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Synergistic Effect of Piperonyl Butoxide, Triphenyl Phosphate and Sesame Oil on Malathion and Deltamethrin Resistant Bapatla Strain of *Rhyzopertha dominica* in Andhra Pradesh

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ABSTRACT

A laboratory experiment was carried out in the Department of Entomology to know the synergistic activity on commonly used insecticides. The synergists such as PBO, TPP and sesame oil showed synergistic factors of 10.85, 27.12 and 0.47 at LC_{50} and 5.97, 6.68 and 1.95 at $LC_{99.9}$ level respectively with malathion. The corresponding synergistic values for deltamethrin were 34.50, 43.12 and 6.05 at LC_{50} and 14.07, 8.97 and 3.51 at $LC_{99.9}$ level. The levels of resistance to malathion and deltamethrin are brought down significantly with all the three synergists *viz.,* PBO, TPP and sesame oil.

Key words: *Deltamethrin,PBO, TPP, Sesame oil,Synergists, Malathion, Rhyzopertha dominica.*

The lesser grain borer, *Rhyzopertha dominica* also known as Australian wheat weevil is a primary pest attacking sound grains of wheat, maize, paddy, sorghum etc. It was first described by Fabricius in 1972 from a shipment of seeds carried from India to South America (Nayar *et al*., 1976). It is one of the storage pests of unhusked paddy and wheat in India. It also damages sorghum, maize and to a lesser extent wood and paper. The adults are more harmful than the grubs and they destroy more than what they eat. The grubs eat upon the kernel leaving husk behind. General practice of protecting stored food grains is through insecticides and continuous usage of these protectants has resulted in health hazards and increased resistance to insecticides in storage pests.

Synergists increase the lethality of insecticides by inhibiting insecticide detoxifying enzymes. This enables synergists to be used as tools for elucidating resistance mechanisms, especially if they are specific inhibitors of a particular resistance conferring mechanism such as detoxification of enzymes and also play a significant role in enhancing toxicity on the resistant strain to a greater extent (Kranthi, 2005). Mechanisms of insecticide resistance can be identified based on differential mortalities by combining various categories of synergists with insecticides (Prabhakar *et al*., 1988). The synergists act as useful indicators of metabolic mechanisms of resistance such as PBO for MFO systems (Chadwick, 1963), TPP for esterases (Casida, 1970).

MATERIAL AND METHODS

The experiment was carried out in the Department of Entomology, Agricultural college, Bapatla, Guntur district, Andhra Pradesh during 2015-16. Adults of *R. dominica* of Bapatla strain were collected from Rice Research Uniit, Bapatla were reared in to the department laboratory on wheat grains at 32±2^{0}C and 75 per cent relative humidity and it was selected as test insect because of it showed higher degree of resistance compared to Ghantasala, Maruteru, Nalgonda and Jangamaheswarapuram. Malathion and deltamethrin were the test insecticides and synergists used in the study were Piperonyl butoxide (PBO), triphenyl phosphate (TPP) and sesame oil.

The adult beetles of one week old were subjected to the bioassay following Jute Cloth Disc Impregnation method (Najithaummer *et al.*, 2013). The respective concentrations of test insecticides and synergists were prepared separately in 1:10 ratio. The insecticide and synergistic mixture was prepared and from that two microlitres was applied to the *R. dominica* by jute cloth disc impregnation method.

Mortality data were recorded at 24, 48 and 72 hours after the treatment (HAT). The experiment was repeated with a wide range of concentrations initially followed by a narrow range so as to get mortality in the range of 5 – 90 per cent and the data were subjected probit analysis (Finney, 1971), using SPSS to calculate LC_{50}, $LC_{99.9}$ and other parameters were calculated. The log concentration probit (LCP) lines were drawn by plotting log concentrations on X-axis and probits on Y-axis and the response of test insect populations was studied at different concentrations of the test insecticides (Finney, 1971). The Synergistic Factor (SF) was calculated by dividing the LC_{50} and $LC_{99.9}$ value of the individual test insecticide with the corresponding LC_{50} and $LC_{99.9}$ value of the test insecticide + synergist mixture at 72 HAT.

$$\text{Synergistic ratio} = \frac{LC_{50} \text{ of insecticide alone}}{LC_{50} \text{ of (insecticide + synergists)}}$$

If the synergistic ratio is <1 - Antagonistic effect
>1 - Synergistic effect
= 1 – No effect

RESULTS AND DISCUSSION

Malathion+Synergists:

The Bapatla strain of *R. dominica* has recorded the LC_{50} and $LC_{99.9}$ values of 0.0217 and 3.4883 per cent for malathion alone at 72 HAT while those of malathion + PBO were 0.0020 and 0.5843 per cent; malathion + TPP were 0.0008 and 0.5218 per cent malathion + Sesamin were 0.0457 and 1.7883 per cent, respectively. The synergistic factors recorded at LC_{50} and $LC_{99.9}$ levels were 10.85 and 5.97 due to PBO, 27.12 and 6.68 due to TPP and 0.47 and 1.95 due to Sesame oil, respectively at 72 HAT.

From the above results it is evident that synergism of malathion with TPP (SF = 27.12 and 6.68) was more which clearly indicated that TPP could effectively reduce the esterase activity in the detoxification of malathion. Similarly the inhibition of carboxyl esterase activity in malathion degradation by TPP was observed in *P. interpunctella* by Bansode *et al.* (1981). Malathion with PBO also showed synergistic effect (SF = 10.85 and 5.97) confirming the oxidative detoxification by MFO. Similarly, Madhumathi and Subbaratnam (2007) reported synergism of malathion with PBO (SF = 7.08) at $LC_{99.9}$ in *Cryptolestes ferrugineus* (Stephens) confirming the oxidative detoxification by MFO. Malathion with sesame oil showed synergistic effect (0.47 and 1.95). Similarly Suraphon *et al.* (2003) revealed that sesame oil showed good synergism with cypermethrin yielding synergistic ratios (SR) that ranged from 1.54 – 6.33 in the contact method and 2.04-5.88 in the no-choice leaf dipping method.

From the results of the present study it is clear that the levels of resistance to malathion could be brought down successfully with all the three synergists *viz.,* PBO, TPP and sesame oil and the degree of synergism was in the decreasing order of TPP > PBO > sesame oil. The decreasing order of synergism with TPP, PBO and sesame oil revealed the role of esterases as well as mixed function oxidases in the detoxification of malathion.

Deltamethrin + Synergists:

The Bapatla strain of *R. dominica* has recorded the LC_{50} and $LC_{99.9}$ values of 0.0345 and 3.4338 per cent for deltamethrin alone at 72 HAT while those of deltamethrin + PBO were 0.0010 and 0.2440 per cent and deltamethrin + TPP were 0.0008 and 0.3825 per cent; deltamethrin + sesame oil were 0.0057 and 0.9774 per cent, respectively. The synergistic factors recorded at LC_{50} and $LC_{99.9}$ levels were 34.50 and 14.07 due to PBO, 43.12 and 8.97 due to TPP and 6.05 and 3.51 due to sesame oil, respectively at 72 HAT.

The synergism of deltamethrin with TPP (SF = 43.12 and 8.97) was more revealing that TPP could effectively reduce the esterase activity in detoxification of deltamethrin. Synergism of deltamethrin with PBO (34.50 and 14.07) was revealing that PBO could effectively reduce the MFO's activity. Similarly the inhibition of MFO's activity and esterase activity in deltamethrin degradation by PBO observed in *T. castaneum* by Ramya *et al.* (2008), whereas the role of inhibition of oxidative detoxification by MFO by PBO in *Sitophilus zeamais* (Motsch) was reported by Samson *et al.* (1990) with synergistic factor of 5.2 and in *T. castaneum* by Sridevi and Dhingra (2000) with synergistic ratio of 2.3 and 2.5 at 1:4 and 1:8 ratios of deltamethrin and PBO. The degree of

Table 1. Toxicity of commonly used insecticides with Synergists such as PBO TPP and Sesame oil against Bapatla strain of lesser grain borer, *R. dominica.*

Insecticidal treatment	LC_{50} % (95% FL) *	$LC_{99.9}$ % (95% FL) *	Slope b (±SE)	Hetero geneity $\chi2$	Regression Equation Y=a+bx	Synergistic ratio**	
						LC_{50}	$LC_{99.9}$
Malathion	0.0217 (0.0162-0.0288)	3.4883 (1.4029-13.8462)	1.054(±0.113)	2.40	Y=2.61+1.39x	-	-
Malathion+ PBO	0.0020 (0.0014-0.0031)	0.5843 (0.1701-4.3696)	0.944(±0.119)	1.93	Y=3.50++1.25x	10.85	5.97
Malathion+ TPP	0.0008 (0.0005-0.0013)	0.5218 (0.1359-5.1322)	0.831(±0.1113)	4.13	Y=3.00+1.00x	27.12	6.68
Malathion+ sesame oil	0.0457 (0.0356-0.0570)	1.7883 (0.9184-5.0872)	1.460(±0.171)	4.09	Y= 2.57+1.78x	0.47	1.95
Deltamethrin	0.0345 (0.0265-0.0444)	3.4338 (1.3685-15.3492)	1.164(±0.145)	5.05	Y=2.20+1.33x	-	-
Deltamethrin +PBO	0.0010 (0.0007-0.0015)	0.2440 (0.0837-1.3362)	0.979(±0.1118)	1.78	Y=4.50+1.50x	34.50	14.07
Deltamethrin +TPP	0.0008 (0.0005-0.0012)	0.3825 (0.1086-3.1382)	0.862(±0.114)	3.38	Y=4.00+1.25x	43.12	8.97
Deltamethrin +sesame oil	0.0057 (0.0038-0.0079)	0.9774 (0.4114-3.7302)	1.040(±0.119)	4.25	Y=2.75+1.25x	6.05	3.51

**The percentage values of LC_{50}, $LC_{99.9}$ and Fiducial Limits (FL) of a data set were obtained from mean mortalities of three replications*

*** Synergistic ratio was calculated by dividing the LC_{50} and $LC_{99.9}$ values of test insecticides with the corresponding LC_{50} and $LC_{99.9}$ values of test insecticide+ synergist mixture*

Lethal concentration and 95% Fiducial limits (FL) were estimated using probit analysis (SPSS 16.0 v.)

The chi-square test revealed the homogeneity of the test population (p<0.05%)

synergism between deltamethrin with sesame oil (SF = 6.05 and 3.51). Vastrad *et al.* (2002) stated that high effect of sesame oil as synergist of synthetic pyrethroids (fenvalerate, deltamethrin, and cypermethrin) against *P. xylostella* in india. They recorded the highest larval mortality by sesame oil and the larval mortality with sesame oil in combination with synthetic pyrethroids increased with concentration.

From the current results it is concluded that the levels of resistance to deltamethrin could be brought down successfully with all the three synergists *viz.,* PBO, TPP and sesame oil. At LC_{50} and $LC_{99.9}$ level the role of esterases was more than the MFO system in the detoxification of deltamethrin.

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