SUMMARY

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:- S. oryzae (L.), R. dominica (F.) and C. maculatus (F.).

The experiments were carried out in the laboratory at 26±1°C, 6±1°C and 60±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 ~~obtained~~ showed that adults of S. oryzae (L.), R. dominica (F.) and C. maculatus (F.) proved to be the most susceptible stages to phosphine at 26±1°C and 6±1°C. The time of exposure was a more critical factor of dosage than the concentration of phosphine.

Phosphine was, however, 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 S. oryzae were (0.9, 9.8, 8.7 and 8.0 days) at 26±1°C and 3.3, 15.6, 12.3 and 47.0 days) at 6±1°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±1°C and (4.9, 88.0, 159.3 and 70 days) at 6±1°C for adults, larvae, pupae and eggs.

These values were (2.6, 7.3, 10.3 and 18.9 days) at 26±1°C and (2.8, 39.5, 30.9 and 58.9 days) at 6±1°C 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±1°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 S. oryzae and R. dominica.

Larval susceptibility to phosphine was in descending order C. maculatus-larvae, S. oryzae-larvae and R. dominica-larvae.

Pupae of C. maculatus were somewhat more tolerant to phosphine than pupae of both S. oryzae and R. dominica.

Eggs of C. maculatus were much more tolerant to phosphine than eggs of R. dominica and S. oryzae.

2. Toxicity of carbon dioxide in controlled atmosphere (CA) to the tested insects:

Studies carried out in the laboratory at 26±1°C and 6±1°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 S. 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 S. 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 LT_{90} level and 26±1°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 LT_{90} level followed by larvae, eggs and pupae.

By comparing the susceptibility of the different stages of C. maculatus at the LT_{90} level, it was found that at 26±1°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 CO_2 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 CO_2 were higher than those obtained in CA contained 75% v/v CO_2 and this result could be due to nearly total depletion of oxygen in the CA of 100% CO_2.

3. Toxicity of mixtures of phosphine plus carbon dioxide to the tested insects:

The effect of addition of 25 and 50% CO_2 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.), R. dominica (F.) and C. maculatus (F.). Results obtained showed the following:

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 PH_3 alone and 13, 4 and 14 hr) by a mixture of phosphine + 25% CO_2 and (11, 7 and 5 hr) by a mixture of phosphine + 50% CO_2 for S. oryzae, R. 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% CO_2 and (41, 11 and 12 hr) by addition of 50% CO_2 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% CO_2 and (29, 37 and 28 hr) by a mixture of 20 vpm PH_3 + 50% CO_2, 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% CO_2 and (49, 49 and 82 hr) by a mixture of phosphine + 50% CO_2.

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% CO_2 and (43, 69 and 58 hr) by a mixture of 20 vpm PH_3 + 50% CO_2, for S. oryzae, R. 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% CO_2 and (99, 83 and 122 hr) by a mixture of phosphine + 50% CO_2, 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 PH_3 alone, (77, 62 and 68 hr) by phosphine + 25% CO_2 and (61, 37 and 44 hr) by phosphine + 50% CO_2, for the various insect species, respectively.

The corresponding values at 6±1°C were (261, 278 and 254 hr) with 20 vpm PH_3 alone, (102, 119 and 119 hr) by phosphine + 25% CO_2 and (106, 42 and 103 hr) by phosphine + 50% CO_2, for the various insect species, respectively.

The same trend was also obtained with mixtures of 40 vpm PH_3 + 25 and 50% CO_2 for the different stages of the tested insect species at the two test temperatures.