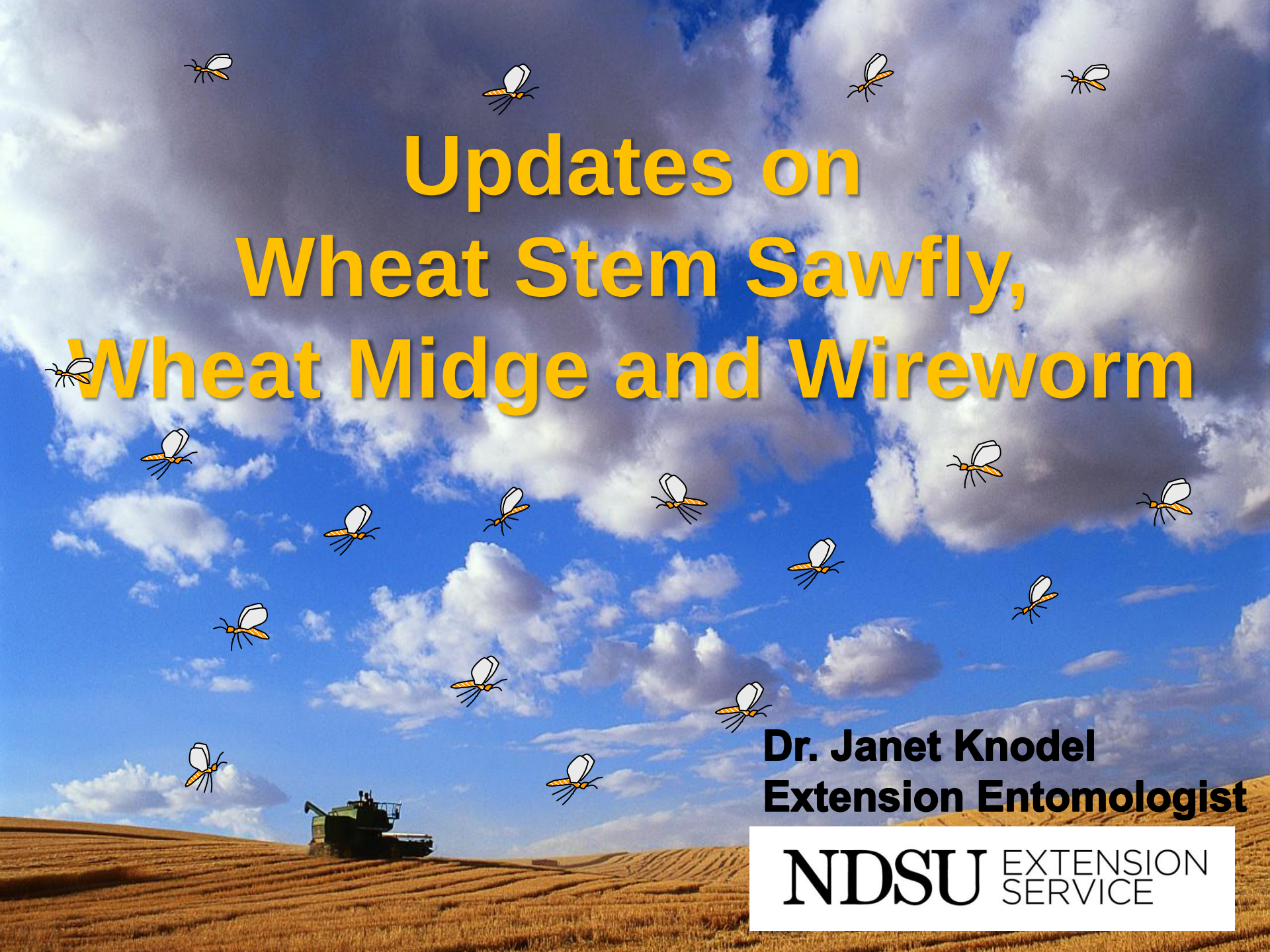


# Updates on Wheat Stem Sawfly, Wheat Midge and Wireworm

**Dr. Janet Knodel**
**Extension Entomologist**

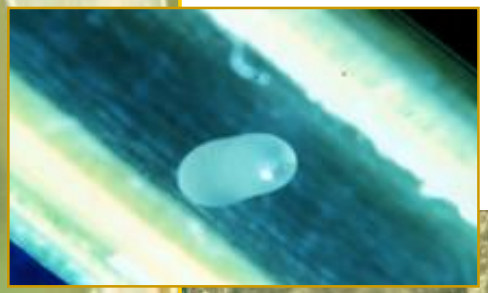
NDSU EXTENSION SERVICE

# Wheat Stem Sawfly
# *Cephus cinctus* Norton (Cephidae)

**Summer**

**Adult**

**Live 5-10 days**



**Egg**

**Larva**

**Pupa**

**Spring**

**Winter**

**Fall**

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# Wheat Stem Sawfly Hosts

- *Cephus cinctus* is native to North America and lives in grasses
- Cultivated hosts include wheat (spring, winter, and durum), rye, triticale, and some barley (larvae don't live long in barley)
- Wild grasses – Timothy, Quackgrass, Smooth broome, wheatgrass
- Oats, corn and broadleaf crops are not suitable hosts

# Damage Caused by Wheat Stem Sawfly

-Reduced yield
-Stunted head with fewer kernels and lower kernel weight
-Reduced protein content
-Lodging
*(Beres et al. 2007, Holmes 1977, Wallace & McNeal 1966, Weiss & Morrill 1992)*

# Lodging Losses

- Lost grain
- Volunteer wheat
  - uses water
  - herbicide

- Decreased snow retention
- Slower harvest
  - more fuel
  - more time
- Equipment damage
- Not good estimate of actual larval infestation

# Acreage Affected and Production Lost Due to Wheat Stem Sawfly In ND 2009

| District | Range of Damage | Total Acres SW,Durum, WW | % Acres Affected | Acres Affected |
|---|---|---|---|---|
| NW 6 counties | 10-25% | 1,988,000 | 15 | 298,200 |
| NC 5 counties | Trace to 15% | 853,000 | 5 | 42,650 |
| WC 5 counties | 10-40% | 795,000 | 25 | 198,750 |
| Central 6 counties | None to 10% | 681,000 | 5 | 34,050 |
| SW 7 counties | 50-85% | 990,000 | 65 | 643,500 |
| SC 5 counties | 10-40% | 722,000 | 25 | 180,500 |
| NE 7 counties | None | 1,592,000 | 0 | 0 |
| SE 7 counties | None | 479,000 | 0 | 0 |

| | | |
|---|---|---|
| **Total acres affected** | | **1,405,682** |
| | | **40 bu/a** |
| | | **$5.00/bushel** |
| | **10% loss =** | **$28 million** |
| | **25% loss =** | **$70 million** |

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# Cultural Strategies

- Crop Rotation
  - –Plant immune or resistant crops
    - Oats immune
    - Barley – sawfly do not thrive
    - Durum – less cutting due to tougher outer stems tissues and increased pith
    - Broadleaf crops = non-hosts
  - –Wheat on wheat favors increases in sawfly populations

# Cultural Strategies

- Delay seeding
  - –Late planting date produces a crop that is unattractive to females for egg-laying
    - Stem elongation begin after the annual sawfly flight
  - –Negative - Yield and grade losses associated with delayed seeding, and increase risk to hail

# Cultural Strategies

- **Trap crops**
  - Plants on edge concentrate adult sawflies, which lay eggs in trap crop
  - Then, destroy trap crop (cultivate, mow, hay) before larvae move down into base of plant prior to plant maturity


Source: D. Weaver, MSU

# Host Plant Resistance

- **Solid-stemmed Varieties**
  - **Viable IPM tool for over 60 years**
    - **First variety – 'Rescue' (released in 1946, Agric. Canada)**
  - **Larvae bore less extensively and reduced negative effects on yield**
    - **Antibiosis**
      - **Mortality due to physical resistance of pith (Holmes and Peterson 1962, Beres et al. 2007)**
      - **Solidity of lower internodes important (Wallace 1966)**
  - **Female WSS Host preference**
    - **Chemical volatile attractant in certain varieties (Piesik et al. 2008, Weaver et al. 2009, Buteler and Weaver 2012)**

# Host Plant Resistance

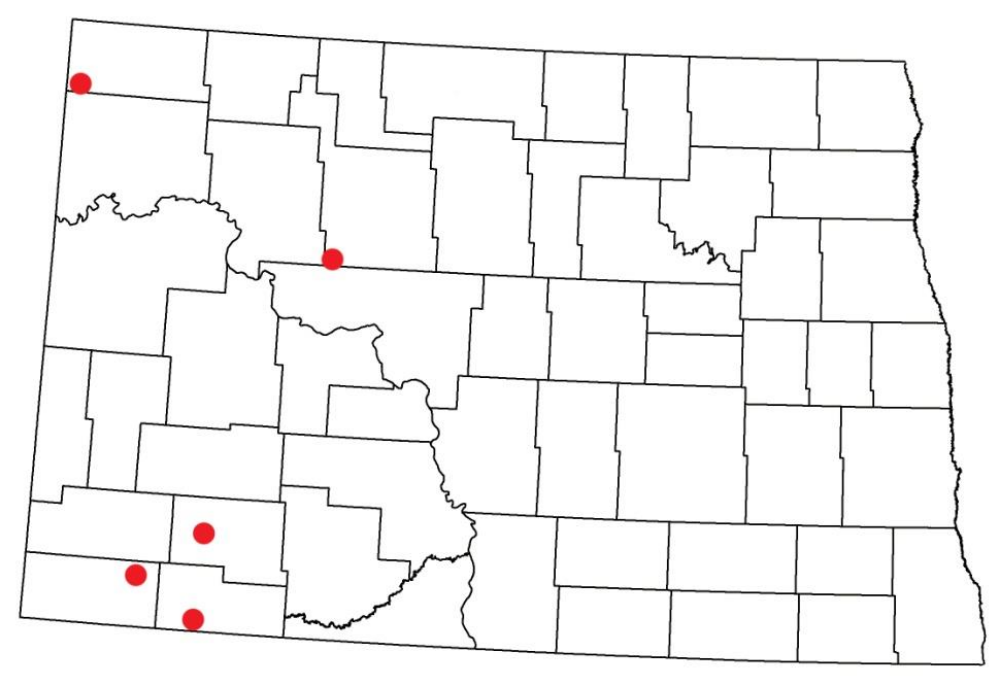
- **Solid-stemmed Varieties**
  - **Older solid-stemmed varieties had negative yield drag (<10%) and lower seed quality**
    - **Producer reluctant to use solid-stemmed varieties (Weiss and Morrill 1992, Beres et al. 2009)**
  - **Do newer solid-stemmed varieties yield more and have better agronomic traits?**
    - **Mott (NDAES 2009) Choteau (MAES 2003)**

# Materials and Methods – HRSW Varieties

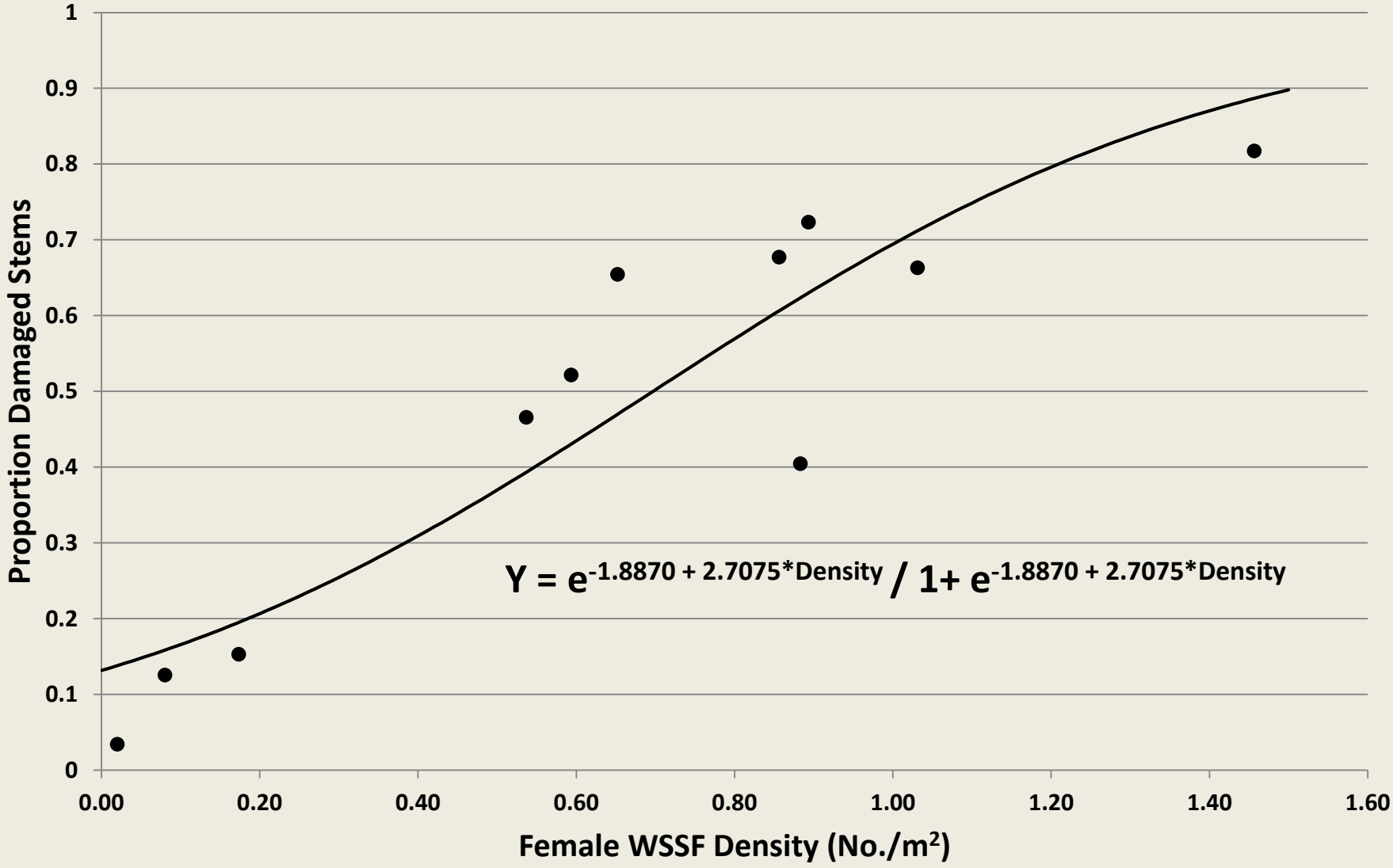
- Mott – North Dakota, 2009
- Choteau – Montana, 2003
- AC Lillian – Saskatchewan, 2003
- Vida – Montana, 2006
- Glenn – North Dakota, 2005
- Reeder – North Dakota, 1999
- Steele ND – North Dakota, 2004

# Material and Methods – Site-Years

- Locations
  - Grenora, Hettinger, Makoti, Regent, Scranton
- Years
  - 2009, 2010, 2011
- Hettinger 2009 lost to hail
- Grenora 2011 not planted due to excess soil moisture
- Total of 13 site-years

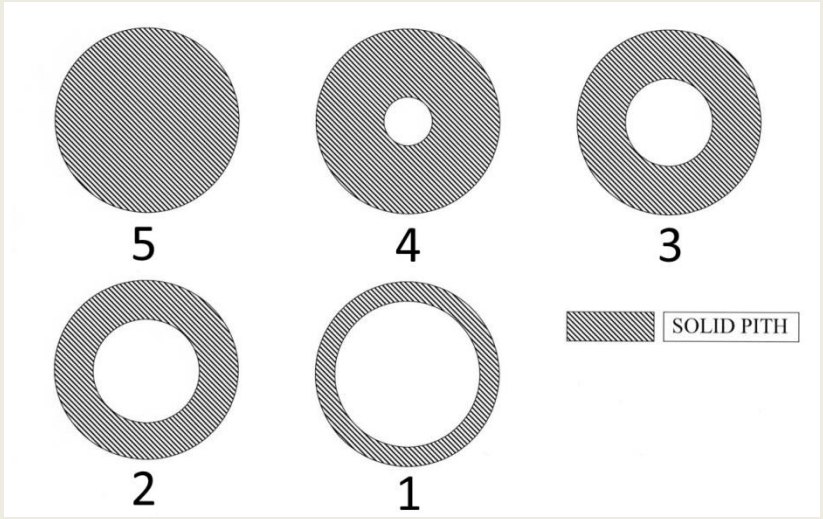


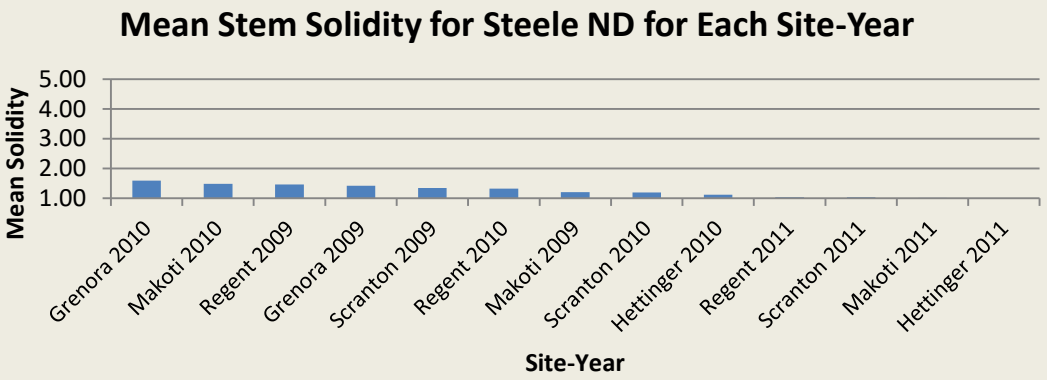
# Relationship Between Adult Female WSSF Density and Proportion Damaged Stems Across All Varieties and Site-Years



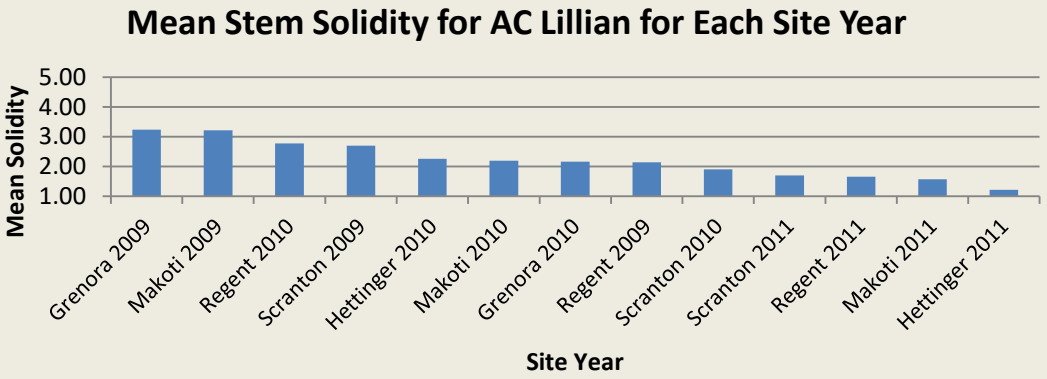
# Materials and Methods – Solidity and Sawfly Infestation

- Data collected at each of the first three above-ground internodes
  - Stem solidity at center of internode (1-5 scale)
  - Presence/absence of sawfly infestation (larva or frass)

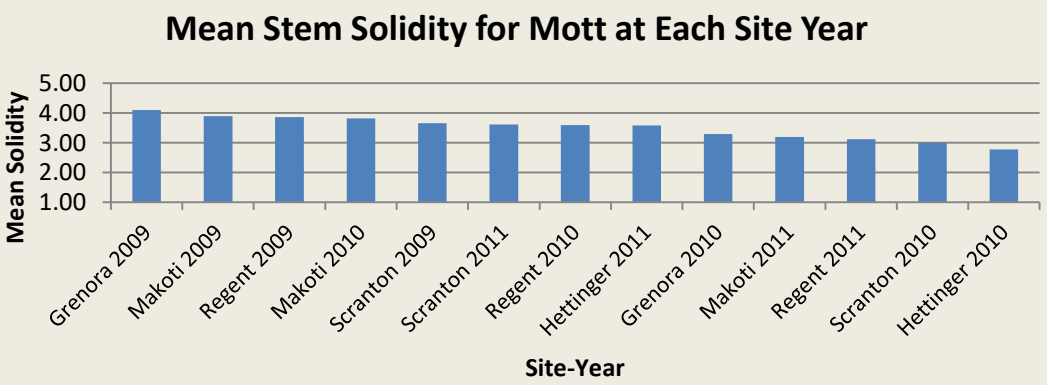



| Year | Mean |
|---|---|
| 2009 | 1.34 a |
| 2010 | 1.34 a |
| 2011 | 1.06 a |



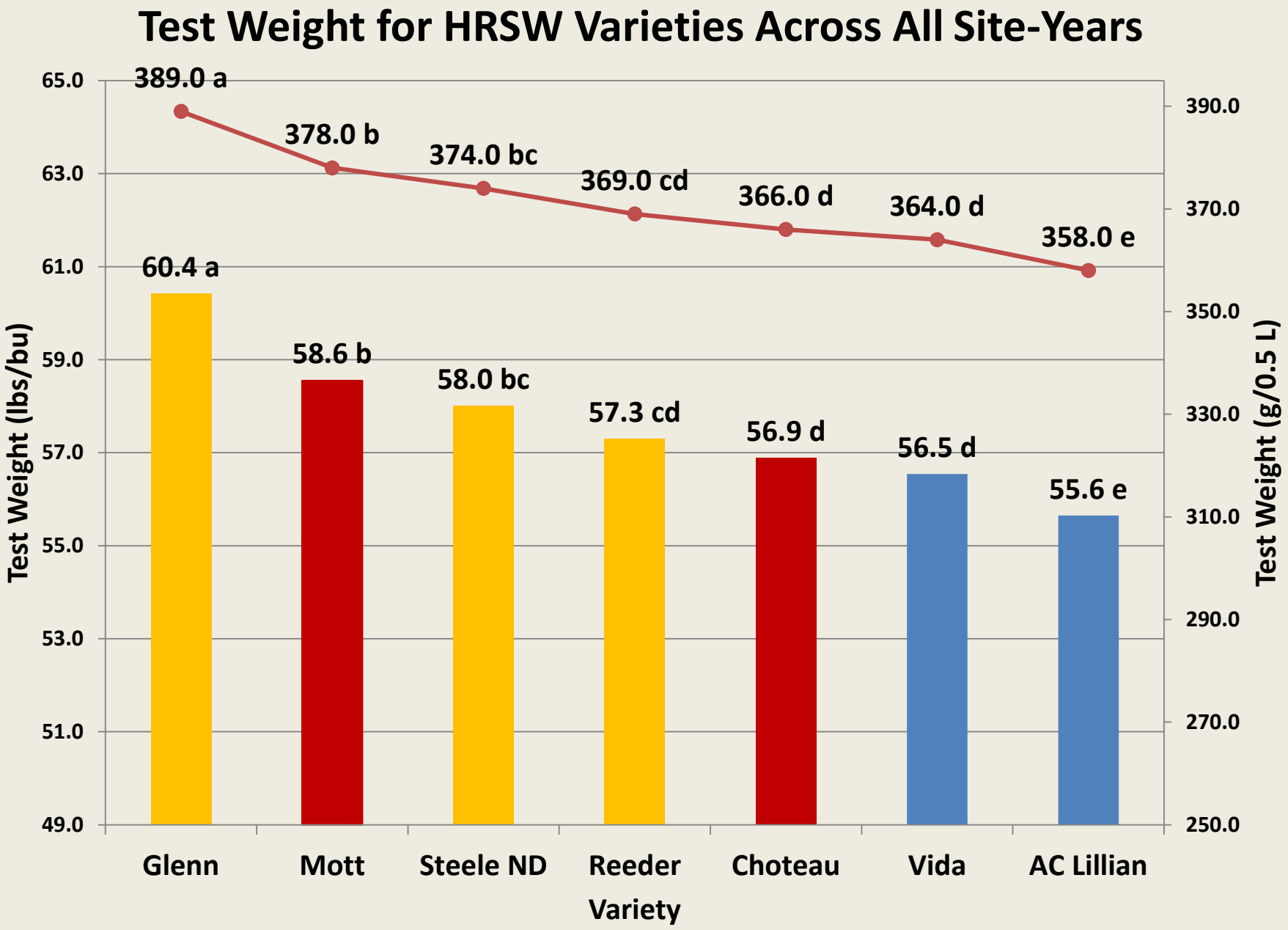

| Year | Mean |
|---|---|
| 2009 | 2.77 a |
| 2010 | 2.26 b |
| 2011 | 1.59 c |



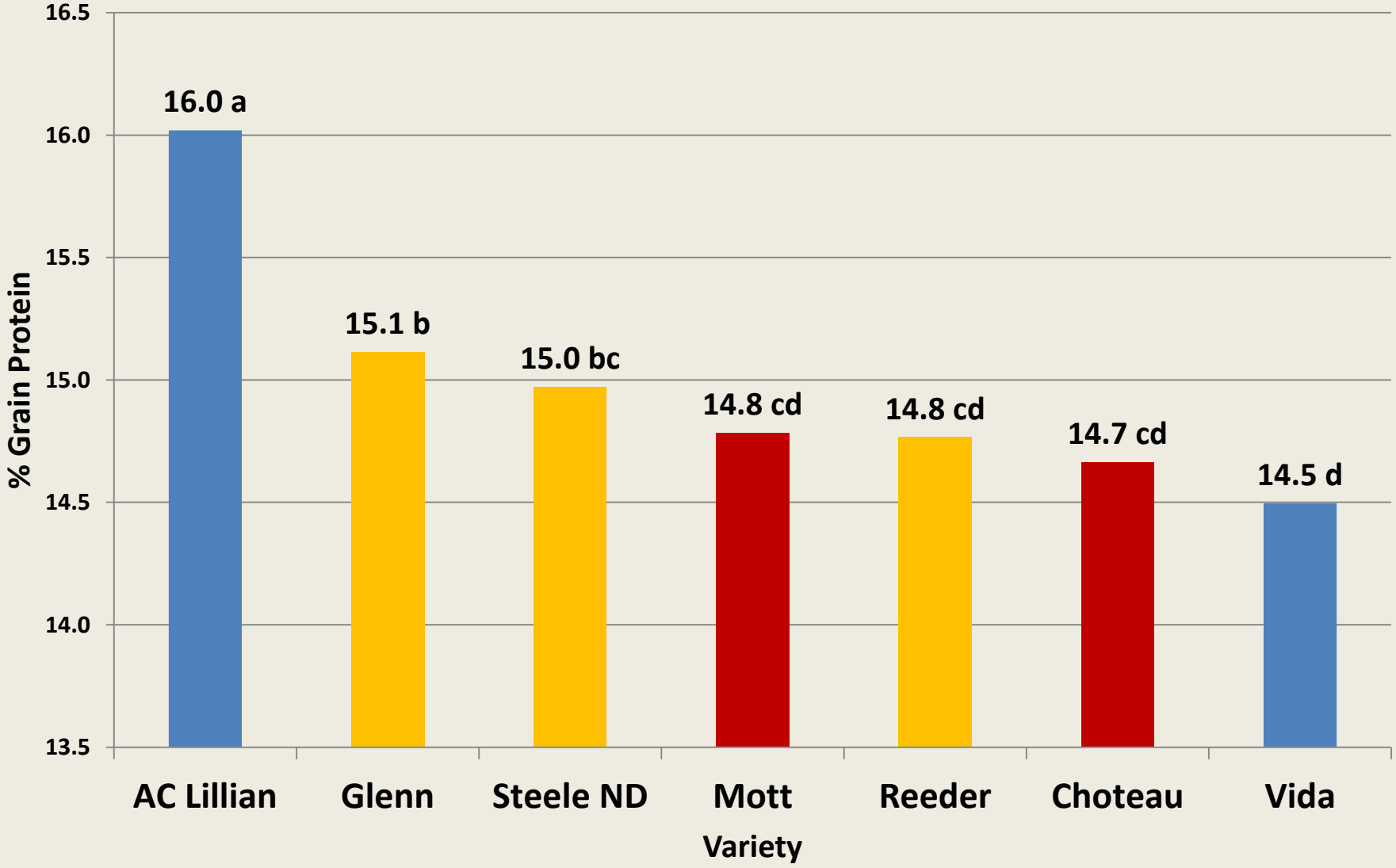

| Year | Mean |
|---|---|
| 2009 | 3.85 a |
| 2010 | 3.29 b |
| 2011 | 3.40 b |

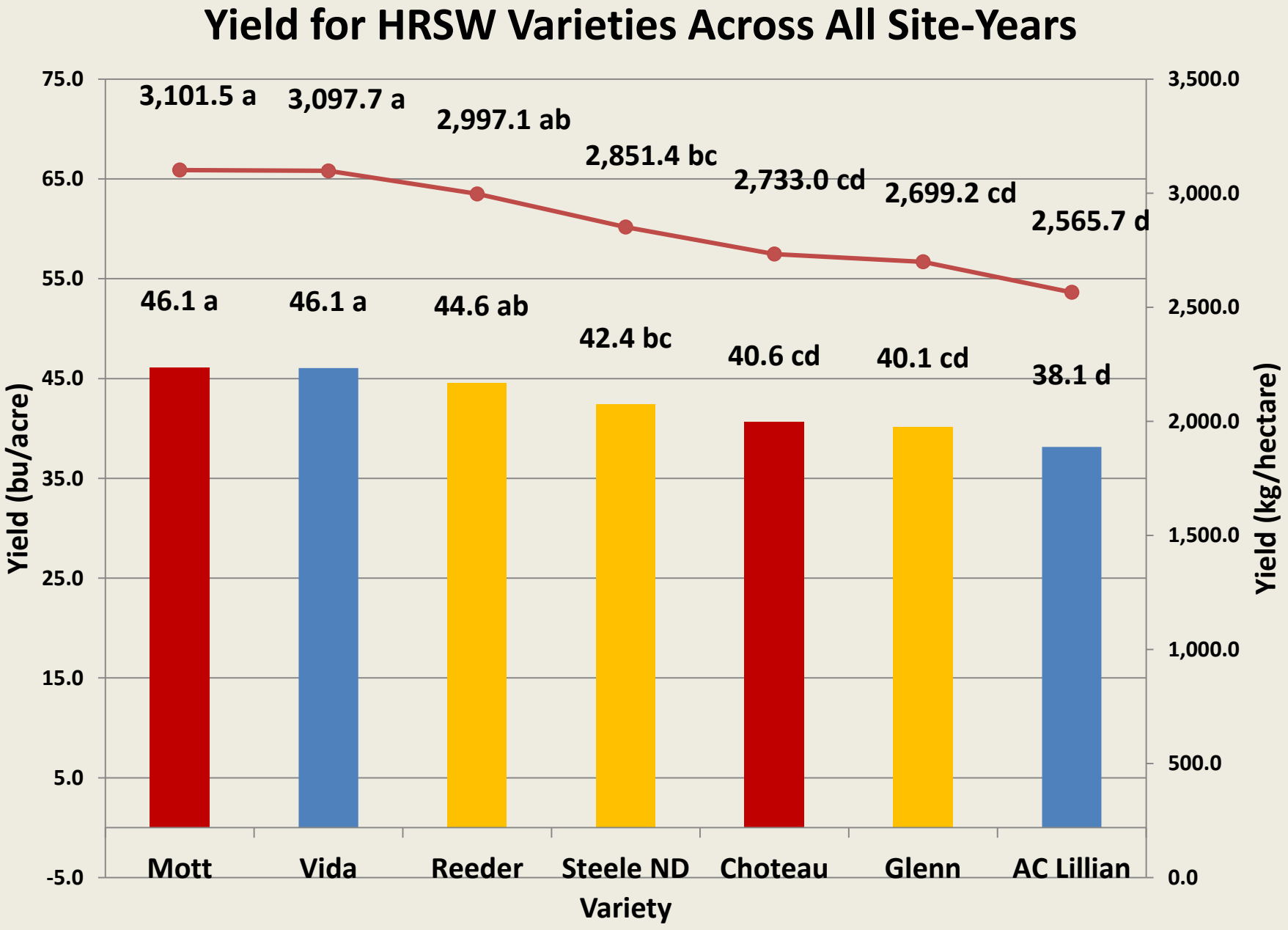
# Conclusion

- **Wheat stem sawfly infestation is influenced by**
  - **Wheat stem sawfly density**
  - **Solidity of stem**


Test Weight for HRSW Varieties Across All Site-Years
389.0 a
378.0 b
374.0 bc
369.0 cd
366.0 d
364.0 d
358.0 e
60.4 a
58.6 b
58.0 bc
57.3 cd
56.9 d
56.5 d
55.6 e
65.0
63.0
61.0
59.0
57.0
55.0
53.0
51.0
49.0
390.0
370.0
350.0
330.0
310.0
290.0
270.0
250.0
Test Weight (lbs/bu)
Test Weight (g/0.5 L)
Glenn
Mott
Steele ND
Reeder
Choteau
Vida
AC Lillian
Variety

# Percent Grain Protein for HRSW Varieties Across All Site-Years



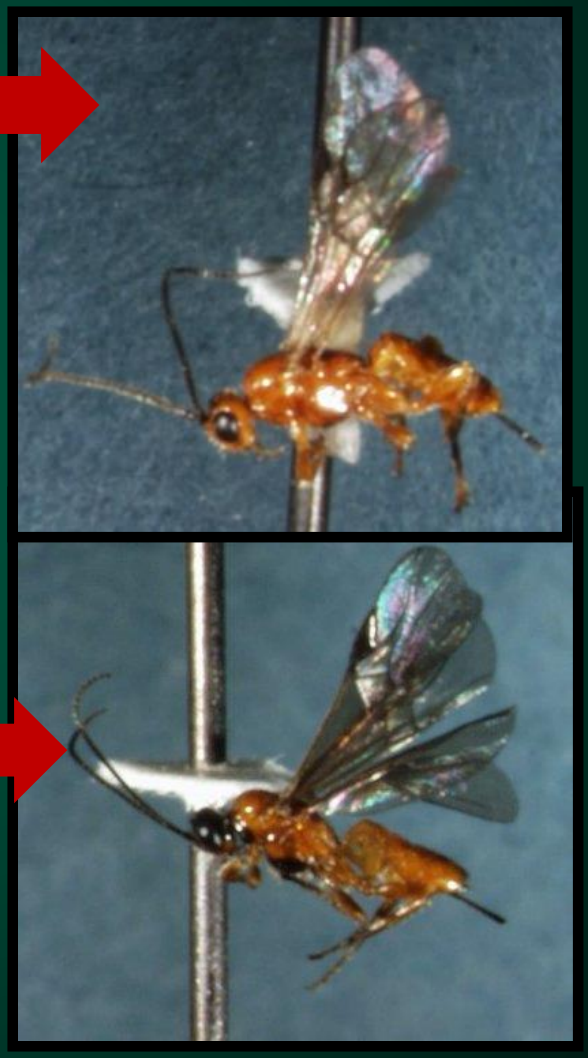

Yield for HRSW Varieties Across All Site-Years
3,101.5 a
3,097.7 a
2,997.1 ab
2,851.4 bc
2,733.0 cd
2,699.2 cd
2,565.7 d
46.1 a
46.1 a
44.6 ab
42.4 bc
40.6 cd
40.1 cd
38.1 d
Yield (bu/acre)
Yield (kg/hectare)
75.0
65.0
55.0
45.0
35.0
25.0
15.0
5.0
-5.0
3,500.0
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
0.0
Mott
Vida
Reeder
Steele ND
Choteau
Glenn
AC Lillian
Variety

# Conclusion

- **Solid-stemmed Mott higher test weight except for hollow-stemmed Glenn and Steele ND**
- **Semi solid-stemmed AC Lillian has the highest protein with Mott in the middle**
- **Mott had the highest yield and comparable to Reeder and significantly higher than Steele ND, Choteau, Glenn and AC Lillian.**

# Biological Control

- *Bracon cephi* (Gahan)
  - Wheat
  - Effective in solid-stemmed wheat varieties
- *Bracon lissogaster Muesebeck*
  - Native grasses



Source: D. Weaver, UMT

# *Bracon cephi and Bracon lissogaster* (Hymenoptera: Braconidae)

- Paralyze host, deposit egg on or near host
- Ectoparasites
- 1+ parasitoid / sawfly
- Development time = 2-3 weeks
- 1+ generations / yr
- Overwinter as pupa

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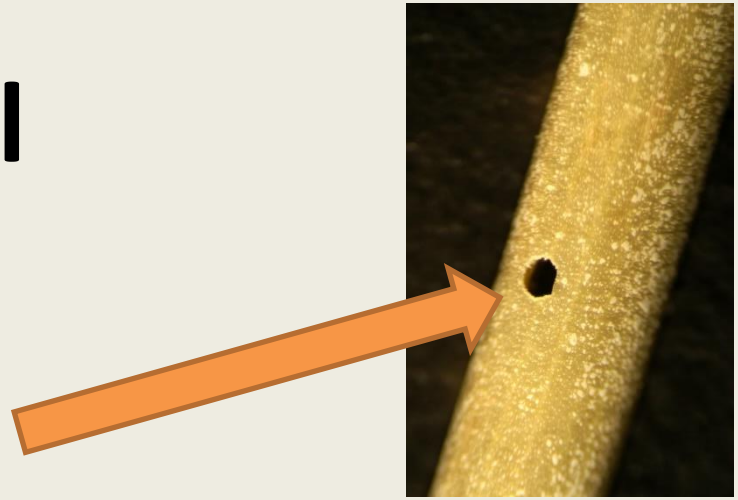
# Biological Control



- *Bracon* spp.
  - Bivoltine (2 generations a year)
  - Female wasp locates sawfly larvae in stem, inject venom and paralyzes it (Beres et al. 2011)
  - Terminates feeding and stems are NOT cut
  - Parasitoids reduce sawfly survival and head damage
  - Parasitism rate can exceed >80% in some fields and caused declines in sawfly populations over several years (Peterson et al. 2011)
  - In high sawfly populations, parasitoids are not sufficient to prevent economic losses (Morrill et al. 1998)

# Parasitoid Conservation


Taller residue is better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*Source: D. Weaver, MSU*


Negative – Destroy parasitoids!

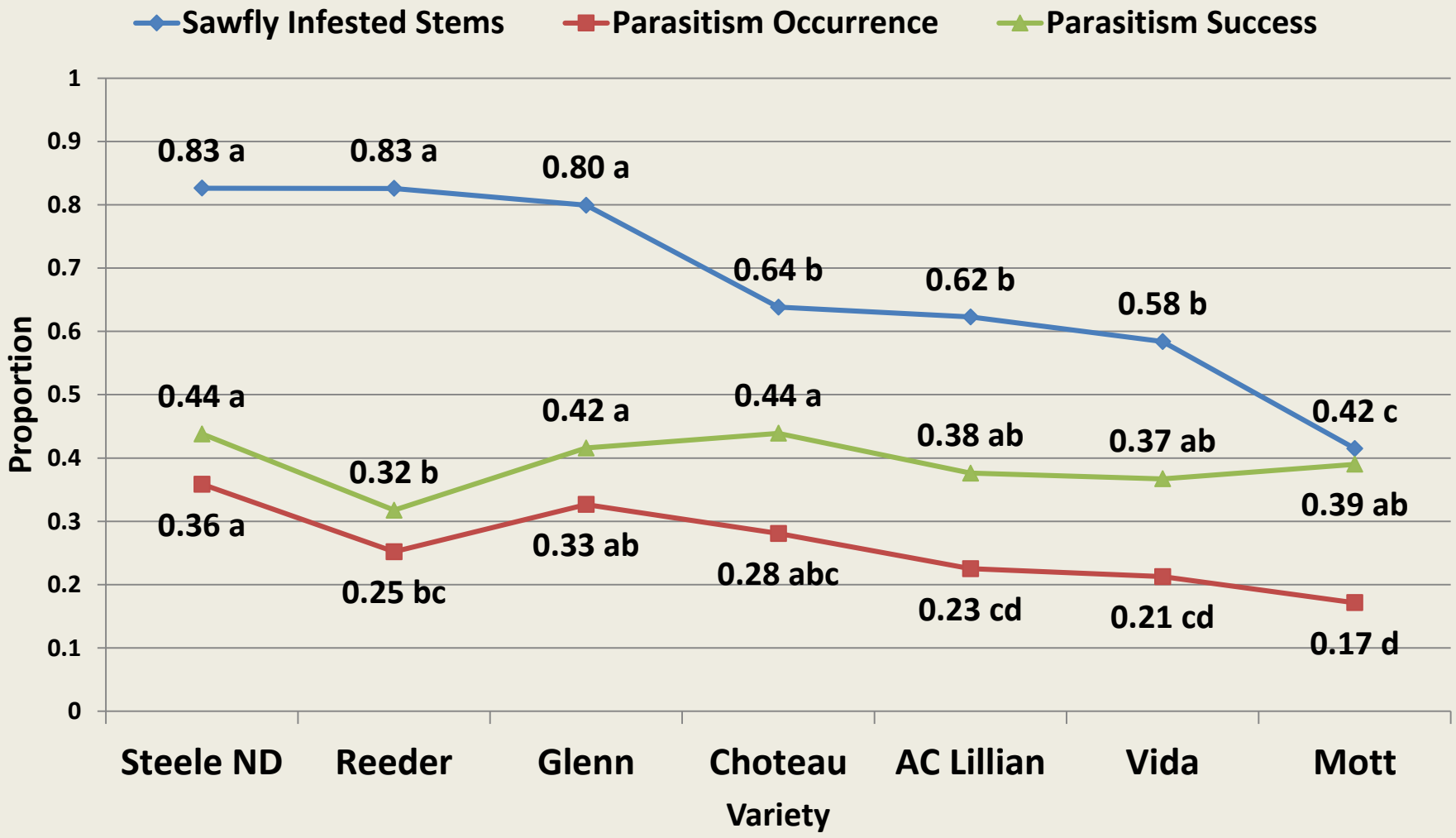
# Survey of *Bracon spp.* 1999-2001

## Wheat Stem Sawfly Parasitoids

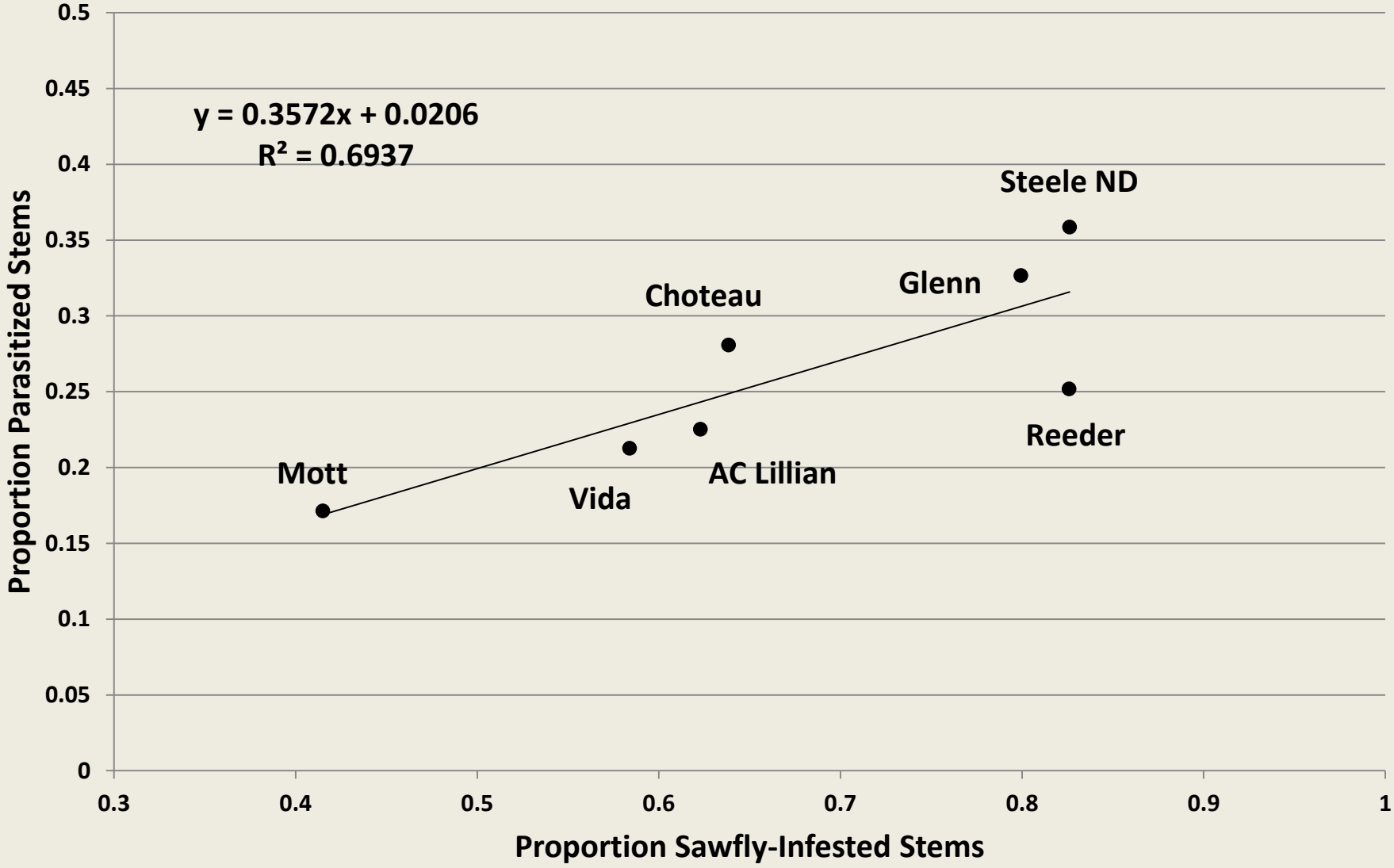

- **Found in 50% of fields surveyed where WSS was present**
- **Parasitism levels: MT = 6.9%, NE = 7.7%, ND= 3.1%**
- **Positive linear regression between parasitism and WSS larvae infested stems**

***Shanower and Waters (2006) J. Ent. Sci.***

# Sawfly Damaged Stems, Parasitism Occurrence, and Parasitism Success Across Five Site-Years With Sawfly and Parasitoid Occurrence



# Relationship Between Sawfly Occurrence and Parasitism Occurrence



# Summary

- **Solid-stemmed spring wheat varieties did not negatively impact parasitism of wheat stem sawfly by *Bracon* spp.**
- **Parasitism rates were positively correlated to wheat stem sawfly infested stems.**

# Insecticide Usage in Wheat Increased in North Dakota

- **2004**
  - **218.9 acres treated (2.6%)**
    - **1.3% OP, 0.3% Pyrethroids, 1% other**
- **2008**
  - **718.4 acres treated (7.9%)**
    - **3.9% OP (Chlorpyrifos), 1.6% Pyrethroids, 2.4% others**
- **2012**
  - **1586.8 acres treated (20.2%)**
    - **6.6% OP (Chlorpyrifos), 4.9% Pyrethroids, 8.7% others**
- **7x Increase in Insecticide use from 2004 to 2012**
  - **Cereal aphids**
  - **Wheat midge**
  - **Grasshoppers**
  - **Wheat stem maggot**
  - **Wheat stem sawfly?**

*Source: Zollinger et al., NDSU Ext .Service, Pesticide Use and Pest Management Practices in ND 2004, 2008 and 2012.*

# Insecticide Treatments and Timings

- Untreated check (naked seed)
- Foliar insecticide
  - Warrior® (lambda-cyhalothrin), 22 g ai/ha (2.56 fl oz/A)
    - 4-6 leaf
    - Flag leaf
- Seed treatment (ST)
  - Cruiser 5FS® (thiamethoxam), Syngenta Crop Protection
    - Low rate = 39 g ai/100 kg (1 fl oz/cwt)
    - High rate = 50 g ai/100 kg (1.33 fl oz/cwt)
  - Foliar insecticide on top of low rate ST at 4-6 leaf
- Dividend Extreme® (difenoconazole + mefenoxam), Syngenta Crop Protection
  - 15 g ai/100 kg (2 fl oz/cwt)

# Treatment Means for Wheat Stem Sawfly at Each Location in 2008-2009

| Treatment | Wheat stem sawfly – % damaged stems | | |
|---|---|---|---|
| | Hettinger 2008 | Makoti 2008 | Makoti[2] 2009 |
| Untreated check | 28.0 ± 6.3a | 75.0 ± 6.0a | 86.5 ± 4.1a |
| Low seed treatment | 33.0 ± 8.5a | 74.0 ± 2.6a | 89.8 ± 3.7a |
| High seed treatment | 25.0 ± 9.4a | 63.0 ± 7.0a | 92.0 ± 2.8a |
| 4–6 leaf foliar treatment | 27.0 ± 6.8a | 69.0 ± 3.0a | 83.0 ± 5.0a |
| Flag-leaf foliar treatment | 22.0 ± 3.5a | 68.0 ± 6.3a | 77.3 ± 7.4a |
| Low seed treatment + 4–6 leaf foliar treatment | 31.0 ± 6.2a | 64.0 ± 7.5a | 73.5 ± 6.4a |

Means within a column followed by the same letter are not significantly different (Tukey's HSD, $P < 0.05$).
[1]Data transformed using square root transformation prior to analysis. Actual means are presented in the table.
[2]Data transformed using arcsine square root transformation prior to analysis. Actual means are presented in the table.

# Treatments Means for Grain Yield

| | 2008 | 2009 |
|---|---|---|
| | Makoti | Makoti |
| Treatment | Grain yield (bu/acre) | Grain yield (bu/acre) |
| Untreated check | 25.9 ± 1.0a | 42.3 ± 1.4a |
| Low seed treatment | 26.9 ± 0.7a | 42.3 ± 0.8a |
| High seed treatment | 26.4 ± 1.3a | 43.9 ± 2.3a |
| 4–6 leaf foliar treatment | 26.3 ± 1.5a | 41.2 ± 2.1a |
| Flag-leaf foliar treatment | 26.5 ± 1.3a | 42.8 ± 2.5a |
| Low seed treatment + 4–6 leaf foliar treatment | 26.3 ± 1.2a | 43.2 ± 1.9a |

Means within a column followed by the same letter are not significantly different (Tukey's HSD, $P < 0.05$).

# Wheat Stem Sawfly (WSS) Conclusions

- **Different insecticide mode of actions, application methods and timings were NOT effective for WSS pest management**
- **Using crop growth stages for timing of insecticide applications were not always associated with WSS emergence and flights**
- **Why?**
  - **Adult WSS emergence period is long (≈1 month)**
  - **Adult WSS has a short life span and spends little time feeding or imbibing water, so insecticides would only kill by 'contact' at time of application (Wallace & McNeal 1966)**

# Wheat Stem Sawfly (WSS) Conclusions

- **Why?**
  - **Eggs, larvae and pupae are protected inside stem (Criddle 1923)**
  - **Most foliar insecticide short residual of <7-10 days**
  - **Adult WSS prefer to oviposit in stems of spring wheat during stem elongation (60-70 days after planting) (Criddle 1923)**
    - **Seed treatment - Thiamethoxam residual = 30-40 days**
- **Extension outreach**
  - **Against unnecessary use of insecticides for WSS control**
- **Knodel et al. 2009. *J. Agric. Urban Entomol.* 26 (4): 183-197.**

# Odds good for drought extending Into 2018

Adnan Akyuz, state climatologist and professor of climatological practice at NDSU

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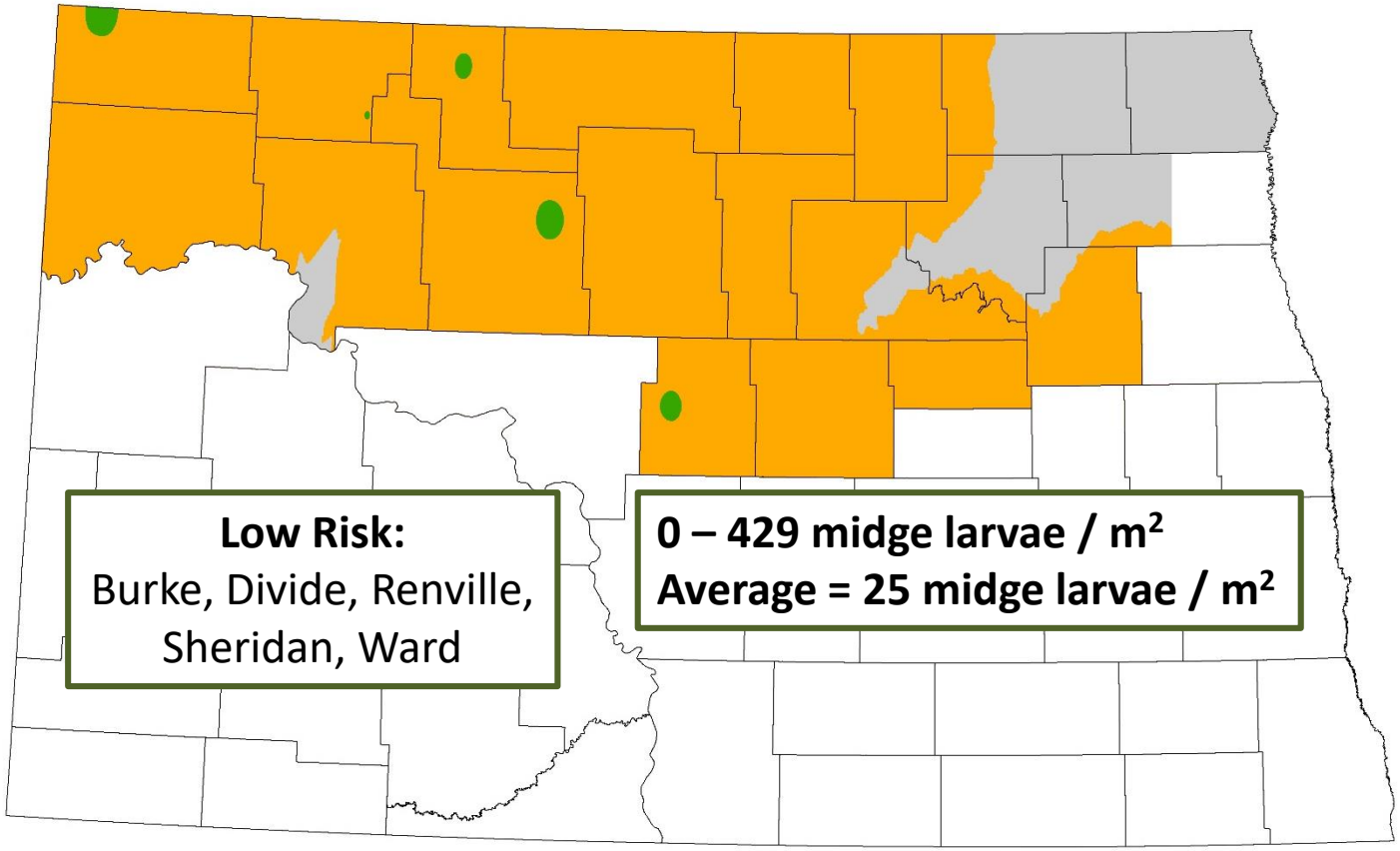
# 2015 Wheat Midge Larval Survey
# North Dakota

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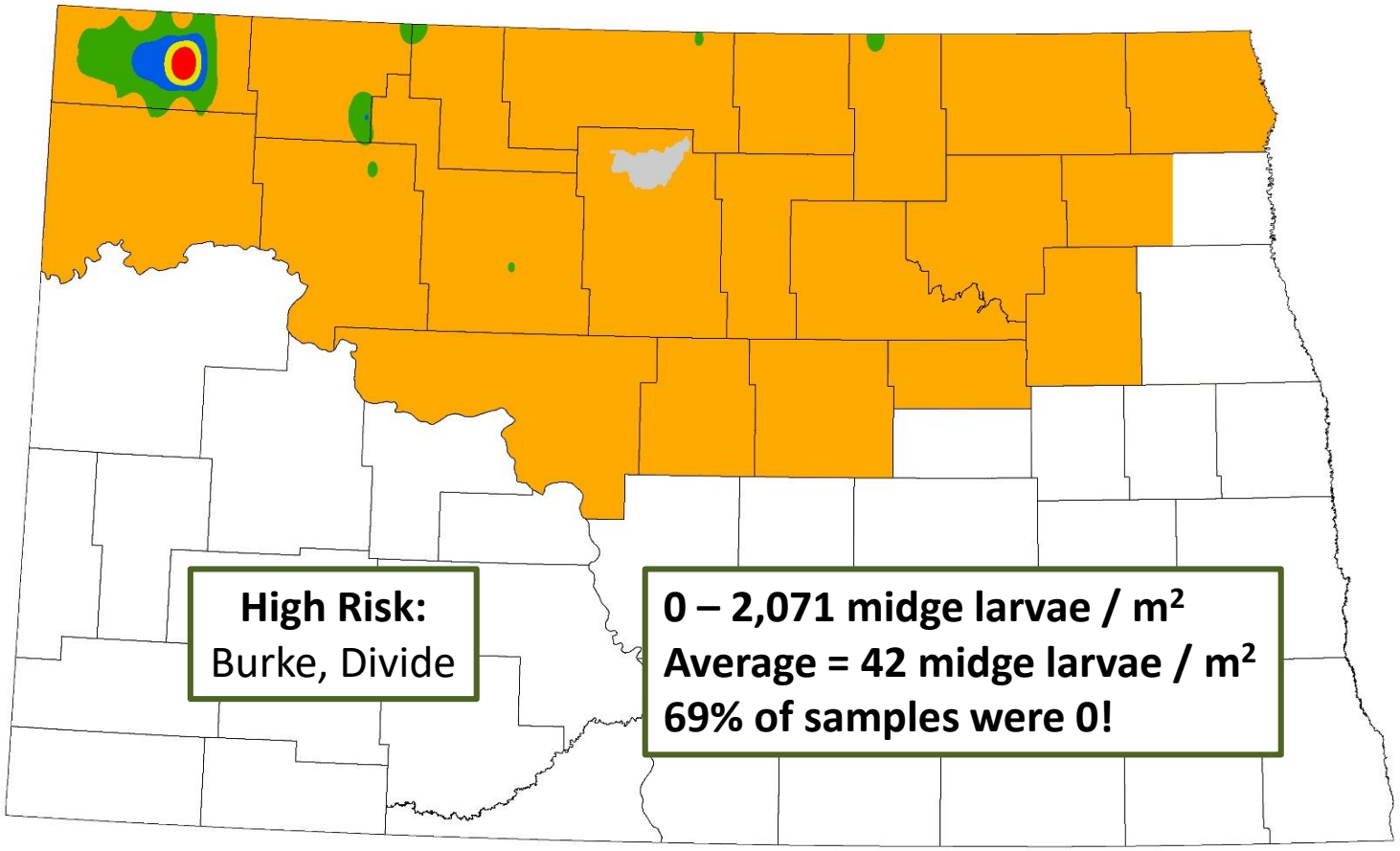
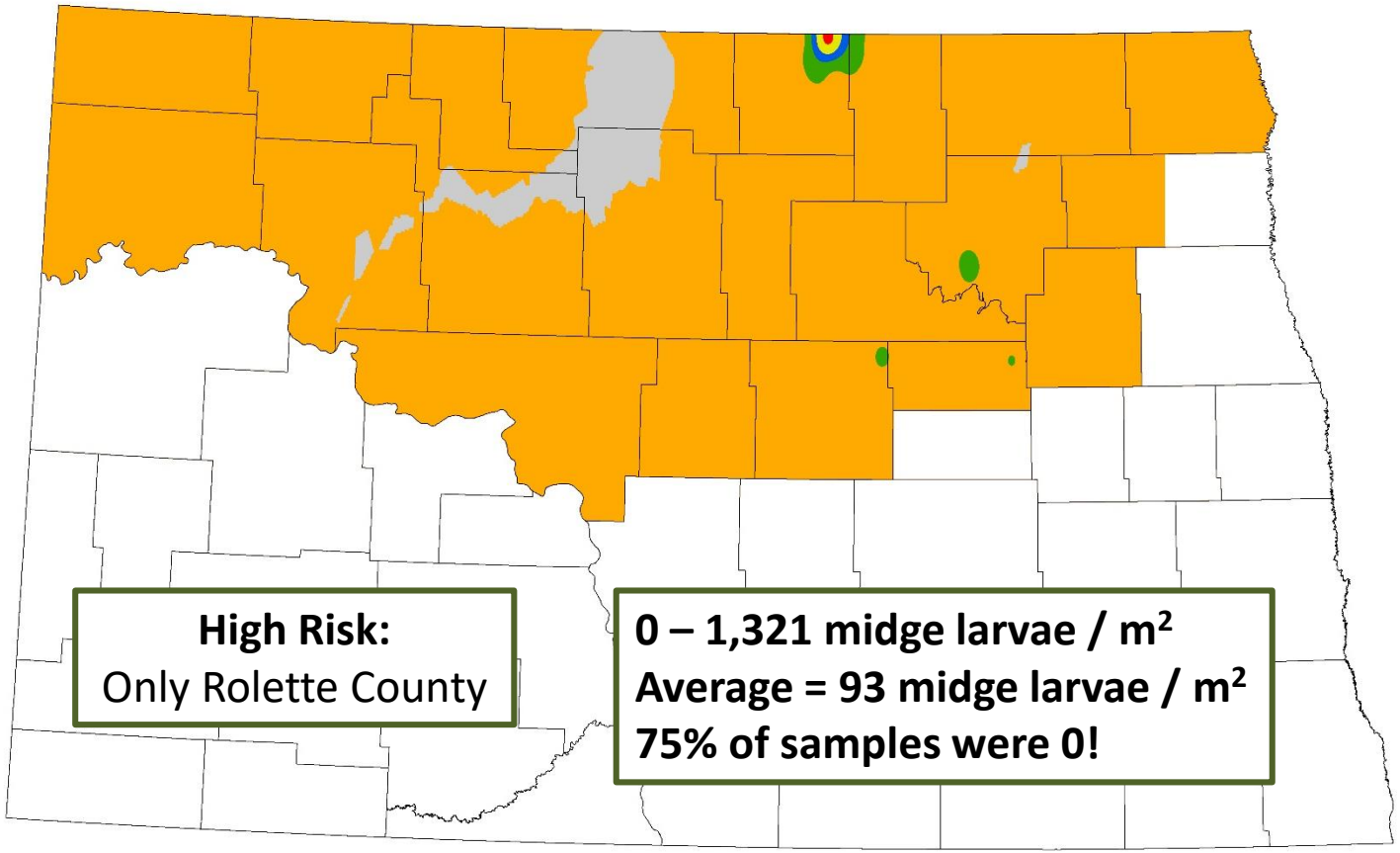
# 2016 Wheat Midge Larval Survey
# North Dakota




NORTH DAKOTA WHEAT COMMISSION

NDSU EXTENSION SERVICE

# 2017 Wheat Midge Larval Survey
# North Dakota

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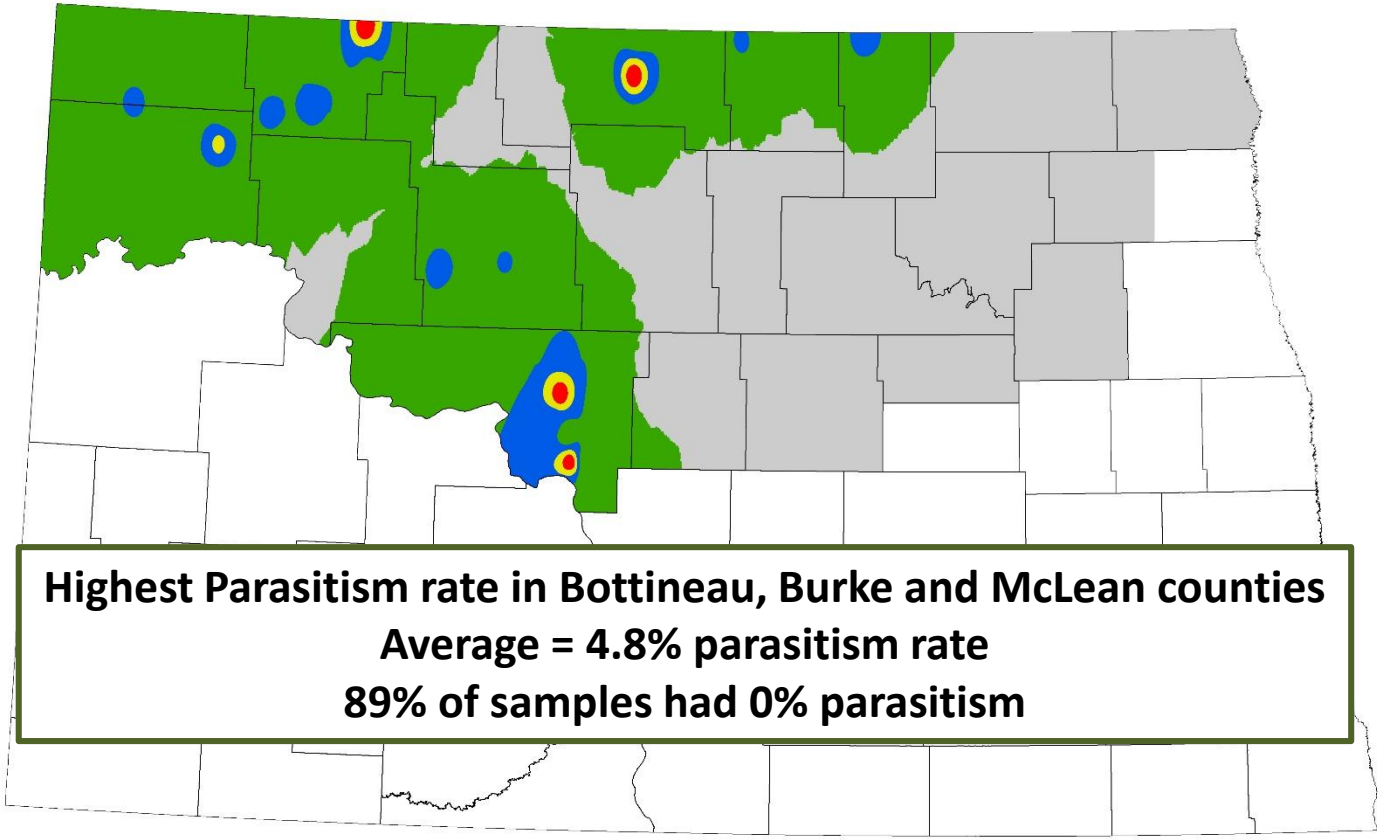
# 2016 Wheat Midge Larval Survey
# Percent Parasitism
# North Dakota



**Highest Parasitism rate in Bottineau, Burke and McLean counties**
**Average = 4.8% parasitism rate**
**89% of samples had 0% parasitism**

Percent parasitized midge larvae

0 | 1-25 | 26-50 | 51-75 | 76-100 | Not surveyed

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# Egan Wheat Variety

Egan Wheat field near Kalispell, MT.
*Photo courtesy of MSU NW Ag. Res. Center*

- MSU Spring wheat breeder
  - Dr. Luther Talbert
- Semi-dwarf
- Resistance to strip rust
- High grain protein
- Available at Montana Seed Program for production and certification
  - Certified blend
  - Lake Seed, Inc. in Ronan, MT. (http://lakeseedinc.com)

# RIB…Refuge In Bag

# Data from MSU - NW Ag. Res. Center

Effect of Sm1 genetic resistance on OWBM, 2012.

| Cultivar | OWBM no./spk | Yield bu/A | Protein % | TWT lb/bu | FN sec |
|---|---|---|---|---|---|
| REEDER | 46 | 34 | 16.7 | 59 | 180 |
| HANK | 102 | 15 | 16.1 | 52 | 193 |
| EGAN | 0 | 52 | 17.8 | 56 | 326 |



*Source: Bob Stougaard, Montana State University Northwestern Agricultural Research Center*

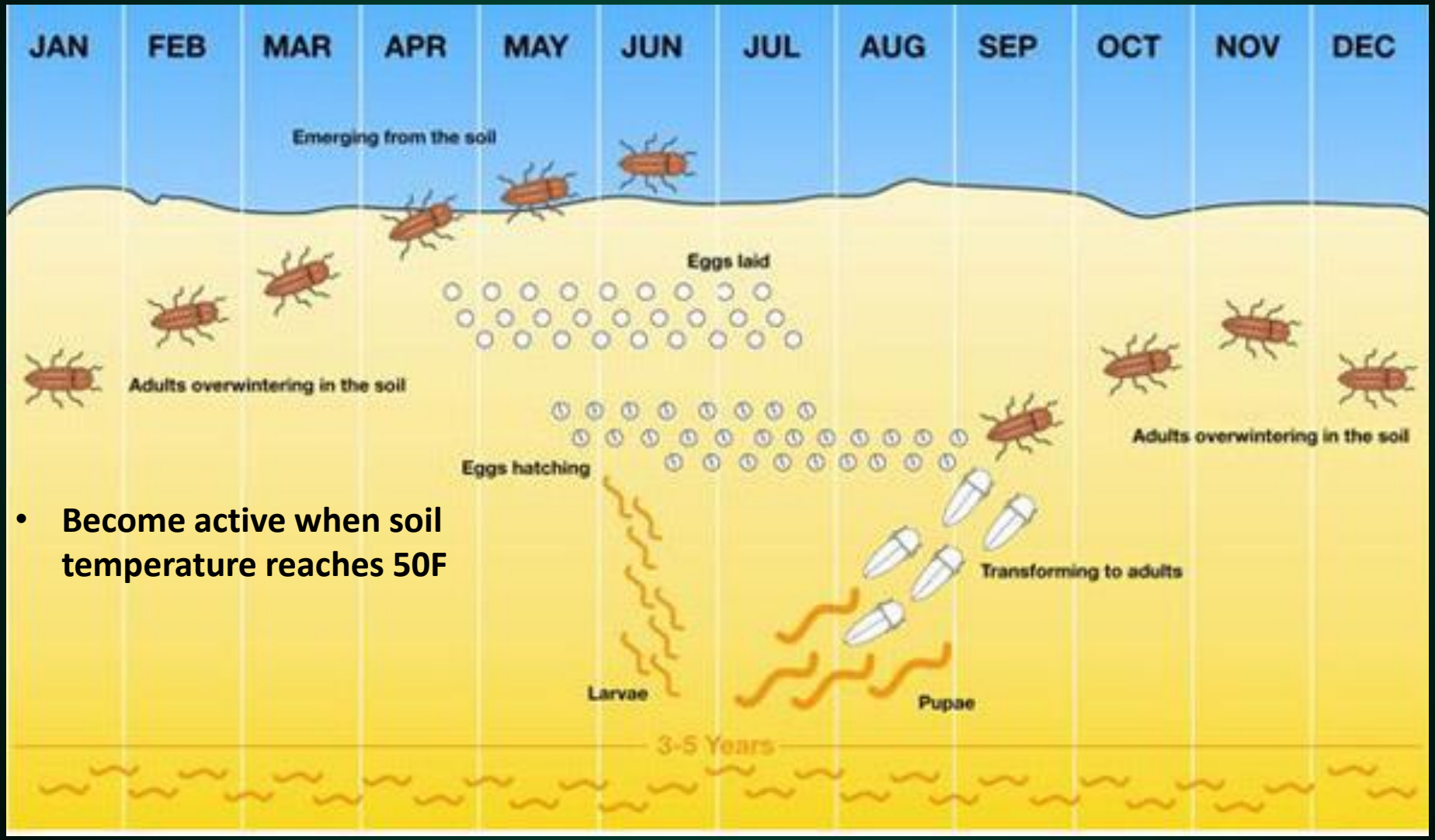
# Wireworms

- Family Elateridae (click beetles)
- Several species in our area
- 3 to 5 year life cycle
- Adults and larvae overwinter in soil from 9” to 24” deep


S. Brown, Univ. GA, bugwood.org

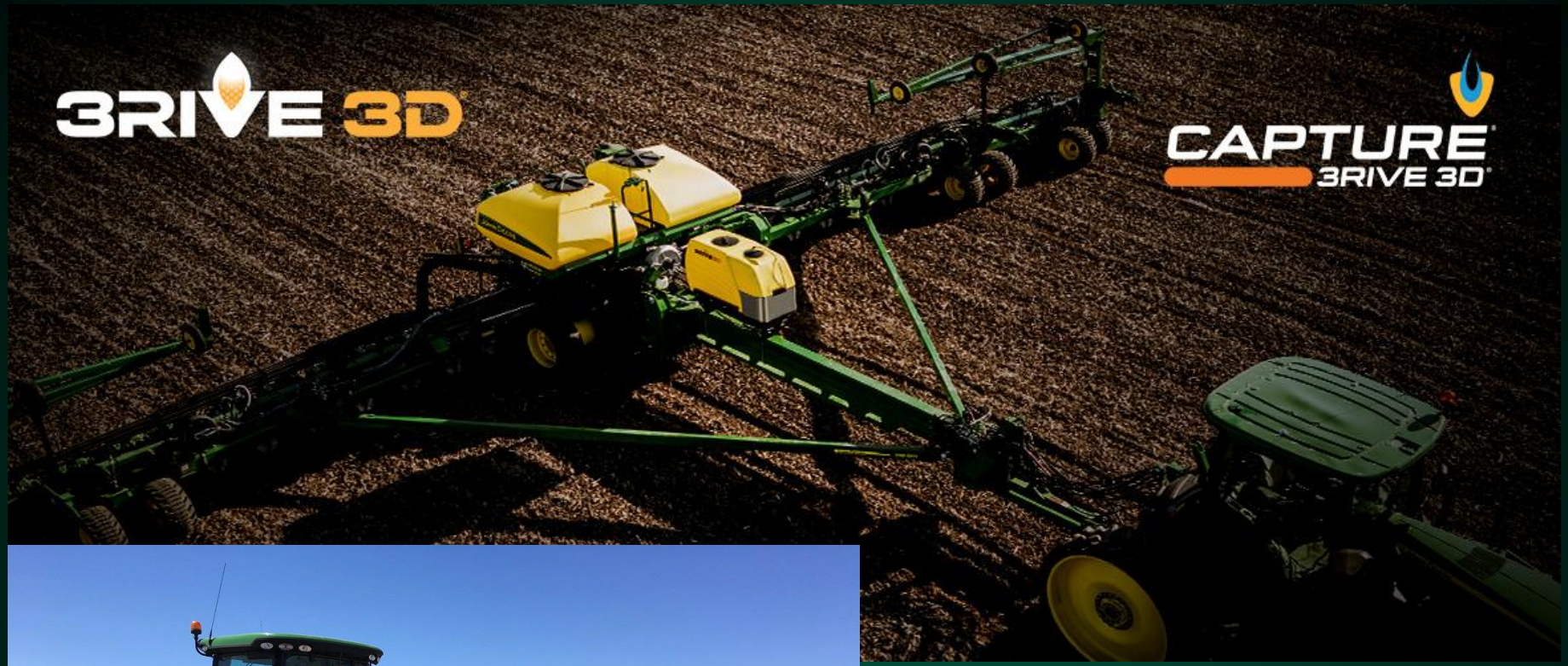

M. Boetel, NDSU

# Wireworms Life Cycle

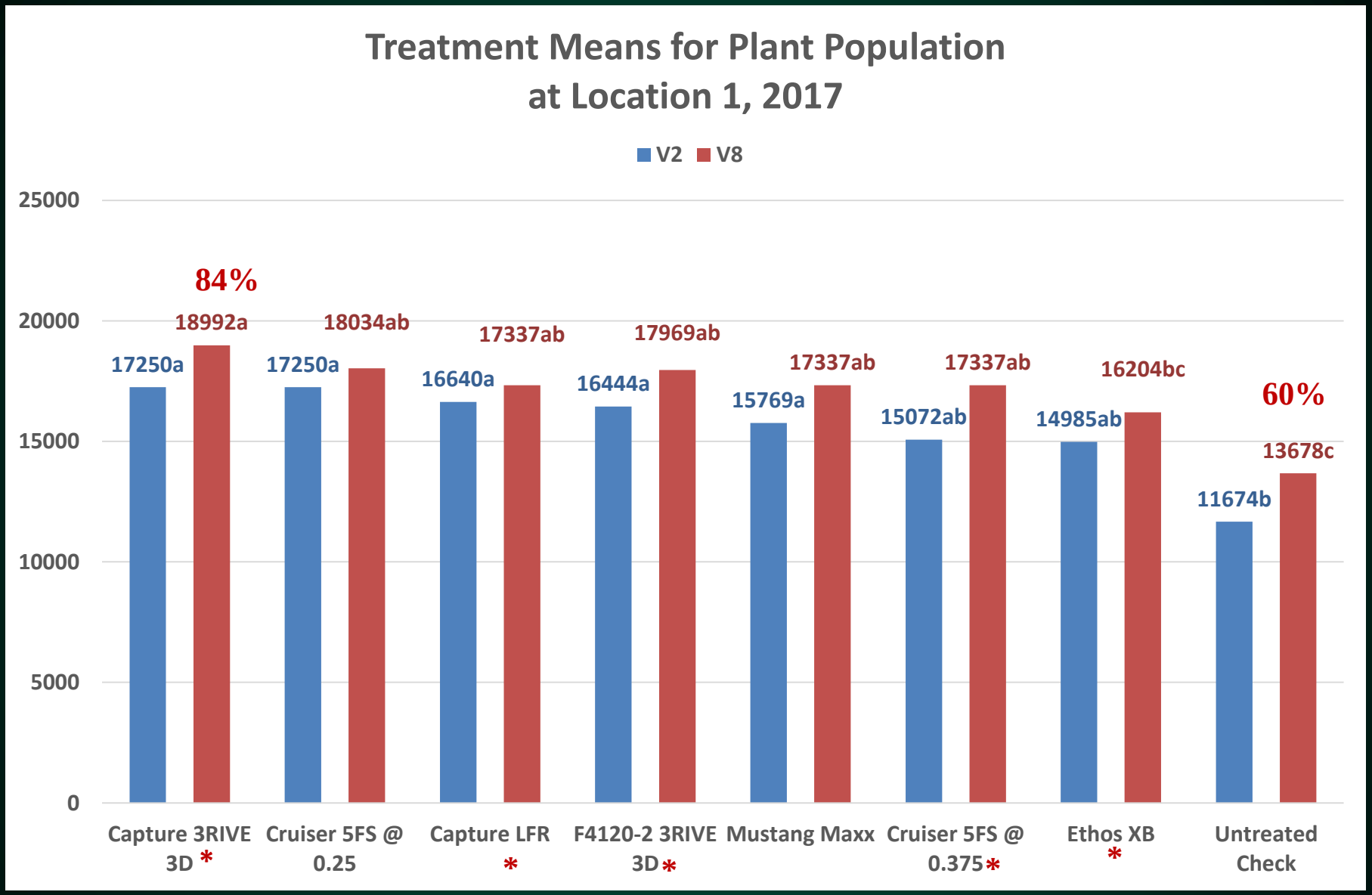



- **Become active when soil temperature reaches 50F**

# If more than one wireworm per trap, use soil insecticide (t-band or in furrow) or insecticide seed treatment!


- In-furrow foam system from FMC
- Cover more ground in less time with fewer water refills
- Saves water, fuel, labor and time




**Seeding rate = 22,650 seeds per acre**

*** Not labeled in sunflowers**

# Wireworm Root Injury


Photo by J. Knodel

Rating 10

Rating 1

Untreated check
Damaged by wireworm

Insecticide treated
Not damaged by wireworm

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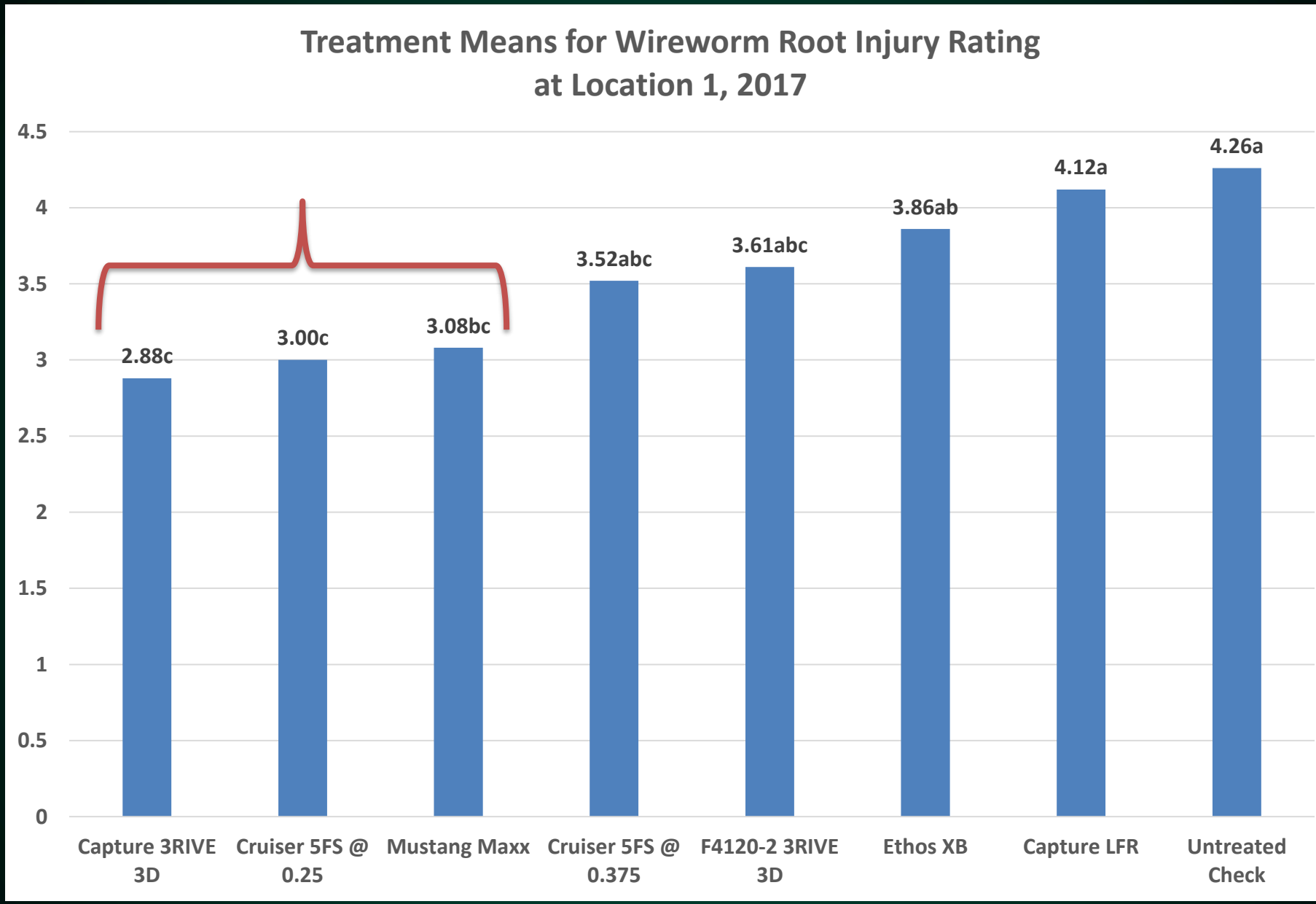
Treatment Means for Wireworm Root Injury Rating at Location 1, 2017
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2.88c
3.00c
3.08bc
3.52abc
3.61abc
3.86ab
4.12a
4.26a
Capture 3RIVE 3D
Cruiser 5FS @ 0.25
Mustang Maxx
Cruiser 5FS @ 0.375
F4120-2 3RIVE 3D
Ethos XB
Capture LFR
Untreated Check

# Wireworm Management

- Thiamethoxam seed treatment and in-furrow pyrethroid applications provided acceptable protection
- Consider your crop rotation and know your field history
- Weed management
- Adjust seeding rate +10% to compensate for wireworm stand loss

Update

E1479 (Revised)

# Integrated Pest Management of Wheat Stem Sawfly in North Dakota

**Wheat stem sawfly adult**
(R.K.D. Peterson, Montana State University)


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## Distribution and History

Wheat stem sawfly, *Cephus cinctus* Norton (Hymenoptera: Cephidae), is widely distributed across North America, from California to the Mississippi River and from British Columbia to Manitoba. It has been reported from as far south as Kansas and New Mexico.

Many authorities consider it a native North American insect that adapted to wheat as European settlers began large-scale cultivation of cereal crops. Alternatively, some researchers have suggested that the wheat stem sawfly may have been introduced into North America inadvertently from northeastern Asia. Whatever its origins, wheat stem sawfly is the most serious insect pest of spring wheat and durum wheat in North Dakota.

Wheat stem sawfly first was reported as a pest of wheat in Saskatchewan and Manitoba in the late 1890s. In 1906, larvae were found attacking wheat in south-central North Dakota. By 1909, losses of up to 25 percent were reported around Minot and in the Red River Valley near Fargo.

The North Dakota infestation reached epidemic levels in 1916 but receded rapidly, and by the early 1920s, wheat stem sawfly was a pest of minor importance. During the 1940s, wheat stem sawfly again became a problem, with as much as 50 percent crop loss reported in northwestern North Dakota.

Sawfly populations have fluctuated across years and locations, although infestation levels and damage are greatest in western North Dakota. Wheat stem sawfly has increased steadily in the past 10 years, with the heaviest economic loss occurring in southwestern North Dakota.

In 2009, a survey of wheat producers statewide revealed that crop loss due to wheat stem sawfly ranged from 10 to 25 percent. However, some fields in southwestern North Dakota had severe lodging, and 100 percent of the spring wheat fields were lost due to wheat stem sawfly in 2009. Based on current production totals and crop values, North Dakota wheat producers lost between $25 million and $70 million in 2009.


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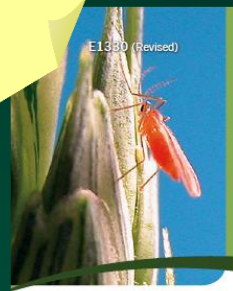

E1330 (Revised)

# INTEGRATED PEST MANAGEMENT of the Wheat Midge in North Dakota


Revised by
**Janet Knodel**, Extension Entomologist and Associate Professor


## Introduction and Distribution

Wheat is the most widely cultivated plant in the world, providing more than 20 percent of the food calories consumed. The wheat midge (or orange wheat blossom midge), *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae), is one of the most destructive pests of wheat. The first reference to a wheat midge larva in wheat was in 1741 in England, although researchers are uncertain if it is the same midge causing trouble today. Wheat midge originated in Europe, and the first record of its occurrence in North America was from Quebec in 1828. Since then, it has been recorded in various locations throughout the Old World and New World, especially in North America, Europe and China. In recent years, wheat midge infestations have been reported in Minnesota, Montana, North Dakota, Alberta, Saskatchewan, Manitoba and British Columbia. In North Dakota, wheat midge occurs throughout the wheat-producing areas and has caused economic damage in the northern tier of the state.

## Host Plants

Wheat midge is an oligophagous insect. Common wheat, *Triticum aestivum* L., is the primary host of the wheat midge throughout its modern distribution in Europe, Asia and North America. All 17 species in the genus *Triticum* are hosts for wheat midge. Other grass hosts include durum wheat (*Triticum durum* Desf.), occasionally rye (*Secale cereale* L.) and barley (*Hordeum vulgare* L.). Wheat midge also will deposit eggs on some grassy weeds, such as quackgrass (*Elymus repens* (L.) Gould), slender meadow foxtail, (*Alopecurus myosuroides* Huds.) and other grasses, but larval development on these grassy hosts is questionable.

## Identification

**Adults** (Figure 1)

The adult wheat midge is an orange-colored, fragile, very small insect approximately half the size of a mosquito. It is about 0.08 to 0.12 inch (2 to 3 millimeters) long with three pairs of long legs. It has a pair of wings, which are oval, transparent and fringed with fine hairs. Two eyes are conspicuous and black.

**Figure 1. Adult wheat midge.**
(Extension Entomology, NDSU)


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https://www.ag.ndsu.edu/extensionentomology/field-crops-insect-pests/wheat

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