Remote Sensing for Detection of Spider Mite and Cotton Aphid in SJV Cotton

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Introduction

Arthropod management practices in California cotton production involve the use of various insecticides and acaricides for protection of yield and quality. Cotton aphid control relies mainly on the neonicotinoid insecticides but organophosphate and carbamate insecticides are also used. Spider mite control relies on acaricides and the chemical types used for both cotton aphids and mites are important for resistance management considerations due to their mode of actions.

Precision agricultural methods have the potential to positively impact San Joaquin Valley (SJV) 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. Thus, arthropod management decisions are currently made on an inter-field basis rather than an intra-field basis.

Remote sensing is a precision tool that can detect wavelengths of energy to provide a sundry 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.

There is no vegetation index or techniques available for detection of arthropods in cotton grown in the SJV, where spider mites and cotton aphids have been recent problem pests. Previous studies at the Shafter Research and Extension Center have shown that spider mite damage can be detected with the use of remote sensing; however, threshold levels important to using remote sensing as a management tool have not been established. A successful treatment program that could be reduced to micro-units has the potential to decrease the amount and frequency of pesticide applications.

Materials and methods

Field plots were infested with natural populations of cotton aphids (*Aphid gossypii* Glover) and spider mites (*Tetranychus spp.* Koch). Differential populations were established in plots using selective pesticides, as well as targeted materials to flare certain arthropods, in 2003 and 2004. The plots had both cotton aphids and spider mites, neither pest, an intermediate number of mites and a high number of aphids, spider mites individually, and aphids individually. Another test used high levels of nitrogen favor aphid populations. Plots received differing levels of nitrogen over 3 week periods. A Capture treatment was added in 2003 and a Warrior treatment was added in 2004 to the sub-plots to flare aphid populations, while other sub-plots contained low aphid levels.

Ground-truthing data were collected by sampling arthropods of interest at weekly intervals within the plots for both experiments. Both cotton aphids and spider mites were sampled in 2003 by collecting 10-leaf samples per plot and counting the individuals in the laboratory; 20-leaf samples were collected in 2004. 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.

In 2004, two similar sleeve cage experiments were performed by enclosing an un-infested leaf with floating row cover material. This allowed light to pass through, kept non-target arthropods out and the arthropods of interest inside the cage. For the first experiment, each leaf was infested with either 10 spider mites, 10 aphids, 10 spider mites and 10 aphids, or was left un-infested. For the second experiment, each leaf was infested with either 20 spider mites, 20 aphids, 20 spider mites and 20 aphids, or was left un-infested. Each day after the start of the infestations, scans were taken on each leaf using a spectroradiometer, in cooperation with the USDA, to quantify leaf reflectance. Additionally, the number of aphids and mites were quantified and the cages were maintained free of natural enemies. Finally, scans on each leaf were taken using a chlorophyll meter, in cooperation with the USDA, to quantify the amount of chlorophyll in each leaf. The spectral data will be analyzed and compared to the arthropod numbers and chlorophyll amount.

Flight data were collected, over the field plots, using both multispectral, Shafter Airborne Multispectral Remote Sensing System (SAMRSS), and hyperspectral, Airborne Visible Near Infrared (AVNIR), camera systems in 2003. Flight data were collected on 4 dates in 2004, using a multispectral camera system contracted through InTime, Inc. Additionally, the spectroradiometer was used to quantify leaf reflectance in each plot. Finally, scans on each leaf were taken using the chlorophyll meter to quantify the amount of chlorophyll.

From the flight data in 2003, a Normalized Density Vegetation Index (NDVI), Normalized Near Infrared Index (NNIR), Normalized Red Index (NR), Optimized Soil Adjusted Index (OSAVI), Chlorophyll Index (MCARI), Green Differential Vegetation Index (GDVI), Green-Peak reflectance value (550 nm), Normalized Green Index (NGI), Phytochemical Reflectance Index (PRI), Normalized Water Index (NWI), Ratio Vegetation Index (RVI) and several of my own indices were then calculated for the hyperspectral data. The indices calculated using the multispectral system, were the NDVI, NNIR, GDVI, Green peak reflectance value, and RVI, in 2003. The data have yet to be analyzed for the flights in 2004. These indices and reflectance values were each analyzed using two-way analysis of variance (ANOVA). Tukey's test, at $\alpha=0.05$, was used to separate means when significant differences were detected ($P<0.05$) by ANOVA. The ground data from the field plots were compared to the index and reflectance values using regression analysis, 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 index and reflectance values.

Results- 2003

In the field test involving spider mites and aphids, all index values calculated using the SAMRSS and AVNIR data were not significant, except for those near the green-peak. Using the SAMRSS data, mite infested plots and those infested with both mites and aphids had significantly lower reflectance values at 550nm than did un-infested plots. Using the AVNIR data, at 579nm, rather than 550nm, mite infested plots had significantly lower reflectance values. The average reflectance values were lower for plots infested with both aphids and mites at 579nm (but not significantly different). For both the SAMRSS and AVNIR data, plots infested with aphids had lower reflectance values at 550nm and 579nm, respectively, but there were no significant differences among treatments (Fig. 1).

No correlations were found between the SAMRSS and AVNIR index values and mite numbers, including the significant green-peak values, even after transformation. Similarly, no correlations were found between the values and aphid numbers, even after transformation.

In the test involving nitrogen and aphid numbers, in 2003, no correlation was found between the SAMRSS values for all indices 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.

Discussion

Not all indices are useful detectors 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, the majority of differences in reflectance can be seen in the infrared bands and water bands. There are may be indices that can use the near infrared bands and water bands to detect arthropod damage, as has been done by Fitzgerald and cohorts here at the Shafter Research and Extension Center. However, based on my research, the green peak may prove to be the band of choice to detect arthropod damage. Hopefully, using the data from this year, 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.

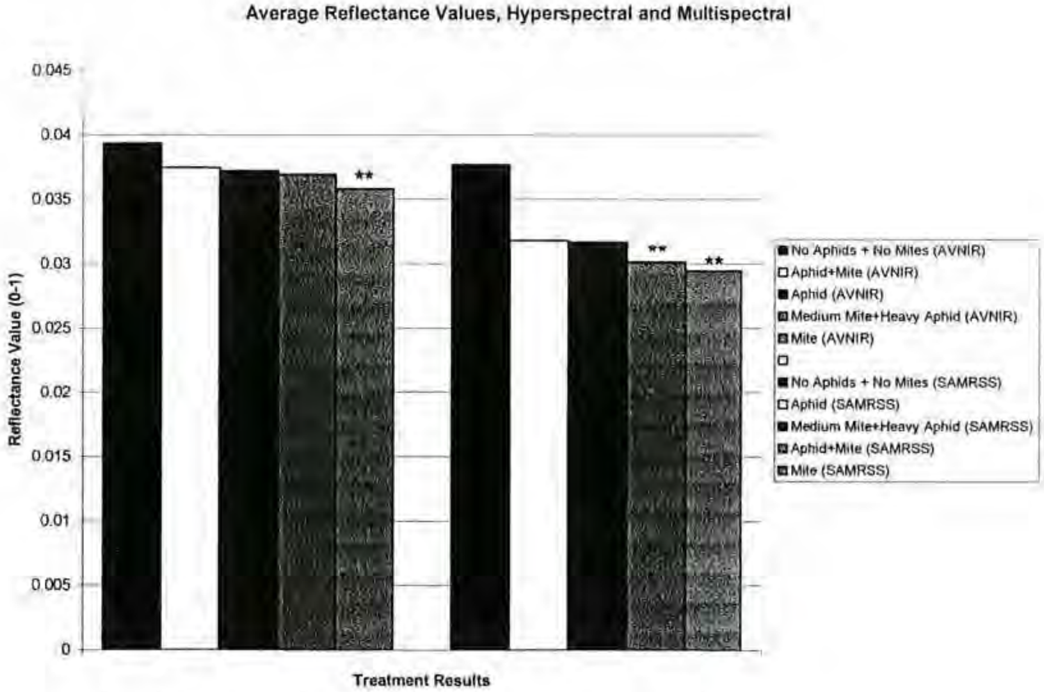

Fig. 1- There were significantly lower reflectance values at 579nm (hyperspectral, AVNIR) for mite infested cotton versus un-infested cotton. There were significantly lower reflectance values at 550nm (multispectral, SAMRSS) for both mite infested cotton and cotton infested with both aphids and mites than un-infested cotton.