Leaf Spot Management in Response to Fungicide Resistance Challenges

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Potato Pathology

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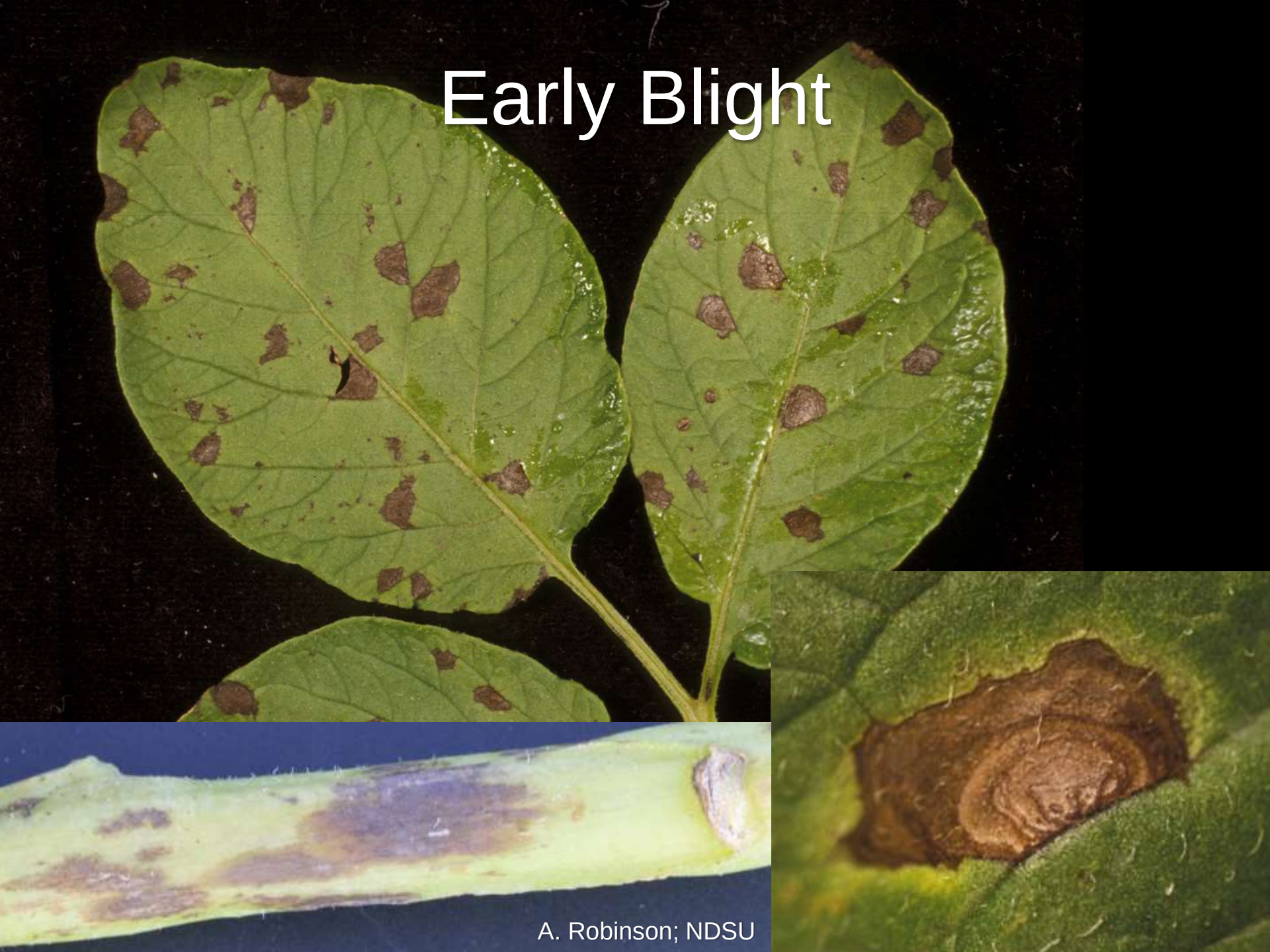
Early Blight



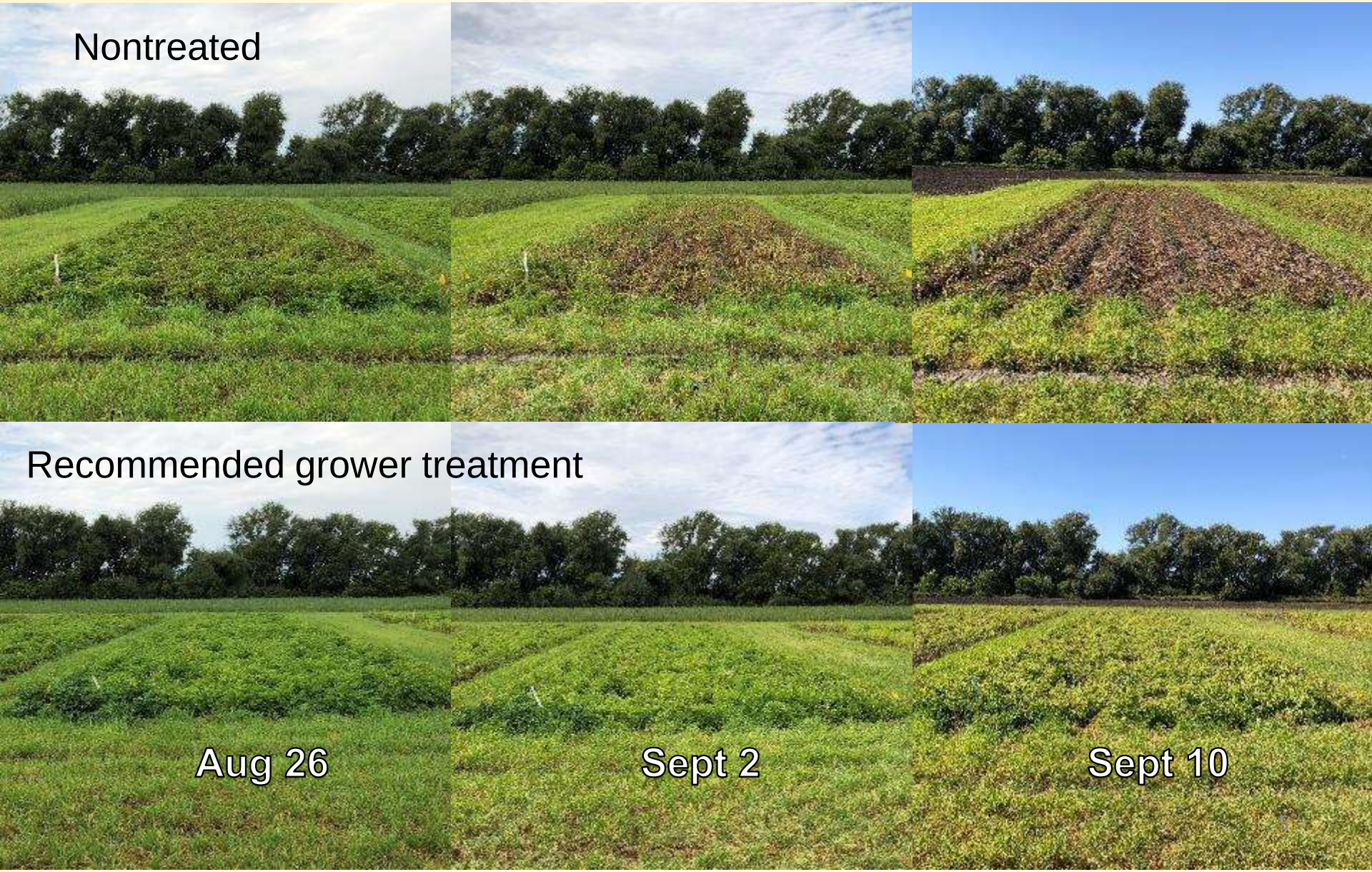
A. Robinson; NDSU

Brown Spot

Ontario Crop IPM


Brown Spot
Ontario Crop IPM

Foliar Leaf Spot Development - 2020



D. Peterson

Example Recommended Fungicide Program Early Blight / Brown Spot / Black Dot

- Commonly 10-12 total applications on a 7-day interval
- QoI (group 11) before row closure aimed at black dot
  - 50-70% ground cover
- Premium fungicides for early blight and brown spot at early- to mid-tuber bulking
- Tank-mix and rotation for resistance management and late blight protectant

Product	Schedule
Chlorothalonil	1
QoI (group 11) + Mancozeb	**2**
Chlorothalonil	3,4
Premium + Mancozeb	**5**
Chlorothalonil	6
Premium + Mancozeb	**7**
Chlorothalonil	8-10

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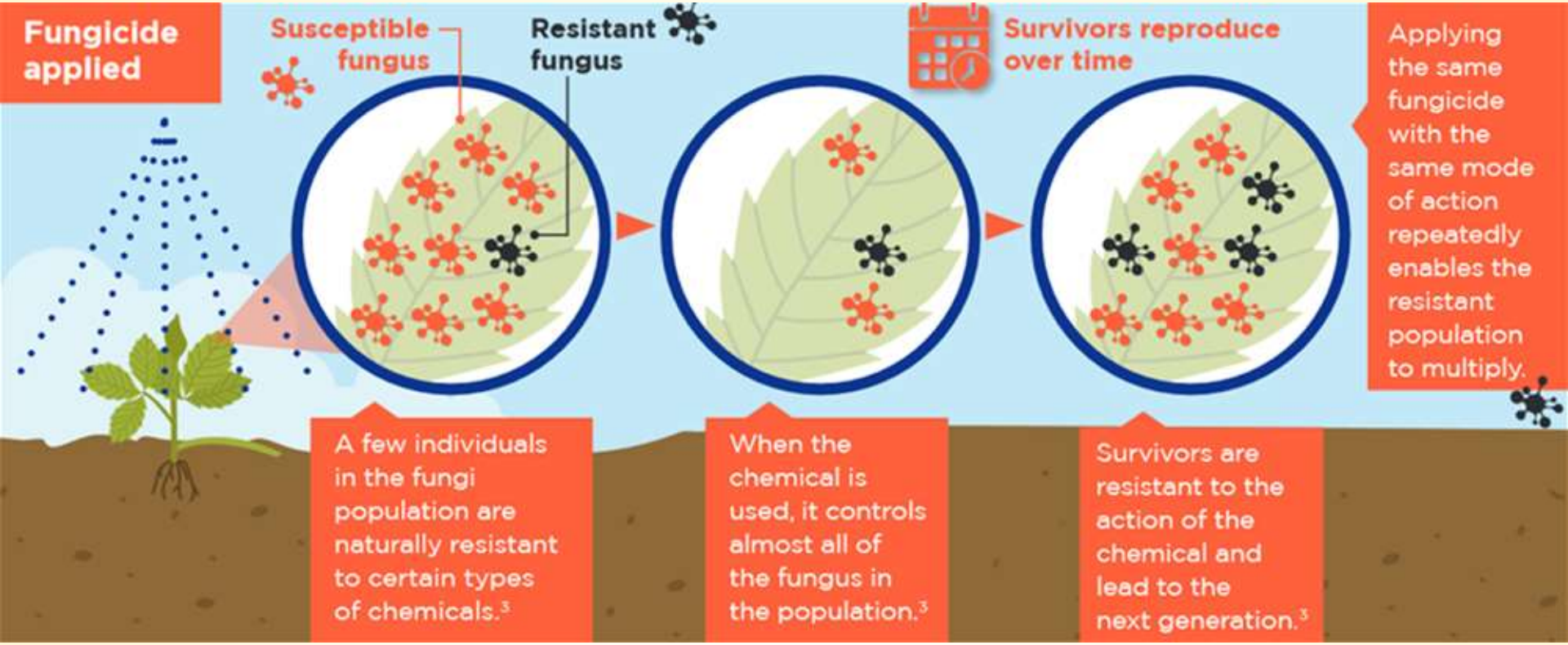
Early Blight Foliar Fungicides

Foliar Product	Active ingredient(s)	FRAC Code	Early Blight*
Various	Chlorothalonil / Mancozeb	M5 / M3	++
Quadris / Headline / Evito / Reason	Azoxystrobin / Pyraclostrobin / Fluoxastrobin / Fenamidone	11 (QoI)	++
Tanos	Famoxadone + Cymoxanil	11 / 27	++(+)
Quash	Metconazole	3 (DMI)	+++
Provysol / Cevya**	Mefentrifluconazole	3	++++
Veltyva**	Mefentrifluconazole + Pyraclostrobin	3 / 11	?++++
Revus Top	Mandipropamid + Difenoconazole	40 / 3	++++
Luna PRO / Proline Gold / Propulse	Fluopyram + Prothioconazole	7 (SDHI) / 3	++++
Aprovia Top**	Solatenol + Difenoconazole	7 / 3	?++++
Miravis Duo	Adepidyn + Difenoconazole	7 / 3	++++
Scala	Pyrimethanil	9 (AP)	+++
Luna Tranquility	Fluopyram + Pyrimethanil	7 / 9	++++
Miravis Prime	Adepidyn + Fludioxonil	7 / 12 (PP)	++++
AgriTin	TPTH	30	++++
++++ Excellent; +++ Good; ++ Fair			

*Based on replicated trial data from an irrigated research site in North Dakota

**Not tested in this formulation

Evolution of Fungicide Resistance



- Evolution of fungicide resistance is more complex than illustrated here.
- Influenced by:
  - Pathogen
  - Fungicide
  - Implementation of resistance management strategies

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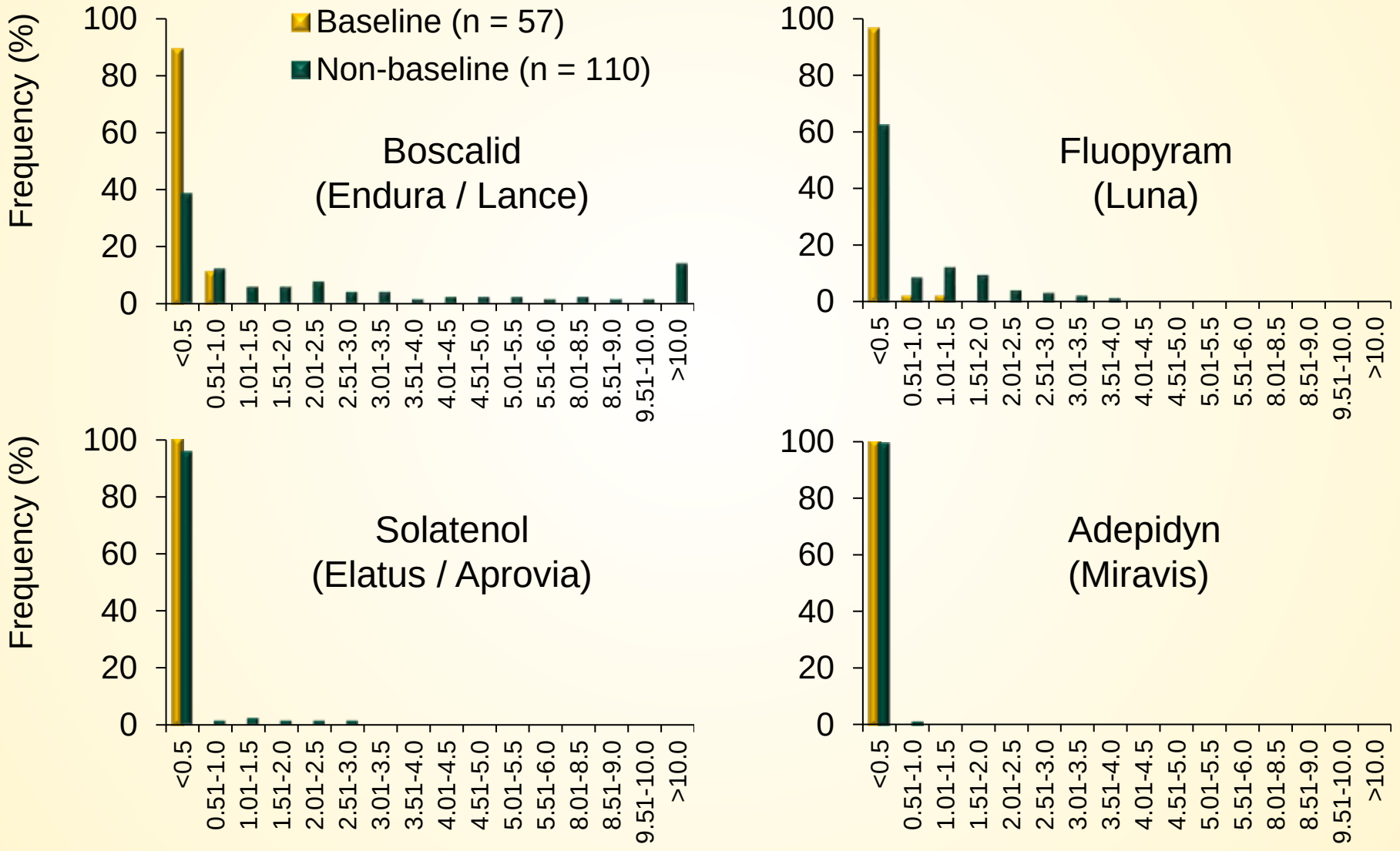
Source: CropLife International

A. solani : SDHI Interactions

Budde-Rodriguez

A. solani : SDHI (Group 7) Interactions

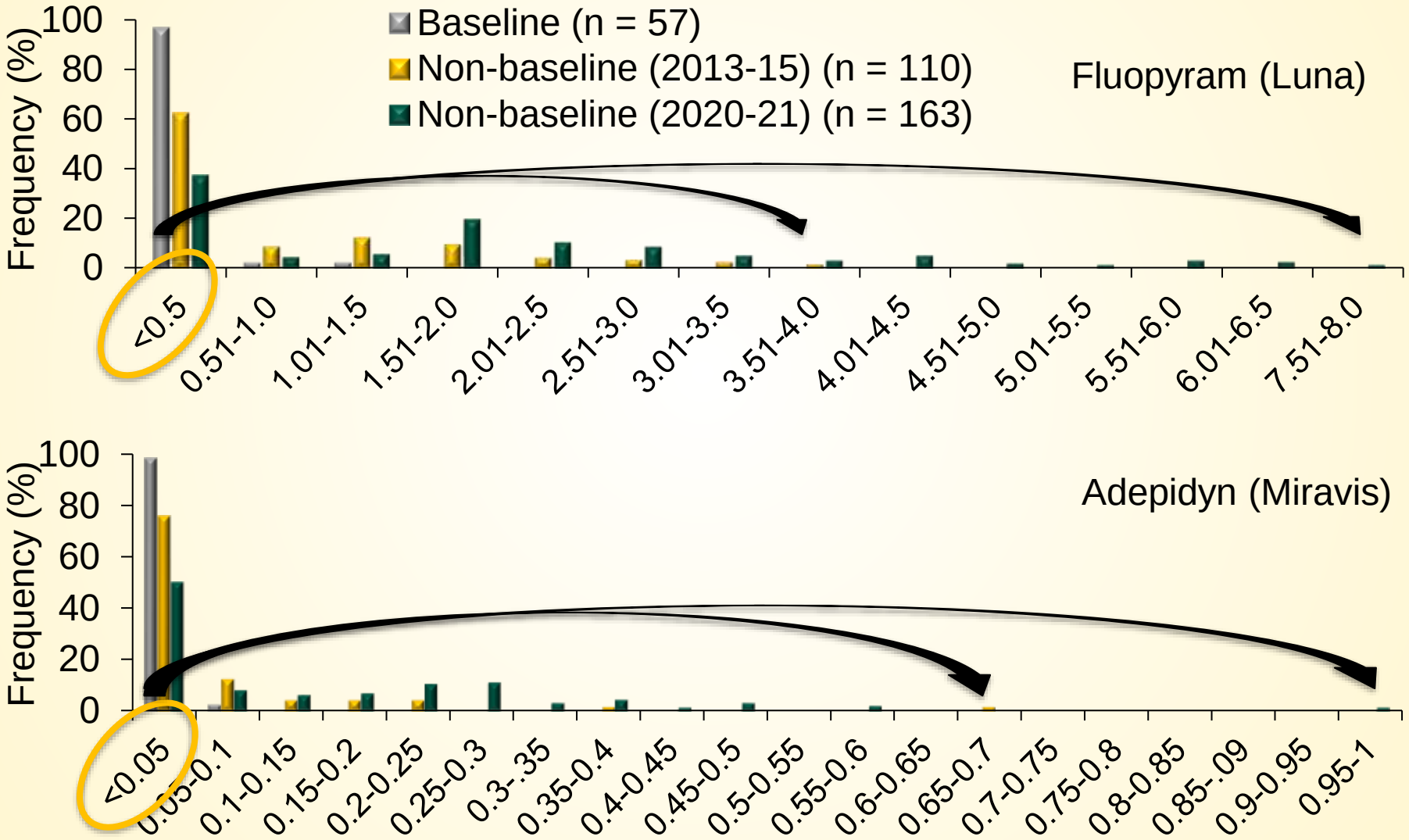
In vitro spore germination – lab data



Budde-Rodriguez et al. 2021a Plant Dis.

A. solani : SDHI – US and Canada (2020-21)

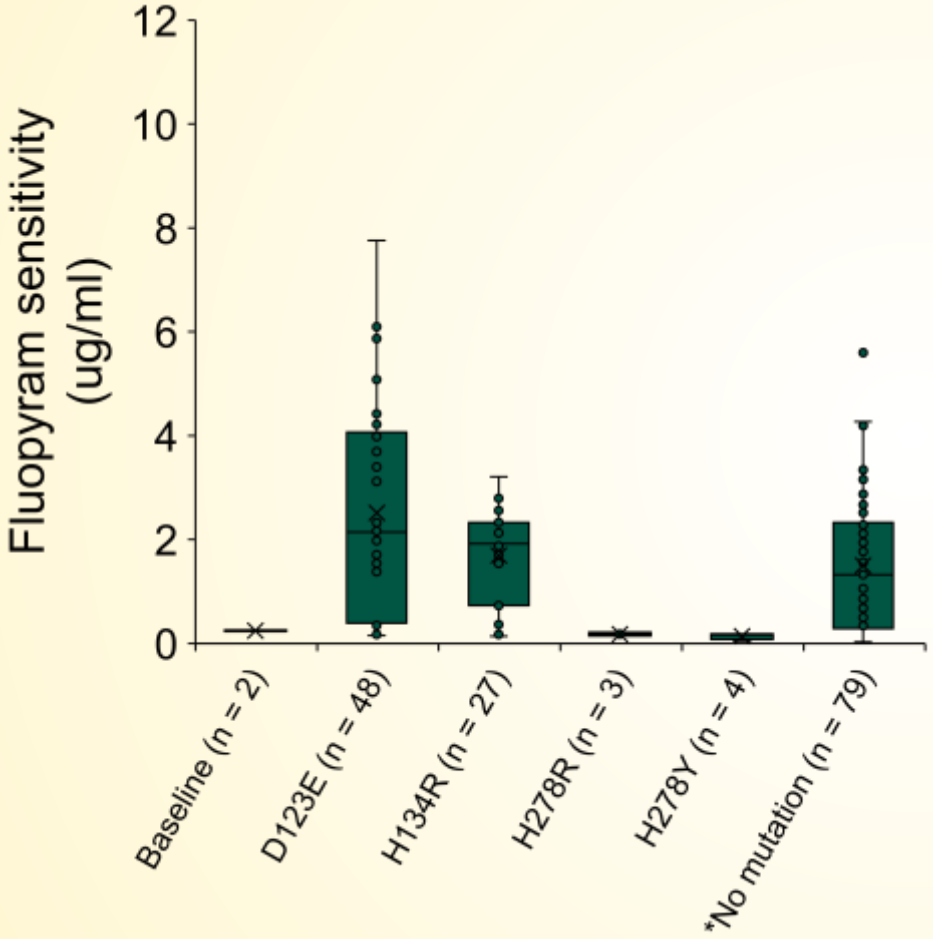
In vitro spore germination – lab data

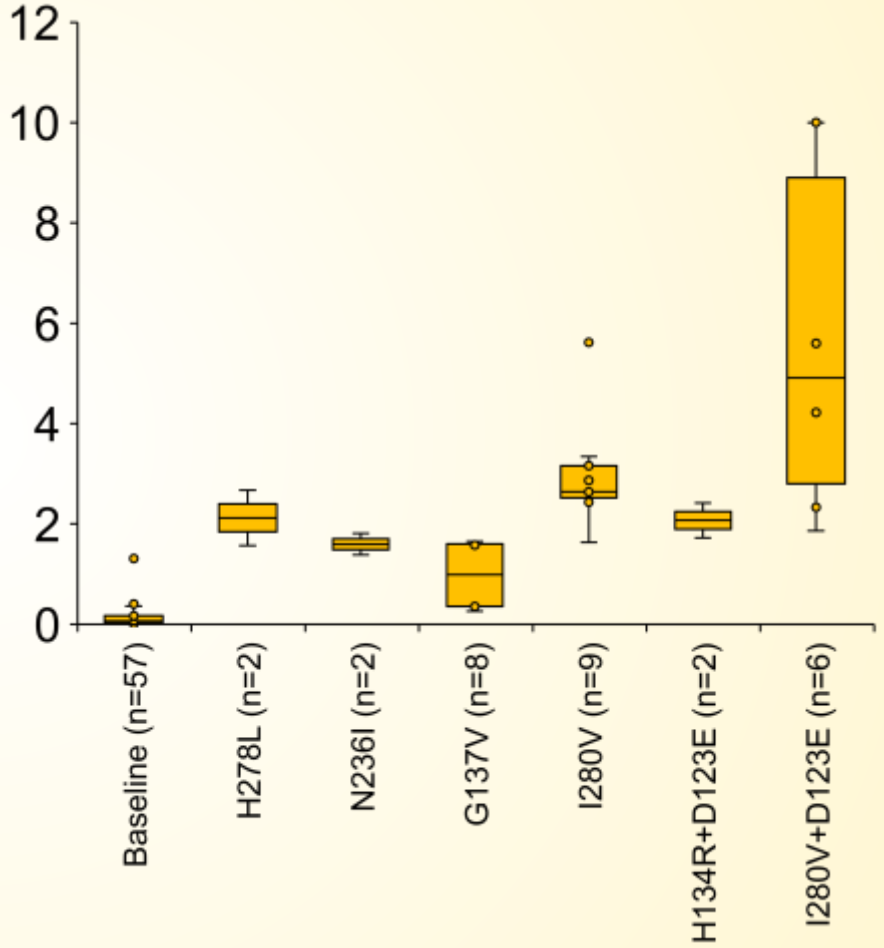


Budde-Rodriguez et al. 2021a Plant Dis.; Shrestha et al. NDSU *unpublished*

A. solani : SDHI (Group 7) Interactions

Lab (spore germination) – mutations that affect SDHI sensitivity





*No known mutation based on PCR to detect the 5 known *sdh* gene mutations 166 *A. solani* isolates

*Sensitivity of 57 baseline and 29 Sdh mutant *A. solani* isolates (Shrestha et al. unpublished)

A. solani : SDHI (Group 7) Interactions

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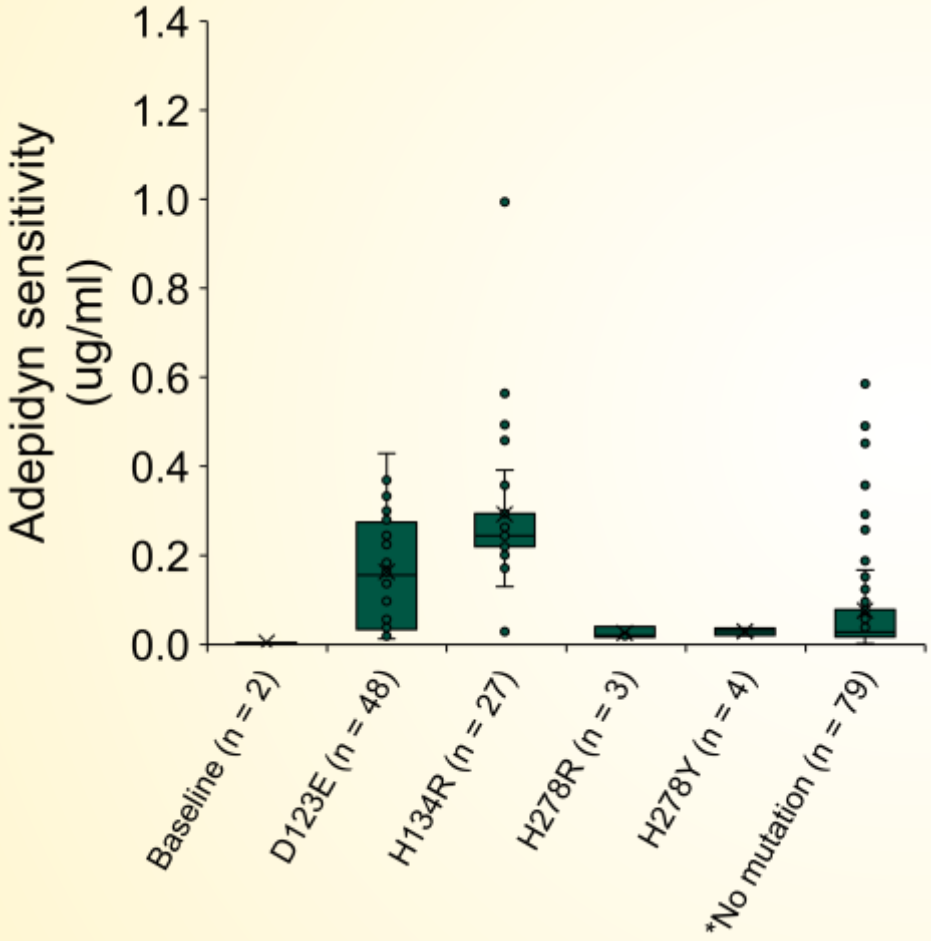

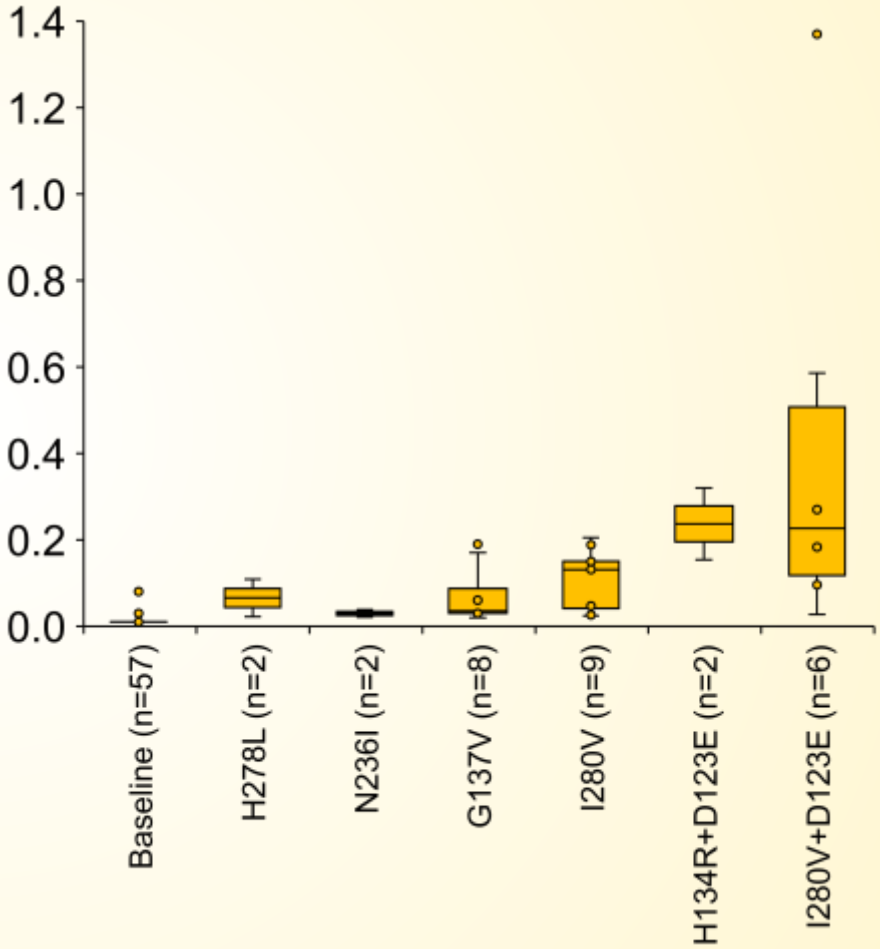

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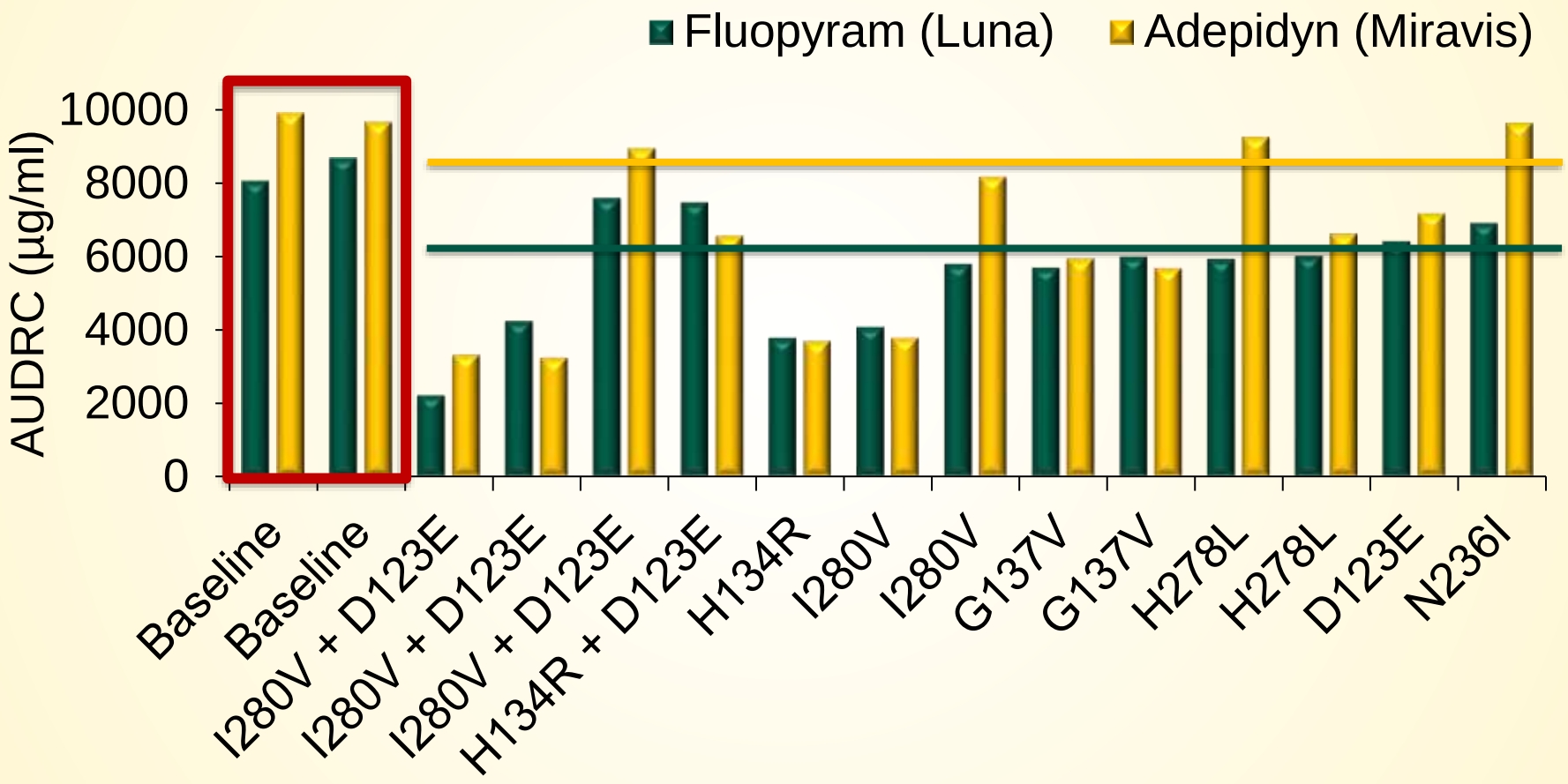
A. solani : SDHI (Group 7) Interactions

Greenhouse - Relative area under the dose response curve



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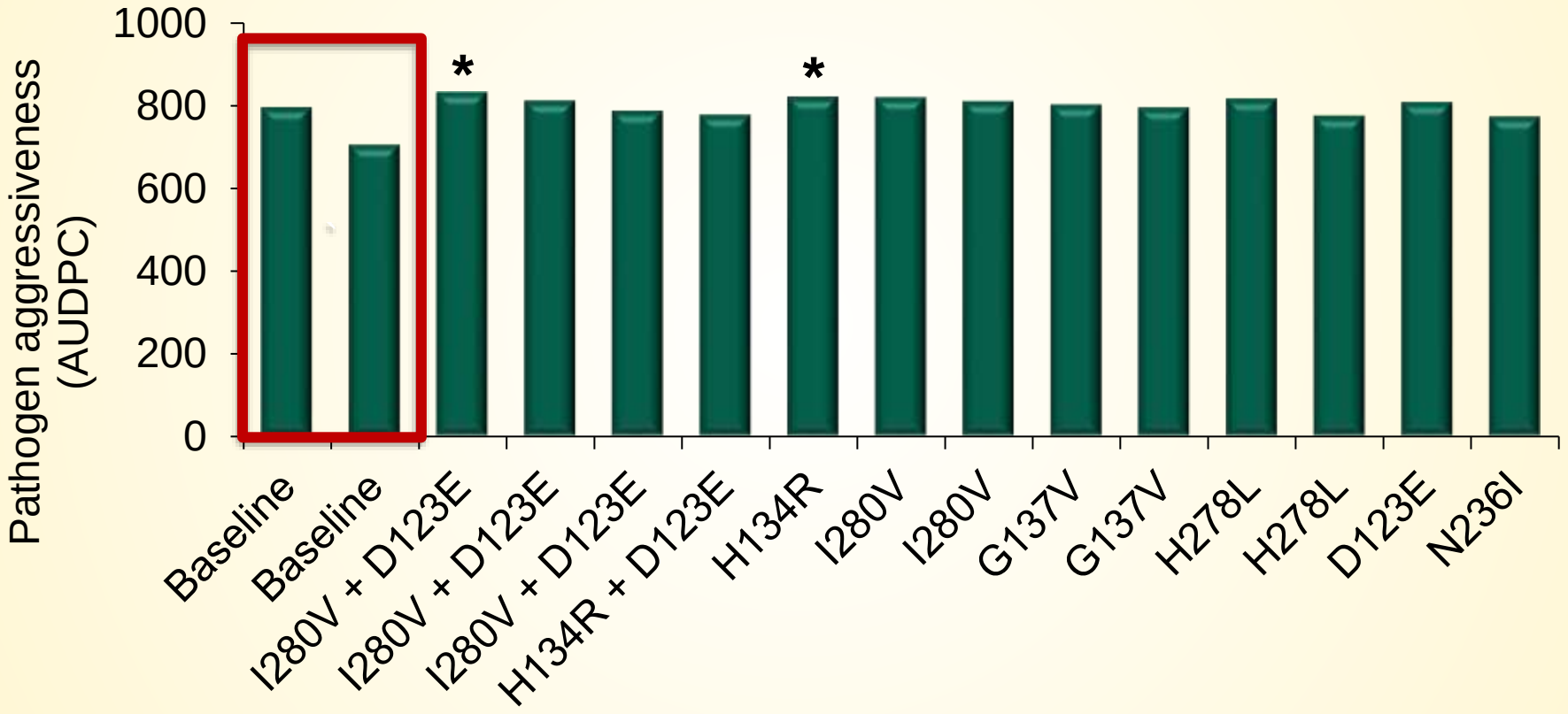
Shrestha et al. unpublished

A. solani Aggressiveness

Greenhouse - Relative area under the disease progress curve



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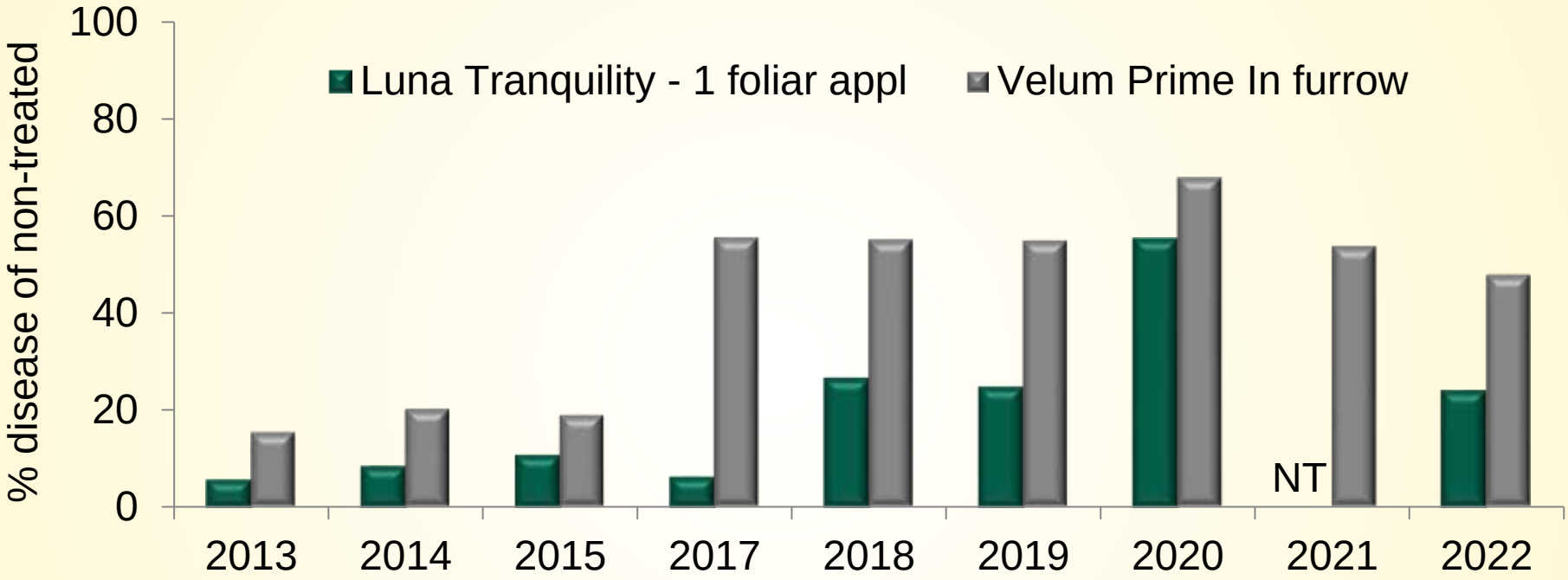
Shrestha et al. unpublished

Efficacy of Luna Tranquility & Velum Prime Over Time

Field - % disease severity when compared to the non-treated control



Luna Tranquility (11.2 oz/a) at application 5 in a 10 application program
Scala (7 oz/a) @ application 7
NT – Luna Tranquility not tested in 2021

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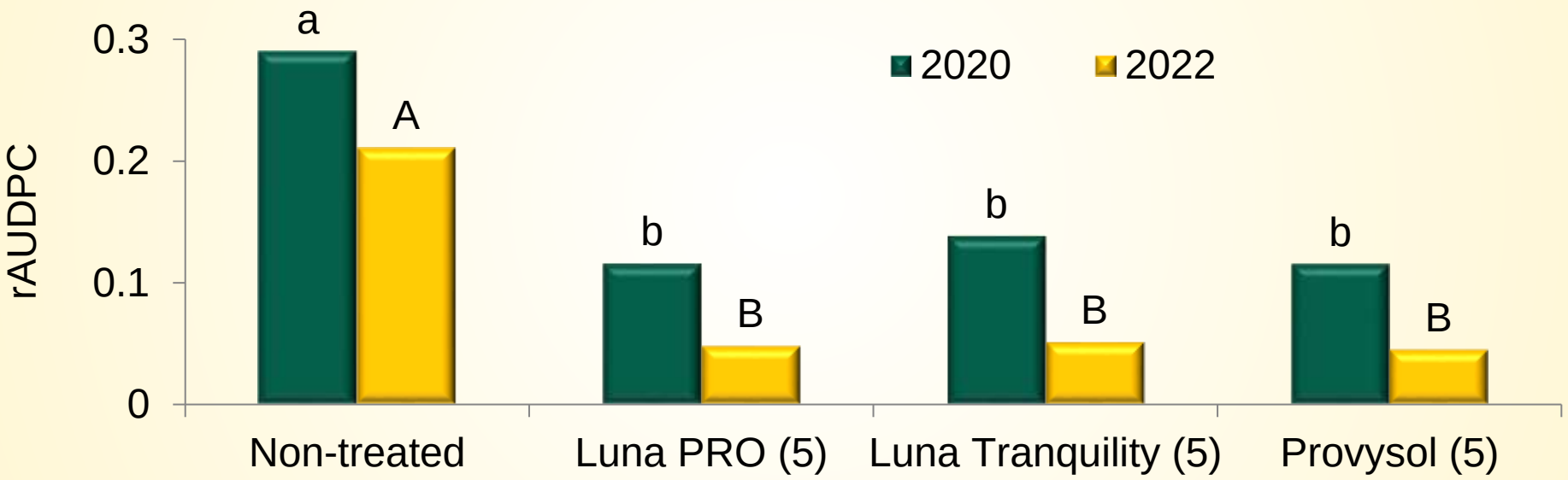
Early Blight Field Trials – 2020 / 2022

Relative area under the disease progress curve

2020 – high disease pressure

2022 – moderate disease pressure



10 application program: QoI (group 11) @ application 2 (aimed at black dot)
Scala @ application 7

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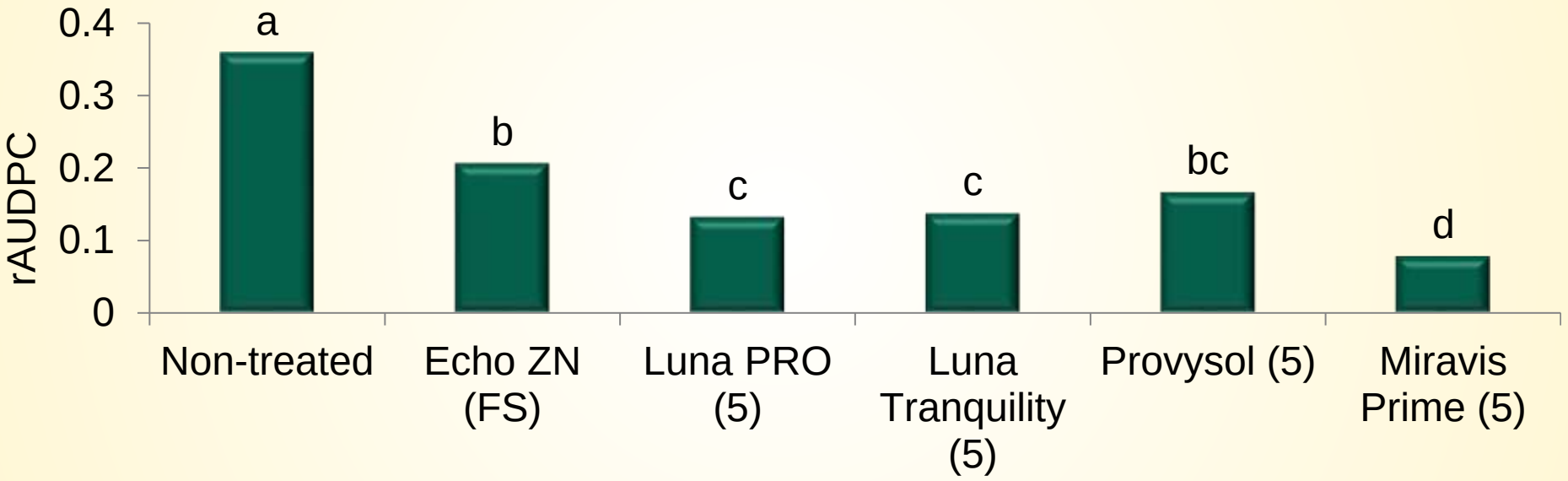
Early Blight Field Trials – 2023

Relative area under the disease progress curve

2023 – very high disease pressure



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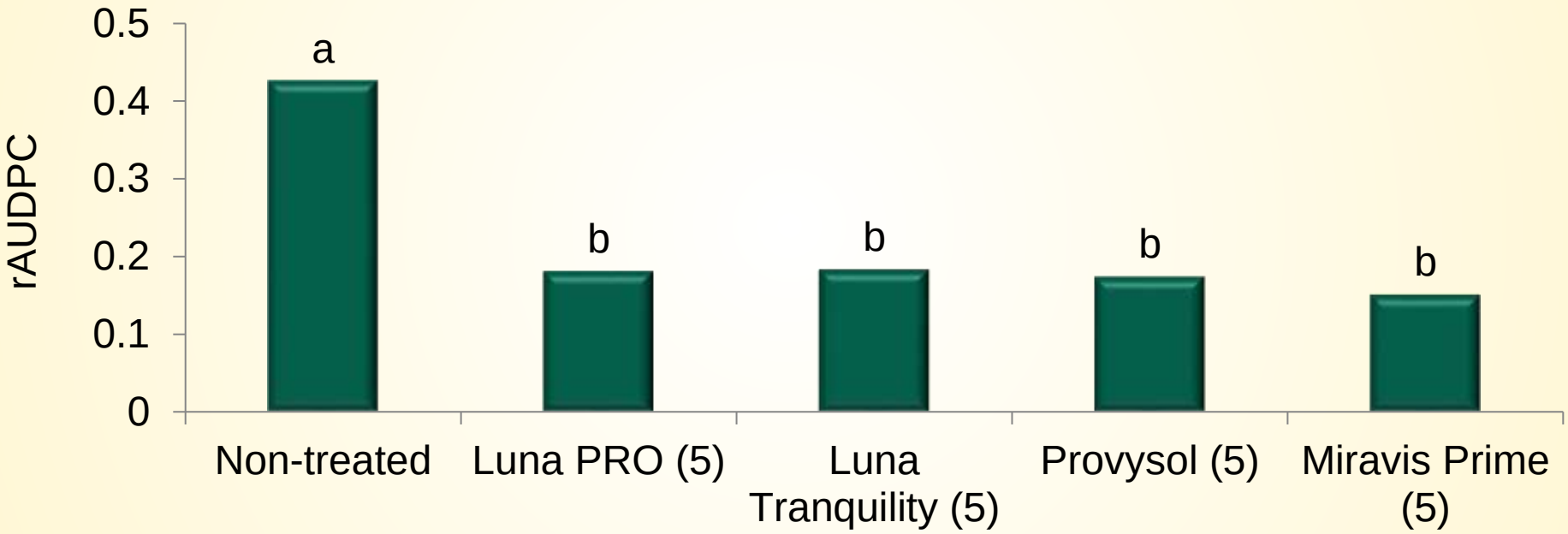
Early Blight Field Trials – 2023

Relative area under the disease progress curve

2023 – very high disease pressure



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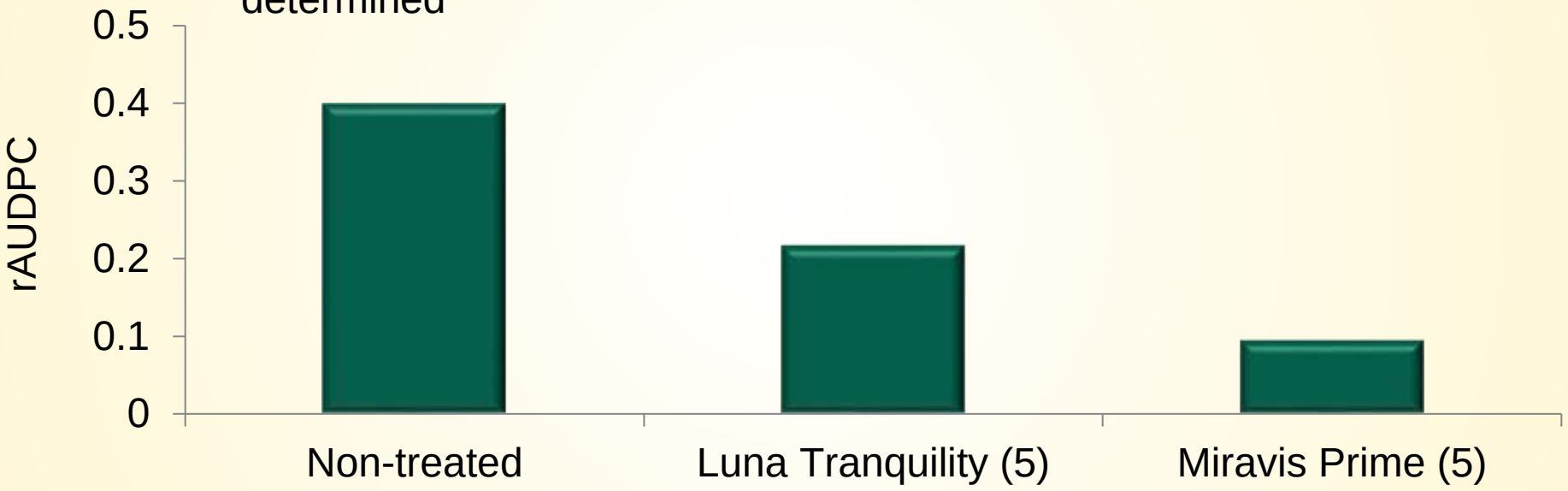
Early Blight Field Trials – 2023

Relative area under the disease progress curve

2023 – very high disease pressure

This trial was **not replicated – significant differences were not determined**



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Scala @ application 7

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A. solani Summary / Conclusions

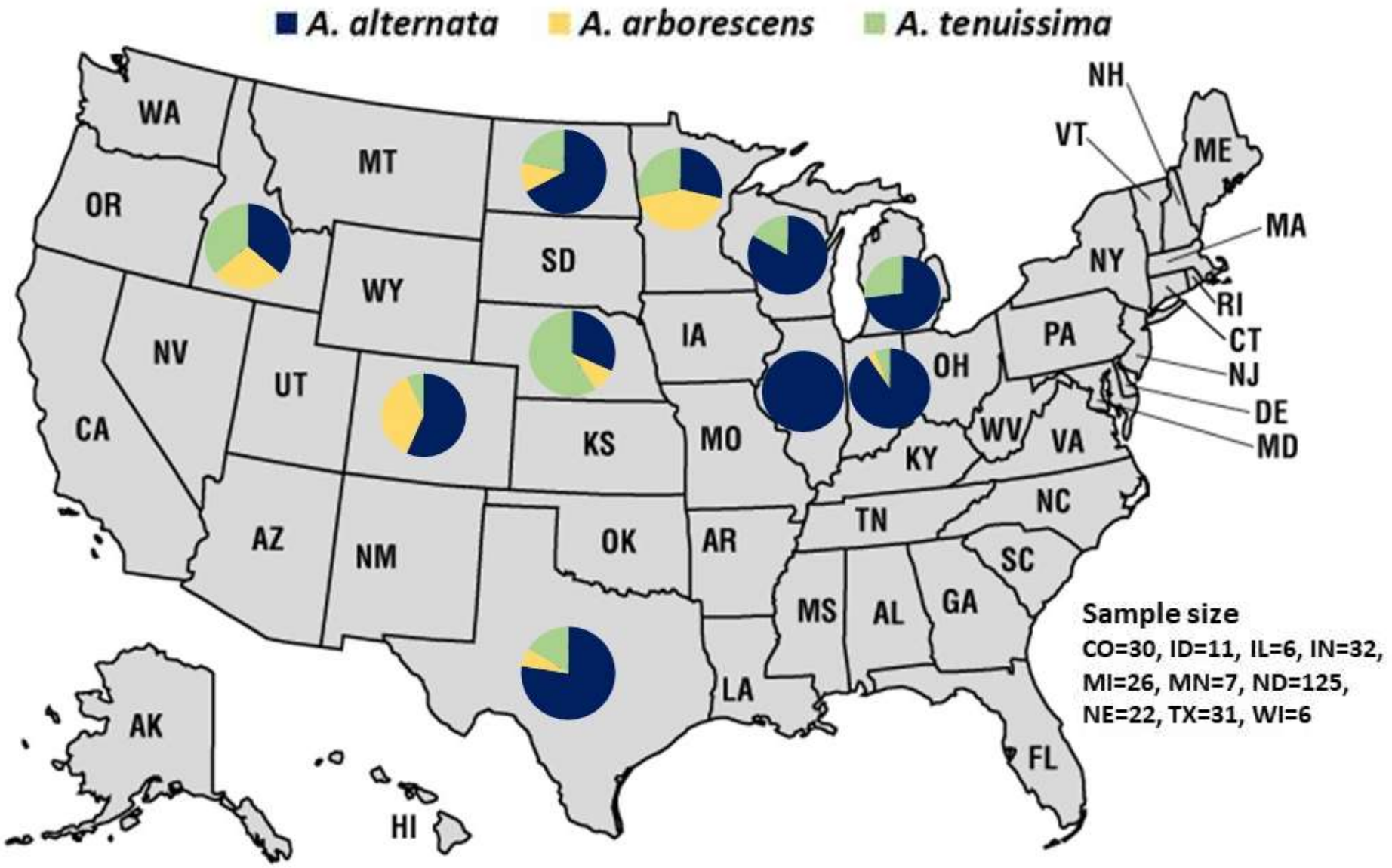
- A shift in in vitro sensitivity was observed to all four SDHI fungicides in non-baseline isolates
  - Monitoring continues to be crucial, especially in recently registered products
  - May be worsening over time
- New mutations have been identified in the *Sdh* gene
  - Some isolates have more than 1 mutation, and appear to be more resistant to SDHI (group 7) fungicides
  - The effect of each mutation under field conditions is difficult to discern
- The use of Velum Prime (fluopyram) or Elatus (solatenol) in-furrow may be placing pressure on the pathogen populations

Leaf Spot Diseases

- Early Blight
  - *Alternaria solani*

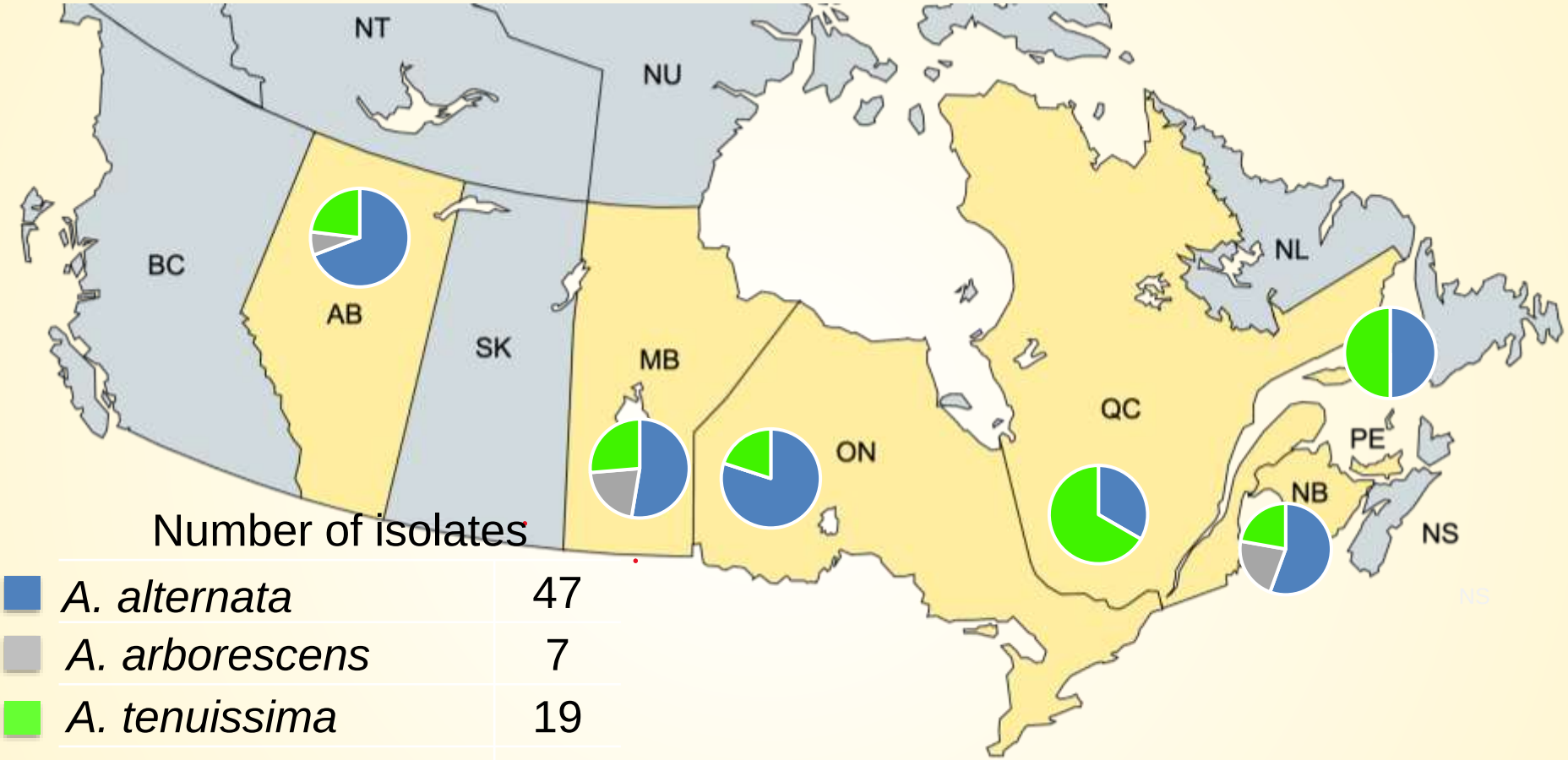
- Brown Spot – Small-spored *Alternaria* species
  - *A. alternata*
  - *A. arborescens*
  - *A. arbusti*
  - *A. tenuissima*

Small-Spored *Alternaria*



Mallik et al. 2022

Small-Spored *Alternaria*



Number of isolates	
A. alternata	47
A. arborescens	7
A. tenuissima	19
Total	73

Created with .mapchart.net

AB (n=13), MB (n=19), ON (n=25),
QC (n=3), NB (n=9), PEI (n=4)

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Small-Spored *Alternaria* Summary

- Brown spot is caused by a complex of at least four small-spored *Alternaria* species
- SDHI (group 7) fungicide reduced-sensitivity / resistance observed in three species
  - Based on spore germination and greenhouse evaluations
  - Field evaluations are needed to confirm these results
- 5 *Sdh* mutations have been identified in *A. alternata* from pistachio in CA
  - Similar to those in *A. solani* (early blight)
- Aggressiveness and fungicide sensitivity may depend on isolate, not species
  - Research in this area is ongoing

Leaf Spot Recommendations

- Resistance continues to develop in the brown spot and early blight pathogens
  - Stewardship of all fungicides of utmost importance
- Practice good resistance management
  - Rotate and combine (tank-mix or pre-packaged) products with differing active ingredients
  - Include multi-site (group M) fungicides
- If resistance exists to one member of the pre- or tank-mix, you are relying solely on the other partner

Leaf Spot Recommendations

- Discontinue the application of boscalid (Lance / Endura) for early blight and brown spot due to lack of efficacy
- Fluopyram (Luna Tranquility / PRO) and adepidyn (Miravis Prime / Duo) remain effective in field trials
  - Application of any SDHI (Group 7) should be limited to one / season
- The application of DMI (Group 3) fungicides (Provysol / Cevya, *Veltyva, Revus Top, Luna PRO) remains effective
  - Little to no reduced sensitivity / resistance has developed to these DMIs
  - Limit to two DMI applications / season

Leaf Spot Recommendations

- Resistance to the AP (group 9) fungicide pyrimethanil (Scala) has been documented in the early blight pathogen in the US, but is not widespread
  - Scala is recommended for brown spot and Botrytis grey mold
- A small number of *A. solani* isolates have been identified with resistance to three fungicide classes (QoI, SDHI, and AP)
- DMI (group 3) and AP (group 9) resistance monitoring evaluations for have not been done on a widespread basis for about 10 years
- Field failures may occur for several reasons, but should be followed with pathogen sensitivity evaluations

Thank You

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Relative Efficacy of Fungicides for the Control of Foliar Diseases of Potato

Product	FRAC Code	Late Blight	Early Blight	White Mold	Black Dot	Brown Spot	Botrytis
Bravo/Echo®	M5	++(+)	++	-	++	++	++
Dithane/Manzate ®	M3	++(+)	++	-	++	+	(+)
Omega ®	29	++++	-	++++	-	-	+++
Endura* ®	7	-	-	++++	+	++(+)	++++
Vertisan* ®	7	-	-	+++	+++	+++	++
Luna Tranquility* ®	7 / 9	-	++++	+++	+++	++++	++++
Priaxor* ®	7 / 11	++	+	++	+++	+++	++
Miravis Prime ®	7 / 12	-	++++	++	++	++++	++
Quadris ®	11	++	++	++	+++	++	-
Headline ®	11	++	++	++	+++	++	-
Evito ®	11	++	++	++	+++	++	-
Tanos ®	11 / 27	+++	++(+)	-	++	++	++
Reason ®	11	+++	++	-	+++	++	-
Scala ®	9	-	+++	-	-	+++(+)	++++
AgriTin ®	30	+	++++	-	++	++++	-
Revus Top ®	40 / 3	++++	++++	-	+	+++	-
Quash ®	3	-	+++	+	+	+++	-
Provysol ®	3	-	++++	-	-	+++(?)	-
Gavel ®	22	++++	+	-	+	+	+
Curzate ®	27	+++	-	-	-	-	-
Ranman ®	21	++++	-	-	-	-	-
Previcur ®	28	+++	-	-	-	-	-
Forum/Acrobat ®	40	+++	-	-	-	-	-
Orondis Ultra ®	49 / 40	++++(+)	-	-	-	-	-
Orondis Opti ®	49 / M5	++++	++	-	++	++	++

++++ = Excellent; +++ = Good; ++ = Fair; + = Poor; - = No activity

Gudmestad and Pasche, 2014©

*A survey conducted in 2013 by NDSU has shown that approximately >95% of *A. solani* isolates have some level of resistance to boscalid (Endura ®). There are five known mutations that convey resistance to Endura, four of these mutations also affect the efficacy of fluxapyroxad (Priaxor ®) and penthiopyrad (Vertisan ®) and these mutations predominate in the population. None of the current mutations in the *A. solani* population appear to affect the efficacy of fluopyram (Luna Tranquility ®).

CSS Farms Foliar Disease Quick Reference Guide

	Early Blight	Late Blight	Black Dot	Brown Spot	Botrytis
Cause	*Alternaria solani*	*Phytophthora infestans*	*Colletotrichum coccodes*	*Alternaria alternata*	*Botrytis cinerea*
Source of inoculum	Debris from previous crop	Seed Cull piles Volunteers	Seed Soil Debris	Debris Multiple Crops	Soil Debris
Hosts other than potato	Hairy nightshade Tomato	Hairy nightshade Tomato Petunia	Pigweed Velvet leaf Nightshade	Many Crops/ Weeds	Many Crops/ Weeds
Parts affected	Leaves EB tuber rot	Leaves Stems LB tuber rot	Leaves, Stems Roots Tuber blemish	Leaves Stems Tubers	Leaves Stems
Time of infection	Mid-Late Season	Anytime	Early Season	Anytime	Anytime
Optimum fungicide timing	Full season Premium mid July & mid August	Full season – 2 appl. before row closure	One appl. 14-21 days after emergence	Mid-season (July)	Early to mid-season
Fungicides for control	Dithane®, Bravo® Tanos®, Scala® Quash®	Dithane®, Bravo® Tanos®, Curzate® Previcur® , Forum® Reason®	Dithane®,Bravo®	Bravo®	Bravo® Miravis P ® - 11.4 oz
Fungicides for premium control	Revus Top® - 7.0 oz AgriTin® - 3.0 oz Luna T® - 11.2 oz Miravis P® - 11.4 oz Provysol® - 3.0 oz	Revus Top® - 7.0 oz Gavel® - 2.0 lb Omega® - 5.5 oz Ranman® - 2.75 oz Orondis Ultra ® - 5.5-8.0 oz Orondis Opti ®- 1.75-2.5 pt	Headline® - 9.0 oz Quadris® - 9.0 oz Luna T® - 11.2 oz Reason® - 6.9 oz Vertisan® - 16.0 oz Priaxor ® - 6.0 oz	Scala® - 7.0 oz AgriTin® - 3.0 oz Luna T® - 11.2 oz Miravis P® - 11.4 oz Quash® - 2.5 oz Vertisan® - 16.0 oz	Scala® - 7.0 oz Endura® - 3 - 3.5 oz Luna T® - 11.2 oz





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