Application of selected Bioinsecticides in management of *Oryzaephilus surinamensis* (Coleoptera: Silvaridae) on *Phoenix dactylifera* (Date fruits)

Popoola K.O.K.

Department of Zoology, University of Ibadan, Ibadan. Nigeria.
kok.popoola@ui.edu.ng / taiwo_kok@yahoo.com

Abstract: The boinsecticidal potency of three botanicals, namely: *Allium sativum* (Garlic), *Allium cepa* (Onion) and *Capsicum annum* (Red pepper) were tested on *Oryzaephilus surinamensis* (Saw- toothed grain beetle) infested with *Phoenix dactylifera* (Date fruits) at exposure periods of three weeks and six weeks in the Department of Zoology, Entomology Laboratory. The boinsecticides used were in powdered and whole forms at three different concentrations of 1.25g, 2.50g and 5.00g. Potency was determined through, fecundity, emergence and mortality rate of the pest under study. At three and six weeks of exposure, mortality between 5.00g concentration of garlic and the control, onion and control were significantly different at $p<.05$. Application of whole red pepper as boinsecticide was more potent than powdered form, which was significantly different at $p<.05$. From the study it may be deduced that the tree botanicals have insecticidal potentials which reduced in potency with increase in time and that garlic was more potent than the onion and red pepper.
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1. Introduction

Oryzaephilus surinamensis **(**Saw- toothed grain beetle) ; The saw-toothed grain beetle, *Oryzaephilus surinamensis* one of the most common insect pest of grains and a variety of stored products, and has been found in high numbers in almost all storage facilities (Beckel *et al.,* 2007). It is a secondary pest in stored grain due to its inability to damage the whole grain; however, its status has changed due mainly to the mechanical damage during harvesting and drying, which results in broken and damaged products going to storage facilities, where this pest species will build up and cause very high infestation problems (Pricket *et. al.,* 1990, Beckel *et. al.,* 2007).

Both adults and larvae attack flours, breakfast cereals, nuts and dried fruits, especially because of their ability as cosmopolitan invaders of packaged food (Mowery *et al.,* 2002). They are very small insect and have the ability to hide in many places in storage facilities, making it difficult to be controlled by insecticides and have built up resistance to several insecticides (Wallbank *et al.,* 2003).

Phoenix dactylifera The date palm is one of the oldest fruit trees in the world, known for its edible delicious fruit, the dates. *P. dactylifera* has long been one of the most important plants of arid, desert areas of Northern Africa, the Middle East and Southern Asia.

P. dactylifera (Linnaeus) (Date) appropriately called "the palm of life", for over 5000 years, has provided food, ornament and material for shelter, fiber and fuel in a harsh environment where relatively few other plants are able to grow (Popenoe, 1973, Hodel *et al.,* 2003). Dates as a fresh fruit ranked number five in the list of tropical/sub tropical fruits after citrus, mangoes, banana and pineapples. While as a dried fruit, dates easily top the list, *P. dactylifera* is the only species cultivated for its (Shauket, 2003).

Botanicals in stored pest control.

Efficient control of stored products pests has long been the aim of entomologists worldwide. Synthetic chemical pesticides have been used for many years to control stored grain pests (Salem *et al*., 2007). However, the potential hazards for mammals from synthetic insecticides, increased concern by consumers over insecticide residues in processed cereal products constitute health risk. For example, residues of methlybromide have been found to exhibit carcinogenic effects in rats (Chomchalow, 2003). The occurrence of insecticide-resistant insect strains with the ecological consequences, increasing cost and technical know how of application, calls for new approaches in control of stored product insect pests (Aslam *et.al*., 2002; Udo, 2005; Fields, 2006; Salem *et. al*., 2007; Mahdian *et al.,* 2008). Therefore, there is a need to look for alternative organic sources that are readily available, cheap, affordable, non-toxic and less detrimental to the environment (Udo, 2005). Peasant farmers and researchers often claim successful use of material of plant origin in insect pest control including spices and powders of plant parts (Akinneye *et al.*, 2006).

Botanicals are plants or plants-derived products having active ingredients for the control of storage

pests. Botanicals have more advantages than chemical insecticides in that they are cheap, effective and non-toxic to man, livestock and the environment. Insects rarely develop resistance to botanicals.

The aim of this research work was to determine the efficacy of garlic bulb, onion bulb and dried red bell pepper fruit for the control of *O. surinamensis* (saw-toothed grain beetle) infestations at various levels of establishment on *P. dactylifera* (Linnaeus) (date fruits).

2. Material and Methods

Insect's pest collection: The insect pests *Oryzaephilus surinamensis* were collected from a culture stock raised in the Entomology laboratory, Department of Zoology of the University of Ibadan, Ibadan, Nigeria. A total of 455 beetles were used for the experiment.

Dates collection: *Phoenix dactylifera,* dates were purchased from Mokola, Ibadan, Oyo state, Nigeria. The fruits were sterilized in an oven for 2hrs at 60^{o}C, to sterilize the dates. 12 holes were made on every dates to mimic damaged crop for easy infestation by *O. surinamensis*.

Collection of botanicals: Purchased garlic bulbs (*Allium sativum*), onion bulbs (*Allum cepa)* and dried pepper (*Capsicum annum L)* weighing 100g, 450g and 130g respectively were bought from Bodija market, Ibadan, Oyo state.

Preparation of Botanicals: Thin sliced garlic bulbs and onion bulbs were oven dried in Gallenkemp oven of OV-160 model at 60^{0}C for 3hrs. After this the dried botanicals were separately ground with an electrical blender and they were stored away in the laboratory in screwed cap jar bottle of 250ml size until when needed.

Determination of Moisture Content of date fruits: Moisture content of the dates was determined using the dry to constant weight method. (AOAC, 1975)

Experimental set-up: Grounded garlic and onion bulbs, dried pepper and ungrounded whole dried pepper were applied at varied quantities of 1.25g, 2.5g and 5.0g in specimen bottles (250ml) containing 25g of dates. The content of each bottle was shaken vigorously to have a thorough coverage of the date's surface with the botanicals. Five adults *O. surinamensis* were added, ensuring that both female and male were present. This was done by allowing mating to occur and the couples introduced. Vaseline was applied around the inner top of the bottles to prevent the pests from walking out of the specimen bottle. The specimen bottles were then covered with muslin cloth and held tightly with rubber band to prevent cross infestation and possible pest escape. In the same way a control set up was prepared, but botanical was not applied. Seven replicates were set up for each botanical at the different level of concentrations and a control giving a total of 91 set up. These were then stored in 3 wooden cages (60x 30 x 30) cm^3 in the Entomology laboratory, University of Ibadan, at a temperature range of 28.0 - 30.0^{o}C for storage period of 3 and 6 weeks. After the storage periods, rate of fecundity, pest emergence and mortality and weight loss in date were recorded.

Statistical analysis: One way analysis of variance was used to determine the level of significance of the botanicals with the control and also among the botanicals. Duncan ranking was also used to show the areas where there was significance. Two way analysis of variance (ANOVA) was done to determine the effect of period of exposure on the botanicals.

3. Results

Determination of botanical efficacy on fecundity, emergence and mortality rate of *Oryzaephilus surinamensis* on treated date fruits within exposure period of 3 weeks.

At the end of 3weeks, three replicates per each botanical concentrations were opened up to dissect the dates. Different developmental stages encountered were identified, counted and recorded. (Table 1)

Determination of botanical efficacy on fecundity, emergence and mortality rate of *O. surinamensis* on treated date fruits with exposure period of 6 weeks was done using the remaining 3 replicates from the set up. These were dissected at the end of 6th weeks of storage. Both live and dead insects were recorded. (Table 2)

Comparison of botanicals efficacy at different exposure periods of storage of 3 and 6 weeks

The percentage values of the emergence and mortality of larval and adult stages were calculated for both exposure periods of 3 and 6 weeks for all the botanicals at different concentrations and these were compared to reveal the efficacy of the botanicals. (Tables, 3, 4, 5 and 6)

Table 1: Mean values of *O. surinamensis*; Fecundity, Emergence and Mortality rate in treated date fruits with botanicals for infestation period of 3weeks

BOTANICALS BOTANICALS	Concentration (g) (Bioinsecticides)		MEAN VALUES ± STANDARD DEVITION (SD) OF					
			Fecundity (Egg number)	Larval Emergence	Larval Mortality	Pupa Emergence	Adult Emergence	Adult Mortality
GARLIC (*Allium sativum*)	1.25		0.00±0.00^{a}	16.67±0.67^{ab}	1.00±0.00^{a}	0.00±0.00^{a}	4.67±0.33^{a}	0.00±0.00^{b}
	2.50		0.33±0.33^{a}	12.00±7.00^{ab}	0.33±0.33^{ab}	0.00±0.00^{a}	4.67±0.33^{a}	0.33±0.33^{b}
	5.00		0.00±0.00^{a}	5.00±3.06^{b}	0.00±0.00^{b}	0.00±0.00^{a}	2.67±0.33^{b}	2.33±0.33^{a}
	CONTROL		0.00±0.00^{a}	30.00±8.72^{a}	0.33±0.33^{ab}	0.00±0.00^{a}	4.67±0.33^{a}	0.33±0.33^{b}
ONION (*Allium cepa*)	1.25		0.00±0.00^{a}	12.00±1.53^{a}	0.33±0.33^{a}	0.00±0.00^{a}	4.33±0.67^{a}	0.33±0.33^{a}
	2.50		0.67±0.67^{a}	11.00±6.03^{a}	0.00±0.00^{a}	0.67±0.67^{a}	4.33±0.33^{a}	0.67±0.33^{a}
	5.00		0.00±0.00^{a}	14.66±7.36^{a}	0.00±0.00^{a}	0.00±0.00^{a}	4.33±0.33^{a}	0.67±0.33^{a}
	CONTROL		0.00±0.00^{a}	30.00±8.72^{a}	0.33±0.33^{a}	0.00±0.00^{a}	4.67±0.33^{a}	0.33±0.33^{a}
PEPPER (*Capsicum annum*)	WHOLE							
		1.25	0.33±0.33^{a}	19.67±3.39^{a}	0.00±0.00^{a}	0.33±0.33^{a}	4.67±0.33^{a}	0.33±0.33^{a}
		2.50	0.00±0.00^{a}	16.00±5.20^{a}	0.00±0.00^{a}	1.00±1.00^{a}	5.33±0.88^{a}	0.33±0.33^{a}
		5.00	0.00±0.00^{a}	28.00±7.23^{a}	0.33±0.33^{a}	0.67±0.67^{a}	6.00±0.00^{a}	0.00±0.00^{a}
		CONTROL	0.00±0.00^{a}	30.00±8.72^{a}	0.33±0.33^{a}	0.00±0.00^{a}	4.67±0.33^{a}	0.33±0.33^{a}
	GROUND							
		1.25	0.00±0.00^{a}	35.67±7.13^{ab}	0.33±0.33^{a}	0.33±0.33^{a}	4.67±0.33^{a}	0.00±0.00^{a}
		2.50	1.33±0.88^{a}	21.67±0.88^{ab}	0.33±0.33^{a}	0.67±0.33^{a}	4.00±1.00^{a}	0.33±0.33^{a}
		5.00	0.33±0.33^{a}	5.33±2.03^{b}	0.00±0.00^{a}	0.00±0.00^{a}	4.33±0.67^{a}	0.67±0.67^{a}
		CONTROL	0.00±0.00^{a}	30.00±8.72^{a}	0.33±0.33^{a}	0.00±0.00^{a}	4.67±0.33^{a}	0.33±0.33^{a}

Means in the same box followed by the same letters are not significantly different by Duncan's multiple range test at $p<0.05$. Values are means of three replicates ± SD

Table 2: Mean values of *O. surinamensis*; Fecundity, Emergence and Mortality rate in treated date fruits for infestation period of 6weeks

BOTANICALS	Concentration (g) (Bioinsecticides)		MEAN VALUES ± STANDARD DEVIATION (SD) OF					
			Fecundity (Egg number)	Larval Emergence	Larval Mortality	Pupa Emergence	Adult Emergence	Adult Mortality
GARLIC (*Allium sativum*)	1.25		0.00±0.00^{b}	23.33±8.29^{ab}	1.33±0.67^{a}	5.67±2.03^{b}	22.33±7.69^{ab}	1.67±0.88^{a}
	2.50		1.00±1.00^{ab}	15.67±10.37^{b}	0.33±0.33^{a}	7.67±2.19^{b}	8.33±2.33^{b}	1.00±0.58^{a}
	5.00		0.00±0.00^{b}	8.00±2.52^{b}	2.00±0.58^{a}	5.33±0.88^{b}	12.33±5.04^{b}	1.00±0.58^{a}
	CONTROL		2.33±0.33^{a}	42.67±0.33^{a}	0.67±0.33^{a}	16.67±0.33^{a}	37.67±0.33^{a}	0.00±0.00^{a}
ONION (*Allium cepa*)	1.25		0.00±0.00^{b}	24.00±2.89^{b}	0.00±0.00^{a}	7.33±2.03^{b}	14.00±2.08^{b}	0.00±0.00^{b}
	2.50		0.67±0.33^{b}	35.00±6.81^{ab}	1.33±0.6^{a}	5.67±2.19^{b}	8.33±0.88^{c}	0.00±0.00^{b}
	5.00		0.00±0.00^{b}	22.33±3.18^{b}	0.33±0.33^{a}	10.00±3.06^{ab}	12.67±2.40^{bc}	0.67±0.33^{a}
	CONTROL		2.33±0.33^{a}	42.67±0.33^{a}	0.67±0.33^{a}	16.67±0.33^{a}	37.67±0.33^{a}	0.00±0.00^{b}
PEPPER (*Capsicum annum*)	WHOLE							
		1.25	0.33±0.33^{b}	24.67±4.67^{b}	0.00±0.00^{b}	8.00±1.73^{b}	11.00±2.52^{c}	1.33±0.33^{a}
		2.50	0.00±0.00^{b}	28.67±1.67^{ab}	2.00±0.00^{a}	15.33±3.84^{a}	23.67±2.33^{b}	1.00±0.58^{ab}
		5.00	0.00±0.00^{b}	32.00±9.01^{ab}	1.00±1.00^{ab}	3.33±1.33^{b}	18.33±1.20^{b}	0.67±0.33^{ab}
		CONTROL	2.33±0.33^{a}	42.67±0.33^{a}	0.67±0.33^{ab}	16.67±0.33^{a}	37.67±0.33^{a}	0.00±0.00^{b}
	GROUND							
		1.25	0.00±0.00^{b}	48.67±9.39^{a}	1.33±0.67^{a}	19.33±4.37^{a}	21.00±0.58^{b}	0.33±0.33^{a}
		2.50	0.00±0.00^{b}	23.67±9.39^{ab}	1.33±0.33^{a}	15.00±5.69^{a}	12.00±2.52^{c}	1.67±0.33^{a}
		5.00	0.00±0.00^{b}	10.00±6.81^{b}	0.67±0.67^{a}	7.67±5.17^{a}	16.00±4.00^{bc}	1.67±0.88^{a}
		CONTROL	2.33±0.33^{a}	42.67±0.33^{a}	0.67±0.33^{a}	16.67±0.33^{a}	37.67±0.33^{a}	0.00±0.00^{a}

Means in the same column followed by the same letters are not significantly different by Duncan's multiple range test at p<0.05. Values are means of three replicates ± S.D.

Table 3: The percentage mean values of mortality and emergence of adult and larva *O. surinamensis* on 25g date treated with garlic powder (Grounded)

PERIOD OF EXPOSURE (WEEKS)	CONCENTRATION (g)	MORTALITY OF LARVA (%)	MORTALITY OF ADULT (%)	EMERGENCE (%)	
				LARVA	ADULT
3	1.25	5.67	0.00	94.33	0.00
	2.50	3.03	6.67	96.97	0.00
	5.00	0.00	46.67	100.00	0.00
	CONTROL	2.20	6.67	99.26	0.00
6	1.25	4.00	5.67	96.00	71.57
	2.50	0.90	10.71	99.10	31.63
	5.00	21.09	5.81	78.89	42.42
	CONTROL	1.50	0.00	98.50	86.70

*Values are means of three replicates.

Table 4: The percentage mean values of mortality and emergence of larval and adult *O. surinamensis* on 25g date treated with onion.

PERIOD OF EXPOSURE (WEEKS)	CONCENTRATION (g)	MORTALITY OF LARVA (%)	MORTALITY OF ADULT (%)	EMERGENCE (%)	
				LARVA	ADULT
3	1.25	3.33	8.33	96.67	0.00
	2.50	0.00	6.67	100.00	0.00
	5.00	0.00	13.33	100.00	0.00
	CONTROL	2.20	6.67	99.26	0.00
6	1.25	0.00	0.00	100.00	62.77
	2.50	3.29	0.00	96.71	38.69
	5.00	1.23	5.93	98.77	56.85
	CONTROL	1.50	0.00	98.50	86.70

*Values are means of three replicates.

Table 5: The percentage mean values of mortality and emergence of adult and larva *O. surinamensis* on 25g date treated with whole pepper.

PERIOD OF EXPOSURE (WEEKS)	CONCENTRATION (g)	MORTALITY OF LARVA (%)	MORTALITY OF ADULT (%)	EMERGENCE (%)	
				LARVA	ADULT
3	1.25	0.00	6.67	100.00	0.00
	2.50	0.00	6.67	100.00	9.52
	5.00	1.96	0.00	98.04	16.67
	CONTROL	2.20	6.67	99.26	0.00
6	1.25	0.00	10.74	100.00	50.23
	2.50	6.56	4.41	93.44	78.41
	5.00	2.22	3.63	97.78	72.48
	CONTROL	1.50	0.00	98.50	86.70

***Values are means of three replicates**.

Table 6: The percentage mean values of mortality and emergence of adult and larva *O. surinamensis* on 25g date treated with ground pepper.

PERIOD OF EXPOSURE (WEEKS)	CONCENTRATION (g)	MORTALITY OF LARVA (%)	MORTALITY OF ADULT (%)	EMERGENCE (%)	
				LARVA	ADULT
3	1.25	0.71	0.00	99.29	0.00
	2.50	1.39	11.11	98.61	0.00
	5.00	0.00	13.33	100.00	0.00
	CONTROL	2.20	6.67	99.26	0.00
6	1.25	3.25	1.45	96.75	76.15
	2.50	6.05	13.47	93.95	55.01
	5.00	2.67	12.12	64.00	62.50
	CONTROL	1.50	0.00	98.50	86.70

***Values are means of three replicates**

4. Discussion

The moisture content of 8-12% for the date fruit and the temperature range of 28-30^{O} obtained in the laboratory showed that the environment was quite conducive and may encourage the breeding of saw-toothed grain beetle. These environmental conditions with warm temperature and moisture content of 8-12% are usually required for the growth and reproduction of different stored insect pest species (Katz, 2003).

Having eliminated the two key factors influencing the growth of most stored insect pests, it may be assumed

that a deviation in the normal pest status in the date was as a result of the treatment applied. Tables 1 and 2 gave an overview of the relationship within the treatment and also with one another along with the control. The effect of each botanical may also be determined from the tables.

At 3weeks (Table 1), onion and whole pepper showed no significant different at $p<0.05$ level, when compared statistically with the control set-up.

However table 5 shows that onion may be effective against adult *O. urinamensis* at concentration of 5.0g, with a mean adult mortality rate of 13.33%. Dates treated with garlic recorded the highest adult mortality rate of 46.67% at its 5.0g concentration.

Two of the major constituents of the essential oil of garlic, *Allium sativum* L., methyl allyl disulfide and diallyl trisulfide, were tested against *Sitophilus zeamais* Motschulsky and *Tribolium castaneum* (Herbst) for contact toxicity, fumigant toxicity, and antifeedant activity. The contact and fumigant toxicities of diallyl trisulfide were greater than that of methyl allyl disulfide to the adults of these two species of insects. These two compounds were also more toxic to *T. castaneum* adults than to *S. zeamais* adults. Older *T. castaneum* larvae were more susceptible to the contact toxicity of the two compounds, whereas younger larvae were more susceptible to the fumigant toxicity of these compounds. Both compounds reduced egg hatching of *T. castaneum* and subsequent emergence of progeny, Yan *et al*., (2000). Futhre more, studies have showed mortality rates of 18.33%, 23.33% and 45.0% of adult *Callosobruchus maculatus* infested on 2.5g, 5,0g and 10.0g garlic treated cowpea grains respectively, Oparaeke *et al*.,(1996),

Whole pepper on the other hand, had no effect on both mortality rates of larva and adult of *O. surinamensis* at 3 and 6 weeks period of exposure (Table 5) whereas ground pepper, had an impact on adult exposure on the botanicals. At 6weeks period of exposure, garlic and onion became less effective against adult resulting in low adult mortality (Tables 4 and 5). This may be as a result of their volatility. With increase exposure period, their insecticidal potential may reduced and so may have less impact on adult mortality.

Nevertheless, at 6weeks, garlic still had some larvicidal effect on *O.s surinamensis* larvae. This was in line with the studies of Thomas *et al*., (1999) in which the use of garlic as a *Culex pipiens* larvicide was found to be effective.

Ground pepper still had an effect on both larvae and adult *O. surinamensis*. It however, increased in its larvicidal action with increase in the period of exposure. This may be due to the prolonged exposure of the larvae to the ground pepper. Unfortunately, there is dearth of information on the effect of ground *Capsicum annum* on *O. surinamensis*. However, Asawalam *et al*., (2007) found that *Capsicum frutescens* had high percentage mortality on *Sitophilus zeamais* and significantly reduced emergence.

The pupal stage was unaffected probably because it is the quiescent stage in which the insect neither feeds nor move about.

This research may be concluded by saying, that the botanicals employed are potential insecticides for protection of stored dates form *O. surinamensis* infestation and also, that botanicals have advantages over broad-spectrum conventional pesticides, because they affect only target pest and closely related organisms, equally they are effective in very small quantities, decompose quickly, and provide the residue free food and a safe environment to live.

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