Hybrid Selection and Fungicide Application for Managing Ear Rots and Mycotoxins in Silage Corn

Harkirat Kaur, Maninder Singh, Martin Chilvers, Christina Difonzo and Kimberly Cassida

Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI

Introduction

- Mycotoxin accumulation in silage corn (*Zea mays* L.) is a growing problem in the Great Lakes Region. It deteriorates the feed quality of silage and may cause health issues in livestock impacting milk production.
- Mycotoxin development occurs due to ear and stalk rots caused by fungal species such as *Gibberella zeae* and *Fusarium verticilliodes, Cladosporium herbarium*.
- The problem has intensified due to favorable environment for fungal infection and increased flight of ear damaging insects such as western bean cutworm (WBC, *Striacosta albicosta*) and European Corn Borer (ECB, *Ostrinia nubilalis*), causing husk wounds and providing easy entry points for infection propagules.
- Therefore, it is important to identify management practices that growers can use to minimize ear-damaging insects and diseases leading to these quality related issues.

Objectives

- To evaluate the effect of hybrid selection and fungicide application on ear damage, mycotoxin accumulation, yield and overall quality in silage corn.
- To quantify and correlate insect feeding and ear rot with mycotoxin accumulation in silage corn.

Materials and Methods

- Field trials were conducted in 2019 and 2020 at various Michigan locations in randomized complete block design with five replications at each location (Figure. 1).
- Treatments included hybrids with differing insect protection levels (Table 1) and fungicide application, using Proline 480 SC (prothioconazole) @ 416.5 ml/ha at silking (R1).

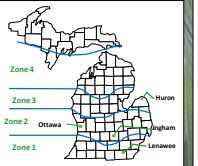


Figure 1. Field trials locations in Michigan (Zones were based on normal GDD data). Ingham and Huron included a fungicide application

Hybrid Class	Protein	Insect Protection
Conventional (Conv)	-	No Insect protection
Agrisure	Cry1F	ECB
Agrisure Viptera (Viptera)	Cry1F + Vip3A	ECB & WBC

Table 1. Hybrid traits used for study had three levels of insect resistance

- Ingham was inoculated with *Fusarium* spp. (strain ph1 and C13AB2A) a day after fungicide spray to increase disease pressure.
- On the day of silage harvest,10 ears from center two rows of four-row plots were used to rate for disease and insect incidence and severity. Ear rot index was calculated as, ear rot incidence x ear rot severity
- Harvesting occurred at mid-dent stage (~60% moisture) using a two-row Champion C1200 Kemper forage harvester with a rear mounted Haldrup M-63 weight system to measure fresh biomass yield.
- Representative samples were collected from each plot for estimating moisture, dried, ground to 1 mm sieve size
- Samples were analyzed for mycotoxins (deoxynivalenol, DON and >20 others) using Liquid Chromatography /Mass Spectrometry (LC/MS).
- Quality parameters, NDF (neutral detergent fibre), NDFD (neutral detergent fiber digestibility), ADF (acid detergent fiber), starch, crude protein (CP) were analyzed using NIRS. Milk yields were determined using Milk equation 2006.
- Data was analyzed using Proc Glimmix in SAS 9.4 using Tukey's adjustment at significance of 0.1.
- Ingham 2019 and Huron 2019 are used for results and discussion except insect and disease ratings.

Results and Discussion

Mycotoxins in Michigan Silage Corn

- Survey of random farmer fields in 2019 showed at least one mycotoxin in each field. 15 mycotoxins were found positive in each of the tested samples which indicated that mycotoxins co-exist in Michigan silage fields.
- 9% samples had higher mycotoxin levels than threshold for deoxynivalenol, DON (5 µg/g), zearalenone, ZON (1 µg/g) and 5% for fumonisin (1 µg/g).

Weather Patterns

- Due to wet spring 2019, planting was delayed at all locations. Lenawee and Ottawa were dropped due to poor emergence and low plant stand. Planting progressed on time in 2020 due to normal rainfall and temperature.
- Most Michigan locations receive 60-70 mm monthly rain during August, but in 2019, rainfall was <15 mm at Ingham and < 20 mm at Huron.
- Dry spell during silking window resulted in low disease development as most of ear rot fungi prefer high humidity. Ingham 2019 had low disease levels despite inoculation.
- 2020, however, was closer to an average year, with timely plantings but was dryer than normal during July at the time of silking and hence lower disease development.

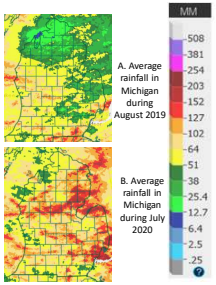


Figure 2. Rainfall trends in Michigan during Silking period

Western Bean Cutworm Damage

- Western bean cutworm was lower in Agrisure Viptera hybrids compared to conventional hybrids(Figure 3), due to insect protection traits in these hybrids.

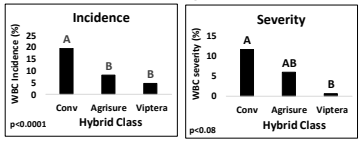


Figure 3. Effect of corn hybrid insect resistance on Western Bean Cutworm (WBC) damage at Ingham in 2019

- There was no impact of hybrid class at Huron 2019, which could be due to a very low insect flight (data not shown).
- At Huron, in 2020, WBC damage was high at Huron and was impacted by hybrids (Figure 4), however, unlike 2019, damage was highest in hybrids from Agrisure trait and similar to conventional hybrids (Figure 4).

WBC damage on Corn Ear; A. WBC husk wounds, B. WBC feeding

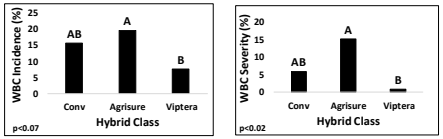


Figure 4. Effect of corn hybrid insect resistance on Western Bean Cutworm (WBC) damage at Huron in 2020 (incidence p = 0.07; severity, p=0.02)

Ear Rot Index

- No interaction was seen between hybrid class and fungicide treatment.
- Ear rot index was lower Agrisure Viptera hybrids compared to conventional hybrids (Figure 5).
- Fungicide application did not decrease disease incidence or severity in any site year. Previous studies have shown both positive and no effects of fungicide.

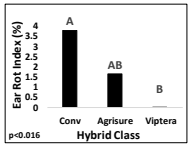
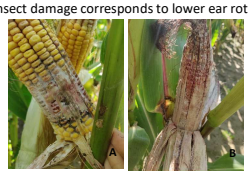


Figure 5. Effect of corn hybrid class on Ear rot index (product of ear rot incidence and severity) Ingham in 2019 (p=0.016)

Ear Rot Index

- Ear rot index at Huron 2020 was lower for Agrisure viptera compared to Agrisure hybrids (Figure 6).
- Results from both years affirm that the hybrid class with minimum insect damage corresponds to lower ear rot infections.



A. Corn ear with white (*F.verticillioides*), pink (*Gibberella zeae*) and black mold (*C. herbarum*); B. *Gibberella* Ear Rot

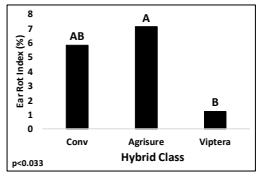


Figure 6. Effect of corn hybrid class on ear rot index (product of ear rot incidence and severity) Huron in 2020 (p=0.033)

Ear Rot and Western Bean Cutworm

- Weak or no correlation was seen between ear rot and western bean cutworm damage in 2019 at both locations (data not shown); which may be due to low insect and disease levels at Huron, and artificial inoculation at Ingham.
- Strong positive correlations were seen between ear rot and WBC damage at Huron in 2020 (Figure 7), emphasizing importance of insect damage on mold development.
- The inconsistency of correlations between ear rot development and insect damage have been found in previous research also as many other factors such as temperature and humidity play a crucial role in ear rot development.

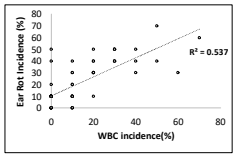


Figure 7. Correlation between ear rot incidence and WBC incidence at Huron 2020

Mycotoxins and Ear Damage

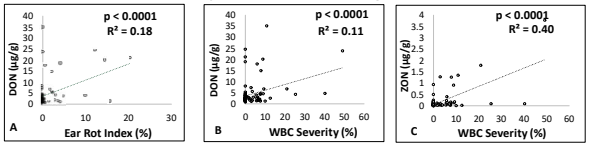


Figure 8. Correlation between ear damage (by disease and insect) and mycotoxin concentration

- A weak positive correlation was seen between ear rot index and DON across both locations (Figure 8 (A)). Higher DON levels corresponded to higher disease index.
- A weak positive correlation was also observed between WBC severity and DON (Figure 8(B)).
- A similar correlation was found between ZON and WBC severity (Figure 8 (C)). ZON levels were in general lower than DON levels at both locations.
- Agrisure Viptera hybrids has lowest DON and ZON levels compared to other two hybrid classes (data not shown), probably due to low insect damage and disease index in those hybrids.
- Fungicide application did not show reduction in mycotoxin content for treated plots, which was similar to no suppression of ear rot development .

Mycotoxins Co-occurrence

- Co-occurrence of multiple mycotoxins was observed in most samples, DON and ZON showed highest levels while all the other toxins are found at very low levels (mostly < 1µg).
- Co-occurrence of mycotoxins leads to ambiguity in issuing the guidelines for toxin levels in many cases and may also result in complex reactions in livestock metabolism.

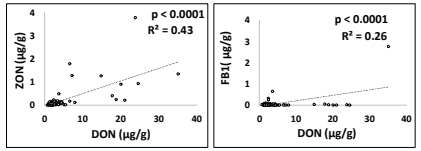


Figure 9. Correlation between mycotoxins found in silage corn in 2019

Dry Yield and Quality

- Hybrid class or fungicide application did not impact dry yield as well as milk parameters for 2019 locations, indicating minimal impact of these management decisions on silage corn.
- Quality parameters such as CP and NDFD were impacted by hybrid class, with CP highest for conventional hybrids, while NDFD was highest for Agrisure Viptera hybrids.
- Fungicide did not have any effect on any of the yield or quality parameters, indicating minimal benefit of fungicide application in this research.

Conclusions and Future Directions

- Mycotoxins and their co-occurrence seems to be prevalent in Michigan and probably other Great lakes states. Hence, in-field management of silage corn is key in minimizing accumulation of mycotoxins.
- Functional hybrid insect protection traits play a crucial role in preventing insect damage to corn ears and restrict the entry of pathogen into host cells and could help suppress of mycotoxin accumulation.
- Weak correlations between insect damage, ear rots, and mycotoxins indicate that benefits of insect management strategies in minimizing mycotoxins in silage corn might be limited to locations with high insect pressure or lack of favorable conditions for disease development at silking
- Fungicide application showed minimal impact on ear rots, mycotoxin accumulation and silage quality at all locations in this study. Previous research has shown variable results based on field conditions and application methods. More research is needed to evaluate the return on investment of fungicide application in silage corn.
- Overall, an integrated management approach must be used to minimize mycotoxins in silage corn including continued research at regional level on ear vs stalk rots, harvest and plant timing, hybrid selection, crop rotation, residue management, and tillage practices.

Acknowledgements

We offer our sincere gratitude to Bill Widdicombe, Katlin Fusilier, Tom Siler, Kalvin Canfield and Mikaela Breuing and the farm cooperators and extension personnel for their contribution. We thank all current and former graduate and undergraduate students for their help and cooperation. Also, we extend our thanks to MMPA, MAAA and Project Green for supporting the research.

Smith, J. L., Limay-Rios, V., Hooker, D. C., & Schaafsma, A. W. (2018). Fusarium graminearum mycotoxins in maize associated with Striacosta albicosta (Lepidoptera: Noctuidae) injury. *Journal of economic entomology*, *111*(3), 1227-1242. Anderson, N. R., Romero, M.P., Ravellette, J. D., & Wise, K. A. (2017, August). Impact of foliar fungicides on Gibberella ear rot and deoxynivalenol levels in corn. Plant Health Progress, 18(3), 186-191. Munkvold, G. P. (2003). Epidemiology of Fusarium diseases and their mycotoxins in maize ears. In *Epidemiology of Mycotoxin Producing Fungi* (pp. 705-713). Springer Netherlands. Goeser, J. (2015). Mycotoxin guidelines and dietary limits. Limay-Rios, V., Schaafsma, A.W. (2018). Effect of Prothioconazole Application timing on Fusarium mycotoxin in Maize grain. J. Agric. Food Chem., 66, 4809–4819