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Delayed mortality, resistance and the “sweet spot”: the good the bad and the ugly in phosphine fumigations

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ABSTRACT

In a series of bioassays, adult mortality after specific exposure intervals to phosphine in selected stored product insect species was examined, as well as the appearance of the so called "sweet spot". The tested insects were: *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae), *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae). For each species, we used populations that had different levels of phosphine resistance. In a first series of bioassays, we used the Detia Degesch Phosphine Tolerance Test Kit (DDPTTK), with various exposures between 15 and 300 min at 3000 ppm, and after the termination of the exposure, the adults were transferred in phosphine-free environment. The majority of the adults of the susceptible populations of all species were instantly immobilized even in the shortest exposure period (15 min), in contrast with adults of the resistant populations that were active even after 300 min. At the post-exposure period, in most cases, most adults of the susceptible populations were dead, whereas adults of the resistant populations recovered regardless of the species and the exposure time. Another series of bioassays at 500, 1000, 2000 and 3000 ppm for 1, 3, 5, 20, 30 and 40 h clearly indicted the appearance of the "sweet spot", i.e., the decrease of mortality with the increase of the concentration, at certain exposure-concentration combinations. In fact, in most of the tested species the "sweet spot" appeared in 1000 and 2000 ppm and at a 5 h exposure interval. This observation is particularly important both in terms of the assessment of resistance and in the context of non-linearity of phosphine efficacy at elevated concentrations. Additional experimental work is needed to clarify if and how this non-linear response is related with the development of resistance to phosphine after exposure to high concentrations for short intervals.

Keywords: Phosphine, Fumigation, Resistance, Stored product insects, Mortality, Non-linear response