CAN PLANT HEALTH SENSORS DETECT INSECT INJURY AND WATER STRESS IN COTTON?

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Abstract

Use of a tractor-mounted plant health sensing system was evaluated in a Cotton Fleahopper/Water Stress experiment arranged in small plots (50 feet by 4 rows) at the Texas A&M AgriLife Research and Extension Center, Corpus Christi, in 2013 and 2014. The plant health sensing system consisted of an optical sensor, an ultrasonic sensor, a GPS receiver, and a data acquisition unit. The unit was used to calculated NDVI and plant height, and direct observations of insect counts, in-season plant response, and yield were also taken. There was treatment discrimination using both the remotely sensed data and the direct measurements of cotton fleahopper counts and yield, but the sensitivity of the remotely sensed data was lower than the direct measures in discriminating treatments. Correlation analysis and multiple regression using 2013 data indicated that in this very droughty year the remotely sensed plant height measure was a good surrogate measure for yield, with excellent separation in yield between irrigated and dryland plots. Using multiple regression, plant height accounted for 47% of the variation associated with yield. While significant, only 3% additional variation was explained by adding cotton fleahopper counts to the model, and another 3% when adding NDIV. Unfortunately this relationship did not re-occur in the less droughty and less cotton fleahopper year of 2014. Overall based on these data, there was modest utility in using the remotely sensed data as an indicator of water stress during a very droughty year, and this was associated with yield potential. But there was no apparent utility in detecting cotton fleahopper-associated plant stress; even though yield in 2013 increased when plots were sprayed for an apparent economic cotton fleahopper populations (2 or 3 sprays) based on a commonly used economic threshold.

Introduction

Cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter) (Hemiptera: Miridae), feeding on cotton squares (Figure 1) causes reduced yield and harvest delays in the southwest and mid-south (USA) cotton growing regions. Cotton fleahopper-induced yield loss reaches up to 6% (Williams 2000). Variable relationship of square loss to subsequent yield loss under similar cotton fleahopper feeding pressure (Ring et al. 1993) present a challenge to cotton fleahopper management using traditional sampling and economic threshold methods. Plant response variability to cotton fleahopper feeding has been partly associated with cultivar differences (Holtzer and Sterling 1980), including heritable traits considered for plant resistance to cotton fleahopper (Knutson et al. 2009). Parajulee et al. (2006) partly attributed severity of cotton square loss to susceptibility differences across stages of cotton development and age of the reproductive tissues when cotton fleahopper moved into fields. Last, plant water stress is well associated with square retention rates (Stewart and Sterling 1989), which may influence and exacerbate plant sensitivity to cotton fleahopper feeding.

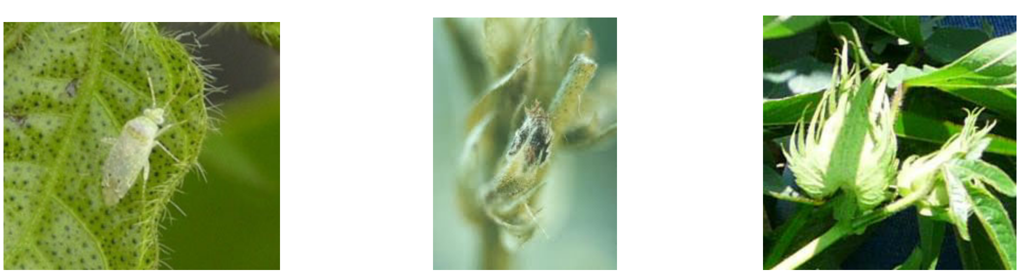

Figure 1. From left to right: cotton fleahopper, a blasted square (damage), and a healthy square. Photos provided by authors and Texas AgriLife Research, Lubbock and Corpus Christi.

Therefore, direct density estimation of cotton fleahopper for decision-making using established economic thresholds may give false indication of damage potential and improperly trigger insecticide applications. Therefore, in-season assessment of plant response would be a valuable addition to the tools for cotton fleahopper management.

Materials and Methods

Here we considered use of an existing plant health sensing system for in-season assessment of plant response to cotton fleahopper feeding and water stress. The system consisted of an optical sensor, an ultrasonic sensor, a GPS receiver, and a data acquisition unit (Sui and Thomasson 2006). Plant height was estimated from the ultrasonic sensor readings, and NDVI was calculated from the optical sensor readings. We hypothesized that 1) these two measures were associated with water stress, cotton fleahopper stress, or both, and 2) provided an indication of yield loss associated with these stress factors.

Field testing in 2013 and 2014 during drought conditions provided opportunity to assess insect activity in a high contrast of dryland (with supplemental irrigation due to severe drought) and irrigated (irrigation targeting 90% crop ET replacement) water regimes. We focused on following a natural cotton fleahopper population in replicated plots under two water regimes (dryland with supplemental irrigation to prevent wilt and irrigated targeting ~90% crop ET replacement), two planting dates, one or two cultivars (Phytogen 367 WRF and Stoneville 5458 B2RF), and controlled with insecticide using one or several thresholds or no insecticide. The treatments were laid out in a split plot design with five replications. Individual plots were 4 rows by 50 ft, and data were collected from the inner two rows. In addition to direct observation of insect activity, in-season plant response, and yield, the plant health system mounted on a tractor tool-bar was used to estimate plant height and NDVI. The sensors were used when the later planting was at the first week of squaring and the earlier planting was at the third week of squaring. Remote sensing observations were taken in additional dates in 2013. The test was conducted in Corpus Christ, Texas at the Texas A&M Research and Extension Center.

For initial analysis, transformed insect counts, yield, plant height, and NDVI were analyzed with ANOVA, conforming to a split-split-split plot design. To further explore the use of the remotely sensed plant height and NDVI measurements, we conducted correlation analysis and multiple regression using yield as the dependent variable and fleahopper per plant on two dates, NDVI, and plant height as independent variables.

Results and Discussion

Measurement sensitivity to water regime, planting date, cultivar, and insect control treatments

The data trends in 2013 and 2014 were similar, with the exception that cotton fleahopper pressure was higher in 2013, which resulted in better discrimination of treatment effects for the fleahopper counts. A threshold of 0.15 cotton fleahopper per plant was commonly exceeded in 2013 and rarely exceeded in 2014. Water stress was also higher in 2013 than in 2014. Therefore, we focused on 2013 results for measurement sensitivity to water regime, planting date, cultivar, and insect control treatments.

There was treatment discrimination using both the remotely sensed data and the direct measurements of cotton fleahopper counts and yield, but the sensitivity of the remotely sensed data was lower than the direct measures in discriminating treatments. Looking at remotely sensed plant height, plants were taller in the irrigated plots and the later planted cotton ($P < 0.002$), but no height difference was detected in the sprayed and unsprayed plots ($P > 0.20$) during two periods of observations (Figure 2), even though there were large differences in cotton fleahopper counts during two rounds of direct observation sampling ($P < 0.0001$) taken about three weeks earlier (Figure 3). Looking at NDVI, reflectance was greater in late planted cotton ($P = 0.02$). But as with plant height, there was no difference in the sprayed and unsprayed plots ($P > 0.10$) (Figure 4), even though there were large differences in cotton fleahopper. Differences in yield clearly showed the water stress effect ($P = 0.0008$). Yield marginally increased when plots were sprayed in 2013 ($P = 0.05$). We next looked at a different data interpretation using correspondence analyses.

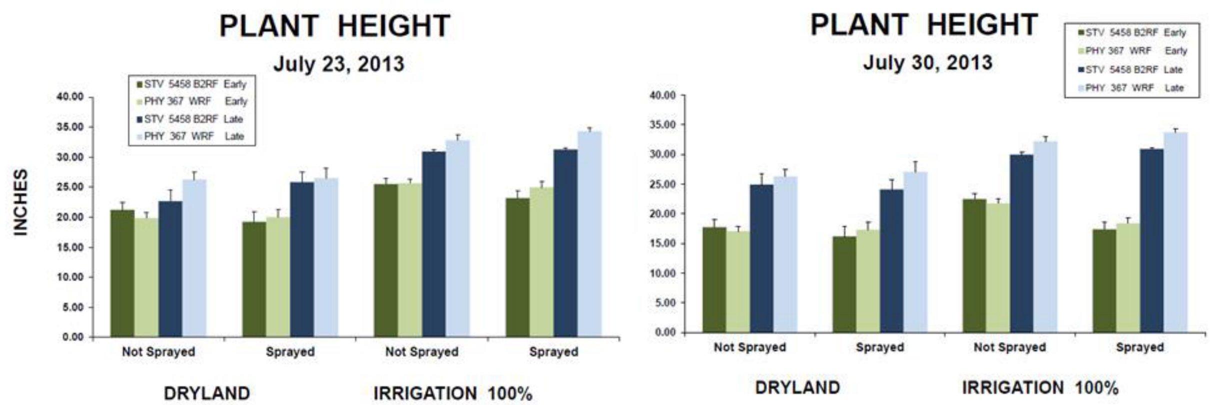

Figure 2. Plant height estimates from the plant health sensor taken during two time periods, 2013, Corpus Christi, TX.

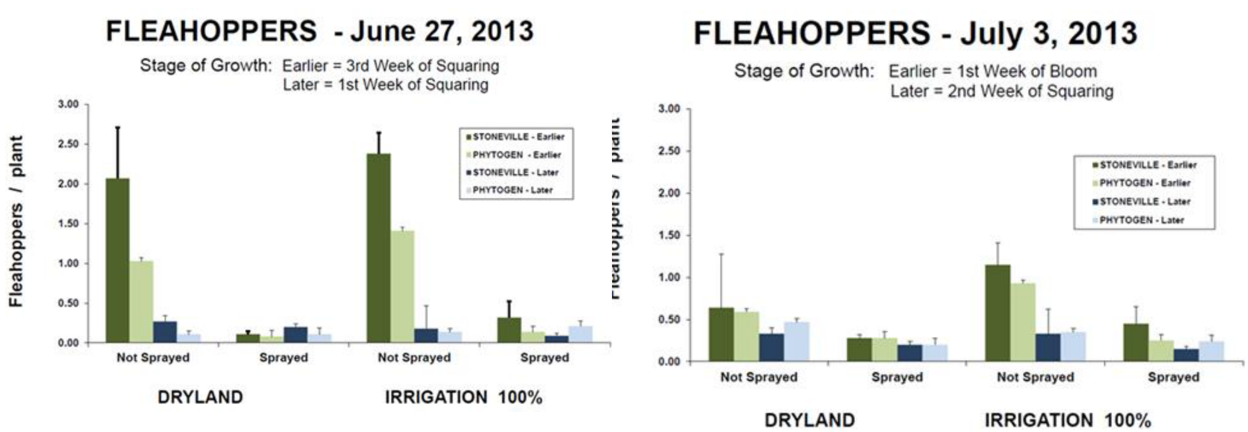

Figure 3. Cotton fleahopper estimates from direct plant inspection taken during two time periods, 2013, Corpus Christi, TX.

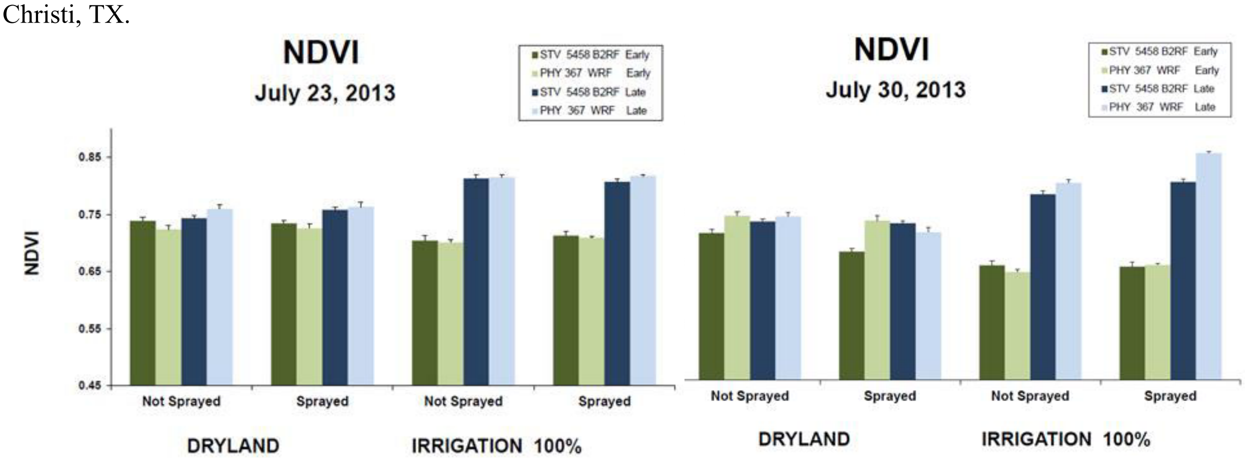

Figure 4. Cotton fleahopper estimates from direct plant inspection taken during two time periods, 2013, Corpus Christi, TX.

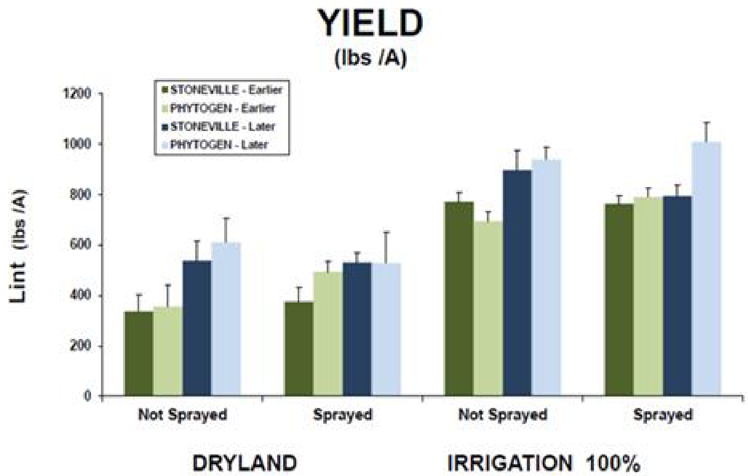

Figure 5. Yield (lint) estimates, 2013, Corpus Christi, TX.

Figure. 6. Yield (lint)—plant correlation for 2013 (left) and 2014 (right), Corpus Christi, TX.

<u>Correspondence analyses</u>

Correlation analysis and multiple regression using 2013 data indicated that in this very droughty year the remotely sensed plant height measure was a good surrogate measure for yield, with excellent separation in yield between irrigated and dryland plots (Figure 5). Using multiple regression, plant height accounted for 47% of the variation associated with yield. While significant, only 3% additional variation was explained by adding cotton fleahopper counts to the model, and another 3% when adding NDIV. Unfortunately this relationship did not re-occur in the less droughty and less cotton fleahopper year of 2014. Yield—plant height correspondence was low (Figure 5). Overall, 11% of the variation in yield was explained by NDVI (7%) and height (4%) in 2014. Interestingly, although we detected a modest yield response to our insecticide treatment in 2013, there was not a strong relationship with yield in simple correlation analysis (Figure 6) and only modest contribution to a multiple regression as noted above.

Overall based on these data, there was modest utility in using the remotely sensed data as an indicator of water stress during a very droughty year, and this was associated with yield potential. But there was no apparent utility in detecting cotton fleahopper-associated plant stress; even though yield in 2013 increased when plots were sprayed for an apparent economic cotton fleahopper populations (2 or 3 sprays) based on a commonly used economic threshold.

In planning for the next field season, we will continue to manipulate water regimes, and will manipulate a much greater range of cotton fleahopper activity by adding several higher spray threshold levels to the experiment.

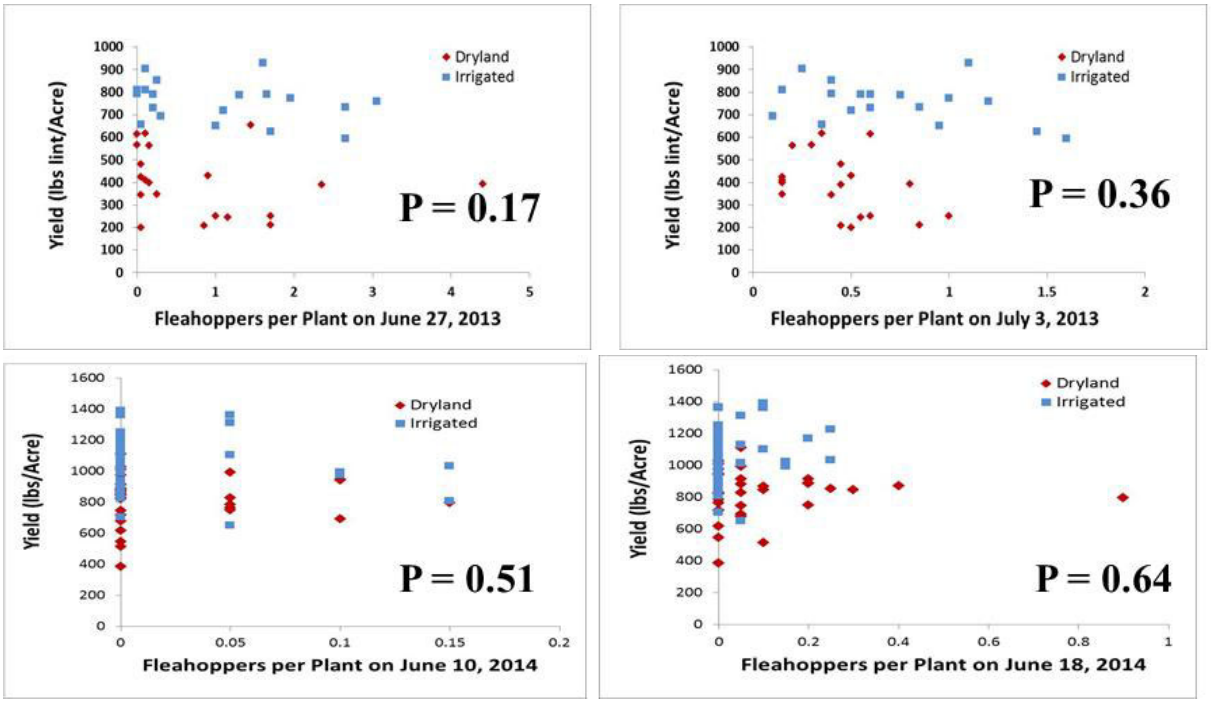

Figure 7. Yield (lint)—cotton fleahopper correlation for 2013 (top) and 2014 (bottom), Corpus Christi, TX.

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