

A close-up photograph of a corn plant. The image shows green leaves and a developing ear of corn with yellow silk. A small, dark-colored insect is perched on one of the leaves. The background is a soft-focus green.

Insect Pest Dynamics and Evolving IPM

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Illinois Extension

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Managing Bt-resistant Corn Rootworm



Western corn rootworm
Diabrotica virgifera virgifera



Northern corn rootworm
Diabrotica barberi

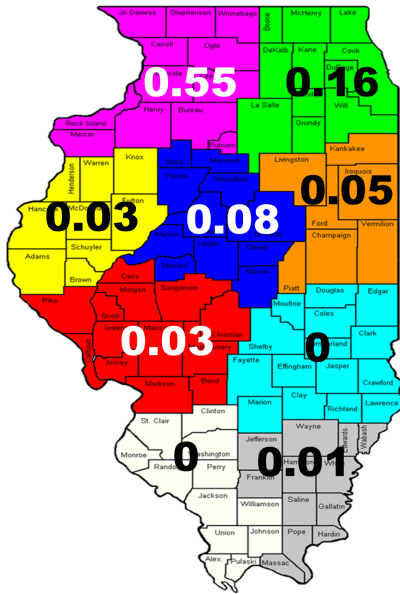
Current Rootworm Situation in Illinois

Overall, rootworm populations are low in Illinois

Western Corn Rootworm

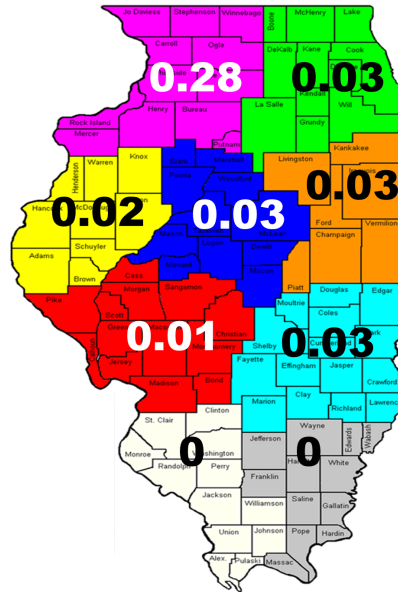
(ave # beetles per plant)

2021



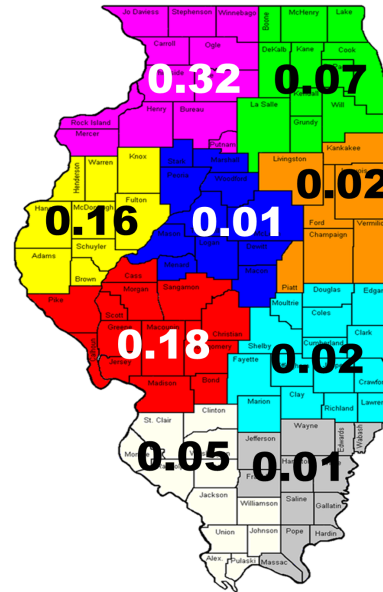
State Ave
0.1

2022



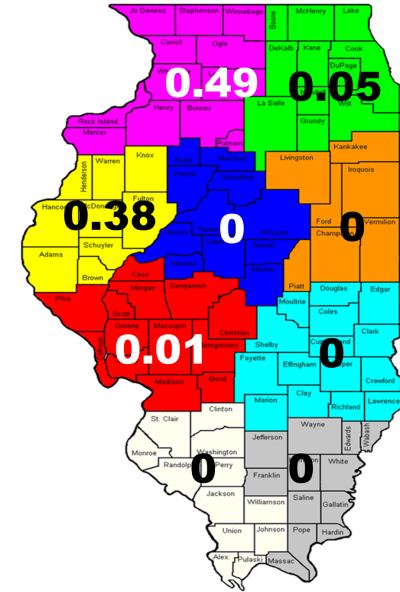
State Ave
0.05

2023



State Ave
0.09

2024



State Ave
0.1



Kelly Estes, State Survey Coordinator
Illinois Cooperative Agricultural Pest Survey Program



Current Rootworm Situation in Illinois

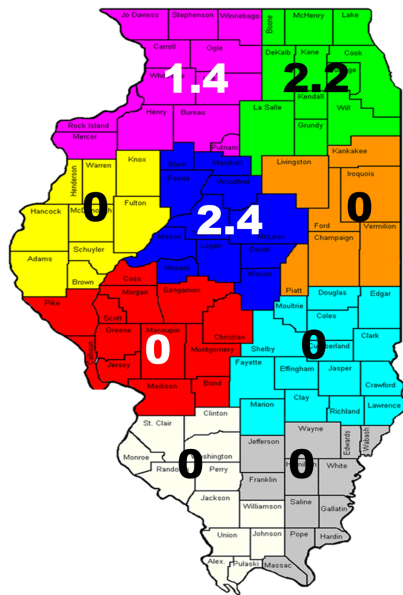
Overall, rootworm populations are low in Illinois

Rotation-resistant WCR pressure is almost non-existent

Western Corn Rootworm

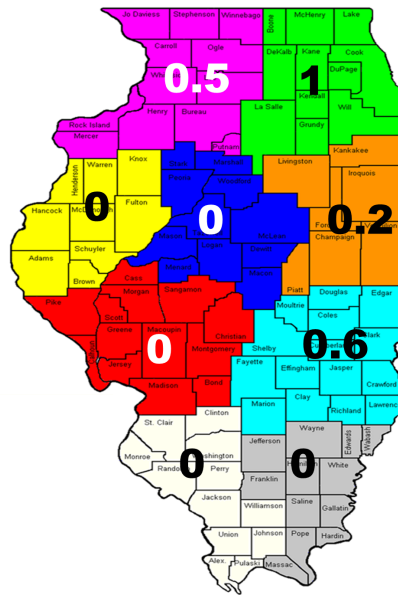
(ave # beetles per 100 sweeps)

2021



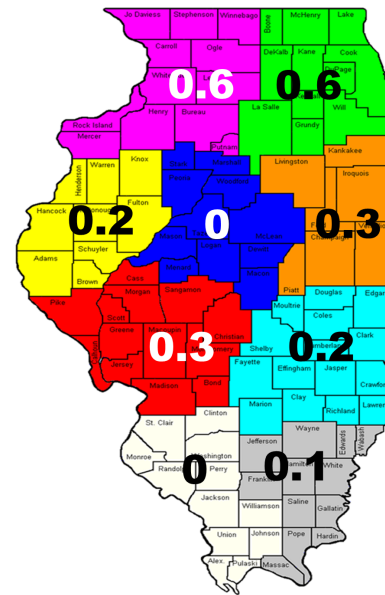
**State Ave
0.7**

2022



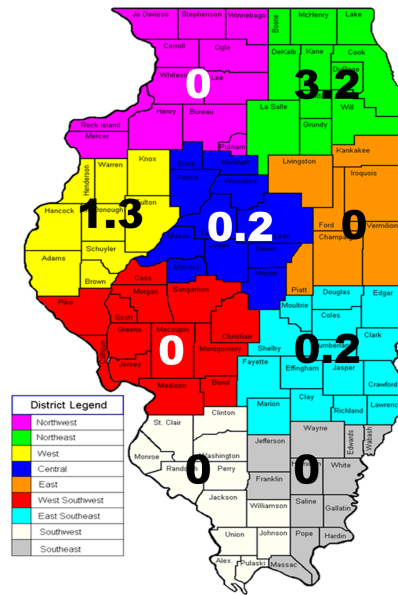
**State Ave
0.25**

2023



**State Ave
0.24**

2024



**State Ave
0.55**



Current Rootworm Situation in Illinois

Overall, rootworm populations are low in Illinois

Rotation-resistant WCR pressure is almost non-existent

Populations of NCR have increased in recent years

Current Rootworm Situation in Illinois

Overall, rootworm populations are low in Illinois

Rotation-resistant WCR pressure is almost non-existent

Populations of NCR have increased in recent years

Populations of both western and northern corn rootworm have resistance to all available Bt traits in some areas

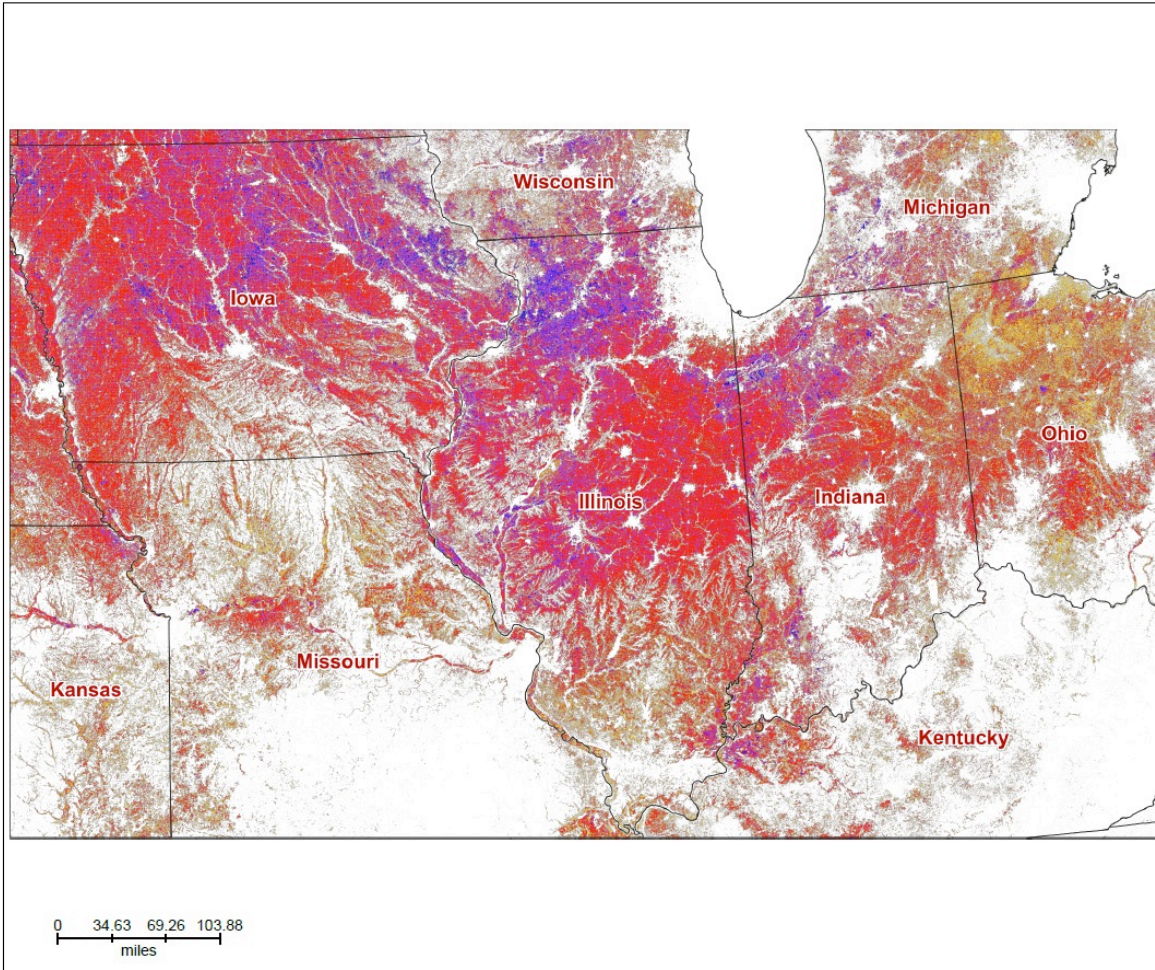
***Most pronounced where corn on corn is common**



Corn Frequency Layer (2008-2023) Area of Interest



Land Cover Categories



- Zero Year
- One Year
- Two Years
- Three Years
- Four Years
- Five Years
- Six Years
- Seven Years
- Eight Years
- Nine Years
- Ten Years
- Eleven Years
- Twelve Years
- Thirteen Years
- Fourteen Years
- Fifteen Years
- Sixteen Years

European Corn Borer



Adam Sisson, Iowa State University

1996: Cry1Ab approved (YieldGard)

2008: Cry1A.105 + Cry2Ab2 introduced (YieldGard VT Pro)

2001: Cry1F approved (Herculex CB/Herculex I)

2018: field-evolved resistance to Cry1F in Nova Scotia, Canada

Corn rootworms



2002: Cry3Bb1 approved (YieldGard RW)

2007: mCry3A approved (Agrisure RW)

2013: eCry3.1Ab approved (Duracade)

2016: eCry3.1Ab cross-resistant with Cry3Bb1 and mCry3A; field-evolved resistance to Cry34/35Ab1

2023: first commercial release of RNAi (SmartStax Pro)

2005: Cry34/35Ab1 approved (Herculex RW)

2009: field-evolved resistance to Cry3Bb1

2014: cross-resistance between Cry3Bb1 and mCry3A

2019: northern corn rootworm also resistant to multiple toxins

Four Bt proteins, “two” modes of action, many combinations

SmartStax = Cry3Bb1 + Cry34/35Ab1

Acremax Xtreme = mCry3A + Cry34/35Ab1

Qrome = mCry3A + Cry34/35Ab1

Agrisure 3122 = mCry3A + Cry34/35Ab1

Duracade = mCry3A + eCry3.1Ab

Similar mode
of action
 (“Cry3” traits)

Cry3Bb1
mCry3A
eCry3.1Ab

Distinct mode
of action

Cry34/35Ab1

(Cross-resistance in WCR among Cry3Bb1, mCry3A, eCry3.1Ab)

<https://www.texasinsects.org/bt-corn-trait-table.html>

Rootworm Trait Packages with RNA-interference Mode of Action

SmartStax Pro

(Bayer)

- Limited release: 2022
- Commercial release: 2023
- Above-ground:
 - Cry1A.105, Cry2Ab2, Cry1F
- Below-ground:
 - Cry3Bb1, Cry34/35Ab1, **DvSnf7**
- Herbicide: glyphosate, glufosinate

Vorceed Enlist

(Corteva)

- Limited release: 2023
- Larger release in subsequent years
- Above-ground:
 - Cry1A.105, Cry2Ab2, Cry1F
- Below-ground:
 - Cry3Bb1, Cry34/35Ab1, **DvSnf7**
- Herbicide: glyphosate, glufosinate, 2,4-D

VT4Pro

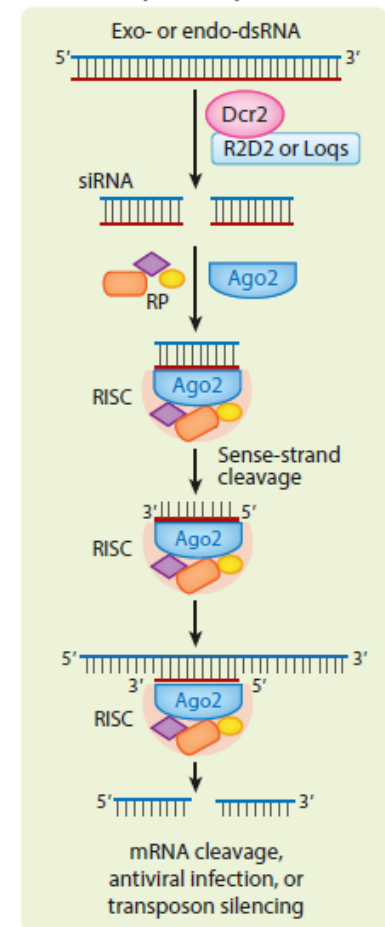
(Bayer)

- Commercial release in 2024
- Above-ground:
 - Cry1A.105, Cry2Ab2, Vip3Aa20
- Below-ground:
 - Cry3Bb1, **DvSnf7**
- Herbicide:
 - glyphosate

How does RNAi work?

- Plant expresses double-stranded RNA (dvSnf7), which insect eats
- dvSnf7 codes for a rootworm protein
- RNA-interference mechanism in the insect shuts down expression of this “foreign” material
- Insect dies around 5 days after dvSnf7 is ingested
- Requires both a local (within-cell) and a systemic (among cells) response – both occur readily in beetles

a siRNA pathway



From Zhu and Palli 2020,
Annu. Rev. Entomol. 65:
293-311

Mode of action comparison

Bt proteins

- Available for corn rootworms (beetles, Coleoptera) and caterpillars (Lepidoptera)
- Fast acting – insect stops feeding immediately, dies soon after
- Causes pore formation in gut
- Resistance is widespread in Illinois (and Iowa)

RNA-interference

- Only available for corn rootworm (works well with Coleoptera)
- Slower – 5 days until insect stops feeding and dies
- Interferes with growth and development
- Potential for resistance demonstrated in lab, none in field yet

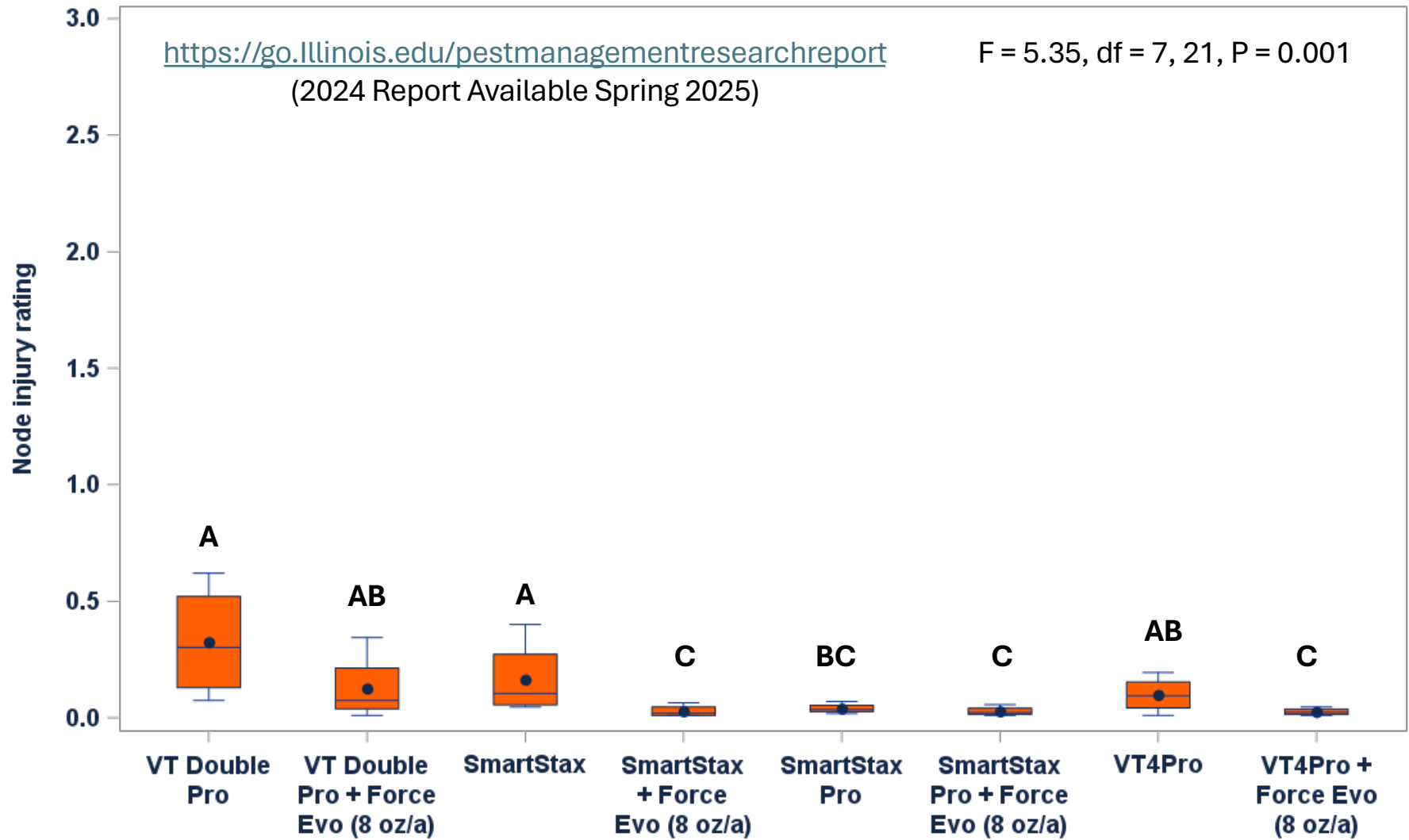
Rootworm Control Evaluations 2018-2023 (2024 coming soon)

<https://go.illinois.edu/pestmanagementresearchreport>

Corn Rootworm Evaluation - Urbana 2024

<https://go.illinois.edu/pestmanagementresearchreport>
(2024 Report Available Spring 2025)

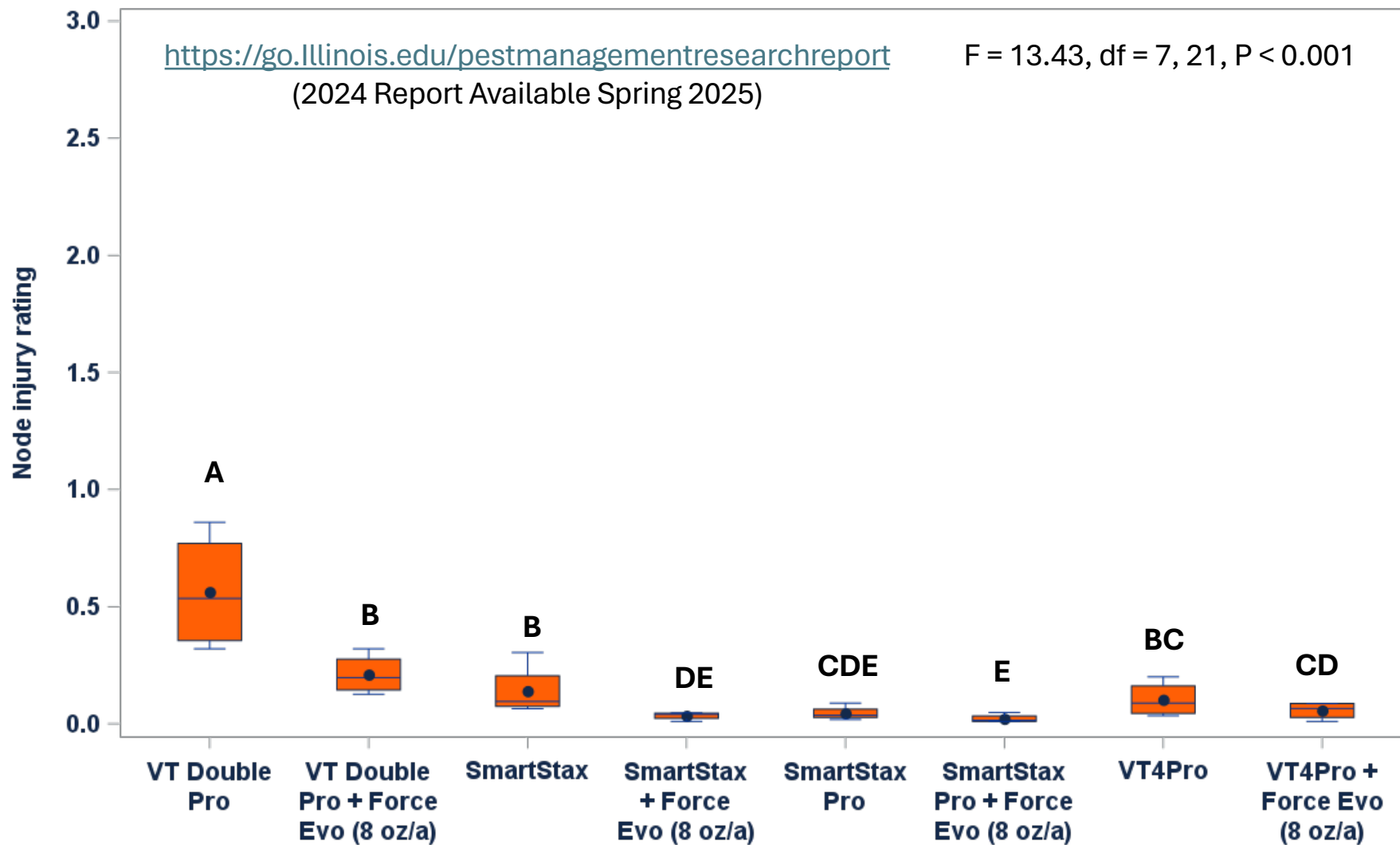
F = 5.35, df = 7, 21, P = 0.001



Corn Rootworm Evaluation - Monmouth 2024

<https://go.illinois.edu/pestmanagementresearchreport>
(2024 Report Available Spring 2025)

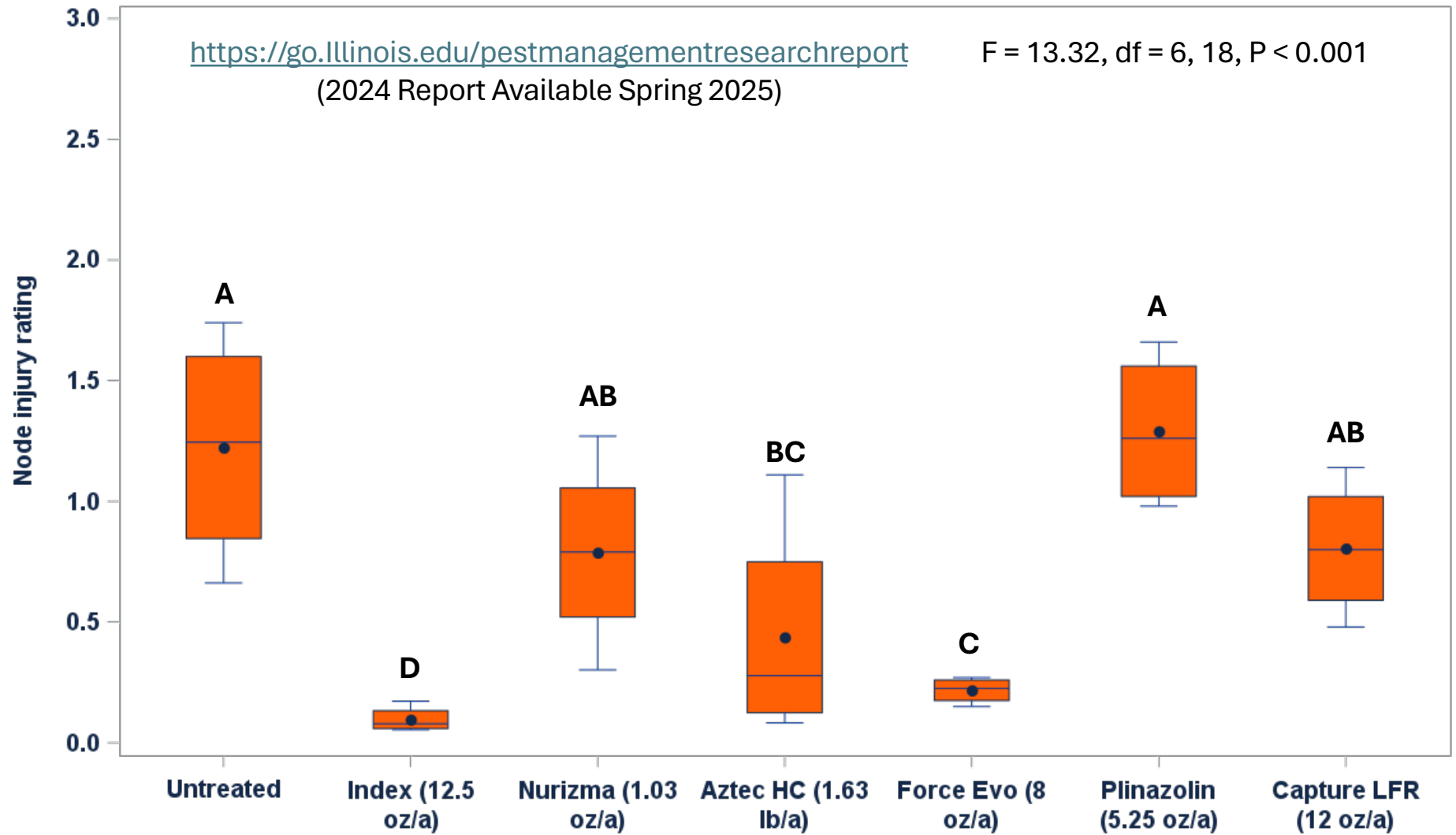
F = 13.43, df = 7, 21, P < 0.001



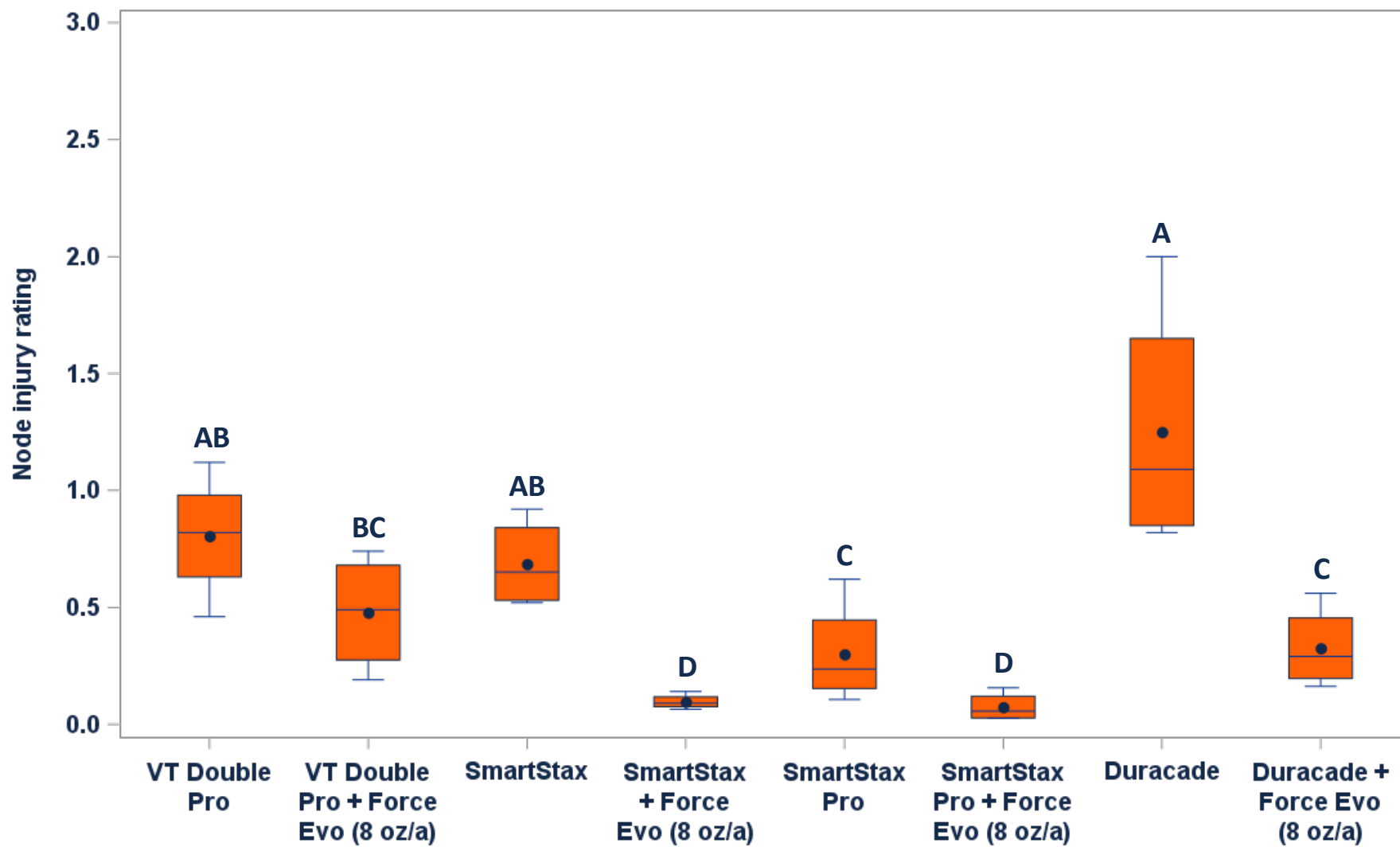
Corn Rootworm Evaluation - Liquid Insecticides 2024

<https://go.illinois.edu/pestmanagementresearchreport>
(2024 Report Available Spring 2025)

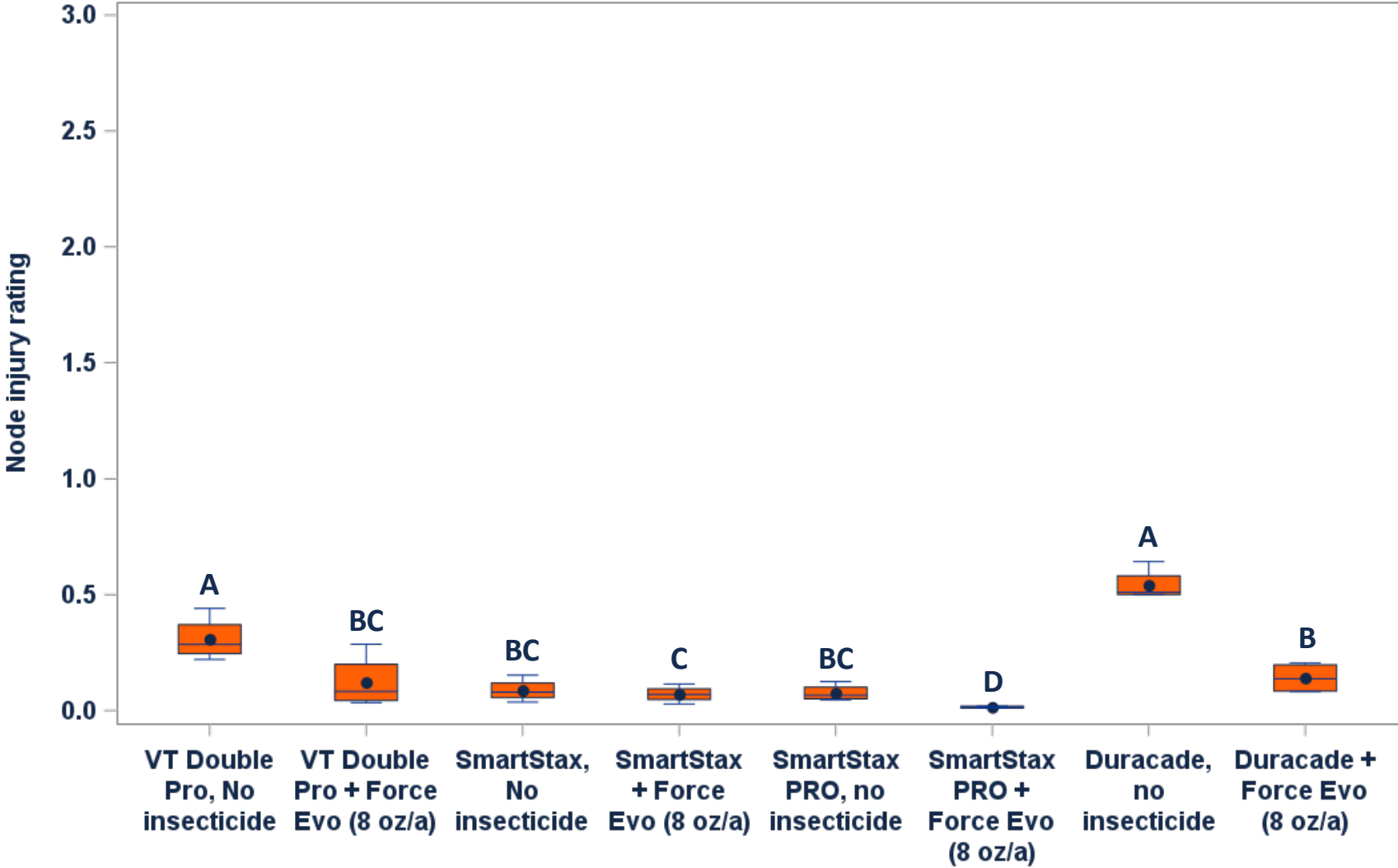
F = 13.32, df = 6, 18, P < 0.001



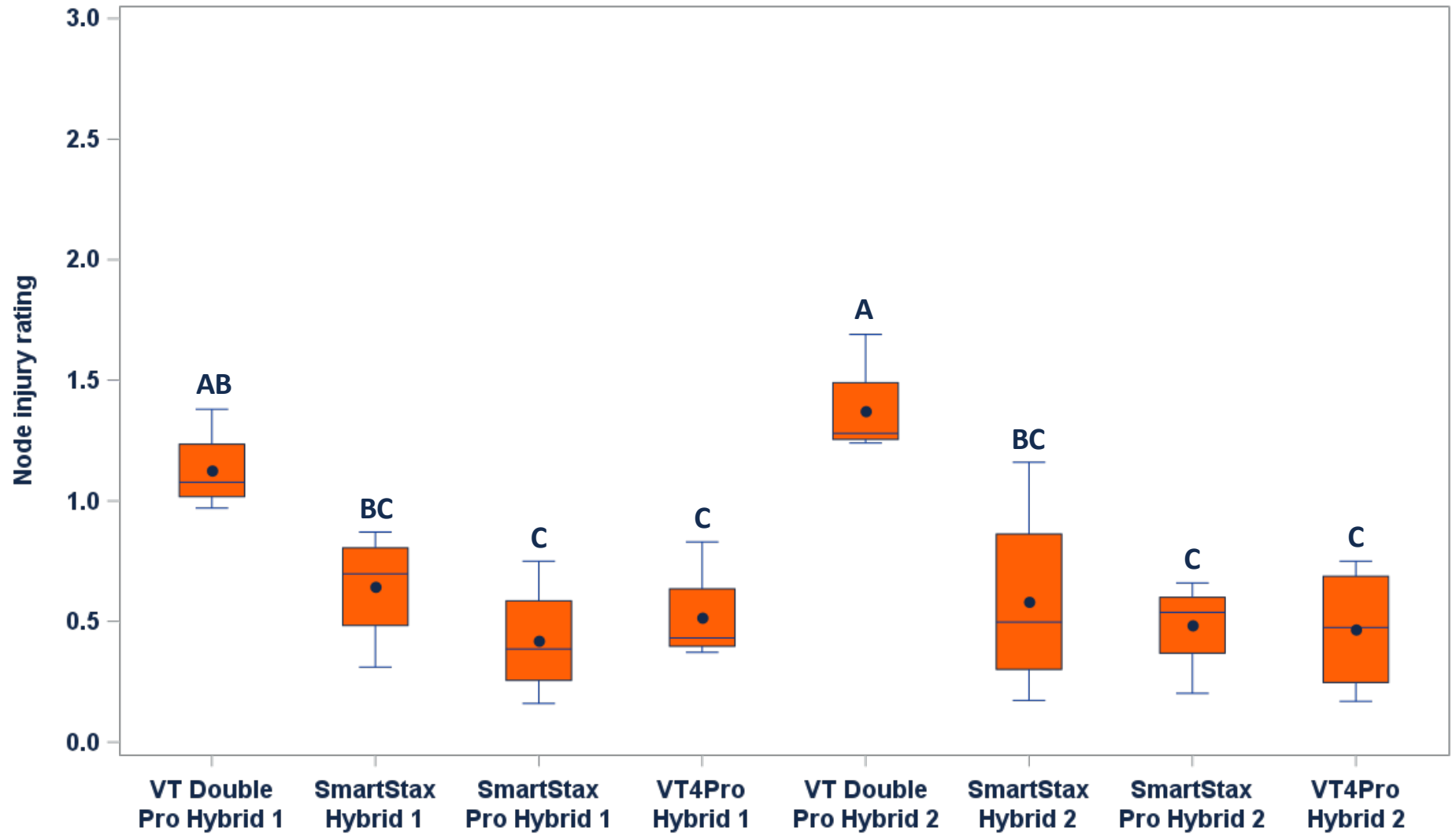
Corn Rootworm Evaluation - Urbana Traits Insecticides 2023



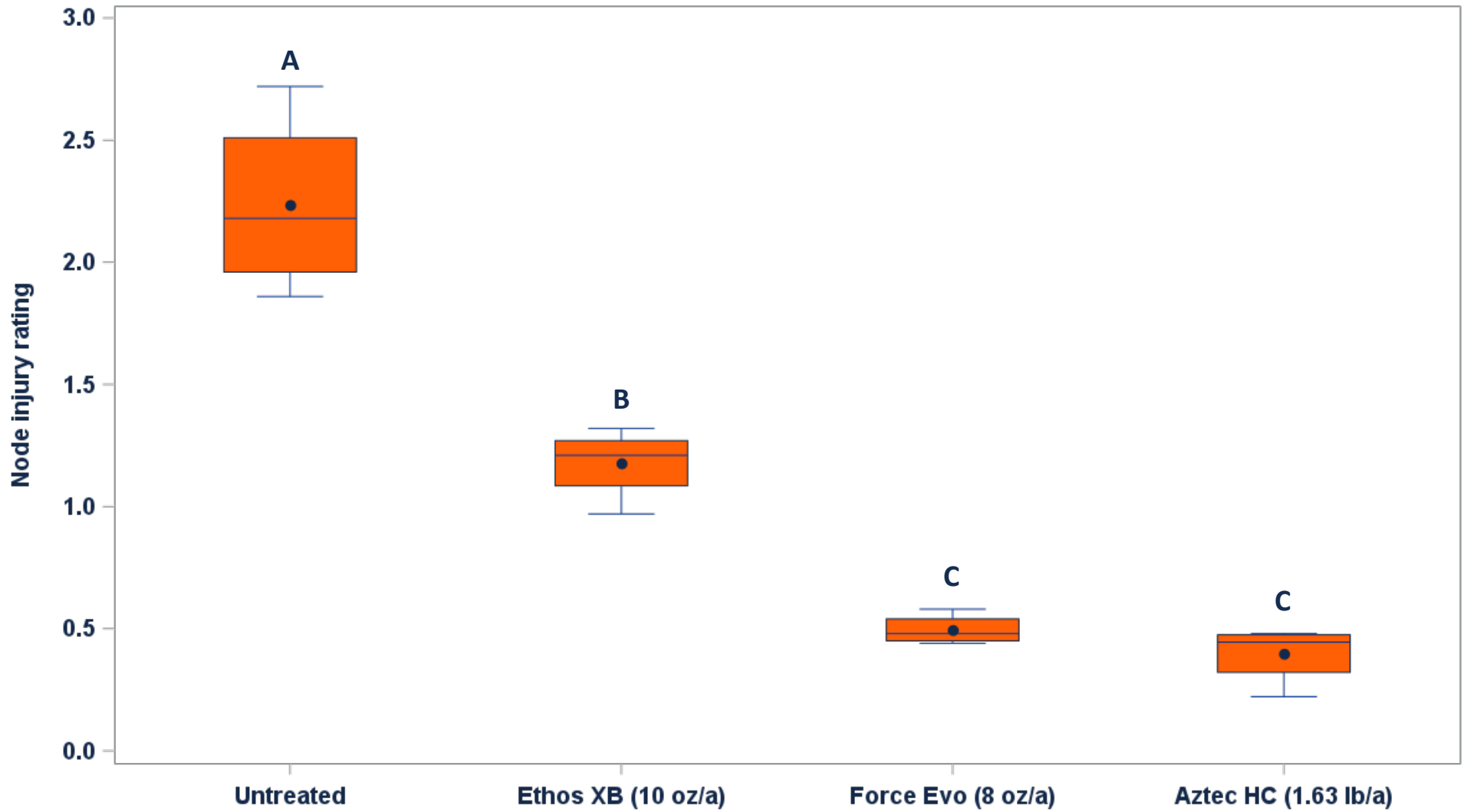
Corn Rootworm Evaluation - Monmouth Traits Insecticides 2023



Corn Rootworm Evaluation - Bayer VT4Pro 2023

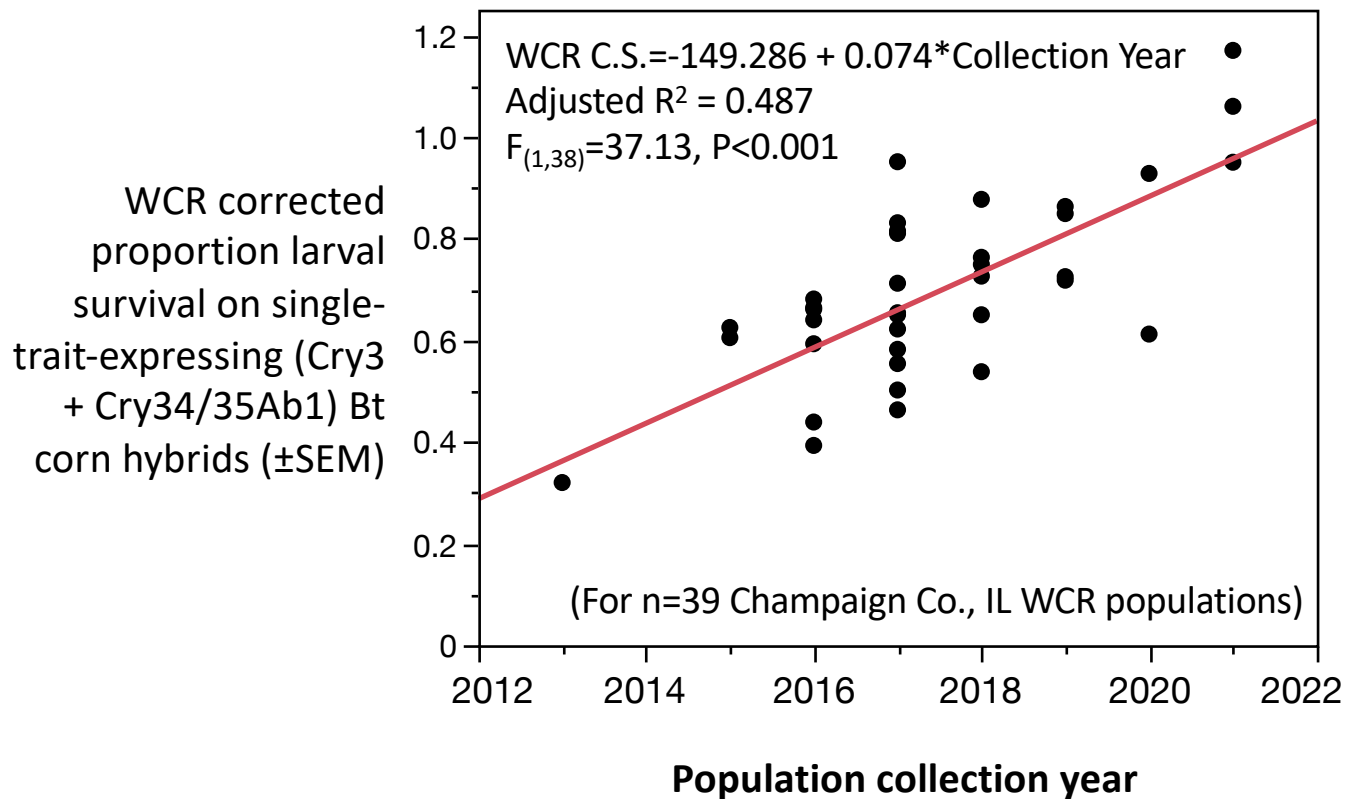


Corn Rootworm Evaluation - Insecticides on Untreated Seed 2023



WCR Resistance to Bt traits is increasing in Illinois.

➤ WCR larval survival on single trait Bt hybrids is increasing at 7.4%/year



- Corrected survival (“C.S.”) is the quotient of proportion larval survival on a Bt maize hybrid divided by proportion larval survival on the corresponding non-Bt hybrid.
- Lower values indicate greater trait efficacy.

Corn Rootworm Summary - IL

- Rootworm pressure has increased since ~2019, but is still below historical (pre-2009) levels
 - Bioassays continue to show increasing resistance in both species to all traits
- Dramatic difference between continuous corn and heavy rotation regions within Illinois
 - High rates of resistance, failures of pyramided traits, high northern corn rootworm populations north of I-80
 - Low to no pressure in much of east central Illinois
 - Injury to first year corn from variant WCR is rare
 - NCR extended diapause not measured recently, but some damage to first year corn observed
- Soil insecticides have not lost efficacy in IL field experiments



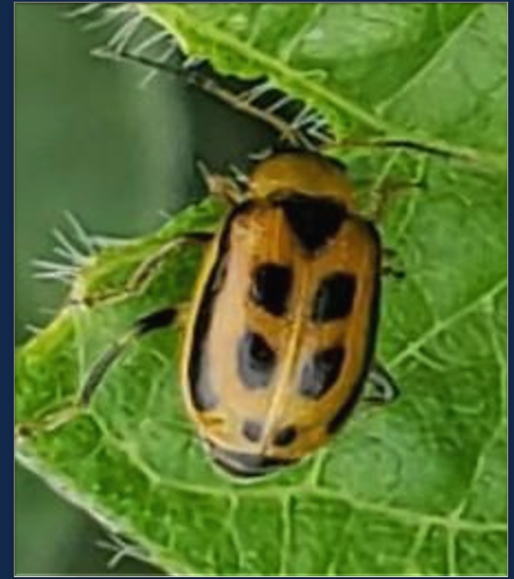
Corn rootworm management recommendations

- Where unexpected damage is observed and/or Bt resistance is expected:
 - Best option: rotate field to soybean (kills all larvae in the soil at hatch)
 - Next best: rotate to a soil insecticide or RNAi trait
 - Worst option: continuous corn, same trait package
- Expect pruning if RNAi traits are challenged with high/Bt resistant CRW populations
- Be aware of your northern corn rootworm population



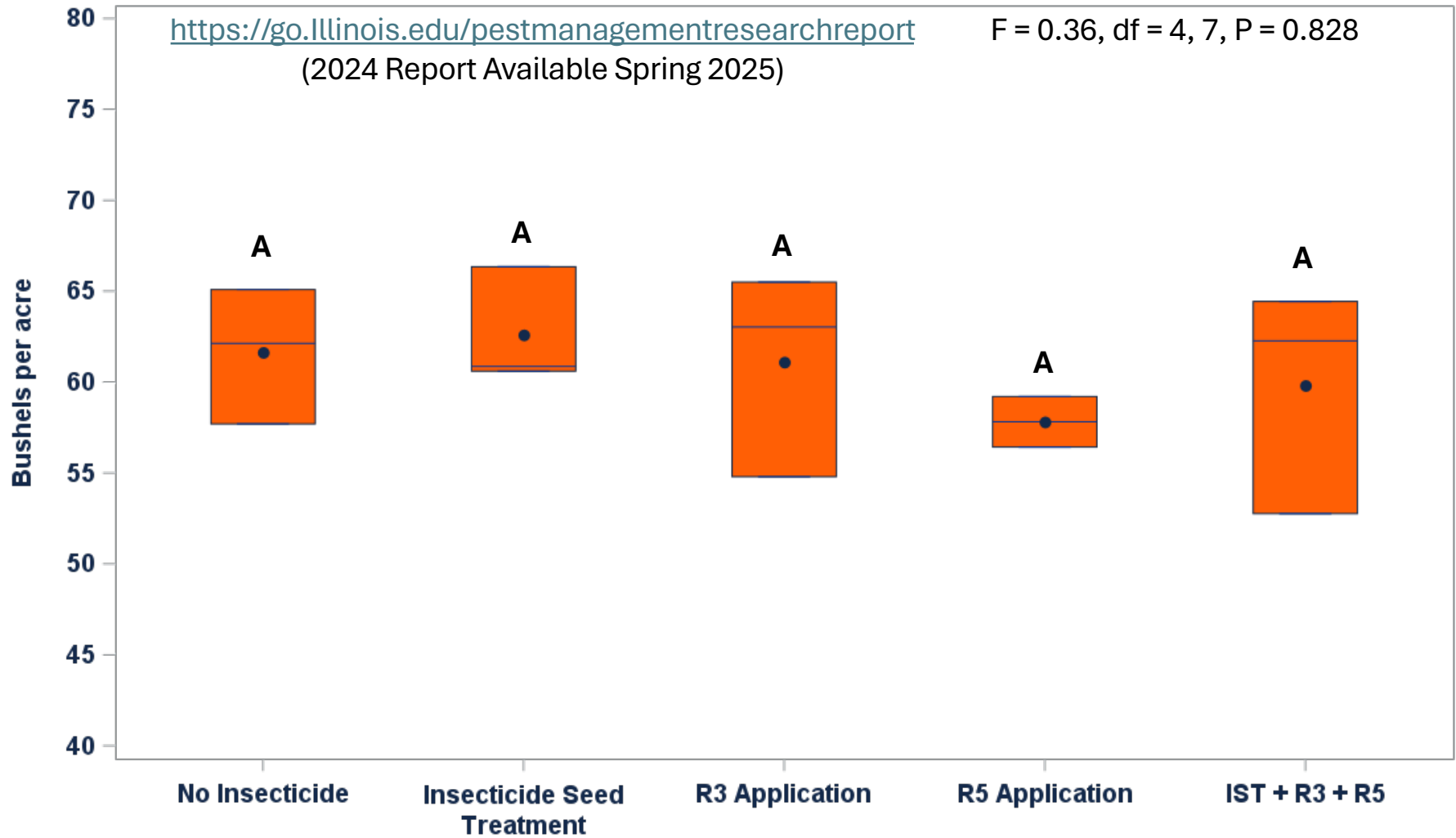
Soybean Insecticides: Return on Investment

- 2024 was Year 1 of a multi-year study to evaluate:
 - How often soybean insecticides protect yield
 - Which insect pests are responsible
 - Where our economic thresholds should be
- Mix of research farm & commercial production sites
- Treatments:
 - No insecticide
 - Seed treatment
 - Application @ R3
 - Application @ R5
 - IST + R3 + R5
 - Additional treatments chosen by on-farm cooperators
- **Year 1: insect pest populations were below economic thresholds at all sites**



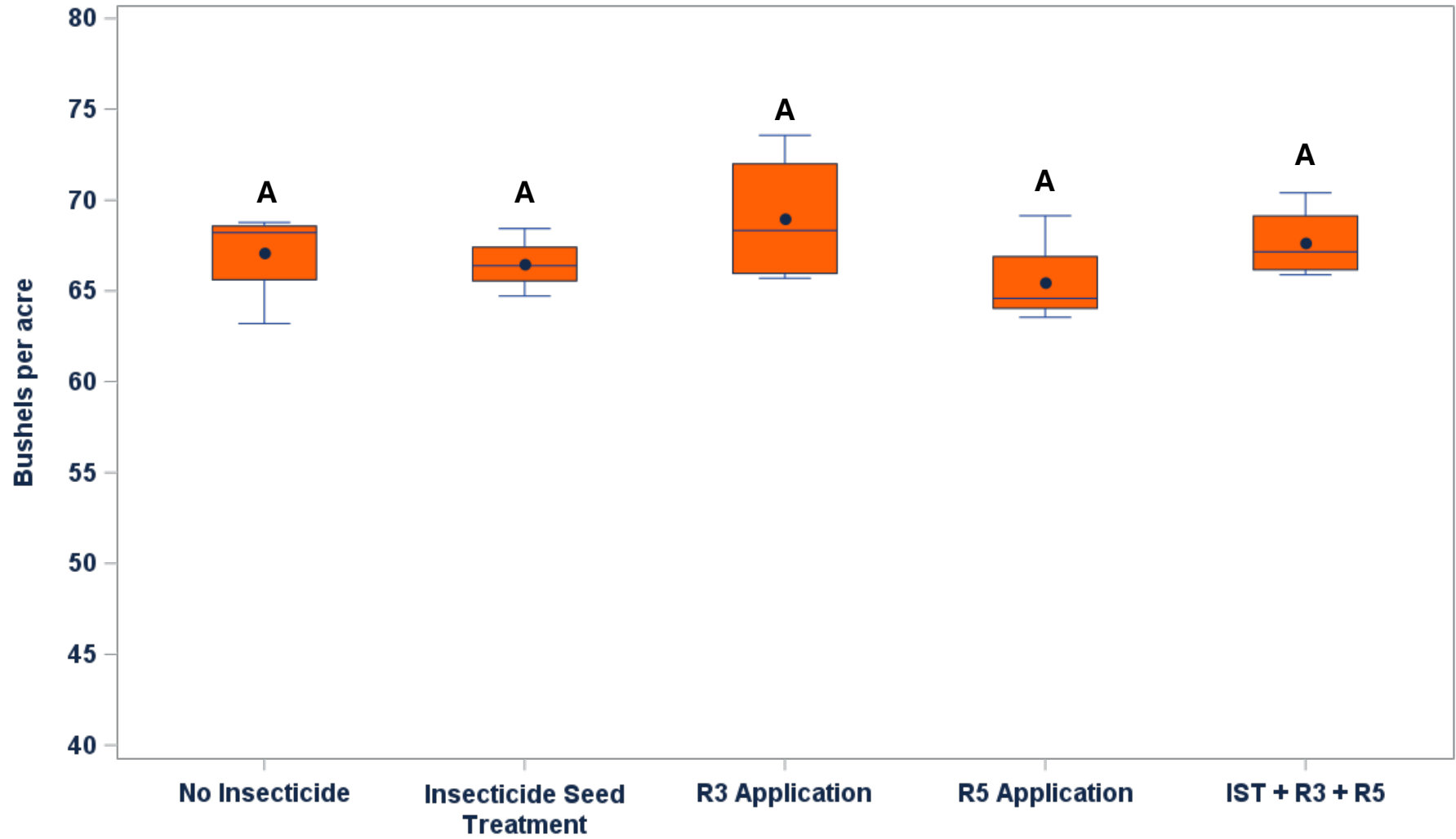
Soybean ROI Experiments - Yield

year=2024 trial=Urbana



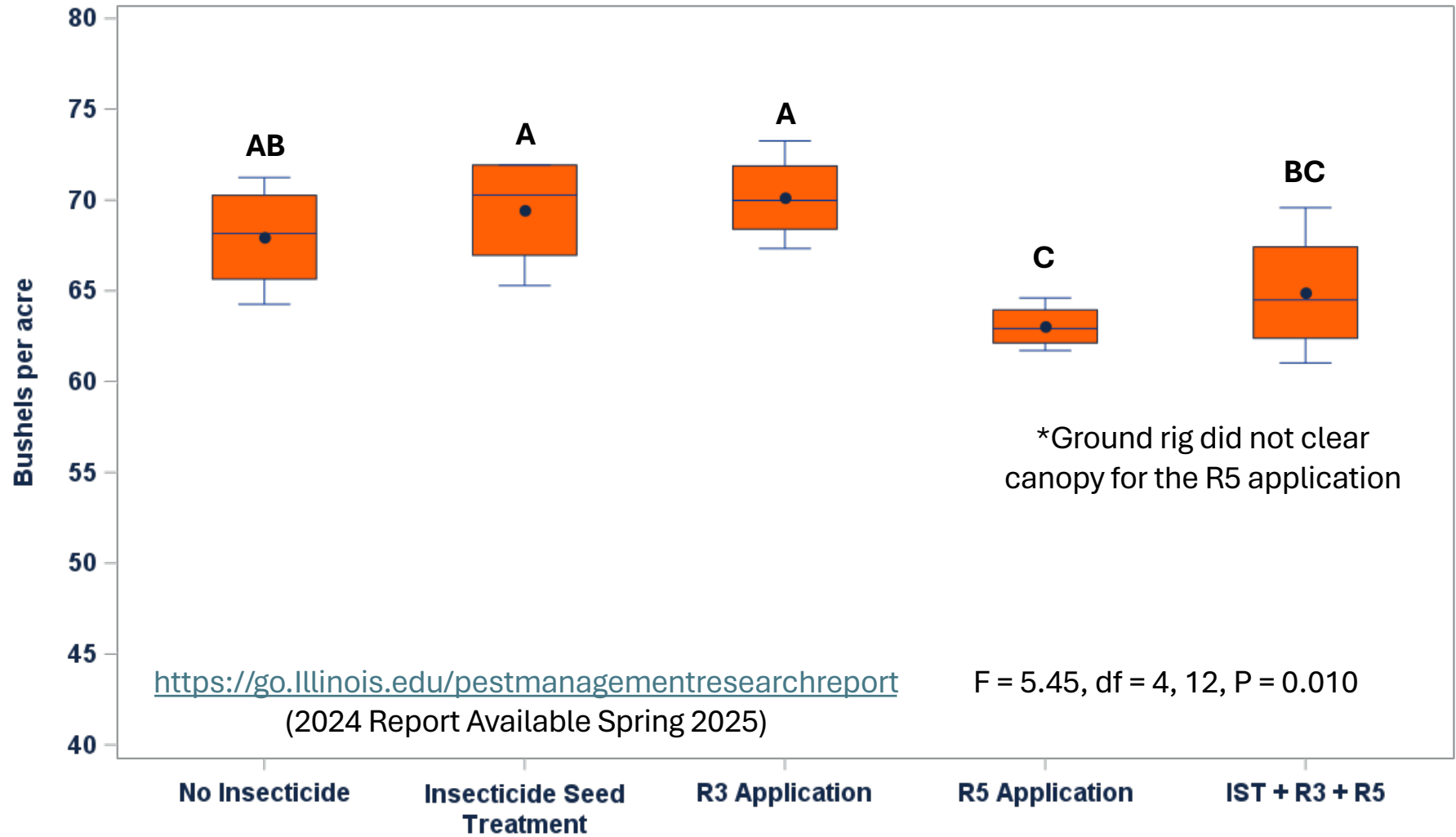
Soybean ROI Experiments - Yield

year=2024 trial=Monmouth



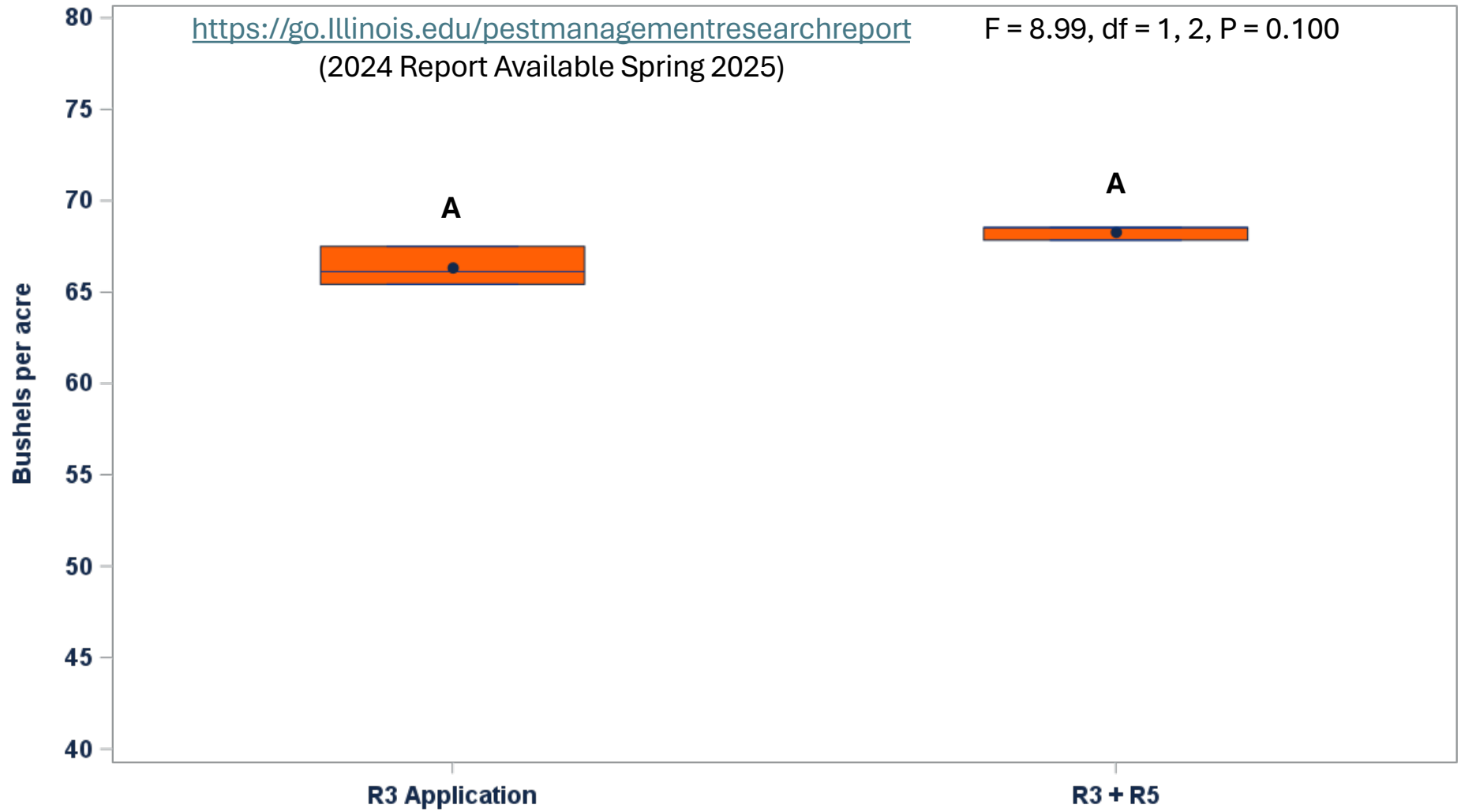
Soybean ROI Experiments - Yield

year=2024 trial=Orr



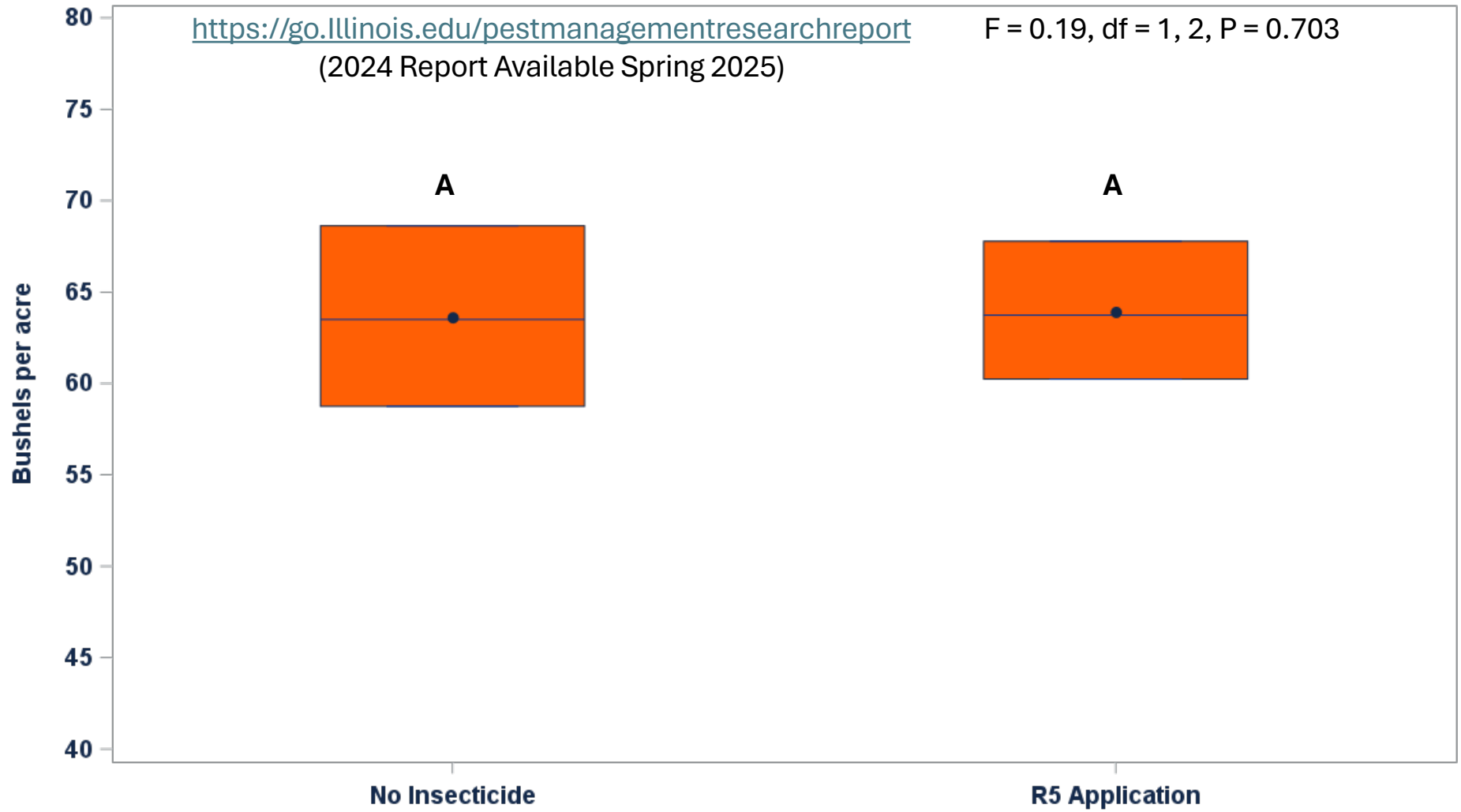
Soybean ROI Experiments - Yield

year=2024 trial=Braun



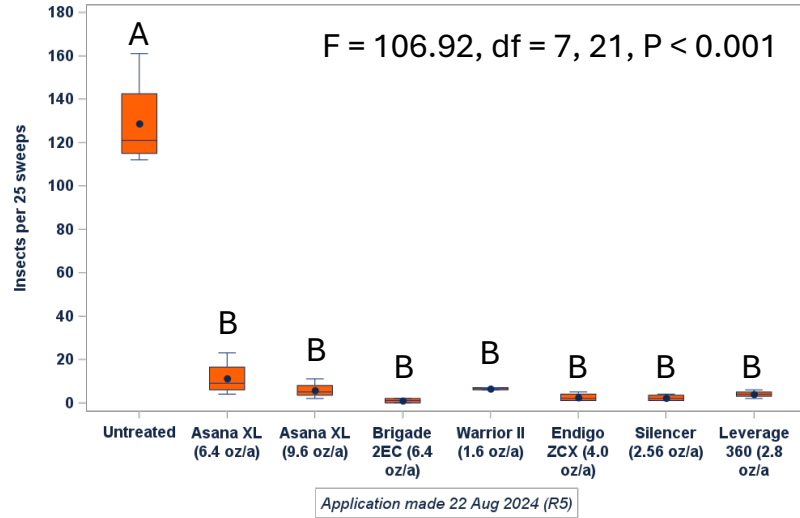
Soybean ROI Experiments - Yield

year=2024 trial=Oglesby



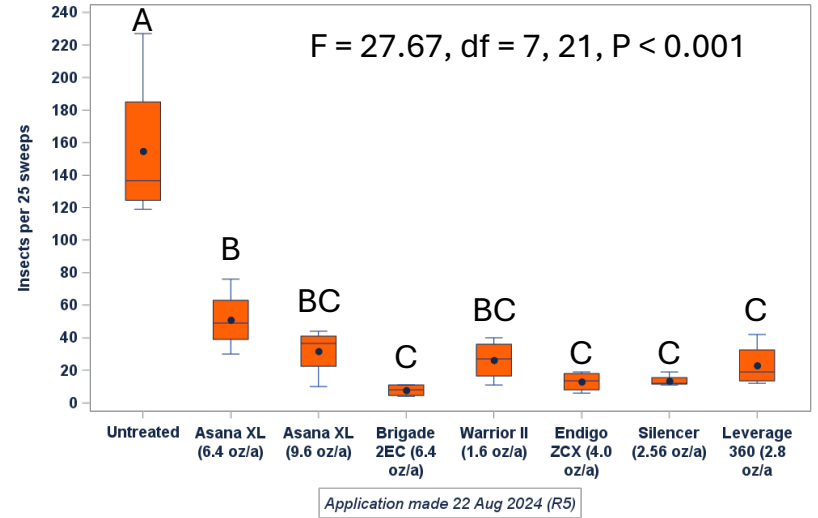
Soybean foliar insecticide evaluation 2024 - bean leaf beetle

dat=4



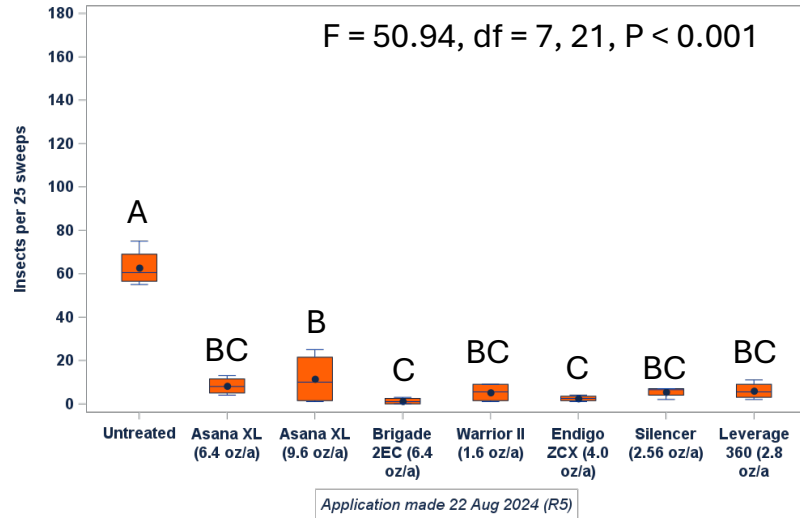
Soybean foliar insecticide evaluation 2024 - bean leaf beetle

dat=7



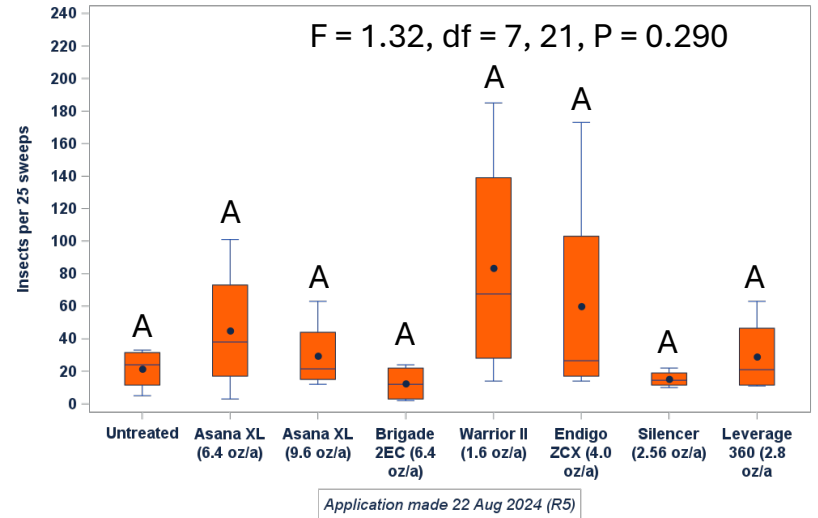
Soybean foliar insecticide evaluation 2024 - bean leaf beetle

dat=11

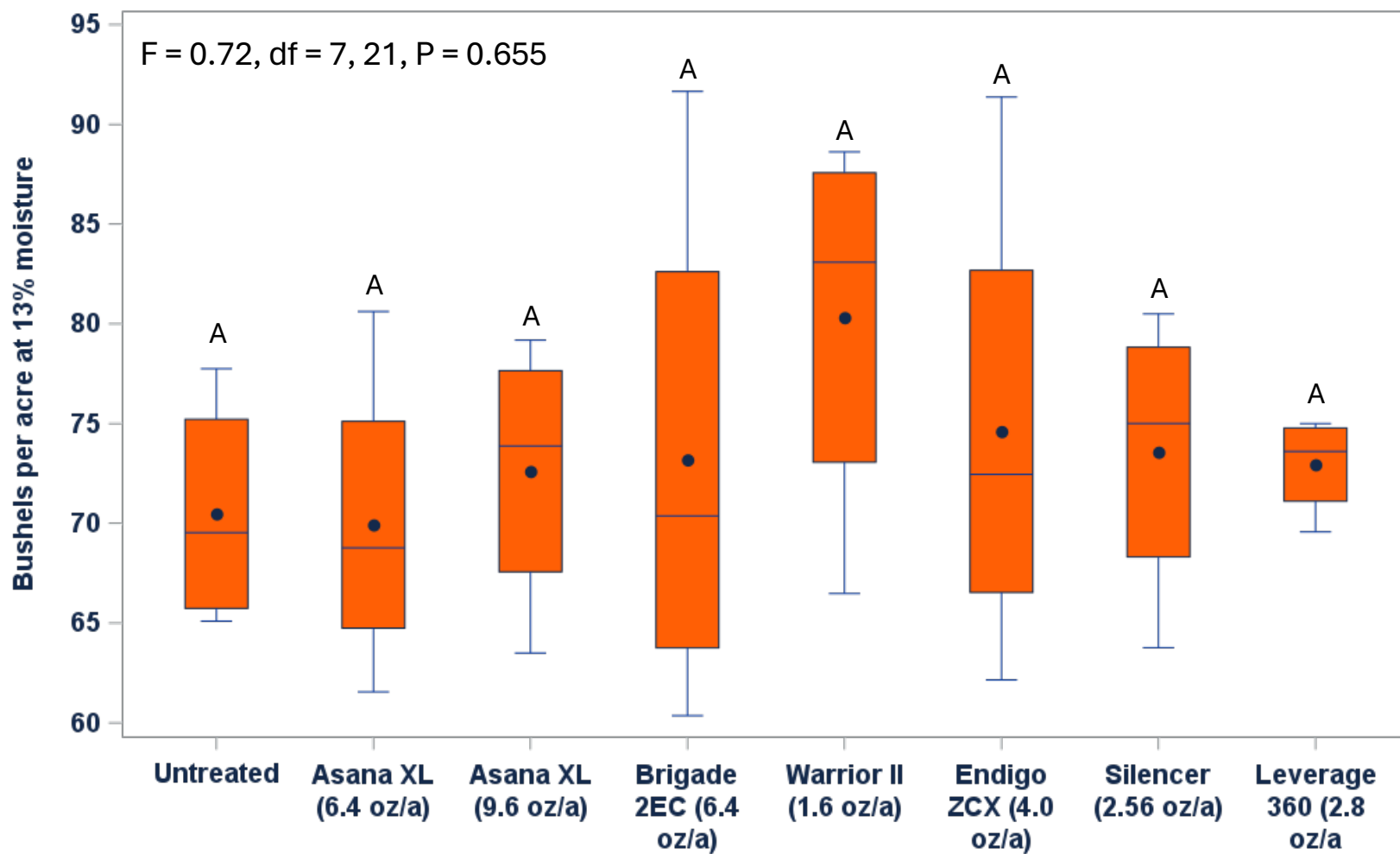


Soybean foliar insecticide evaluation 2024 - bean leaf beetle

dat=14



Soybean foliar insecticide evaluation 2024 - soybean yield



Soybean pest management summary

- It takes a lot of defoliation to reduce yield
 - Economic threshold:
 - 30% before R3
 - 10% R3-R5
 - 15% R6
- Insecticides applied at threshold are effective against the pests we see most frequently (bean leaf beetle, stink bugs, green cloverworm, etc)
- Pest populations at R3 are usually low in IL
- The insecticides we use most often do not persist at a lethal rate in the field for very long
 - < 14 days



Managing aphids in corn



Corn leaf aphid



Bird cherry-oat aphid

A photograph of a corn plant showing signs of infestation. The tassel and stalk are heavily covered with a greenish, fuzzy growth, likely aphids. The leaves are also showing signs of damage, with some discoloration and small, dark spots. A hand is visible in the upper right corner, holding a leaf to inspect it.

Corn leaf aphid

- Tassel, ears, stalk
- Inside whorls

Bird cherry-oat and other cereal aphids

- Under leaf

Corn leaf aphid basics

- Pest of sorghum, cereals, and corn
 - Outbreaks in field corn are rare
- Overwinter in southern U.S. on barley, cereals
 - Reported as far north as southern IN
- Develop asexually, produce live offspring (no egg stage is known)
- Varietal resistance reported in several hosts, including corn
 - Defensive compounds
 - Tassel exposure
 - Many examples of differences among varieties where mechanism is unknown
- Threshold:
 - 50% of plants with colony formation (> 50 aphids) during late whorl-early tassel (more if moisture is adequate)
 - Yield loss more severe under drought stress



Frank Peairs, Colorado State University, Bugwood.org

5364098

2024 takeaways

- Notable differences among hybrids – is this something we can predict?
- When an insecticide is necessary, coverage will be critical
- Aphids build up and collapse rapidly
 - Fungal diseases, predators, crowding
- Scout just before & at tassel
- What made 2024 unusual – both the magnitude and the timing of the aphids



FREE ONLINE AGRICULTURAL INSECT PEST IDENTIFICATION MODULES!

JOIN NOW!

Link to:
Log in to Learn @ Illinois Extension



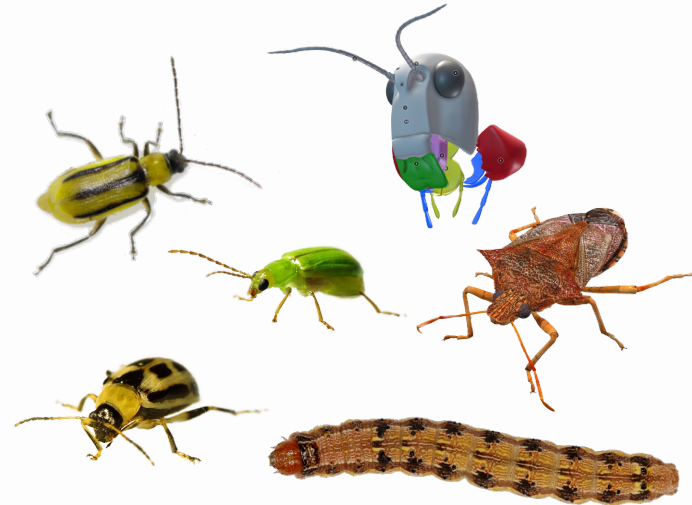
What will you learn?

Participants will be trained on insect identification and then tested on their performance.

Continuing Education Units (CEUs)
will be available for Certified Crop
Advisers!

SOME MODULES COVERED

- Insects' general structure
- External morphology of the head, thorax and abdomen.
- How to distinguish corn rootworms.
- How to distinguish plant-feeding vs predatory stinkbugs.
- How to distinguish caterpillars associated to corn and soybean.



Resources:

Applied Pest Management Research (2024 report available soon):

<https://go.illinois.edu/PestManagementResearchReport>

Production information: <http://go.illinois.edu/cropcentral>

Illinois Agronomy Handbook: <https://go.illinois.edu/agronomyhandbook>

Soybean defoliation scout card:

https://aginsects.osu.edu/sites/aginsects/files/imce/Soybean%20defoliation%20draft%208_4_22.pdf



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