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AGRICULTURE &
NATURAL RESOURCES
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EXPERIMENT STATION

CMREC
Beltsville Facility

ROOTS IN RESEARCH

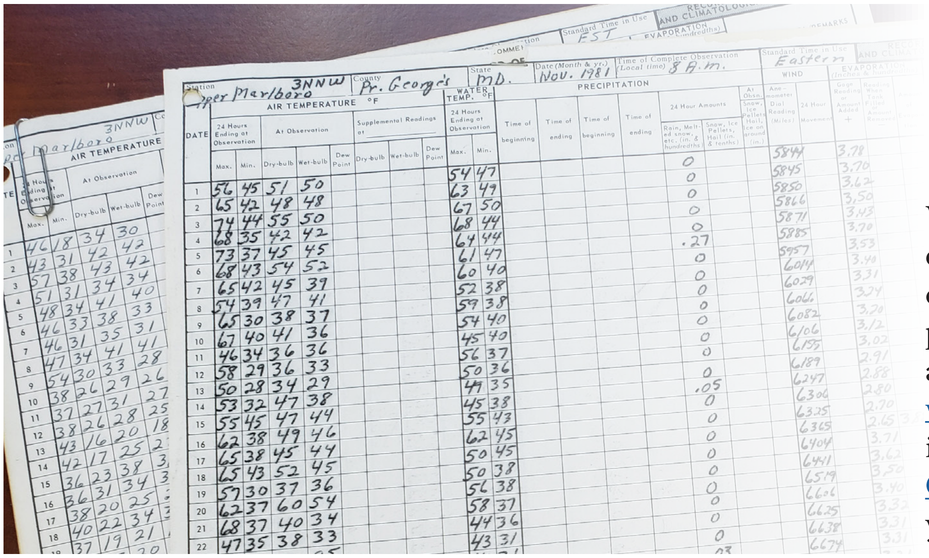
Yield of 2023

In This Issue:

The 2023 growing season can be summed up in a single word: “dry.” Changes in rainfall patterns and hot, dry summers are just one of the stresses that MD farmers can expect to face under a changing climate. Many of the research projects carried out at the UMD RECs are helping to find solutions to help farmers cope with drought stress and other climate change factors. From genetic improvements to crops and alternative crop rotations, to cover crop management and climate monitoring, the studies carried out at our RECs are designed to ensure the success of MD agriculture through adaptive and resilient cropping strategies. Enjoy this summary highlighting the hard work that UMD researchers are doing in pursuit of solutions to agriculture’s most pressing problems.

Alan Leslie
MAES Center Director
WMREC | CMREC | LESREC

To view this newsletter electronically, scan the QR code!

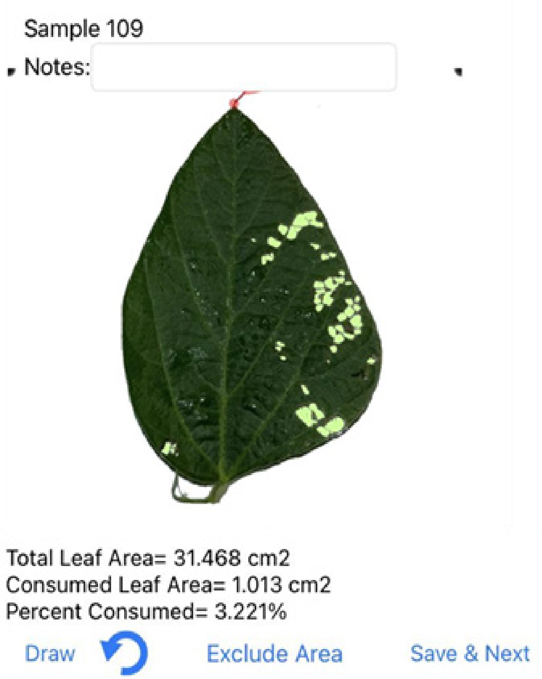


Beltsville Weather Station

Weather data for Beltsville is displayed on our website. The information can be displayed by month, or by the year in a printable format. To compare weather data averages by the month or year, check out our [website](#)! If your research requires this data in a different format, please contact [Sheila Oscar](#) and he will help to get the information you are requesting.

Effect of Planting Date on Seasonal Timing of Pest Complexes and Insecticide Efficacy

Kelly Hamby, Associate Professor and Extension Specialist, Department of Entomology
Lasair ní Chochlain, M.S. Student, Department of Entomology


Sample 109
Notes:
Total Leaf Area= 31.468 cm2
Consumed Leaf Area= 1.013 cm2
Percent Consumed= 3.221%

[LeafByte](#) mobile app was used to measure soybean leaf defoliation. To better understand when insect pest pressure threatens full season soybean production, the impact of planting date on the overlap between pest pressure and vulnerable soybean growth stages, and the efficacy of tank mixing an insecticide with a post-emergence herbicide application, we conducted a two year study in two fields at CMREC Beltsville and WyeREC. Soybeans were planted as early as possible (around May 1) and one month later and treated with herbicide alone just before canopy closure or herbicide plus Warrior II (lambda-cyhalothrin, 1.92 fl oz/acre) insecticide. Pest pressure, damage, soybean growth, and yield were compared throughout the growing season. Planting in May improved yield in one site year; however, the earlier planting also usually experienced a bit heavier pest pressure. Pest pressure was typically below economic threshold levels and the insecticide application never improved yield.

We would like to thank the Maryland Soybean Board for their support of this project.

Cover photo credit: Nathan Hepp

Roots in Research
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Optimizing Early Season Pest Management for Maryland Field Corn

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Field corn insect pest management decisions begin before planting, including selecting hybrids with or without different plant incorporated protectants and/or insecticide seed treatments. At planting, in-furrow insecticides can also be used. These products vary in their efficacy and residual control as well as impacts to beneficial natural enemies that feed upon pests. In addition, they redundantly target many of the same sporadic early season insect pests while potentially not controlling others. We compared pest management efficacy and pest pressure between an untreated control (bare seed), Poncho® 250 (clothianidin 0.25 mg/seed) treated seed, and an in-furrow application of Capture LFR® (bifenthrin 13.6 fl oz/acre.) This experiment was conducted in both a Bt hybrid with a plant incorporated trait package for above ground caterpillars and a non-Bt hybrid, with three replicate plots of each treatment at three farms over three years. Poncho more consistently reduced insect damage than Capture (which did reduce insect damage in non-Bt corn) and also improved stand. However, neither insecticide improved yield even in the one year and location where wireworms were controlled. To better understand their impact on natural enemies, particularly carabid ground beetles that may feed upon slugs, we also compared carabid beetle and slug abundance. In addition, we measured natural enemy feeding activity (predation) by placing sentinel caterpillars in the field overnight and evaluating how many were killed. Predatory carabid beetles commonly occurred and predation ranged from 0-100% across individual sentinel prey cards, with around 16% of the caterpillars killed on average. The insecticide treatments did not impact slugs captured in shelter traps, slug damage, carabid beetle abundance, or amount of predation (caterpillars killed overnight). Ultimately, untreated non-Bt corn yield well at all sites and years of our experiment and the pest pressure we observed did not reach treatment thresholds. Using foliar insecticides to target specific issues as they reach levels of economic concern more effectively and economically controls insect pests.

For more results and details see our Agronomy News Article: https://blog.umd.edu/agronomynews/2023/11/28/optimizing-early-season-pest-management-for-maryland-field-corn/

We would also like to thank the Maryland Grain Producers and Utilization Board for providing funding for this work.

Severe Defoliation of Vegetative Maize Plants Does Not Reduce Grain Yield: Further Implications with Action Thresholds

Carlos A. Blanco , Gerardo Hernandez , Kevin Conover , Galen P. Dively, Urbano Nava-Camberos ,
Maribel Portilla , Craig A. Abel , Paul Williams, and William D. Hutchison

Abstract. It is commonly perceived that early defoliation of maize (Zea mays L.) is a significant risk for maximum grain yields. However, several studies designed to assess biotic and abiotic factors that reduce leaf area reported contrasting results. When maize suffers defoliation before developing its seventh leaf (V7 stage), plants can often compensate without impacting grain production. Seventy-five percent of 20 reviewed publications that offer empirical information indicated severe defoliation did not affect maize yield when plants were less than V7. We present field results for six maize hybrids, lines, and a landrace with severe (75%) defoliation one, two, or three times before reaching V7, in Maryland. Results showed that despite multiple, severe defoliation, there were no significant differences in grain yield ($P > 0.05$). Despite seven amounts of defoliation, yields for each defoliation amount did not differ from yields for intact plants. One early defoliation at V2 significantly produced more grain than did the nondefoliated check ($P < 0.05$). Results confirm the ability of maize to compensate or over-compensate for vegetative-stage defoliation. Results are also discussed in relation to recent reviews of previous studies. It is imperative to reconsider unnecessary recommendations to apply insecticide against maize defoliators when maize plants have yet to develop the seventh leaf.

Introduction

Maize (Zea mays L.), the most cultivated and productive cereal crop in the world (FAOSTAT 2022), is defoliated by several insect pests, with yield loss by feeding on foliage, ears, or both (Hutchison and Cira 2017). Black cutworm, Agrotis ipsilon (Hufnagel), is a sporadic and early-season pest globally (Capinera 2007, Blanco et al. 2016). In the past 6 years, fall armyworm, Spodoptera frugiperda J.E. Smith, has become one of the most widespread, damaging pests of maize (FAO 2022, Kenis et al. 2022, Mendesil et al. 2023). About 200 million hectares are currently threatened by this invasive species (FAO 2022). Dominant control methods for fall armyworm and many early pests continue to rely on applications of synthetic insecticides, and genetically engineered maize that produces proteins from the bacterium, Bacillus thuringiensis (Purdue University 2009; Blanco et al. 2010, 2016; Capinera 2020). Damage by fall armyworm on maize leaves is visible, and defoliation might result in less grain yield. For decades, 20% of plants damaged by fall armyworm has been recommended as an "action threshold" without thorough methodological assessment between early foliar damage and presumed impact on yield (Prasanna et al. 2018, ICAR-IIMR 2019). Natural black cutworm, fall armyworm, and mechanical defoliation studies confirmed effect of the pests, as well as hail damage on grain production (e.g., Overton et al. 2021). Several studies using a variety of maize hybrids and genetic lines showed that when defoliation occurred at early stages of maize development (<V4), yield was not negatively or consistently impacted (Brown and Mohamed 1972, Mahmoodi et al. 2008, Klein and Shapiro 2011, Battaglia et al. 2019, Thomason and Battaglia 2020, Blanco et al. 2022). However, in a few studies, grain loss of <20% occurred (Hanway 1969, Harrison 1984, Chisonga et al. 2023). Other studies attempted to quantify natural herbivory by fall armyworm during plant stages V1-V6; some varied considerably, including 12100% reduction at different plant development stages (Hruska and Gladstone 1988, Willink et al. 1993, Deshmukh et al. 2020, Sunil Kumar et al. 2020). Others found no significant or negative effect on yield (Morrill and Greene 1974, Cruz and Turpin 1983, Buntin 1986, Andrews 1988, Marenco et al. 1992, Kumar 2002, Lima et al. 2010, Abendroth et al. 2011, Dal Pogetto et al. 2012, Babendreier et al. 2020, Thomason and Battaglia 2020, Harrison et al 2022, Chisonga et al 2023). Crookston and Hicks (1978) reported that as much as 100% defoliation of V1-V4 maize increased grain production, suggesting compensatory plant response (Showers et al. 1979, Pedigo et al. 2021). Reviewing the inconsistencies, Overton et al. (2021) concluded that defoliation-yield relationship during early plant growth was inconsistent and required further study. Black cutworm, when it produces minimal damage to the maize apical meristem but much defoliation without reducing plant stand, has not had consistent effect on maize yield (Levine et al. 1983, Whitford et al. 1989, Oloumi-Sadeghi et al. 1992).

Use of insecticide to protect young maize from fall armyworm has had mixed results. According to Deshmukh et al. (2020), some applications during the early vegetative stage of maize can double grain yield. However, most studies found no significant increase in yield (Morrill and Greene 1974, Lima et al. 2010, Sunil Kumar et al. 2020, Harrison et al. 2022). Nevertheless, growers worldwide use insecticide to control fall armyworm larvae in early vegetative stages (V1-V4) (Blanco et al. 2010, 2014, 2016, 2022; ICAR-IIMR 2019; Chimweta et al. 2020). Insecticide and application are expensive. In Mexico alone, economic burden and environmental impact is more than 3,000 tons of insecticide active ingredient per year to treat seven million ha of maize with one to three applications against fall armyworm (Blanco et al. 2010), and a third of that amount against black cutworm (Blanco et al. 2014). The recent global invasion of fall armyworm increased insecticide use, production cost, and environmental impact. Maize in Africa (41 million ha), Asia (66 million ha), Americas (72 million ha), Australia (0.06 million ha), and perhaps soon in Europe (18 million ha) could be treated with insecticide (Hruska 2019, Yang et al. 2021) against a pest unlikely to reduce grain production when damage occurs in young maize plants. One to three insecticide applications commonly made during early maize development (Blanco et al. 2014) would increase production costs by more than $75/ ha (Blanco et al. 2022). If maize growers produce a global average of 5.8 ton/ha (FAOSTAT 2022), and the current price per ton is ~$260, economic justification of an application must be associated with yield loss of ~300 kg/ha. Smallholder farmers, who make up most of the producers in the world (Prasanna 2011), have a limited production budget and find it difficult to invest in pest control, fertilizer, or better seeds (Blanco et al. 2022, Chisonga et al. 2023). The last two expenditures reflect decisions before pests appear, while the unpredictable damage of fall armyworm and other pests might not justify even a single application of insecticide. Hruska (2019) assessed economics of maize smallholders, arguing they should spend at most US$8.00/ha on pest control. However, risk-averse crop consultants sometimes recommend spraying when 5 to 10% maize plants are damaged (Prasanna et al. 2018, ICAR-IIMR 2019), while researchers recommend an action threshold of 2040% (Bessin 2019, du Plessis et al. 2020, Chisonga et al. 2023, Tejeda-Reyes et al. 2023). The recommendations need to be re-evaluated based on empirical data.

In this paper, we expanded on our recent research, to present results of a field study assessing the impact of multiple defoliation events and 75% defoliation per event for several commonly grown maize hybrids, lines, and a landrace. We also examined peer-reviewed articles that provide empirical evidence to further characterize the relationship among fall armyworm, and black cutworm herbivory, and artificial defoliation (<V6 stage) and maize yield loss.

Materials and Methods

Three hybrid cultivars (Hipopótamo, P0506AM, and SYN750 y), two lines (F1, and San Lorenzo), and one landrace (Qro 1) were planted at 74,165 seeds per hectare in plots of eight (0.75-m center) rows, 7.6 m long with 3-m alleys between replicates on 12 May 2022, in a randomized complete block arrangement of four replicates at the University of Maryland Research Experiment Station, Beltsville, MD.

Plots were managed with a side-dress application of 45 kg/ha of nitrogen at planting, and 112 kg of N and 22 kg of sulfur application per hectare. Weeds were controlled with preemergence, tank mix application of glyphosate, atrazine, pyroxasulfone, and mesotrione before maize emergence. Insect pests were scarce during the experiment; therefore, no insecticide was applied. The experimental field received 13.7, 6.6, 10.6, 18.2, 6.4, and 8.3 cm of monthly precipitation between May and October. Drip irrigation was provided when needed.

At V1-V2 developmental stage (13 days after planting), 75% of the foliage of rows 1, 2, 3, and 4 of each treatment/replication was cut with scissors. At 25 days after treatment, V3-V4 developmental stage, we cut 75% of the foliage in rows 2, 3, 6, and 7. At 34 days after planting (V5-V6) 75% of the foliage was cut in rows

3, 4, 7, and 8. Row 5 without foliage removed was the check. At harvest (172 days after planting, ~20% grain moisture), a final number of plants per plot was recorded, and <30 ears randomly selected were removed by hand in each row. Ears were initially weighed in the field during harvest, and a subsample of five to 10 ears per plot was kept for 45 days at 12-19°C to adjust for moisture loss. Analysis of yield produced for different treatments was done by one-way ANOVA once differences in yield by maize lines were shown to have no interaction with cutting times.

In a separate field of the experiment station, consecutive maize plants of cultivar Pioneer 1289yhr were defoliated at 9 days after planting as 1) 50% foliage cut with scissors; 2) 50% foliage removed by using a paper puncher to punch 0.6-cm holes in leaves; and 3) maize plants with intact foliage. Forty-five plants received treatment 1, 2, or 3 in a row. The procedure was repeated in two adjacent rows. All ears of rows 1, 2, and 3 were harvested at 163 days after planting and left to dry as described previously. Grain of ear was weighed, and the number of seeds counted in a subsample of 100 g per ear were used to calculate kernels per plant. ANOVA was used to test the treatments compared with the check. All data analyses, graphs, and results were produced using R statistical language and packages (R Core Team 2023). To review literature on fall armyworm and lepidopteran defoliation studies on maize, we accessed recent review articles (e.g., Overton et al. 2021) and searched Agricola and Google Scholar databases. Although some fall armyworm-related studies focused on sorghum (Sorghum bicolor (L.) Moench) and other crops, we limited our scope to maize.

Results and Discussion

Regardless of whether hybrids or open-pollinated varieties (OPVs, landraces) were tested, defoliation to 75% leaf removal before the V7 development stage did not significantly affect grain yield (P > 0.05) (Fig. 1). In a previous study, we reported 66% of the foliage at different times did not affect grain yield (Blanco et al. 2022). Measuring the effect of more defoliation (75%) in hybrids, lines, and a landrace showed herbivore control during <V6 maize did not protect yield but increased production costs and environmental impact. In this independent and more extensive field experiment, we found no effect of artificial defoliation of young maize on grain yield. Maize defoliation in the two reports greatly exceeded the highest score (9) in the Davis scale (Davis et al. 1992).

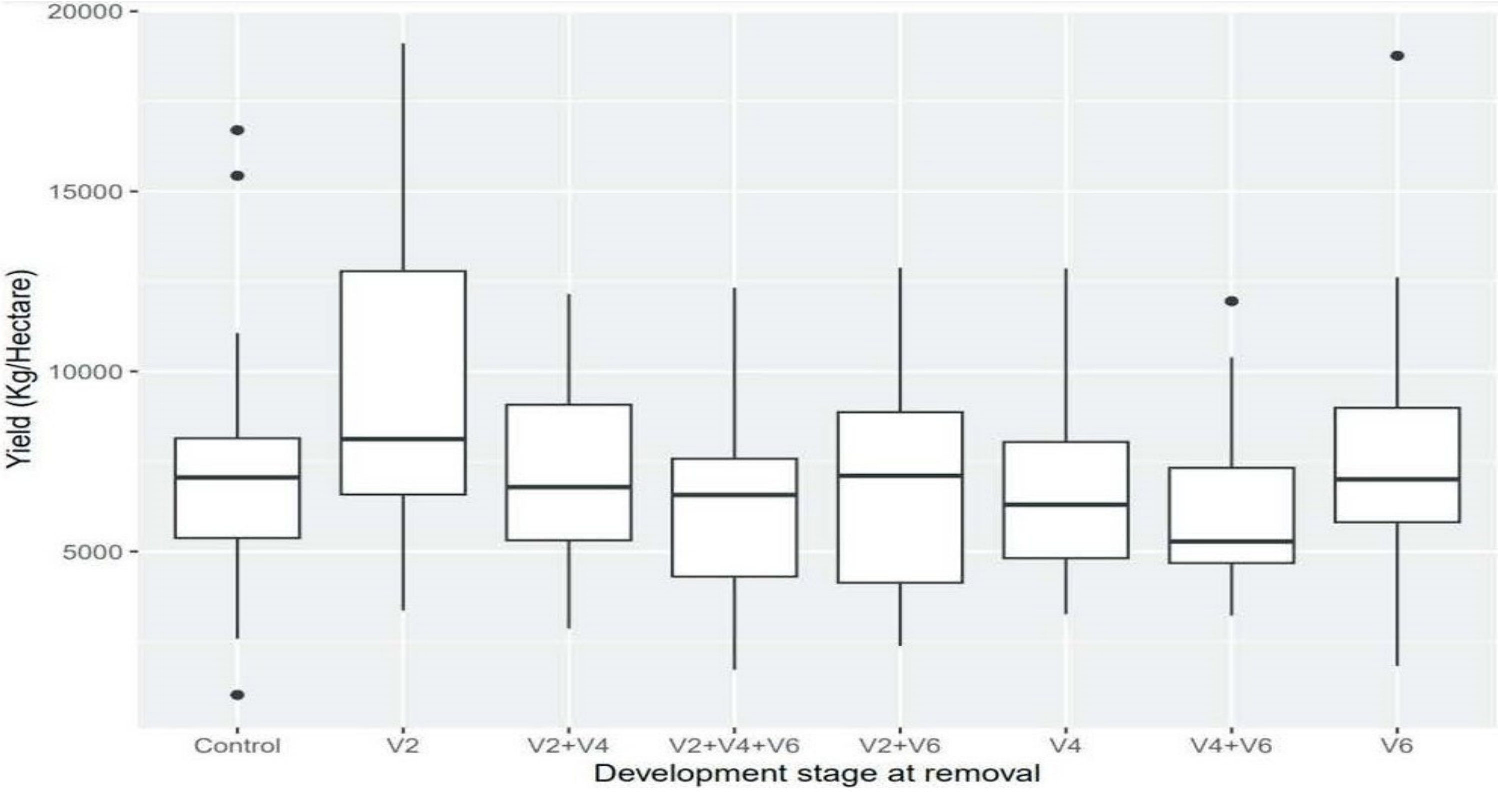

Fig. 1. Mean grain yields of plants from six maize lines with 75% of foliage removed at three development times. F = 2.192, p = 0.0369 for sample size n = 24.

Maize pests such as fall armyworm do not typically cause severe (75%) defoliation, nor do they repeat attack 11-13 days later. Our experiment simulated severe damage - ¾ of maize foliage removed one, two, and three times in 20 days – that did not reduce grain yield. Yield did not change in response to treatments compared to the check. One defoliation at V2 increased yield compared to cutting three times at V2+V4+V6 (Tukey's p adjusted = 0.046) and twice at V4+V6 (Tukey's p adjusted = 0.02); these were the only significant differences (see Fig. 1). Although Levene's test showed no differences between variances (p = 0.24), large variation in V2 suggested different maize hybrids / lines / landrace influenced results. This was confirmed by ANOVA for yield by hybrid / line / landrace (p << 0.001) and shown in Fig. 2; however, two-way ANOVA indicated no interaction between line and treatment (P = 0.54). Lack of interaction allowed effect of treatment alone to be analyzed.

Early defoliation has increased yield due to compensatory response of some crop species (Pedigo et al. 2021). The apical meristem of maize remains below or at ground level before the plant reaches V6 (Buntin 1986, Fortin et al. 1994, Blanco et al. 2022); maize can compensate for foliar damage before whorl stage. Even defoliation at V6 did not affect yield (Fig. 1).

Results using artificial defoliation could have an effect similar to foliar herbivory. We found no evidence that fall armyworm or other maize defoliators such as black cutworm affect plants by mechanisms other than leaf herbivory. Because artificial defoliation can produce a homogeneous effect in each cut plant, it might be a better method than summarizing erratic damage effects of plant pests on foliage. Accumulation of defoliation during gradual herbivory under natural conditions results in less area loss over time than does immediate defoliation (Blanco et al. 2022).

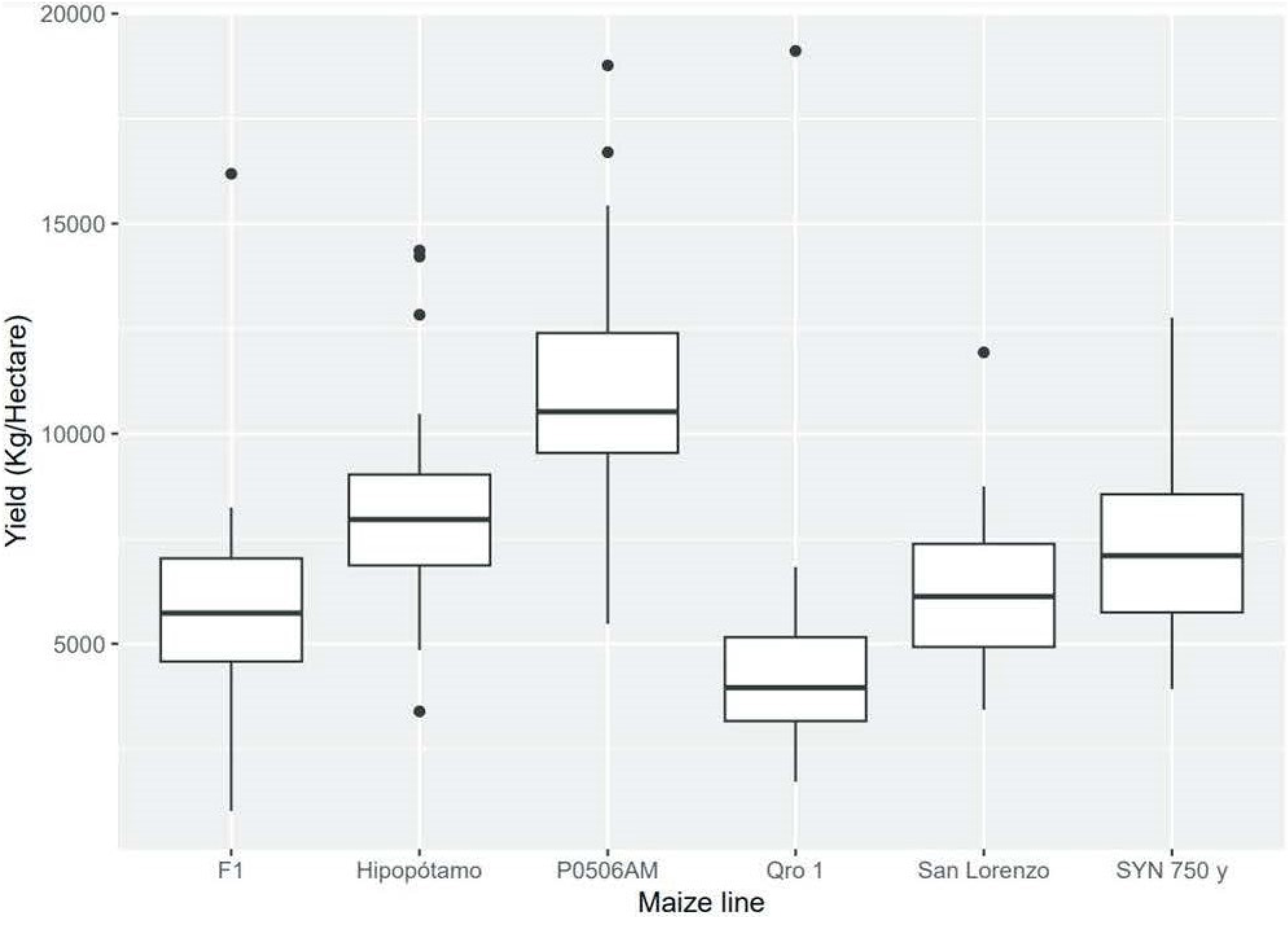

Fig. 2. Average yield of three hybrids (Hipopótamo, P0506AM, SYN 750 y), two lines (F1 and San Lorenzo), and one maize landrace (Qro 1) under different defoliation regimes. F = 26.49, p << 0.001 ***, with sample size n = 32.

Severe defoliation also did not affect the number of plants per maize line (P = 0.21, Fig. 3). However, artificial defoliation of 75% of maize leaves at V3 and V5 significantly reduced the yield of two hybrids in a study by Santos and Shields (1998). This might be because of genetic differences in the hybrids compared to those in our study, and/or differences in defoliation methods.

Using insecticide to protect early maize from pests has produced inconclusive effects (Oloumi-Sadeghi et al 1982, Kumar 2002). Control of fall armyworm and black cutworm with insecticide may be simultaneously reducing other early maize pests (Blanco et al. 2014, Oliveira et al 2022). Insecticide seed coating and spray to prevent pest early damage can affect multiple pests (Harrison et al. 1980, Evans and Stanly 1990, Marenco et al. 1992, Wilde et al. 2007, Jaramillo-Barrios et al. 2020); therefore, the effect of reduction of herbivory by a single pest might be the effect of insecticides on multiple pests.

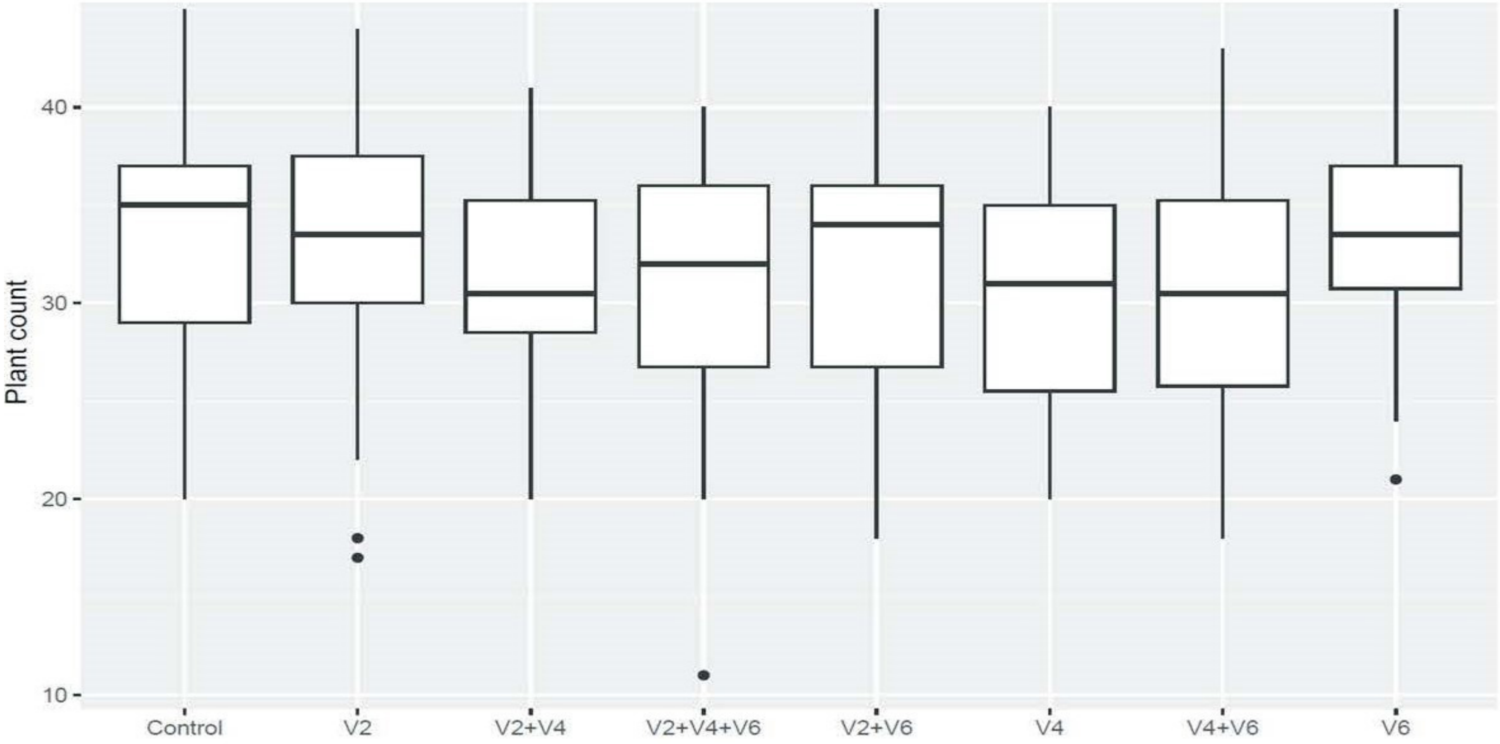

Fig. 3. Final plant count of six maize hybrids, lines, and a landrace. F = 1.426, p = 0.196 for sample size n = 28.

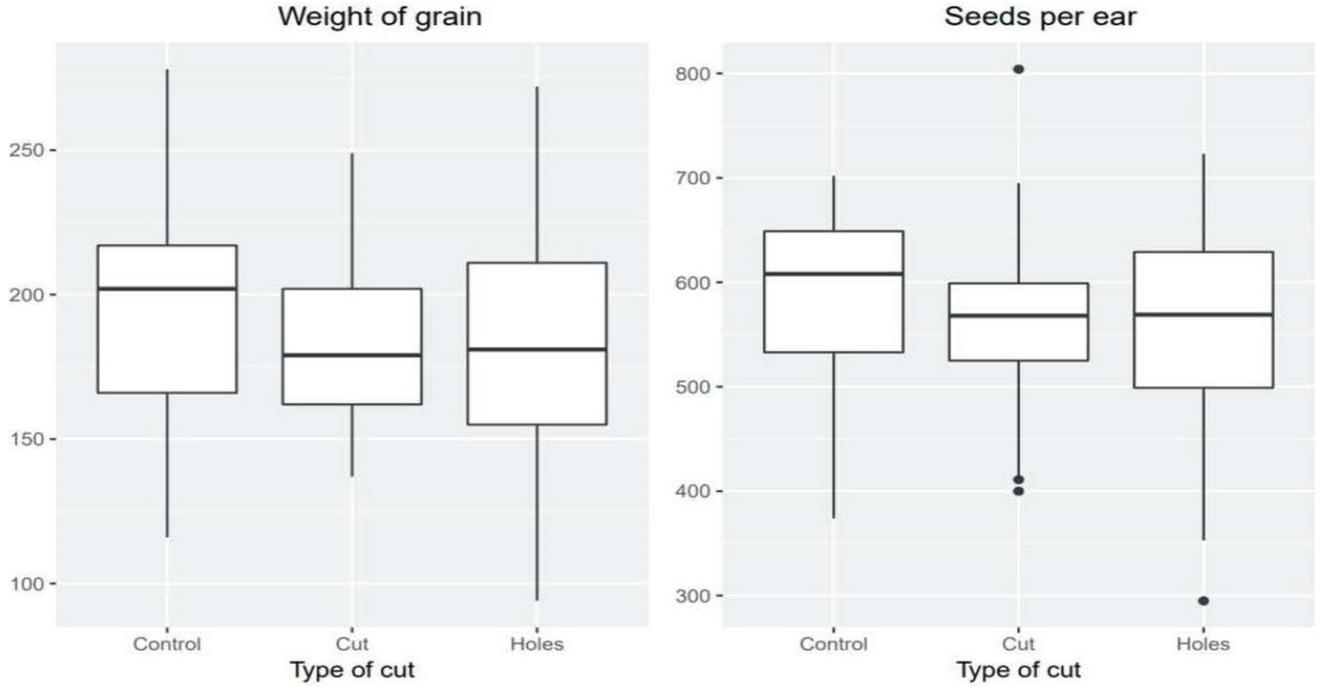

Fig. 4. Grain weight (grams, left; F = 1.22, p = 0.30, n = 45) and number of seeds (right; F = 2.01, p = 0.14, n = 45) per ear from maize hybrid Pioneer 1289yhr with three types of defoliation.

To assess the effect of different artificial defoliation, 50% of leaves were removed by cutting with scissors in one plant and 50% by punching holes in leaves of another plant that produced leaf damage similar to fall armyworm (e.g., ragged leaf feeding injury). We found no significant difference between the two types of defoliation, nor when compared to the nontreated check (p = 0.23 and p = 0.14) (Fig. 4).

Table 1. Published Reports of Empirical Data Documenting the Extent of Defoliation Impact on Maize, in Response to Artificial (Mechanical) or Insect Pest Defoliation Methodology. Reference Citations are Limited to Defoliation During the Early Vegetative Growth Stages, VE-V6.

Cuadro 1. Publicaciones con Datos Empíricos sobre el Impacto de la Defoliación del Maíz en Respuesta al Daño Mecánico o Infestación de Plagas. Las Referencias se han Limitado a Aquellas que Provean Información de Defoliación en las Etapas VE a V6.

IMPACT on maize yield		NO impact on maize yield	
Insect Defoliation	**Artificial defoliation**	**Insect Defoliation**	**Artificial defoliation**
Hruska and Gladstone 1988	Santos and Shields 1998	Morrill and Greene 1974	Hanway 1969
Willink et al. 1993	Thomason and Battaglia 2020	Cruz and Turpin 1983 (FAW)	Brown and Mohamed 1972
Deshmukh et al. 2020	Whitford et al. 1989	Kumar 2002 (FAW)	Showers et al. 1979
		Lima et al. 2010 (FAW)	Mahmoodi et al. 2008
		Dal Pogetto et al. 2012 (FAW)	Klein and Shapiro 2011
		Harrison et al. 2022 (FAW)	Battaglia et al. 2019
		Chisonga et al. 2023 (FAW)	Blanco et al. 2022

Black cutworm: BCW, *Agrotis ipsilon*; Fall armyworm: FAW, *Spodoptera frugiperda*. See references cited for complete citations.

Although the economic injury level by early defoliators of maize will be better understood and validated in multiple countries using different cultivars (Pedigo et al. 2021), it is important to realize that few studies examined yield impact of early defoliation time (VE-V6) in maize. This is true for feeding studies with fall armyworm or black cutworm and mechanical defoliation (Overton et al. 2021, Blanco et al. 2022). However, following our review of 21 studies summarized in Table 1, most (75%) did not find a significant effect on crop yield by feeding damage by fall armyworm or black cutworm, nor did most studies using artificial defoliation. In a greenhouse study of damage by fall armyworm feeding on maize, direct and indirect yield impacts were observed (Chisonga et al. 2023); however, using Structural Equation Models (SEM), damage by leaf feeding explained less than 3% of the variation in yield. This might be useful in explaining results of previous studies on maize.

Considering lack of significant differences in maize yield in our study to 75% defoliation, as well as most studies reviewed (Table 1; Overton et al. 2021, Blanco et al. 2022) there is substantial evidence that in many scenarios, insecticide use for early season infestation by fall armyworm can often be avoided. Expenditures on unnecessary pest control of early defoliators could be better used during the reproductive growth stage to protect developing ears and thus direct benefits toward grain yields. Economic or action thresholds for reproductive stage maize (R1) should be examined for more hybrids and lines.

Funding decisions by farmers for managing fall armyworm might be better allocated for judicious application of fertilizer, or use of cover crops and other cultural practices to increase plant vigor (Chisonga et al. 2023). Longer term research investments for specific regions also should continue to examine the impact of biological control agents, expedite improved maize genetics, including use of maize hybrids, or a shift to medium or longer maize maturities that might allow plants to recover and compensate from early feeding damage by fall armyworm (Kenis et al. 2022). Such changes in management of fall armyworm are particularly important for millions of smallholders where invasions by fall armyworm continues, and in many cases, farmers are not entirely familiar with the ecology and IPM options to manage fall armyworm (Blanco et al. 2014, Kenis et al. 2022). Not using insecticide during early vegetative growth (VE to whorl) allows new or introduced parasitoids of fall armyworm to thrive, expand their impact (Kenis et al. 2022), and support more effective conservation biological control. This is important for management of fall armyworm in developing and industrial countries where more multi-faceted IPM is necessary to not only avoid unnecessary insecticide use, but also minimize ongoing risk of fall armyworm resistance to insecticides (Gutiérrez-Moreno et al. 2019, Hruska 2019, Harrison et al. 2022, Kenis et al. 2022).

Sweet Corn Sentinel Monitoring Network: 2023 Results and Trends

Galen P. Dively, Department of Entomology, University of Maryland

Collaborators: Terry Patton, Kristian Holmstrom, David Owens, Michael Crossley, Helene Doughty, Sean Malone, Tom Kuhar, Daniel Gilrein, Shelby Fleischer, Timothy Elkner, Jared Dyer, Brian Nault, Kelsey Fisher, Jocelyn Smith, Holly Byker, Julien Saquez, Jason Wells, Kelley Tilmon, Chris DiFonzo, Amy Raudenbush, Bill Hutchison, Fei Yang, Robert Wright, Craig Abel, Decker Ashley Lynn, Christian Krupke, Nicholas Seiter, Bradley McManus, Anthony Zukoff, Brian McCornack, Dominic Reisig, Steven Roberson, Anders Huseth, Francis Reayjones, Tom Bilbo, Dave Buntin, Katelyn Kesheimer, Whitney Crow, Huang Fangneng, Pat Porter, Dalton Ludwick, Yves Carriere, Kelly Hamby

Starting in 2017, the sweet corn sentinel monitoring network has been tracking changes in corn earworm (CEW) susceptibility to Cry and Vip3A toxins expressed in Bt corn and cotton. Each year, Syngenta and Bayer-Seminis provided sweet corn seed that is repackaged and distributed to volunteer collaborators to establish sentinel plantings of Bt hybrids (expressing Cry1Ab, Cry1A.105+Cry2Ab2, and Cry1Ab and Vip3A) planted side by side with non-Bt isolines. All collaborators used the same sampling and data collection protocol to generate metrics showing differences in control efficacy between Bt and non-Bt plots, expressed as the percentage of ears damaged, density of surviving larvae per ear, and the amount of kernel area consumed per ear. To estimate the range of allele frequencies for CEW resistance to each Bt toxin, the phenotypic frequency of resistance (PFR) was calculated as the ratio of larval density in Bt ears relative to the density in non-Bt ears. Using this approach, a significant reduction in control efficacy coupled with an increased PFR was viewed as a genetically based change in CEW susceptibility and confirmation of field-evolved resistance.

The 2023 network involved 62 sentinel plantings in 25 states (TX, LA, AL, MS, AZ, GA, SC, NC, VA, MD, DE, PA, NJ, NY, CT, OH, IN, IA, IL, NE, SD, KS, WI, MN, MI) and 4 Canadian provinces (ON, QC, NS, NB). Collaborators in 12 states and ON established multiple plantings at different times and/or locations. Most plantings included five sweet corn hybrids: Attribute ‘BC0805’ expressing Cry1Ab, Attribute II ‘Remedy’ expressing Cry1Ab and Vip3A, and their near non-Bt isoline ‘Providence’ (Syngenta Seeds); and Performance Series ‘Obsession II’ expressing Cry1A.105+Cry2Ab2, and its non-Bt isoline ‘Obsession I’ (Bayer-Seminis Seeds). In addition, 11 sentinel locations established plots of the Milky Way hybrid (Syngenta Seeds) expressing Cry1Ab and Vip3A. Altogether, a total of 29,821 ears were examined to record the location and amount of kernel consumption, larval density by instar, and presence of exit holes. Complete data sets of 56 sentinel plantings were submitted and analyzed, whereas 5 plantings were not sampled due to poor plant growth and ear formation. High CEW infestations caused kernel damage to >70% of the non-Bt ears in 36 plantings. Summed over all sentinel plantings, 76.3% of the non-Bt ears were damaged, with 1.28 larvae and 6.41 cm2 of kernel consumption per damaged ear. In comparison, the percentage of CEW-damaged ears expressing Cry1Ab, Cry1A.105+Cry2Ab2, and Cry1Ab+Vip3A averaged 70.7%, 64.9% and 0.61%, respectively. The number of larvae and kernel consumption averaged 1.27 and 5.28 cm2 in damaged Cry1Ab ears, and 1.13 and 4.77 cm2 in damaged Cry1A.105+Cry2Ab2 ears, respectively. Collaborators sampled a total of 12,247 Cry1Ab+Vip3A ears to detect changes in CEW susceptibility to the Vip3A toxin. Only 17 of the 69 Remedy and Milky Way plots had live larvae feeding at the ear tip, which were mainly 2th and 3rd instars, averaging 0.004 larvae per ear and usually associated with < 1 cm2 of kernel injury. Forty-two of the 68 Remedy and Milky Way plots were uninfested and undamaged.

The network also monitored susceptibility changes and regional differences in European corn borer (ECB), fall armyworm (FAW), and western bean cutworm (WBC) populations. Ten sentinel locations recorded FAW ear damage in non-Bt plots, ranging from 2-24%. Four locations (NE, ON, NB, and QC) recorded WBC damage in non-Bt ears (ranging from 15- 32%), BC0805 ears (ranging from 4-25%), and Obsession II ears (ranging from 1-60%). Twelve trials recorded ECB ear damage in non-Bt plots (ranging from 2-30%), primarily at locations with low adoption of Bt corn. Most noteworthy, the CT sentinel planting reported the first occurrence of live ECB larvae and tunneling damage in plants of Cry-expressing sweet corn in the US. The following summarizes the ECB infestations in each sweet corn hybrid: 20.5% of the Obsession II (Cry1A.105+Cry2Ab2) plants had either shank and/or stalk tunneling, with 12.4 live 5th instar ECB per 100 plants; 33.0% of the Obsession I (non-Bt) plants had either shank and/or stalk tunneling, with 38 live 5th instar ECB per 100 plants; 17.0% of the Providence (non-Bt) plants with either shank and/or stalk tunneling, with 17 live 5th instar ECB per 100 plants; 34.5% of the Remedy (Cry1Ab + Vip3A) plants with either shank and/or stalk tunneling, with 15 live 5th instar ECB per 100 plants; and 13% of the BC0805 (Cry1Ab) plants with either shank and/or stalk tunneling, with 3 live 5th instar ECB per 100 plants. Follow-up sampling of all ears at the CT sentinel location was conducted to collect surviving larvae for laboratory analysis.

For CEW estimates of the PFR, it was assumed that any live 2th thru 6th CEW larvae that survived to cause kernel damage in a Bt ear indicates some level of resistance to the expressed toxins, that could result in mature larvae surviving to contribute resistance alleles in the next generation. Not all data sets were used to calculate PFRs for each sentinel planting, depending on whether all five hybrids were planted. Furthermore, only data from plantings reporting >50% damaged ears and infested with >50% 4th, 5th and 6th instars were used to calculate PFRs. Forty-five of the 56 sentinel plantings satisfied these criteria for one or both Cry toxins; the remaining plantings either had very low CEW infestations or the timing of ear sampling was too early to record the number of surviving late instars per ear. Forty-nine trials satisfied the selection criteria for the Cry1Ab+Vip3A toxins. The following summarizes the PFRs for each individual or pyramided Bt toxin(s), in comparison with previous sentinel monitoring results.

Cry1Ab (BC0805 vs Providence): The level of CEW phenotypic resistance has significantly increased, since Cry1Ab sweet corn was commercially introduced in 1996. PFRs estimated from sentinel plantings each year in Maryland averaged 0.28 during 1996-2003 and 0.64 during 2004-2016. Based on results of the expanded monitoring network, PFRs averaged 0.99 in 2017, 0.85 in 2018, 0.76 in 2019, 0.95 in 2020, 1.06 in 2021, 1.07 in 2022, and 1.09 in 2023. The percentage of damaged ears and kernel consumption per Bt ear, along with larval development delays, remained about the same during the last three years. However, the most noteworthy finding is that 22 of the 35 BC0805 plantings that satisfied the selection criteria in 2023 reported higher CEW densities per Cry1AB ear compared to densities per non-Bt ear (PFR>1). The difference in larval densities is the result of behavioral changes in sublethally intoxicated larvae. In a non-Bt ear, many early instar CEW can freely feed together initially, but then become cannibalistic once they reach the 4th instar stage.

Cry1A.105+Cry2Ab2 (Obsession II vs Obsession I): Phenotypic frequencies have steadily increased since 2010, averaging 0.19 during 2010-2013 and 0.41 during 2014-2016. Sentinel network results continue to show some evidence of further resistance development to the dual Cry toxins, with PFRs averaging 0.67 in 2017, 0.93 in 2018, 0.70 in 2019, 0.89 in 2020, 0.95 in 2021, and 0.92 in 2022. In 2023, the estimated PFR was 0.85, based on 31 of the 47 sentinel plantings of Obsession II vs Obsession I that satisfied the selection criteria. Eleven sentinel locations reported higher CEW densities in Obsession II, resulting in PFRs ≥ 1. However, over the last three years, there has been no consistent increase in phenotypic frequency, kernel consumption, or percentage of older instars surviving Cry1A.105+Cry2Ab2 ears. Pyramiding with other Bt toxins, particularly Vip3A, in field corn and cotton may have reduced the selection pressure on these two Cry toxins, thus resulting in a slower rate of resistance development.

Cry1Ab and Vip3A (Remedy/Milky Way vs Providence): Previous studies in MD and MN during 2013-2016 reported virtually no CEW survival or damage in Vip3A-expressing sweet corn. However, sentinel monitoring starting in 2017 began to report larval survival with expansion of the network to more southern locations. During 2017-2019, 0.72% of the 9,369 Vip3A ears sampled had minor tip damage associated primarily with 2thand 3rd instars. Furthermore, results by year show a small but noticeable increase in the number and age of surviving larvae. Of the 20,312 ears sampled during 2020-2022, 156 ears (0.77%) had minor damage (<0.5 cm2, primarily on the tip), but only 25 of these ears (0.12%) were infested with a total of 82 live larvae (78% early instars). Trials reporting most of the ear damage and older larvae in Vip3A ears were southern locations (TX, LA, MS, AL, NC). However, not all of these damaged ears were tested for Vip3A expression, so there is the possibility that some ears resulted from contaminated non-Bt or Cry-expressing seed. Nevertheless, assuming all ears with live larvae expressed Vip3A, the overall PFR estimated from trials conducted during 2020-2022 was 0.0044.

In 2023, additional sentinel plots were planted with the Vip3A expressing Milky Way sweet corn, and most collaborators sampled higher number of Remedy and Milky Way ears to increase the chances of detecting early signs of resistance to the Vip3A toxin. Twelve of the 49 sentinel plantings that satisfied the selection criteria were infested with a few surviving CEW, with PFRs for Vip3A resistance ranging from 0.003 to 0.070. In contrast with previous sentinel results, sentinel locations in IL, NE, IA, VA and NC had the highest PFRs (≥0.020) showing evidence of Vip3A resistant alleles, compared to southern locations in TX, AL and LA reporting PFRs ≤0.007. The higher PFRs in the more northern sentinel locations may be the result of migrate CEW moths that were previously subjected to a generation of Vip3A selection pressure in the south. In any case, these results continue to indicate early signs of CEW resistance to Vip3A, yet there was no evidence of any increase in 2023 compared to the 2020-2022 results. Furthermore, the Vip3A expressing sweet corn still provided excellent ear protection against CEW in all sentinel plantings.

UMD Bee Lab and the New UMD Bee Squad

https://www.umdbeelab.com/ https://umdbeesquad.com/

The Honey Bee Lab at the University of Maryland has diverse personnel with multidisciplinary scientific backgrounds who bring a fresh perspective to solving problems. Research in the laboratory is focused on an epidemiological approach to honey bee health. We are proud to share our research into the major mechanisms that are responsible for recurring high loss levels in honey bee populations, such as pests and pathogens associated with honey bees, loss of natural forage habitat due to large monocultural croplands, and pressure from human induced changes in the environment.

Our team has led and managed the USDA APHIS National Honey Bee Disease Survey since 2009. We are also a major partner and founding member of the Bee Informed Partnership (BIP), who collaborates closely with beekeepers from across the country to study and better understand the loss in honey bee colonies in the United States.

You can find Realtime results about these efforts at our database portals: https://research.beeinformed.org/state_reports/

Click here to purchase UMD Honey

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If you are able to help support our mission to improve honey bee health, we greatly appreciate whatever you can give.

You may donate online using the University of Maryland "Giving to Maryland" Honey Bee Lab Donation Site.

Thank you for your support!

Enhanced Cover Cropping for Nutrient Management - Two Fields

Ray Weil, Professor of Soil Science

Below are two videos showing no-till planting into a typical rye cover crop terminated in mid-April, 3 weeks before planting compared to an enhanced cover cropping practice of "planting Green" into a much bigger living multi-species green cover crop.

The enhanced cover crop promises to fight climate change and improve soil health by sequestering 4-5 times as carbon from the atmosphere into the soil, as well as reducing fertilizer needs by fixing 50 to 100 lbs of nitrogen per acre.

Click here to view video 1 and video 2

Fundamentals of Soil Science Course - Catena in the Field

Eni Baballari - Environmental Science and Technology, University of Maryland

Every semester, students of ENST200, Fundamentals of Soil Science, take the drive to the Central Maryland Research and Education Center (CMREC) - Beltsville Facility to study soils in the field.

During this field trip, curious students of soils use augers to dig deep into the many layers of soil, called horizons. They get soil from four different locations, representative of the local topography. They deposit their diggings into a trough and come together with their soil troughs from four locations to see them side-by-side and discuss differences between them. They talk about the 5 soil formation factors (parent material, climate, organisms, topography, and time) and how each of these has influenced the local soil. Importantly, they also talk about the influence that soil properties have on the land use capabilities, such as farming or installation of a septic tank field.

Students love this trip and we look forward to continuing to showcase the wonder of soil!

Instructor (front left), graduate teaching assistant (front right), undergraduate teaching assistant (right, holding a soil auger), and students (back) pose for a photo with the soil profiles in troughs in front of them.

Impact of Cover Crop Termination Method on Soil Moisture and Temperature

CMREC – Beltsville Field Experiment 2022-2023

Cara Peterson, PhD Candidate
Dr. Kate Tully, Associate Professor, Agroecology Lab,
Department of Plant Sciences and Landscape Architecture
Dr. Steven Mirsky, Research Ecologist

Sustainable Agricultural Systems Laboratory, Agricultural Research Service, USDA To prepare for spring planting, farmers rely on mechanical (e.g., roller-crimping, mowing, tilling) and chemical methods to terminate their winter cover covers. Most growers using cover crops in conventional grain production systems terminate their cover crops in the spring by spraying broad spectrum post-emergent herbicides. Additionally, farmers in both conventional and organic production systems might roller-crimp their winter cover crop, effectively flattening the cover crop biomass into a mulch layer. Recent research has focused on herbicide selection and roller-crimper timing for effective cover crop termination, however there is limited knowledge about the impact of these choices on spring soil moisture dynamics and cover crop residue decomposition.

Herbicide selection, specifically the choice between a contact and systemic product, could lead to differences in the plant senescence, evapotranspiration, and decomposition rates of the living and dead cover crop. The application of a systemic herbicide, such as glyphosate, results in a gradual senescence of the plant tissue and maintenance of the plant structure, meaning transpiration through the plant could potentially continue for a sufficient time after cover crop termination to result in drier soil moisture levels than a similar field of cover crops sprayed with a faster-acting herbicide. In contrast, rapid disintegration of plant cell membranes and the ensuing loss of plant structure after exposure to a contact herbicide may lead to a quick decline in cover crop water uptake, although this has not yet been documented in the scientific literature. Regarding mechanical termination, flattening cover crops with a roller-crimper reduces evapotranspiration and conserves soil moisture. Expedited contact with the moist soil surface and microbes after roller-crimping will hasten tissue decomposition and nutrient release compared to cover crop residue that remains upright.

A field study was conducted in the spring of 2022 and 2023 to investigate differences in soil moisture and temperature, as well as the decomposition rates of a cereal rye (*Secale cereale L.*) cover crop terminated with a systemic herbicide (glyphosate) versus a contact herbicide (paraquat), with an additional roller-crimper treatment. With increasing variability in spring precipitation due to climate change, optimizing these cover crop termination methods for both dry and wet conditions is essential to increasing agroecosystem resiliency.

Experimental design

Experimental plots were established in the spring of both 2022 and 2023 at the CMREC-Beltsville facility. The two field sites are on very sandy and well-drained soil, and the experiment is simultaneously being executed at sites on slower-draining soils with higher clay content at the USDA ARS BARC facility nearby. When the cereal rye winter cover crop reached anthesis, the optimal growth stage for termination by roller-crimping, half of the cover crop plots were rolled. One week later, the cereal rye plots were sprayed with the two herbicide treatments in perpendicular direction to the roller-crimper path to achieve four termination treatments: Rolled+Paraquat; Standing+Paraquat; Rolled+Glyphosate; and Standing+Glyphosate. Two control treatments without a cover crop were also established: bare fallow and straw mulch.

Time domain reflectometry (TDR) sensors were installed at surface level, 10 in., 20 in., and 30 in. depths to continuously measure and record soil moisture and temperature. To quantify cover crop decomposition, a litterbag study was also included in the experiment. In residue decomposition studies, the cover crop biomass substrate is typically collected at termination, however that would negate the termination treatments put in place in this experiment. Therefore, the biomass substrate material was collected two weeks after the herbicide treatments were sprayed. The litterbags were then placed back in the field plots and moved to a nearby corn field after fertilizer side-dressing had occurred to provide realistic conditions for cover crop residue during the remainder of the production season.

Results

Heavy and frequent precipitation in the spring of 2022 led to similar soil moisture levels across the termination treatment plots. At both the CMREC-Beltsville and USDA-BARC fields, soil water content remained high and no treatment differences in cumulative infiltration or evapotranspiration were observed. Although spring 2023 began with regular rainfall, a long dry period in June allowed for more differences to emerge in soil moisture and temperature. Cumulative infiltration was lower in the straw plots than most of the cover crop plots (Rolled + Glyphosate, Standing + Glyphosate, Rolled + Paraquat), however this is likely due the mature cereal rye cover crop drawing up available soil moisture before termination (Image 5). The highest cumulative evapotranspiration occurred in the bare fallow, but otherwise soil moisture loss was similar across all cover crop termination methods and the straw fallow plots. Mean daily temperature at the soil surface was also similar across all treatments without regard to chemical or mechanical termination strategies. The daily flux in temperature, or amplitude, did change by mechanical termination treatment, however, with higher daily amplitudes observed in Rolled+Glyphosate and Rolled+Paraquat than the Standing+Glyphosate both years at the CMRECBeltsville experimental plots.

Results from both years of residue decomposition study component demonstrated no differences in decomposition rates among the termination treatments. This could be a result of terminating the cereal rye cover crop at a later growth stage in order to accommodate the rollercrimper treatment. As cereal rye matures, the carbon to nitrogen ratio of the plant tissue residue decreases, which slows the residue decomposition in comparison to cereal rye terminated at earlier growth stages. If this experiment was replicated, our recommendation would be to apply the chemical termination treatments earlier in the season without the roller-crimper to elucidate any differences in cover crop decomposition on younger cereal rye plants.

Overall, this experiment found no differences in soil moisture, soil surface temperature or residue decomposition between cereal rye sprayed with a systemic or contact herbicide. Rolled cereal rye did exhibit higher fluctuations between minimum and maximum soil temperatures than the cereal rye that remained standing, which could be important for growers concerned with cash crop or weed seed germination. Otherwise, the results of this study reinforced the message that a cover crop residue facilitates recovery of soil moisture used by the cover crop before termination and reduces soil moisture loss during hot and dry periods.

Image 1: Cereal rye cover crop plots, May 12, 2022, immediately after roller-crimping treatments.

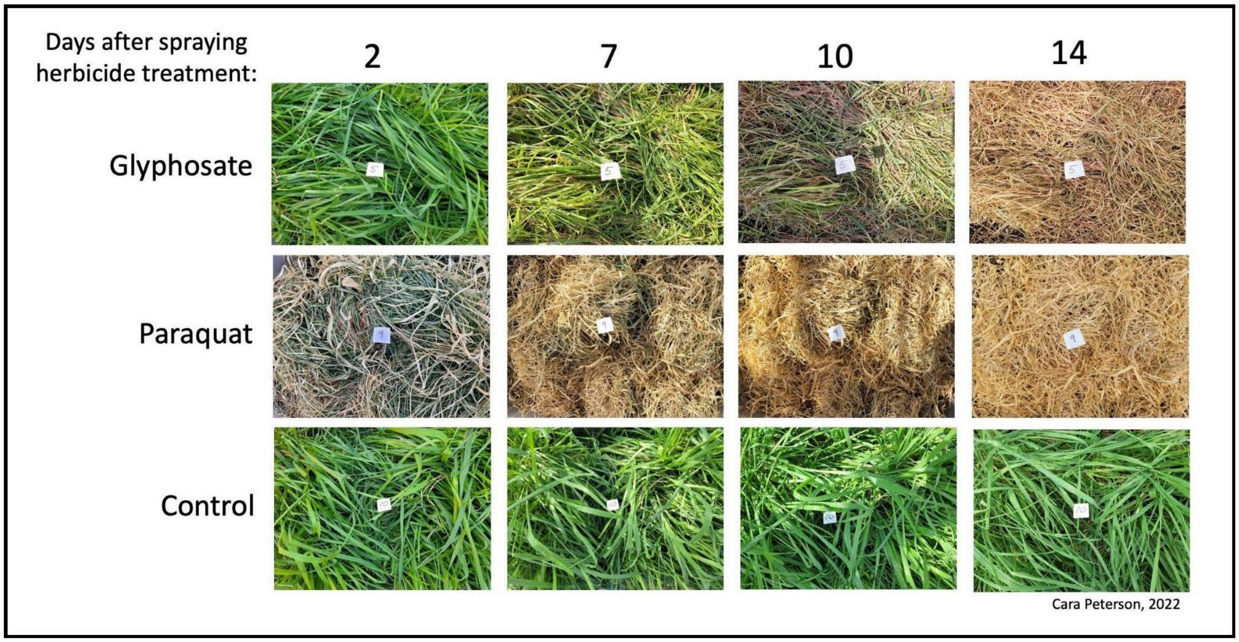

Image 2: Test plots of cereal rye sprayed with glyphosate and paraquat, shown alongside a control treatment, demonstrating the different efficacy rates of the two herbicides.

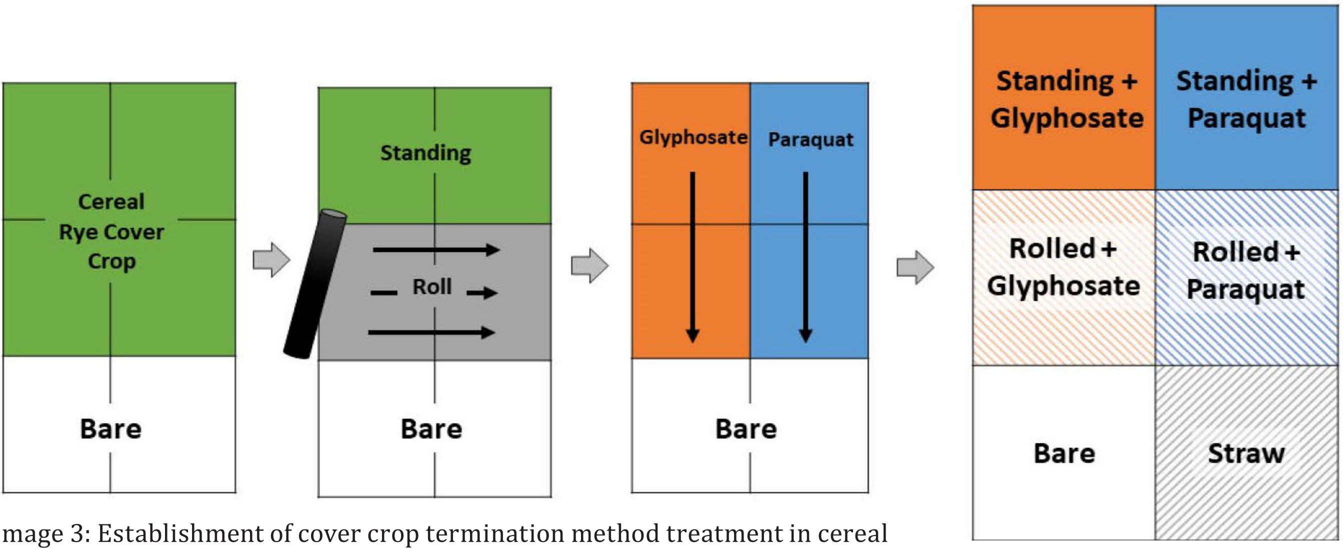

Image 3: Establishment of cover crop termination method treatment in cereal rye cover crop and example plot map of one replicate.

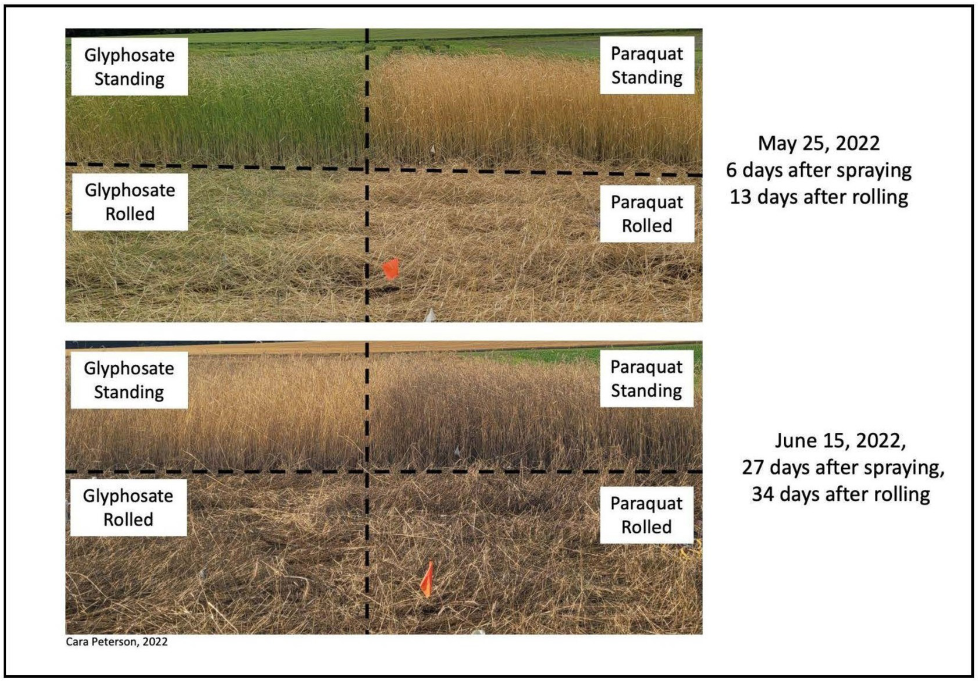

Image 4: Termination method treatments in cereal rye cover crop plots at CMREC-Beltsville.

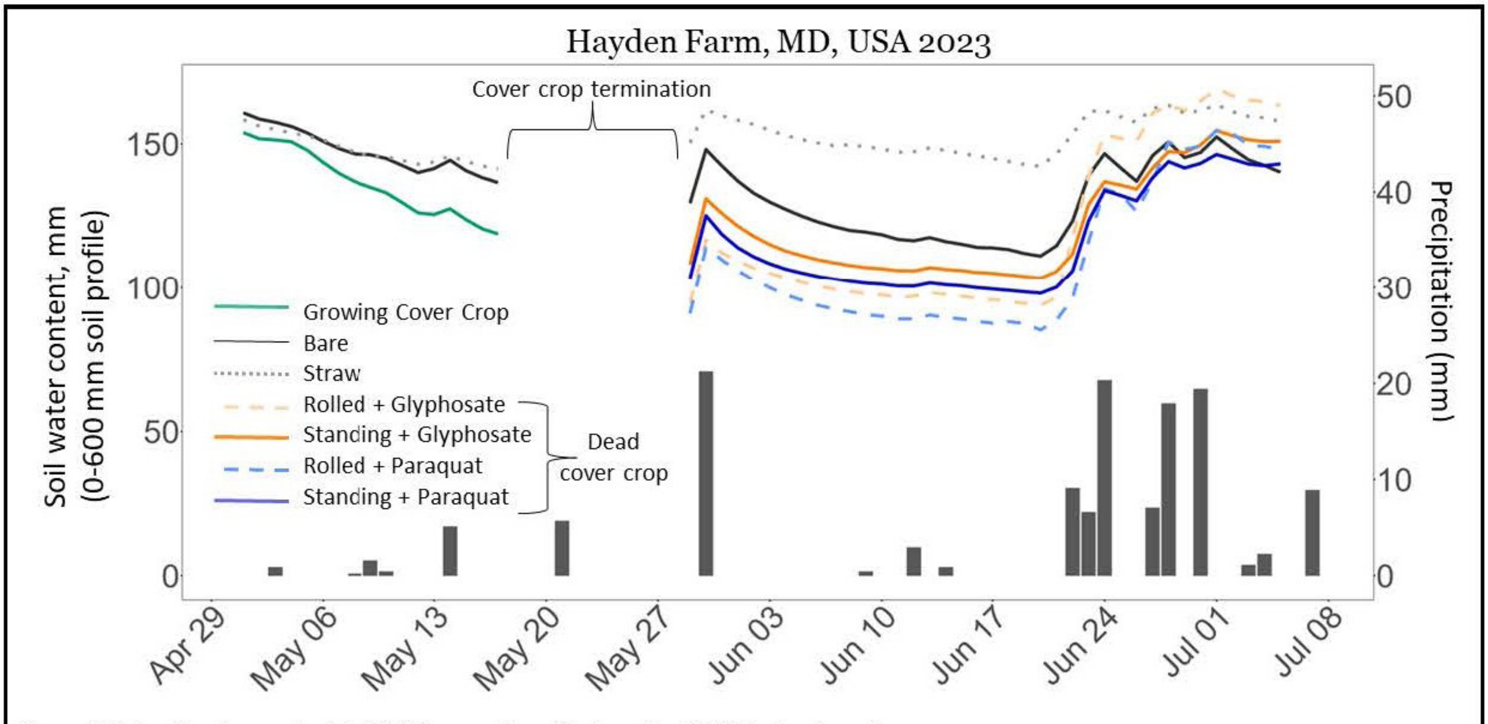

Figure: Total soil water content in 0-600 mm soil profile in spring 2023 by treatment.
1 May–12 May: Cereal rye cover crop (green)
12 May: Half cereal rye plots roller-crimped;
19 May: Cereal rye plots sprayed with either systemic (glyphosate) or contact (paraquat) herbicide.
22 May–30 June: Cover crop plot data represented by termination treatment.

Image 5: Mean total soil water content in 0-600 mm soil profile by cover crop termination method or bare and straw fallow in 2023 at CMREC – Beltsville. Dark vertical bars are daily precipitation recorded at facility.

Image 6: Cereal rye biomass in litterbags for biomass decomposition component of field study. At set times throughout the season, one litterbag is collected from each treatment and replicate group to assess biomass loss over time. Cara Peterson, 2022.

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