Session 4

Physical and Chemical Processes in the Application of CA and/or Fumigation

Chairpersons
Noel White
Carl Reed

28S CAF

ADOPTION OF HERMETIC STORAGE FOR MILLED RICE USING VOLCANI CUBES® IN THE PHILIPPINES

Cecilia V. De Dios,[1,*] Maria Finesa A. Cosico,[1] D.D. Julian,[2] J.V. Dator,[2] Ma. Elvira M. Martinez[1] and R.L. Tiongson[2]

[1]*The National Food Authority (NFA), Technology Resource Development Department, Technical Research Division, Quezon City, Metro Manila, Philippines [*e-mail: ccm@nfa.gov.ph];* [2]*Bureau of Postharvest Research & Extension, Muñoz, Nueva Ecija, Philippines*

A pilot trial was conducted on the adoption of hermetic storage using Volcani Cubes® for long-term storage of milled rice at the NFA Warehouse in Cabanatuan City, N.E., Philippines. The storage cubes consist of an upper and a lower section of plastic sheeting zipped together to provide an hermetic seal. The objective of this trial was to evaluate the preservation of milled rice in the cubes, without employing fumigants, in a tropical climate. Nine stacks of milled rice imported from Vietnam were kept in Volcani Cubes; three untreated control stacks were used as reference. Initial infestation was extremely low due to the recent fumigation of the test commodity. After 3, 6 and 11 months of continuous storage, oxygen concentrations in milled rice kept in Volcani Cubes dropped to 11.4%, 5.4% and 2.7%, respectively. The hermetic conditions suppressed insect development and, where the atmospheres contained sufficiently low levels of oxygen, mortality of insects was achieved. The modified atmospheres were able to retard insect growth and development, as evidenced by weak and abnormal progeny of *Rhyzopertha dominica.* This is further supported by the decrease in live insect counts. The quality of rice stored under hermetic conditions in the cubes remained high throughout the storage period. In contrast, the untreated control stacks stored in a normal warehouse atmosphere were heavily infested after 3 months of storage. Between 4 and 6 months of storage, six out of the nine stacks in Volcani Cubes showed insect holes presumably inflicted by *R. dominica,* but damage to the commodity was negligible. Further refinements were suggested for this environment- and user-friendly hermetic storage technology for the quality preservation of milled rice without the use of fumigants, in the Philippines climate.

MEASUREMENT OF DELAYED EVOLUTION OF PHOSPHINE FROM SOLID FORMULATION THROUGH PLASTIC PACKAGING

J. van S. Graver* and S. Pratt

*Stored Grain Research Laboratory, CSIRO Entomology, Canberra, ACT 2601, Australia [*e-mail: jan.vansgraver@ento.csiro.au]*

Phosphine production was monitored in the laboratory and in farm-scale silos (15 t) using a technique, developed in China, for retarding the evolution of PH_3 by enclosing solid aluminium phosphide formulations in polyethylene bags. An apparatus comprising a computer-controlled sampling manifold and an electrochemical sensor was used to monitor, determine, and record PH_3 concentrations continually. Cylinders of assayed PH_3 diluted in nitrogen were used as standards. In the laboratory, polyethylene bags of known water permeability containing aluminium phosphide tablet(s) were placed in chambers and exposed to a stream of humidified air (70% r.h.). The delay in PH_3 production with

respect to unenclosed tablets was determined by monitoring the PH_3 concentrations in the effluents from the chambers. In the silo study the PH_3 levels were monitored in two matched sealable bins containing wheat, which were fumigated with *(a)* unenclosed tablets and *(b)* tablets in plastic bags placed in the headspace. The utility of the 'delayed evolution' technique was considered in relation to the need to prolong exposure periods for effective PH_3 fumigations.

MOVEMENT OF PHOSPHINE GAS IN UPRIGHT CONCRETE ELEVATORS

C. Reed

Dept. of Grain Science and Industry, Kansas State University, Manhattan, KS 66506, USA [e-mail: carlgs@ksu.edu]

Phosphine monitors with electrochemical cells and data-loggers were used to describe movement of PH_3 gas escaping from fumigated grain in upright concrete grain bins. The monitors were placed in ground and below-ground worker areas, outside the elevator, and at bin-top locations to characterize PH_3 concentrations in worker breathing zones and in air near the facility. A monitor suspended from the bin roof recorded the fumigant concentration in the air inside the bin and above the grain. Data were taken at each location at 15-min intervals during 23 separate fumigation events at 15 grain elevators in Kansas, USA. In the hard red winter wheat areas of the USA, wheat typically is fumigated as it is moved from one bin to another. Most upright, concrete elevator bins have several unsealed openings at or near the roof level, 30 to 45 m above the ground. Usually the fumigated grain is considerably warmer than the mean ambient temperature. The predominant direction of gas movement was upward through the fumigated grain. PH_3 concentration in the grain over-space increased and decreased daily, reaching the maximum in mid-morning and the minimum in late evening. The pattern was consistent with the theory that chimney effects produce a generally upward airflow through the grain, with the rate of air movement influenced by the temperature differential between the grain and the ambient air. When the upward air movement through the grain surface is rapid and the wind is calm, PH_3 moves into the grain over-space more rapidly than it escapes through roof-level openings in the bin, creating high fumigant concentrations in the over-space air. Enclosed worker areas at the bin-top level or above were more likely to contain PH_3 concentrations greater than the official regulatory exposure limits (0.3 ppm) than were worker areas at ground or below-ground levels. Several climatic factors in addition to the work practices and policies related to fumigation safety were found to affect the level of worker exposure to fumigant. The potential for worker exposure to elevated fumigant concentrations was greatest after windows in roof-level worker areas had been closed for several hours.

INTEGRATION OF INERT DUST INTO CONTROL OF STORAGE PESTS IN BULK GRAIN IN STORAGE IN AUSTRALIA

Sylvia Allen

Stored Grain Research Laboratory, CSIRO Entomology, Canberra, ACT 2601, Australia [e-mail: sylvia.allen@ento.csiro.au]

In Australia an inert dust (Dryacide®) is used to protect the boundary layers of grain bulks. Both the storage structure and the surface of the grain bulk can be treated with

Dryacide. The type of dust application varies depending on the primary treatment of the grain, aeration or fumigation. For aeration, admixture of Dryacide to the top 0.3 m of grain is used to protect against insect re-invasion of the grain bulk surface, and to reduce or possibly eliminate any existing adult population. For low-flow fumigation with PH_3 (SIROFLO®), a thin layer (100 g m^{-2}) of Dryacide is used and applied by blowing dust across the surface of the grain bulk. The purpose of the dust layer is to retard the loss of PH_3 to the headspace. It also provides greater stability in PH_3 concentrations over time. Optimal use of inert dusts depends on the goal, the physical factors which may reduce fumigant loss, and the biological factors that may affect insect control. Laboratory and field data were presented to describe these factors.

PROSPECTS OF LOW PRESSURE FOR USE IN THE DISINFESTATION OF STORED PRODUCTS

G.N. Mbata and T.W. Phillips*
Dept. of Entomology and Plant Pathology, Oklahoma State University, Stillwater, OK 74078, USA
*[*e-mail: tomp@okstate.edu]*

Effects of low pressure on mortality of different life stages of three stored-product insects, Indianmeal moth *(Plodia interpunctella),* lesser grain borer *(Rhyzopertha dominica),* and red flour beetle (*Tribolium castaneum*), were determined in the laboratory. Insects were exposed to a pressure of 32.5 mm Hg at 25, 33, 37 and 40°C. Adults of all three species were very susceptible to low pressure, and had 100% mortality within 3 h. The immature stages of the lesser grain borer were more tolerant to low pressure and required a longer exposure period for 100% mortality to be achieved. Exposure of eggs of the lesser grain borer to 32.5 mm Hg for 5 days at 25°C did not cause 100% mortality of eggs. All stages of the Indianmeal moth and red flour beetle were killed within 2 days of exposure to 32.5 mm Hg at room temperature. Elevated temperatures reduced the exposure periods required to obtain 100% mortality of the insects. For instance, a temperature of 40°C caused l00% mortality of all stages of Indianmeal moth within 2 h. The exposure periods required to cause 100% mortality at 32.5 mm Hg and the different temperatures investigated ranged from 12 to 175 h for all stages of the lesser grain borer, 2 to 28 h for all stages of Indianmeal moth, and 3 to 28 h for all stages of the red flour beetle. The eggs, being the most tolerant stage for all the insects studied, were investigated further at various combinations of pressures and temperatures.

SIROCIRC® RECIRCULATORY PHOSPHINE FUMIGATION SYSTEMS AT THE XIZUI GRAIN TERMINAL, DALIAN, CHINA

C. Newman,[1] G. Russell,[2] W. Shore,[3] D. Gock[4] and R. Ryan[5]
[1]*Grain Tech Systems Pty. Ltd., Juerhutong, Dongcheng District, Beijing, P.R. China [e-mail: cna@public2.bta.cn];* [2]*Stored Grain Research Laboratory, CSIRO Entomology, Canberra, ACT 2601, Australia;* [3]*GasApps Australia, Unit 6, Sydney, NSW 2148, Australia;* [4]*CYTEC Australia, Sydney, NSW 2153, Australia;* [5]*British Oxygen Co. (BOC) Gases Australia, Sydney, NSW 2164, Australia*

SIROCIRC® is a new phosphine recirculation technology for stored grain disinfestation, developed by the CSIRO Division of Entomology, Australia. SIROCIRC is a development of the well-proven SIROFLO® technology that uses PH_3 gas mixed with CO_2 [ECO$_2$FUME®] as the fumigant medium. SIROFLO and SIROCIRC technologies offer technical, environmental, entomological and operational advantages over traditional tablet-based fumigation methods, by uniformly distributing and maintaining low concentrations of PH_3 over extended periods of time in storages that are not gastight. This is achieved by providing a continuous flow of gas and air into the storage, and by maintaining a positive pressure within the storage. In the case of SIROFLO, the gas is lost through leaks in the structure; with SIROCIRC, some gas is recovered from the headspace above the grain and recirculated back through the grain, thereby effecting savings in gas and reducing the cost. Grain Tech Systems is currently installing nine SIROCIRC systems at the new Xizui Grain Terminal near Dalian in China. The terminal is not only the newest grain terminal in the world, but also the largest, with a total silo storage capacity of over 1 million tonnes. Furthermore, the terminal incorporates what must be the largest grain silos in the world: a group of 20 × 30,000 tonne cells. The fumigation systems incorporate several new technical features including on-site mixing of the PH_3 [VAPORPH$_3$OS®] and CO_2 gases, and an optional high-flow, high-concentration delivery capability. The paper described the concepts and design of the Xizui fumigation systems, and illustrated the installation work currently in progress.

APPLICATION OF VACUUM IN A TRANSPORTABLE SYSTEM FOR INSECT CONTROL

S. Navarro,[1,*] J.E. Donahaye,[1] R. Dias,[1] A. Azrieli,[1] Miriam Rindner,[1] T. Phillips,[2] R.T. Noyes,[2] P. Villers,[3] T. Debruin,[4] R. Truby[5] and R. Rodriguez[5]

[1]*Dept. of Stored Products, Agricultural Research Organization, The Volcani Center, Bet Dagan 50250, Israel [*e-mail: vtshlo@netvision.net.il];* [2]*Oklahoma State University, Stillwater, OK 74078, USA;* [3]*GrainPro Inc., Concord, MA 01742, USA;* [4]*Haogenplast Projects Ltd., Kibbutz HaOgen, 42880, Israel;* [5]*Mesoamerican Development Institute, Lowell, MA, USA*

It was demonstrated that the response of insects to low pressures is temperature- and moisture-dependent. At 25°C and 65% r.h. complete mortality of insect adults was obtained within 7 h when exposed to 20 mm Hg. *Trogoderma granarium* larvae were the most resistant species, a 120-h exposure being necessary under the same conditions. To control the quiescent *T. granarium* larvae within a 72-h exposure time, it was necessary to increase the temperature to 30°C. The encouraging reports led to the idea of developing a transportable system to render the technology a practical tool for the control of insect pests. Two sets of experiments were carried out using a 15-m^3-capacity plastic container termed the Volcani Cube®. This container consists of a flexible liner and is characterized by its transportability. The first test was carried out in Foxboro, MA, USA using an oil-lubricated vacuum pump (3 hp) to reduce the pressure to 25 mm Hg within 25 min. Then the pressure was maintained at between 25 and 29 mm Hg for 17 days. Three sets of bioassay replicates were retrieved, on day 3, 10 and 17 of treatment. Complete mortality of test insects was observed after the 3-day exposure to vacuum. The second test of vacuum was carried out in Israel using a similar setup for the vacuum pump and the Volcani Cube. The purpose of the tests was to study the technology that would contribute to improved performance. Vacuum was maintained within 22 and 75 mm Hg for over 25 days.

FIELD EVALUATION OF ALUMINUM PHOSPHIDE FORMULATIONS AS A FUMIGANT FOR THE CONTROL OF STORAGE INFESTATIONS

M.G. Andrada,* C.G. Alingod, M.E.S. Lim, Maria Finesa A. Cosico and Ma. Elvira M. Martinez

*The National Food Authority (NFA), Technology Resource Development Department, Technical Research Division, Quezon City, Metro Manila 1100, Philippines [*e-mail: ccm@nfa.gov.ph]*

The NFA continuously searches for alternative pesticides that are cost effective. It embarked on a research project to evaluate other commercially available fumigant formulations in the market, such as Quickphos, which is suggested to be as effective as Phostoxin, which is the one currently used by the agency for phosphine formulations. Data obtained from an analysis of variance showed that as regards technical performance, Quickphos, when applied either in single or double dosage, exhibited the same effect as Phostoxin in the control of stored-product insects such as *Rhyzopertha dominica, Sitophilus* spp. and *Tribolium castaneum,* yielding 100% mortality. Regardless of the dosage used, gas concentration generated by Phostoxin was significantly higher than by Quickphos. The gas concentration of a double dose of both fumigants was significantly higher than a single dose. The peak gas concentration attained at different monitoring times did not differ significantly between the two fumigants tested. Furthermore, the interaction of dosage and time in relation to gas concentration revealed a wide variety of responses, with one variable having a more pronounced effect than the other. Quickphos is less expensive than Phostoxin. The agency will be able to realize a substantial savings, specifically on fumigation, if the former is used in the administration of pest control.