FINAL PROJECT REPORT

PERFORMANCE EVALUATION OF PLANT PROTECTANTS TO REDUCE GRAIN YIELD LOSSES DUE TO DROUGHT, MYCOTOXINS, AND SPIDER MITES

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With Dr. Nansen terminating his affiliation with Texas AgriLife Research in January 2012, this report represents the final report produced by his research team. The main purpose is to thank TCPB for their support in 4 of the 5 years Dr. Nansen worked at the Lubbock Center. Here, we highlight some recent discoveries that we believe may be of relevance to corn breeders and to other researchers focusing on identifying ways to improve corn production in the Southern High Plains.

Project background

Spider mite infestations in corn are NOT controlled with current or any known future Bt (*Bacillus thuringiensis*) transgenic toxins, and have been highlighted by TCPB as a top research priority. Spider mites can have considerable adverse effect on corn grain yields. Drought stress by itself has direct adverse effect on corn grain yields but losses due to drought stress are further exasperated by increased susceptibility to spider mites, and drought stress may also affect risk of mycotoxin incidence. The completed one-year field study was conducted under two levels of pivot irrigation (100% and 75% ET) at the Texas AgriLife Research and Extension Center in Halfway using the hybrid 214-14VT3P. Three solar protectants, Purshade Ultra, Reflect and a 2010 formulation of Purshade, were applied as a 20 % formulation at 5 gallons per acre at either “early” (V10) or “late” (at tasseling) plant stage. Also included in the trial was a biofungicide, *Bacillus subtillis* strain QST713 (Serenade), applied as a foliar treatment (3 lbs/ac) at 18.3 gallons per acre for both plant stages previously mentioned. All spray applications were made using a CO2 back pack sprayer. “Early” applications were made using a standard horizontal boom while “late" applications were made using a high clearance boom. ConeJet hollow cone spray nozzles TXVS-3 were used for Purshade applications while TeeJet DG8002VS nozzles were used for Serenade applications. Throughout the growing season in two-week intervals, we collected the following data from the field plots: plant height and weight, leaf temperatures at three vertical positions within the canopy, and chlorophyll and reflectance data from leaf materials. For yield, 30 corn ears from each treatment plot were harvested, hand shelled, and weights were adjusted to 15.5 % moisture. Mycotoxin levels were determined by the Office of the Texas State Chemist.

Plant weight and grain yield

Wet plant weights followed an asymptotic function (Figure 1) with no significant difference between the two irrigation levels ($F_{1,54}$=0.18, P=0.67) and no significant effect of Purshade or Serenade applications ($F_{5,54}$=2.16, P=0.07). Similarly, we did not observe significant effects of irrigation level ($F_{1,62}$=3.30, P=0.51), Purshade or Serenade applications ($F_{5,62}$=11.22, P=0.91) on harvested grain yield differences among the treatments (Figure 2).

Figure 1: Weight of corn over time in the control group (Halfway field) . Arrows indicate the spraying dates for the other groups, (A: early application, B: late application). Black circle: High water level, red: Low water level. Day 0= the 22nd of June 2011

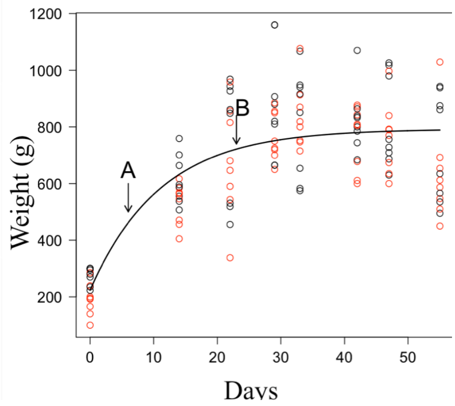
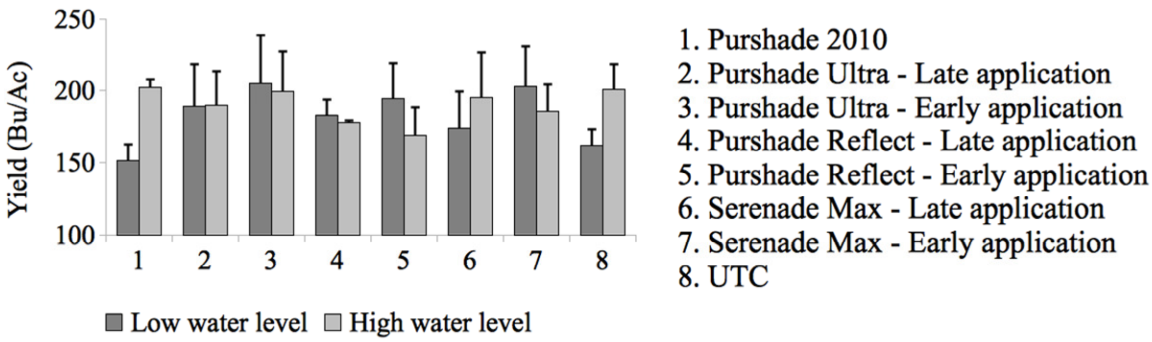


Figure 2: Corn yields in bushels per acre at 75% (low) and 100% (high) ET irrigation levels.



Leaf temperature

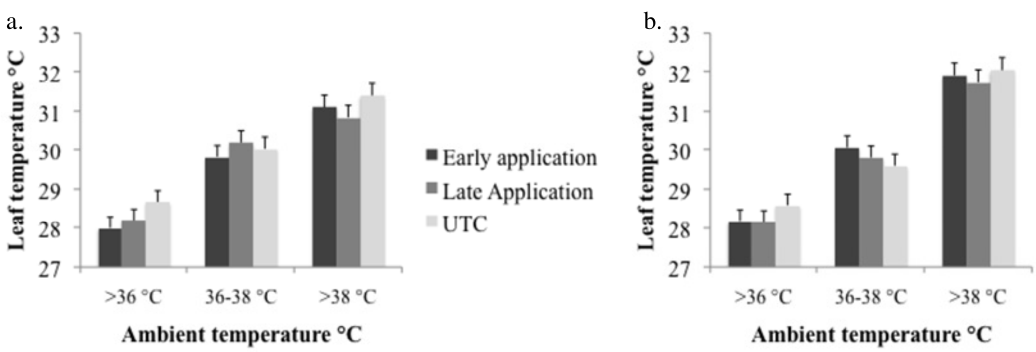


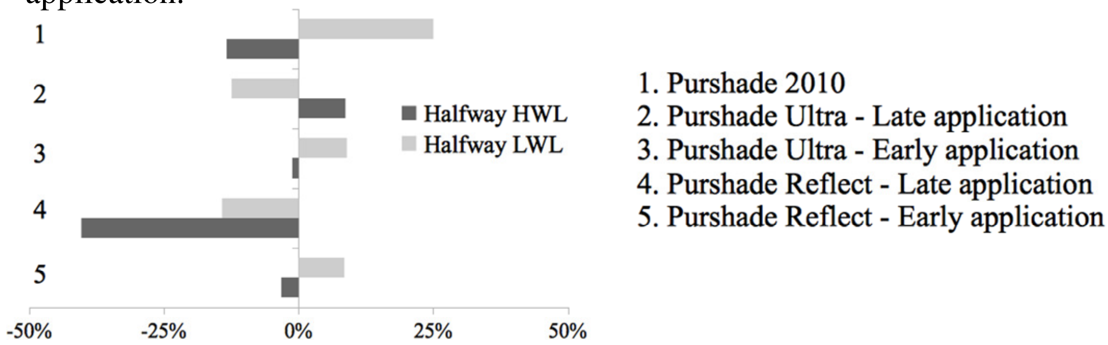
Figure 3: Leaf temperature of the corn in high (a) and low (b) irrigation levels based on three intervals of ambient temperatures.

As an example of how leaf temperatures can be used to study and monitor impact of drought, we have included data obtained from plots treated with Purshade (Figure 3). Statistical analysis showed that leaf temperature was strongly influenced by ambient temperature ($F_{1,62}$=57.77, P<0.001) and leaf position ($F_{1,62}$=37.70, P<0.001). Leaf temperatures were significantly higher under 75% ET irrigation than on 100% ET irrigation ($F_{1,62}$=21.40, P<0.001). Statistical tests showed that Purshade formulations did not differ from each other (P=0.22), but were significantly different from those acquired from untreated control plants when ambient temperature was over 40°C (P<0.001). However, time of application was crucial, as only late application of Purshade significantly decreased leaf temperature (χ^2=19.01, d.f.=4, P<0.001, Figure 3).

Chlorophyll concentration

In plots treated with Purshade, we quantified differenec in chlorophyll concentration compared to respective untreated control plots – thus, a percentage increase means that the chlorophyll concentration was higher in Purshade treated compared to control (Figure 4). Almost all treatments showed less than 20% difference compared to untreated control and a somewhat inconsistent trend between irirgation levels. Thus, we conducted combined statistics across the different treatment factors and showed that there was statistical a significant decrease in chlorophyll concentration at 75% ET irrigation compared to 100% ET irrigation (P<0.001).

Figure 4: Changes in chlorophyll concentration of corn leaves after Purshade application.



When analyzing across irrigation levels, we found that only one of the three Purshade applications (Purshade 2010) had significant effect on chlorophyll concentration in corn leaves

(Purshade 2010: $F_{1,30}<0.01$, P=0.97; Purshade Reflect: $F_{1,50}=2.54$, P=0.11; Purshade Ultra: $F_{1,50}=1.43$, P=0.22).

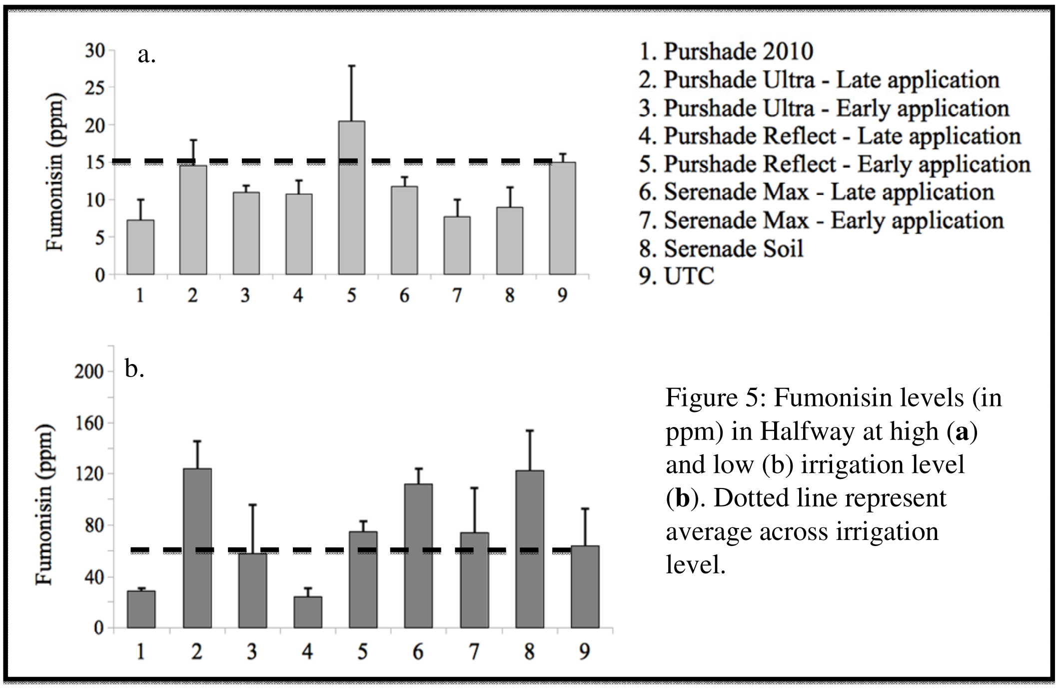


Figure 5: Fumonisin levels (in ppm) in Halfway at high (**a**) and low (b) irrigation level (**b**). Dotted line represent average across irrigation level.

Fumonisin Levels

There was a highly significant effect of irrigation level on fumonisin level in corn samples ($F_{1,62}=817.49$, $P<0.001$), as samples acquired from 75% ET irrigation had, on average, 4 times higher levels than those from 100% ET irrigation (Figure 5). We found significant differences between the Purshade treatments ($F_{5,63}=224.6$, $P<0.05$) with the Purshade 2010 formulation significantly reducing fumonisin levels about 50% compared to untreated control plants. We also found that late application of Purshade Reflect decreased levels of fumonisin. Serenade Max and Serenade Soil only decreased fuminosin levels significantly at the 100% ET irrigation.

Conclusion

Based on this one-year field study conducted under pivot irrigation at the Texas AgriLife Center in Halfway, we outlined some of the mechanisms and their interactions when corn plants were subjected to two levels of drought stress. It should be pointed out that the 2011 growing season was exceptionally warm, dry and windy, so even the corn plants under 100% ET irrigation likely experienced sub-optimal growing conditions. Drought stress increased leaf temperature, decreased chlorophyll concentration, and it caused concerningly high levels of fumonisin incidence. At 75% ET irrigation, the majority of corn samples had fumonisin levels exceeding thresholds for diary cows. Furthermore, fumonisin levels were, on average, 4 times higher at 75% ET irrigation compared to those from 100% ET irrigation. Thus, drought stress seems to strongly increase risk of fumonisin incidence. However, we demonstrated that – even in a growing season with highly challenging abiotoc conditions – the use of Purshade decreased fumonisin incidence up to 50% without negatively affecting yields.

Lignin content is driving suitability of maize leaves to spider mites

Based on a thorough analysis of a series of studies conducted under experimental field conditions, we have recently finalized a manuscript, in which we claim to have identified a possible explanation for increased susceptibility of corn to spider mites when corn plants are grown under drought stress. During two field seasons, five commercial corn hybrids were grown under three experimental irrigation regimes, and leaf samples were collected weekly and used: 1) in choice bioassays to determine spider mite preference for each hybrid across irrigation regimes, 2) to acquire hyperspectral imaging (reflectance profiles) to characterize relationship between spider mite preference and reflectance in the 405-907 nm range, and 3) to characterize the nutritional composition of whole maize plants. From this study, we found that drought stress reduces photosynthetic activity (measured based on reflectance data) in corn plants, and this reduction in photosynthetic activity led to, among other significant changes in corn plant composition, a significant reduction of lignin content of corn leaves. Based on choice bioassays, we demonstrated that corn leaves with low lignin content were more preferred by spider mites than leaves with higher lignin content. This is intuitively logic, as spider mites feed on plant cell content, and lignin is one of the key constituents of plant cell walls. So a high lignin content means stronger/thicker cell walls, which is known to adversely affect feeding by herbivores, such as spider mites. As we were able to accurately quantify lignin content in corn leaves and also show a negative correlation between lignin content and spider mite preference, we have provided support for focusing on lignin synthesis as part of spider mite resistance in corn. Furthermore, our results support research into reflectance based decision support tools, in which reflectance data is used to manage risk of spider mite infestations.