

Studies on efficiency of some fumigants against some stored product insects

Refaat Abd El-Shafy Mohamed

The objective of this work was to investigate the efficiency of phosphine, carbon dioxide alone and their mixtures against some important insect species causing damage to stored cereal grains and pulses in Egypt, namely: *E. oryzae* (L.), *R. dominica* (F.) and *C. maculatus* (F.). The experiments were carried out in the laboratory at $26 \pm 1^\circ\text{C}$, $6 \pm 1^\circ\text{C}$ and $60 \pm 5\%$ RH. A circulatory multi-flask apparatus was designed to provide a fumigation chamber suitable for the test insects. Phosphine was generated from PHOSTOXIN-pellets (product of DEGESCH Co. FR. of Germany). Carbon dioxide was provided as a pure gas of 99% in a pressure cylinder, which was connected with a pressure regulator. Results obtained could be summarized under the following topics:

1. Efficiency of phosphine against various stages of the tested insects: Fumigation tests were conducted with fixed concentrations of phosphine (20, 40 and 80 vpm) at varying exposure periods. The results showed that adults of *E. oryzae* (L.), *R. dominica* (F.) and *C. maculatus* (F.) proved to be the most susceptible stages to phosphine at $26 \pm 1^\circ\text{C}$ and $6 \pm 1^\circ\text{C}$. The time of exposure was a more critical factor of dosage than the concentration of phosphine. Phosphine was more effective at higher temperature against all stages of the three insect species tested than at lower one. For example, with a concentration of 80 vpm phosphine, the exposure times for 100% mortality in case of *E. oryzae* were (0.9, 9.8, 8.7 and 8.0 days) at $26 \pm 1^\circ\text{C}$ and (3.3, 15.6, 12.3 and 47.0 days) at $6 \pm 1^\circ\text{C}$ for adults, larvae, pupae and eggs, respectively. The corresponding values in case of *R. dominica* were (0.9, 26.4, 9.4 and 11.9 days) at $26 \pm 1^\circ\text{C}$ and (4.9, 88.0, 159.3 and 70 days) at $6 \pm 1^\circ\text{C}$ for adults, larvae, pupae and eggs were (2.6, 7.3, 10.3 and 18.9 days) at $26 \pm 1^\circ\text{C}$ and (2.8, 39.5, 30.9 and 58.9 days) at $6 \pm 1^\circ\text{C}$. These values for the various developmental stages of *C. maculatus*, respectively. By comparing the exposure time values required to obtain 100% kill for the different stages of the tested insects at $26 \pm 1^\circ\text{C}$ and 80 vpm phosphine, it was found that the adult stages of the various insects were more susceptible to phosphine than the immature stages. The adults of *C. maculatus* were much more tolerant to phosphine than the adults of both *E. oryzae* and *R. dominica*. Larval susceptibility to phosphine was in descending order *C. maculatus*-larvae, *E. oryzae*-larvae and *R. dominica*-larvae. Pupae of *C. maculatus* were somewhat more tolerant to phosphine than pupae of both *E. oryzae* and *R. dominica*. Eggs of *C. maculatus* were much more tolerant to phosphine than eggs of *R. dominica* and *E. oryzae*.
2. Toxicity of carbon dioxide in controlled atmosphere (CA) to the tested insects: Studies carried out in the laboratory at $26 \pm 1^\circ\text{C}$ and $6 \pm 1^\circ\text{C}$ to evaluate the efficacy of various CO_2 concentrations (12.5, 25, 50, 75 and 100% v/v) in controlled atmosphere (CA) for controlling the various stages of *E. oryzae*, *R. dominica* and *C. maculatus* showed that carbon dioxide was more effective at higher temperature than at lower one and insect mortalities were increased generally as the concentration of CO_2 was increased. Adults of *E. oryzae* were the most susceptible stage to CA contained various concentrations of CO_2 followed by larvae, eggs and pupae. When the results were compared at the LTgO level and $26 \pm 1^\circ\text{C}$. The same trend was also observed at the lower temperature for atmospheres contained CO_2 concentrations between 12.5-75% v/v. Results revealed also that at the two test temperatures adults of *R. dominica* were the most susceptible stage to CA contained CO_2 at the LTgO level followed by larvae, eggs and pupae. By comparing the susceptibility of the different stages of *C. maculatus* at the LTgO level, it was found that at $26 \pm 1^\circ\text{C}$ the order of tolerance to CA contained 25, 75 and 100% CO_2 was in

decreased order pupae > larvae > eggs > adults. At 6±1°C the order of tolerance to the various CO₂ concentrations was also pupae > larvae > eggs > adults. The lethal time values recorded for the adults of the tested insects at the lower temperature in CA contained 100% v/v CO₂ were higher than those obtained in CA contained 75% v/v CO₂ and this result could be due to nearly total depletion of oxygen in the CA of 100% CO₂.

3. Toxicity of mixtures of phosphine plus carbon dioxide to the tested insects: The effect of addition of 25 and 50% CO₂ to 20 and 40 vpm phosphine was studied in the laboratory at 26±1°C and 6±1°C for controlling the various stages of *S. oryzae* (L.), *S. dominica* (F.) and *C. maculatus* (F.). The results obtained showed the following:

Results

- Time to mortalities were shorter at higher temperature than at lower one.
- The adult stage of the tested insects was the most susceptible stage to the mixtures of phosphine + carbon dioxide at the two test temperatures. The lethal time values required for a certain mortality were generally reduced in the presence of carbon dioxide at the two test temperatures. For example at 26±1°C the lethal exposure values needed to obtain 90% adult mortalities were (17, 16 and 22 hr) with 20 vpm PH₃ alone and (13, 4 and 14 hr) by a mixture of phosphine + 25% CO₂ and (11, 7 and 5 hr) by a mixture of phosphine + 50% CO₂ for *S. oryzae*, *S. dominica* and *C. maculatus*, respectively. The corresponding values at 6±1°C were (119, 98 and 122 hr) with phosphine alone, (50, 11 and 17 hr) by a mixture of phosphine + 25% CO₂ and (41, 11 and 12 hr) by addition of 50% CO₂ to phosphine, for the various insect species, respectively. For the larvae and at high temperature, times to 90% mortalities were (51, 44 and 67 hr) with phosphine alone, (31, 35 and 66 hr) by phosphine + 25% CO₂ and (29, 37 and 28 hr) by a mixture of 20 vpm PH₃ + 50% CO₂, for the forementioned insect species, respectively. The corresponding values at lower temperature were (162, 282 and 211 hr) with phosphine alone, (58, 94 and 64 hr) by a mixture of phosphine + 25% CO₂ and (49, 49 and 82 hr) by a mixture of phosphine + 50% CO₂. For the pupae and at 26±1°C, the lethal time values required for 90% kill were (51, 133 and 60 hr) by phosphine alone, (39, 70 and 43 hr) by phosphine + 25% CO₂ and (43, 69 and 58 hr) by a mixture of 20 vpm PH₃ + 50% CO₂ for *S. oryzae*, *S. dominica* and *C. maculatus*, respectively. The corresponding values at 6±1°C were (141, 267 and 158 hr) by phosphine alone, (87, 95 and 113 hr) by phosphine + 25% CO₂ and (99, 83 and 122 hr) by a mixture of phosphine + 50% CO₂, for the forementioned insect species, respectively. For the eggs and at 26±1°C, the lethal exposures for 90% mortalities were (122, 133 and 120 hr) by 20 vpm PH₃ alone, (77, 62 and 68 hr) by phosphine + 25% CO₂ and (61, 37 and 44 hr) by phosphine + 50% CO₂, for the various insect species, respectively. The corresponding values at 6±1°C were (261, 278 and 254 hr) with 20 vpm PH₃ alone, (102, 119 and 119 hr) by phosphine + 25% CO₂ and (106, 42 and 103 hr) by phosphine + 50% CO₂ for the various insect species, respectively. The same trend was also obtained with mixtures of 40 vpm PH₃ + 25 and 50% CO₂ for the tested insect species at the different stages of . . . the two test temperatures. Results revealed also that addition of CO₂ to phosphine increased the efficiency of phosphine at the LT₅₀ level inducing an additive or a synergistic effect on mortalities of the various stages of the insect species tested. At the LT₉₉ level, the increased also the efficiency and larvae of *S. oryzae*, *S. dominica* and *C. maculatus*. But for pupae and eggs, the addition of CO₂ to phosphine induced, in some cases, an increase in the efficacy of phosphine. and in other cases an antagonistic effect was obtained.