Insect growth regulators in pest management programs

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Reduced-risk Insecticides

- Seen as replacements for organophosphate and carbamate neurotoxins
- Examples: pyrethroids, insect growth regulators, natural products, neo-nicotenoids
- Renewed interest in IGRs for stored products

IGRs in Stored Products

- Grain protectant treatments
- Surface treatments to floors and walls of structures (food warehouses, mills, etc.)
- Aerosols and fogging treatments to interior of food storage structures

Grain treatments

- Methoprene is only IGR registered in the USA
- Originally registered in the 1980s (Diacon) as a grain protectant
- Misunderstandings regarding IGRs, was not extensively used by industry
- Sales were poor, product was withdrawn

Methoprene Re-born

- Diacon II re-registered as a grain protectant in 2002
- Supplemental label issued in 2004 for aerosol and surface treatment
- Several recent tests conducted with stored-product insects

Methoprene in Stored Grains

- Usually little or no adult mortality with IGRs
- Combination treatments of IGRs with other reduced-risk insecticides are being evaluated
- Results can vary among grain commodities

Insect Pests of Stored Grains

- Beetles are the main pests, Indianmeal moth does occur but damage is not usually severe
- Lesser grain borer is an internal feeder, probably the most important pest of wheat
- Rice weevil is also an internal feeder
- Secondary beetle pests occur as well

Biology of LGB

- Females lay eggs on exterior of kernels, neonates hatch and bore inside
- Entire life cycle is spent inside the kernel, usually one larva per kernel
- Adults exit kernels, creating a large hole and an insect-damaged kernel (IDK)

Diatomaceous Earth (DE)

- Inert dust used to control insects in stored grains, affects physical properties, even when used at label rates
- LGB particularly difficult to kill with DE
- Variation in effectiveness among grain commodities and with insect species

DE and Methoprene

- Combination treatments on rough rice, long (Cocodrie), short (S-102), medium grain (M-205)
- Rice treated first with 0, 0.25, 0.50, 0.75, and 1.0 ppm methoprene, then with 0, 125, 250, 375, and 500 ppm DE (_ = label rates)
- 25 combinations, 5 replicates, 20 g of rice in plastic vials was the experimental unit

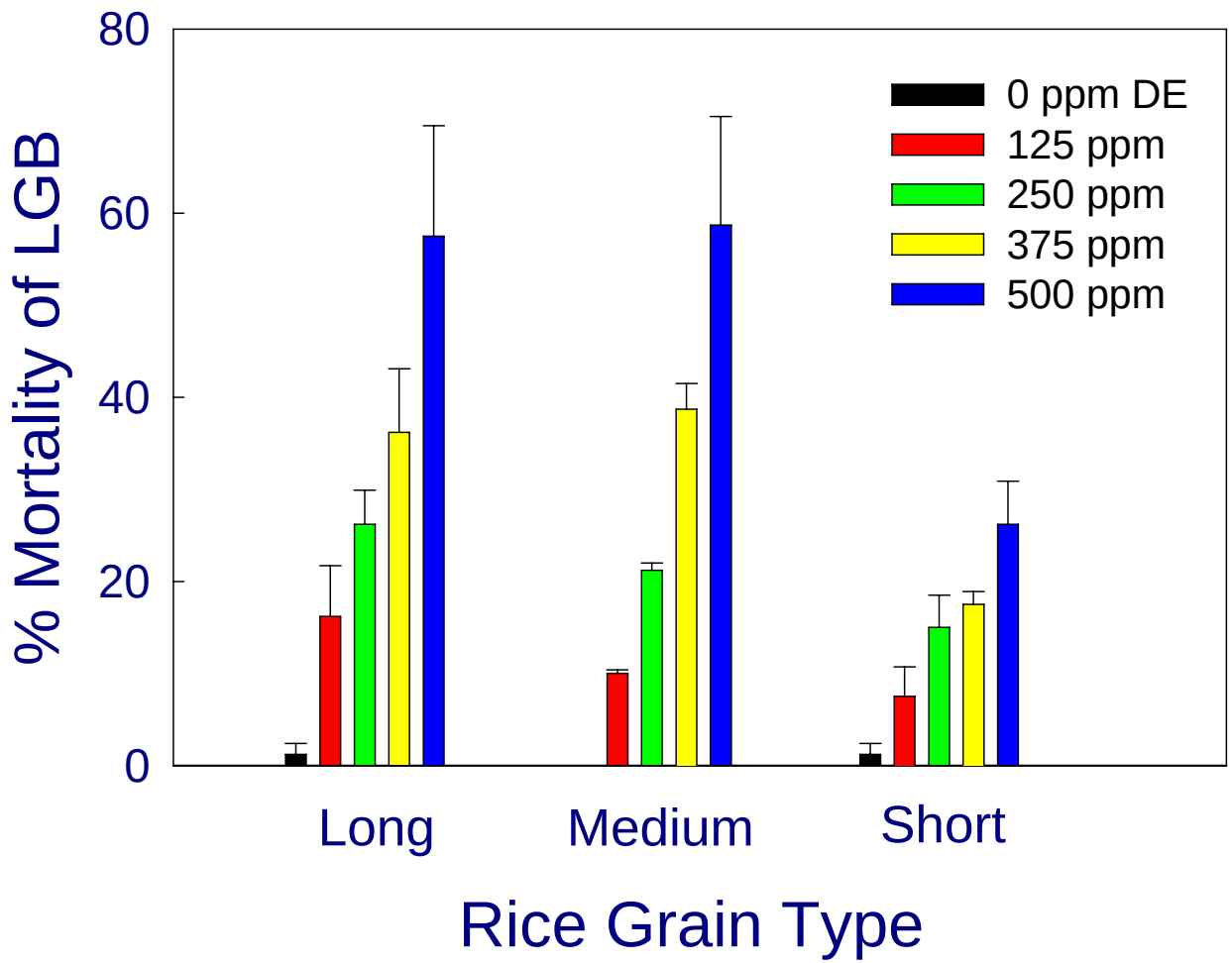
Methods Continued

- Humidity of 75% RH maintained in plastic boxes with saturated NaCl
- 20 adults exposed in each vial for 2 wks at 32°C-75%RH
- Mortality assessed, parental adults discarded
- Vials returned to boxes, held for 8 weeks, F1 progeny counted

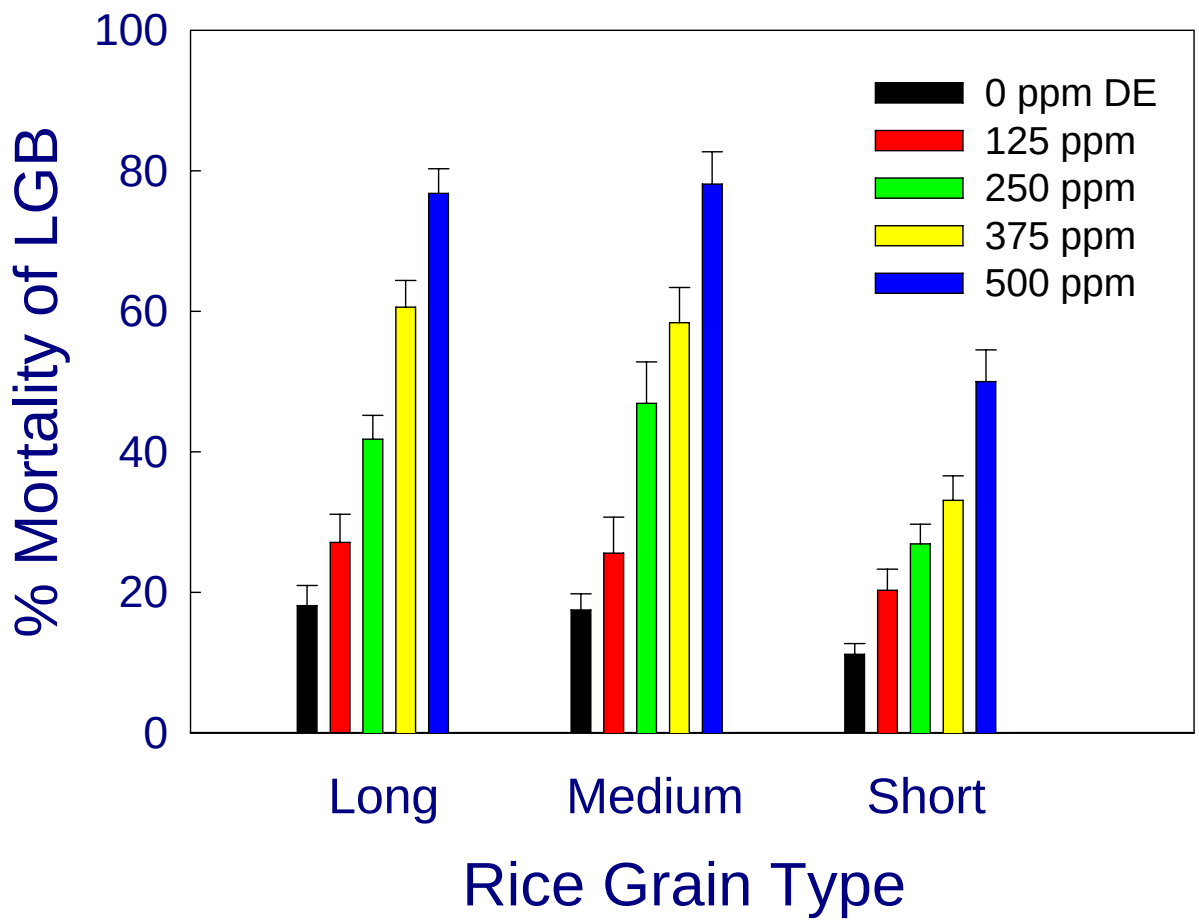
Results: Parental Adults

- Mortality with DE alone did not exceed 70% even at the label rate of 500 ppm
- Greater mortality in Cocodrie and M-205 than in S-102
- Mortality slightly higher in the methoprene treatments, not an expected result

Mortality with DE, No Methoprene



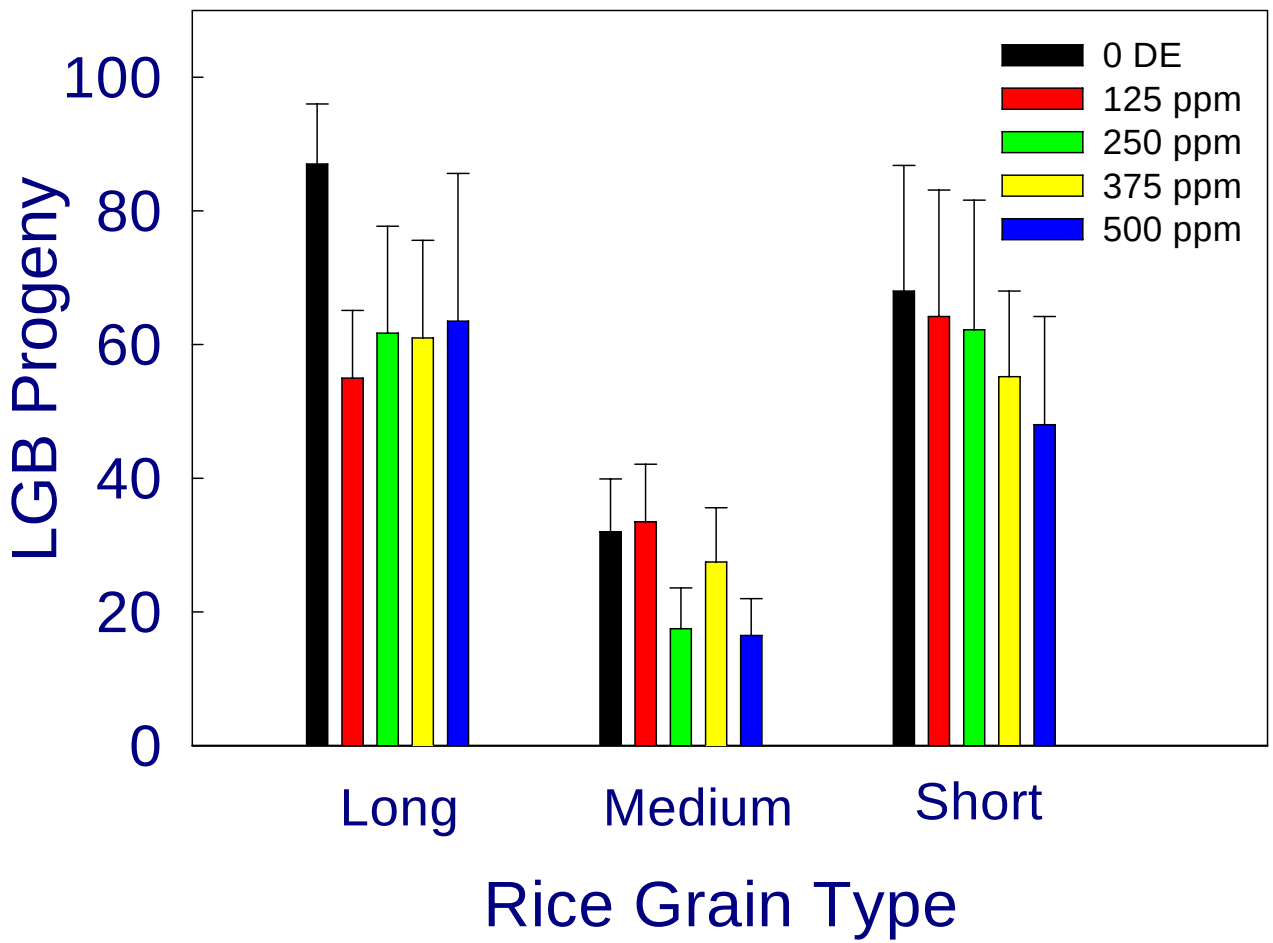
Methoprene Rates (-0) Combined



Results: Progeny

- Extensive progeny production in rice treated with DE alone
- More progeny in Cocodrie and S-102 than in M-205 (different from parental results)
- Progeny suppression was 99 to 100% with any level of methoprene (Data not shown)

Progeny with DE, No Methoprene



Indian Meal Moth

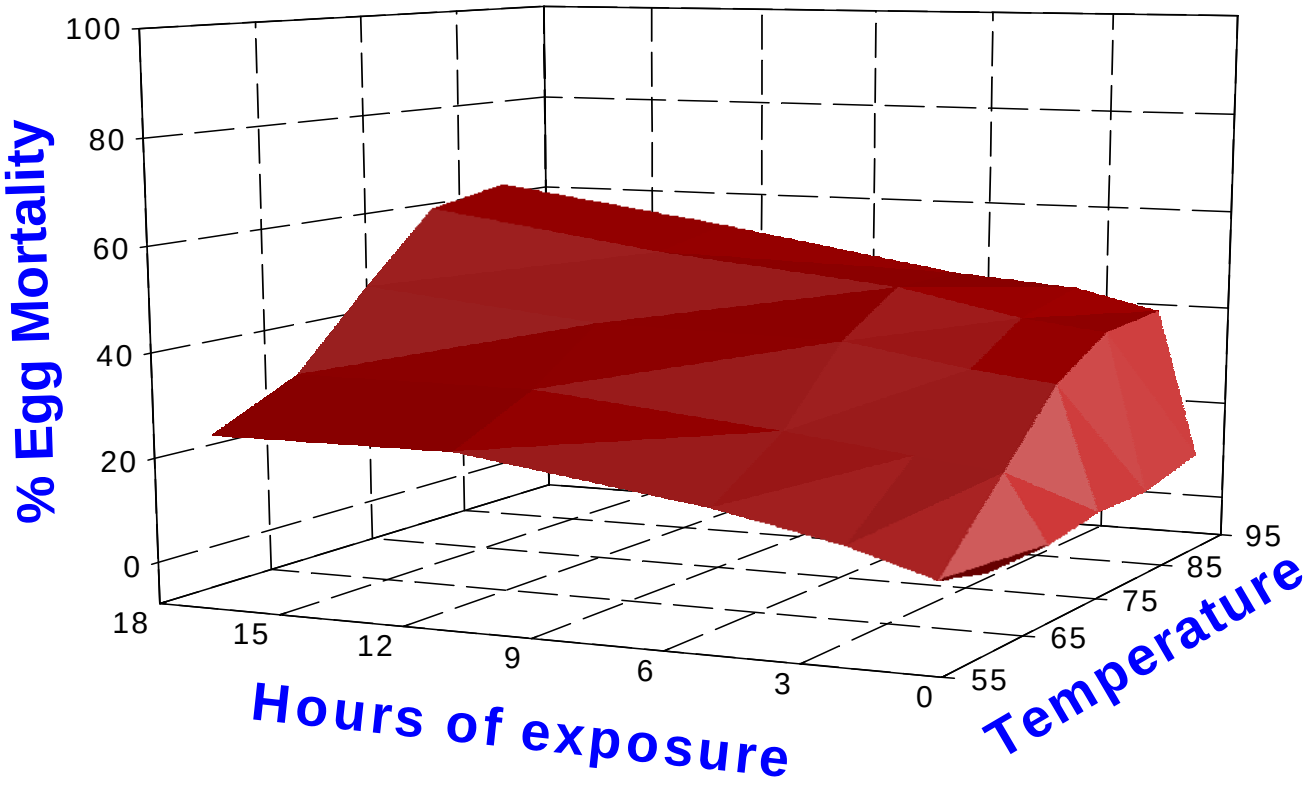
- Perhaps the most economically-important pest of stored and processed food
- Also known as a “pantry pest”, many homeowners are familiar with this pest
- Larvae consume products, cause webbing, difficult to kill with conventional insecticides

Indian meal moth (IMM)
Plodia interpunctella

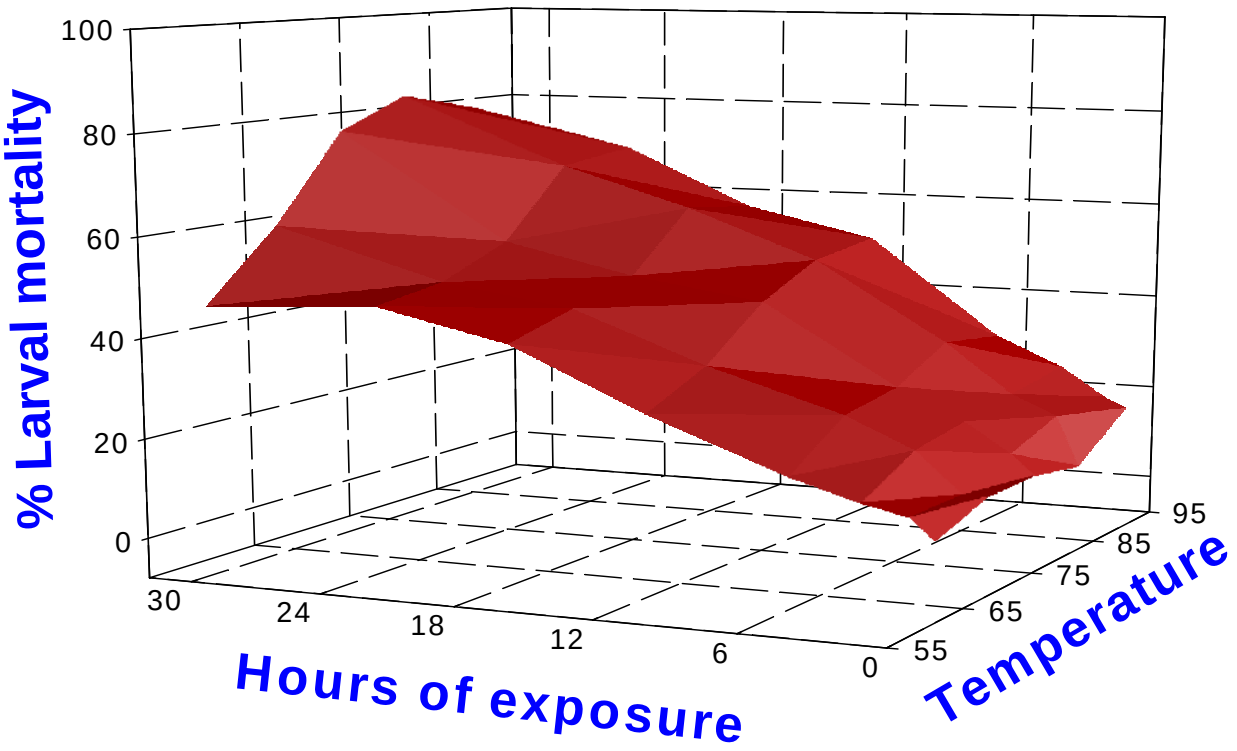
IGR Hydroprene (Gentrol)

- Exposed wandering-phase instars on concrete treated with label rate
- Conducted tests at different temperatures and exposure intervals
- Results depicted in 3-D graphs

Eggs exposed to hydroprene, label rate (1 oz/1 gallon/1500 ft^2)



Larvae exposed to hydroprene, label rate (1 oz/1 gallon/1500 ft^2)



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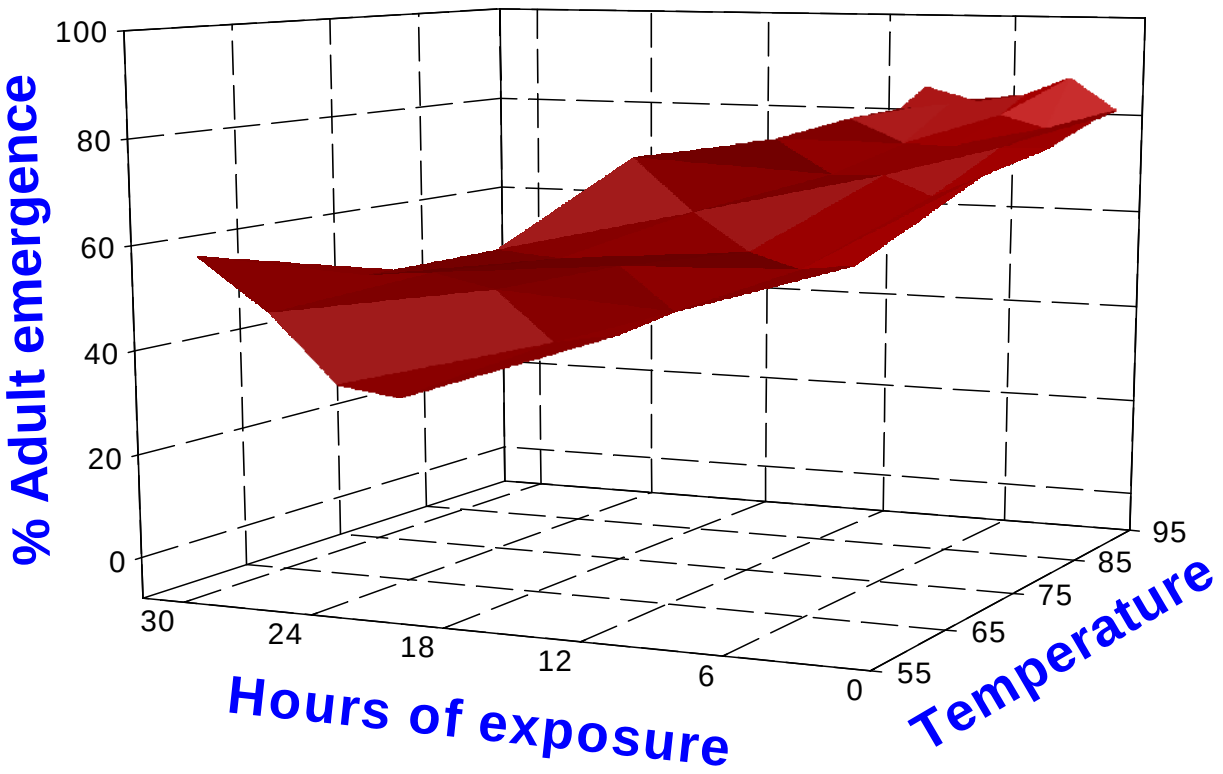


Arrested Larvae

Results for Hydroprene

- Killed larvae, reduced adult emergence
- Delayed adult emergence
- Hydroprene is volatile, little residual control
- Will other IGRs control the Indianmeal moth

IMM on Commodities

- Generally not a major pest of corn and wheat
- Larval masses cause extensive webbing
- On commodity that is particularly vulnerable to IMM is birdseed

IMM Webbing on Corn

IMM Webbing on Corn

Larval Tunnels in Chicory

Larval and Frass in Chicory

Tests with Birdseed

- Birdseed treated at 1, 2.5 or 5 ppm (label rates)
- Late late-instar IMM larvae exposed on treated birdseed for 1-8 hours
- Removed, put on untreated birdseed, held for adult emergence

Results

- Little adult emergence at 2.5 and 5 ppm
- Low adult emergence at 1.0 ppm
- Larvae often arrested, if they did pupate they do not emerge as adults
- New tests initiated with shorter exposure intervals of 0-60 minutes at 1 ppm

Results of New Test

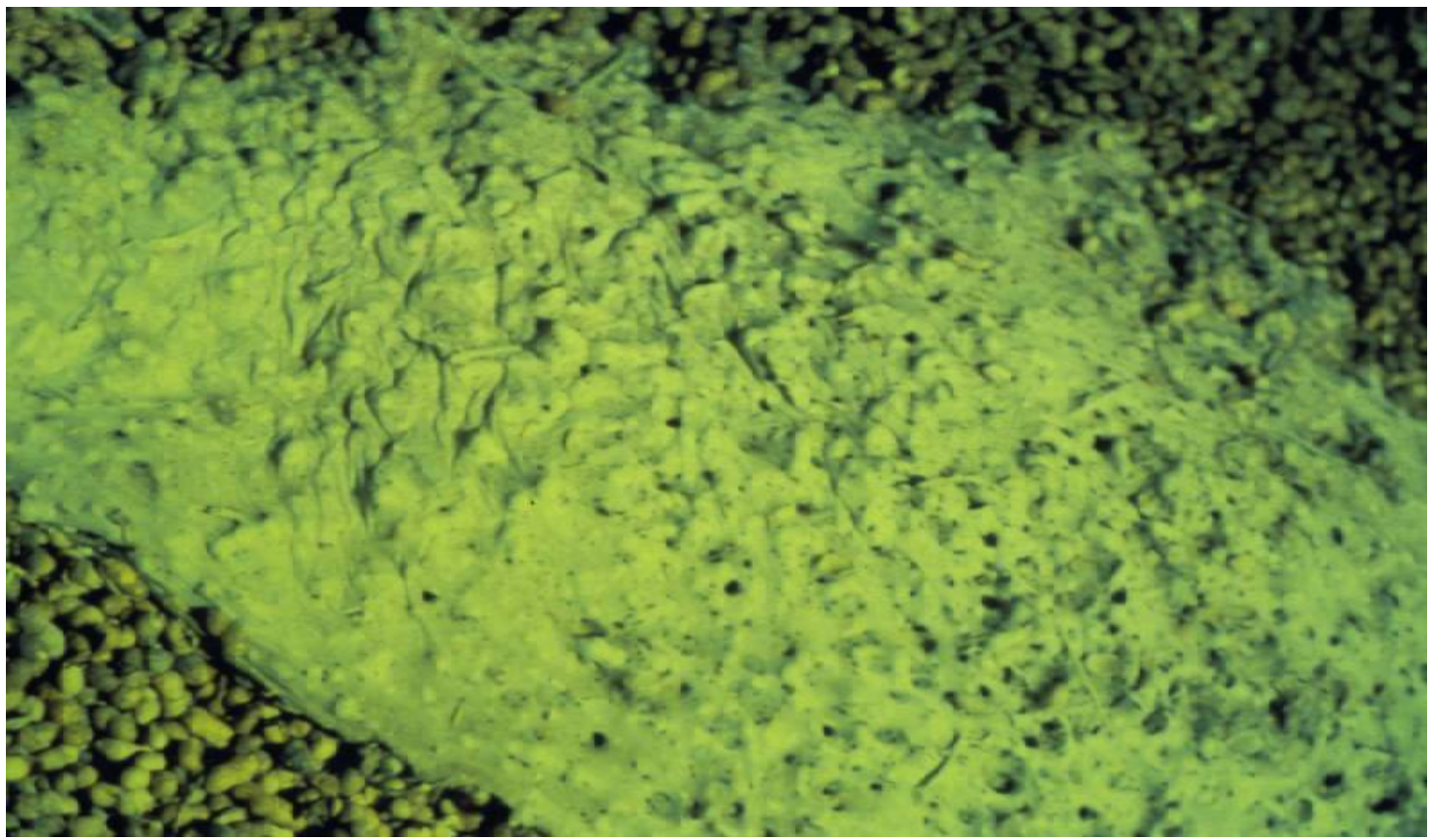
- Lower exposure intervals resulted in some emerged deformed adults
- Indianmeal moth very susceptible to methoprene on treated commodities
- Results were similar for tests on wheat

More Commodity Treatments

- Peanuts in southeastern USA stored primarily as bulk in-shell peanuts
- IMM is a major pest
- Larvae enter through cracks in peanut pods
- Consume and tunnel through kernels

Peanut Warehouse

IMM Webbing on Peanuts



Field Trials

- Initiated last year in Virginia and Georgia
- Applications of methoprene to stored peanuts
- IMM being monitored, residues analyzed
- Data will be analyzed after all peanuts are unloaded from the warehouse

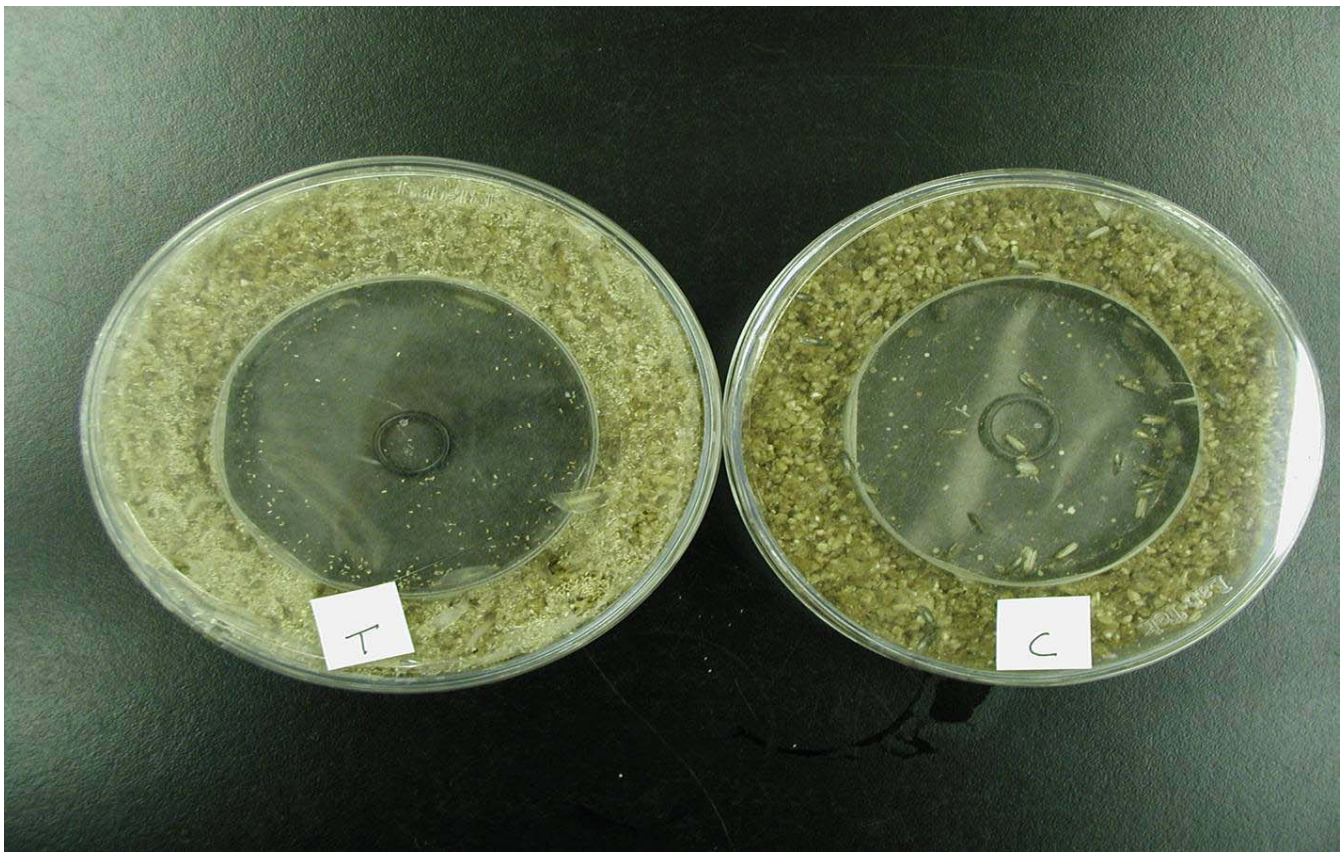
Residual Bioassays

- Peanuts treated at 1 ppm last September in VA sent to lab in Manhattan in January
- Bioassays conducted in 29 January and 22 February, wandering-phase larvae exposed on treated and untreated peanuts
- Total adult emergence was 83 and 91% on untreated peanuts, none on treated peanuts

Novel Experiments, Methoprene

- Treated coating papers used in packaging with the IGR methoprene
- Exposed Indian meal moth eggs on these papers
- Assessed adult emergence

Exposure Arenas



% Adult Emergence From Eggs Exposed on Kraft Paper

Mg[AI]/in^2	5 replicates
Untreated	87 ± 3.4
1.6×10^{-5}	76 ± 4.5
6.2×10^{-5}	65 ± 4.7
1.2×10^{-4}	37 ± 5.4
3.0×10^{-4} (label rate)	**5 ± 1.4**
4.6×10^{-4}	< 1

Cooperative Projects

- Industrial companies produce polymer coatings for pet food bags
- Can methoprene be incorporated into the packaging laminates to control IMM
- On-going current research projects

Experimental Trials with IMM

- Treating various coating papers with methoprene, using industrial processes
- Exposed wandering-phase larvae and eggs on paper treated with a range of concentrations
- Examined adult emergence and fecundity of those adults

Results

- Lethal effects instead of sub-lethal effects
- Data comparable to previous results with IGR hydroprene
- Similar results in cooperating labs
- More replicates and testing needed for definitive conclusions

Explanation of Results

- Insecticide could be bound up in the laminate layers
- UV coatings could be affecting methoprene efficacy
- New tests with Kraft paper bag material

Aerosols and ULV fogs

- Tests being conducted in large commercial food-storage facility
- Insecticides applied by a ULV fogging system
- Different products are being evaluated
- Several species/life stages are the targets

Aerosol Tests With Methoprene

- Applications at label rate, larvae put in sets of Petri dishes ringed with Vaseline barriers, placed on the floor, exposed for 2h
- No exposed late-instar Indian meal moth emerged as adults
- Even distribution of fog in the testing room

Fog Distribution: Methoprene

Summary

- Methoprene seems to be very effective against wandering-phase IMM larvae
- New strategies must be developed to incorporate methoprene into packaging
- Educational efforts needed to ensure understanding of IGRs