COLLEGE OF AGRICULTURE & NATURAL RESOURCES

MAES | MARYLAND AGRICULTURAL EXPERIMENT STATION

CMREC Beltsville Facility

ROOTS IN RESEARCH

Yield of 2024

In This Issue:

After a good year for small grains, the 2024 crop year was a good reminder of the value of crop insurance for the CMREC-Beltsville facility. With prolonged drought conditions through most of the growing season, average yields for corn and soybeans were numbers we hope to never see again. Mirroring the ups and downs of the growing season, we had a fair amount of staff turnover at the facility this year as well. We welcomed in two new Ag Tech Leads: Richard “Trey” Whelton III and Jacob Rasmussen. Within the same year we also bid farewell to Jacob, who now works in DC promoting food accessibility at farmers markets, and Chris Athey, who now works at the WMREC facility. Some of the highlights for this year include the cover crop management field day, held in early May, and the farm manager, Kevin Conover, being recognized for 40 years of service at the AGNR awards ceremony on campus.

Alan Leslie
MAES Center Director
WMREC | CMREC | LESREC

To view this newsletter electronically, scan the QR code!

UMD Bee Lab and the UMD Bee Squad

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.

Click here to purchase UMD Honey

Donations
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!

Roots in Research
CMREC Beltsville, Clarksville, Turfgrass and Upper Marlboro, LESREC Poplar Hill and Salisbury, and WMREC Keedysville are published by the University of Maryland Extension

Elizabeth McGarry, Editor
emcgarry@umd.edu
301-226-7400
University of Maryland Extension

Sheila Oscar, co-Editor
soscar@umd.edu
410 742-1178 x301
University of Maryland

Fundamentals of Soil Science Course - Catena in the Field

Eni Baballari - Environmental Science and Technology, UMD

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!

Cover Crop Management Field Day

On a cloudy Thursday in early May, the Beltsville facility welcomed around 35 visitors attending the "Planting Green Workshop," which was a field day event demonstrating different cover crop management practices. The event was organized by Dr. Ray Weil, and was supported by several partner agencies, including Northeast SARE, NRCS, the MD Soybean Board, Future Harvest, and the Million Acre Challenge. The workshop highlighted some of the ongoing research that the Weil lab is conducting in cover crop management, especially delaying termination to increase biomass. There was a soil pit, where Dr. Weil discussed the effects that different cover crops have on soil health and the movement of water and nutrients through the soil profile. There was also a demonstration of planting green in standing, dense cover crops, and a discussion of the multiple benefits that this strategy can provide. Attendees left with a deeper understanding of the multiple benefits that cover crops provide, and tools for better managing cover crops on their farms.

Spring Termination of Cover Crops - How Timing Affects Crop Stands and Yields

Ray Weil and Cassandra Gabalis
Department of Environmental Science and Technology

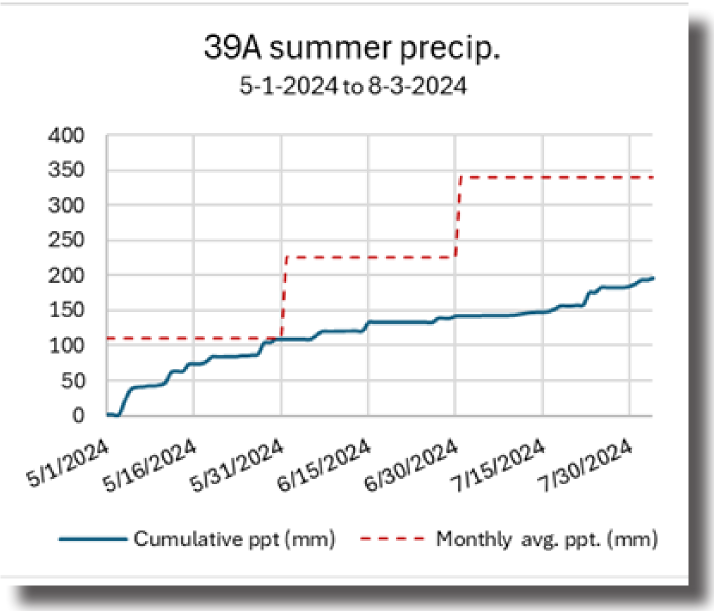

Figure 1. Average monthly and 2024 daily cumulative precipitation (mm) at CMREC

Summer 2024 saw extreme drought conditions in Maryland, including at the Central Maryland Research and Education Center (CMREC) farm in Beltsville, MD. May rainfall was about normal, but the following summer months had almost no rain at all (Figure 1). With the severe drought, the cover crops had a clear effect on conserving summer soil moisture, and the use of winter cover crops affected corn and soybean yields.

Soybean yields were determined by hand-harvesting. Averaged across in both sandy loam and silty clay loam soils (fields 39A and 7E) and all termination timings, soybean yields in plots with a preceding rye cover crop were significantly higher than in plots with a preceding cover crop clover-rye-radish mixture (Figure 2, left). Looking more deeply into this data, we see that the depressing effect of the clover-rye-radish MIX cover crop did not occur for the mid-termination (planting green and terminating at the same time in early May). Termination timing did not affect soybean yields for the no cover (weeds only) or rye cover treatments.

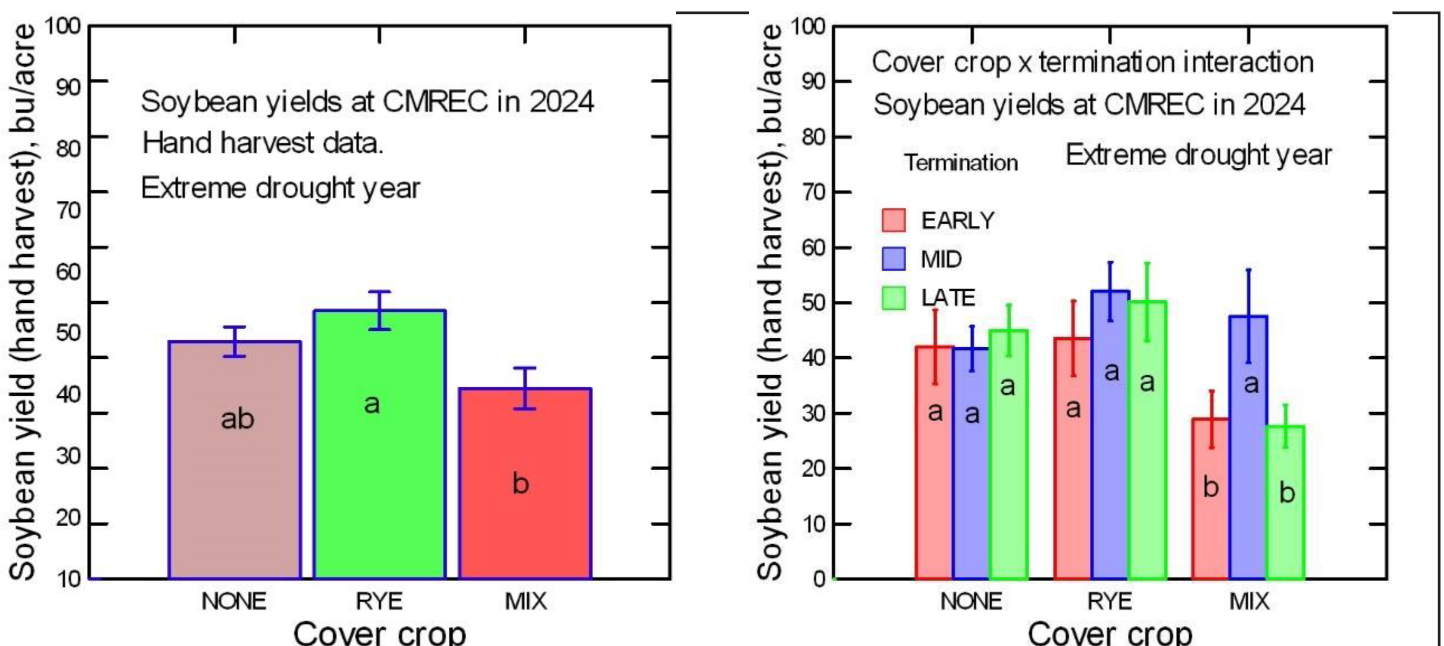

Figure 2. Soybean yields on two soils at CMREC benefited in 2024 from being planted into a rye cover crop. Early and late (but not mid-planting green) termination of clover-rye mix reduced stands and subsequent yields.

Figure 3 Effect of preceding cover crop treatment on visible differences in drought stress symptoms and corn growth in July 2024 on sandy soil after receiving only 20 mm (0.8 inches) of rain during the previous 5 weeks of hot weather.

Corn yields and stand counts were determined in two adjacent 6.1 m lengths of row at the center of each plot. Differences in corn stand counts (Figure 4, left) were observed on the silty soil, with early cover crop termination resulting in lower corn stand counts than mid or late termination. In both fields at CMREC-Beltsville corn yields were very low due to severe drought, but higher corn grain yields (Figure 4, right) occurred where cover crops were used. In the sandy field, corn following a rye cover crop yielded higher than corn following no cover crop. In the silty field, corn following a cover crop mixture yielded higher than corn yields than corn following no cover crop. The immediate benefits of high-biomass cover crops and planting green tend to show up most clearly during drought-stressed years.

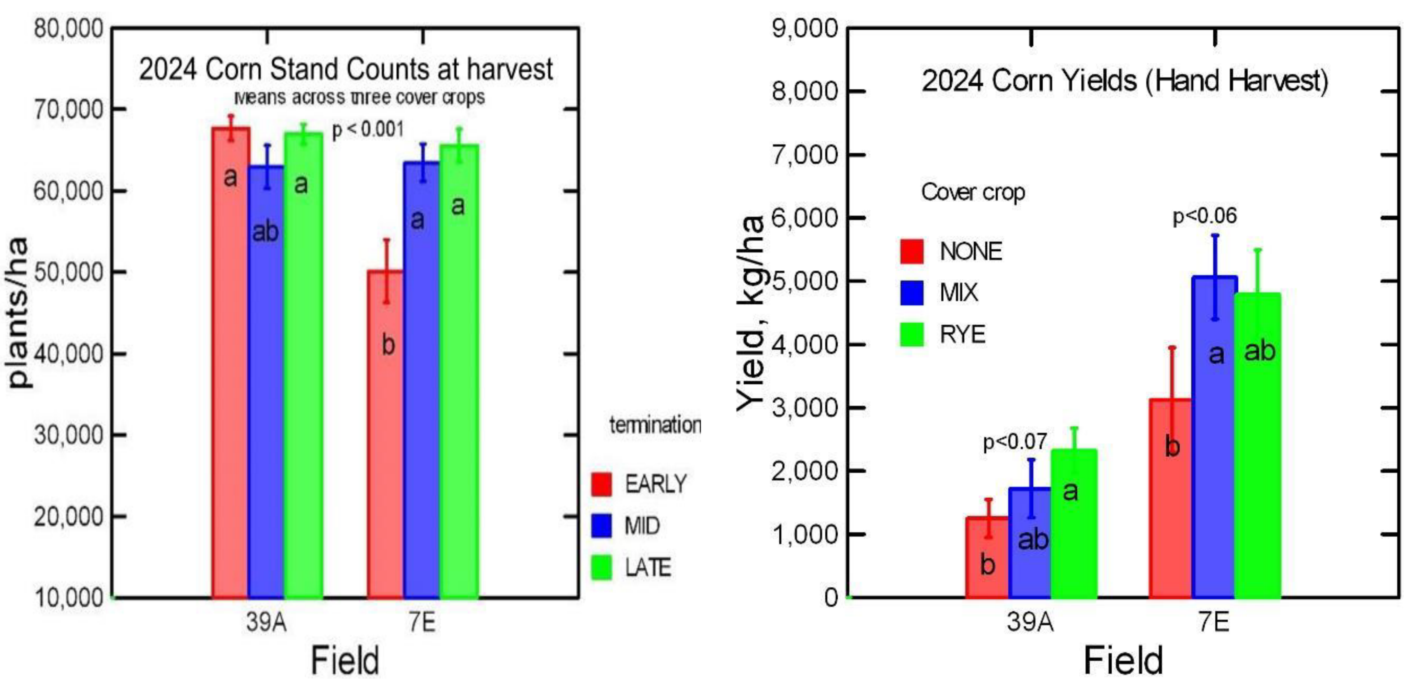

Figure 4. Corn stands on the silty clay soil (Field 7E) at CMREC were reduced with early kill across cover crop types, possibly due to wetter soils at planting. Corn grain yields were very low due to extreme drought, especially on sandy soils (Field 39A), but were significantly higher where cover crops were used. Soils were less dry in summer around tasseling under the cover crop residues.

Sweet Corn Sentinel Monitoring Network: 2024 Results and Trends with Previous Years

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

<u>Collaborators:</u> Terry Patton, Kristian Holmstrom, David Owens, Michael Crossley, Helene Doughty, Sean Malone, Tim Bryant, Kemper Sutton, Tom Kuhar, Daniel Gilrein, Heather Grab, Timothy Elkner, Jared Dyer, Brian Nault, John Mahas, Kelsey Fisher, Jocelyn Smith, Caitlin Congdon, Holly Byker, Julien Saquez, Jason Wells, Kelley Tilmon, Chris DiFonzo, Amy Raudenbush, Fei Yang, Genevieve Higgins, Heather Darby, Robert Wright, Craig Abel, Decker Ashley Lynn, Christian Krupke, Nicholas Seiter, Bradley McManus, Dominic Reisig, Steven Roberson, Anders Huseth, Francis Reayjones, Tom Bilbo, Whitney Crow, Dave Buntin, Huang Fangneng, Pat Porter, Dalton Ludwick, Yves Carriere, Kelly Hamby

Introduction and Background

Sweet corn sentinel monitoring has been conducted annually since 2017 to track changes in corn earworm (CEW) susceptibility to Cry and Vip3A toxins expressed in Bt corn and cotton. Each year, Syngenta and Bayer-Seminis provide sweet corn seed that is repackaged and distributed to volunteer collaborators to establish sentinel plantings of non-Bt and Bt hybrids. All collaborators use the same planting and data collection protocol to generate metrics showing differences in control efficacy between Bt and non-Bt plots. To estimate the allele frequencies for CEW resistance to each Bt toxin, the phenotypic frequency of resistance (PFR) is 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 is viewed as a genetically-based change in CEW susceptibility and confirmation of field-evolved resistance. In 2024, the objective was to continue monitoring for changes in resistance development to the Bt toxins, with greater emphasis on the Vip3A toxin and better timing of larger ear samples to detect early signs of resistance. This report summarizes the 2024 results and trends with previous years.

Overall monitoring network results

The 2024 network involved 56 sentinel plantings in 28 states (TX, LA, FL, MS, AZ, MS, GA, MO, SC, NC, VA, MD, DE, PA, NJ, NY, CT, MA, VT, OH, IN, IA, IL, NE, SD, KS, WI, MN, MI) and 4 Canadian provinces (ON, QC, NS, NB). Collaborators in CT, MD, VA, MN, SC, GA, TX and ON established multiple plantings at different times and/or locations. Forty-two of the plantings included five sweet corn hybrids: Attribute 'BC0805' expressing Cry1Ab, Attribute II 'Remedy' expressing Cry1Ab and Vip3A, and their 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). Twelve plantings included only larger plots of the Providence and Remedy hybrids to focus more precisely on resistance to the Vip3A toxin. Additionally, other Cry1Ab+Vip3A-expressing hybrids (Milky Way and Revision) were planted at all MD sentinel sites to increase the chances of detecting resistance development to the Vip3A toxin.

Complete data sets of 54 sentinel plantings were submitted and analyzed, whereas two sentinel plantings were not sampled due to poor plant growth and/or animal damage. Altogether, a total of 24,928 ears were examined to record kernel consumption, number of CEW per instar, location of damage (tip, upper, lower), and presence of exit holes. High CEW infestations caused kernel damage to >70% of the non-Bt ears at 37 sentinel plantings. Summed over all plantings, 73.3% of the non-Bt ears were damaged, with an overall average of 1.1 larvae per ear and 5.0 cm 2 of kernel consumption per ear. In comparison, the overall percentage of CEW- damaged ears expressing Cry1Ab, Cry1A.105+Cry2Ab2, and Cry1Ab+Vip3A averaged 62.9%, 61.3% and 0.4%, respectively. The number of larvae and kernel consumption averaged 1.23 and 4.79 cm 2 per damaged Cry1Ab ear, and 1.05 and 3.92 cm 2 per damaged Cry1A.105+Cry2Ab2 ear, respectively. Overall levels of larval numbers and kernel consumption per ear in 2024 were lightly lower the levels in 2023, which was likely due to differences in CEW population pressure, rather a change in the frequency of resistance to the Cry toxins.

Collaborators sampled a total of 10,428 Cry1Ab+Vip3A expressing ears from all plantings to detect changes in CEW susceptibility to the Vip3A toxin. Of these, only 5 sentinel plantings were infested with live larvae feeding at the ear tip, which were mainly 2th and 3 rd instars associated with < 1 cm 2 of kernel injury. Several collaborators reported older CEW instars in Cry1Ab+Vip3A ears but ELISA gene testing determined that the ears came from non-Bt plants. No older instars were found alive in ears expressing the Vip3A toxin. These results indicate that CEW resistance to the Vip3A toxin has not increased compared to the resistance levels reported in 2023.

Other lepidopteran pests

The sentinel network also monitored susceptibility changes and regional differences in populations of fall armyworm (FAW), western bean cutworm (WBC), and European corn borer (ECB). Twelve sentinel sites (2 in MD, NJ, 2 in VA, SC, GA, FL, 2 in TX, AZ, and NB) reported ear damage by FAW in the non-Bt plots, ranging from 1-12% of the plants infested. No FAW infestations were detected in sentinel plots expressing Cry1A.105+Cry2Ab2, and only two plantings reported injury on 1-3% of the plants expressing Cry1Ab. Only three sentinel sites (IA, NB, NS) recorded WBC damage in non-Bt ears (ranging from 1-24%), BC0805 ears (ranging from 3-25%), and Obsession II ears (ranging from 4-15%). Levels of WBC damage were likely over- estimated at these and other northern sentinel locations because the specific cause of kernel injury in ears without any larvae could not be determined. Overall, infestations of FAW and WBC were lower in 2024 compared to levels reported in 2023.

In response to the ECB resistance development in eastern Canada and CT, many collaborators sampled plants in the Providence and Remedy sweet corn plots to assess ECB infestations. The Remedy plots provided the best indicator of resistance to the Cry1Ab toxin because the Vip3A oxin has no effect on ECB, and thus there is no interspecies interaction with CEW. A combined total of 3,452 Providence and Remedy plants were split to record ECB larvae and tunneling injury at 23 sentinel plantings (10 in MD, 2 in NY, NJ, VA, FL, IN, IA, NE, 4 in CT, NS). Most noteworthy, collaborators found no evidence of any ECB injury in non-Bt plants at sentinel sites in central and eastern MD, VA eastern shore, and Geneva NY, indicative of the area-wide suppression of this pest in the mid-Atlantic region.

At the CT and NS sites, larger samples of 50 to 100 plants each of the five hybrids were examined to increase the chances of detecting early signs of ECB resistance to the Cry toxins. The highest levels of non-Bt plants infested were recorded at two western MD plantings (30- 40%), Riverhead, NY (40%), Deerfield, MA (40%), and at four sentinel sites in CT (17.5-20%). Larger samples of 100 plants of each hybrid were examined for ECB injury at the Valley, Grismoth, Hamden1, and Hamden2 sentinel sites in CT. Pooled over these sites, the percentage of infested plants in the non-Bt, Cry1Ab, and Cry1A.105+Cry2Ab2 expressing plots averaged 19%, 1.6%, and 3.8%, respectively. The ECB infestation levels at these CT sites were significantly lower than those recorded at the Hamden site in 2023, which averaged 18% and 21% in the Cry1Ab and Cry1A.105+Cry2Ab2 plots, respectively. This suggests that the resistance levels reported in 2023 at the Hamden site may have resulted from the southern dispersal of moths from resistant Canadian populations, rather than locally-evolved resistance.

Estimates of the phenotypic frequency of resistance

To estimate PFR, it is assumed that any live 2 th thru 6 th instar CEW that survived to cause kernel damage in a Bt ear indicates some level of resistance to the expressed toxins, which could result in mature larvae surviving to contribute resistance alleles in the next generation. Not all data sets from sentinel plantings were used to calculate PFRs, depending on whether all five hybrids were planted. Furthermore, only data from plantings reporting >50% damaged ears and infested with >50% 4 th , 5 th and 6 th instar larvae were used to calculate PFRs. Thirty-three of the 54 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 older larvae per ear. Thirty-seven trials satisfied the selection criteria for the Cry1Ab+Vip3A toxins. The following summarizes the PFRs for each individual or pyramided Bt toxins, in comparison with previous sentinel monitoring results.

<u>Cry1Ab (BC0805 vs Providence)</u>: Since Cry1Ab expressing sweet corn was commercially introduced in 1996, the level of CEW phenotypic resistance has significantly increased. 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, 1.09 in 2023, and 0.95 in 2024. The percentage of damaged ears and kernel consumption per Cry1Ab ear, along with larval development delays, remained about the same during the last four years. Nine of the 26 BC0805 plantings in 2024 had higher numbers of surviving CEW per Bt ear compared to numbers per non-Bt ear, resulting in PFRs > 1. A PFR of 1 essentially indicates that all CEW larvae in the population have some level of resistance to the Cry 1Ab toxin. PFR values > 1 are the result of behavioral changes in sublethally intoxicated larvae. In a non-Bt ear, early instar CEW freely feed together without any interaction, but then become cannibalistic once they reach the 4 th instar stage. This aggressive behavior eventually results in only one or sometimes two mature larvae surviving in a non-Bt ear. Sublethal intoxication by the Cry1Ab toxin inhibits the cannibalistic behavior, allowing more larvae to feed and survive together in Bt ears. Although the effects of this behavioral inhibition may have leveled off in recent years, larval recruitment in a Cry1Ab-expressing plant may actually produce more CEW moths emerging compared to recruitment from a non-Bt plant. However, it is still unclear as to how many larvae actually reach the mature stage, pupate and successfully emerge as normal reproductive adults; and, more importantly, contribute resistant alleles in the next generation.

<u>Cry1A.105+Cry2Ab2 (Obsession II vs Obsession I)</u>: Phenotypic frequencies of resistance to the dual Cry toxins have steadily increased since 2010, averaging 0.19 during 2010-2013 and 0.41 during 2014-2016. Sentinel network results continue to show evidence of further resistance development, with PFRs averaging 0.67 in 2017, 0.93 in 2018, 0.70 in 2019, 0.89 in 2020, 0.95 in 2021, 0.92 in 2022, and 0.85 in 2023. In 2024, the estimated PFR was 0.82, based on 26 sentinel plantings of Obsession II vs Obsession I that satisfied the selection criteria. Six sentinel locations reported higher CEW densities in the Obsession II plots compared to densities in the Obsession I plots, resulting in PFRs > 1. Overall, the phenotypic frequencies have leveled off over the last five years of monitoring, and there has been no consistent increase in kernel consumption or percentage of older instars surviving Cry1A.105+Cry2Ab2 ears. Pyramiding with other Bt toxins, particularly Vip3A, in field corn and cotton have likely reduced the selection pressure on the two Cry toxins, thus resulting in a slower rate of resistance development.

Cry1Ab and Vip3A (Remedy/Milky Way/Revision 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 show larval survival with the 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 mainly with 2 th and 3 rd 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 cm 2 , primarily on the tip), but only 25 of these ears (0.12%) were infested with a total of 82 live larvae (78% early instars). The majority of ear damage with older larvae in Vip3A ars was reported from southern locations (TX, LA, MS, AL, NC). However, not all of these damaged ears were tested for Vip3A expression, so some ears on plants may have 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 numbers of ears to increase the chances of detecting early signs of resistance to the Vip3A toxin. Twelve of the 49 sentinel plantings were infested with a few surviving early CEW instars, with PFRs for Vip3A resistance ranging from 0.003 to 0.070. Interestingly, sentinel locations in IL, NE, IA, VA and NC had the highest PFRs showing evidence of Vip3A resistant alleles, compared to the southern locations. This difference 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.

In 2024, larger samples of ears from Vip3A expressing plants were examined for CEW survival, and a number of collaborators used ELISA gene tests to confirm Vip3A expression, which reduced the number of false positives due to non-Bt expressing ears. In contrast with previous sentinel results, only five sentinel locations (Wooster OH, Riverhead NY, Ames IA, Dean Lee LA, Lubbock TX) reported PFRs ranging from 0.0009 to 0.0022. Given this range of PFRs, the 2024 results show no change in CEW susceptibility to the Vip3A toxin compared to previous years; thus, the field efficacy of the Vip3A-expressing sweet corn continued to provide excellent ear protection against CEW in all sentinel plantings.

NOTICE TO BENEFICIARIES AND PROSPECTIVE BENEFICIARIES

Name of Organization: **University of Maryland MAES**

Name of Program: **Entire entity**

Contact Information for Program Staff: Alan Leslie, MAES Center Director (CMREC, LESREC & WMREC), 301-276-1241, aleslie@umd.edu

Because this program is supported in whole or in part by financial assistance from the Federal Government, we are required to let you know that:

(1) We may not discriminate against you on the basis of religion, a religious belief, a refusal to hold a religious belief, or a refusal to attend or participate in a religious practice;

(2) We may not require you to attend or participate in any explicitly religious activities (including activities that involve overt religious content such as worship, religious instruction, or proselytization) that are offered by our organization, and any participation by you in such activities must be purely voluntary;

(3) We must separate in time or location any privately funded explicitly religious activities (including activities that involve overt religious content such as worship, religious instruction, or proselytization) from activities supported with direct Federal financial assistance; and

(4) You may report violations of these protections, including any denials of services or benefits by an organization, by contacting or filing a written complaint with the Office of the Assistant Secretary for Civil Rights, Center for Civil Rights Enforcement, Program Complaint Division by mail, fax, or e-mail at:

Mail:
United States Department of Agriculture
Director, Center for Civil Rights Enforcement
1400 Independence Avenue, SW
Washington, DC 20250-9410

Fax: (202) 690-7442
Email: program.intake@usda.gov

(5) If you would like to seek information about whether there are any other federally funded organizations that provide these kinds of services in your area, please contact Latoya Hicks at lhicks12@umd.edu.

This written notice must be provided to you before you enroll in the program or receive services from the program, unless the nature of the service provided, or exigent circumstances make it impracticable to provide such notice before we provide the actual service. In such an instance, this notice must be provided to you at the earliest available opportunity.

COLLEGE OF AGRICULTURE & NATURAL RESOURCES

MAES | MARYLAND AGRICULTURAL EXPERIMENT STATION

Central Maryland Research and Education Center
Beltsville Facility

12000 Beaver Dam Road
Laurel, MD 20708
301-226-7488

https://agnr.umd.edu/research/research-and-education-centers-locations/cmrec/beltsville

Facility Personnel & Support

Kevin Conover
Facility Manager
kconover@umd.edu

Richard Whelton
Agricultural Technician Lead
rwhelton@umd.edu