

Title: Stored Grain IPM: Practical Information and Experience for On-Farm Storage Practitioners

Project Leaders:

J. Keith Waldron, NYS IPM Livestock and Field Crops Coordinator, Cornell University
Michael J. Stanyard, Cornell Cooperative Extension, NWNY Dairy, Livestock, Field Crops Team

Introduction:

USDA estimates suggest that producers may lose as much as 10% of the grain crop from the time of harvest until the grain is fed or processed (1).

Much attention has been placed on IPM education for individuals producing field corn, soybeans, wheat and other field/cash crop commodities. Unfortunately, few Integrated Pest Management (IPM) educational opportunities have been available to producers in the northeast for protecting these commodities while stored on-farm. IPM training would help producers minimize or avoid common stored product management problems. A modest potential gain (of 1%) due to improved pest management could have a significant positive economic impact on overall profitability. Enhanced pest management of commodity grains stored on-farm would directly benefit individual growers. These improvements would help ensure a quality product entering the overall grain commodity stream resulting in better grain protection and economic benefits to local and regional grain mills and food processing industries.

Background and Justification

On-farm storage of harvested field corn, soybean and wheat is an important component of cash crop production and marketing. Depending on contracts and futures market price, producers may hold a stored commodity product for periods of several months to more than 1 year before on-farm use or shipping to commercial mills and brokers.

It has been estimated that more than 15 billion bushels of grain are stored in the United States each year. Time spent in storage puts commodities at risk from damage by insects, molds, vertebrate pests, heat sprouting and other factors affecting spoilage. Nationally, these losses have been estimated to be more than \$1 billion annually (2).

In 2007, NY produced 70 M bushels of grain corn, 7.7 M bushels of soybeans and 4.4 M bushels of wheat at a total estimated value of \$4.05 B (3). In the past five years (2007-2002) commodity market value has increased along with increased costs of production. For wheat, 2007 prices averaged \$6.75 / bu compared to \$3.28 in 2002, soybean price increased to \$9.75 from \$5.85 in 2002 and field corn for grain was \$4.30 / bu from \$2.87 / bu in 2002. As an example of grower response to commodity market prices, soybean acreage has increased in NY from 100K in 1998 to an estimated 250K in 2008. The increased value of these grain commodities along with associated increases in production input costs has increased interest and need for IPM and methods to improve the cost efficiency of crop production *and* storage.

Direct-feeding damage by insects reduces grain weight, nutritional value, and germination of stored grain. Insect infestations are often associated with conditions that also cause or favor

contamination, odor, mold, and heat-damage problems that reduce the quality of the grain and may make it unfit for processing into food for humans or animals. Commercial grain buyers often rely on producers to store their own grain for a time and deliver it to the mill throughout the year. Maintaining quality of stored grain is important to mill operators and to growers trying to maximize their profitability. Mills are forced to reject grain that does not meet food quality standards or may pay a reduced price for a lower grade product. This is often due to poor pest management on the farm (4, 5).

IPM principles and methods can be successfully applied to minimize or avoid many of these pest induced storage risks. Many of these methods are cultural combining sanitation and temperature management. Successful storage is accomplished by starting with clean, whole, insect-free grain in the storage facility and by maintaining moisture and temperature at low levels. Grain moisture and temperature must be monitored since they are associated with the development rate of insect and mold populations (2).

Producers, elevator operators, processors, and distributors must understand the marketing system, storage problems encountered, management options available, and the cost: benefit analysis for these options. This storage situation is complex, and components cannot be managed independently. Proper on-farm storage is the first step to protect and maintain a pest-free grain commodity stream. High-risk grain that enters the grain marketing system at any position will put other grain stored with it at risk. If not detected early, loads of infested grain will contaminate clean grain as it moves throughout the storage facility thereby putting the entire grain mass at risk of reduced quality, profitability, and future marketability. An integrated management approach is clearly necessary to develop economically- and environmentally-sound stored grain programs (2).

Stored grain integrated pest management (IPM) methods can be successfully applied to minimize or avoid many of these risks. However, training opportunities on these IPM methods have been limited in the Northeast. Grower interest in IPM to improve stored grain quality is evidenced by the number of information requests received by cooperative extension personnel and grain mill operators (5).

A train the trainer effort to provide extension educators, Certified Crop Advisors (CCA), and other professionals with an overview of on-farm stored grain IPM practices would increase awareness and improve skills to better protect commodities during on-farm storage. This information would then strengthen outreach efforts to grower stakeholders through educational efforts and on-site visits. Improvements to grain protection would enhance net profitability of commodity production by limiting post harvest losses.

Objectives

1. Provide train-the-trainer educational opportunity to enhance use, knowledge, understanding and application of IPM principles and practices to on-farm stored grain.
2. Improve dissemination of stored grain IPM principles and practices through grower education by workshop participants.

Procedure:

The Northeast Region On-Farm Stored Grain IPM Train-the-Trainer Workshop was organized and held June 11-12, 2009 at the Ramada Inn in Ithaca. This was the first On-Farm Stored Grain IPM workshop offered in NY by Cornell Cooperative Extension and NYS IPM Program.

The program was structured to provide participants with an overview of on-farm scale grain storage mechanics and fundamentals from harvest through longer term storage, factors affecting grain quality including information on grain handling, aeration and moisture management, pest identification and management, bin monitoring, safety, IPM guidelines, and resources. To enhance outreach and potential impacts this workshop would be designed as a train-the-trainer program. The agenda for the 1.5 - 2 day workshop would be designed with input from an advisory committee comprised of cooperative extension educators, commercial stored grain operators, private consultants and university pest management specialists. In addition to presentations by Cornell Cooperative extension and NYS IPM Program personnel, the two day program featured nationally known speakers from the stored grain industry. The educational format included a combination of live and dvd presentations, and a laboratory insect identification session. The workshop concluded with an on-farm visit to enhance experiential training aspects and the practical application of information.

The workshop agenda is shown in appendix 1. A resource binder was compiled and shared with all participants and printed copies of the presentations were available from the project leaders. In addition, participants received a labeled collection of stored grain insect specimens (Table1).

Table 1. Stored Grain insect specimens*

COLEOPTERA - Curculionidae <i>Sitophilus granarius</i> (Linnaeus) Granary Weevil	COLEOPTERA - Tenebrionidae <i>Tribolium castaneum</i> (Herbst) Red Flour Beetle	COLEOPTERA - Silvanidae <i>Ahasverus advena</i> (Waltl) Foreign Grain Beetle
COLEOPTERA - Curculionidae <i>Sitophilus oryzae</i> (Linnaeus) Rice Weevil	COLEOPTERA - Tenebrionidae <i>Tribolium confusum</i> Jacquelin du Val Confused Flour Beetle	COLEOPTERA - Laemophloeidae <i>Cryptolestes pusillus</i> (Schoenherr) Flat Grain Beetle
COLEOPTERA - Curculionidae <i>Sitophilus zeamais</i> Motschulsky Maize Weevil	COLEOPTERA - Silvanidae <i>Oryzaephilus surinamensis</i> (Linnaeus) Sawtoothed Grain Beetle	COLEOPTERA - Laemophloeidae <i>Cryptolestes ferrugineus</i> (Stephens) Rusty Grain Beetle
COLEOPTERA - Bostrichidae <i>Rhyzopertha dominica</i> (Fabricius) Lesser Grain Borer	COLEOPTERA - Silvanidae <i>Oryzaephilus mercator</i> (Fauvel) Merchant Grain Beetle	LEPIDOPTERA - Pyralidae <i>Plodia interpunctella</i> (Hubner) Indian Meal Moth
LEPIDOPTERA - Gelechiidae <i>Sitotroga cerealella</i> (Olivier) Angoumois Grain Moth		

* Specimens provided by: USDA Stored Product Insect Research Unit, Grain Marketing & Production Research Center, Manhattan, KS 66502

Participants completed an end of workshop evaluation to provide feedback on program content and suggestions for future efforts. The survey questionnaire is shown in Appendix 2 and 3. Workshop evaluations were very positive.

As a direct result of the workshop eighteen Cooperative Extension Educators and industry personnel representing NY, PA, MA, OH and MI received training in IPM for On-Farm Stored

Grain. In addition the PD's have given additional extension presentations on Stored Grain IPM including two presentations in the Advanced Training session of the Northeast Certified Crop Advisor training held in Waterloo NY, December 2009.

Projected benefits:

It is anticipated that these efforts have helped improve IPM knowledge and skills of cooperative extension, certified crop advisor (CCA) and agriculture industry personnel relative to stored grain protection, improved the network of professionals with interest and responsibilities in stored grain protection, will result in enhanced outreach and timely application of stored grain IPM information and techniques to producers with on-farm grain storage, will help improve the average quality of grain supplied to local grain mills and brokers as the result of improved on-farm grain storage. It is hoped that the workshop has helped enhance communication between field crop producers, cooperative extension and other agricultural industry personnel resulting in improvements to the amount and quality of stored grain IPM information and efforts in the northeast region.

Field crop producers stand to benefit through enhanced farm profitability associated with harvested grain commodities through a reduction of potential pest induced losses and protection of crop value. Businesses using stored products stand to benefit from access to a high grade pest free off farm product, maintenance of a pest free commodity stream, protection of overall grain flow quality, and reduced costs associated with pest induced losses, grain sanitation, and pest control inputs. Consumers ultimately stand to benefit from availability of quality product at reasonable cost.

Workshop Presenters:

Keith Waldron, Senior Extension Associate, Livestock, Field and Forage Crop IPM Coordinator, Cornell / NYS IPM Program, NYSAES, Geneva, NY

Mike Stanyard, Senior Extension Associate, Field Crops Specialist & Team Leader
NWNYS Dairy, Livestock, & Field Crops Team, Cornell Cooperative Extension, Newark, NY

Gary Bergstrom, Professor, Department of Plant Pathology, Cornell University, Ithaca, NY

Scott Chant, President, Safe-Grain/Maxi-Tronic Inc, Mason, OH

Shawn Dunning, President, Agri-Fab & Repair, Pavilion, NY

Lynn Braband, Senior Extension Associate, Cornell / NYS Community IPM Program,
Rochester, NY

Wayne Bauer, Safety and Security Director, Star of the West Milling Co., Frankenmuth, MI

George Holmes, Wheat / Corn Producer, Trumansburg, NY

Acknowledgements:

USDA Stored Product Insect Research Unit, Grain Marketing & Production Research Center,
Manhattan, KS 66502

Dr. James Throne, Entomologist / Research Leader - insect specimens

Dr. Frank Arthur, Entomologist - insect management

Dr. Paul Flynn, Entomologist - sampling

Dr. Kathy Flanders, Extension Entomologist, Auburn University, Auburn, AL

Francois Lachance, Plant Manager, Star of the West Milling Company, Churchville, NY

Janice Degni, SCNY Team Coordinator, Dairy & Field Crops Specialist, Cornell Cooperative Extension, Cortland, NY

Mike Helms, Extension Associate, Pesticide Management / Education Program, Cornell University

Trece Incorporated, Adair, Oklahoma 74330

Ward Tingey, Professor, Department of Entomology, Cornell University

Funded by a minigrant from the Northeastern IPM Center

Appendix 1.
Stored Grain IPM Workshop Agenda
Ramada Inn, Ithaca NY
June 11 - 12, 2009

Day 1 - Ramada Inn

8:30 - Registration and Continental Breakfast

9:00 - Welcome, Objectives / Overview, Introductions – Keith Waldron / Mike Stanyard

9:15 - Stored Grain issues in NY - Keith Waldron / Mike Stanyard

9:20 - Effect of Grain Handling, Storage, And Conditioning Practices –
Shawn Dunning, Agri-Fab & Repair

10:00 - Molds and Mycotoxins (Gary Bergstrom, Cornell Plant Pathology)
Management Implications / Options

10:30 - Break

10:50 - Grain Bin preparation – pre-binning basics - Keith Waldron / Mike Stanyard

11:20 - Stored Grain Mgmt Overview – Part A - Scott Chant, Safe-Grain/Maxi-Tronic, Inc

12:00 - Lunch

1:00 - Stored Grain Mgmt Overview - Part B - Scott Chant, Safe-Grain/Maxi-Tronic, Inc

2:00 - Managing Vertebrates in/around grain storage facilities - Lynn Braband , NYS IPM

2:45 - Stored Grain Insects - Mike Stanyard, NWNYS Dairy, Livestock, & Field Crops Team

3:30 - Break

3:50 - Grain Bin Safety – "Entering a grain bin can be deadly."
Wayne Bauer, Safety and Security Director, Star of the West Milling Co.

5:00 – Wrap up / How are we doing?

5:40 - Dinner – (Ramada)

7:00 - Leave for Cornell Campus – Room 2109 Comstock Hall, Entomology

7:15 - Laboratory – Cornell Campus
Identification of common stored grain insects and grain molds

9:00 - Return to Hotel

Day 2 - Ramada Inn

8:30 - Continental Breakfast

9:00 - Review, Q/A?

9:15 - Stored Grain Bin Sampling and Pest Management Tactics - Keith Waldron / Mike Stanyard

10:00 - Break

10:20 - Stored Grain IPM Training Video / Review / Discussion?

11:20 - Complete evaluation, feedback, suggestions?

11:45 - Lunch

12:30 - Field Trip – On-Farm Grain Storage

Host: George Holmes, Field Crop Producer, Trumansburg, NY

3:00 - Workshop Over

Appendix 2. Stored Grain IPM Workshop Evaluation Questionnaire, June 11 - 12, 2009

1. Please rate the usefulness of the meeting topics on a 1 (not useful) to a 5 (very useful) scale:

Topic	Ranking					Comments
	1	2	3	4	5	
Grain Handling, Storage, Conditioning Practices						
Molds and Mycotoxins						
SLAM / Pre-binning preparation						
Stored Grain Mgmt Overview – Part A						
Stored Grain Mgmt Overview – Part B						
Vertebrate IPM						
Stored Grain Insects						
Grain Bin Safety						
Cornell Lab visit Insect/Molds						
Grain Bin Monitoring and Insect Management						
Stored Grain IPM Video						
On-Farm Visit						

2. Did the workshop meet your expectations?

Below expectations Met expectations Exceeded expectations

Comments:

More on back of page:

3. Usefulness of Workshop:

Most Useful Part	Least Useful Part
------------------	-------------------

4. Usefulness of Laboratory Visit:

Most Useful Part	Least Useful Part
------------------	-------------------

5. Usefulness of Farm Visit:

Most Useful Part	Least Useful Part
------------------	-------------------

6. What aspect of this training are you most likely to use in your extension/outreach programming?

7. Would you recommend your colleagues attend this workshop if one were held again?
___ Yes ___ No

8. Please share any constructive comments or suggestions to improve this workshop:

9. Suggestions for future Field, Forage and/or Livestock IPM *Train-the-Trainer* workshops?

10. Other comments and suggestions:

Thanks for your feedback and participation!

Appendix 3. Participant Responses to End of Stored Grain IPM Workshop Questionnaire.

1. Please rate the usefulness of meeting topics on a 1 (not useful) to a 5 (very useful) scale:

Response	Grain Handling, Storage, Conditioning Practices	Mold and Mycotoxin	SLAM / Pre-binning preparation	Stored Grain Mgmt Overview – Part A	Stored Grain Mgmt Overview – Part B	Vertebrate IPM
1		5	3	4	4	3
2	3	4	2	5	5	1
3	3	4	4	5	5	4
4	5	5	5	5	5	5
5	5	5	5	5	5	4
6	5	5	4	5	5	3
7	5	5	5	5	5	3
8	5	5	5	5	5	4
9						
10	5	4	3	4		3

Comments:

Grain Handling, Storage, Conditioning Practices

- The PPT notes were helpful
- Good review
- Pros & Cons of various equip could have been emphasized - grain quality - clean out
- Excellent
- Excellent, So much to learn in this area. What are the considerations for new sites?

Molds and Mycotoxins

- Good explanation and answers to questions
- Good overview
- Excellent
- General overview pretty general

SLAM / Pre-binning preparation

- He assumed a base line of knowledge some of us didn't have but ok
- Ok, a basic review
- An outstanding, excellent excellent presentation
- First presentation should give clearer overview of what problems we're trying to avoid, how prevalent they are. This will put everything in perspective
- Good intro, Aha moment day 2 that organized topics around SLAM

Stored Grain Mgmt Overview – Part A

- Entertaining speaker, very clear and receptive to question
- Scott Chant - excellent, I want his PowerPoint
- Great speaker experienced very detailed knowledge

- Excellent
- Very good
- Excellent lots of new, relevant critical mgt info, could be expanded into hands on exercises - see systems in the field

Stored Grain Mgmt Overview – Part B

- Scott Chant presentation excellent
- Great speaker experienced very detailed knowledge
- Excellent
- Excellent lots of new, relevant critical mgt info, could be expanded into hands on exercises - see systems in the field

Vertebrate IPM

- Could have presented more examples directly related to bins, farms, interesting dilemmas
- Not very good - get company rep from Bell Labs to do this
- Interesting but seemed less directly related to stored grain issues. Slides needed more titles
- Would have liked less detail about individual more control data - what really works?
- Would have liked more specific control information
- If prioritizing topics - seemed less relevant practical than bin engineering & mgt info some good info - could be shorter

	Stored Grain Insects	Grain Bin Safety	Cornell Lab Insect/Molds	Stored Grain Bin Sampling and IPM Tactics	Stored Grain IPM Summary Video	On-Farm Visit
1	4	4				
2	4	3	4	4	5	
3	4	4	4	4		
4	5	5		5	5	
5	5	5	5			
6	3.5	4	4	4	4	5
7	5	5	5	5	4	5
8	4	4				
9						
10	5	5	4	4		

Comments:

Stored Grain Insects

- Good materials PPT handouts
- Especially interested to learn about rice weevil life cycle
- I would have liked more pictures to illustrate different stages instead of one picture / pest
- Good information Audio was reasonable

Grain Bin Safety

- Should have started presentation with example of how accident happens at the beginning
- Could have spent more time on prevention and reuse
- Outstanding very helpful very important
- Good topic. Disorganized include photo's and charts in PowerPoint. Less stats. Need more clarity what are the dangers we're trying to avoid - how to the accidents happen? (Start with this)
- Excellent Alert, sensitization to danger

Cornell Lab visit Insect/Molds

- Very good session. Keith and Mike are both very knowledgeable
- Time too short
- Neat, Way cool one of my favorite parts. Very useful, I appreciate all the work that went into preparing this.
- Disorganized ran too late, but good. Maybe have specimens set up on microscopes head of time, unless you want to specifically train people on microscopes use.
- It would be fun to have a vial of grain particles with several dead grain insects and then look for & ID the bugs
- Interesting worthwhile exercise

Stored Grain Bin Sampling and IPM Tactics

- Good review do more on chemicals, esp. farm grants & different application methods
- Good overview
- Great Discussion, Probably the single most important & useful talk answering question and making recommendations
- Very good but need to find more specific guidelines for action thresholds, differences between sampling methods. I can sample but how do I know what to do with the information
- Good a little redundant

Stored Grain IPM Video

- I'm going to order the CD
- Especially nice as good to see on farm techniques in actions
- Provided good discussion
- Not sure a little too heavy on insecticides, maybe something from a more similar climate would be better.

On-Farm Visit

- Did not attend
- Very useful integration
- Having Shawn there was essential to this visit
- Excellent to tie things together, Shawn was an excellent resource!! We need to figure out how to use him as a resource

2. Did the workshop meet your expectations?

Met Expectations: 4; Exceeded expectations: 6

Comments:

- Excellent variety in this training (samples, PPT's, Q/A, tour)
- Could have used another day (too short)
- Very worthwhile workshop. It would be nice if the notebook had tabs / labels so we know what is in each section. I had high expectations
- Very good flow of topics

3. Usefulness of Workshop:**Most Useful Part**

- Force to face Q/A resources
- Sampling insect ID
- Good overview, very nice reference materials
- Entire workshop useful
- Keith & Mike presentation SLAM, products, Pest ID
- Grain handling / drying / monitoring (day 1)
- Learned more about How storage bins work
- Where do we want to go from here? Maybe we should have? Planning committee to think about where we want to go with future educational efforts

Least Useful Part

- Rodent was ok, could be better, Gary Bergstrom session on mold sampling esp. needs to add sclerotia on wheat for ergot which is dockage also. Also never strategies for testing, list of labs, strategies etc. Get Gretchen Kuldau in from PSU
- N/A
- All useful
- Dinner Thursday was too long

4. Usefulness of Laboratory Visit:**Most Useful Part**

- Did not attend
- Very good - glad to have real samples not just pictures
- Fascinating to see the actual insect greatly enlarged. Better than "plates"
- Going through each one what to look for to distinguish from other similar ones
- Helped to reinforce the earlier ppt

Least Useful Part

Do it during the day & have tour of labs

Time too short

None

Rushed mildly chaotic

5. Usefulness of Farm Visit:

Most Useful Part

DNA

Did not attend

Reality check (to hear a producers point of view)

Shawn B's commentary

Shawn's knowledge & expertise farmer's experience & perspective

Least Useful Part

DNA

6. What aspect of this training are you most likely to use in your extension/outreach programming?

- SLAM, scout / monitor
- Sanitation / prevention techniques
- Mike Helms list of products / Mike Stanyard's talk on products & methods of treatment
- Safety for sure. Good to have a better understanding of aeration & equipment not sure how soon I'll need this info, but feel much more confident if called upon
- Aspects of all of it. Will immediately emphasize safety aspects. I will order stickers and distribute
- Everything was very useful

7. Would you recommend your colleagues attend this workshop if one were held again?

Yes: 8 No: 0

Comment:

- We will redo this in PA

8. Please share any constructive comments or suggestions to improve this workshop:

Comment:

- I wish we could have advertised more aggressively & sooner, so more people could have benefitted from around the NE
- Beef up the sections on chemicals and a section on organic grain storage & control & especially on for? Have a finished CD for extension agents to take with them.
- Video covering safety issues
- Excellent loose-leaf info binder. Would be nice to have a Table of Contents
- Another day longer
- Go through insecticides in more details chemical family, toxicity, mode of action so that we better underrated the specifics of the treatments
- Grain deductions that the farmer may in cure

9. Suggestions for future Field, Forage and/or Livestock IPM *Train-the-Trainer* workshops?

- Expanded rodent control workshop that is farm specific Norway rat, roof rat, deer mouse, shrew etc and specific to poultry, dairy agronomic, orchard etc practices. I'd be willing to help out with future training or ?
- Comprehensive insect / diseases overview of major NY field crops corn, alfalfa, grasses, soybeans, small grains etc
- In-depth weed control programs

10. Other comments and suggestions:

- Could you offer this as a session at the next IPM symposium? Could the PPT's be posted on the web with some of the resources?
- Thanks for extending the invitation. Do a slide or poster on a jigsaw picture showing all the components of grain IPM featuring the different components (monitoring, sanitation, environmental mgt, chemical, biological, storage safety, SLAM etc at all part of the solution. Have a slide showing the snap covers that fit over the fans and vents. It prevents critters going in those air duct systems
- This was a good overview for someone like me who never has had the "big picture" training in this area, excellent workshop.
- Minor - Thurs afternoon break could have been moved one talk earlier. I would have been time with sandwiches for lunch - two hot rich meals in a day is a lot (would help reduce cost. Didn't see a list of commercial certification categories with respect to stored a grain pesticides. Future ref - Nellie Brown - has a safety talk on fumigation
- Wow, very informative