



Corn rootworm update

Tim Nowatzki, Jeff Klever, Jim Bing, Clint Pilcher

8/13/20

Key Messages For Today

- Qrome® products are the most optimized for yield, agronomics, and efficacy in the Corteva Agriscience portfolio
 - Understanding how the Cry34/35Ab1 proteins protect roots
 - Recent performance data validates efficacy expectations relative to all Cry34/35 containing products
- Corn rootworm root pruning can contribute to root lodging, BUT not all lodging can be blamed on corn rootworm
- Proactive CRW population management maximizes performance of all Cry34/35Ab1 based products
 - Rootworm challenges are localized
 - Population management = Crop rotation & adult beetle control. Soil applied insecticides only under limited circumstances and in consultation with extension, crop consultants or other local experts.
 - Reduce CRW root injury and improve standability on challenging acres with IST 1250
 - Challenging acres = those acres subject to **high corn rootworm pressure & elevated tolerance to Bt traits**

Root Evaluations at Corteva Agriscience – IFS Trials

WHEN? R2 stage, mid to late July

Defining CRW Pressure Levels:

- Low: <0.75
 - Moderate: 0.75-1.75
 - High: >1.75
- Require at least moderate pressure or greater to adequately characterize CRW traits

0–3 Node Injury Scale

Rating*	Description
0.00	No feeding injury
1.00	1 node or equivalent of an entire node eaten to within 1½ inches of the stalk
2.00	2 complete nodes eaten to within 1½ inches of stalk
3.00	3 complete nodes eaten to within 1½ inches of stalk (highest rating that can be given)

* Rate minor scarring as 0.02; Heavy scarring as 0.09
injury between complete nodes noted as percentage



No feeding injury



1 node eaten within 1½ inch of stalk

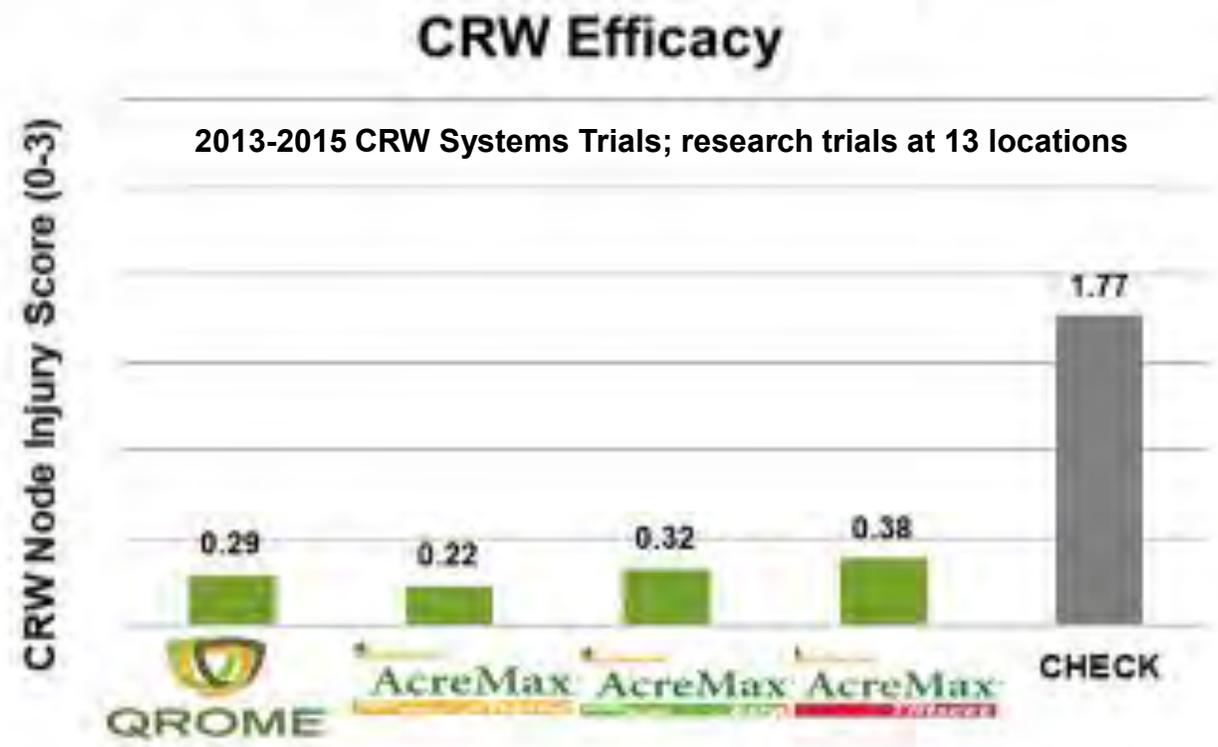
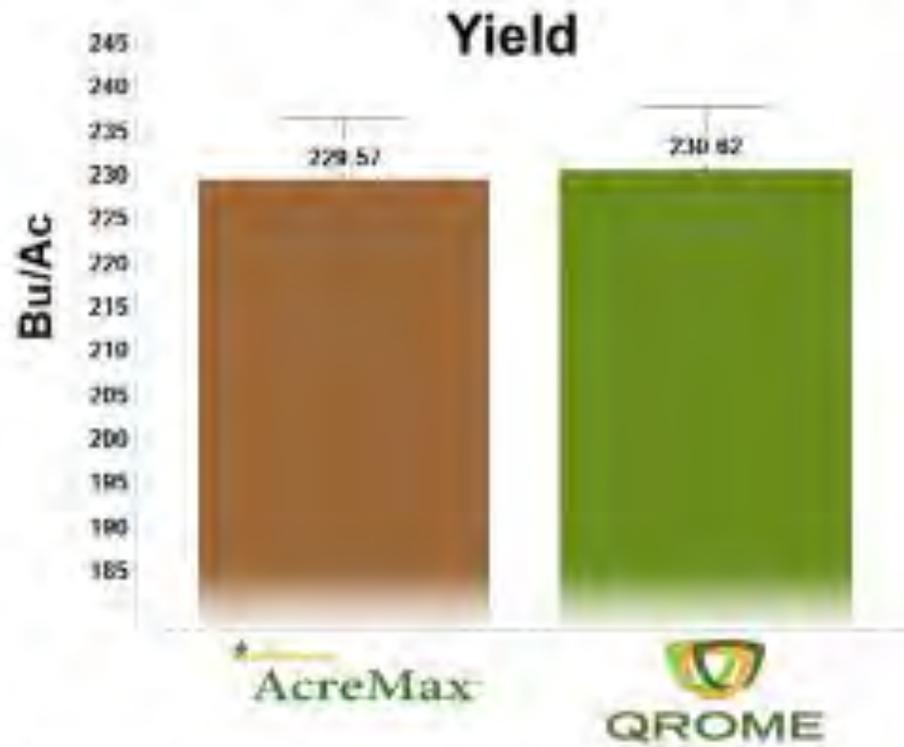


2 nodes eaten within 1½ inch of stalk



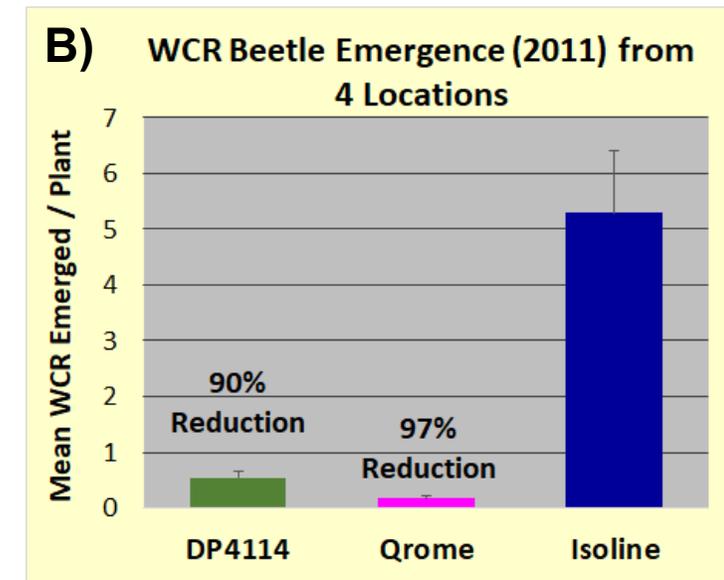
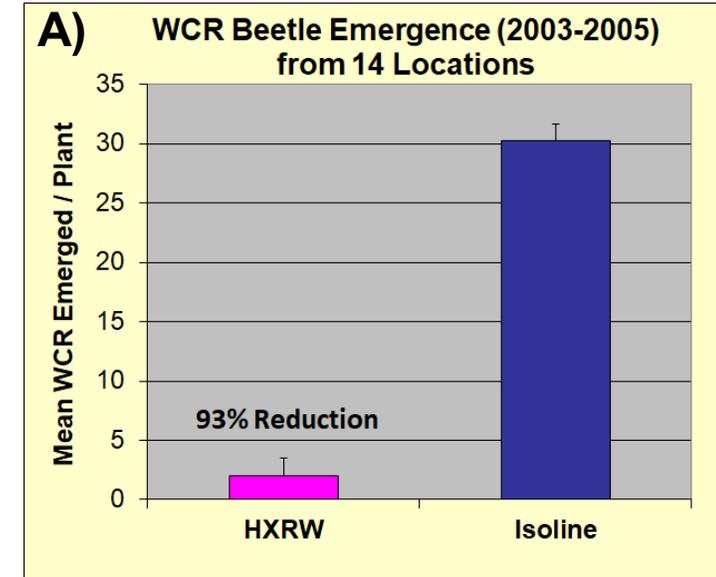
3 nodes eaten within 1½ inch of stalk

Historical Qrome® Product Yield and Efficacy Data (2013-2015)

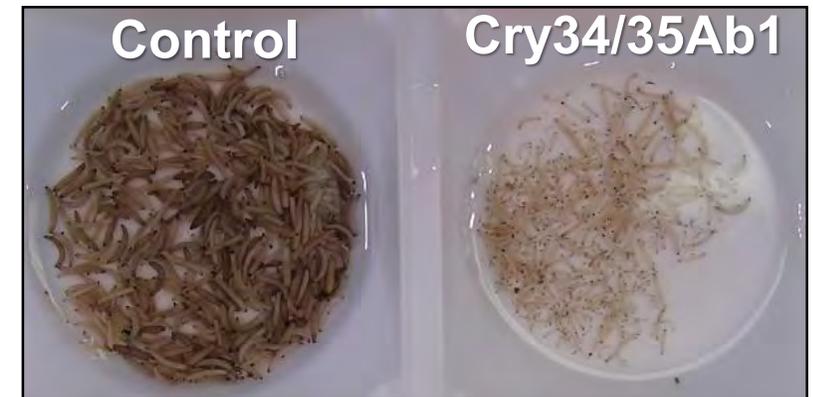
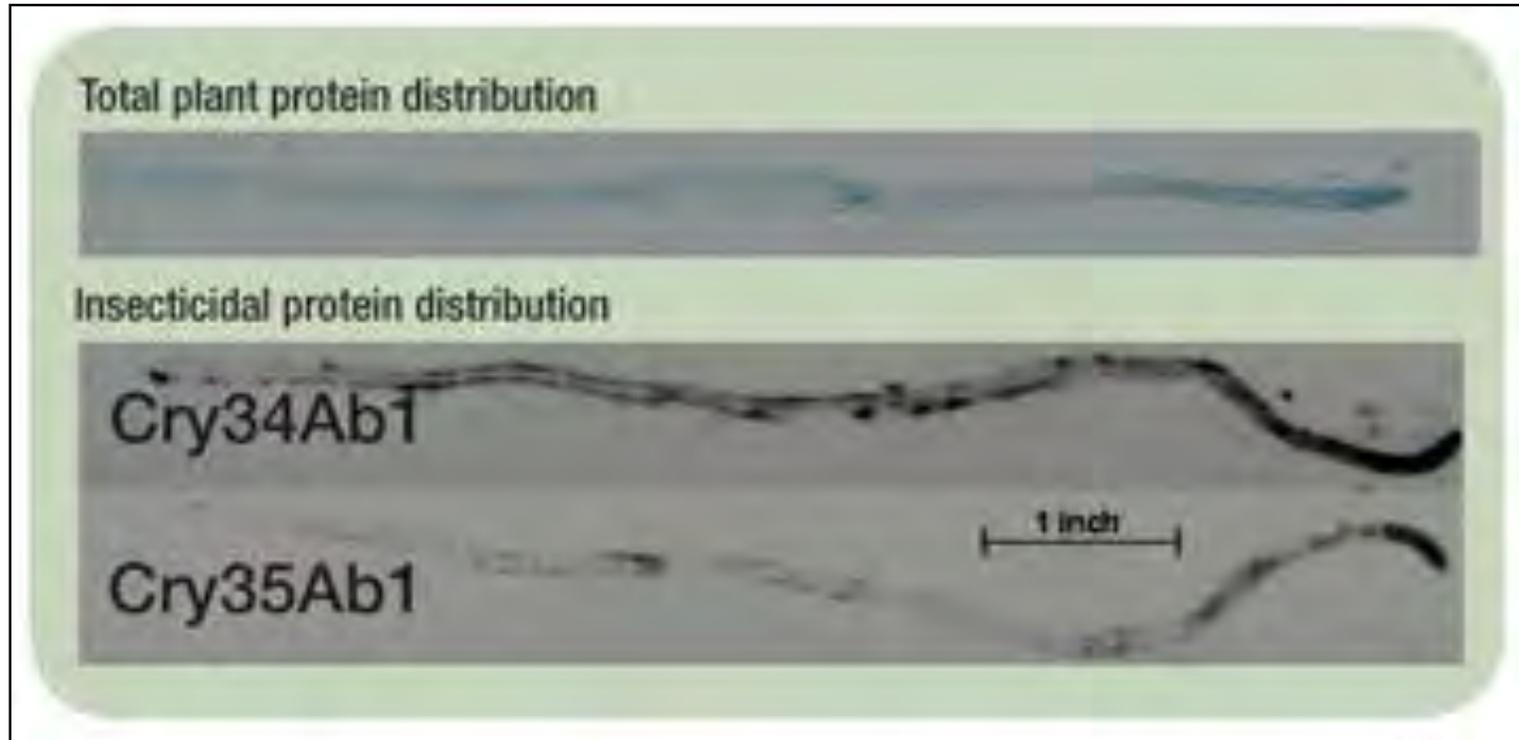


Mechanism of Cry34/35 Root Protection

- Both Qrome[®] and SmartStax[®] trait technologies contain Cry34/35 and Cry3 proteins
- All current commercial CRW traits are non-high dose
 - Some larvae survive and emerge as adults
- Larval response to Cry34/35 proteins
 - Works as a toxin and an antifeedant
 - Effect is chronic (stunting, delayed development) and most larvae eventually die
 - Larger larvae are less affected by the proteins
- Root injury can increase with CRW population density with all Bt technologies including: Herculex[®] RW, Optimum[®] AcreMax[®] XTreme, Qrome, and SmartStax



Larvae are Exposed to Variable Concentrations



Larvae Extracted After 17 Days of Exposure

Chronic effect of delayed development, larvae eventually die

- Spatial variation occurs within Cry34/35 roots
- Provides effective exposure

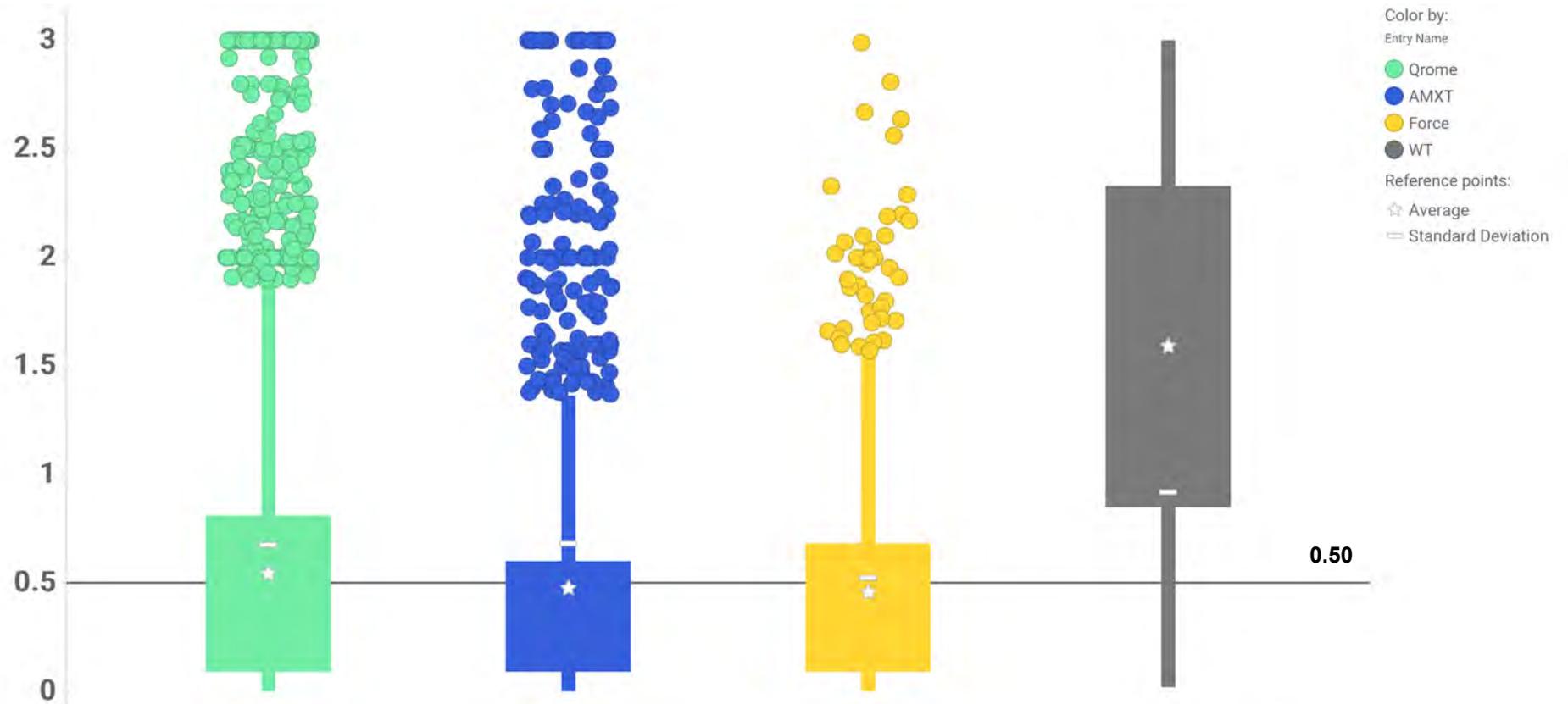


Qrome[®] Product Efficacy

2018-2020 IFS Research Trials

2018 to 2020 Avg CRWNIS

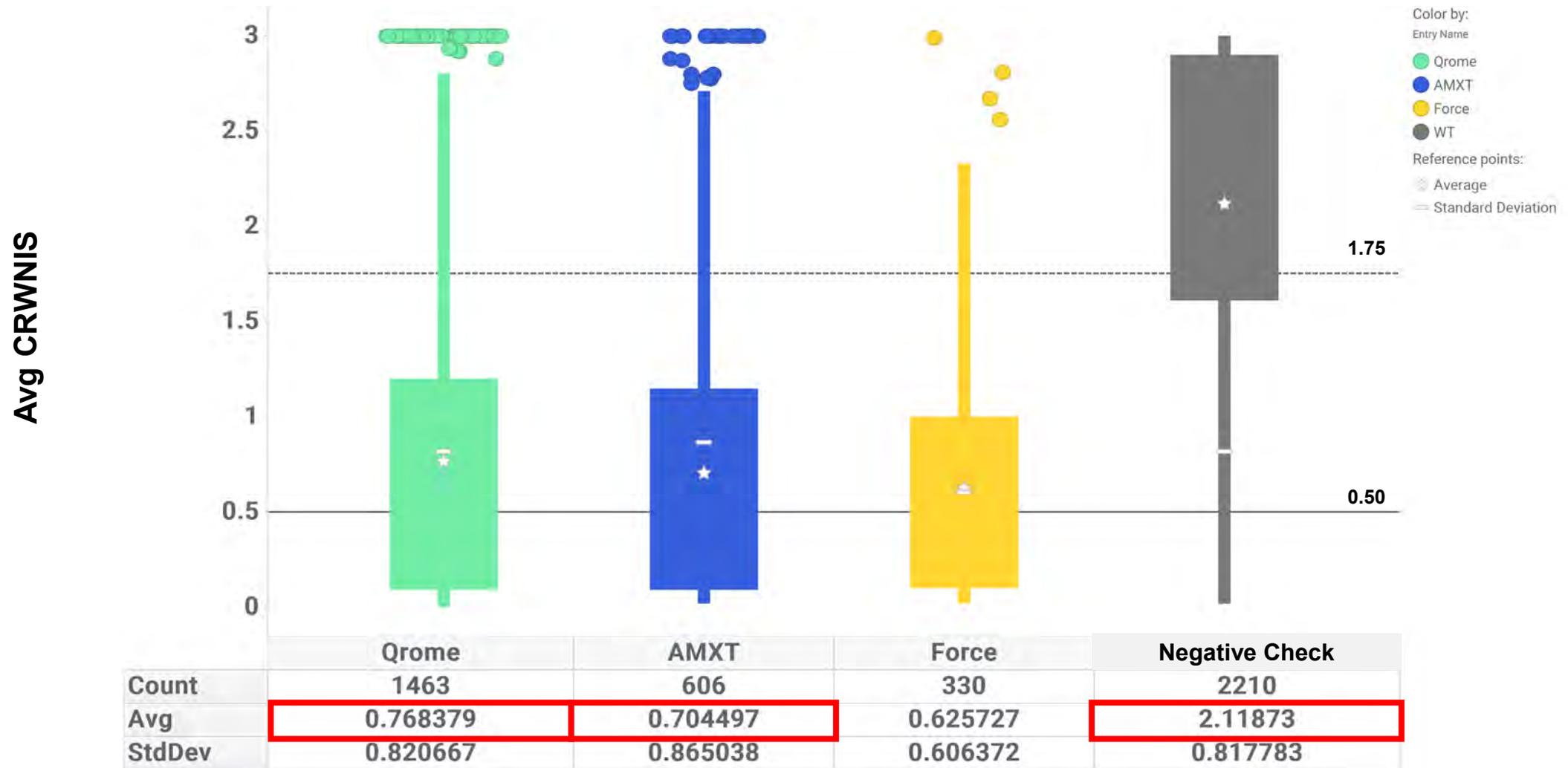
Avg CRWNIS



	Qrome	AMXT	Force	Negative Check
Count	3161	1248	784	5119
Avg	0.543283	0.474259	0.454971	1.59203
StdDev	0.675834	0.68073	0.5256	0.921214

Count: # of Roots

2018 to 2020 Avg CRWNIS – High Pressure Locations



Count: # of Roots

What made corn rootworm challenging in 2020?

- Previous years of “low to moderate” corn rootworm pressure – fewer instances of corn rootworm population management tactics implemented (i.e. adult spraying or crop rotation)
- Underestimation of 2019 adult beetle production due to lack of key indicators (i.e. lodging)
- Dry soil conditions in late summer/fall of 2019 ideal for egg deposition
- Mild winter with snow cover providing insulation = shallow soil freeze
- Early spring with ideal planting conditions and below normal early summer precipitation in affected geographies
 - Very successful corn rootworm egg hatch & establishment
 - No saturated soils in spring during egg hatch
- Timing of late June/early July saturated soils and multiple high wind events prior to brace root development with most of the genetics
- Favorable corn vs soybean markets

Many factors affect corn root lodging

- Many agronomic factors involved with root lodging:
 - Hybrid genetics – root mass, depth of roots
 - Plant growth stage, height of plant
 - Size and girth of ear(s) – physics can take over
 - Soil tilth, type & structure
 - Soil moisture
- Corn rootworm:
 - *Corn rootworm root pruning can contribute to root lodging, BUT not all lodging can be blamed on corn rootworm!!!*
 - A minimum of $\frac{1}{2}$ node must be pruned (and typically at least $\frac{3}{4}$ of a node) before the corn plant is susceptible to lodging
 - Timing of root feeding relative to root and brace root development
 - Root regenerative capacity (genetics & timing of feeding)

- Environmental:
 - Amount of rainfall
 - Wind speed and duration

Best Management Practices

Manage Each Field Individually

- 1) Proactively Lower Populations:**
 - Crop Rotation - primary
 - Bt trait pyramids
 - Adult Beetle Control (thresholds)

Note: Depending on geography (rotation variants), history or trait use, & CRW resistance to foliar sprays, each tactic above may be limited in its ability to lower CRW populations.

- 2) Root & Yield Protection of continuous corn under heavy pressure (on *Bt* corn):**
 - IST 1250
 - Soil-Applied Insecticides only
 - in consultation with extension, crop consultants or other local experts*

Consult with your Pioneer Sales Professional to build a plan for your fields



Decision Tree – for Continuous Corn (know population size & field management history)

Is current CRW population in field of interest LOW or HIGH?

- LOW

- Non-CRW trait with IST 1250 or soil-applied insecticide or Bt-CRW pyramid
- Crop rotation would reset the population – keep it low!

- HIGH – How many years of continuous corn?

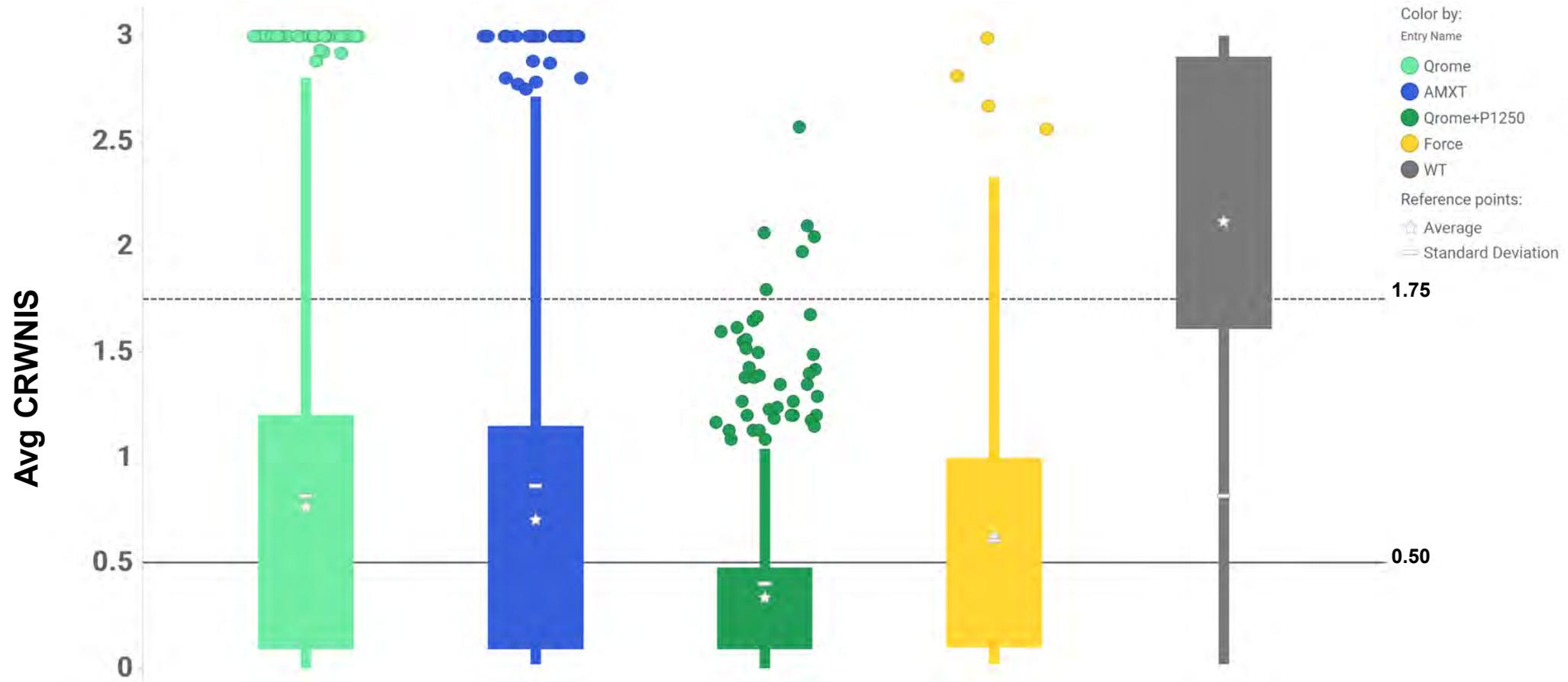
- < 3 years since last rotation – Options: crop rotation, adult control, Bt-CRW pyramid or non-Bt hybrid with soil-applied insecticide
- ≥ 3 years since last rotation....if true, then how many years has Cry34/35 been used in field?
 - If < 3 years of use – Options: rotate crop, adult control, Bt-CRW pyramid (containing Cry34/35)
 - If ≥ 3 years of use Cry34/35 containing products have been used and grower is unwilling to rotate:
 - Reduce population size using adult control (population management)
 - Use Cry34/35 pyramid with IST 1250 or soil-applied insecticide^a
 - If Bt pyramid performance is not sufficient, use adult control (population management) in combination with non-CRW traited hybrid with soil-applied insecticide to protect roots and yield.

Estimating Corn Rootworm
Population Size

	Low	High
Beetles/plant/day	<1	>1
Beetles/trap/week	<21	>50
Root injury score	<0.5	>1.0

^a Used only under limited circumstances and in consultation with extension, crop consultants or other local experts

2018 to 2020 Avg CRWNIS – High Pressure Locations



	Qrome	AMXT	Qrome+P1250	Force	Negative Check
Count	1463	606	632	330	2210
Avg	0.768379	0.704497	0.337706	0.625727	2.11873
StdDev	0.820667	0.865038	0.401146	0.606372	0.817783

Count: # of Roots

Key Messages For Today

- Qrome® products are the most optimized for yield, agronomics, and efficacy in the Corteva Agriscience portfolio
 - Understanding how the Cry34/35Ab1 proteins protect roots
 - Recent performance data validates efficacy expectations relative to all Cry34/35 containing products
- Corn rootworm root pruning can contribute to root lodging, BUT not all lodging can be blamed on corn rootworm
- Proactive CRW population management maximizes performance of all Cry34/35Ab1 based products
 - Rootworm challenges are localized
 - Population management = Crop rotation & adult beetle control. Soil applied insecticides only under limited circumstances and in consultation with extension, crop consultants or other local experts.
 - Reduce CRW root injury and improve standability on challenging acres with IST 1250
 - Challenging acres = those acres subject to **high corn rootworm pressure & elevated tolerance to Bt traits**



Qrome® products are approved for cultivation in the U.S. and Canada. They have also received approval in a number of importing countries, most recently China. For additional information about the status of regulatory authorizations, visit <http://www.biotradestatus.com/>

Herculex® I and Herculex® XTRA insect protection technologies by Dow AgroSciences and Pioneer Hi-Bred. Agrisure® is a registered trademark of, and used under license from, a Syngenta Group Company. Agrisure® technology incorporated into these seeds is commercialized under a license from Syngenta Crop Protection AG. YieldGard®, the YieldGard Corn Borer design and Roundup Ready® are registered trademarks used under license from Monsanto Company. Liberty®, LibertyLink® and the Water Droplet Design are trademarks of BASF. Poncho® is a registered trademark of BASF. Force® is a registered trademark of Syngenta. SmartStax® multi-event technology developed by Dow AgroSciences and Monsanto. ®SmartStax and the SmartStax Logo are registered trademarks of Monsanto Technology LLC. Always follow IRM, grain marketing and all other stewardship practices and pesticide label directions. B.t. products may not yet be registered in all states. Check with your seed representative for the registration status in your state. Always read and follow label directions.

®, TM, SM Trademarks and service marks of Dow AgroSciences, DuPont or Pioneer, and their affiliated companies or their respective owners. © Corteva 2020

Appendix

Below Ground Corn Rootworm Traits by Product

Event & Protein	Bayer & Corteva Agriscience SmartStax®	Corteva Agriscience Optimum® AcreMax® Xtra	Corteva Agriscience Optimum® AcreMax® XTreme	Corteva Agriscience Qrome®	Syngenta Agrisure® 3122 E-Z Refuge®	Syngenta Agrisure Duracade® 5122 E-Z Refuge®
Event 88017 Cry3Bb	X					
Event MIR604 mCry3A			X	X	X	X
Event 5307 eCry3.1Ab						X
Event 59122 Cry34/35Ab1	X	X	X		X	
Event DP4114 Cry34/35Ab1				X		