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GROUND TRUTHING OF REMOTE SENSING FOR COTTON APHID (*APHIS GOSSYPII*) AND SPIDER MITES (*TETRANYCHUS SP.)* IN SAN JOAQUIN VALLEY COTTON

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Abstract

Multispectral and hyperspectral analysis from remote sensing, a precision tool in development, can detect differences in crop health. This information should be coupled with observations on the ground for ground-truthing of arthropod populations and other plant stress factors. This allows the information seen in the image to be associated with biological factors in the field. Hopefully the spectral data will provide information in a timely manner so that remedial measures can be taken and the use of remote sensing images can be integrated into arthropod management practices for producers of cotton in the San Joaquin Valley.

Introduction

Arthropod management practices in California cotton production involve the use of insecticides and acaricides for increased yield and quality. Cotton aphid control relies mainly on the neonicotinoid insecticides but organophosphate and carbamate insecticides are also used and are important for resistance management considerations due to their mode of actions. Restriction of these and other pesticides under the Food Quality Protection Act will hinder Integrated Pest Management in California cotton.

Precision agricultural methods have the potential to positively impact San Joaquin Valley (SJV) grown cotton. If the area where pests are located within fields can be known, pesticide applications can potentially be greatly reduced both in frequency and in amount. Spider mite and cotton aphid infestations in the SJV tend to be heterogeneous, with some areas of high infestation and some areas of negligible infestations in fields. However, the currently available ground sampling methods make it impossible to detect all infestations within the large fields of the SJV- typically 80 to 190 acres. Arthropod management decisions are currently made on an inter-field basis rather than an intra-field basis.

Remote sensing is a precision tool with its roots in the aerospace and defense industries that collects spatial information of land-masses with large datasets. Several wavelengths can be recorded to provide a wealth of information including plant coverage versus soil coverage, plant health, soil type, etc. To provide relative information on plant vigor, this information can be converted into a vegetation index on an intra-field basis up to one to several meters in resolution. The wavelengths used and reflectance detected is also precise enough to detect plant response to different types of plant injury caused by different arthropod pest damage and other factors. Thus, this technology is precise enough to provide information on an intra-field basis for use in agricultural situations and this information can be used to provide information to reduce pesticide application to micro-units within the field for individual arthropod pests.

Work has been done in the southern US to develop a vegetation index for insect pests, with success in combining remote sensing from the air and a ground approach using a drop cloth in a line-intercept pattern in cotton fields to sample for tarnished plant bug (*Lygus lineolaris*). It has been demonstrated that this pest infests areas of vigorously growing cotton over more sparsely growing areas. Combining remote sensing methods with less time consuming ground sampling methods have been shown to be able maintain the sensitivity of sampling necessary for economic control this pest (Willers et.al. 1999). As, a result, in Mississippi, spraying for tarnished plant bug can be limited to infested areas in vigorously growing cotton and has been shown to be successful in limiting insecticide application with no negative impacts on yield (Seal et al. 2001). This work is also being continued currently in Louisiana.

There is, however, no vegetation index or techniques available for cotton grown in the SJV, where spider mites and cotton aphids have been recent problem pests. Spider mite damage can be detected with the use of remote sensing (Fitzgerald et al. 1999 and Fitzgerald et al. 2000) however threshold levels important to using remote sensing as a management tool have not been established. The potential exists to establish a system in the SJV similar to that of the tarnished plant bug system in the South for spider mites and aphids. This would decrease the cost involved in detecting heterogeneous populations of arthropod infestations on an intra-field basis and has the potential to decrease the amount and frequency of pesticide applications.

Materials and Methods

Acala cotton, variety Maxxa was planted on May 5 at the Shafter Research and Extension Center near Shafter, CA. Field plots were infested with natural populations of cotton aphids (*Aphid gossypii*) and spider mites (*Tetranychus sp.*). Differential populations were established in plots using selective pesticides on August 11 (Assail 70WP at 1.1 oz./A, Zephyr 0.15E at 12 fl. oz./A, Capture 2EC at 3.8 fl. oz./A, and Orthene 75S at 11 oz./A). Plots that had both cotton aphids and spider mites (untreated), neither pest (Assail+Zephyr), an intermediate number of mites and a high number of aphids (Capture), spider mites individually (Assail+Orthene), and aphids individually (Zephyr). Spider mites are a perennial pest of cotton in the SJV and populations normally develop by July. However, due to an unseasonally wet spring, the cotton was planted later than usual and, consequently, aphid populations did not develop until early August. Cotton aphids have been a severe pest of the SJV during the last ten years. Because aphid populations are favored by high nitrogen levels (Cisneros and Godfrey. 2001), all plots were fertilized with 225 lbs. N/acre to favor population development (this amount is on the upper end used by growers). All treatments were established in a completely randomized block design with four replicates.

Another test took advantage of the fact that high levels of nitrogen favor aphid populations (Cisneros and Godfrey. 2001). A series of plots was established in which certain plots received differing levels of nitrogen over 3 week periods. Nitrogen was shanked into the soil in mid-June, the beginning of July, the end of July, and the middle of August. Aphid populations were slow to build in all the plots. Thus, a Capture treatment was added on August 14 to the sub-plots in an attempt to flare aphid populations within these sub-plots and to create untreated sub-plots with a natural aphid infestation. All treatments were established in a completely randomized block design with four replicates.

Ground truthing data were collected by sampling for the arthropods of interest at weekly intervals within the plots. Both cotton aphids and spider mites are efficiently sampled by collecting 10-leaf samples per plot and counting the individuals in the laboratory under 50x magnification. Leaves were washed onto a fine mesh sieve and the retained material back-washed onto filter paper for storage and later quantification of spider mite number. Flight data were collected from the air with both multispectral, Shafter Airborne Multispectral Remote Sensing System (SAMRSS), and hyperspectral, Airborne Visible Near Infrared (AVNIR), camera systems. A Normalized Density Vegetation Index (NDVI) (Rouse et al. 1974), was then calculated using ENVI software for visualization and Excel for calculations. The ground data were compared to the NDVI values and it was attempted to determine at what point plant stresses from aphids and/or spider mites could be detected, if at all with the NDVI values.

In a related study, cotton plants were grown in a greenhouse using amended nutrient potting soil in six-inch pots. Groups of cotton aphids (*Aphis gossypii*), spider mites (*Tetranychus urticae*), and both cotton aphids and spider mites were infested onto the plants in separate cages. Using a hand held spectrometer (GER 1500) and an integrating sphere (LI-COR), measurements were taken every two to three days. Reflectance values from the tops of the treatment leaves were generated from the spectrometer. Only one index, NDVI, has been used to compare the reflectance values obtained among the different experimental groups. The number of aphids and spider mites were counted. The greenhouse experiments contribute to knowledge about how the cotton plants respond to these different arthropod infestations. This will allow the development of a “signature” for plant stress from each arthropod pest. It is theorized that plants injured by spider mites will respond differently spectrally than those damaged by cotton aphids and that plants damaged by cotton aphids will respond differently than untreated plants. This information will facilitate concentrating on these identified wavelengths during the analyses of the field data.

Results

In the field test involving spider mites and aphids, the SAMRSS and AVNIR NDVI values among the plots were not significant, although pests were present (Fig. 1 and 2). No correlations were found between the SAMRSS and AVNIR NDVI values and mite numbers, even after transformation. Similarly, no correlations were found between the NDVI values and aphid numbers, even after transformation.

In the test involving nitrogen and aphid numbers, no correlation was found between the SAMRRS NDVI values and the aphid numbers. The AVNIR data were unavailable for use because the image quality was affected by wind on the flight date of interest. However, the aphid numbers were lower than expected even after the attempt to flare them in sub-plot with Capture. The numbers ranged from 0.25 to 16.8 aphids per leaf in the sub-plots, with an average of 4.15 aphids per leaf per sub-plot.

In the greenhouse experiments, a negative correlation was found between NDVI values and time after infestation. This correlation was significant for aphids ($\alpha = 0.05$), mites ($\alpha = 0.05$), and for one out of two treatment groups of leaves infested with both spider mites and aphids ($\alpha = 0.05$). There was no significant correlation found in the uninfested leaves between NDVI values and time ($\alpha = 0.05$).

Also, in the greenhouse experiment, uninfested leaves had significantly lower average NDVI values than the average NDVI values of the aphid infested leaves. The average NDVI values of the mite infested leaves and the average NDVI values of the aphid and mite infested leaves were not significantly different from any of the other treatments.

Discussion

NDVI may not be the best index of plant health for spider mite or aphid damage on cotton in the SJV. When the reflectance values for each of the individual treatment plots are averaged together into treatment groups (untreated, Assail+Zephyr, Catpure, Assail+Orthene, and Zephyr), the majority of differences in reflectance can be seen in the infrared bands and water bands. NDVI was an index designed to detect differences between areas of vigorously growing dense plants and those plants that may not be as vigorously growing and less dense. Thus, there is probably a better index that can use one, or some of the bands, in the near infrared bands and water bands to detect arthropod damage. The differences seen using NDVI between the treatment groups in the greenhouse were most likely seen because of less sources of error adding to the experimental effect. Within field variation due to soil, water, and pressure from surrounding stands may increase variability between similar treatments. Also, air humidity, row, pitch and yaw of the airplane, and a number of other factors can affect the airborne image. These sources of error are not present in the greenhouse and may have contributed to the differences detected by the spectrometer between treatments. Hopefully variation can be significantly reduced and a better vegetation index can be used in the future to elucidate early spider mite and cotton aphid infestation in the SJV.

References

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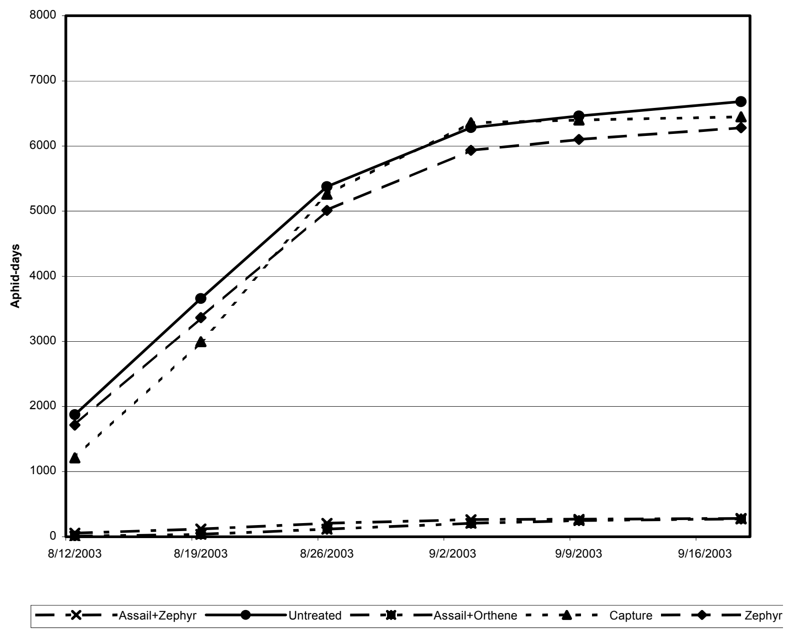

Figure 1. Aphid days after treatment in aphid and spider mite test. Treatment date was 8-11-03. ENVI image evaluated from 8-20-03.

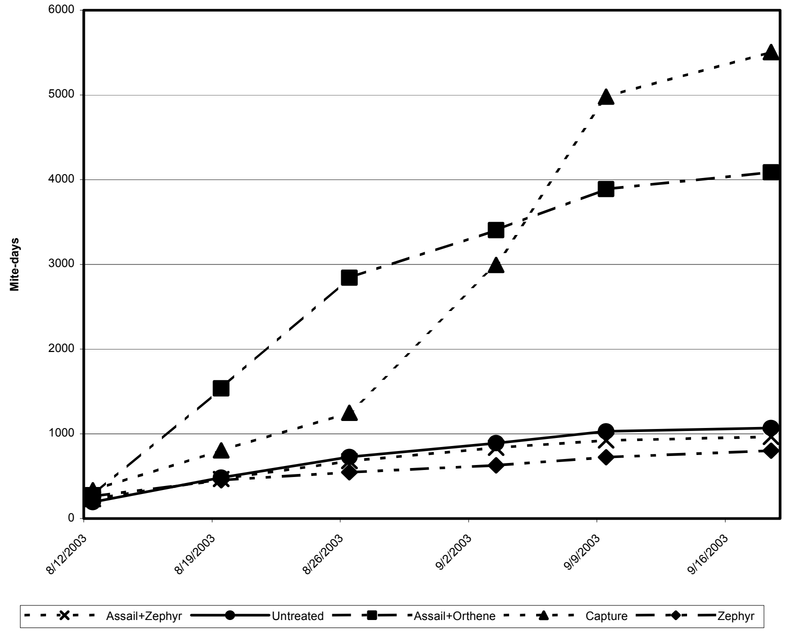

Figure 2. Mite days before and after treatment in aphid and spider mite test. Treatment date was 8-11-03. ENVI image evaluated from 8-20-03.