UPDATE ON ELECTRONIC MONITORING OF STORED-PRODUCT INSECTS

Dennis Shuman* and Nancy D. Epsky

Protection of bulk-stored agricultural commodities from insect infestations and the direct loss caused by insects are costly. Monitoring of insects to estimate population density is essential in an integrated pest management system for postharvest commodities. Initiation of insect control methods based on economic threshold analysis can eliminate unnecessary "scheduled" insect-control treatments. Many alternatives to methyl bromide (and other problematic fumigants and treatments) will be financially attractive only with early warning of emerging infestation problems. Automated insect monitoring systems involving computer acquisition of data from sensors distributed throughout stored commodities can eliminate the need for scheduling costly manual inspections by remotely displaying the data in real-time from all storage regions. These data can alert personnel to the need for a manual inspection or to initiate control measures, and can be input directly to spatial analysis programs (Brenner *et al.*, 1998), expert management decision support systems, and computer-controlled automatic insect deterrent systems. During and after control measures are applied, the incoming sensor data can provide spatial maps of control efficacy. Whereas the information acquired from a sample is like an instantaneous snapshot of a small fraction of the stored-product and that acquired with a passive trap is like a snapshot integrated over time (from when the trap was deployed), the information acquired with an automated monitoring system is dynamic comparable to moving picture. This dynamic picture provides greater time resolution which permits discernment of the interplay between spatial and temporal population trends. As a practical matter, the fine time resolution can also reveal abrupt changes in sensor data that would be physically preposterous and thus indicative of an error condition.

The Electronic Grain Probe Insect Counter (EGPIC) System (U.S. Patent No.5,646,404 issued 7/97) was developed to provide automated realtime monitoring of insects by using modified grain probe traps (Shuman *et al.*, 1996). In general, traps can be very sensitive to low insect densities because they monitor continuously and can be enhanced with chemical attractants. However, traps must be periodically inspected, which is labor intensive, limits the temporal availability of data, and restricts placement to easily accessible locations. The EGPIC System overcomes these limitations by electronically counting insects (across the full range of species' sizes encountered in stored-grain) as they pass through an infrared-beam sensor head attached to the bottom of each probe. Arrays of probes, deployed throughout a storage facility, can then transmit this count data to a central computer. The most crucial component of the EGPIC System is the insect sensor (the electronic grain probe). It is the point where the biology meets the technology, within a harsh and restrictive environment, and therefore requires the greatest interdisciplinary research and development effort. Shuman and Weaver (1996) described many details of the current electronic grain probe, its design honed by the results of earlier commercial site field tests in Madison, WI and Williston, FL (Weaver *et al.*, 1996).

During the past year, a large-scale field validation study with different commodities at multiple sites (wheat in Kansas, Oklahoma, and Montana; corn in Kansas and Florida; almonds in California) was inaugurated at an EGPIC cooperative research workshop held at CMAVE, ARS in Gainesville, FL during May, 1998. The study's purpose is to performance test the current EGPIC System under field conditions, to promote its technology transfer and commercialization, to continue engineering refinement for large-scale applications, and to make the prototype system available to stored-product scientists as a research tool. Replicates of the eight-probe capacity prototype system were fabricated by Analytical Research Systems, Gainesville, FL, characterized with several insect species in our Gainesville laboratory, and then distributed to Dr. R. T. Arbogast, Dr. R. Brenner, (ARS, Gainesville, FL), Dr. J. E. Throne, Dr. F. H. Arthur (ARS, Manhattan, KS), Dr. C. Burks (ARS, Fresno, CA), Dr. D. K. Weaver (Montana State Univ., Bozeman, MT) and Dr. T. W. Phillips (Oklahoma State Univ., Stillwater, OK).

Several engineering modifications were made during the past year. Some of the field test sites rely on phosphine fumigation for insect control. As a result of previous system malfunction problems encountered after phosphine fumigations at the Williston, FL field test, the current systems employ hermetically sealed electrical connectors (Mini-Con-X connectors, Conxall, Villa Park, IL) and the encasement of all exposed conductors in silicon sealant. Initial laboratory tests with phosphine (Dr. J. Leesch, ARS, Fresno, CA) have been encouraging and EGPIC Systems will be left operating in the field during bin fumigations to observe the temporal change in insect activity as well as system durability. Another problem encountered in earlier field tests was extraneous insect counts due to electrical transients induced by mechanical jarring of the probe signal cables. This problem was eliminated by selection of a different cable (#83553, Belden, Richmond, IN) based on laboratory impact tests. Modifications made for medium-scale fabrication of the probes led to a recognition of the detrimental effect of internal infrared-light reflections (diffusing the beam) in the sensor head. The original sensor head body was made of PVC plastic pipe but was changed to black Delrin (DuPont, Wilmington, DE) by the fabricator because of its superior machinability. The resulting loss of detection sensitivity was eliminated by abrasion of the smooth inner surface of the machined Delrin.

Research is continuing on development of a next generation EGPIC with the following features: (a) Auto-biasing for probe infrared phototransistors. Currently the bias voltage needs to be manually adjusted each time a probe is connected. (b) Improved size discrimination. The phototransistor output signal varies with the insect size, allowing an manually adjustable threshold level to limit the minimum detectable object size. However, laboratory data indicate that significant output signal variability is due to non-uniform beam intensity across the pathway of the falling insect. Multiple beams, which can reduce this variability, are being researched for improved resolution of the minimum size threshold and for providing species discrimination based on size. (c) Increased probe capacity per system. Each probe will have its own insect count digital register to provide compatibility with the Serial Multiplexing Addressable Register Transmission System or SMARTS (U. S. Patent allowed), a distributed multiplexing tree network that enables one computer to collect count data from up to one million probes with a minimal amount of cable (Shuman and Nasah-Lima, 1996). A SMARTS Universal Node (SUN) printed circuit board has been designed and manufactured. Jumper options on the SUN board allow it to be used throughout any SMARTS network configuration over a wide range of transmission speeds. A ten node network is being constructed for a first SMARTS field test and a user interface for the SMARTS software is being developed.

References Cited

Brenner, R. J., D. A. Focks, R. T. Arbogast, D. K. Weaver, and D. Shuman. (1998). Practical use of spatial analysis in precision targeting for integrated pest management. American Entomologist 44: 79-101

Shuman, D., J. A. Coffelt and D. K. Weaver. (1996). A Computer-based Electronic Fall-through Probe Insect Counter for Monitoring Infestation in Stored-products. Trans. of the ASAE 39(5): 1773-1780.

Shuman, D. and M. N. Nasah-Lima. (1996). A distributed multiplexing transmission network for acquiring data from spatially divergent sensors. 1996 ASAE Ann. Intern. Meeting, Phoenix, AZ. ASAE Paper # 963040. 16 pp.

Shuman, D. and D. K. Weaver. (1996). Innovations in electronic monitoring of stored-grain insects. Proceedings of the 1996 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, Orlando, Florida, November 4-6, 1996: pages 57-1 through 57-4.

Weaver, D., R. Arbogast, and D. Shuman. (1996). A field trial of electronic insect monitoring equipment in stored grain in Florida. Proceedings of the 1996 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, Orlando, Florida, November 4-6, 1996: pages 58-1 through 58-4.