EFFICACY OF PHOSPHINE AS AN ALTERNATIVE TO MEBR AGAINST DRIED FRUIT BEETLE

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Turkiye is the leading country in the production of dried fruits and edible nuts, and dominates the world markets in this respect. Among edible nuts and dried fruits, hazelnuts, raisins, dried apricots and dried figs are of significant importance for Turkish agricultural export. Due to their importance, they are considered as the traditional agricultural export products of Turkiye. The sum of the exported value of dried fruits and edible nuts in 2005 reached 1,713 US$ (www.igeme.gov.tr).

The dried fruit beetle, *Carpophilus hemipterus* (L.) (Nitidulidae : Coleoptera) is one of the major pests on dried figs in Aegean region of Turkiye. Due to a complete ban of methyl bromide which was the main fumigant for the dried figs, alternative control methods are urgently needed. Phosphine fumigation can be an alternative control method for conventional fumigation during the processing of the figs. To evaluate the efficacy of phosphine on the dried fruit beetle, laboratory tests were conducted at 15^{o}C, which is the lower temperature limit of the dried fig harvest and processing season, and at the concentration of 200 ppm that is often encountered at improper sealing conditions in case of tarpaulin for bulk fumigation. In the experiments, 1 to 2 day-old eggs, 15 day-old mature larvae, 1 to 3 day-old pupae and 1 week-old adults of the dried fruit beetle were exposed to phosphine at 75% ± 5 r.h. for different exposure periods.

According to the results (Table 1), phosphine applications at a concentration of 200 ppm at 15^{o}C gave a complete mortality in all life stages of *C. hemipterus* in 36 h of exposure. Results also showed that complete mortality time of eggs, larvae, pupae and adult stages of *C. hemipterus* was found to be 36 h, 12 h, 24 h, and 16 h, respectively. Complete mortality times of 1- and 2-day-old eggs were 36 h and 20 h, respectively. For 1-, 2- and 3-day-old pupae, total mortalities were obtained after 24 h, 16 h, and 14 h of exposure, respectively (Table 2).

We had difficulties in comparing our findings to those in the literature due to lack of information on the mortality of *C. hemipterus* at low phosphine concentrations and at low temperatures, particularly on the variations in response to different development stages. Vincent and Lindgren (1972) reported that LC_{95} data for eggs, larvae, pupae and adults of *C. hemipterus* after an exposure to hydrogen phosphide for 24 h at 26.7^{o}C were 0.0031 mg/l (2.04 ppm), 0.008 mg/l (5.27 ppm), 0.032 mg/l (21.08 ppm) and 0.003 mg/l (1.98 ppm), respectively. In another study with *C. hemipterus* at 26.7^{o}C, Muhareb et al. (2003) found that after an exposure to phosphine (EcoFume, 2% phosphine + 98% CO_2) at a concentration of 187.5 ppm for 24 hours, egg mortality was 85%. When exposed to a concentration of 194.4 ppm for 36 hours, egg mortality increased to 92%. In the same study, larval and pupal mortality, after en exposure to 416 and 875 ppm for 24 hours were reported as 99.5% and 100% for larvae and 95% and 100% for pupae, respectively. In case of adults, they obtained 99.5% and 100% mortality when adults were exposed to 418 and 879 ppm for 24 h.,

respectively. These researches indicate that phosphine can be effective against *C. hemipterus* in relatively short exposure periods. There are other clues in the literature regarding the effectiveness of phosphine in short exposures periods for other insect pests. Keever et al. (1998), who worked on the efficacy of phosphine on development stages of *Lasioderma serricorne* (F.), reported that after an exposure of 150 ppm at 32.2^{o}C, the mortalities were 99.7% for eggs, 100% for larvae, 99.8% for pupae and 100% for adults. Akan (2003) who studied the effectiveness of phosphine on different life stages of *Oryzaephilus surinamensis* (L.), found that with an exposure to phosphine at a concentration of 150 ppm at 30^{o}C, complete mortality times for eggs, larvae, pupae and adults were 18 h, 0.75 h, 12 h and 4 h, respectively. According to Flinn et al. (2001), LT_{95} data of development stages of *Rhyzopertha dominica* (F.) after an exposure to phosphine at a concentration of 164.7 ppm (0.25 g/l) at 15^{o}C were 1.5 d for eggs, 0.8 d for larvae, 1.7 d for pupae and 1.2 d for adults.

We conclude that phosphine can be effective against *C. hemipterus* in short exposure periods and thus can be considered as a candidate for replacement of MeBr in dried fig sector in Turkiye. Further studies in the field conditions are needed to justify laboratory results.

Acknowledgement*:* Partially supported through the projects entitled "*Project to Phase-Out Methyl Bromide in the Dried Fig Sector in Turkey* (TTGV-P2/30m)" funded by the World Bank through the Multilateral Funds for the Implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer; "*Mites infesting stored products in Diyarbakir and Sanliurfa provinces and their control* (TARP 1848)" funded by The Scientific and Technical Research Council of Turkey (TUBITAK).

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Table 1. Percent mortality [a] of different development stages of *Carpophilus hemipterus* after exposure to 200 ppm phosphine over different exposure times at 15°C

Life stage	Ages of insects[b] (days)	Exposure periods (hours)												
		2	4	6	8	10	12	14	16	20	24	28	32	36
Eggs	1	c	c	c	0.2	c	23.3	c	62.2	67.1	78.9	83.3	95.3	100
	2	c	11.8		34.5	c	78.1	c	83.0	100				
Larvae	12	12.7	56.4	84.1	98.0	98.1	100							
	1	c	c	c	c	21.2	35.4	68.1	85.1	89.4	100			
Pupae	2	c	c	c	29.7	39.2	71.4	90.3	100					
	3	c	c	c	6.5	79.8	92.0	100						
Adults	8	25	56.3	91.1	93.3	94.8	96.8	97.7	100					

[a] Mortalities were corrected by using Abbott's formula.

[b] Age for larval stage from hatching; pupae from pupation; and adults from emergence.

[c] Not tested.