

A Pilot Project to Evaluate the Use of Geographic Information Systems (GIS) to Analyze Regional Data on Pests and Diseases of Vegetables

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Abstract

Geographic Information Systems (GIS) are computer databases that organize information in a spatial framework. This allows the analysis of data based in part on location. A pilot project has been set up in the Yuma Valley to explore the use of GIS to study the influence of crop sequences, weeds, urban areas, and insect vector populations on the incidence of virus diseases of vegetables. The goal is to learn to collect field observations in such a way that long term regional trends can be understood and visualized. Such information can then be used in management plans.

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Introduction

Historically, Arizona crops have been subjected to unexpected disease or insect outbreaks such as the lettuce infectious yellows virus and the associated whitefly problems of the 1980's, and the whiteflies particularly in 1991. In the typical crisis atmosphere that results, agricultural leaders and policy makers are frequently pressured to divert resources to short term solutions without a long term view of the consequences of such actions. At the same time, production managers, individually, are making decisions based on an evolving mix of personal experience, local anecdotes, commercial pest control advice, and fragmented early reports from public research and extension programs.

To help both farmers and administrators make reasonable management decisions, a system to synthesize, store, and analyze accurate information on these problems is desirable. In the pilot project for the Yuma Valley described below, we are trying to learn how best to store field observations in databases on a regional basis and conversely how best to make field observations that have meaning when stored in such databases. This report describes how the database is organized, the kind of information that is being collected, and some preliminary attempts to apply unique analysis techniques to it.

Methods

The most important pest and disease outbreaks in crops develop on a regional scale. The key to organizing field observations on a regional scale is computer-based geographic information systems (GIS). GIS databases can be organized in such a way that the data are keyed to universal coordinates that allow data to be displayed on computer generated maps and diverse data sets based on the same coordinate system to be compared. Universal Transverse Mercator (UTM) coordinates are used in our study. These are the metric equivalent of latitude and longitude. Detailed Arizona Soil Conservation Service (ASCS) maps show the location and size of all the fields in the Yuma Valley. There is an 8.5 by 11 inch map for each section in the valley. Observations made from these maps are stored in the database identified by ASCS map number, township, range, section and quarter section (160 acres). The UTM coordinates of the center of each quarter section are stored and thus, data for each quarter section can be summarized on a map. For example, the map in figure 1 shows the crop with the most acreage in each quarter section based on observations made between January 24 and February 14, 1992.

Computer data sets showing map features such as roads, canals, ditches etc for the state of Arizona were obtained from the Arizona State Land Department Arizona Land Resource Information System (ALRIS). The lines on the map in Figure 1 show the location of major canals and ditches obtained from ALRIS with the crop sequence information overlaid.

We believe that maintaining crop sequence data over a number of years will help us understand cycles of disease incidence and insect infestations. The data set includes repeated observations of crops growing in about 2,500 fields with an average size of 20 acres, but ranging in size from less than an acre to 160 acres. These data can be summarized graphically based on the coordinates of the quarter section in which they are located. Figure 1 is one such summary - showing the crop with the most acres in a quarter section. Sometimes, it is more helpful to view the data by looking at many different maps simultaneously. For example, figure 2 on the following page shows 20 different maps. Each map shows the location of quarter sections having at least 15 acres of a particular crop on a particular survey. The goal of such a database is to be able to recall shifting patterns of crop sequences from one season to the next easily and graphically and to compare them with observations on insects and disease incidence.

The data are collected by a worker experienced in the agricultural practices of the valley who drives throughout the valley with the ASCS maps and notes any changes in crops that may have occurred. Because the field worker surveys the valley every three weeks, he is very familiar with what is growing and can quickly note changes on maps. The survey takes several days to complete and in addition to observations on crop sequences, the observer rates the area around the fields for the degree of weeds in general and *Malva parviflora* in particular. One of the ongoing challenges is to define what kind of information can be gathered in such surveys. Time constraints are critical when such a large area is to be covered.

Results and Discussion

Examples of the crop sequence information are shown in figures 1 and 2. In addition to the crop sequence information, in a separate data collection effort, 43 insect traps are set out at defined sites along the roads to monitor for whiteflies and aphids. The traps are set out either weekly or every other week for 24 hours. Data from the 43 traps can be averaged for the entire valley to show overall population trends (Figure 3). Comparing Figure 3 with Figure 2 shows that a good deal of the lettuce crop emerged after whitefly trap counts dropped dramatically. The migratory whitefly population levels shown in Figure 3 were not evenly distributed throughout the valley. Using a process for computing moving spatial averages, called 'kriging', a map is developed which shows an estimate of whitefly levels throughout the valley based on the 43 trap locations (Figure 4). Such a procedure makes it easier to see a rough overview of the pattern. Such rough overviews can be tested with more detailed trapping if a particularly important pattern seems to be emerging in a particular area.

Finally, lettuce infectious yellows disease incidence, based on plant symptoms, was estimated for 803 lettuce fields in 200 quarter sections between November 4, 1991 and January 28, 1992. Ten acre portions of fields were rated from 1 to 5 based on a subjective impression of how many plants in that portion of the field showed symptoms typical of lettuce infectious yellows. Fields having more than 10 acres were rated in more than one location within the field. Despite very high populations of whitefly early in the season, very few fields showed any plants with symptoms of lettuce infectious yellows virus (Figure 5). Figure 5 codes each quarter section according to the highest level of symptom rating of any field in the quarter section. Most quarter sections are coded as having no fields with symptoms. It should be noted that when lettuce fields were evaluated for symptoms of lettuce infectious yellows virus, the presence or absence of whiteflies was also recorded. Whiteflies in low numbers were seen in the lettuce fields throughout the winter (as late as January 21, 1992), long after migratory populations had dropped below levels detectable in the traps.

There are a number of possibilities that may have contributed to few symptoms of lettuce infectious yellows observed this season. It is possible that the new biotype may not be as effective in transmitting the virus as the previous biotype of the sweet potato whitefly¹. Other factors that may have helped include a lower level of weediness throughout the valley as a whole last fall and, possibly, a somewhat delayed planting of the main lettuce crop. We hope that we can learn to collect information in such a way that will allow us to contrast patterns observed during years of low incidence of disease symptoms, such as this one, with years of higher incidence of disease such as have occurred in the past and may occur in the future.

At this point we feel that this will be an "information processing system" useful as a means for monitoring pest and disease levels. This information then becomes a tool for the development of management programs.

¹Cohen, S., J. E. Duffus, and H. Y. Liu. 1992. A new *Bemisia tabaci* biotype in the southwestern United States and its role in silverleaf of squash and transmission of lettuce infectious yellows virus. *Phytopathology* 82:86-90.

Crop Sequence Map - Yuma Valley

Trip 8: January 24 to February 14, 1992

Key:

-  Lettuce
-  Cole
-  Citrus
-  Alfalfa
-  Wheat
-  Melon
-  Cotton

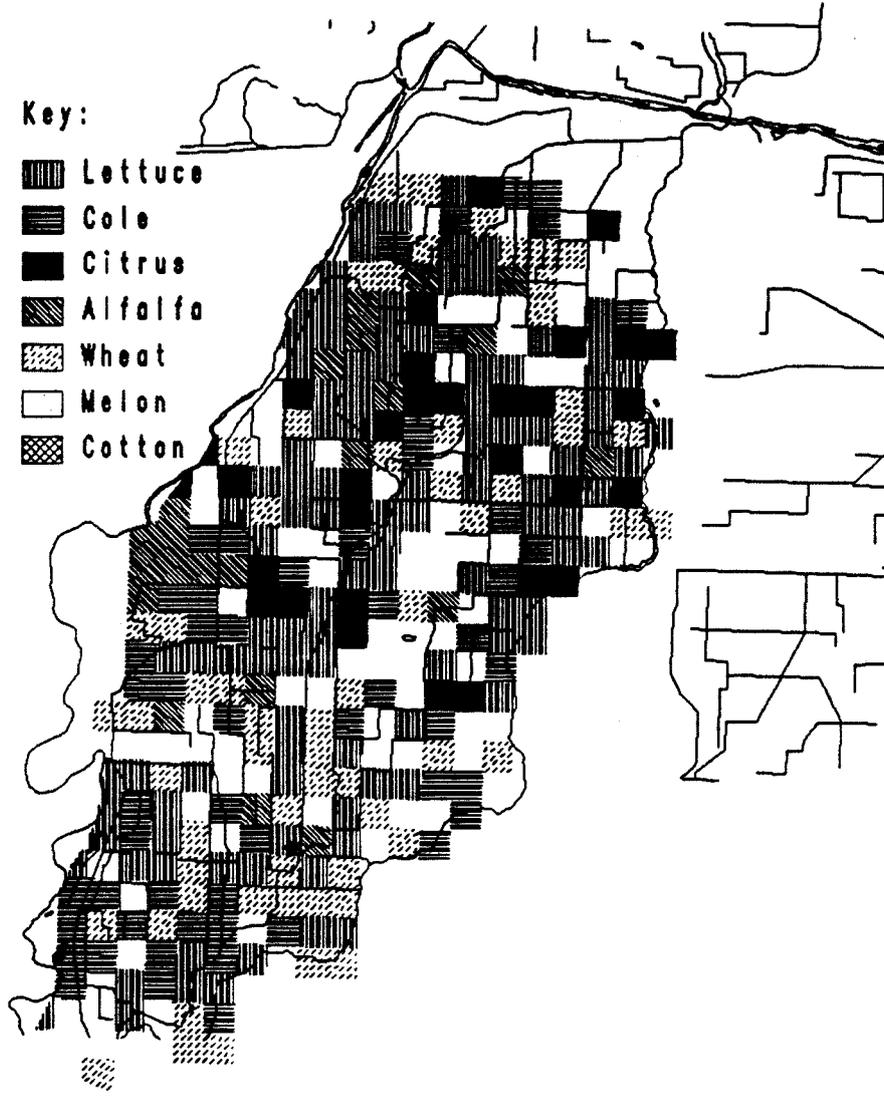


Figure 1 Crop sequence map showing the crop with the most acreage in each quarter section at the time of the survey.

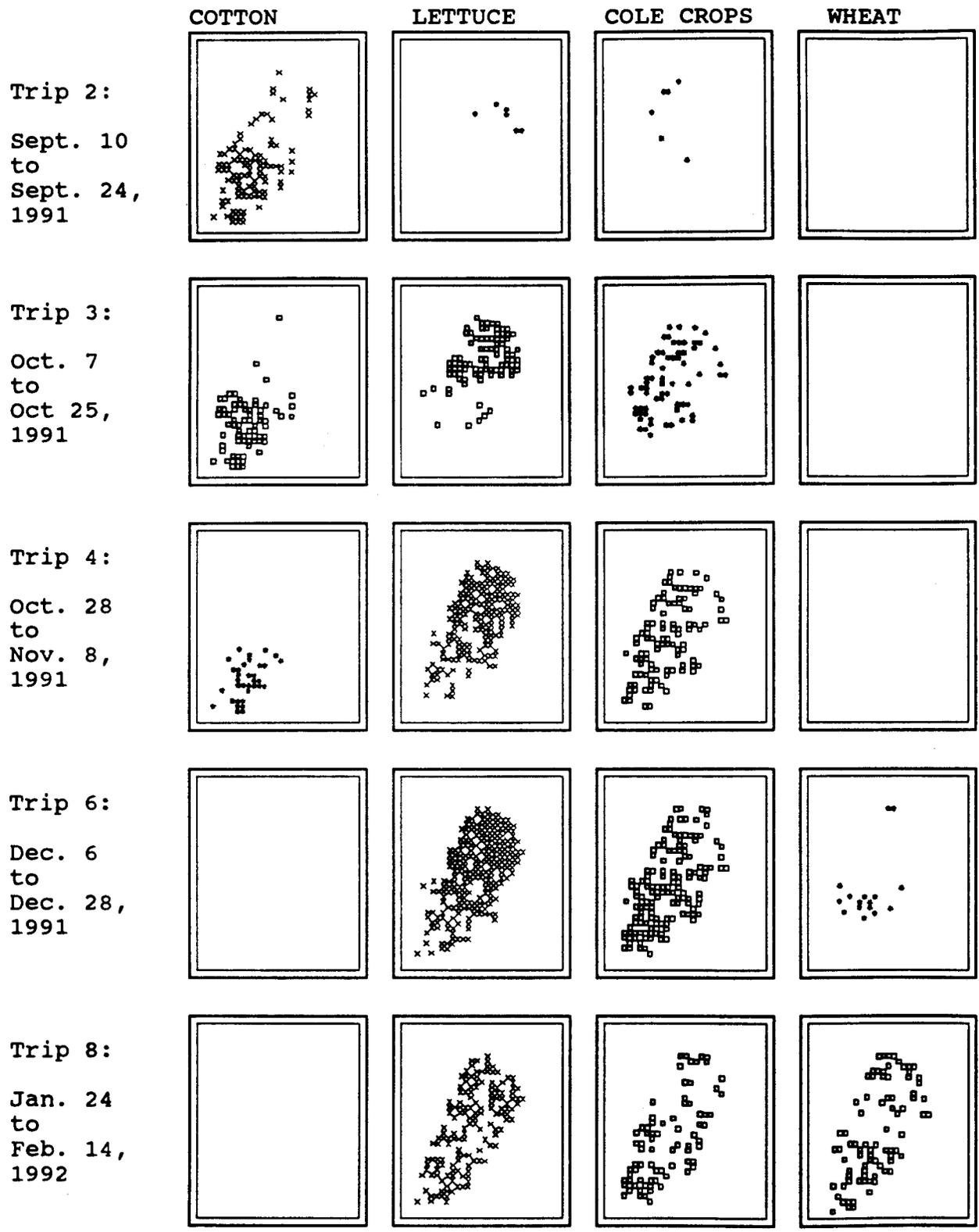


Figure 2. Crop sequence profiles in Yuma Valley 1991-1992 showing quarter sections with 15 acres or more of a specified crop.

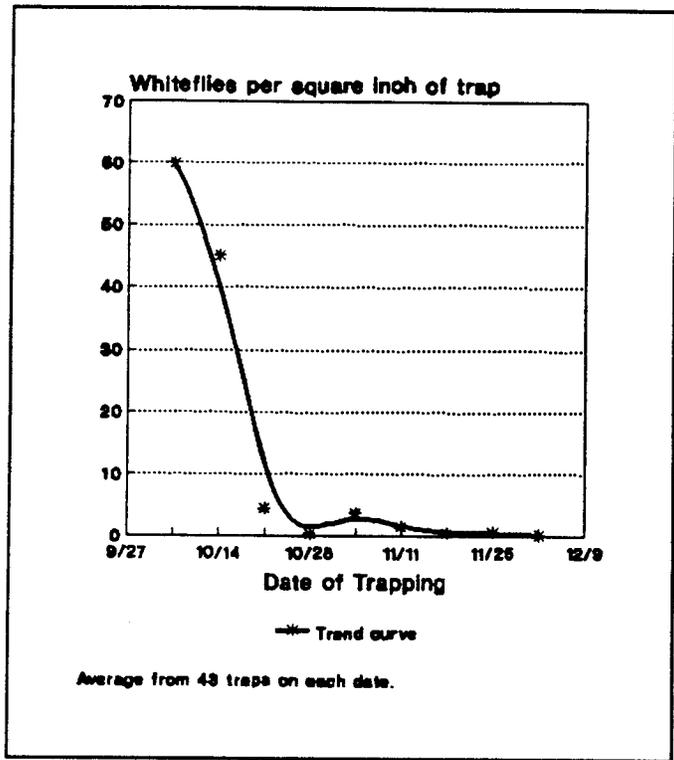


Figure 3. Whitefly populations averaged from 43 trap positions throughout Yuma Valley during the fall of 1991.

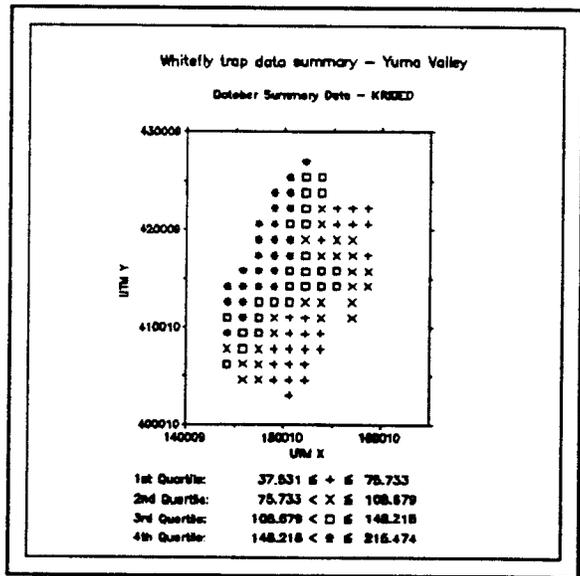


Figure 4. GeoEAS plot of October 1991 whitefly trap data kriged.

Incidence - Yuma 1991
Lettuce Infectious Yellows Virus
Symptoms Nov. 1991 - Jan. 1992

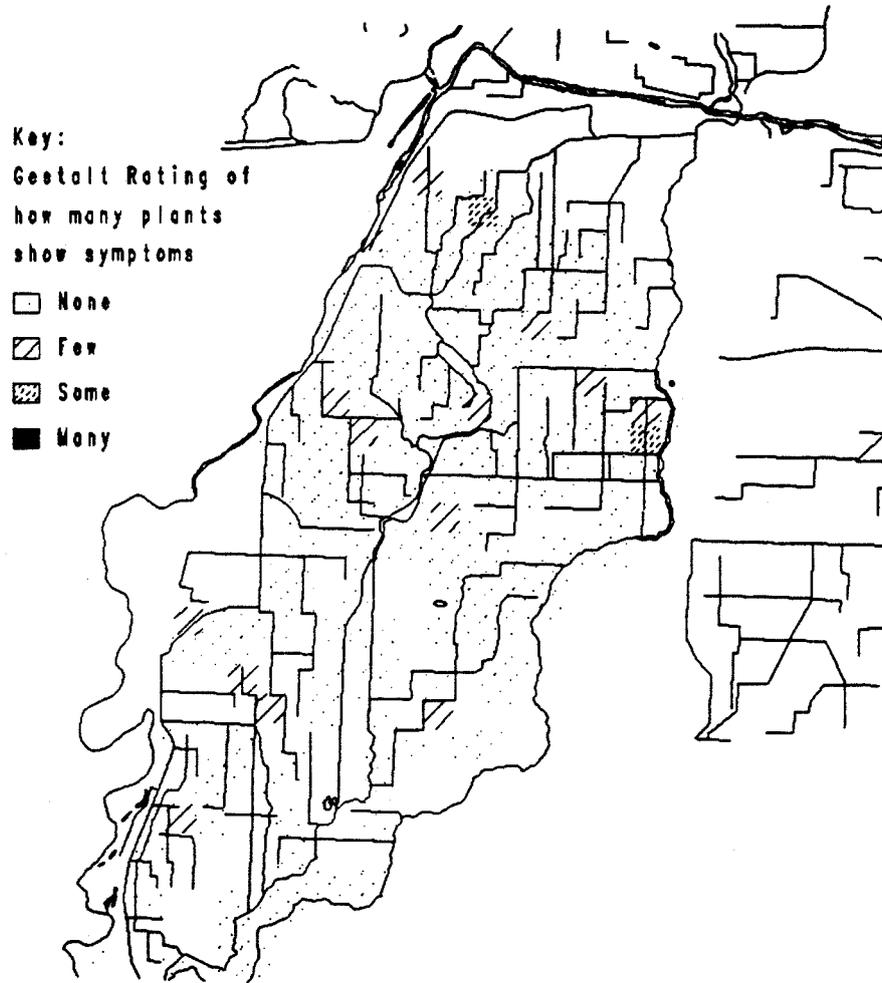


Figure 5 Field evaluations for symptoms of Lettuce Infectious Yellows Virus. 1991-92 season.