CORN MARKETING PROGRAM

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2023 CMPM Research Report

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TABLE OF CONTENTS

At the Corn Marketing Program of Michigan (CMPM), research is one of the most important ways that we invest your checkoff dollars. Our research is aimed at improving the profitability of Michigan's corn farmers. From the development of management strategies for emerging diseases and weeds to finding new uses and markets for corn – our investment helps ensure a brighter future for corn farming in Michigan.

This year, we prioritized proposals for new research opportunities that addressed the following areas:

- **Innovative new uses for corn and corn by-products that are environmentally friendly and relevant to consumers.**
- **Pest management practices related to weeds and diseases that are economically feasible and environmentally sound.**
- **Water management, water quality, and drainage strategies.**
- **Cost effective production methods that may be high input or low cost, ultimately achieving profitable corn production.**

We're proud of the research we funded in 2022 and we hope you'll take the time to review the progress made on each project.

Thank you to all of Michigan's corn farmers for the support of CMPM and we look forward to continuing to serve you.

Sincerely,

Matt Holysz
President
Corn Marketing Program of Michigan

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Controlled Drainage: A conservation drainage practice to reduce phosphorus loss from subsurface-drained fields

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Objective and Methods

The main objective of this project is to investigate the effectiveness of controlled drainage for reducing nutrient loss from subsurface-drained farms. The on-farm experiment was in Lenawee County, Michigan (Figure 1 left; site labeled as "BL"). The experiment had two half-fields, one with free drainage and the other with controlled drainage. Reductions in flow and loads were calculated based on the paired-field approach (Clausen and Spooner 1995). Other stakeholders have funded different aspects of this project alongside the Corn Marketing Program of Michigan (CMPM) in 2022 including the Michigan Department of Agriculture and Rural Development (MDARD) and the Michigan Department of Environment, Great Lakes and Energy (EGLE).

Findings

This research report represents the fourth and final year of study in partnership with CMPM, although aspects of this project will continue with external funding. In 2022, we found that controlled drainage significantly reduced drainage discharge by 68% and nitrate load by 78% compared to free drainage. Because controlled drainage did not significantly affect nitrate concentration, drainage discharge reduction played a significant role in reducing nitrate load. Reduction of nitrate load with controlled drainage has been well-

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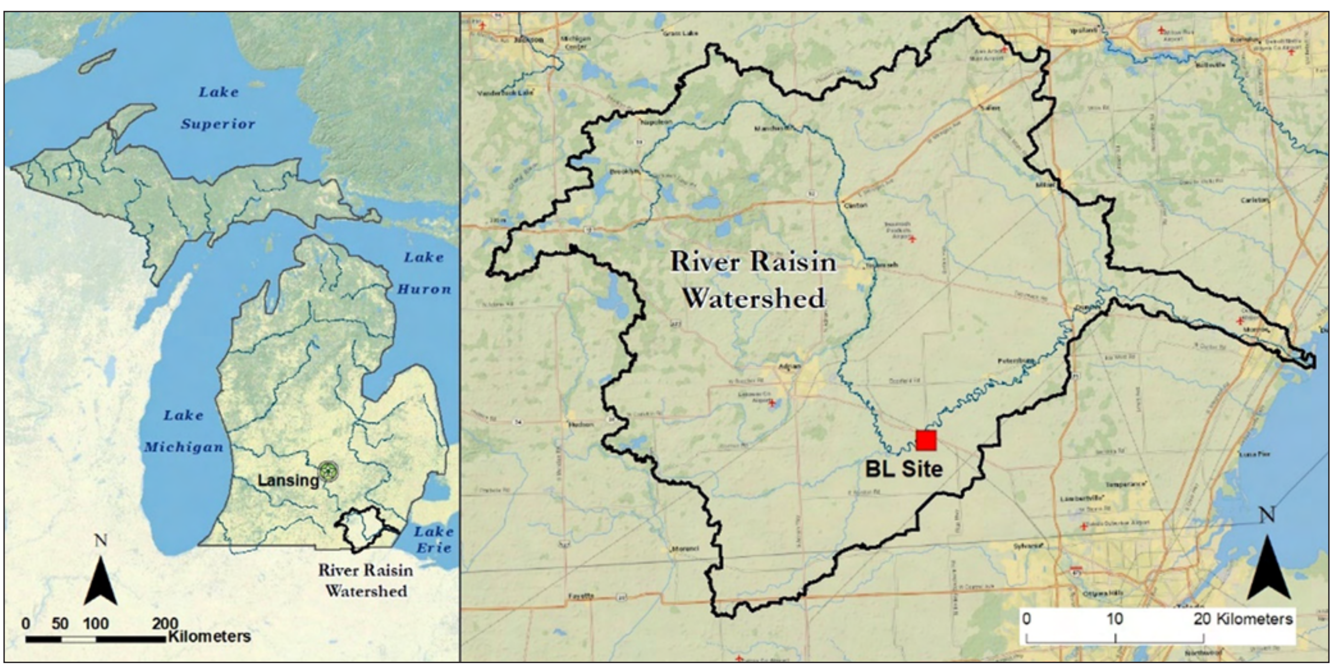
FIGURE 1

Left: Map of Michigan with the location of the study site. *Right:* A photo of the monitoring equipment at the site.



documented. The combined results of this study and the literature show that controlled drainage is a promising practice in reducing nitrate load from drainage discharge.

At the study site (Figure 1 right), we found that controlled drainage significantly reduced total phosphorus load by 37% and dissolved reactive phosphorus by 20% compared to free drainage during the combined water years 2021 and 2022. Similar to nitrate, drainage discharge reduction was the main mechanism for total phosphorus and dissolved reactive phosphorus load reduction under controlled drainage.

The performance of controlled drainage varied during each of the water years. The controlled drainage treatment had a positive impact on reducing phosphorus load in water year 2022, but it had a small adverse effect of releasing phosphorus load in water year 2021 (Figure 2). Overall, controlled drainage reduced phosphorus load during the combined water years of 2021 and 2022,

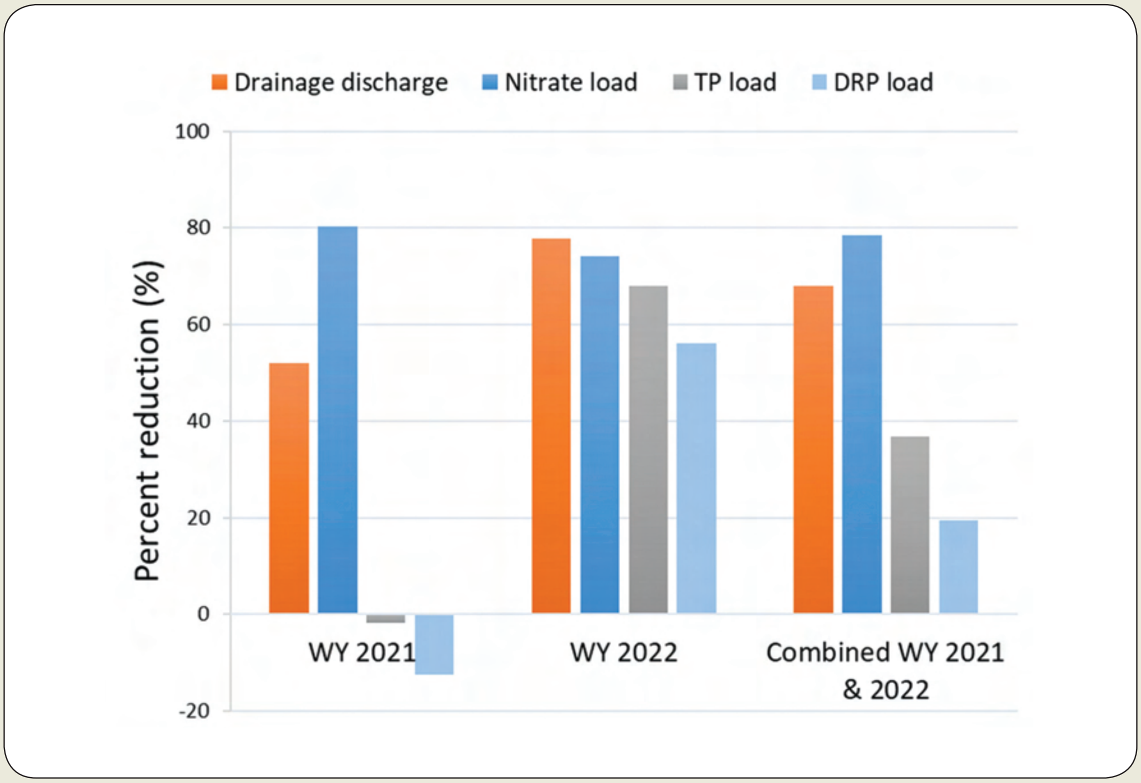
Conclusions and Future Work

Preliminary results showed that controlled drainage significantly reduced nitrate and phosphorus load compared to free drainage during the combined water years of 2021 and 2022. Therefore, in this multi-year study, controlled drainage showed potential as a promising practice for reducing nutrient loss from drainage discharge.

Because of the varying response of the performance of controlled drainage in each of the water years 2021 and 2022, future work is needed to provide an in-depth insight into the performance of controlled drainage under varying weather conditions.

FIGURE 2

The effect of controlled drainage in reducing drainage discharge, nitrate load, TP load, and DRP load during water year 2021, water year 2022, and the combined water years 2021 & 2022. A positive percent reduction means that CD reduced nutrient load. A negative percent reduction means that CD had an adverse effect of releasing P load in only one water year. Overall, CD reduced nitrate and phosphorus load during the combined water years 2021 & 2022.



Predicting agronomic performance in Michigan Genomes 2 Fields: An ongoing collaboration with NCGA

Dr. Addie Thompson, Michigan State University, thom1718@msu.edu

INTRODUCTION:

Genomes to Fields (G2F) is a multi-state collaboration supported by corn grower groups across the country. The overarching goal is to improve modeling and predictions of how different genotypes perform in diverse environmental conditions (climate, soil, and other factors). This project incorporates aspects of fundamental biology and plant development, computational modeling, quantitative genetics and statistics, and agronomic crop modeling. Michigan State has taken part in these trials as a way of ensuring that our state's growing conditions are represented in this landmark dataset.

OBJECTIVES:

Our primary objective was to leverage genomic information with Michigan-specific phenotypic and environmental data to enable working knowledge and prediction of plant performance under Michigan growing conditions and improve predictions into diverse environments. New this year, the organization hosted a yield prediction contest. Groups were to use genotypic and environmental data from the 2014-2021 field seasons across sites to predict the 2022 results. Teams submitted their predictions for every variety in each environment.

METHODS:

Our Michigan trial consisted of 400 hybrids planted in two replications in a randomized complete block design, for a total of 800 plots. From each plot, we collected data according to the project's standard protocol: stand count, plant and ear height, dates of anthesis and silking, root and stalk lodging, grain yield, test weight, and harvest moisture. In addition, our location collected aerial imagery and spectral data. We also collected more detailed information about the growth rate of different varieties, such as leaf initiation rate. The standard data from each of the states' sites gets deposited after a delay to the project website: https://www.genomes2fields.org/resources/.

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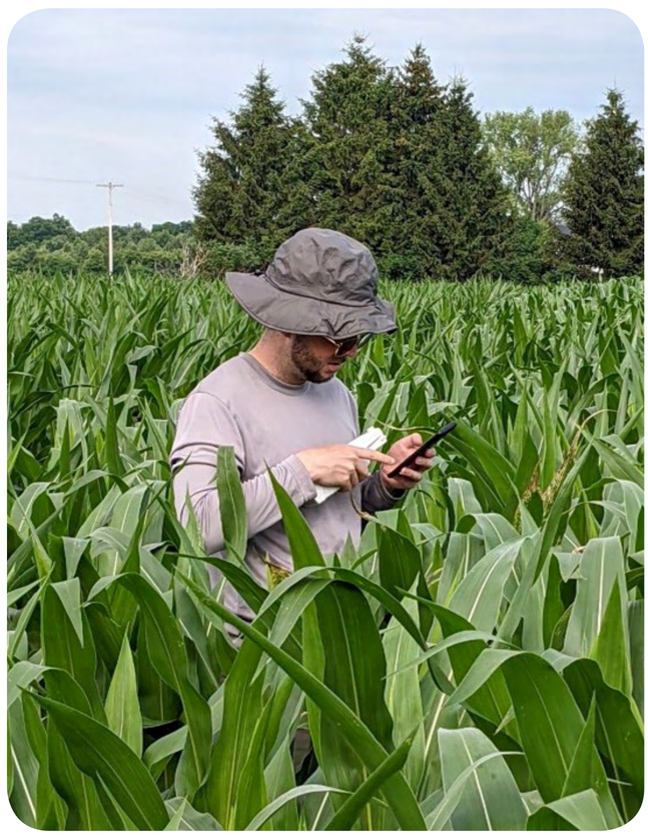

FIGURE 1

PhD student Brandon Webster collects photosynthesis data in a hybrid field.

KEY RESULTS:

The Michigan 2022 field season was a success. Major outcomes included:

- Training of multiple graduate and undergraduate students, including visiting students and scholars from other institutions.
- Students presented ongoing work via posters and talks at conferences and meetings.
- The prediction contest drew participants from more than 20 countries around the world, in 128 teams from a mix of academic, industry, and government groups.
- The winner of the prediction contest was a team four young scientists in Corteva's Latin America group, all of whom had attended public universities in the US for one or more portions of their education.

FIGURE 2

Visiting undergraduate researcher Donielle Brottlund from the University of Missouri collects chlorophyll measurements.

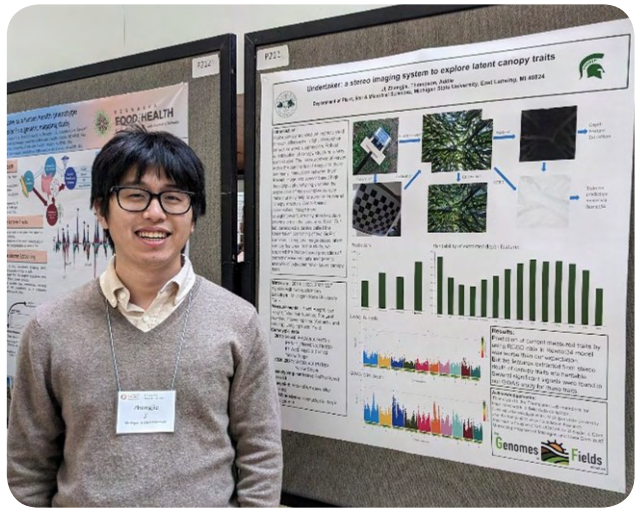

FIGURE 3

PhD student Zhongjie Jie presents his poster on phenotyping innovations at the Maize Genetics Conference. Zhongjie's PhD thesis projects in drone and image-based phenotyping as well as genomic prediction approaches have all used Michigan's Genomes to Fields datasets.

FIGURE 4

A subset of the Thompson lab attended the University Undergraduate Research and Arts Forum, where undergraduate research projects were showcased via research poster presentations.

Utilizing early maturing corn hybrids to maximize cover crop biomass, soil health, corn yield, and sustainable integrated weed management in Michigan

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Weeds are troublesome, aggressive, and competitive plants that reduce corn yield. Integrated weed management (IWM) strategies are needed for long-term sustainable corn production in Michigan. One IWM tactic is planting cover crops, however a major barrier to cover crop adoption in Michigan and the Upper Midwest is achieving the large amount of biomass needed for weed suppression. Overall, the physical barrier of cover crop residue on the soil surface is most important for weed control. Interseeding cover crops into standing corn is often the recommendation made to establish cover crops earlier in the season to achieve desired biomass. Although an innovative approach, a barrier to this method is the cost of equipment needed to interseed, costs associated with paying outside sources to interseed, and lack of summer precipitation to establish interseeded cover crops.

Another approach to maximizing cover crop biomass production is to utilize the breeding improvements that have been made in corn resulting in high yielding early maturing hybrids that can be planted in early spring and harvested early in the fall, thus allowing for earlier cover crop planting and the potential to maximize biomass production prior to cash crop planting the following spring. In addition to maximizing cover crop biomass, being able to plant cover crops earlier

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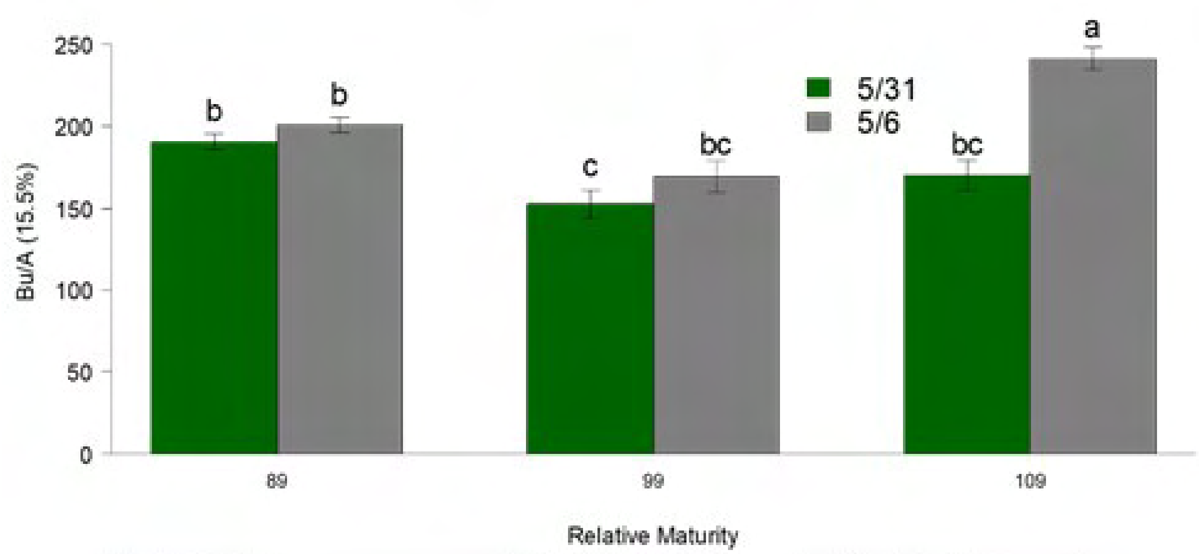
FIGURE 1

Corn yield of 89, 99, and 109 relative maturity corn hybrids planted on May 6 or May 31, 2022. Bars labeled with the same letter are not statistically different (p > 0.05).



in the fall will increase the duration of living ground cover and is a known tactic to reduce water runoff and soil erosion.

This project, in its second year of funding from the Corn Marketing Program of Michigan, investigated the use of early maturing corn hybrids, corn planting date, herbicide program, and cover crop species composition on subsequent weed control and crop yield. Establishing and growing cover crops is not a one size fits all practice therefore this project will provide another tool to tailor to individual cropping systems and overall goals.

Project objectives and goals: produce significant cover crop biomass to provide weed control benefits in Michigan. Investigating early maturing corn hybrids, early cover crop planting, and weed control will increase adoption and economically sustainable crop production in Michigan.

1) Evaluate the effects of early maturing corn hybrids, planting date, herbicide program, and cover crop species composition, on weed control, crop yield, and economic returns.

2) Deliver optimized practices to growers and the Michigan corn industry.

To address these objectives a field study was conducted at the agronomy farm at Michigan State University. The study is a split-plot randomized block design with four replications. Whole plots were assigned to one of three corn hybrids with 89, 99, and 109 relative maturities. Sub-plots were split into two corn planting dates (5/6/22 and 5/31/22), one of two cover crop species combinations (winter hardy grass only, winter hardy grass-legume mix), and the following spring termination timing of cover crops: one week prior to soybean planting or at soybean planting. Plots were planted with an Almaco SeedPro360 planter with SkyTrip GPS and are eight rows wide spaced at 30 inches and 25 feet long. Yield impacts of planting date and hybrid maturity were assessed at harvest. One month after cover crop planting, cover crop establishment was measured. In spring of 2023 the project team will assess cover crop survivorship, biomass, and C:N ratio. Furthermore, to assess the impacts of cover crop planting date and biomass, in the spring of 2023 weed communities will be assessed throughout the duration of the experiment in two 1 m2 quadrats per sub-plot. Weeds present will be identified to species and counted biweekly. Weeds present at the end of the season will be harvested prior to seed shatter, dried, weighted, and seeds counted.

There was no difference in yield between 89 and 99 relative maturity corn hybrids that were planted either early (5/6/22) or late (5/31/22) (Figure 1). However, the 109 relative maturity corn hybrid planted early (5/6/22) yielded approximately 70 Bu/A more compared to 109 relative maturity hybrid planted later (5/31/22). Corn planting date and hybrid maturity impacted cover crop planting, with the earlier maturing corn hybrids harvested first allowing for cover crops to be planted earlier than later maturing corn hybrids planted at the same date. Overall, harvest occurred over a 1.5 month time span which allowed for multiple cover crop planting dates and will provide us the opportunity to evaluate a wide variety of spring biomass levels on weed suppression (Figure 2).

Results from this research will be disseminated to growers and stakeholders throughout Michigan after completion in spring of 2023. Information from this research will be presented at Erin Burns' regular Extension presentations at statewide and regional winter 2022-2023 extension meetings and summer 2023 field tours. Newsletter articles and factsheets generated from research findings will be posted on the MSU Weed Science website. Overall, this project will aid in successful and economically sound weed control that can be applied under highly variable growing seasons resulting from changes in weather. Ultimately, this research will help growers reduce uncertainty, adapt their cropping systems to the upcoming changes in climate, and provide growers with environmental and economically sustainable solutions to maximize yield.

FIGURE 2
Cover crop growth.

Optimizing management of tar spot

Dr. Martin Chilvers, Michigan State University, chilvers@msu.edu

Tar spot development in 2022

Apart from some planting delays due to moisture, the 2022 growing season brought relatively dry conditions across most of the state. The lack of frequent rainfall and low humidity throughout most of the season resulted in the reduced frequency and duration of leaf wetness events. Leaf wetness is crucial for most pathogens, as spores typically require free moisture for plant infection. As conditions were relatively dry after planting tar spot was slow to develop, and we seemed to escape most of the early disease development which can set the stage for explosions of the disease as we head into flowering and ear development. For comparison as shown in Figure 1. At our primary trial location near Decatur, MI we detected tar spot on July 7th in 2021, with a subsequent rapid ramp up of tar spot disease intensity. In 2022, tar spot was not detected until August 12th and there was little subsequent disease development. Even if there had been moisture events in late August of 2022 there may not have been enough tar spot present for disease to ramp up quickly. Statewide, although there were some reports of tar spot in mid-July, there were not sufficient leaf moisture events for the disease to develop into a significant threat. Likewise, many counties still didn't have tar spot confirmations even by the middle of August. Nationally we have been monitoring tar spot development by county, of note is the continued expansion of tar spot out of the Great Lakes region, with recent spread into South Dakota and Kansas as examples. This data can be viewed at https://corn.ipmpipe.org/tarspot/.

Findings and Future Research

Multistate fungicide trials in 2022 focused on comparing fungicide efficacy and timing, but also the value and economics of two applications. For maximum disease suppression we compared various fungicide products as a single pass at silking (VT/R1), with a second application three weeks post the VT/R1 application. Of the states that participated including Illinois, Indiana, Iowa, and Michigan, very little tar spot developed. Locations in Ontario and Wisconsin saw moderate tar spot pressure. When looking at data across all locations, two applications reduced tar spot development, however in general fungicide applications did not result in significant yield protection. Data from these trials was used to update the corn foliar fungicide efficacy chart for 2023, which can be found by searching the Crop Protection Network https://cropprotectionnetwork.org/
https://cropprotectionnetwork.org/publications/fungicide-efficacy-for-control-of-corn-diseases.

In 2022 we also continued efforts to develop data sets to train and test the tar spot disease forecasting app "Tarspotter" developed by our colleagues at UW-Madison. The Tarspotter app is free to download and can be found on your smartphone app store. Using data from 2022, the model in the Tarspotter app has been revised and reevaluated. Tarspotter can be used to assess tar spot disease risk based on weather variables for multiple pinned locations within the app. When using the app, keep in mind that it is still important to scout fields to see if disease is present and be mindful of crop growth stage. We typically see the best fungicide timing for tar spot suppression is from silking (VT/R1) through to milk (R3) or dough stage (R4).

Graduate student Jill Check continued tar spot epidemiology studies which included tracking disease development and spore release over time. Although there was little disease to track in 2022, this year's data will be invaluable to refining risk models and understanding weather variables related to tar spot fungus spore release and dispersal. Jill's work has been critical in exploring the role of plant population and nitrogen rates in tar spot development. Jill found that although very low plant populations (~30k plants/A) did see an increase in tar spot development, the effect of hybrid

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susceptibility was a much greater driver of disease development and yield impact. The studies also determined that nitrogen application rates did not affect tar spot development over the five site-years examined. Planting populations and fertility programs should continue to emphasize best agronomic and economic practices. However, it needs to be remembered that hybrid resistance to tar spot is a cornerstone of disease management.

Graduate student Emily Roggenkamp developed a real-time quantitative PCR assay to detect and identify the tar spot fungus prior to visual symptom development. Essentially, it is a DNA technique that allows us to determine if the tar spot fungus is present in a sample. Together with colleagues around the Midwest, the assay has been able to detect spores of the tar spot fungus 2 weeks prior to disease symptomology. This tool could enable us to provide an early warning system of disease development. Emily also worked with postdoc Joshua MacCready in the lab to sequence a genome of Phyllachora maydis (the tar spot pathogen), which has provided insight into the biology of the pathogen as well as identified fungal effectors that may be involved in the infection process and yield loss due to tar spot symptoms. We are working with collaborators to further characterize these putative P. maydis effectors as they may help in corn disease resistance breeding.

In addition to our grain corn work, we were awarded a Michigan Alliance for Animal Agriculture (MAAA) grant to examine the management of tar spot on silage corn. Although there are differences between grain and silage production, we will be able to leverage work in grain corn and silage corn to further management of this challenging disease. In 2022, graduate student Peyton Phillips conducted trials examining hybrids, hybrid x fungicide and chop timing on silage yield and quality.

This work was supported in part by the Corn Marketing Program of Michigan, Project GREEEN, and MSU AgBioResearch.

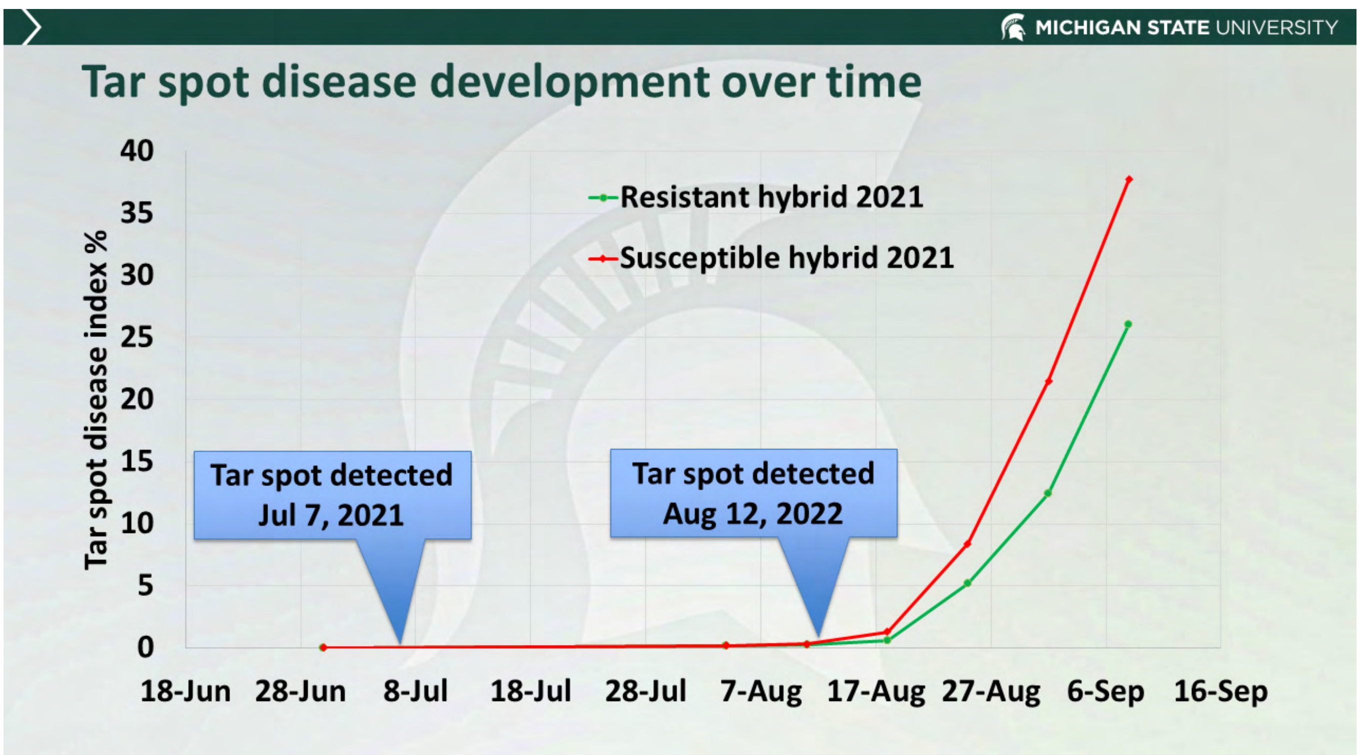

FIGURE 1

Visual tar spot detection in field in 2021 vs 2022 and disease development in 2021 on 'resistant' and 'susceptible' hybrid, note how a 'resistant' hybrid slows disease development. So little tar spot developed in 2022, that it was not possible to plot disease on this chart.

Quantifying corn physiological consequences due to tar spot disease to inform management decisions

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Project Synopsis:

Tar spot is a fungal disease of corn that has recently become a threat in Michigan and the North Central Region and has led to yield losses as large as 50 Bu/a in Western Michigan. It is crucial to understand how this pathogen interacts with the corn plant. As an obligate biotroph, the tar spot pathogen requires plant metabolites (such as carbohydrates produced in photosynthesis) as a food source to grow and reproduce. Under high disease pressure the pathogen will put a strong demand on plant resources, and hence impact plant strength and grain yield. This along with leaf lesions reduce healthy leaf surface area for photosynthesis and carbohydrate production and will eventually reduce the yield. Understanding the response of different corn hybrids to these demands to make informed decisions (e.g., fungicide application) is critical in preventing the negative influence of disease on corn growth and productivity. Also, since timing of management options is extremely critical for this disease, it is important to develop and understand the time series between tar spot disease progression and leaf physiological health. The overall goal of this study was to understand the differential physiological impact of tar spot in susceptible/resistant corn hybrids for photosynthetic productivity and metabolic changes to help determine the necessity and timing of management strategies. The specific objectives for this study were:

1. To evaluate the effects of tar spot severity on photosynthetic metabolism and metabolic defense responses in corn hybrids with variable levels of resistance to tar spot and at varying levels of fungicide treatment.

2. To understand the impact of tar spot and fungicide treatments on whole plant carbohydrate relations, dry yield, and quality of corn grain.

3. To associate changes in photosynthetic capacity to visual leaf lesion area using a non-linear model to determine predictiveness of visual assessment on disease severity.

Methods and Procedures:

Corn was planted at two locations: Ingham and Ottawa on 5/11/22, and 5/17/22, respectively. Four row wide plots (22 ft long x 10 ft wide) were laid in a randomized complete block design with 4 replications. Treatments included three hybrids differing in their resistant levels to tar spot (resistant, tolerant, and susceptible) and three fungicide treatments, 1) non-treated 2) one fungicide application at the silking stage (R1) and 3) two applications of fungicide [one at R1 and one at dough stage (R3)] using Delaro 325 SC at label rate of 8oz ac-1. Ingham location was inoculated at V8 by spreading 150 grams of diseased leaf litter per plot, ahead of forecasted rain. Following R1, the trials were scouted for tar spot. Photosynthetic measurements were done weekly starting the first week of August (Fig. 1). Plants from non-yield rows were destructively sampled and brought back to the lab for determining carbohydrate contents, hormone profiles, and other metabolites.

Preliminary Results:

In 2022, tar spot severity was low (<20%) and it was observed only at the Ottawa site with first symptoms in mid- Sept. Photosynthetic rate decreased linearly over the growing season for all three hybrids and the rate of decline was not significantly different among these hybrids (Fig. 1). Maximum photosynthetic rate under no disease severity was not different among three hybrids and for fungicide treated and non-treated plots. Photosynthesis declined with an increase in disease severity (Fig. 2). Disease severity was lower in plots with two fungicide applications than in plots

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with just one application or non-treated control plots. The reduction in photosynthetic rate due to tar spot was significant between hybrids only later in season due to delayed onset of disease. Results indicate that incorporation of resistant traits to fight the infections may come at an additional cost of a higher decline in overall carbon assimilation even at a lower disease level. However, more data is needed to validate these findings. No difference in yield was associated with tar spot due to late disease incidence and low severities.

Impacts and Future Directions:

The preliminary results from this study showed that foliar diseases (such as tar spot) result in reduction of photosynthetic capacity of the plant, both due to necrotic visual lesions as well as virtual lesions (area around visual lesions where leaf functions are impacted). Selection for resistant traits might result in a fitness penalty and a greater decline in photosynthesis at a given disease level. Therefore, selection for disease tolerant hybrids that can minimize disease levels as well as its impacts on leaf functions might be beneficial. Ongoing sample/data analyses along with 2nd year trials funded by the Corn Marketing Program of Michigan will help improve understanding of impacts of tar spot on photosynthetic and other leaf functions.

FIGURE 1

Left: **Decline in leaf photosynthetic rate in three hybrid classes over the growing season at Ottawa field trials.** ***Right:*** **In-field measurement of photosynthetic rate using Licor 64000XT.**

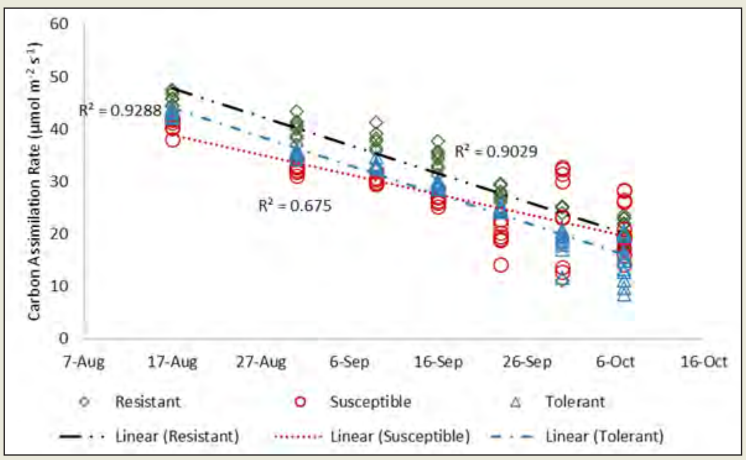
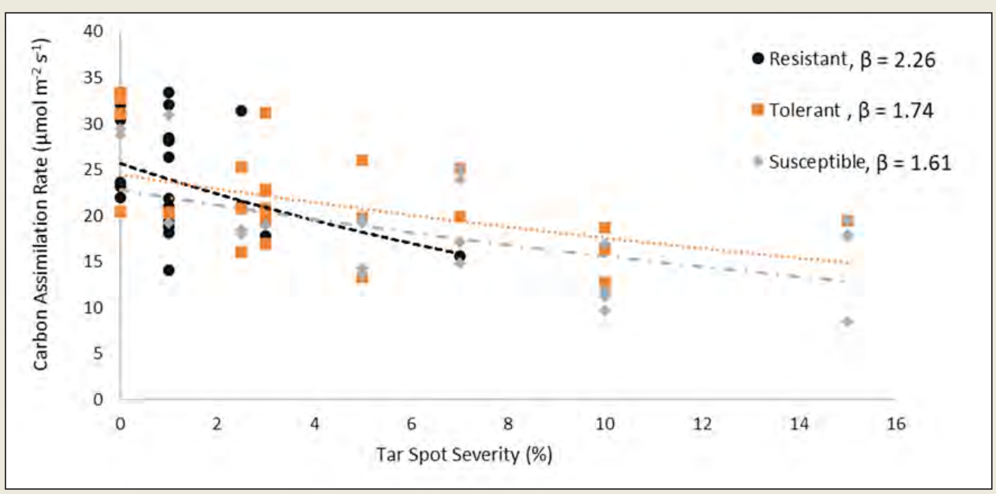


FIGURE 2

Decline in leaf photosynthetic rate due to increase in disease severity in three hybrid classes at Ottawa. β values indicate the loss in photosynthesis with a unit increase in disease severity, higher values indicate greater relative reduction.



Evaluation of fungicide application methods and timing for effects on tar spot control and corn yield

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Suppose they gave a war and nobody came is an anti-war slogan from the 60's. It was a reminder of the situation regarding Tar Spot fungus of corn in 2022. Despite rapid spread of tar spot each year since 2016 and widespread severe infestation in 2021, tar spot was not the problem that it was expected to be in 2022. Growers prepared by using research information and other tools that had become available. This included fungicide trials and recommended products, the phone app Tarspotter, and seed company recommendations for more tolerant hybrids. As prepared as growers seemed to be at the start of 2022, there was still a need for more research to provide more tools. In fact, the Corn Marketing Program of Michigan (CMPM) provided funding for three projects involving with tar spot, one of these conducted by the North Central Research Station (NCRS). The NCRS is a 1400-acre research and production farming operation in Clinton County near St. Johns. Tar spot had been observed in corn there for several years and had become severe in some areas in 2021. As a research station, it was felt that there were some areas that had not been comprehensively tested in the field. An experiment was designed and established to evaluate the following factors individually and in combination to determine which would have the best outcome on disease control, yield and economics.

Research questions and methods

1. Fungicide. Veltyma from BASF is one of the fungicides that had shown merit in university trials and may even provide some residual control. **2. Corn Growth Stage.** For best tar spot control, fungicides like Veltyma are recommended to be applied from tassel (VT) and silking (R1) to milk stage (R3). Such applications require high-clearance sprayers or aerial application. Could application at an earlier stage, such as on five feet corn that most self-propelled sprayers could cover, be economically effective even with less tar spot control than that at later stages? 3. **Hybrid selection.** While all corn will get tar spot, there are differences in the level of susceptibility. Could hybrid selection forgo or reduce the need for fungicide? **4. Fungicide Placement.** Fungicide trials have involved boom applications from high-clearance ground sprayers, or simulations of that. The canopy at that growth stage would hinder complete foliage coverage, which may be necessary for optimal control. Identified research trials have not included application equipment that can cover foliage beneath the canopy. 360 UNDERCOVER from 360 Yield Center enables under-the-canopy application with an multi-directional nozzle cluster. The NCRS has used this system for several years with general corn fungicides and has had good results. Based on these factors, a research trial developed with the following factors:

1. Check: No Fungicide

2. Veltyma (7 oz/A) – Boom only, at 5 ft tall corn (V10)

3. Veltyma (7 oz/A) – Boom only, at VT (8-9 ft tall corn)

4. Veltyma (7 oz/A) – Boom and 360 UNDERCOVER at 5 ft tall corn (V10)

5. Veltyma (7 oz/A) – Boom and 360 UNDERCOVER at VT (8-9 ft tall corn)

Corn Hybrids: Dekalb tolerant and susceptible (both 102-day RM). The researchers are thankful to Nutrien Ag Solutions of Breckenridge for providing the Veltyma and Dekalb hybrids used. The experiment was established under irrigation as a split-plot design (6-row plots: 3 rows each for tolerant and susceptible) with four replications of treatments. Plot length was 275 feet long. The inside two rows of each hybrid were harvested for yield by a combine utilizing a Har-

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vest Master Grain Gage system. Numerous measurements for treatment effects on tar spot control were conducted.

The arrangement of the 360 UNDERCOVER nozzle system is shown in the picture (right). Previous testing with spray cards showed much better under-canopy foliage wetting with this system compared to boom only. All applications were with a modified Hagie STS 10 sprayer at a spray volume of 16 gallons per acre and 70 psi (pictures at right and below).

First application was made to 5-foot-tall corn. It was decided to use corn height rather than a growth stage because height is the key factor. The mark on the pipe is 5-feet. The second application was at VT/R1 where the corn was considerably higher and would be impossible for all but high-clearance sprayers.

Findings

A DJI P4 drone flew the plots nine times from late July to early October, collecting a multitude of spectral measurements. Due to minimal disease, there were no treatment effects observed. The difference from tar spot infection in 2021 vs 2022 was striking, as seen in the pictures both taken in late-September at the NCRS (right). The corn leaf on the right was from the 2022 experiment. Weekly infestation maps released by ipmPIPE.org showed less infection in Michigan in 2022. Within the two hybrids, fungicide, regardless of placement, did not increase yield. Between the hybrids, the "tolerant" hybrid yielded significantly higher than the "susceptible" hybrid when averaged across all treatments, 207.2 vs 187.8 Bu/A, respectively. It is thought that since 2022 was drier than 2021, that there wasn't enough prolonged leaf surface wetness for infection. Regardless, it is felt that this research project should continue as an evaluation of multi-factor control measures, because severe tar spot will likely return. This experiment will be repeated in 2023 with funding from CMPM.

Conceptual process engineering enabling transformation of lactic-to-acrylics and separation of mixtures

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Abstract:

Acrylic acid and acrylates form a $10B market for chemicals used across paints, coatings, adhesives, and superabsorbent polymer businesses. Låkril Technologies is developing a catalytic dehydration technology to convert corn-derived lactic acid and ethanol to sustainably produced bio-acrylics at cost-parity to traditional petrochemical routes. This represents a market expansion directly driving value creation of about 90 bushels of corn per metric ton of acrylic produced, or about 2 million bushels of corn per year for each 30kMTA typically sized plant. Using the research funds, we performed conceptual process engineering to de-risk the separation process and design the chemical engineering process for production of acrylic acid at scale.

Project Results:

We purchased the required software (ASPEN+ process simulator, SaaS) and computer to run the software. We engaged an experienced project engineer (Dave Wegerer) and collaborated on an initial design concept, which has been developed into a functional flowsheet. These flowsheets are the precursor to a piping and instrument design (P&ID) from which a plant could be constructed. We have focused initially on the key central step of the process, the conversion of lactic acid to acrylic acid with a feed design basis of 15-25wt% lactic acid in water. A simplified graphical version of the current flowsheet is shown in the figure (next page).

To design the reactor section, we used a 15wt% lactic acid solution as feed, heating of the feed to 300ºC, and a simple gas / solid contacting fixed bed reactor. The reactor product composition was projected from laboratory evaluation data for the bifunctional catalyst comprising a solid acid and engineered amine which has been shown to provide high yields of acrylics from corn-derived lactic acid. , To develop the flow scheme for the separation section, we then had to consider:

1) unconverted lactic acid

2) acrylic acid purity

3) water, both that produced during the dehydration and included with the lactic acid feed

4) side product separation (acetaldehyde and carbon oxides)

5) distillation column parameters

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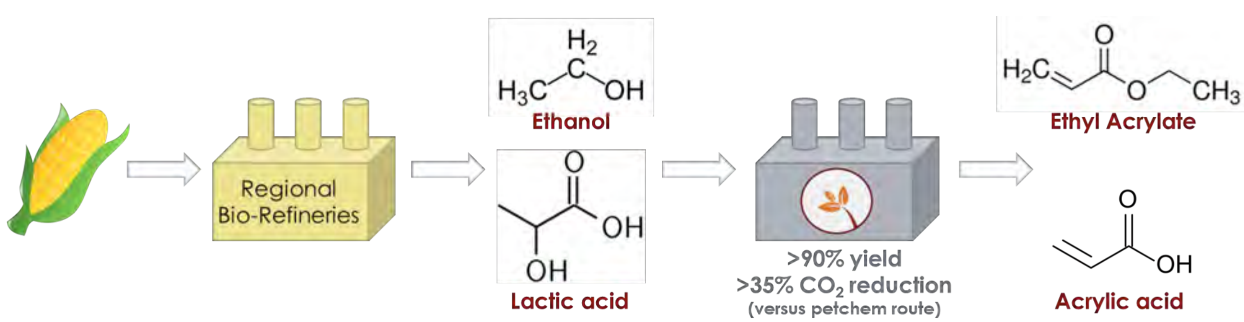

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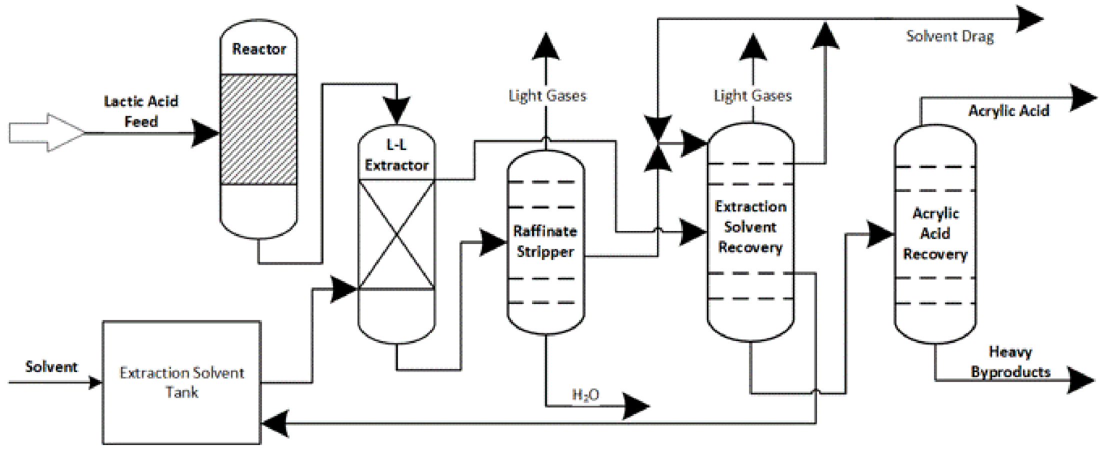

Key Findings and Future Plans:

A key portion of the flow scheme is a liquid-liquid extraction (LLE) unit for concentration of the acrylic acid in the product stream in the presence of water. Higher water content in the feed means larger LLE and more energy cost. Lower water feeds decrease unit sizing and decreases capital cost without affecting distillation significantly. Liquid-liquid extraction units were initially used in propylene oxidation and then gradually replaced with more efficient separation techniques over time. We have started with a liquid-liquid separation here as alternative separation techniques need additional R&D work to be considered for commercialization.

Following concentration of the acrylic acid (AA) into the extraction unit raffinate, the raffinate passes to a distillation column where a significant amount of water is removed. The bottoms of this column pass to the AA product column where AA is purified to 99.6+% for sale (currently 99.8%, but we will probably relax this in a future iteration to reduce energy utilization). We have found that parameterization of the interaction of the impurity 2,3-pentanedione with AA within the Acrylic Acid Recovery column is poor and requires experimental work as using some parameter sets show 23PD distills, while others put it with heavy byproducts. This will be the focus of the FY23 project funded by the Corn Marketing Program of Michigan.

We also performed an initial technoeconomic analysis using the ASPEN+ software. As we knew going into this conceptual process engineering project, the lactic acid feedstock is the primary cost of acrylic acid production. Depending on the price we assign, lactic acid is between 40 and 60% of the AA cost of production. The chart at left shows the current design with a price of $800/MT on lactic acid basis. Energy utilized is the second largest cost due to the recycle loop on the extraction unit and refrigeration needs on some distillation columns. We are studying how to reduce these energy uses while producing a robust process for separation of AA from the reactor product stream.

Moving from 15-25wt% lactic acid showed significant decreases in the capital cost. As lactic acid becomes more concentrated, it becomes more expensive, but brings significantly less water into the system, thereby reducing volumes processed for the same AA output volume. This becomes both a technical and economic optimization of the process on which we are working currently via other programs. Through heat integration and additional optimization of distillation columns, we have identified pathways to take us to a 25% decrease in cash cost of production, and hence below the current price of production of petrochemical acrylic acid.