Evaluating Sealing Quality of Grain Storage Bins Combined with Appropriate Phosphine Application Strategy to Minimize Insect Resistance in U.S.

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Taylor Conley, Master’s Student at Oklahoma State
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Others Involved:
Carol Jones – Oklahoma State University
Mark Casada – USDA-ARS, CGAHR
Rumela Bhadra – Kansas State University
Frank Arthur – USDA-ARS, CGAHR
Ronaldo Maghirang – Kansas State University
Brian Adam – Oklahoma State University
Dirk Maier – Iowa State University
Samuel Cook – Kansas
Problem Identification

- Phosphine is a well-known and widely used fumigant
- Resistance in storage insects developing
- Ineffective fumigations are a main cause of insect resistance
  - Inadequate grain bin sealing
  - Not all life stages of insects exterminated
  - *Rhyzopertha dominica*, or Lesser Grain Borer primary resistant insect
- Insufficient fumigations lead to unnecessary grain losses
  - Improper sealing is main cause of inadequate fumigations
Influences on Bin Leakage

- Environmental factors
  - Wind velocity and direction
  - Presence of other structures
  - Ambient and internal temperatures
  - Moisture content of air
- Insufficient sealing
Steps Taken to Improve Fumigation

• General improved sealing of bin
• Closed Loop Fumigation (CLF) utilizes airflow to evenly distribute fumigant
• Draws air from headspace and injects it at bottom of bin
• If bin is sealed, CLF reduces leakage by reducing pressure differentials
Proposed Solutions

• **Objective:** Develop and deploy leakage testing methods in order to determine sealing and phosphine dosage required for effective fumigations.
• Develop standard constant pressure test procedures
• Quantify total leakage for storage bin
• Allows for determination of initial dose of phosphine for a successful fumigation
• Used to determine required application rates to maintain target fumigation concentration
• Accurate use of phosphine minimize rate of insect resistance development
Pressurization Tests

• Quantification of bin leakage allows better control of fumigation process

• Pressure Decay Test:
  • Structure pressurized
  • Pressure monitored as it falls
  • Time for pressure to reach half its initial amount = $P_{1/2}$

• Constant Pressure Test:
  • Constant pressure maintained in structure via fan
  • Airflow rate required to maintain pressure monitored
  • Higher airflow = more pressure loss = leakier structure
  • Determined more appropriate testing method for temporarily sealed/unsealed grain bins
Defining Sealing Standards for Methods

• Bins pressure-tested with at least two of the three levels of sealing
• Unsealed = normal storage method of U.S. grain bins
  • No sealing on bin performed
• Temporarily sealed
  • Sealing vents, hatches, aeration fan intakes, downspouts, and conveyor fill points with tape and plastic
• Completely sealed
  • Best sealing techniques
  • Modified bin design
Methods: Pressure Decay Tests

- Pressure decay tests performed on completely and temporarily sealed bins
- $P_{1/2} \geq 5$ min when initial pressure is 500 Pa
- Small-scale steel bins $P_{1/2} \geq 3$ minutes
- Empty – partially loaded $P_{1/2} < 3$ minutes
- If not met, bin not completely sealed
Methods: Constant Pressure Test

- Constant pressure tests performed on completely and temporarily sealed bins
- Variable speed blower attached to opening
- Volumetric flow rates of air up to 500 Pa
- Constant pressure test and pressure decay test results compared to determine best pressure testing method for bin type
Expected Results

• Completely sealed bin able to hold up to 50% of initial pressure for no less than five minutes
• Only completely-sealed/well-sealed bins successfully tested with pressure decay test
• Temporarily-sealed bins not expected to produce meaningful results from a pressure decay test
Initial Test: Methods

- Weather conditions affect pressure loss
- Test temperature, relative humidity (RH), solar radiation, and wind speed
- 500 bu full canola bin set up to perform pressure test
- Tested at different times of day
- Conditions recorded with anemometer (wind speed) and Onset HOBO sensor devices
Initial Test: Methods (cont.)

• Bin “temporarily” sealed
• Plastic sheets taped around entrance, ventilation fan, and outlet with extra strong duct tape
• Three coats of elastomeric paint applied at base of bin
Initial Test: Methods (cont.)

• 1-1/2 in hole drilled in top of bin – PVC pipe attached in hole
• PVC extension created to attach shop vacuum
• Shop vacuum pressurizes bin
• Both pressure decay and constant pressure tests to be performed
Preliminary Testing

• After temporarily sealing with plastic and tape, preliminary pressure decay test ran
• U – tube manometer connected to bin valve
• Avg. of only 5 second half-life – nowhere near the expected amount!
• Three coats of elastomeric paint applied after test
• Constant pressure tests?
Expected Results (cont.)

• Higher wind speed results in faster rate of pressure loss

• More sun radiation = more light intensity; creates higher temperatures in bin than in atmosphere
  • Larger gradient between temperatures causes more leakage from bin

• Higher temperatures also increase pressure loss of bin
Conclusions

- Pressure testing provides quantitative measure of expected leakage
- Predict amount of phosphine required for fumigation
  - Exterminate all stages of insects → reduce phosphine resistance
- Deliverables:
  - Straightforward pressure test protocol to relate to phosphine leakage levels
  - Potential for standard pressurization fan
Questions?

Thank you for your time!