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Do Larval Density-Based Thresholds Predict Economic Risk from True Armyworm in Modern Wheat Varieties?

Natasha Weppler[1], Yasmine Farhan[1], David Hooker[1], Jocelyn L. Smith[2]

[1] Department of Plant Agriculture, University of Guelph Ridgetown Campus, 120 Main St. E. Ridgetown, Ontario, N0P 2C0

[2] School of Environmental Sciences, University of Guelph Ridgetown Campus, 120 Main St. E. Ridgetown, Ontario, N0P 2C0

TAW

True Armyworm
Mythimna unipuncta



About the Insect

- True armyworm (TAW) is a **sporadic** agricultural pest in North America
  - Necessitate only occasional control
- Prefers **grass** crops
  - Skeletonize grass foliage
  - Consume leaf material
  - Head clipping in severe infestations
- Annually immigrate from southern USA and Mexico

(OMAFA, 2025a)

Defoliation Effects

TAW Feeding Injury



Head Clipping

Leaf Feeding

(Steinkraus and Mueller, 2013)

Where Does Wheat Yield Come From?

Estimated contributions of wheat photosynthetic organs to grain filling and potential grain yield.

EAR
13-33%
(Maydup et al., 2010)

FLAG LEAF
26%

PENULTIMATE LEAF
13%

ANTIPENULTIMATE LEAF
3%

(Seck et al., 1991)

Defoliation Effects

Impact of True Armyworm (Lepidoptera: Noctuidae) Feeding on Wheat Yields in Arkansas[1]

Donald C. Steinkraus and Arthur J. Mueller

Department of Entomology, University of Arkansas, Fayetteville, AR 72701 USA

J. Entomol. Sci. 38(3): 431-438 (July 2003)

Abstract Wheat leaf consumption by the true armyworm, *Pseudaletia unipuncta* Haworth, was determined in the laboratory in 1993, 1994, and 1995. Total mean wheat leaf area consumed per larva from eclosion to pupation varied significantly from year to year (77.4-135.4 cm^2) with an overall mean leaf area consumed of 103.2 cm^2. Wheat field plots were infested with third-instar armyworms and allowed to consume wheat foliage at boot and anthesis stages until preset defoliation levels were met (0, 10, 25, and 50% defoliation in 1993, and 0, 35, 50, 65, and 75% defoliation in 1994, 1995, and 1996). Overall, no significant differences were seen between treatments in number of heads or mean weight of seeds per head in any year suggesting that at boot and anthesis stages Arkansas wheat can sustain up to 75% defoliation by armyworms with little loss in yield. Even at population levels that resulted in 75% defoliation head cutting was negligible.

Key Words Armyworm, *Pseudaletia unipuncta*, wheat, thresholds, larval feeding



- Wheat tolerated up to 75% TAW defoliation at boot and flowering with minimal yield loss.
- No significant difference in head number or mean seed weight per head among treatments.
- Head cutting remained negligible, even at 75% defoliation.

(Steinkraus and Mueller, 2013)

TAW

True Armyworm
Mythimna unipuncta

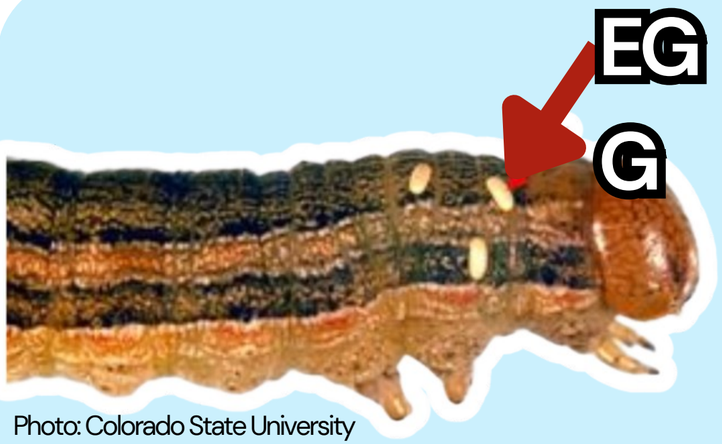


Photo: Colorado State University

4–5 TAW larvae in a 30 cm² area

- Un-parasitized
- < 2.5 cm in length

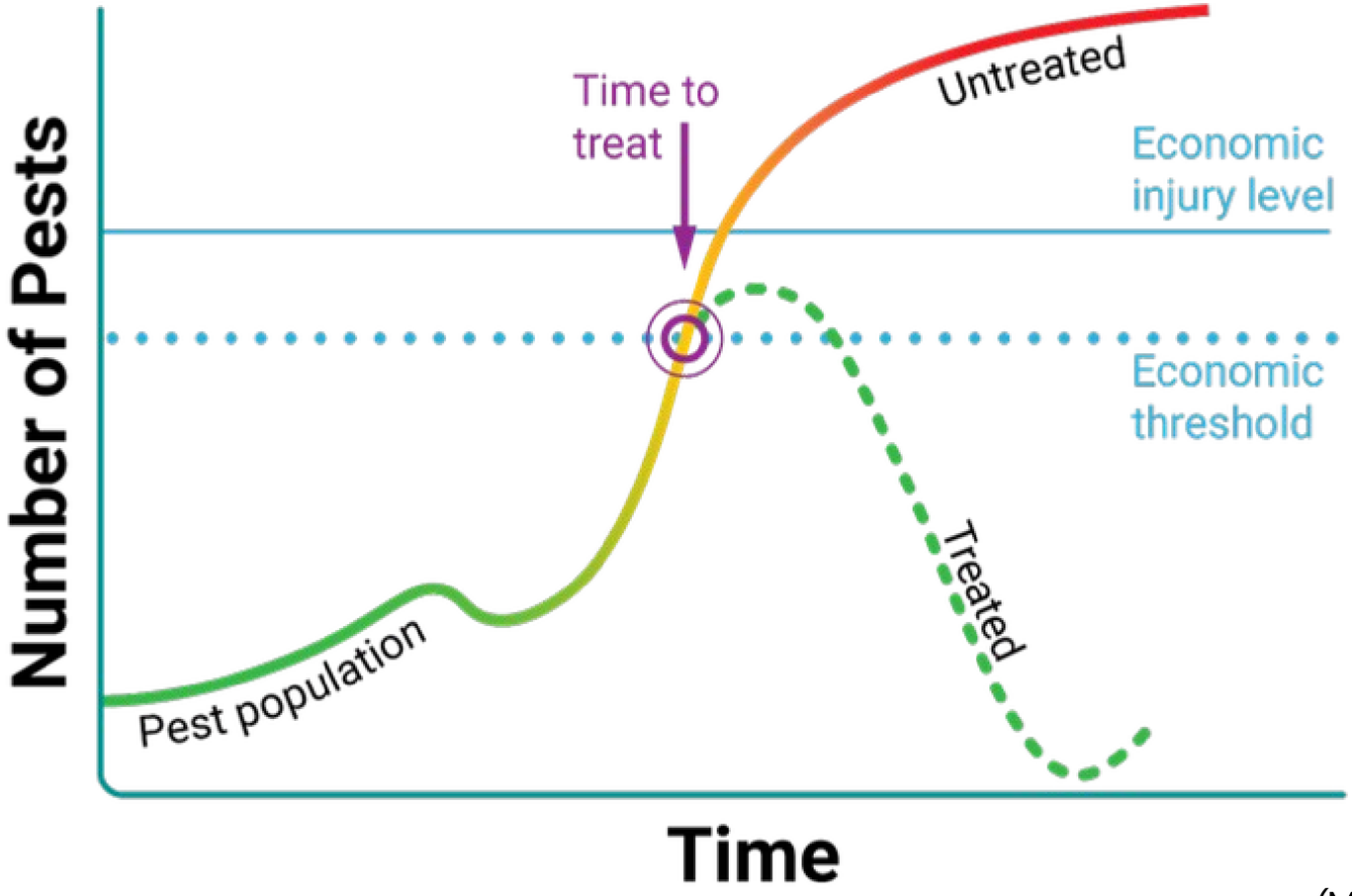
(OMAFA, 2025a)

Recommended Threshold

Economic-Injury Level (EIL)

"The lowest population density of a pest that will cause economic damage; the amount of pest injury which will justify the cost of control."

(Stern et al., 1959)



(MyCrops, n.d.)

TAW

True Armyworm
Mythimna unipuncta

Current Management

Biological Control

- Parasitoids & other predatory species
- Typically keep TAW from reaching damaging levels
- Cool, wet springs are not favourable for TAW parasites

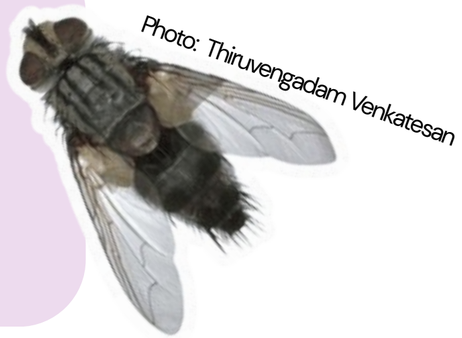


Photo: Thiruvengadam Venkatesan



Chemical Control

- If TAW are >2.5 cm (1 in.) long there is no benefit in spraying insecticide
  - Most of the feeding damage has already occurred
- Treatment may be confined to infested areas
- If migrating from adjacent fields, spraying along a field border may be sufficient

Efficacy: ★★★☆	Efficacy: ★★★☆	Efficacy: ★★★☆	Efficacy: ★★★☆	Efficacy: ★★★☆	Efficacy: ★★★☆	Efficacy: ★★★☆
IRAC 1B	IRAC 1B	IRAC 28	IRAC 5	IRAC 28	IRAC 3A ⚠	IRAC 28
Insecticide*	Insecticide*	Insecticide*	Insecticide*	Insecticide*	Insecticide*	Insecticide*
Malathion 500 EC	**Malathion 85E**	**Coragen**	**Delegate**	**Shenzi 400 SC**	**Matador 120EC**	**Coragen Max**
a.i.(s): malathion	*a.i.(s): malathion*	*a.i.(s): chlorantraniliprole*	*a.i.(s): spinetoram*	*a.i.(s): chlorantraniliprole*	*a.i.(s): lambda-cyhalothrin*	*a.i.(s): chlorantraniliprole*
REI: 12 hour(s)	*REI: 12 hour(s)*	*REI: 12 hour(s)*	*REI: 12 hour(s)*		*REI: 24 hour(s)*	*REI: 12 hour(s)*

(OMAFA, 2025b)

Do Larval Density-Based Thresholds Predict Economic Risk from True Armyworm in Modern Wheat Varieties?

Objective

Evaluate the effects of TAW density, wheat growth stage, and insecticide treatment on grain yield and economic returns to reassess economic thresholds for modern wheat varieties.

Hypothesis

Modern wheat varieties can tolerate greater TAW larval densities without economically significant yield loss, resulting in different economic thresholds than currently recommended.

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Methodology

Experimental Design

TREATMENT	ACTIVE INGREDIENT	RATE (mL/ha)	CEREAL GROWTH STAGE	TAW DENSITY (no. larvae/30cm²)
Non-treated	N/A	N/A	Boot Flowering Milk	0, 4, 32
CoragenMax	chlorantraniliprole	83	Boot Flowering Milk	0, 4, 32
CoragenMax + Miravis Ace	chlorantraniliprole + pydifumetofen + propiconazole	83 1000	Boot Flowering Milk	0, 4, 32

Methodology

Experimental Design

Main Factor: Insecticide Treatment

1 Non-treated	2	1	3
2 chlorantraniliprole	1	2	2
3 tank mix	3	3	1



Methodology

Experimental Design

Sub-Factor: Cereal Growth Stage

1
2
3



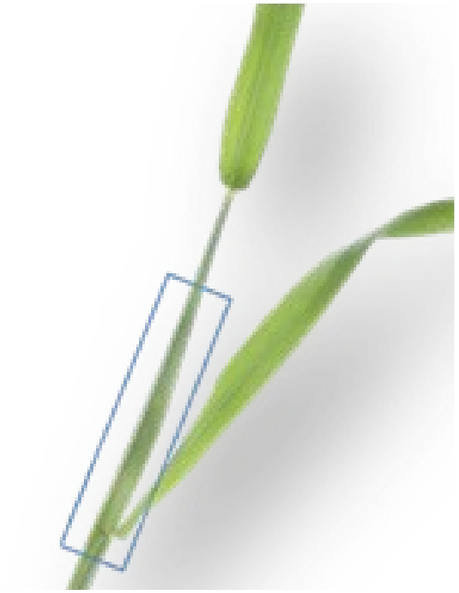
Methodology

Sub-Factor: Cereal Growth Stage

Experimental Design

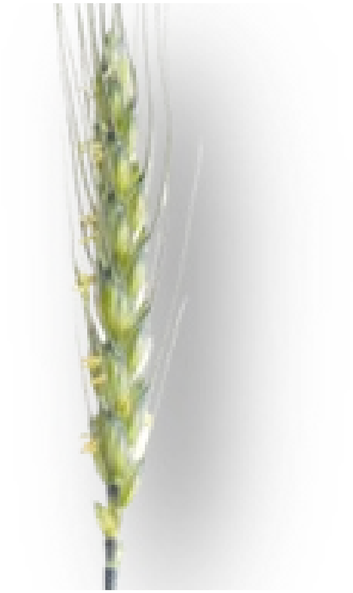
Fusarium Head Blight

1.1	1.3	1.2
3.3	3.1	3.2
2.1	2.2	2.3



X.1 Boot

(GS40-49)
Wheat head in the leaf sheath gives a swollen appearance.



X.2 Flowering

(GS60-69)
Anthers dangle outside the florets to pollinate plant.



X.3 Milk

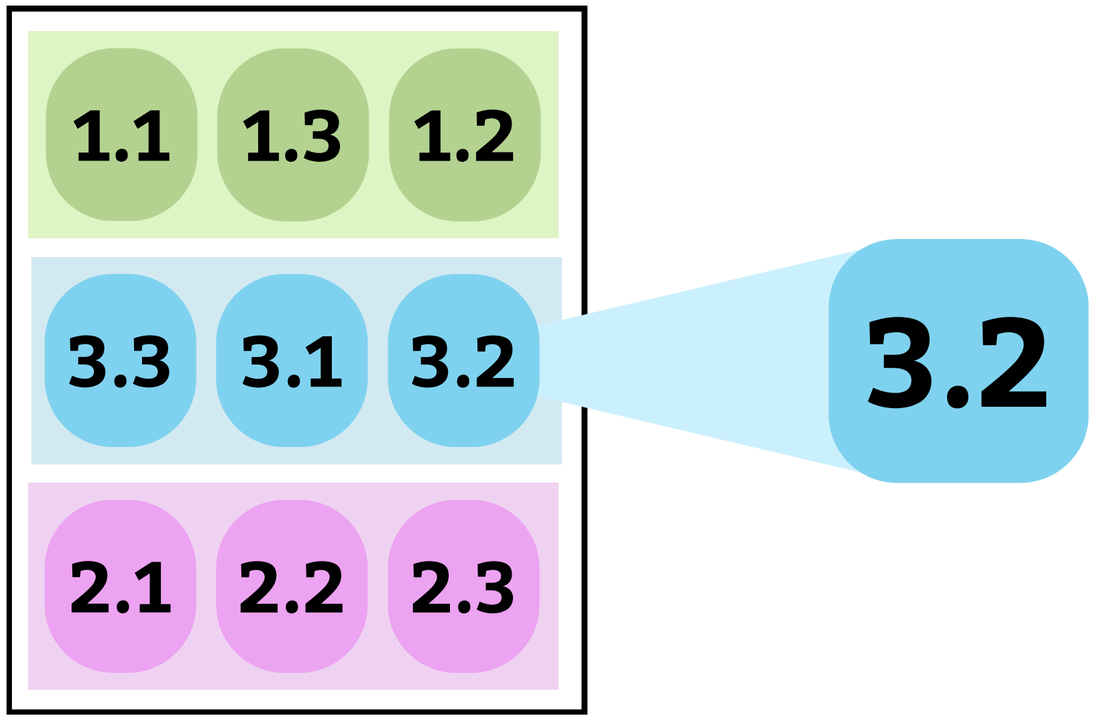
(GS70-79)
Kernels begin to accumulate starch and protein.

(GFO, 2023)

Methodology

Sub-Sub-Factor: Density

Experimental Design



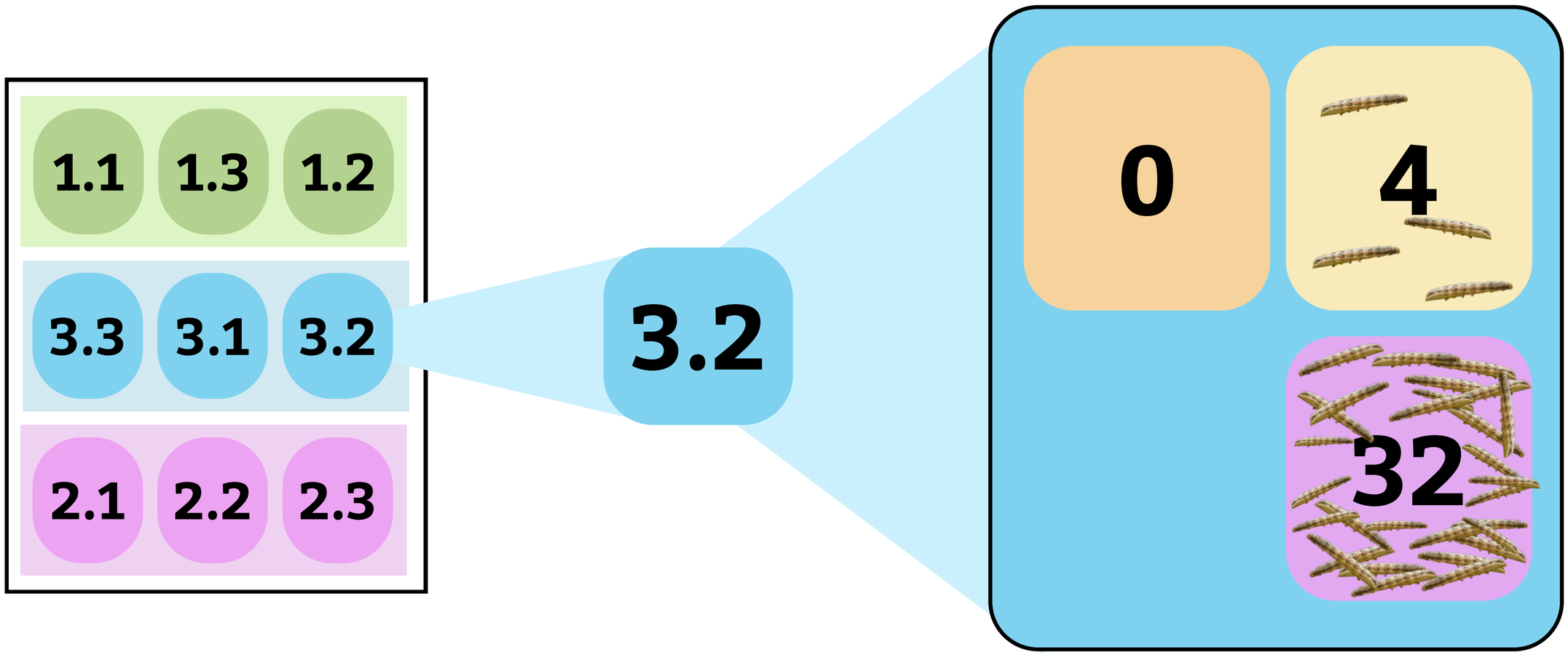


Methodology

Sub-Sub-Factor: Density

Experimental Design

No. 3rd instar TAW per 30 cm²



Methodology

Field Procedures







Ridgetown & Winchester ON

2022-2025

Methodology

Field Procedures

INSECT COLLECTION



MOTH REARING



Temp: 25°C ± 1°C
RH: 90%
Photoperiod: 16h light:8h dark

ENCLOSURE SETUP



Area: 30 cm x 60 cm
Material: No-See-Um mesh
Baseline: Count tillers

ARTIFICAL INFESTATION



- At boot, flowering, and milk stages

Methodology

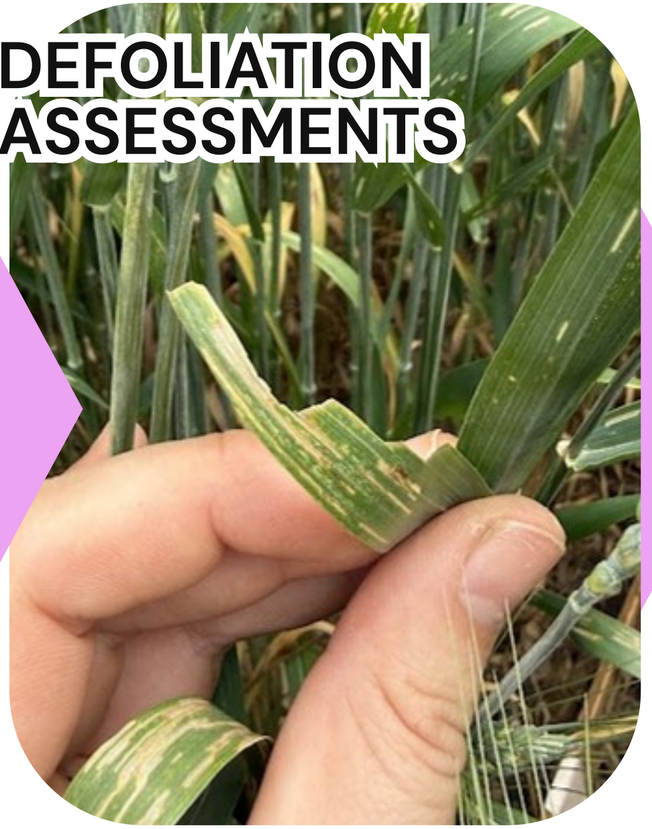
Field Procedures

TREATMENT APPLICATION



- 24h after artifical infestation

DEFOLIATION ASSESSMENTS



- 3, 7, 14, & 21 days after application

IMAGE-J DIGITAL ASSESSMENTS



- 28 days after application

HARVEST



- **Grain Yield**
- Aboveground Biomass
- Seed Count

Methodology

Statistical Analyses

Only data from 2023 winter wheat plots are being presented today.

Flag Leaf Defoliation
Beta Regression

$$\Phi^{-1}(p) = \beta_0 + \beta_1 D + \beta_2 T + \beta_3 S + \cdots$$

Where: p = proportion of flag leaf defoliation; D = larval density; T = insecticide treatment; S = growth stage; β = regression coefficients.

- Analyzed flag leaf injury using PROC GLIMMIX
- Evaluated growth stage × treatment × larval density
- Accounted for repeated observations within plants

Grain Yield (kg/ha)
GLMM Regression

$$\hat{Y} = \beta_0 + \beta_1 D + \beta_2 T + \beta_3 S + \cdots$$

Where: $\hat{Y}$ = predicted grain yield; D = larval density; T = insecticide treatment; S = growth stage; β = regression coefficients.

- Analyzed grain yield using PROC GLIMMIX
- Evaluated growth stage × treatment × larval density
- Compared linear, quadratic, and log-linear models

Yield Loss (kg/ha)
Treatment Comparisons

$$\hat{Y}_L = \hat{Y}_{UN} - \hat{Y}_T$$

Where: $\hat{Y}_L$ = predicted yield difference; $\hat{Y}_{UN}$ = untreated yield; $\hat{Y}_T$ = insecticide-treated yield at the same growth stage and larval density.

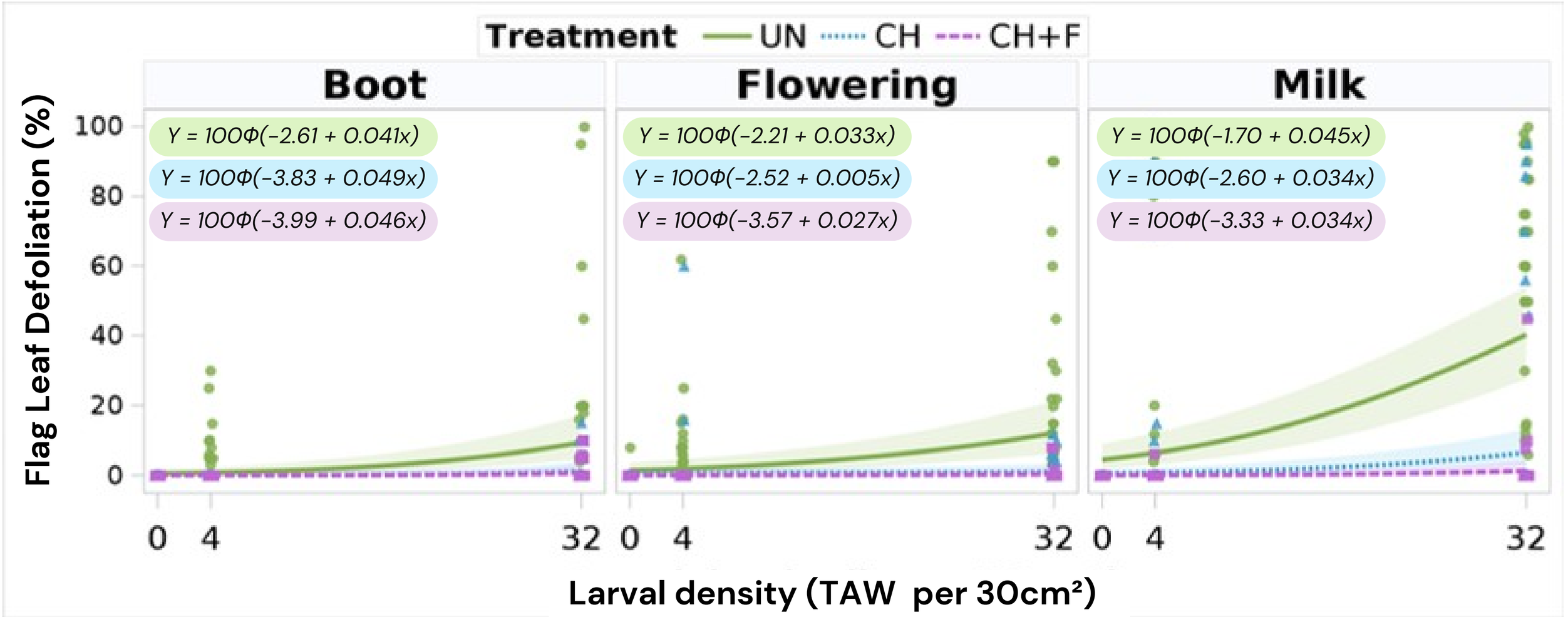
- Calculated yield differences at equivalent growth stages and larval densities
- Generated regression estimates with 95% confidence intervals

RESULTS

Flag Leaf Defoliation (%)

Points represent observed values, lines represent beta regression estimates, and shaded areas indicate 95% confidence intervals.

$R^2 = 0.4837$

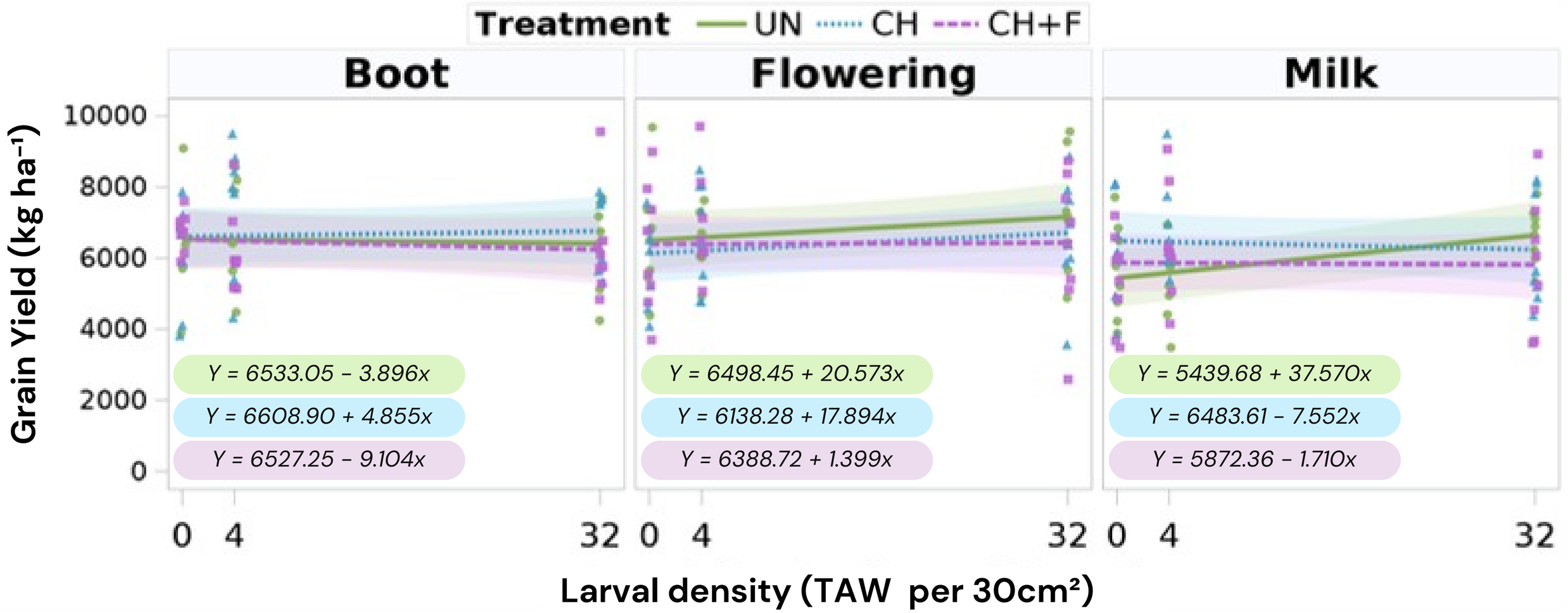


RESULTS

Grain Yield (kg ha^{-1})

Points represent observed values, lines represent linear regression estimates, and shaded areas indicate 95% confidence intervals.

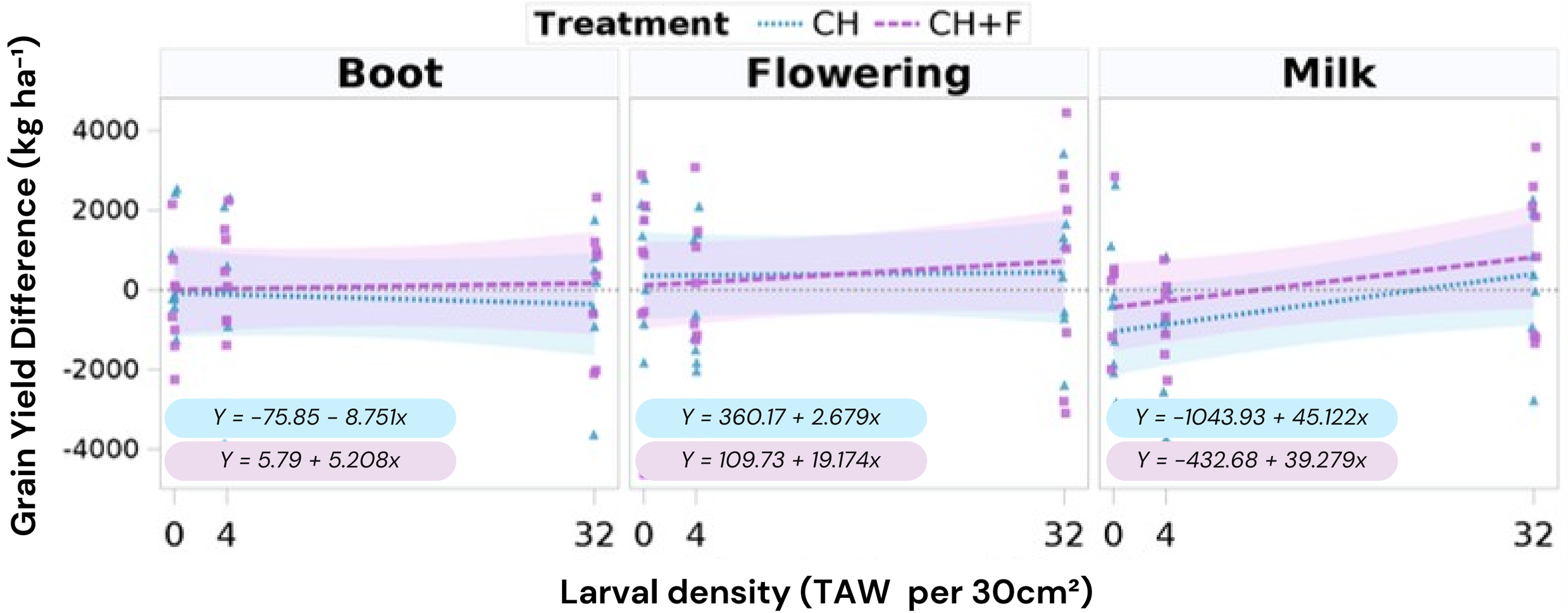
$R^2 = 0.5752$



RESULTS

Grain Yield Loss (kg ha⁻¹)

Lines represent model-estimated treatment contrasts, shaded areas indicate 95% confidence intervals, and the horizontal zero line indicates economic break-even.



Methodology

Economic Threshold

Net Return
Linear Mixed-Effects Regression

$$NR = (\hat{Y} \times P_w) - C_T$$

Where: NR = net return (CAD/ha); $\hat{Y}$ = grain yield (kg/ha); P_v = wheat price (CAD/kg); C_t = treatment cost (CAD/ha).

- Calculated grain revenue using wheat market prices
- Deducted insecticide, fungicide, and application costs
- Evaluated growth stage × treatment × larval density using PROC GLIMMIX
- Compared linear, quadratic, and log-linear models

Break-even Point
Net Return Comparisons

$$\Delta NR = \hat{N}R_T - \hat{N}R_{UN}$$

Where: ΔNR = treatment net-return advantage (CAD/ha); T = treated; UN = untreated.

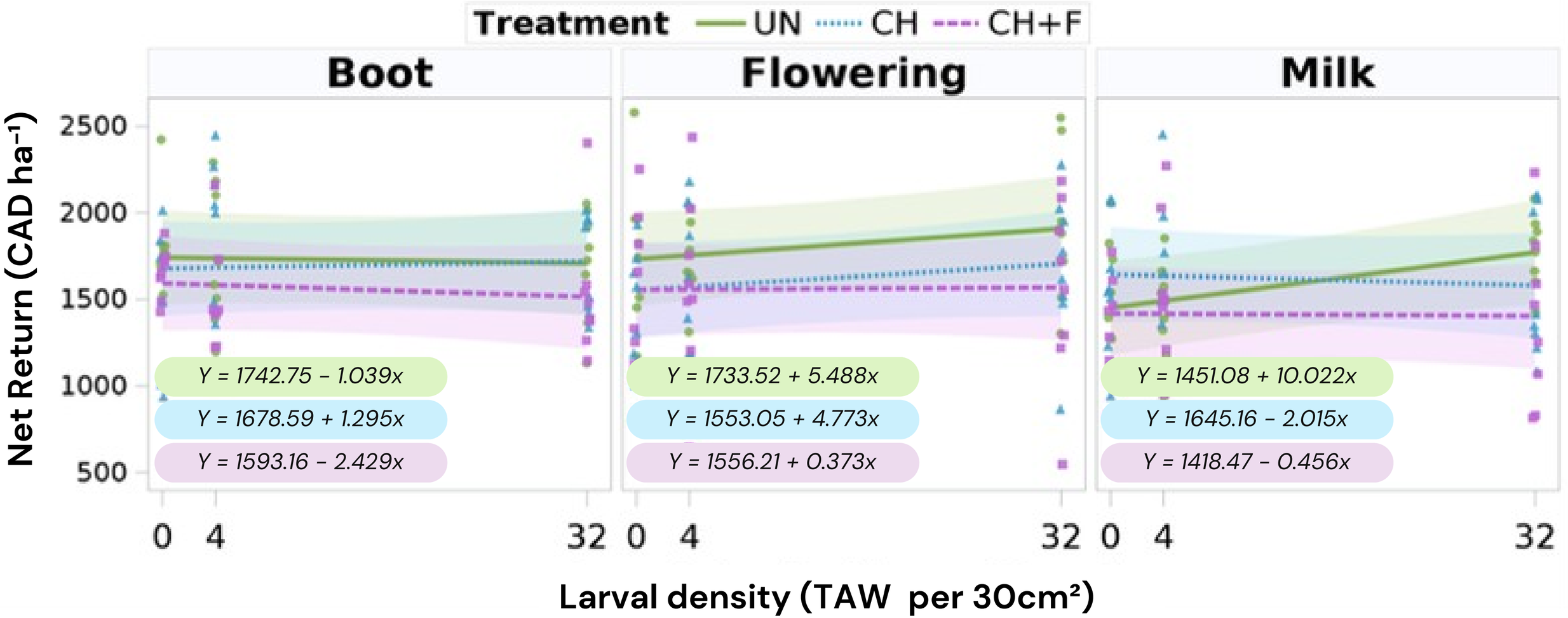
- Compared predicted net returns across growth stages and larval densities
- Identified break-even densities where ΔNR was set to zero
- Evaluated profitability across 0–32 larvae/30 cm²
- Calculated model-based net-return differences with 95% confidence intervals

RESULTS

Net Return (CAD ha^{-1})

Points represent observed values, lines represent linear regression estimates, and shaded areas indicate 95% confidence intervals.

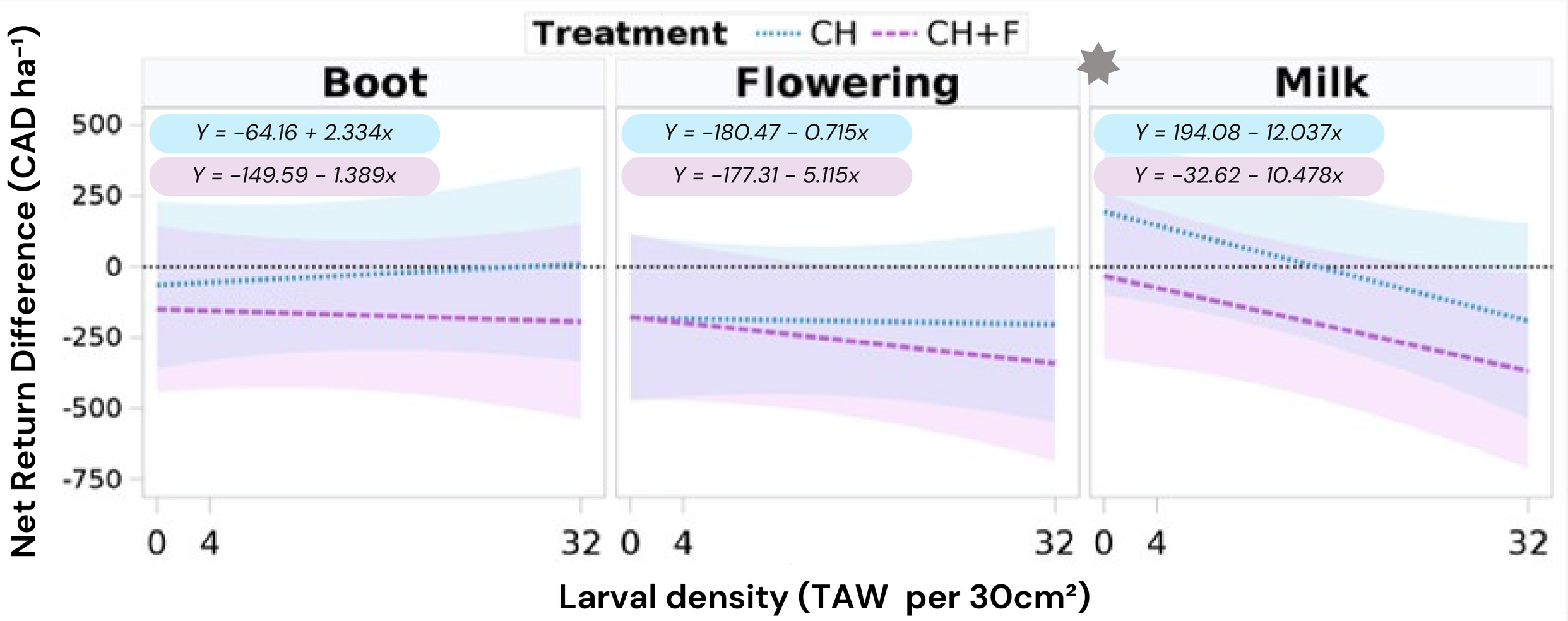
$R^2 = 0.5903$



RESULTS

Break-Even Point

Lines represent model-estimated treatment contrasts, shaded areas indicate 95% confidence intervals, and the horizontal zero line represents economic break-even.



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CONCLUSION

1

Defoliation and Yield Response

- Defoliation increased with larval density but yield responses were variable.

2

Economic Response to Treatments

- Yield and net-return benefits were inconsistent.
- Break-even estimates varied, limiting conclusions about economic thresholds.

The small-scale caged experimental design, potential density-dependent mortality, and environmental variability may have influenced observed responses.

TAW

True Armyworm
Mythimna unipuncta

Current Theshold

All Crop Stages:

- 4–5 larvae in 30 cm²

Proposed Thresholds

Boot & Flowering:

- 16 larvae in 30 cm²



Future Directions

Investigate Wheat Tolerance

- Evaluate compensatory growth and yield responses following defoliation.
- Determine whether modern wheat cultivars tolerate greater injury than those used to establish historical thresholds.

Establish Economically Justified Thresholds

- Determine larval survival, feeding duration, and cumulative defoliation across infestation densities.
- Identify the level of pest injury that produces measurable yield loss.
- Develop and field-validate economic injury levels and corresponding action thresholds.

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(OMAFA, 2025a)

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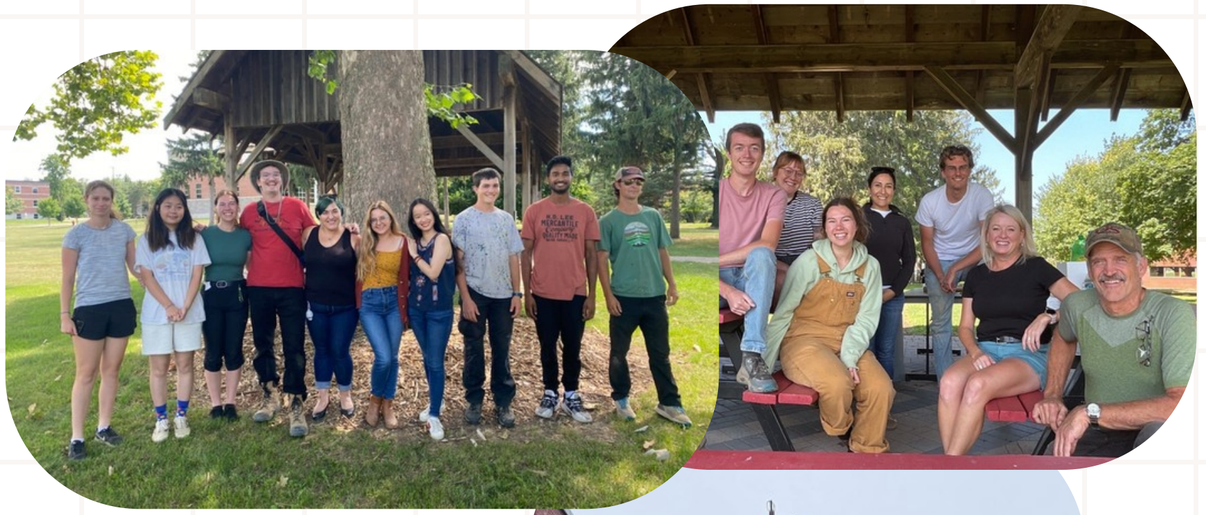
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All photos without labelled sources were provided by Natasha Weppler (2022-2026).



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THANK YOU, QUESTIONS?





Ontario

GRAIN FARMERS OF ONTARIO

Natasha Weppler[1], Yasmine Farhan[1], David Hooker[1], Jocelyn L. Smith[2]

[1] Department of Plant Agriculture, University of Guelph Ridgetown Campus, 120 Main St. E. Ridgetown, Ontario, N0P 2C0

[2] School of Environmental Sciences, University of Guelph Ridgetown Campus, 120 Main St. E. Ridgetown, Ontario, N0P 2C0