Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 3131-3134
Received: 21-07-2018
Accepted: 22-08-2018

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Residual toxicity of newer insecticide molecules in treated stored maize against lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae)

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Abstract
A storage experiment was conducted to study the residual toxicity of newer insecticide molecules on *R. dominica* in stored maize under ambient storage condition. The observations were recorded on adult mortality and presence of dead adults of test insect at tri-monthly interval up to nine months of storage period. Among the insecticides evaluated the spinosad 45 SC @ 2ppm and emamectin benzoate 5 SG @ 2ppm treatments were recorded with higher adult mortality in residual toxicity experiment and the least number of dead adult under natural infestation over different periods of storage. From the present investigations revealed that spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm were found to be most effective up to nine months after treatment imposition in combating the *R. dominica* in stored maize.

Keywords: Spinosad, emamectin benzoate, maize, *R. dominica*, adult mortality

Introduction
Maize or Corn (*Zea mays* L.) is a versatile cereal crop grown over a range of agro climatic zones. Globally, maize is known as queen of cereals because, it has the highest genetic yield potential among the cereals. It is not only an important human nutrient, but also a basic element of animal feed and raw material for manufacture of many industrial products like corn starch, corn oil, corn syrup and bio-fuel. It is cultivating on nearly 150 m ha in about 160 countries that contributes 36% (782 m t) in the global grain production (Anon., 2015a) [3]. India has 5 percent of maize acreage and contributes 2.5 percent of world production. During 2015, it was cultivated on about 9.5 million hectares, producing 23.29 million tons of grain with 2451 kg/hectare yield (Anon., 2015b) [4].

During postharvest storage, maize grains are vulnerable to many insects. Among those, Lesser grain borer *Rhyzopertha dominica*, Weevils complex *Sitophlilus* spp., Angoumois grain moth *Sitotroga cerealella* (Olivier), Khapra beetle *Trogoderma granarium* Everts and Red flour beetle *Tribolium castaneum* (Herbst) are important (Ebeling, 2002) [8]. It is estimated that 5 to 10 percent of world's grain production is lost due to ravages of insect pests. These losses reach to 50 percent in tropical countries where temperature and humidity run high during summer season (Ahmad and Ahmad, 2002) [1]. Estimates of post-harvest losses of cereal grains ranged between 5 to 35 percent in the world (Boxall *et al.*, 2002) [5]. In India, up to 12 percent of post-harvest losses were caused by insect pests (Mohan, 2003) [15]. This reflects on the magnitude of pest problem in storage.

The lesser grain borer is a serious and primary pest that feeds internally on stored commodities such as paddy, wheat, maize and sorghum including pulses (Edde 2012) [9]. The beetle has been reported to be highly polyphagous and cosmopolitan in tropical and subtropical regions of the world, but it has also been found in warm and temperate regions (Haines, 1991) [11]. Relative to other stored grain insect pests, *R. dominica* is the most difficult insect pest to control with insecticide grain protectants, because many of the currently approved grain protectants are either not effective against the insect, or the insect has developed resistance to them. For instance, *R. dominica* is resistant to methoprene (Lorini and Galley, 1999) [14]; several pyrethroid-based grain protectants (Collins, 2006) [7] and to all approved organo phosphorus insecticides (Edde, 2012) [9]. Though fumigation by phosphine has been effective in the control of *R. dominica* (Chaudhry, 2000), its resistance to phosphine is of major global concern internationally (Collins, 2006) [7].

Insecticides are one of the most effective weapons for disinfesting and protecting stored products from infestation. There is also need to find the chemicals that can effectively prevent the storage losses, easily available, affordable, safer and least detrimental to environment. The effectiveness of insecticide as a seed protectant for long term storage depends on its longer residual toxicity. Since *R. dominica* is a major insect pest of stored maize causing severe damage, preventing long term storage, the present investigation was undertaken to screen out the effective insecticides for the management of *R. dominica* by evaluating newer molecule insecticides for their residual toxicity.

Material and Methods

A storage experiment was conducted in Entomological laboratory at All India Coordinated Research Project on Seed Technology, National Seed Project, University of Agricultural Sciences, Gandhi Krishi Vignan Kendra, Bengaluru during June 2014 to March 2015, to study the effect of newer molecule insecticides for effective control of *R. dominica* on maize. Freshly harvested certified seeds of Hema hybrid maize were taken from NSP. Recommended quantity of insecticides was diluted in five ml water to treat one kg of seed for proper coating. After treatment, seeds were dried in shade and packed in two kg capacity gunny bags and kept for storage under ambient condition. Similarly, control was maintained without any treatment for comparison. The experiment was conducted in completely randomized design (CRD) with nine treatments and three replications.

Adult mortality in Residual toxicity experiment: Plastic containers with 100 g of treated seeds were transferred with freshly emerged 10 adults of *R. dominica*. Mortality of insects was recorded at three, seven and ten days after adult release, immediately after treatment imposition and at three, six, and nine months after treatment imposition.

Adult mortality of natural infestation under ambient storage condition: Number of dead insects was counted in all the treatments by taking 400 maize seeds of representative sample randomly.

Statistical analysis: The data after suitable transformations (wherever required) were subjected to statistical analysis following analysis of variance (ANOVA) technique for completely randomized design (CRD) to draw inference at 5% level of significance.

Results and Discussion

Residual toxicity of insecticides on *R. dominica* adult mortality in store maize

After treatment imposition, at three days after adult release, the highest (100.00%) mortality was recorded in spinosad 45 SC @ 2 ppm, emamectin benzoate 5 SG @ 2 ppm, rynaxypyr 20 SC @ 2 ppm, indoxacarb 14.5 SC @ 2 ppm, chlorfenapyr 10 EC 2 ppm and profenofos 50 EC@ 2 ppm treated seeds. The results obtained at seven days after adults release, revealed that all treatments recorded with 100 percent mortality except untreated control (6.67%). Same trend was observed at ten days after adult release, whereas untreated control recorded with 16.67 percent mortality.

The results obtained at three days after adult release, at three months of treatment imposition revealed that spinosad 45 SC @ 2 ppm, emamectin benzoate 5 SG @ 2 ppm and rynaxypyr 20 SC @ 2 ppm recorded highest percentmortality (100% each), they were on par with each other and differed significantly from other treatments. The results obtained at seven days after adults release revealed that indoxacarb 14.5 SC @ 2 ppm and chlorfenapyr 10 EC@ 2 ppm treated seeds recorded with same level of mortality (100%) and both differed significantly with profenofos 50 EC @ 2 ppm (93.33 percent), deltamethrin 2.8 EC @ 1 ppm (90.00%) and novaluron 10 EC @ 2 ppm (86.67%). Least mortality was recorded in untreated control (6.67%). At 10 days after adult release 100 percent mortality was recorded in all insecticide treatments, however untreated control (13.33%) observed with least mortality.

Three days after test insect released at six month of treatment imposition the observations revealed that, spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm exhibited the highest mortality (83.33% each) and they were on par with indoxacarb 14.5 SC @ 2 ppm, rynaxypyr 20 SC @ 2 ppm and chlorfenapyr 10 EC 2 ppm (76.67% each). Seven days after adults release the highest mortality was recorded in spinosad 45 SC @ 2 ppm (96.67%) which was on par with emamectin benzoate 5 SG @ 2 ppm recorded (93.33%). Ten days after adults release spinosad 45 SC @ 2 ppm, emamectin benzoate 5 SG @ 2 ppm, rynaxypyr 20 SC @ 2 ppm, indoxacarb 14.5 SC @ 2 ppm and chlorfenapyr 10 EC 2 ppm displayed 100 percent mortality.

Table 1: Residual toxicity of new insecticide molecules on adult mortality of *R. dominica* in treated maize seeds

Treatments		Mortality (%)											
		0 MAT			3 MAT			6 MAT			9 MAT		
		3 days	7 days	10 days	3 days	7 days	10 days	3 days	7 days	10 days	3 days	7 days	10 days
T_1	Emamectin benzoate 5 SG @ 2 ppm	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	83.33 (66.12)^{a}	93.33 (77.68)^{a}	100.00 (89.96)^{a}	76.67 (61.20)^{a}	86.67 (68.83)^{a}	96.67 (83.82)^{a}
T_2	Spinosad 45 SC @ 2 ppm	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	83.33 (66.12)^{a}	96.67 (83.82)^{a}	100.00 (89.96)^{a}	80.00 (63.90)^{a}	90.00 (71.54)^{a}	100.00 (89.96)^{a}
T_3	Indoxacarb 14.5 SC @ 2 ppm	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	90.00 (71.54)^{b}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	76.67 (61.20)^{a}	90.00 (74.97)^{ab}	100.00 (89.96)^{a}	73.33 (58.98)^{ab}	83.33 (66.12)^{ab}	93.33 (77.68)^{a}
T_4	Rynaxypyr 20 SC @2ppm	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	76.67 (61.20)^{a}	90.00 (74.97)^{ab}	100.00 (89.96)^{a}	76.67 (61.20)^{a}	86.67 (68.33)^{a}	96.67 (83.82)^{a}
T_5	Chlorfenapyr 10 EC @2ppm	100.00 (89.66)^{a}	100.00 (89.66)^{a}	100.00 (89.66)^{a}	90.00 (71.54)^{b}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	76.67 (61.20)^{a}	90.00 (74.97)^{ab}	100.00 (89.96)^{a}	73.33 (58.98)^{ab}	83.33 (66.12)^{ab}	93.33 (77.68)^{a}
T_6	Profenofos 50 EC @2ppm	100.00 (89.96)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	83.33 (66.12)^{c}	93.33 (77.68)^{b}	100.00 (89.96)^{a}	66.67 (54.76)^{b}	76.67 (61.20)^{bc}	96.67 (83.82)^{a}	63.33 (52.75)^{bc}	73.33 (58.98)^{bc}	76.67 (61.20)^{b}
T_7	Novaluron 10 EC @ 2 ppm	96.67 (83.82)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	76.67 (61.20)^{c}	86.67 (68.83)^{b}	100.00 (89.96)^{a}	56.67 (48.83)^{b}	70.00 (56.97)^{c}	83.33 (66.12)^{b}	43.33 (41.14)^{d}	56.67 (48.83)^{d}	66.67 (54.76)^{b}
T_8	Deltamethrin 2.8 EC @ 1ppm	96.67 (83.82)^{a}	100.00 (89.96)^{a}	100.00 (89.96)^{a}	83.33 (66.12)^{c}	90.00 (74.97)^{b}	100.00 (89.96)^{a}	66.67 (54.76)^{b}	76.67 (61.20)^{bc}	90.00 (66.12)^{b}	56.67 (48.83)^{cd}	63.33 (52.75)^{cd}	73.33 (58.98)^{b}

T_9	Untreated control	3.33 (6.14)[b]	6.67 (12.29)[b]	16.67 (89.96)[b]	0.00 (0.00)[d]	6.67 (12.29)[c]	13.33 (21.14)[b]	0.00 (0.00)[c]	3.33 (6.14)[d]	10.00 (18.43)[c]	0.00 (0.00)[e]	0.00 (0.00)[e]	3.33 (6.14)[c]
	SEm±	3.55	2.05	0.90	1.73	4.01	0.90	2.11	5.45	3.44	2.53	2.42	4.37
	CD at (P = 0.05)	10.54	6.08	2.68	5.14	11.91	2.98	6.28	16.19	10.23	7.53	7.20	12.99
	CV (%)	7.75	4.36	1.89	4.47	9.14	1.90	7.05	15.08	7.75	8.87	7.56	11.65

Figures in parentheses are Arc sine transformed values; MAT: Months after treatment; Means followed by same alphabet in a column do not differ significantly

Observations recorded at three days after insect released at nine months of treatment imposition revealed that, spinosad 45 SC @ 2 ppm (80.00%) recorded highest mortality which was on par with emamectin benzoate 5 SG @ 2 ppm and rynaxypyr 20 SC @ 2 ppm (76.67% each) but differed significantly with remaining treatments. The next best treatments in the order were indoxacarb 14.5 SC @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm (73.33% each), followed by profenofos 50 EC @ 2 ppm (63.33%) and deltamethrin (56.67%). Among the insecticides evaluated, novaluron @ 2 ppm (41.14%) treated seeds suffered with least mortality. No mortality was observed in untreated control. Seven days after adult release spinosad 45 SC @ 2 ppm effected with 90.00 percent mortality, which on par with the emamectin benzoate 5 SG @ 2 ppm and rynaxypyr 20 SC @ 2 ppm (86.67% each). The next best in the order were indoxacarb 14.5 SC @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm (83.33% each), differed significantly with profenofos 50 EC @ 2 ppm (73.33%), deltamethrin 2.8 EC @ 1 ppm (63.33%) and novaluron @ 2 ppm (56.67%). Untreated control observed with zero percent mortality. Even 10 days after adult release, spinosad 45 SC @ 2 ppm could result in 100 percent mortality, which was on par with emamectin benzoate 5 SG @ 2 ppm, rynaxypyr 20 SC @ 2 ppm (96.67% each), indoxacarb 14.5 SC @ 2 ppm, chlorfenapyr 10 EC @ 2 ppm (93.33% each) which differed significantly over profenofos 50 EC @ 2 ppm (76.77%), deltamethrin 2.8 EC @ 1 ppm (73.33%) recorded and novaluron @ 2 ppm (66.67%). Untreated control (3.33%) also had least mortality.

From the present investigations it is revealed that spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm were found to be most effective up to nine months after treatment imposition. The next best treatments in the order were indoxacarb 14.5 SC at 2 ppm, rynaxypyr 20 SC @ 2 ppm and chlorfenapyr 10 EC @ 2 ppm. The profenofos 50 EC @ 2ppm, deltamethrin 2.8 EC @ 1ppm and novaluron 10 EC @ 2 ppm found effective up to six months of storage by causing 100 percent mortality of test insects at 10 days after adults release (Tab. 1). The findings of the present study were supported by the results of Getchell and Subramanyam (2005) [10] who demonstrated that the LT50 values based on immediate mortality for *R. dominica* ranged from 0.45 to 0.74 dead; corresponding values based on delayed mortality ranged from 0.04 to 0.23 dead, suggesting delayed toxic action of spinosad in *R. dominica*. The findings on effectiveness of deltamethrin 2.8 EC @ 1 ppm up to six months of storage was in agreement with the results of Alleoni and Baptista (2002) [2], which proved that effective control of *R. dominica* was obtained with deltamethrin at 0.5 and 1.0 ppm after six months on stored maize. Shrama and Michaelraj (2006) [16] who observed that maize seeds treated with spinosad @ 1.0 or 2.0 mg a.i./ka resulted 100.00 percent mortality even after four months, when adults were exposed to treated grains for 10 days every month up to four consecutive months. The findings on effectiveness of
chlorfenapyr 10 EC @ 2 ppm upto nine months after treatment were closely supported by Kavallieratos *et al.* (2011) [12] who demonstrated that chlorfenapyr as a potential grain protectant against the adults of *R. dominica*. The relatively lower efficacy of novaluron 10 EC @ 2 ppm against *R. dominica* was closely suppored by the observations of Kostyukovsky and Trostanetsky (2006) [13] where in novaluron at concentrations rangingfrom 0.1 to 100 ppm resulted zero mortality of *T. castaneum* adults in treated whole wheat grains.

Effect of insecticide seed treatment on mortality *R. dominica* adults in maize under natural infestation

No dead adult was observed among all the treatments at three months after storage (Table 2). Observations at six months after treatment imposition revealed no dead adults in spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm treated seeds. Least number of dead adults was observed in indoxacarb 14.5 SC @ 2 ppm, rynaxypyr 20 SC @ 2 ppm and deltamethrin 2.8 EC @ 1 ppm (1.00 adult each). They were on par with each other but differed significantly with chlorfenapyr 10 EC @ 2 ppm (1.33 adult), profenofos 50 EC @ 2 ppm (1.67 adult) and novaluron 10 EC @ 2 ppm (2.00 adult). Untreated control (3.00 adult) recorded with the highest number of dead adults. At nine months after storage, the least (1.00 dead adult) was in spinosad 45 SC @ 2 ppm which differed significantly with remaining treatments. The next best in order were emamectin benzoate 5 SG @ 2 ppm, rynaxypyr 20 SC @ 2 ppm (2.00 adult each), closely followed by indoxacarb 14.5 SC @ 2 ppm, deltamethrin 2.8 EC @ 1 ppm (2.33 adult each) and chlorfenapyr 10 EC @ 2 ppm, (2.67 adult). Profenofos 50 EC @ 2 ppm (3.00 adult) and novaluron @ 2 ppm (3.67 adult) differed significantly over other treatments. Untreated control recorded the highest number (7.33) of dead adults. Present observations revealed that among the insecticides spinosad 45 SC @ 2 ppm and emamectin benzoate 5 SG @ 2 ppm were recorded with greater residual toxicity and thereby higher adult mortality, hence the least number of dead adult was recorded over different periods of storage.

Table 2: Effect of insecticide seed treatment on presence of dead *R. dominica* adults in maize at different storage period

Treatments		**Presence of dead*R. dominica* adults/400 seeds**		
		3 MAT	**6 MAT**	**9 MAT**
T_1	Emamectin benzoate 5 SG @ 2 ppm	0.00 (0.00)	0.00 (0.00)[a]	2.00(8.13)[b]
T_2	Spinosad 45 SC @ 2 ppm	0.00 (0.00)	0.00 (0.00)[a]	1.00(5.74)[a]
T_3	Indoxacarb 14.5 SC @ 2 ppm	0.00 (0.00)	1.00(5.74)[b]	2.33(8.74)[bc]
T_4	Rynaxypyr 20 SC @ 2 ppm	0.00 (0.00)	1.00(5.74)[b]	2.00(8.13)[b]
T_5	Chlorfenapyr 10 EC @ 2 ppm	0.00 (0.00)	1.33(6.53)[bc]	2.67(9.36)[bc]
T_6	Profenofos 50 EC @ 2 ppm	0.00 (0.00)	1.67(7.33)[cd]	3.00(9.97)[cd]

T_7	Novaluron 10 EC @ 2 ppm	0.00 (0.00)	2.00(8.13)^{de}	3.67(11.01)^{d}
T_8	Deltamethrin 2.8 EC @ 1 ppm	0.00 (0.00)	1.00(5.74)^{b}	2.33(8.74)^{bc}
T_9	Untreated control	0.00 (0.00)	3.00(9.97)^{e}	7.33(15.70)^{e}
	SEm±	NA	0.38	0.41
	CD (P = 0.05)		1.12	1.23
	CV (%)		11.91	7.53

Figures in parentheses are Arc sine transformed values; Means followed by same alphabets in a column do not differ significantly; MAT: Months after treatment; NA: not analyzed

References

1. Ahmad M, Ahmad A. Storage of food grains. Farm. Outlook, 2002; 1:16-20.
2. Alleoni B, Baptista GC. Control and damage of *R. dominica* (F.) (Coleoptera: Bostrichidae) on stored corn (*Zea mays* L.). de Revista de Agricultura (*Piracicaba*)., 2002; 77(1):79-88.
3. Anonymous. Global Corn Production, 2015a. https://www.statista.com/statistics
4. Anonymous. Food and Agricultural Commodities Production, 2015b. http://faostat.fao/.
5. Boxall RA, Brice JR, Taylor SJ, Bancroft RD. Technology and management of storage. In: Golob, P. Farrell, G. Orchard, JE. (eds), Crop post-harvest: Sci. Technol. Principles and Practices., Natural Resource Institute, Univ. Greenwich. 2002; 1:141-232.
6. Chaudhry MQ. Phosphine resistance. Pesticide Outlook. 2000; 11:88-91.
7. Collins PJ. Resistance to chemical treatments in insect pests of stored grain and its management. In: Proc. 9th Internat. Working Conf on Stored Prod Prot, Brazil, 2006, 277-282.
8. Ebeling W. Pests of stored food products. In: Urban Entomology, U. C., Riverside, 2002, 1-43.
9. Edde PA. A review of the biology and control of *R. dominica* (F.) the lesser grain borer. J of Stored Products Res. 2012; 48:1-18.
10. Getchell AI, Subramanyam B. Effectiveness of spinosad on four classes of wheat against lesser grain borer, *Rhyzopertha dominica* and rice weevil, S. oryzae. J Econ. Ent. 2005; 96(3):643-652.
11. Haines CP. Insects and Arachnids of tropical stored products: their biology and identification. (A training manual). Natural Resources Institute, Chatham, UK, 1991, 246.
12. Kavallieratos NG, Athanassiou CG, Hatzikonstantinou AN, Kavallierratou HN. Abiotic and biotic factors affect efficacy of chlorfenapyr for control of stored-product insect pests. J food protection. 2011; 74(8):1288-99.
13. Kostyukovsky M, Trostanetsky A. The effect of a new chitin synthesis inhibitor, novaluron, on various developmental stages of *Tribolium castaneum* (Herbst). J Stored Prod Res. 2006; 42:136-148.
14. Lorini I, Galley DJ. Deltamethrin resistance in *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae), a pest of stored grains in Brazil. J of Stored Products Res., 1999; 35:37-45.
15. Mohan S. Issue in the management of insects of food grain. In: Proceedings of the National Symposium on frontier areas of Entomologiacal Research, New Delhi, 2003, 423.
16. Shrama RK, Michaelraj S. Efficacy of spinosad as seed protectant against the pests of stored maize. Pesticide Research J. 2006; 18(2):173-176.