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Managing the Ecosystem for IPM: Effect of Reduced Irrigation Allotments

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Summary: Managing key pests requires managing the environment in which their populations build and move. Understanding the role of cropping landscapes in population development across spatial and temporal scales is critical for increasing bio-intensive IPM practices. The landscape is continually changing and impacting the relationship between crops and insects. Alfalfa plays a key role in absorbing Lygus as they leave fields. Reduced availability of irrigation resources has caused a major shift in cropping patterns. Responses to these irrigation reductions include deficit irrigation of alfalfa, shifting alfalfa from a net sink for Lygus to a net source with respect to cotton. Integration of production and pest management practices is essential to optimize the management of forces driving agriculture.

Introduction
IPM is a system approach that recognizes the value of ecological interactions between organisms across spatial and temporal scales. Unlike permanent trees and vines, field and row crops are ephemeral in their placement in a particular landscape, their presence ebbing and flowing through a year. In permanent crops, insect pest complex tend to develop from within the field borders, while row and field crop pests tend to move from external sources. In addition, row crops generally provide a very short window of opportunity to build insect ecosystems with planting to harvest lasting 60 to 180 days. As one crop is prepared for harvest (including irrigation termination), it become unsuitable as a host for many herbivores, predators and parasites, resulting in a general movement into a more suitable habitat, generally into the neighboring field. If that field is at an ecological equilibrium prior to the movement, it becomes out of balance, due to no fault of the managers, with key pests exceeding threshold and requiring insecticide intervention.

IPM requires wider thinking beyond the individual field boundary. Understanding the influence of the cropping mosaic represented by the sources and sinks of arthropods is paramount to developing large scale, wide area management programs (Goodell, 2009a). The Western Tarnished Plant Bug (Lygus hesperus) referred in this paper as Lygus, is an excellent insect for discussion of IPM at the landscape level. Lygus is a candidate for large scale management. Our work over the past decade has provided excellent guidance in achieving that goal, including three years of intensive area wide sampling as part of a USDA-CSREES RAMP grant.

The Landscape’s Role in Lygus IPM
A key component in a developing a landscape approach is the understanding of the roles crops play as sources and sinks for Lygus (Goodell & Lynn-Patterson, 2005). A source is considered to be a suitable crop for Lygus population development which may (alfalfa seed, black eyed beans, cotton) or may not be (safflower, alfalfa forage, sugar beets, vegetable crops) adversely affected by its presence. The suitability as host for population increase varies with plant/insect interaction (Goodell et al, 2002) When source crops become unsuitable as hosts due to harvest preparation or removal by harvest, movement of Lygus (and other insects) will move into adjoining crops,
seeking shade, water and nutrition. If this movement occurs during a period when the sink or receiving crop is vulnerable, yield loss can be quick and widespread. The distance from which a crop can act as a source varies with the host, but can be nearly one mile for Lygus bugs leaving seed alfalfa (Carriere et al 2006).

However, cropping landscapes change. Crops change in their abundance and distribution which alters the sink/source relationships. Cotton’s role in the landscape has dramatically decreased, challenging the existing IPM approaches in cotton (Goodell, 2009b). One example of this changing landscape can be illustrated with the increased safflower acreage in 2008 in west side Fresno and Kings Counties. Safflower is a major host for Lygus, acting as “bridge” crop between spring and summer. Overwintered Lygus will settle into safflower, reproduce and the population will increase to large numbers. The resulting population will move out of safflower in June when irrigation ceases. Managing Lygus in safflower to prevent movement is critical in protecting neighboring cotton and alfalfa seed.

In 2008, 36,245 acres of safflower were planted within the area being monitored for RAMP in a wide area of West Fresno County. Fields of safflower were dispersed across the landscape intermixed with cotton and other crops with a high degree of cropping interface. Very little of the safflower was managed for Lygus, resulting in multiple insecticide treatments in cotton and substantial yield loss (Adamczyk, 2009; Williams, 2008).

In 2009, nearly the same amount of safflower was planted but in large contiguous clusters. In addition, the Lygus in safflower was well managed and the population prevented from building and moving into adjacent cotton. Few problems were reported in cotton due to Lygus movement, illustrating the value of concentrating sources of Lygus while effectively managing the population within the concentrated area.

Comparing safflower placement between 2008 and 2009 (Figure 1) demonstrates how a landscape can be planned. In 2008 there were 36,245 acres of safflower with a total of 317 miles of field borders. In 2009, 30,573 acres were planted but had only 106 miles of field borders, a reduction of 66% (Figure 2). This equates to only a third of the number of field contacts between safflower and other crops, as compared to 2008. Lygus located in the central fields of this safflower planting were required to travel many miles to reach alternate hosts. Management of Lygus could be focused in the fields directly adjacent to the cotton, potentially reducing the number of insecticide applications required to reduce the Lygus population in the safflower area.

**Alfalfa Forage and Lygus IPM**
Not all crops remain unsuitable after harvest. Alfalfa forage is a unique and important field crop when considering managing Lygus in the landscape. Alfalfa forage is:

- perennial, providing extended habitat over years
- harvested for its vegetative rather than reproductive components
- not stressed prior to harvest by removing irrigation
- a favored host for Lygus
- not adversely affected by the presence of Lygus populations
In the landscape, alfalfa acts as sponge, intercepting Lygus from other crops. When alfalfa habitat is managed, Lygus can be prevented from moving and establishing in cotton. By leaving a sufficient amount of uncut alfalfa during mowing in May and June, a large portion of the Lygus population can be herded into uncut strips (Summers et al 2004; Goodell, 2003). Similarly, if an area has an abundance and good distribution of alfalfa (Figure 3) in which cut and uncut fields are in close proximity, the uncut fields will act as a sink, drawing in Lygus from cut fields (Goodell, 2009b). In areas that have almost no alfalfa fields, Lygus is reported as a frequent problem in cotton. Having alfalfa in a landscape can provide a valuable management tool in mitigating Lygus movement into cotton and some farms have incorporated alfalfa as strategic part of their landscape plan.

Implication of Deficit Irrigation in Alfalfa to Lygus IPM

However, alfalfa can become as problematic as safflower if it is allowed to suffer irrigation stress. If the field is allowed to dry in July, Lygus will be forced out of the field just as if it were seed alfalfa. The alfalfa Lygus sink becomes a major Lygus source for cotton. The use of deficit irrigation on alfalfa as a water saving tactic has a major impact on IPM in the immediate area. Widespread adoption of deficit irrigation could shift the dynamics of the source/sink relations and result in increased risk to crop loss and increased use of insecticides to management Lygus.

When deciding to place an alfalfa field into a deficit irrigation program, consider the field to be a source not a sink with resulting management risk and costs for bordering cotton. This role of alfalfa hay as major contributor to Lygus is a fundamental difference between southwestern desert landscapes and the SJV. In these areas, alfalfa hay is not harvested in mid-summer due to reduced quality and irrigation savings are implemented during this period. Management of the Lygus in the drying alfalfa field must be managed like safflower or alfalfa seed to prevent mass movement into susceptible cotton. Applications of insecticides will accomplish this goal but also destroy the natural enemy complex and disrupting an important ecological service alfalfa plays in the landscape.

When developing landscape level IPM programs, it is essential that communication occur between production and pest management researchers. If a practice changes substantially the dynamics of the system, unintended consequences can occur. Integration between production and pest management is paramount if programs are to remain viable.

Linking water issues with pest management is important. Communication is critical between industry working groups, UC work groups, as are discussions among participants at workshops, extension meetings, and state symposia. If deficit irrigation of alfalfa becomes more widespread, new approaches to Lygus management will be required. For example, an approach similar to strip harvest could be employed by continued irrigation on a limited, but critical number of strips in a field. These reduced acres could still be managed for harvest or simply watered to maintain them as suitable habitat to keep Lygus from moving.

Each producer would need to conduct their own risk-benefit analysis to determine the value such an approach. The calculation of the degree of risk would still need to be conducted in order to truly determine the real cost of the decision. Component costs of allowing alfalfa to dry out in mid-summer might include:
• loss of production alfalfa hay (at expected quality for the period)
• loss of cotton production due to increased Lygus damage
• loss of ecological services provided by natural enemy complex in alfalfa
• increased cost of insecticides to protect cotton
• increased insecticide load in environment

**Conclusion**
Changing major factors within landscape has substantial but unintended consequences. While the changes may be inevitable, the community within that ecological landscape can still develop approaches that mitigate predicted outcomes. This outcome is possible through communication and system integration to develop a new steady state in the landscape that minimizes risk to the environment, maximizes ecological services provided to the community and optimizes profit to the farmer.

**References:**


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Figures

Figure 1. Safflower acreage in Fresno-Kings Counties from 2007 to 2009. Area was mapped as part of USDA-CSREES RAMP study. Note the concentration of acres and minimizing of contact between safflower and bordering crops during the three year time period.
Figure 2. Acres of safflower and total length of field perimeter

Figure 3. Schematic representation of the complexity of the relationship between alfalfa and cotton in a San Joaquin Valley cropping landscape. The best arrangement for Lygus management in cotton is in the upper right portion; the poorest arrangement is in the lower left portion of the diagram. Source: Goodell, 2009b