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Editors
James J. Stapleton
Charles G. Summers
Beth L. Teviotdale
Peter B. Goodell

Cooperative Extension
Agricultural Experiment Station
Statewide IPM Program

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EDITORIAL: LAST PRINTED EDITION OF UCPPQ

The UC Plant Protection Quarterly enters its 12th year of publication with a burst of color and a commitment to electronic publishing. Readers may have noticed that in recent editions, increasing use of links to relevant color photos, graphics, etc. has been made. Also, those who have accessed the electronic version of UCPPQ may have noticed that many of the graphs and illustrations appear in color, rather than the black-and-white used in the printed version. Although the Statewide IPM Program has covered printing costs since the inception of UCPPQ, we have determined that publishing a printed version in color is unnecessary.

Because of the increasing disparity between the printed and electronic versions of UCPPQ, as well as the increasing costs and staff time needed to produce a printed version, the editors have made the decision to cease mailing printed copies to ANR personnel. Beginning with the next edition, ANR personnel (and other interested parties) will be notified by list server that UCPPQ has been published to the net. At that time, you may access, read, and print material from the newsletter at your convenience. Only subscribing libraries will continue to receive a printed version.

The editors are sensitive to the needs of individual ANR academics. If you are a farm advisor or specialist in a remote location and feel that lack of a printed copy will adversely affect you, please notify us and we will do our best to see that you continue to receive a printed copy.

J. J. Stapleton, C. G. Summers, B. L. Teviotdale, and P. B. Goodell
Editors

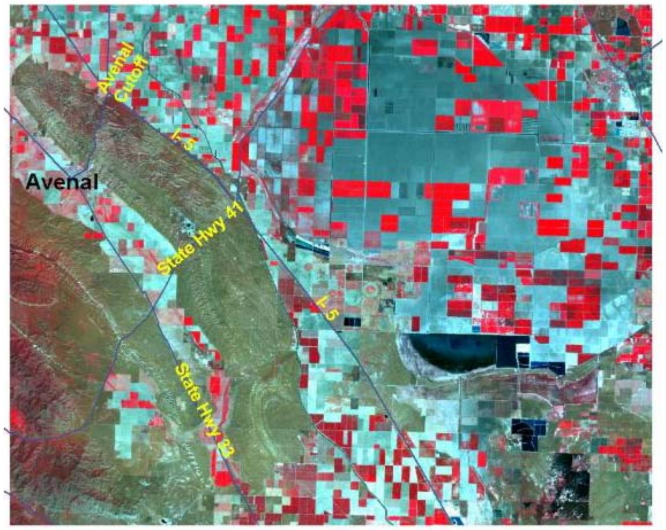

Figure 1. Color infrared Landsat image on April 25, 2001 of western Fresno County using green, red and near infrared bands. Brighter red colors indicate strong vegetative reflectance. Note reddish tinge at Avenal Cutoff, indicating patches of tarweed.

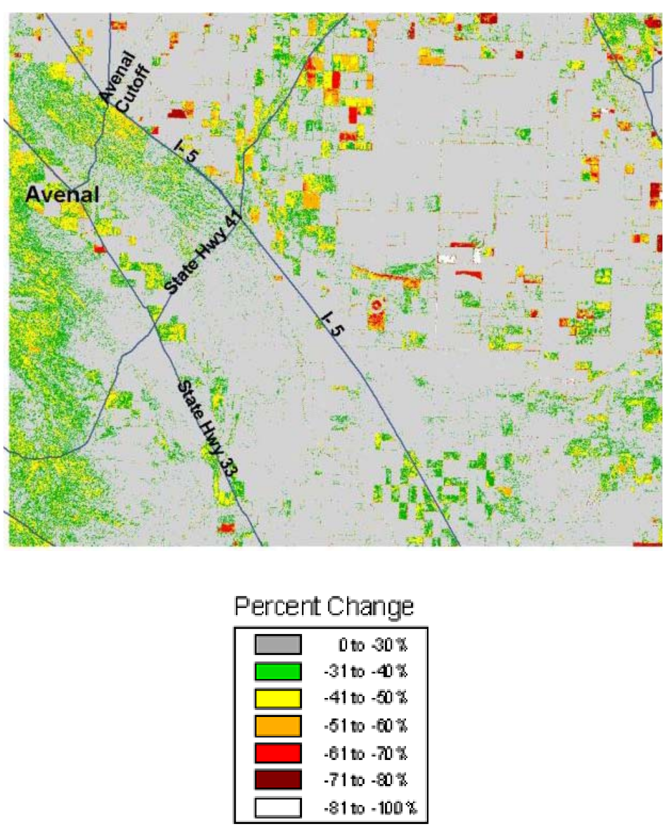

Figure 2. Change in percent normalized difference vegetation index (NDVI) between April 25 and May 11, 2001 in western Fresno Co.

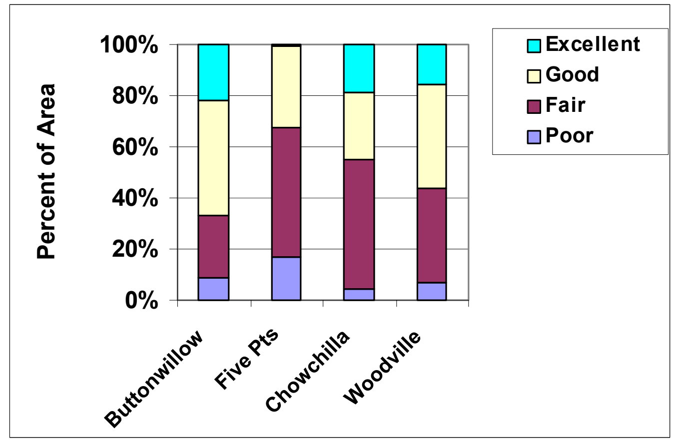

Figure 3. Percent of four areas occupied by plants in the San Joaquin Valley ranked by their suitability as lygus hosts in 2001.

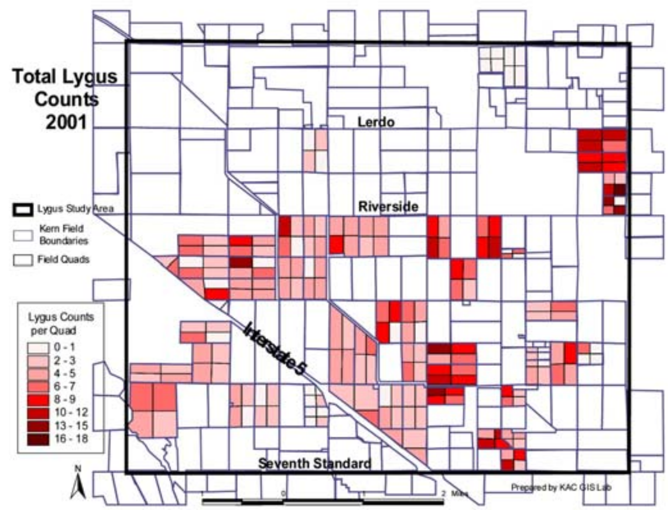

Figure 4. Total lygus captured from cotton in Buttonwillow, Kern County. Counts are for total bugs/50 sweeps.

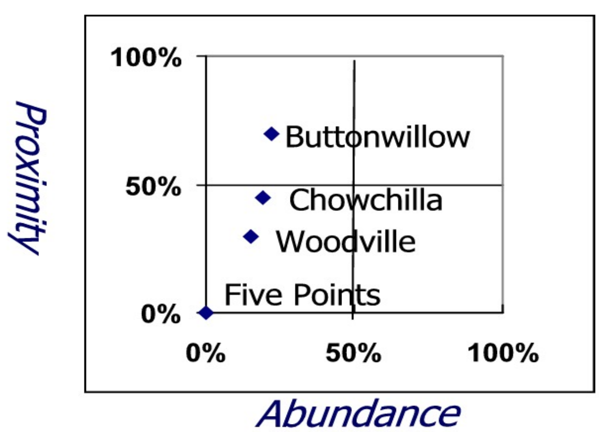

Figure 5. A method of characterizing lygus environments based on alfalfa forage abundance and proximity. Proximity is the percent of alfalfa fields located within 25 ft or less or another alfalfa field. Abundance is the percent of area planted to alfalfa.

USING GIS APPROACHES TO STUDY WESTERN TARNISHED PLANT BUG IN THE SAN JOAQUIN VALLEY. *P.B. Goodell, K. Lynn and S.K. McFeeters, Cooperative Extension, Statewide IPM Program and GIS Laboratory, U.C. Kearney Agricultural Center*

Abstract

The western tarnished plant bug (*Lygus hesperus* Knight) is a key pest in many crops in the San Joaquin Valley (SJV), including cotton, dry beans, seed alfalfa, and various fruits and vegetables. Populations of this indigenous insect are at very low densities in spring, but build through the summer on a variety of host plants. As one plant or crop becomes unsuitable, the insect moves into neighboring crops. Geographic Information Systems (GIS) provides an ideal tool to study the concentration and movement of lygus through the season. GIS techniques were used to characterize various landscapes in the study area that provide lygus habitat. Several townships were analyzed throughout the SJV to identify differences in cropping patterns, particularly of cotton and alfalfa. In addition, Landsat satellite imagery was processed to identify areas of senescing natural vegetation that were in close proximity to cultivated areas. Finally, actual lygus population dynamics bordering farm areas were mapped using real-time field data. These approaches provide a powerful tool to understand the landscape in terms of lygus population development and movement. The concept of crops and plants acting as sources out of which lygus move, or sinks into which lygus move, can be studied on a regional scale. The role of individual crops, such as alfalfa hay, on the intensity of lygus in an area might be used in a predictive manner to prescribe regional management of this pest. GIS also provides useful tools to help cotton growers and consultants visualize complex crop interactions and lygus movement.

Introduction

The western tarnished plant bug (*Lygus hesperus* Knight) or lygus bug is an important insect pest on many crops including cotton, beans, lettuce, seed alfalfa, strawberries, and tree fruit. Their population density is low in the spring and increases during the summer. Many crops and weeds can act as hosts during this population buildup. In certain years, the insects can develop high population densities in the foothills surrounding the San Joaquin Valley (SJV) and threaten cotton as the native vegetation becomes unsuitable as a host. Within the SJV, populations increase, and as one host crop is prepared for harvest, lygus are forced to move into neighboring crops. As crops are harvested through the season, lygus are forced to concentrate into smaller areas of remaining crops.

During the 1990s, lygus is estimated to have caused an average yield loss of $18,789,254, or 1.88% of the total production value in cotton. Since lygus builds primarily as an external pest and moves into fields as surrounding hosts become unsuitable (Goodell, 2000), the SJV cotton producer must sample the field frequently to avoid early and mid-season fruit loss. Thus, a cotton field may be in biological balance one day but out of balance the next, due to an external event not of the farmer's making. In cases in which the movement of lygus is concentrated and intense, control options are limited to broad-spectrum insecticides that can result in secondary pest outbreaks, lead to an "insecticide treadmill," and threaten profitability (Goodell et al., 1997).

The concept of the SJV cotton crop being embedded in a landscape mosaic of lygus sources and sinks was suggested over 30 years ago (Stern, 1969). The ecological understanding of lygus buildup and movement led to improved management tools. For example, every year since 1978, the foothills surrounding the SJV have been surveyed for the presence of lygus. In 1978, population densities of lygus built to high levels and resulted in an extended movement into the SJV that caused severely depressed cotton yields and higher production cost due to increased insecticide expenses. The combination of winter and spring rainfall and the resulting growth flush of native plant hosts determines the severity of the lygus threat in May and June (Goodell, 1998). Surveys have consisted of locating hosts and sampling for lygus populations with a sweep net along a loosely established route of roads that cross through these areas. The abundance of hosts and the population density of lygus are corrrelated to the likelihood of economic damage, and a statement of the potential threat is issued to the cotton industry in late May. Resource constraints and access to private land have been limitations to our ability to survey large areas.

During the 1960s, a series of cultural management practices were developed to mitigate the movement of lygus into cotton fields and offer alternatives to corrective insecticide treatments. These practices included the treatment of sources before lygus movement (Sevacherian et al., 1977), interplanting preferred hosts with cotton (Stern et al., 1969; Goodell and Eckert, 1998), and preserving habitat by managing alfalfa hay (Stern et al., 1967). While some of these practices were widely accepted (e.g. treating safflower), most were found to be impractical. The importance of alfalfa hay in managing lygus in a regional context has recently been emphasized (Goodell et al., 2000; Goodell 2000), but specific guidelines are still lacking. Thus, 30 years later, the cotton industry is still reliant on chemically based management strategies, due in part to our incomplete understanding of lygus movement across a large area. Understanding the spatial relationships of lygus sources and sinks could lead to improved decision-making and offer guidance to the utilization of cultural and chemical control strategies.

Geographic Information Systems (GIS) offer powerful tools to increase our knowledge of cropping systems interactions. Our goals in these studies were to:

1. apply GIS to spatially analyze the diversity of landscape mosaics within the SJV, as related to lygus hosts
2. use satellite imagery to investigate the spatial and temporal pattern of senescing natural vegetation along the western rim of the SJV, and apply this regional pattern as a data layer (map) in the GIS;
3. use GIS to follow lygus populations within a complex landscape community (spatial and temporal dynamics); and
4. investigate using the above mentioned data layers to predict lygus movement.

Methods and Materials

Improving lygus infestation projections. Landsat 7 imagery consists of radiance data for seven reflectance bands (a panchromatic band at a spatial resolution of 15 meters, and six others at 30 meters) and two thermal emission bands (at a spatial resolution of 60 meters). Landsat 7 passes over a given scene every 16 days and provides an image that is 170 km by 185 km in size (31,450 km^2). The scene that covered the western edge of the SJV along the Interstate 5 (I-5) corridor was path 42, row 35, and the time period of interest was March through early May. Thumbnail images and descriptions of the scenes were available on the Internet for inspection shortly after the satellite passed overhead. These images were inspected for clarity and absence of cloud cover. Only two dates provided clear, unobstructed views, April 25 and May 11 2001, and were purchased for analysis. The images were incorporated into GIS systems to overlay roads, towns, and political boundaries which allowed specific locations to be identified and visited.

The image data that were used in the analysis were rectified to one another to facilitate change detection analyses. Atmospheric haze correction was performed on the raw image data using water bodies as dark targets. Regressions were performed and the results were used to adjust the raw values for atmospheric haze prior to conversion to reflectance values. The image data were then converted to planetary reflectance in the manner described in Chapter 11 of the Landsat 7 Science Data Users Handbook (Anonymous, 2002). This was done to reduce between-scene variability through a normalization for solar irradiance. This is important, because solar irradiance will change between image dates due to changing solar illumination angles and Earth-Sun distances. Failure to compensate for these changing parameters could lead to “change” being detected at a given location when none may have occurred.

To enhance the presence of vegetation, color infrared images were developed using the green, red, and near infrared reflective bands. The resulting color infrared images indicated healthy vegetation in reddish tones that contrasted well with the bluish-green tones of soil surfaces. These images were used to locate areas of vegetative growth. A normalized difference vegetation index (NDVI) was used to characterize vegetation health. NDVI was calculated for each Landsat image using their respective red (RED) and near infrared (NIR) bands according to the following equation:

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{RED}) / (\mathrm{NIR} + \mathrm{RED}) \quad (1)$$

Although the theoretical values for NDVI range from –1 for water surfaces to +1 for dense, healthy, vegetated surfaces, actual values fell well within these limits. Since it was desired to locate areas where vegetation was senescing, an image of the percent change of NDVI (PCNDVI) was calculated using the following equation:

$$\mathrm{PCNDVI} = \{(\mathrm{NDVI}_{\mathrm{May\ 11}} - \mathrm{NDVI}_{\mathrm{April\ 25}}) / \mathrm{NDVI}_{\mathrm{April\ 25}}\} * 100\% \quad (2)$$

The PCNDVI image was examined along with the color infrared images. It was found that areas with very high negative values of PCNDVI corresponded well with fields of harvested crops. Conversely, areas with very low negative values of PCNDVI corresponded well with areas of little vegetation change. For example, such areas might have little healthy vegetation growing at all in both Landsat scenes. Thus, to improve the interpretability of the PCNDVI image, only those areas with PCNDVI values between -31% and -80% were used in the analysis, and the resultant image was color-coded to facilitate interpretation. Ground observations were utilized to corroborate the results.

Contrasting cropping patterns in the SJV. The cropping patterns in SJV townships (ca. 36 miles^2) were compared, including Five Points (Fresno County), Buttonwillow (Kern County), Chowchilla (Madera County) and Woodville (Tulare County). Crops were inventoried using a variety of methods. At Buttonwillow, a query of the Kern County Ag Commissioner Pesticide Use Permit database was conducted. At Five Points, the area was physically surveyed. For Chowchilla and Woodville, historic California Department of Water Resources (DWR) crop maps were utilized for 1995 and 1993, respective. The data were converted to Arc View® shape files. When alfalfa and cotton were present, the ratio of the crops was analyzed. Tables of crop frequency were developed, and nearest neighbor analysis for alfalfa was conducted to determine the median distance between alfalfa fields.

Crops were classified according to their suitability as a lygus host using a 1 (poor) to 4 (excellent) scale (Table 1). Ratings were subjective, based on experience. In some crops such as almonds, the understory vegetation may or may not be a good host. In field crops such as garlic and onions, weeds may be the host rather then the crop.

Mapping lygus in cotton. A community project in Buttonwillow, Kern County, was developed. An area of approximately 8,000 acres was selected because of the cooperation among neighbors, and the fact that the area was serviced by only two pest control advisors (PCAs). The Kern County Agricultural Commissioner provides a current crop map for the county each year. This map is provided in ArcView® shape file format, and was used as the base map to monitor lygus movement. The cotton fields in the study area were divided into quadrants and the weekly lygus data (taken by PCAs) were taken to coincide. In this way, the spatial resolution of the collected data was significantly improved. The weekly lygus samples were taken as part of the routine pest management activity of the growers' PCAs.

Results

Improving lygus infestation projections. We were able to locate potential lygus hosts using the color infrared images of the Landsat scene. In the area along the I-5 corridor, rainfall provided ideal conditions for the development of tarweed (*Hemizonia* sp.) The color infrared image of this area, acquired on April 25, provided sufficient detail to identify large patches of healthy vegetation (Figure 1). The location of these vegetation patches corresponded with known sites of tarweed distribution. Thus, the pattern of distribution of healthy stands of this potential lygus host was identifiable from the image. Changing reflectance patterns indicated reduced plant distribution further south, and ground observations supported this interpretation. In 2001, lygus was not present on this host. The change in reflectance patterns was substantial between April 25 and May 11, as rain subsided and temperatures increased, and were displayed as color-coded values of PCNDVI (Figure 2). Ground surveys confirmed that the vegetation in locations with PCNDVI values between -31% and -80% had almost completely dried out and was unsuitable for hosting lygus.

Contrasting cropping patterns in the SJV. The four townships studied had similar crop diversity, with 10 to 11 different crops or crop groupings in each area (Table 2). Cotton was the predominant crop in the landscape at all locations, and trees, alfalfa or vegetable crops were next in abundance, depending on the location. Trees and vines were most abundant in Woodville and Chowchilla, but Five Points had more vegetables. Buttonwillow had the greatest amount of alfalfa, followed by Chowchilla and Woodville.

The areas differed in the variety and amount of lygus hosts (Figure 3). Five Points had more area with "Good" and "Fair" hosts (83%) than Buttonwillow (69%), Woodville (73%) or Chowchilla (77%). Alfalfa represented the majority of crops ranked as an "Excellent" host. The ratio of cotton to alfalfa was 1.4 to 1 in Chowchilla, 1.5 to 1 in Woodville and 2 to 1 in Buttonwillow. There was no alfalfa in the Five Points survey area.

Mapping lygus in cotton. The Buttonwillow area consisted of about 5,000 acres of mixed crops managed by family farmers. Weekly lygus data were collected from June 21 to August 3, 2001. Weekly data were placed on the map and color coded to population density (Figure 4). Historically, lygus are not an annual problem in this area (T. Touma, Bio-Ag Consulting, personal communication). The population densities during 2001 reflected this observation, with total numbers for the season ranging from zero to about 18 per 50 sweeps with an average per week of 2 per 50 sweeps which is well below an economic injury level.

Discussion

GIS offers tools that could help develop IPM strategies and grower adoption. Generally, IPM has been developed and practiced at the field and farm level.

Moving IPM beyond the farm to the regional level of system integration offers opportunities for new decision-making and management approaches. Lygus has long been recognized as a prime candidate for regional management, but we have heretofore been limited by a lack of tools to investigate its ecology over such wide and diversely managed areas.

These studies make an initial attempt at using the GIS tools to expand our view of the landscape in which lygus develops, moves and creates pest management concerns. Two key elements were explored in these studies; first our ability to locate non-cultivated host development over a wide area, and second, the characterization of large areas relative to crop diversity, abundance of key crops, and the spatial relationship between key sources of lygus and the susceptible sinks.

We demonstrated that our spring survey efforts can be improved by using existing Landsat 7 satellite images to locate potential hosts and track their decline. While the presence of such hosts does not ensure high lygus numbers, integrating the satellite imagery into GIS map layers provides opportunities to visit specific sites for sampling, thus optimizing limited labor and time resources. Alternatively, a bottom-up approach can be employed, in which known hosts are sampled and precisely located through the use of geographical positioning systems (GPS). As hosts senesce, the area can be estimated and its contribution to lygus population in the SJV projected.

Drawbacks to using Landsat imagery include the requirement for cloud free days and the lengthy period (16 days) between overflights. A missed opportunity due to cloud cover results in a month between images. Satellites with more frequent overflights are available, but spatial resolution is reduced from 30 m with a 16 day re-visit on Landsat, to 250 m with a 1-2 day revisit on the MODIS sensor on NASA's EOS AM-1 satellite, for example. Further research is required to develop a balance between spatial resolution and frequency of images. Finally, estimating total coverage of an area by a specific host cannot be done without corroborative ground observations. Identification based solely on reflectance may be unreliable due to similarity of signatures among plants. Coupling of space-based imagery with *a priori* knowledge from ground observations improves the reliability of both technologies.

Tools useful in characterizing landscapes continue to be developed (Forman, 1999). Scale is an important component in understanding and interpreting the complexity of landscape mosaics that contain basic spatial elements of patches, corridors, and matrices. Our analysis is still incomplete, but we believe alfalfa forage should be a focus in understanding lygus movement between sources and sinks. We chose the township (6 miles by 6 miles) as our level of scale because it is large enough to incorporate farms and fields, but small enough to conduct ground surveys. The DWR land use data was on a slightly larger scale (ca. 10,000 more acres per unit) but is still useful for comparative purposes.

The presence of alfalfa in the landscape may play a pivotal role in lygus biology. It is a preferred host of lygus and the only widely grown crop that is not harvested for its reproductive parts. Alfalfa is not allowed to senesce, but is cut every 28 to 30 days during its peak vegetative state. Strip cutting alfalfa has been demonstrated to be a valuable tool in limiting lygus movement into cotton (Stern et al., 1967; Goodell et al., 2000). In situations where alfalfa fields are abundant in an area and are located in close proximity to each other and to cotton, lygus severity in cotton is reported to be reduced (Goodell et al., 2000).

GIS provides a convenient tool to visualize the relationship of alfalfa to cotton. Further analysis with GIS tools provides an indication of alfalfa abundance (percent area cover) and proximity (nearness to other alfalfa fields). For example, in three of the four landscapes studied, Woodville, Chowchilla and Buttonwillow, alfalfa represented 15%, 19%, and 22% of the total area, with 30%, 45% and 70% of the fields located within 25 ft of another field, respectively (Table 3). By placing these factors on two axes, we believe an important tool for characterizing landscapes for lygus movement can be created (Figure 5). In extreme situations, areas might have no alfalfa or have large areas of contiguous alfalfa. The placement of landscape areas between these extremes may provide an important tool in predicting and determining the annual severity of lygus infestations in cotton.

The Buttonwillow community may provide an ideal location to test the value of alfalfa in managing lygus on a regional scale. Further analysis incorporating nearest neighbors is required to identify sources of populations that moved into cotton, and to relate the lygus movement to crop production activities, such as harvest preparation. One obvious factor of interest in alfalfa is its cutting cycles. Providing these data in near real time is an important goal. The grower community expressed interest in seeing the lygus distribution maps and learning more about lygus movement within their area. We are currently developing Internet-based applications to provide lygus data and enable the community of growers and PCAs to visualize the population distribution of lygus.

The value of GIS in community management of lygus is just beginning. These powerful tools will aid in improving our understanding of lygus movement within a geographic area. Perhaps as important, they can provide a means to visualize the complex crop interactions and help PCAs and growers better manage this key pest.

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Table 1. Subjective ranking of crops as lygus hosts found within San Joaquin Valley study areas in 2001.

Crop	Host classification	Numerical ranking
Alfalfa	excellent	4
Almond	Fair	2
Apples	Fair	2
Broccoli	Fair	2
Cherry	Poor	1
Corn	Fair	2
Cotton	Good	3
Garbanzo	Poor	1
Garlic	Fair	2
Grain	Poor	1
Grape	Fair	2
Lettuce	Fair	2
Melons	Poor	1
Onions	Fair	2
Peach	Good	3
Pistachio	Fair	2
Safflower	excellent	4
Sugar beets	excellent	4
Tomato	Fair	2
Tomato, processing	Good	3
Veg. Seed Crop	Good	3
Wheat	Poor	1

Table 2. Composition of crops in four locations of the San Joaquin Valley in 2001.

Buttonwillow		Five Points	
Crop	Acres	Crop	Acres
Cotton	7,713	Cotton	6,187
Alfalfa	4,016	Tomato, processing	5,537
Almonds/Pistachio	2,898	Fallow	3,528
Corn fodder	1,175	Onion/garlic	2,879
Wheat	1,233	Grain	2,223
Cherry	333	Tree/Vine	733
Tomato, pro.	367	Melons	551
Uncultivated ag land	87	Almond	456
Vineyard	337	Field Crop	326
Safflower	46	Vegetable	232
Miscellaneous vegetables	188		
Total Acres	18,392	Total Acres	22,652

Woodville		Chowchilla	
Crop	Acres	Crop	Acres
Cotton	8,591	Cotton	9,394
Other Deciduous	5,975	Almond/Pistachio	7,319
Corn	5,670	Alfalfa	6,778
Alfalfa	5,542	Corn	4,548
Grapes	3,560	Pasture	1,858
Grain	2,344	Grain	1,586
Vegetable	1,657	Fallow	2,622
Other Field	1,285	Grape	1,321
Almond/Pistachio	714	Other deciduous	661
Fallow	2,050	Tomatoes	26
Subtropical	172	Subtropical	12
Pasture	72		
Total Acres	37,631	Total Acres	36,126

Table 3. Alfalfa forage abundance and proximity in four areas of the San Joaquin Valley. Abundance is the percent of area planted to alfalfa. Proximity is the percent of fields located within 25 ft or less of another field.

Location	Abundance	Proximity
Five Points	0%	0%
Woodville	15%	30%
Chowchilla	19%	45%
Buttonwillow	22%	70%

PERSPECTIVE

THRIPS IN ALFALFA, BUT THE BOVINES DON'T CARE

Charles G. Summers, Department of Entomology, University of California, Davis, and U. C. Kearney Agricultural Center

Authors Note: Based on a presentation given at the 31st California Alfalfa Symposium, Modesto, CA. 12 December 2001.

Introduction

Thrips (Thysanoptera) are minute, slender-bodied insects usually possessing two pairs of long, narrow wings, the margins of which are fringed with long hairs. Some species cause injury to plants by direct feeding and others by vectoring plant viruses, while still others are predatory on mites and small insects. Because of their high populations in alfalfa and their easily identifiable injury (see below), some have long considered thrips to be major alfalfa pests. In a fall 2000 survey of western states, thrips were listed as one of the three top pests of alfalfa in Nevada and Washington (Putnam et al., 2000). Here, I discuss the situation regarding thrips in California alfalfa and review thrips recommendations from other alfalfa growing states.

Species. Alfalfa supports large thrips populations, particularly in the spring and early summer. The most common species found in California alfalfa is western flower thrips, *Frankiniella occidentalis* (Pergande) (Summers et al. 1981; Summers and Godfrey 2001). Western flower thrips is about 1 mm long, with the female larger than the male. The female varies from yellow to dark brown, and has a more rounded abdomen. The male is always pale yellow and has a narrower abdomen. Onion thrips, *Thrips tabaci* Lindeman, has been most commonly reported on alfalfa in the mid-west. Recently, bean thrips, *Caliothrips fasciatus* (Pergande) [also referred to as *Caliothrips phaseoli* Hood] has been found in the Imperial Valley on seedling alfalfa (Eric Natwick, personal communication). Adult females of onion thrips are about 1.1 to 1.2 mm long, yellow, with brownish blotches on the thorax and the median portion of abdomen. Antennae are gray with the first segment lighter than other segments. Males are rare. Immature bean thrips have orange or red spots at either side on the end of their abdomen, while adults are usually dark with white bands on their wings. A fourth species, *Scolothrips sexmaculans* (Pergande), the sixspotted thrips, is a predator of mites, mite eggs and small insects. Adult sixspotted thrips are tiny, brownish, slender insects characterized by three dark spots on each forewing.

Feeding and Injury. Thrips mouthparts form a lacerating-sucking cone and the insects feed by rasping and lacerating the food tissues, usually fruit or leaf epidermis, and then sucking up the resulting juices. On fruit, the rasping causes scarring. Such scarring causes no significant injury, is purely cosmetic and does not affect yield or quality, but the blemish that results usually leads to the fruit being rejected as "less than perfect." Some fruits on which thrips are routinely treated for cosmetic purposes include: avocado, citrus, grapes, nectarine, peach, plum and strawberry. On leaves, the rasping leads to deformed and crinkled leaves resulting from uneven growth around the injury (feeding) site. Such feeding causes the surface of the leaf to become whitened or silvery and somewhat flecked or stippled in appearance. Feeding, particularly near the leaf mid-rib, causes curling and distortion of the leaves; they often have a cuplike or puckered appearance.

Thrips in Alfalfa. While there are no data available on possible yield reduction from thrips feeding in alfalfa, the University of California has long advocated that thrips not be treated. A number of convincing arguments can be made for not applying chemical controls. In one of the few studies on thrips control in alfalfa, Rethwisch et al. (2002) evaluated 15 materials/rates and found that populations of adult thrips in treated plots did not differ for those in the untreated control four days after spraying. Plots treated with chlorpyrifos and a low rate of λ-cyhalothrin had thrips populations significantly higher than those in the untreated control. Likewise, the number of immature thrips rebounded to pre-treatment levels in most treatments after only four days. Higher numbers of immature thrips were noted in all pyrethroid treatments than in the untreated check at four and seven days post treatment. These data suggest that thrips are very difficult to control and maintaining low populations by chemical means could likely require repeated applications. Any chemical sprays in late winter-spring risk serious damage to predator and parasitoid populations in alfalfa (Summers and Cothran 1972; Summers et al. 1975; Summers 1998). These parasitoids and predators are important in aphid management and later in the season for control of lepidoptera larvae. Also, thrips serve as an important food source for predatory insects including minute pirate bug (*Orius* spp.), big-eyed bugs (*Geocoris* spp.), and lacewing larvae (*Chrysoperla* spp.). They are particularly important prey early in the season.

State Recommendations for Thrips Control in the United States. Only four states, Colorado, Georgia, Nebraska and Idaho, have specific recommendations for thrips control in alfalfa (Table 1). No state, not even those recommending treatment, has an established economic threshold for thrips. Of the four states recommending treatment of forage alfalfa, Colorado and Nebraska's recommendations are for onion thrips, not western flower thrips, Idaho's recommendations are for seed alfalfa, not forage alfalfa, and Georgia does not specify a thrips species (seed is not grown in Georgia so it can be assumed that the recommendation is for forage alfalfa).

Table 1. State recommendations for thrips control in alfalfa as of 2001.

State	Control Recommended		Comments	Economic Threshold Available	
	Yes	No		Yes	No
Alabama		x			x
California		x			x
Colorado	x		Onion thrips on regrowth		x
Georgia	x		If leaves are distorted or discolored		x
Idaho	x		On seed alfalfa only		x
Illinois		x			x
Iowa		x			x
Indiana		x			x
Kansas		x			x
Kentucky		x			x
Missouri		x			x
Minnesota		x			x
Montana[1]	—	—			x
Nebraska	x		Onion thrips on regrowth		x
New Mexico		x			x
New York		x			x
Nevada		—	Listed as a pest, but no recommendation given		x
Ohio		x			x
Oklahoma		x			x
Oregon		x			x
Pennsylvania		x			x
South Carolina		x			x
Texas		x			x
Utah		x			x
Vermont		x			x
Washington		—	Listed as a pest, but no recommendation given		x
Wyoming		x			x

[1] Listed in states recommendations, but not referred to as a pest or a non-pest and no specific recommendation given.

Possible Exceptions That May Require Treating Thrips. As with most situations, "one size does not fit all." Possible exceptions to the "do not treat thrips" recommendation could include the following: 1) very high populations of bean thrips and/or onion thrips. These species are relative newcomers to alfalfa and are considerably more destructive than flower thrips; 2) bean thrips on seedling stands, particularly in the southern deserts. Again, this is a relatively new association and may require additional studies to eliminate it as a pest under the defined conditions; 3) dry land alfalfa that may be considerably more susceptible to thrips injury than irrigated alfalfa.

Summary

There is no evidence that thrips, particularly western flower thrips, causes either yield or quality losses in California forage alfalfa. The cost of treatments, materials, and application costs far outweigh any benefits. In addition, disruption to natural enemy populations and the potential for outbreaks of other pests must be taken into account. The recent arrival of bean thrips on seedling alfalfa in the Imperial Valley needs additional investigation to determine its pest status.

Given that thrips cause no reduction in quality, and likely have no impact on taste, it is evident that "the bovines don't care." Add to this the fact that alfalfa yields are not impacted, and the grower should not care either.

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ABSTRACT

WESTERN ORCHARD PEST AND DISEASE MANAGEMENT CONFERENCE, JANUARY 9-11, PORTLAND, OR

Laboratory Study of the Effects of Volck Oil on San Jose Scale Stages, *Elizabeth E. Grafton-Cardwell and Yuling Ouyang, Department of Entomology, University of California, Riverside, and U.C. Kearney Agricultural Center*

Plum twigs infested with various stages of San Jose scale were either dipped or sprayed with concentrations of Volck oil ranging from 1-6%. The survival of 1st instar, 2nd instar, 3rd instar scale and the fecundity of females were evaluated after 8 days. Dipping scales in 1, 2, 4, or 6% oil killed all stages equally well. When oil was sprayed on the twigs, concentrations of 4 and 6% oil were significantly better in killing scale and reducing fecundity of females than 1 or 2% oil. First and 2nd instar scales were easier to kill with oil than older instars. These results confirm that greater coverage and a higher percentage of oil are needed to effectively control San Jose scale. When organophosphates were added to the dormant application for San Jose scale, California stone fruit growers reduced water volume and the concentration of oil in the mix. As organophosphate resistance builds and growers return to treatments of oil alone, they need to return to higher volumes of water and maintain the oil concentration at high level.

Photo by Jack Kelly Clark

Figure 1. Adult Western Flower Thrips. Credit UCIPM Pest Management Guidelines for Alfalfa Hay.

Credit New York State Agricultural Experiment Station at Cornell University for Photo

Figure 2. Adult Onion Thrips. Credit Li, Y., W. T. Wilsey, C. R. Weeden and A. M. Shelton. [eds.]. Pests of the Northeastern United States. http://www.nysaes.cornell.edu/ent/factsheets/pests/ot.html

Photo by Jack Kelly Clark.

Figure 3. Adult Bean Thrips. Credit UCIPM Pest Management Guidelines for Cotton.

Photo by Jack Kelly Clark.

Figure 4. Adult Sixspotted Thrips. Credit UCIPM Pest Management Guidelines for Alfalfa Hay.

Figure 5. Western Flower Thrips Damage on Alfalfa. Credit UCIPM Pest Management Guidelines for Alfalfa Hay.

Photo Credit: HYPP Zoology--Thrips tabaci—Onion thrips. http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6thrtab.htm

Figure 6. Onion Thrips Damage on Alfalfa. Contrast This to Western Flowers Thrips Damage Shown in Figure 5.