon pea NSCWCC-50, obtained from IAR&T, Ibadan, Nigeria. Clean seeds showing no visible sign of weevil egg covers, presence of adults or their exit holes were used. The pigeon pea seeds were disinfested by storing them in a deep-freezer for two weeks before use.

Preparation of Insecticidal of Eugenia *Powders*

Dry flower buds of *Eugenia aromatic and* fruits of *Piper guineenses* Chum and Thomn were purchased from local herbal store in Owerri, Nigeria. The plant parts were oven dried at 60°C for 48 hrs and ground to powder form in an electric mill and the powders were sieved to pass through a 300um mesh using a British Laboratory

Test standard sieve. Each powder was stored in an air tight polythene bag placed in a wooden cupboard in the laboratory. Each prepared powder was used within one month of preparation. The two synthetic insecticides dust used were pirimiphos-methyl (Actellic) and permethrin (Coopex) and both were obtained from an Agro allied chemical store located within Owerri metropolis.

Experiment 1- Mortality of *C.chinensis* in pigeon pea treated with *E. aromatic* powder alone and in combination with pirimiphose- methyl or permethrin dust. In this experiment, 20g of maize grain in a plastic plate (8.5cm diameter) was treated with *E. aromatic* powder alone and in combination with pirimiphose-methyl or permethrin dust in 20 adults of *C. chinensis* (less than one week old and unsexed) were introduced. Five rates of *E. aromatic* powder (0.02, 0.04, 0.06, 0.08 and 0.lg) were each applied sole, and each rate in combination with either 0.lg of pirimiphos-methyl or permethrin dust was included. A control was set up involving no application of plant powder or synthetic insecticide. Each treatment was replicated three times, including the control. The experiment set-up was placed in a wooden cupboard in the Research Laboratory. Adult, mortality in the introduced *C. chinensis* was taken 24, 48 and 72 hours post introduction. Number of adult exit holes on seeds was the variable used to determine seed damage after Fi progeny emergence (Ofuya and Arogundade, 2008) and this was taken 50 days post-treatment.

Experiment 2- Mortality of *C. chinensis* in pigeon pea treated with *P. guineense* powder alone and in combination with pirimiphos- methyl or permethrin dust. The procedure described in Experiment 1 was followed except that *P. guineense* was used instead of *E. aromatica.*

Data Analysis

All data were subjected to analysis of variance, Percentage data were transformed using arcsine transformation before analysis. Mean values were separated using Duncan's multiple Range Test at the 5% level of probability.

Results and Discussion

Results

At 24hrs post- infestation, percentage mortality of *C. chinensis* was significantly higher in treatments involving 0.lg *Eugenia* and 0.08g *Eugenia* mixed with 0.1g permethrin than in other treatments (Table 1). Eleven (11) treatments, including the unprotected control and those involving synthetic insecticides once recorded zero percentage mortality, signifying the inefficacies of the treatments. At 48hrs post-infestation, treatment involving *Eugenia* (0.lg) mixed with permethrin (0.lg) produced the highest significant adult mortality of 81.6% which was significantly different from values recorded mortality in treatments involving *Eugenia* (0.08g) mixed with permethrin (0.lg) and *Eugenia* (0.lg) mixed with 0.lg pirimiphos- methyl (Table 1). Nine (9) treatments, including the unprotected control and those involving use of synthetic insecticides alone recorded zero percentage mortality. At 72hrs post - infestation, 100% mortality was recorded in treatments involving *Eugenia* + permethrin (0.lg + 0.lg) and *Eugenia* + pirimiphos- methyl (0.lg + 0.lg) and *Eugenia* + pirimiphos-methyl (0.08g + 0.lg). Seven treatments, including the unprotected control and those involving use of synthetic insecticides alone recorded zero percentage mortality (Table 3). Number of adult exit holes was significantly highest in the control treatment. It was lowest in treatments involving combination of *Eugenia* powder with permethrin or pirimiphos-methyl (0.lg + 0.lg and 0.1 + 0.08g). Eleven treatments including control recorded zero % adult mortality of *Callosobruchus chinensis* at 24hrs post-infestation (Table 2). The significant highest adult mortality was recorded in treatment involving 0.1 g *Piper* powder mixed with 0.lg pirimiphos-methyl (15.0gcd) and this was maintained up till forty eight hours post infestation. Seven treatments didn't record any adult mortality including control. No treatment combination showed 100 % adult mortality rate, at 72 hrs post-infestation (Table 2). However, nine treatments recorded zero adult mortality. Pigeon pea seeds in the control treatment had the highest number of adult exit holes. Pigeon pea seeds treated with *Piper* powder mixed permethrin (0.lg + 0.lg) recorded significantly fewest adult exit holes (Table 2).

Discussion

There have been global calls for caution in the use of synthetic organic insecticides in crop protection against pest attacks because of human health hazards caused as a result of their usage and other environment consequences (Ofuya and Akingbohungbe, 2007). However, the best method of balancing the chemical usage and the environmental consequences is to reduce the rate of application (Neog and Singh, 2012). The results of this study have shown that there is great potential in reducing the rate of application of synthetic organic insecticides by mixing with sub-lethal doses of insecticidal plant materials or botanicals. Botanicals are usually perceived to be relatively safe and nontoxic to humans and more environment- friendly (Nyodu and Jamir, 2015) and may reduce the undesirability of the synthetic organics in this duration. Ofuya and Akingbohugbe (2007) reported that an application rate of 0.4 g/20 g of *E. aromatied* and *P.guineese* powder was effective in the control of *C.maculatus* in cowpea as 100% adult mortality was recorded at 48 and 72 hrs post-infestation. In this study, a sub-lethal dose of 0.lg *E. aromatica* mixed with a low rate (0.lg) of either permethrin or pirimiphos-methyl per 20 grams of seed also produced 100% adult mortality of *C. chinensis* at 48 and 72 hrs. *Piper guineese* singularly applied at 0.lg produced significant mortality (56%) of *C. chinensis* at 72hrs. Raghumamu (2015) and Singh *et al*. (2014) indicated that a few plants in the Nigeria flora with confirmed biological efficacies against species of stored products insects were sufficient insecticidal to merit scientific formulation. Mixing insecticidal plant materials with synthetic organics can be regarded as mixed formulation of insecticidal (Nayer and Pedigo, 2006). Ganeshaiah (2016) demonstrated that pirimiphos- methyl can be used at reduced rates if combined with vegetable oils to control infestations of *C. chinensis* in stored pigeon pea. Also, Gahukar (2014b) used water extracts of neem and other local plants in minor pulses among which were chickpeas, cow peas, pigeon peas and Bambara beans and observed that storage pests were in effective and the application rate was able to kill the pests within 48 and 72 hours of application. The low rate of the synthetic organic appeared to have synergized the sub-lethal dose of the botanical to produce increased toxicity to the insects. For instance, the low rate of each synthetic organic used did not cause mortality of the insects at the times of observation, but when mixed with 0.08 g and especially 0.lg of each botanical, the mortality caused to the insects was about doubled. Synergism in mixed formulations of insecticides has been reported (Nayer and Pedigo, 2006; Karthikayen *et al.,* 2015). Homoligosis is a phenomenon in which a stimulating effect is induced in insect or other arthropods with sub-lethal dose of possible combinations which causes the female to lay more viable eggs that develop to adult (Kosar *et al*., 2016). In this study, there appears to be *a* resemblance of this phenomenon when *Piper* powder alone was applied for the control of *C. chinensis.* A significantly higher number of adult beetles, indicated by the number of exit holes, emerged at the dose level of 0.02g than in the control.

Conclusion

The result of this work has further substantiated a good potential of combining low doses of insecticidal plant powder and low doses of synthetic organic dusts for maintenance of pigeon pea seed quality, effective protection of stored grains against insect infestation arid damage. All possible combinations of low doses of both the insecticidal plant powders and synthetic organic dusts should be tested so that the best mix can be determined and disseminated for use.

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Table 1: Adult *C. chinensis* mortality in *Eugenia* powder alone and in combination with permethrin and pirimiplios methyl

Treatment combination	Rate of application	Mean% 24hrs	Adult mortality	+S.E.in g/20g in 72hrs	Mean no of adult exit hole
Eu- alone	0.02	0.0a	0.0a	0.0a	40.0gf
	0.04	0.0a	0.0a	0.0a	27.3 fg
	0.06	1.6a	6.6ab	16.6ab	I8.0bc
	0.08	3.3ab	2l.6bc	46.6cd	18.0bc
	0.1	10.0cd	36.6cd	56.6cd	15.0b
Eu+permethrin	0.02+0.1	0.0a	0.0a	0.0a	38.0fg
	0.04+0.1	0.0a	0.0a	0.0a	31.0fg
	0.06+0.1	0.0a	11.6ab	30.0bc	25.0bc
	0.08+0.1	16.6e	75.Ode	85.Ode	11,0ab
	0.1+0.1	16.6e	81 6e	100.0g	7.0ab
Eu+pirimiphos	0.02+0.1	0.0a	0.0a	0.0a	45.2fg
	0.04+0.1	0.0a	0.0a	1,6a	35.0cd
	0.06+0.1	0.0a	11.6ab	23.3bc	22.0bc
	0.08+0.1	11.6cd	60.0cd	1.00e	8.0ab
	0. 1	13.3d	76.6cd	100g	6.0ab
Per alone	0.1	0.0a	0.0a	0.0a	47.5gf
Piri-methyl alone	0.1	0.0a	0.0a	0.0a	45.0fg
Control		0.0a	0.0a	0.0a	60.0g

Note: Means bearing the same letters are not significantly different at p=0.05 (DMRT)

Table 2: Adult *C. chinensis* mortality in *Piper guineense* powder alone and combination with permethrin and pirimiphos methyl

Treatment combination	**Rate of application**	**Mean% 24hrs**	**Adult mortality 48hrs**	**+S.E.in g/20g in 72hrs**	**Mean no of adult exit hole**
Piper alone	0.02	0.0a	0.0a	0.0a	47.6fg
	0.04	0.0a	0.0a	0.0a	24.3bc
	0.06	0.0a	1.6a	13.3ab	21.0bc
	0.08	1.6a	16.6bc	28.3bc	1 8.0bc
	0.1	10.0cd	20bc	40.0bc	I4.0bc
piper+permethrin	0.02+0.1	0.0a	0.0a	0.0a	3.0fg
	0.04+0.1	0.0a	0.0a	0.0a	35.0fg
	0.06+0.1	0.0a	30.0bc	30.0bc	32.0cd
	0.08+0.1	8.3 be	75.0de	75.0dc	I4.0ab
	0.1+0.1	11.6cd	86.6de	86.6de	11 .0ab
Piper+pirirmipho	0.02+0.1	0.0a	0.0a	0.0a	38.0 fg
	0.02+0.1	0.0a	0.0a	0.0a	38.0fg
	0.04+0 1	0.0a	0.0a	0.0a	34.0fg
	0.06+0.1	0.0a	11.6ab	30.0bc	30.2fg
	0.08+0.1	8.3bc	63.3cd	83.3de	20.0bc
	0.1+0.1	15cd	68.3cd	83.3de	18.0bc
Permertrin alone	0.1	0.0a	0.0a	0.0a	47.8 fg
Pirimiphos-Methyl	0.1	0.0a	0.0a	0.0a	48.2fg
Control		0.0a	0.0a	0.0a	42.0f

Note: Means bearing the same letters are not significantly different at p=0.05 (DMRT)