



Remote detection and quantification of wheat infected with *Wheat streak mosaic virus* in the Texas panhandle



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Introduction

Much of the wheat in the Texas panhandle is dual purpose, planted as winter forage for grazing livestock as well as for grain. Wheat for grazing is typically planted early in order to maximize forage production, but this increases the risk of disease and insects. As a result, viral pathogens have been of concern for Texas wheat producers for years. Economic losses due to virus diseases can be devastating to all wheat producers whether the crop is grazed or harvested.

Of all pathogens affecting wheat in the Texas Panhandle, *Wheat streak mosaic virus* (WSMV) is the most common. It is vectored by the wheat curl mite (*Eriophyes tosichella* Keifer) (2). The mites acquire WSMV by feeding on hosts infected with the virus. Infections can occur both in the fall and spring. Foliar symptoms include yellow streaking, mottling and stunted growth (Fig. 1).

In 2004, a Landsat survey was conducted across the northern 26 counties of the Texas Panhandle. The large geographical area made it difficult to obtain adequate ground truth data to accurately classify the image. As a result, detection error was high across the area. Therefore, the objective of this survey was to develop methodology to accurately detect and quantify the incidence of WSMV across a region of the Great Plains, using Landsat imagery and then expand this methodology to larger areas.



Figure 1. Close up of WSMV infected wheat exhibiting typical symptoms.

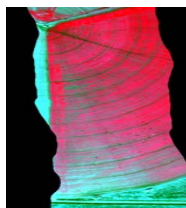


Figure 2. False color image of a field of wheat severely infected with WSMV. Infection was most severe on southwest corner.

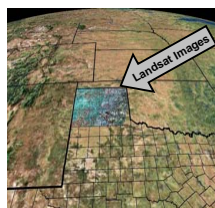


Figure 3. Globe view with Landsat images embedded on Texas panhandle.

Materials & Methods

In the fall of 2005, several wheat fields across the panhandle were tested by ELISA for WSMV to positively identify diseased wheat fields. After identifying several diseased fields, Landsat 5 imagery was acquired for the Texas Panhandle (Fig. 3). Initially, an image was acquired in January 2006 to identify wheat fields during dormancy in the area. Normalized difference vegetative index (NDVI) was calculated using the ENVI (Environment for Visualizing Images) software to identify wheat fields and create a mask on subsequent imagery (Fig. 4B). Additional images were acquired throughout the growing season as they became available. For ground truth data, selected fields throughout the county which had previously tested positive for WSMV, were physically sampled and rated as healthy, moderate, and severe. These data were used in a maximum likelihood algorithm as the basis for classification within the mask of the image (Fig. 4D). This process was repeated until known diseased fields were correctly identified. Classification error was measured with confusion error matrix. Confusion error matrix is used to show the accuracy of a classification by comparing each result with ground truth data (1). Fields that were classified as severe were tested by ELISA for the presence of WSMV. The area of each class was then measured with ENVI to estimate the area in the county that was infected with WSMV.

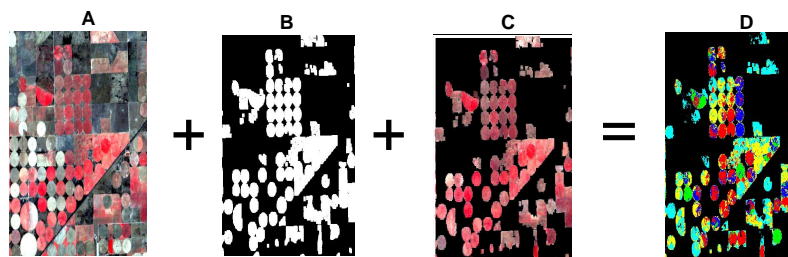


Figure 4. To classify the areas of interest, a mask (B) was created using NDVI values and overlaid on the original image (A) to get wheat fields only (C). These areas were classified using the maximum likelihood algorithm (D). The classes range from lush healthy wheat (red) to severely chlorotic (cyan).

Results and Discussion

In January 2006, 56,168 ha of wheat were detected by Landsat imagery as compared to 65,967 ha recorded by the FSA (S. Young – CEA, *personal communication*). The difference was likely due to late emergence in some fields not detected by Landsat imagery. Of the 56,168 ha detected by Landsat, 17,893 ha were classified as severe infection with WSMV and 34,897 ha were classified as moderate to healthy wheat. Overall, 95% of the known ground truth points were classified by the algorithm correctly (Table 1). Furthermore, 19 fields that classified as severe and not previously tested were selected and all were positive for WSMV. According to the Castro county extension agent, of the 65,967 ha planted, 49,684 ha of the crop either failed or was grazed out and only 16,281 ha were cut for grain (S. Young – CEA, *personal communication*) (Fig. 4). Using satellite imagery in late April, 22,290 ha of wheat were detected. Of that, 10,700 ha were classified as severely diseased and 11,590 ha were classified as healthy or moderately diseased (Fig. 5). This indicates that as much as 48% of the wheat harvested was severely infected with WSMV. The overall accuracy for the April image was 99%. The 33,878 ha of wheat that were detected in January but not detected in April were designated as unclassified. This was primarily due to disease, drought and graze-out. In many cases, all three factors played a role resulting in no wheat left for harvest. These results indicate that Landsat imagery can be used to accurately detect and quantify incidence of WSMV over a large area. However, there are variables that mimic WSMV symptoms and the spectral responses of these stresses need to be investigated more thoroughly to further increase the accuracy of detection. After preliminary studies on a local scale, we have confidence that this methodology has tremendous potential to quantify disease over a much larger area such as the entire Great Plains region.

Table 1. Confusion error matrix for the classification on the January 2006 image. The columns are the ground truth pixels and the rows are the classification pixels. The highlighted numbers indicate the number of pixels that were correctly classified. There were 312 pixels classified as severe chlorosis, of which 288 pixels were classified correctly, 24 were misclassified and 0 were unclassified.

Class	Healthy	Light chlorosis	Moderate	Severe chlorosis
Healthy	671	0	0	10
Light chlorosis	27	150	2	0
Moderate	0	7	123	14
Severe chlorosis	0	0	3	288

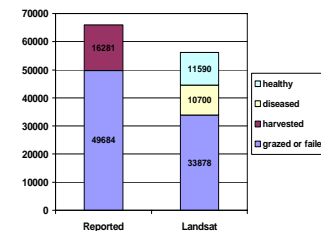


Figure 5. Comparison of actual planted and harvested wheat (end of season) with Landsat detected wheat (April 2006).

References

- Campbell, J.B. 1996. *Introduction to remote sensing*. 2nd ed. New York, NY: The Guilford Press.
- Matthews, R. 1991. *Plant virology*. 3rd Edition ed. San Diego, CA: Academic Press, Inc.