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RESISTANCE EVALUATION IN *RHYZOPERTHA DOMINICA* (COLEOPTERA; BOSTRICHIDAE) TOWARDS PHOSPHINE AND DELTAMETHRIN UNDER LABORATORY CONDITION

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ABSTRACT

The most destructive pest of stored grain commodities is *Rhyzopertha dominica* (F.), which causes tremendous loss in favorable conditions. During the hot and humid conditions the pest population builds up sharply and deteriorates the quality of stored grains. Mostly, the fumigants and insecticides are used for sustainable management of pest. The residual toxicity of deltamethrin and phosphine gas was evaluated against *Rhyzopertha dominica* known as the lesser grain borer. The grains commodities were treated with the 6 concentrations of insecticides (0.01, 0.02, 0.03, 0.04, 0.05 and 0.06 ppm) and phosphine (0.006, 0.007, 0.008, 0.009, 0.01 and 0.011 ppm) to test percent mortality of insect pest under laboratory conditions. The percent mortality data of insecticides and phosphine were noted after 24, 48 and 72 hours and 7, 14 and 21 days. The overall study results showed that maximum mortality was 76.65% in susceptible strains while 42.80% in resistant strain against deltamethrin. The maximum mortality at 0.011ppm against phosphine 56.35% and 31.15% was observed in resistant and susceptible populations of *Rhyzopertha dominica*. The overall data indicated that after 72 hours the lesser grain borer 3.65 times fold resistant against deltamethrin while 0.882 time fold resistance against phosphine after seven days interval over the susceptible strains.

Key words: *Rhyzopertha dominica*, deltamethrin, phosphine, resistance

INTRODUCTION

The most severe destructive and damaging stored grain pest is *Rhyzopertha dominica* (F.) that deteriorates the quality and germination percentage by feeding in the interior portion of the commodities. Among cereal crops, corn, wheat and rice are the main crops in nutritional sources (Girish *et al*., 1975; Campbell and Sinha, 1976; Jood *et al*., 1996). The stored grains pests produce aflatoxin poisonous materials that cause health hazards problems (Kapoor and Jood, 1993; Swaminathan, 1997). This makes the food commodity unpalatable for human consumption (Vassanacharoen *et al*., 2008).

The lesser grain borer laying eggs inside the grains and breeds rapidly in a favorable environment, and adult is the strongest flier and move quickly from one commodity to other (Chittenden, 1911; Edde *et al.*, 2005; Neethirajan *et al*., 2007 Ozkaya *et al*., 2009; Mahroof *et al*., 2010; Edde, 2012; Astuti *et al*., 2013). The hot and humid environmental conditions are suitable for proper growth and development (Emekci *et al*., 2004; Khan and Marwat, 2004; Arthur *et al*., 2012). The larvae of this pest remain inside the grains until the growth and development have not been completed and whole life cycle of 25 days at 34°C and 68 ± 5% relative humidity completed (Chanbang *et al*., 2007; Nadeem *et al*., 2011; Edde, 2012).

The most successful insecticide such as deltamethrin and bifenthrin were used to control this pest but resistance has been reported against deltamethrin (Lorini, 1992; Lorini, 1993; Lorini and Schneider, 1994; Wilkin *et al*., 1994, 1999). The stored grain pests are also efficiently controlled by applying fumigant like phosphine gas (Daglish, 2004). This controlling method is cheap, ecofriendly and easy to apply (Nayak and Collins, 2008). The gases mode of action is to kill the pest by creating suffocation in the environment (Fluck, 1973; Berners and Sadler, 1988; Chaudhry, 1997; Benhalima *et al*., 2004; Collins *et al.*, 2005). The repeated application of phosphine gas causes resistance development (Benhalima *et al.*, 2004; Collins *et al.*, 2005; Wang *et al*., 2006; Lorini *et al*., 2007; Manivannan, 2016).

The key objective of the present research was to evaluate the resistance in *Rhyzopertha dominica* against phosphine and deltamethrin.

MATERIALS AND METHODS

The research trial was conducted in the Entomological Storage Management Cell, Department of Entomology, University of Agriculture, Faisalabad.

Materials: Petri dishes, camel hair brush, insect population, desiccation chamber, filter paper, micropipette, deltamethrin, microscope, phosphide tablets

Collection and rearing of Insects: The population of *Rhyzopertha dominica* was collected from the grain market and Food Department Godown. This population was reared on wheat grains for proper growth and development in plastic jars. The temperature and relative humidity of 30 ± 2°C and 65 ± 5% were maintained. A total of 100 numbers of adult insects were placed in each jar for 3- days for oviposition. Then adults were removed from jars. The population was a buildup and until the homogenous population was obtained, which was used for bioassay.

Evaluation of Insecticides and phosphine resistance against lesser grain borer: The insecticide deltamethrin (Guardian 1.5 EC, Ali Akbar Group) was purchased from the market. After that the six concentrations (0.01, 0.02, 0.03, 0.04, 0.05 and 0.06 ppm) were made. Similarly, the

Six Phosphine concentrations (0.006mg/L, 0.007mg/L, 0.008mg/L, 0.009mg/L, 0.01 mg/L and 0.011mg/L) were used. The following formula was used to calculate the resistance factor/ratio:

$$\text{Resistant Factor} = \frac{LC_{50} \text{ of Resistances Strain}}{LC_{50} \text{ of Susceptible Strain}}$$

Method of Bioassay: The filter paper was method used for bioassay against *Rhyzopertha dominica* (F.). Each concentration was applied separately on the filter paper and dried this one for one hour. The Thirty numbers of adults were released in each petri dish. Each treatment was replicated three times. The deltamethrin and phosphine regarding mortality were noted after 24, 48, 72hours and 7, 14, 21days interval, respectively. The mortality data were analyzed by using the probit analysis and Analysis of Variance (ANOVA).

Abbott's formula used to compute the mortality;

$$\text{Corrected Mortality (\%)} = \frac{(Mo - Mc) \times 100}{100 - Mc} \qquad \text{(Abbott, 1925)}$$

Mo = Mortality observed in treatments

Mc = Mortality observed in control

RESULTS

The current experiment was conducted to evaluate the resistance in *Rhyzopertha dominica* (F.). The susceptible and resistant population were made under laboratory conditions. The population strain was collected from Muzaffargarh. Results are given as under

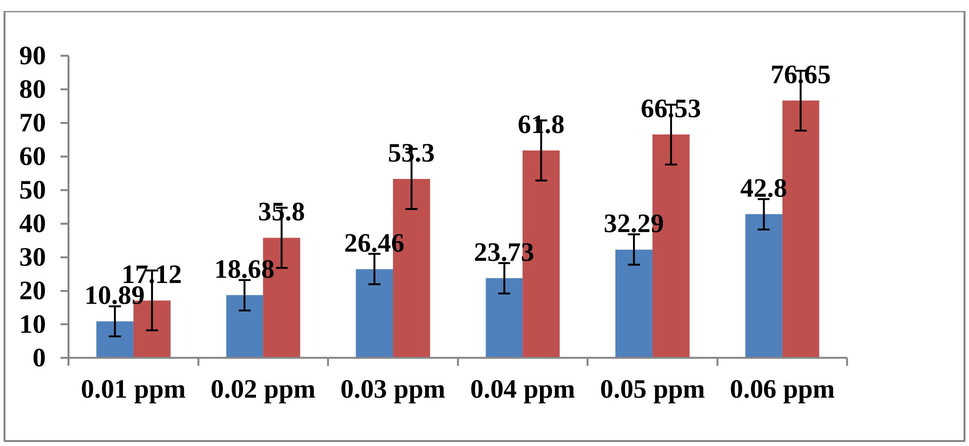

Fig- 1: Comparison of mean % mortality at various deltamethrin concentrations in Muzaffargarh and laboratory strains against *Rhyzopertha dominica*.

Mean percent motility in the given (Fig-1) indicated that the mortality increased with increasing concentrations. The maximum dead population was 42.80% and 76.65% at 0.06 ppm in field and the lab population was obtained.

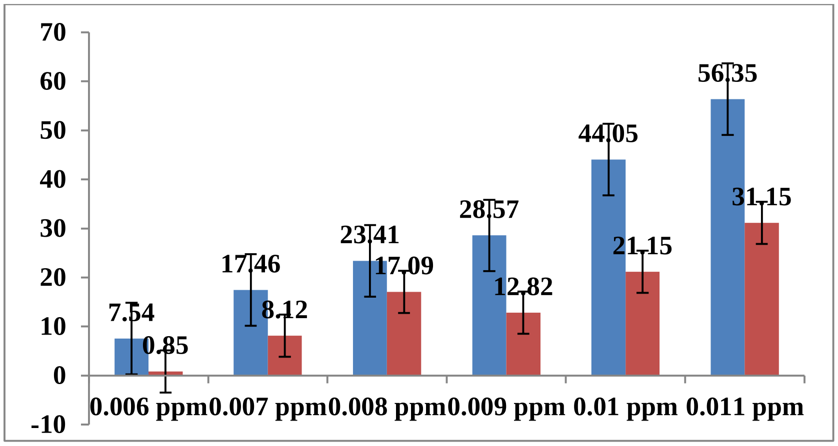

Fig- 2: Comparison of mean % mortality at various concentrations of Phosphine in Muzaffargarh and laboratory strains against *Rhyzopertha dominica*.

The (Figure 2) indicated that the highest mortality was 56.35% and 31.15% in field and lab strains population of *Rhyzopertha dominica* respectively was obtained.

The data regarding mean mortality of *Rhyzopertha dominica* was 56.35% in field population at 0.011 ppm while 31.15% mortality was observed in laboratory strains.

Table 1: Comparison of mean % mortality at different concentrations of deltamethrin after various exposure times against Muzaffargarh and Laboratory strain of *Rhyzopertha dominica*.

Exposure Time	Mortality ± SE in field	Mortality ± SE in laboratory
24 hours	19.84 ± 2.98 a	47.86 ± 5.46 a
48 hours	24.46 ± 2.46 b	51.36 ± 4.78 b
72 hours	31.13 ± 2.33 c	56.42 ± 4.42 c

The overall results of mortality showed that by increasing the time interval the mortality increased. The maximum mortality was observed 31.13% after 72 hours against deltamethrin shown above (Table 1).

Table -2: Comparison of mean % mortality at different phosphine concentrations after various exposure times against Muzaffargarh and Laboratory strains of *Rhyzopertha dominica*.

Exposure Time	Mortality ± SE in field	Mortality ± SE in laboratory
7 days	25.40 ± 3.79 b	8.33± 3.03 a
14 days	31.15 ± 4.19 a	16.24 ± 2.43 b
21 days	32.14 ± 4.34 a	21.58 ± 2.30 c

The above given (Table- 2) indicated that the maximum mean mortality (32.14 %) while the minimum was 25.40% after 21 and 7 days interval under field conditions. The maximum mortality (21.58 %) was recorded after 21 days interval under laboratory conditions.

Table 3: Comparative assessment of resistance level in both strains of *Rhyzopertha dominica* (F.) through Probit analysis against deltamethrin and phosphine after various time intervals.

Locality	Strains (LGB)	Exposure Time	LC_{50}	95% Fiducial limit	R.F
Muzaffargarh	MGS	24 hours	0.0793219	0.0649946-0.1119401	2.31
Laboratory	LS	24 hours	0.0342971	0.0310191-0.0375460	2.31
Muzaffargarh	MGS	48 hours	0.101428	0.0726204-0.208705	3.31
Laboratory	LS	48 hours	0.0306325	0.0269266-0.0341969	3.31
Muzaffargarh	MGS	72 hours	0.0929397	0.0639040-0.232573	3.65
Laboratory	LS	72 hours	0.0254598	0.0214910-0.0290192	3.65
Muzaffargarh	MGS	7 days	0.0110320	0.0104804-0.0118777	0.882
Laboratory	LS	7 days	0.0124971	0.0116772-0.0140816	0.882
Muzaffargarh	MGS	14 days	0.0103986	0.0099274-0.0110612	0.773
Laboratory	LS	14 days	0.0134391	0.0120128-0.0167833	0.773
Muzaffargarh	MGS	21 days	0.0102308	0.0098048-0.0108021	0.656
Laboratory	LS	21 days	0.0155882	0.0126707-0.0285489	0.656

LGB= lesser grain borer, MGS= Muzaffargarh Gowdon strain, LS= Laboratory Strain

$$\text{Resistance factor (R.F)} = \frac{LC_{50}\text{ of Resistant Strain}}{LC_{50}\text{ of Susceptible Strain}}$$

The LC_{50} value of deltamethrin at various concentrations was evaluated by using probit analysis (Table- 3). The resistance ratio showed that the maximum 3.65 times fold resistance was observed in susceptible strains of lesser grain borer after 72 hours while 0.88 fold time resistance against phosphine over laboratory strains after seven days interval.

DISCUSSION

The current experiment was conducted to check the resistance ratio against deltamethrin and phosphine in *Rhyzopertha dominica.* The insecticide and phosphine gas was easy to apply and had a minimal residual effect on the food commodity. The resistance developed in insect pests was due to the repeated and blind application of insecticides.

The overall results regarding the application of deltamethrin against lesser grain borer indicated that the field strains given maximum mortality than the lab strains. Our trials findings were also similar to previously conducted experiments to test the toxicity level of deltamethrin against lesser grain borer (Manzoor and Sattar, 2013). The findings indicated that highest mortality observed at 0.06 ppm was 76.65% in the laboratory population.

The response of phosphine gas against *Rhyzopertha dominica* was evaluated to test resistance ratio. The population collected from the field showed more resistance than lab strains. Maximum mortality was recorded 56.35% at 0.011ppm. The current trial results showed similarity with the results reported by Collin *et al.*, (2017). He observed the 80% population was resistant. The judicious application of insecticides proved to cause the resistant factor in the insects Opit *et al.*, (2012). The results concluded that the resistance exists in *Rhyzopertha dominica* population against deltamethrin while minimal resistance was observed in phosphine.

Conclusion

Wheat is one of the most staple foods in Pakistan which has more nutritious value. This commodity is infested by different insect pests that deteriorate the quality of food especially the *Rhyzopertha dominica*. Various management strategies such as botanicals, plant oils and synthetic insecticides can be used against this pest. But due to judious application of synthetic insecticides causes the development of resistance in insect pests. The resistance is the main key factor which to be checked for its resistance ratio and survival rate.

Author Contribution: MS Collected data and wrote manuscript, KR helped in write up while FA, UNU and MS critically reviewed the manuscript.

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