

RESISTANCE OF *RHIZOPERTHA DOMINICA* (F.) (COLEOPTERA: BOSTRYCHIDAE) TO PHOSPHINE IN THE PHILIPPINES

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ABSTRACT

Five field and one laboratory strains of *Rhizopertha dominica* were tested using the FAO discriminating dose test for adult insects. Three of the field strains were collected from the National Food Authority (NFA) warehouses in selected sites where phosphine fumigation is commonly practiced. The sites represented the three major islands in the Philippines, namely, Metro Manila in Luzon, Cebu City in the Visayas and General Santos City in Mindanao. The other field strains were collected from private warehouses in South Cotabato and Rizal.

High resistance level of >400X was observed in the field strains collected from the NFA warehouses in Cebu City, Metro Manila and General Santos City. In contrast, low levels of resistance were detected in a strain from a private warehouse in South Cotabato (1.13X) and in the laboratory strains (1.65X), while the Rizal strain was still susceptible to phosphine.

The Cebu City strain was the most resistant and was subjected to a series of concentration to determine phosphine concentration and the minimum exposure period required for effective control. A concentration of 0.89/L at 7 days exposure in 25±2°C environment provided the desired control. Based on this result, a dosage rate of 2 mg/m³ for a minimum of 7 days exposure at 25°C and above is recommended for the industry use.

INTRODUCTION

The lesser grain borer, *Rhizopertha dominica* (F.) is one of the most abundant insects in maize and paddy in the Philippines (Sabio *et al.*, 1983) and the most difficult to control (Sayaboc *et al.* 1986, 1990). This can be attributed to its tolerance to high temperatures and its ability to survive in grains with low moisture content. *R. dominica* is also known to be resistant not only to organophosphorous compounds such as pirimiphos methyl and malathion (Sayaboc and Acda, 1990) but also to phosphine (Gibe *et al.*, 1995). Resistance to phosphine by stored insects was first reported in 1995 in the government owned National Food Authority (NFA) warehouses in Metro Manila and Cebu City (Gibe *et al.* 1995). High level of resistance was detected in *R. dominica* strains. The development of resistance is attributed to its continuous exposure to repeated poor phosphine treatments. Resistance was also present in *Sitophilus zeamais* at low levels. Other major pests such as *Sitophilus oryzae* and *Tribolium castaneum* were found susceptible.

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The development of resistance in *R. dominica* at high levels prompted us to extend resistance testing to other locations and in private warehouses to further evaluate level of resistance and determine the phosphine concentration and exposure period required for the control of tolerant strains of adult insects.

MATERIALS AND METHODS

Insect collection

Field strains of *R. dominica* were collected by sieving infested grains from the NFA and private warehouses. At NFA, collection was made in areas where fumigation is commonly practiced. These represent the three major islands in the country namely, Metro Manila in Luzon, Cebu City in the Visayas and General Santos City, in Mindanao. In private warehouses, insects were obtained in South Cotabato and Rizal. Insects collected were reared in the laboratory using methods provided by the Entomology Branch of the Queensland Department of Primary Industries (QDPI), Australia. Aside from the insects collected, fenitrothion selected *R. dominica*, bred at the NAPHIRE laboratory for more than 10 years was also used as test insect.

Resistance test

The strains were tested using the FAO recommended method and concentration (Anon., 1975). Phosphine was generated from a commercial aluminum phosphide formulation and collected over acidified water.

Adult beetles (1-2 weeks old) were confined within glass rings on a filter paper base inside gas-tight dessicators. Required concentration of phosphine was injected using a gas-tight syringe through a rubber septum in the lid of the dessicator. Insects were exposed to a range of four concentrations for 20 hours at $25 \pm 2^\circ\text{C}$. After exposure, insects were held in culture medium. Mortality was assessed after 14 days. Percent mortality were later subjected to probit analysis.

Among the strains tested for resistance, the strain with the highest level of resistance was subjected to further tests. In this case, the Cebu strain was the most resistant based on the dosage range used. Toxicity tests on adult *R. dominica* were carried out at 25°C and 70% RH. Adults of *R. dominica* aged 1-2 weeks were tested in dessicators according to the FAO method (Anon., 1975). Insects were exposed for 20 hours, 3 days and 7 days. Mortality assessment was carried out 14 days after the designated exposure period.

RESULTS AND DISCUSSION

High level of resistance was detected in strains collected from Cebu City, Metro Manila and General Santos City while the strains from Rizal and South Cotabato provinces collected in private warehouses were found susceptible (Table 1). In this experiment, Rizal strain was used as a reference strain.

Table 2 shows the different dosages of phosphine that provided 100% kill of the highly resistant strains of *R. dominica*. The concentration at which survival was observed is also presented. Cebu strain had the highest dosage requirement of 12.04 mg/l to obtain a 100% kill while Metro Manila and General Santos City strains required 8.0 mg/l. Cebu strain survived the same dosage with 92.79% mortality.

Table 1. Response of adult *R. dominica* exposed to phosphine for 20 h based on mortality assessed after 14 days.

STRAIN	SLOPE (\pm SE)	LC 50	LC 99.9)	RF
		mg/l (95% FL)	mg/l (95% FL)	
CEBU CITY	3.61 (\pm 0.5)	2.43 (1.788 - 2.960)	17.452 (10.857 - 47.85)	514.81
METRO MANILA	2.56 (\pm 0.4)	1.14 (0.763 - 1.475)	18.458 (10.07 - 61.41)	544.48
GEN. SANTOS	2.15 (\pm 0.3)	0.62 (0.393 - 0.811)	16.827 (9.997 - 41.796)	496.37
SO. COTABATO	5.19 (\pm 0.5)	0.0097 (0.0088-0.011)	0.0384 (0.0314 -0.0514)	1.13
LAB STRAIN	6.0 (\pm 0.7)	0.017 (0.015 - 0.019)	0.056 (0.0434 - 0.086)	1.65
RIZAL (Susceptible)	4.7 (\pm 0.4)	0.0075 (0.0067 - 0.0082)	0.0339 (0.0276 - 0.045)	-

LC - lethal concentration

FL - Fiducial Limit

RF - resistance factor

Table 2. Dosages allowing survival and giving control of adults of *R. dominica* at 20 h exposure with their corresponding mortality (%)

STRAIN	DOSAGE (mg/l)	
	WITH SURVIVAL	COMPLETE CONTROL
CEBU CITY	8.0 (92.79)	12.04 (100)
METRO MANILA	4.0 (95.00)	8.0 (100)
GEN. SANTOS CITY	4.0 (93.33)	8.0 (100)
LAB. STRAIN	0.03 (92.97)	> 0.03
RIZAL (Susceptible)	-	0.03 (100)

Mills (1986) recommend a concentration of >0.80 mg/l for a 7-day exposure at 25° C for the control of highly resistant adult of *R. dominica*. This would give a C x T product of >134.4 mg.hr/l and can be considered marginal compared with the recommended 150 mg.hr/l for 7-days at 25° C by Winks *et al.* (1980). In this study, a concentration of 0.89 mg/l at 7-day exposure provided the same control (Table 3.) Tyler *et al.* 1983 recommended that a C x T product of 150 mg.hr/l for a minimum of three days is adequate. This is theoretically acceptable, however, in practice, this may not be appropriate. The tolerance of egg and pupal stage is considerably greater than that of the larvae and adults (Winks, 1986a). It is an advantage to lengthen exposure periods in order to allow sufficient time for tolerant stages to develop to less tolerant levels (Winks, 1987).

Table 3. Dosages allowing survival and giving control of adults of *R. dominica* (Cebu strain)

EXPOSURE PERIOD AT 25° C	REF. STRAIN		CONCENTRATION mg/l		
	0.03	0.71	0.89	1.0	1.5
20 hours	100	-	-	-	-
3 days	-	-	-	98.33	100
7 days	-	99.12	100	-	-

Winks *et al.* (1980) found a C x T product of 150 mg.hr/li for at least 7 days exposure appropriate to control all resistant species of insects while Mills 1986 found this concentration marginal for the control of the resistant *R. dominica* which is also true with the results obtained in this experiment (Table 4.). Winks *et al.* (1980) expected 150 mg.hr/l to be achieved in 7 days at a dosage rate of 1.5 g/m³ in a well sealed enclosure. In this case, a slight increase in the dosage rate from 1.5 g/m³ to 2.0 g/m³ at 7 days exposure was required to attain effective control.

Table 4. Phosphine concentrations needed to control populations of resistant *R. dominica* at 25° C.

EXPOSURE PERIOD	C x T (mg.hr/li)	
3 DAYS	108	104.4*
7 DAYS	149.5	134.4*

* Mills (1986)

Phosphine fumigation still plays a major role in controlling infestation. Phosphine could still achieve effective control provided that adequate gas

concentration can be maintained and exposure period extended in such a way that tolerant stages in the insect development reach susceptible stages within the entire exposure period.

The National Food Authority (NFA) has been using phosphine for the past 30 years and still relies on phosphine use at present. Phosphine is currently applied at 2 to 3 g/m³ for 3 days exposure period. Based on the result of this experiment, the same rate is recommended but, the exposure period should be extended to a minimum of 7 days.

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