Integrated Mycotoxin Management in Corn Grain Through Control of Ear Rot and Western Bean Cutworm

Katlin Blaine, Maninder Singh, Martin Chilvers and Christina DiFonzo
Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI

Introduction

- Mycotoxins have increasingly been an issue in corn (*Zea mays* L.) in the Great Lakes region due to the interaction between a new ear feeding insect *Striacosta albicosta* (western bean cutworm, WBC), favorable environmental conditions for fungal growth, and susceptible hybrids.
- When ear rot infections occur, the risk of mycotoxins in corn grain increases.
- Growers need better information to manage the threat of ear rots and associated mycotoxins in their fields.

Objectives

- To quantify and correlate WBC damage with ear rot and mycotoxin levels.
- To determine the effect of foliar fungicide applications on ear rot, associated mycotoxins, and yield in corn hybrids with differing resistance to ear rot.

Materials and Methods

- Field experiments were conducted in 2017 at nine locations across Michigan.

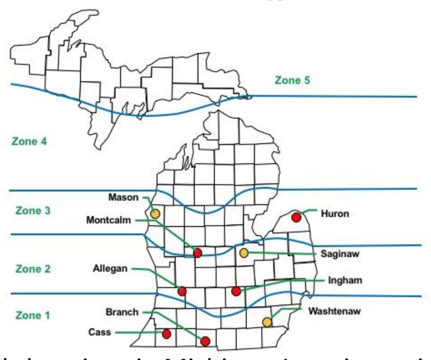

Figure 1. Field trials locations in Michigan. Locations with red dots indicate fungicide application, yellow dots indicate no fungicide.

- Plots were four rows wide and 6.7m long with 0.76m row spacing and 84,000 plants/ha
- Plots were manage according to grower standards
- Two factors were used (hybrid selection and fungicide application) in a RCBD design.

Table 1. Hybrids used in 2017 had three levels of ear rot resistance, provided by the company. Within each resistance level a hybrid with and without the Cry1F *Bt* protein for WBC control was used.

Ear Rot Resistance	With Cry1F	No Cry1F
Below Average	DKC53-56	DKC53-58
Average	DKC54-38	DKC54-40
Above Average	DCK55-20	DKC55-21

- The fungicide Proline® (prothioconazole) was applied at 416.5 ml/ha at R1 using a high clearance backpack CO_2 sprayer at six locations
- Prior to machine harvest, 20 ears were hand harvested from the center two rows
- The center two rows were harvested with a plot combine equipped with an auto weigh system to determine yield.
- Ears were rated for incidence (% of ears damaged per plot) and severity (% kernels damaged per ear with injury) of both WBC and ear rot, ear rot index was also calculated as the product of the incidence and severity
- Ears were threshed, cleaned, ground to 1mm screen size, and tested for deoxynivalenol (DON) and zearalenone
- Data was analyzed using Proc Glimmix in SAS using a Tukey's adjustment with a statistical significance of 0.05.
- Presented results based on the 2017 growing season, zearalenone was not detected in any sample therefore only DON results are shown

Results and Discussion

Weather Patterns

- Weather conditions were dry during the time of silking in 2017 in Michigan (Figure 2).
- *Fusarium graminearum*, the fungal pathogen that produces DON, requires high humidity for spore production[2].

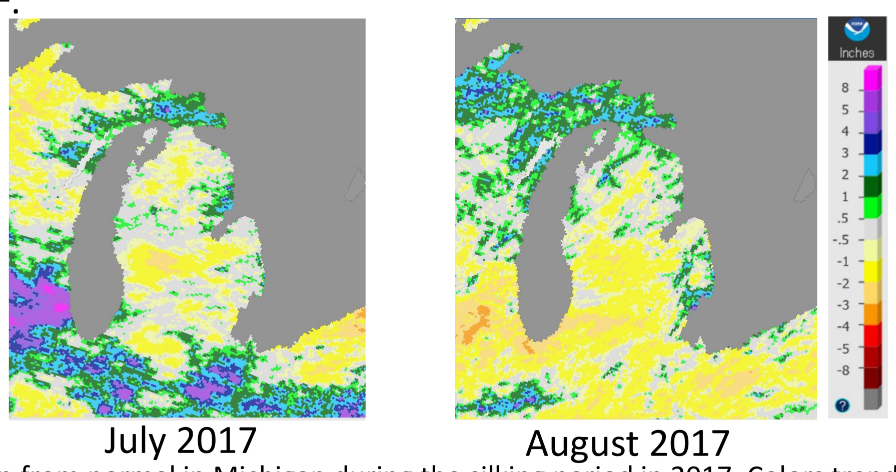

Figure 2. Rainfall deviation from normal in Michigan during the silking period in 2017. Colors trending toward the red end of the spectrum indicate dry conditions. Colors toward the purple end indicate wet conditions. Maps generated from the National Weather Service's Advanced Hydraulic Prediction Service.

Western Bean Cutworm and Ear Rot

- A positive correlation occurred between WBC incidence and ear rot incidence (Figure 3).
- This correlation demonstrates the importance that WBC control may have on ear rot incidence reduction and associated mycotoxins.

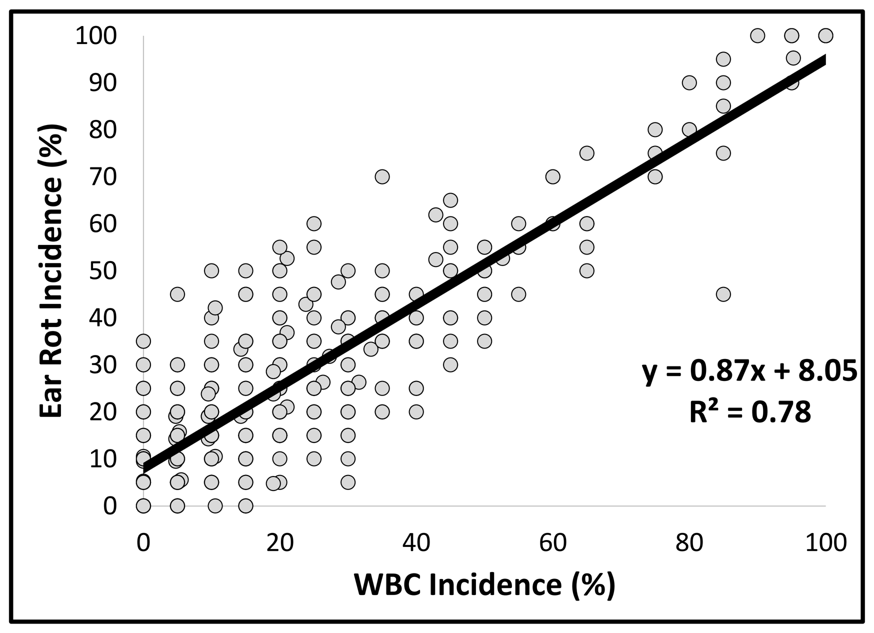

Figure 3. Correlation between western bean cutworm (WBC) incidence and ear rot incidence across all nine locations (p-value <0.0001).

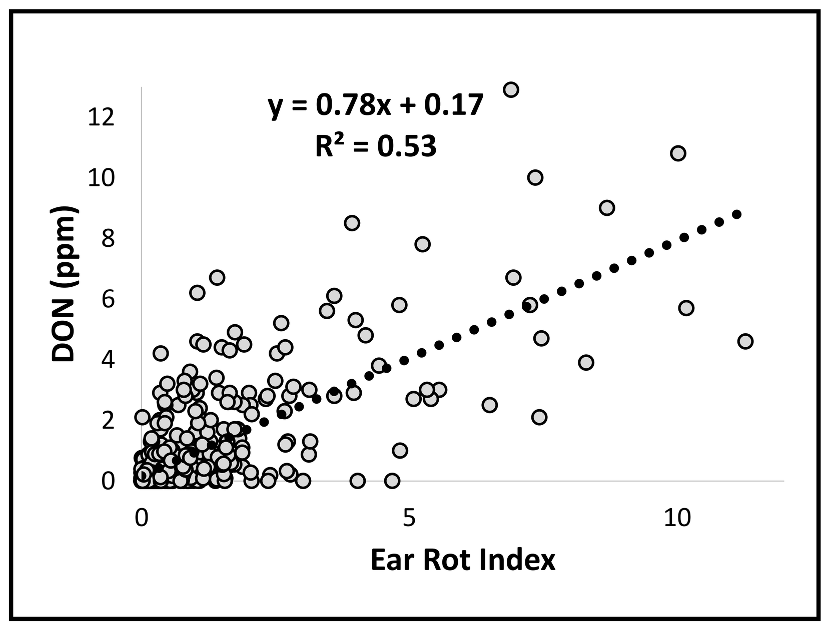

Figure 4. Correlation between ear rot index and deoxynivalenol (DON) levels across all nine locations (p-value <0.0001)

Ear Rot Index and Deoxynivalenol Levels

- A positive correlation was found between the ear rot index and DON levels (Figure 4).
- This correlation shows the importance of reducing ear rot disease to reduce mycotoxins in corn grain.

Hybrid Effect on Western Bean Cutworm

- Within ear rot resistance levels there was no difference in WBC damage between hybrids with the Cry1F Bt protein and hybrids without Cry1F (Figure 5)
- WBC has recently developed resistance to Cry1F making it no longer effective at controlling WBC in the Great Lakes region[3].
- Among resistance levels differences in WBC incidence and severity appeared to be related to maturity ratings.

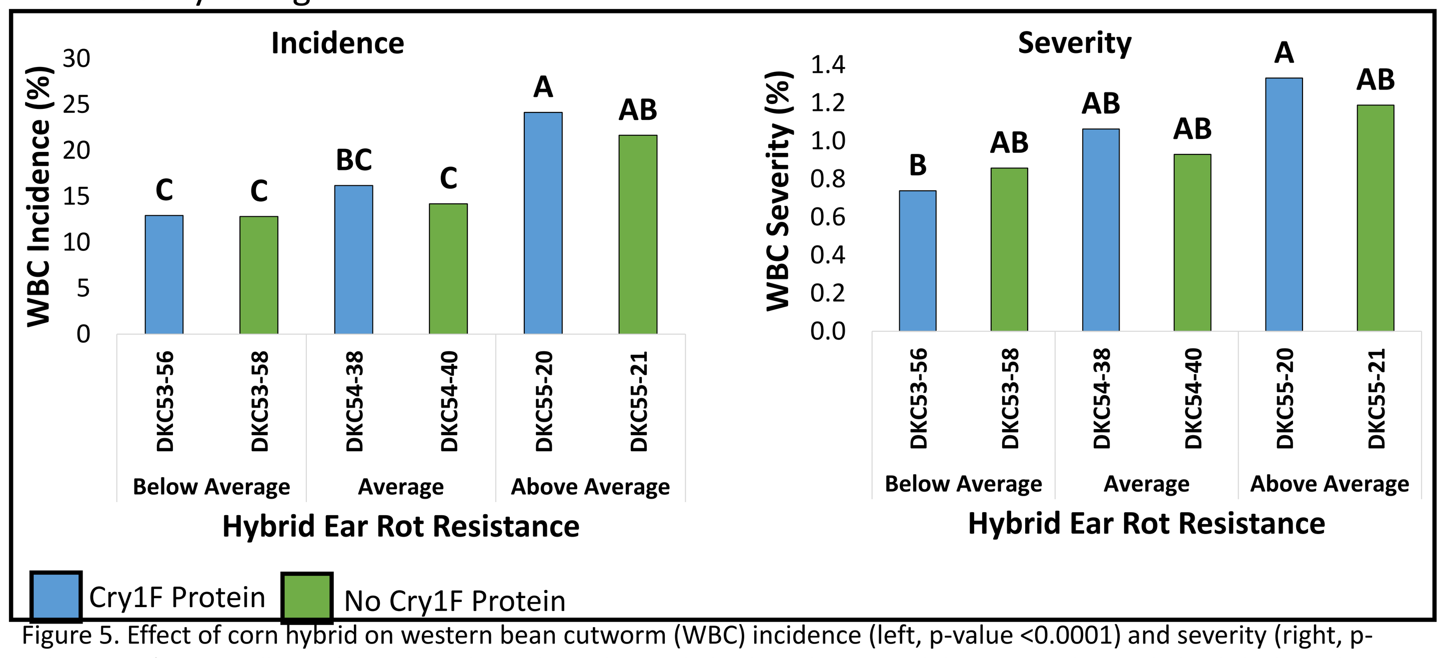

Figure 5. Effect of corn hybrid on western bean cutworm (WBC) incidence (left, p-value <0.0001) and severity (right, p-value= 0.04) across all nine locations. Blue color indicates hybrids with Cry1F while green indicates hybrids lacking the Cry1F trait. Bars with the same letter do not differ based on a p-value of <0.05.

Results and Discussion

Hybrid Impacts on Ear Rot, Deoxynivalenol, and Yield

- Ear rot incidence was significantly impacted by hybrid (Figure 6). Hybrids with above average resistance ratings (DKC55-20, DKC55-21), had higher ear rot incidences than hybrids with lower resistance ratings.
- Variability in resistance to ear rot could be due to low levels of disease in 2017 or WBC damage to ears allowing the fungus to bypass silk resistance mechanisms.
- Ear rot severity did not differ between any of the hybrids (data not shown), possibly due to low kernel resistance in hybrids.
- DON differed significantly by hybrid (Figure 6). DKC54-38 had the highest DON levels.
- Yield did not differ by hybrid (data not shown).

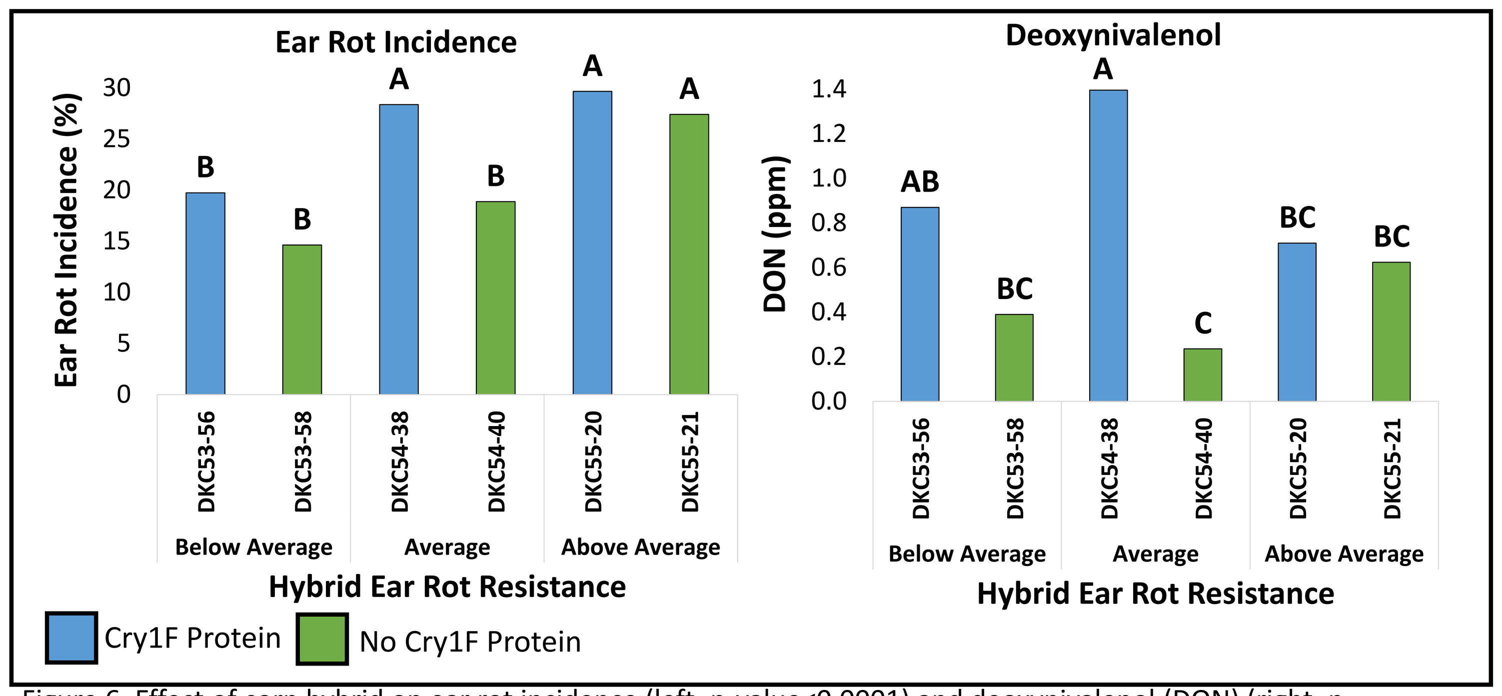

Figure 6. Effect of corn hybrid on ear rot incidence (left, p-value<0.0001) and deoxynivalenol (DON) (right, p-value<0.0001) across nine locations. Blue color indicates hybrids with Cry1F while green indicates hybrids lacking the Cry1F trait. Bars with the same letter do not differ based on a p-value of <0.05.

Fungicide Impact on Ear Rot, Deoxynivalenol, and Yield

- Fungicides had no impact on ear rot incidence or severity, both within each location and across locations (data not shown).
- Previous research has shown inconsistencies with fungicides reducing ear rot and DON levels[4].
- Inconsistencies could be due to application method, fungicide movement, physical barrier of the husk, or the fact that WBC damage to ears allows the disease to bypass the silks, which the fungicide is designed to protect.
- Fungicide application resulted in 42.2% lower DON levels than non-treated plots across all sprayed locations (Figure 7).
- Fungicides increased yield at two of six sprayed locations (Cass and Branch), both of which were irrigated (Figure 8).

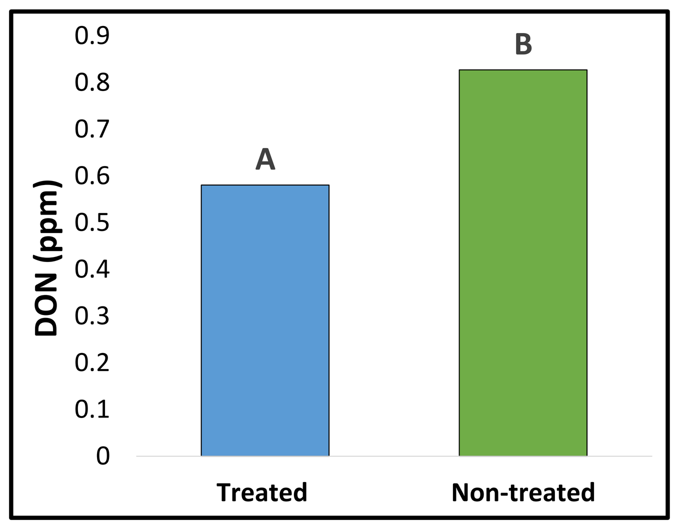

Figure 7. Effect of fungicide on deoxynivalenol (DON) in treated and non-treated plots across all sprayed locations(p-value=0.04).

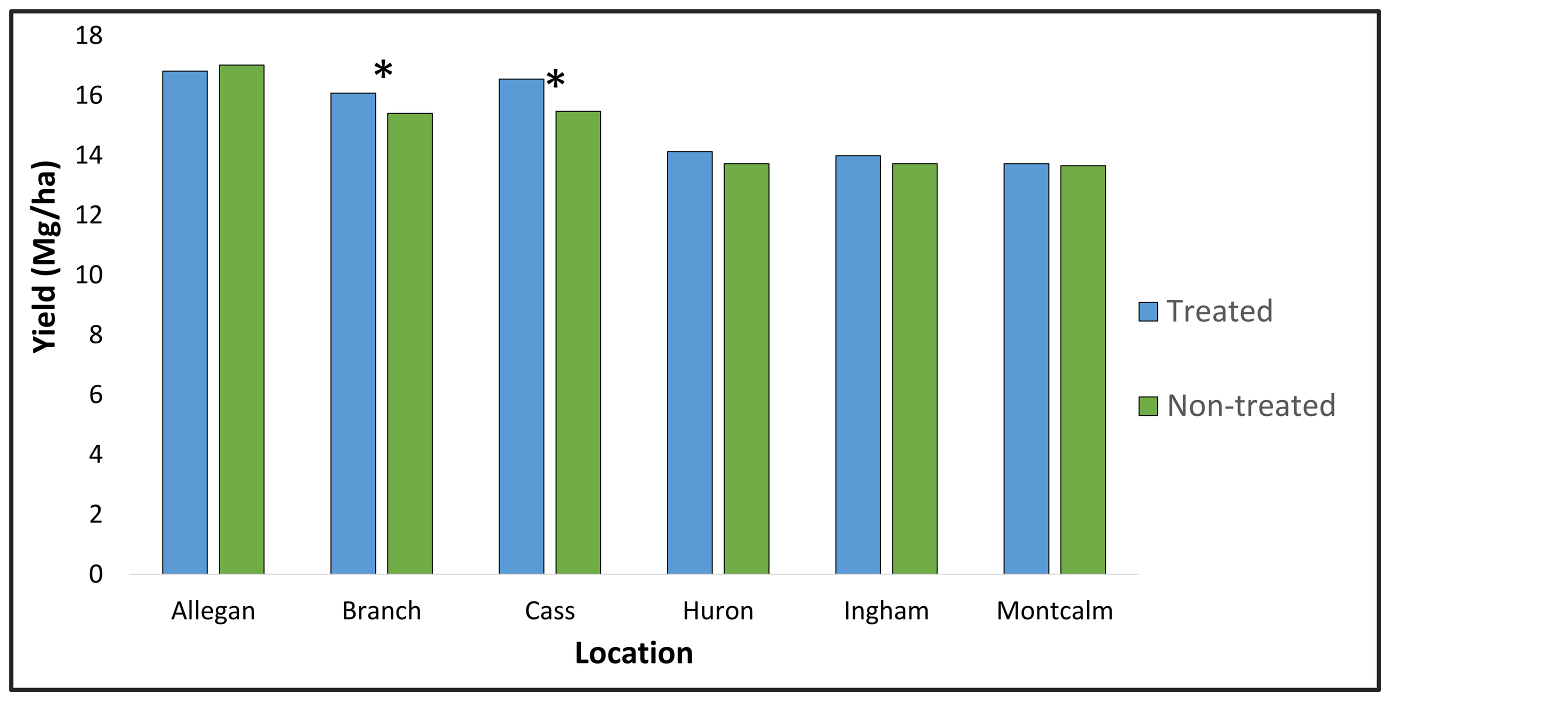

Figure 8. Effect of fungicide on grain yield within location. Locations marked with an * have statistically different yields between treated and non-treated plots based on a p-value of <0.05.

Figure 9. Western bean cutworm (WBC) egg masses on leaves (left), WBC larvae on corn ear (middle), *Fusarium graminearum* on corn ears (right)

Conclusions

- The correlation between WBC damage and ear rot incidence demonstrates the importance of insect control to reduce ear rots and associated mycotoxins.
- Because of the failure of Cy1F Bt protein against WBC growers must take an integrated approach when controlling WBC, including scouting and timely spraying or using other insect proteins (such as Vip3a).
- Ear rot resistance ratings, provided by companies, did not match ear rot levels found in fields.
- Fungicide was found to reduce DON levels across all locations and increase yield in irrigated fields.
- An integrated approach must be used to control ear rots and associated mycotoxins including; WBC management, hybrid selection, and fungicide applications along with other management strategies not discussed here including residue reduction, harvest timing, and post harvest drying.
- Future research for 2018 and beyond will focus on using other insecticidal traits such as Vip3a to control WBC in the Great Lakes region.

[1]Groth, J. V., Ozmon, E. A., & Busch, R. H. (1999). Repeatability and relationship of incidence and severity measures of scab of wheat caused by Fusarium graminearum in inoculated nurseries. *Plant Disease*, *83*(11), 1033-1038. [2]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. [3]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. [4]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.

Acknowledgements

Special thank you to Bill Widdicombe, Lori Williams, Adam Byrne, all current and former graduate and undergraduate students, and our farmer cooperators for all of their contributions. Also, thank you to the Corn Marketing Program of Michigan for their financial support, Bayer for their donation of the fungicide, and Monsanto for donation of the seed.