The Bagrada Bug in the Palo Verde Valley

The bagrada or painted bug, Bagrada hilaris, is a pest of the Cruciferae family which includes cabbage, kale, turnip, cauliflower, mustard, broccoli, radish, etc., and has been found to attack papaya, potato, corn, sorghum, and cotton throughout Eastern and Southern Africa where it is originally from.

In Southern California beginning in 2008, an unidentified stink bug has been collected in lettuce, broccoli, melon and later in alfalfa fields in Riverside and Imperial counties. The unidentified stinkbug was submitted to the USDA insect diagnostics lab where it was confirmed to be Bagrada hilaris. Initially the area of infestation was thought to be small but has expanded southward into Imperial County and La Paz county in Arizona where it can be readily found. It is unknown if the southward expansion of this invasive stinkbug is due to habitat selection or availability of host plants. Most likely it is a combination of both but little is known of the biology of B. hilaris.

Bagrada bugs are members of the Pentatomidae or “stink bug” family. These stink bugs are smaller than average and measure 1/5th – 1/4th inch long. Females are larger than the males and both have distinctive black and orange coloration. Females can lay an average of 50-80 eggs during their lifetime. Eggs are laid individually or in clusters of approximately 2-4 eggs. The eggs are oval in shape and off-white in color developing to an orange color as the eggs age. Development time from egg to adult is ≈ 31-46 d and adults survive ≈28 d. All stages of Bagrada bugs can be found on a plant. Adults and nymphs weaken healthy plants by consuming extracted sap with their piercing sucking mouthparts which leave large stippled or wilted areas on the leaves and often stunt the growth of newly formed central shoots or heads of plants. Bagrada bug populations can build up rapidly, damaging the entire crop. In Africa where this insect comes from originally, the working economic threshold for Bagrada bug is 1 bug/10 ft.² on plants in the early growth stage increasing to 3 bug/10 ft.² on mature plants.
This does not translate well to our cropping systems so new methods of sampling for this particular insect need to be determined. However traditional methods for monitoring stink bugs seems to be working well in the various cropping systems. Chemical management of these insects has been achieved with 4-5 applications of insecticide but chemical resistance has been detected. Research at the UC Desert Research Center indicates that pyrethroids and chlorpyrfos do have activity against bagrada bug adults and nymphs.

The extent to which B. hilaris proves detrimental to agriculture in Southern California is unknown. However, given that its host range incorporates several economically important crops (cotton, melon and broccoli) in Southern California it is indicative that management would be necessary. Chemistries that are effective against stink bugs are limited with federally mandated safety standards, especially considering that resistance could potentially develop. A more integrated approach to pest control that reduces the use of insecticides by incorporating alternative pest control strategies would be beneficial to production of crops like broccoli and melon.
Insect “Hoppers” in alfalfa

Introduction

Alfalfa, Medicago sativa L. has been cultivated in California since it was first introduced from Chile in 1850. Alfalfa was originally “discovered” in Iran and has been cultivated throughout the world. Production of alfalfa hay in California exceeded 950 (x1,000) acres in 2009 which produced 6,650(x1,000) tons with an estimated value of 1,383,200 (x1,000) dollars. Given that California is an alfalfa “poor” state and must import alfalfa to supplement the states production needs makes it critical that alfalfa hay production be maintained or increased.

Several insects can reduce alfalfa yields such as the potato leafhopper (PLH) which is highly polyphagous and capable of successful reproduction on over 200 plant species in 25 different families. Potato leafhoppers found in California grown alfalfa are actually made up of a complex of insects that include the Potato leafhopper, Empoasca fabae, the Garden leafhopper, Empoasca Solana, and the Mexican leafhopper, Empoasca mexera. Potato leafhoppers are a severe pest of alfalfa in the eastern half of the USA and portions of Canada. Potato leafhopper infestations in California are considered mild but severe infestations requiring management have occurred as recently as 2009. Feeding by PLH in alfalfa reduces stem length and mass, increases leaf/stem ratio, and decreases morphological stage of development. Other alfalfa hoppers that can be of concern are the Threecornered alfalfa tree hopper, Spissistilus festinus Say which can be found throughout the year in California alfalfa.

Biology

Potato leaf hopper

The leafhoppers that make up the PLH complex all have a similar appearance being small (3.2 mm long) with bright green wedge-shaped bodies. Nymphs (immatures) also have green wedge-shaped bodies and run rapidly when disturbed. They may run forward, backward, or from side to side. Their unique movement
plus their bright color and shape distinguishes them from *Lygus* bug nymphs and other slower moving insects like aphids. Other green leafhoppers may be present in alfalfa, but they are much larger in size.

Potato leafhoppers are migratory insects which overwinter in the southern US between southern Louisiana and northern Florida. Potato leafhoppers make their annual northward migration into the US each spring along with the wind corridor and eventually infest an area in the US from the Atlantic coast to the Rocky Mountains. It is unknown if any PLH actually return from the northern US to the southern gulf states during the fall. The long-distance migrants are predominantly female with a sex ratio of 25 females to 1 male when first found in an alfalfa field and most of the females are gravid and able to initiate a new generation once they arrive to the new location. In California, PLH have 3-4 generations a year that occurs in May – September and can survive on a wide host range of >200 cultivated and wild plants which include fruit trees, forage crops, and vegetables. The average reproductive life is 30-35 days for females and 33 days for males. Female PLH are capable of laying 2-3 eggs daily which they insert into the alfalfa stem, petioles and leaf blades soon after mating. Eggs hatch in 7-10 d producing wingless nymphs which go through 5 molts and are fully mature in ≈ 14 d (≈ 826 DD).

**Damage**

Adults and nymphal PLH extract plant sap from the undersides of leaves using their stylet mouthparts to pierce the leaf surface when feeding. During feeding, the insect is simultaneously injecting saliva which carries toxic substances into the plant. These toxic substances in turn cause phloem blockage within the plant. It seems likely that both introduction of saliva during PLH feeding and mechanical wounding by stylet movement causes the wound response associated with vascular blockage. The result of the plant being unable to translocate materials causes portions of the plant above the point of blockage to die. The physiological response of alfalfa plants is very characteristic and referred to as “hopperburn”. It was not until 1927 that the connection between alfalfa yellowing (hopperburn) and the potato leafhopper was experimentally demonstrated. Alfalfa plants suffering from hopperburn exhibit overall stunting and veins of infected leaves will turn white with a characteristic “V” shaped chlorosis. As leaves
desiccate, they become limp and eventually turn necrotic and drop off. Potato leafhopper damage in alfalfa cumulates in reduced yields, reduced quality (especially lower protein content) and contributes to reduced stand longevity. Susceptibility of alfalfa to yield and quality reductions declines as stems mature. Yield reduction can extend into the next cutting cycle even in the absence of PLH if the phloem blockage in plant stems remains intact after harvest. Drought stress and/or Boron deficiency are similar in appearance and sometimes can be confused with hopperburn.

Management of Potato Leafhopper in Alfalfa

There are two strategies to manage PLH infestations that are not mutually exclusive from one another. The first is application of an effective insecticide to reduce PLH populations below the economic threshold for alfalfa. Economic thresholds for PLH vary slightly from state to state depending on the plant height of the alfalfa and production goals. The general consensus (Table 1) for management of PLH is that tolerance for PLH should be increased as the alfalfa crop grows. This is due to greater production loss that can occur in early alfalfa growth from stunting due to PLH induced phloem blockage (see above) compared to mature growth. A combination of alfalfa plant height, insecticide application costs/Acre, and alfalfa value/Ton is used by some states to determine PLH economic thresholds but has not been evaluated in California.

Table 1. Selected state comparison of the economic threshold for potato leafhopper in forage alfalfa by plant height.

<table>
<thead>
<tr>
<th>Provider</th>
<th>Average number of PLH in alfalfa (plant height/inches)</th>
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<tbody>
<tr>
<td></td>
<td>3</td>
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<tr>
<td>Oklahoma</td>
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<td>Iowa</td>
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<td>Missouri</td>
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<td>Illinois</td>
<td>0.2</td>
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<tr>
<td>Ohio</td>
<td>3</td>
</tr>
</tbody>
</table>

Management strategies depend on regular sampling of alfalfa fields to determine PLH densities. Sampling for PLH in alfalfa can be achieved with a standard 15-inch diameter sweep net using “sweeps” from right to left in a continuous 180° arc in front of the sampler. The rim of the net should strike the top 6-8 inches of alfalfa plants with the net held slightly less than vertical so the bottom edge strikes the alfalfa before the top edge. This will facilitate getting the insects into the net. Each 180° arc counts as one sweep. A common practice is to take a sweep from right to left, walk a step, and take another sweep, left to right. After taking the desired 10 sweeps, quickly pull the net through the air to force all insects into the bottom of the net bag and grasp the net bag at about the
mid-point to trap the insects in the bottom of the sweep net. Count the insects of interest and divide totals by 10 to get the average number of insects per sweep. Getting a good representation of insect numbers in the alfalfa field requires a minimum of four sweep net sample areas starting from the field margin and working your way across the interior of the field.

Chemical insecticide treatments are often the only choice when population reduction is needed immediately. Appropriate insecticides should be selected to effectively manage PLH, and avoid injuries to field-workers, and non-target organisms (e.g., natural enemies, pollinators, birds and fish). Consider the intended uses, restrictions and expectations carefully before selecting a particular product or formulation. Price alone should not be the deciding factor for which product to purchase. Be sure to rotate insecticides across all available classes and modes of action to slow PLH resistance development. It is important to re-sample fields for PLH after chemical applications have been made to determine the effectiveness of the treatment, especially early in the alfalfa regrowth period.

**Important steps to slow development of insecticide resistance**

- Monitor insect populations and spray only when populations have reached or exceeded the economic threshold
- Maintain vigorous plant growth
- Limit season long selection pressure – spraying for one insect impacts other insects at the same time
- Rotate insecticide chemistry classes and/or modes of action
- Use appropriate application rates
- Use all available tactics to manage insect populations, ie, biological, cultural, and chemical (Goodell et al. 2001)

Use of early harvests can reduce PLH populations if alfalfa stands have more than 60% of the buds flowering, consider a early harvest in the next 7 days to avoid spraying. In this situation, the field should be resampled soon after harvest to determine the need for control. If the field cannot be harvested in 7 days and economic population levels are present, apply a short residual insecticide. If the alfalfa has experienced “hopper burn”, significant yield loss has already occurred and the field should be cut instead of sprayed.

Three-cornered alfalfa tree hopper

The three-cornered alfalfa tree hopper (TCAH) is a member of a group of insects often called treehoppers because they actively hop and fly when disturbed. Unlike the PLH, the TCAH is found in California year-round and is an occasional late summer and fall pest of alfalfa in the desert areas of Southern California and in Arizona. Considerable work has been done on TCAH as an economic pest of soybeans but little has been done since this insect was first identified as a pest in forage alfalfa.

Biology

Three-cornered alfalfa hoppers adults are green, ≈ 6.4 mm long, and are taller than wide due to an expanded segment (prothorax) behind the head that extends over the abdomen. Nymphs are also green and wingless, lacking the enlarged prothorax. Each segment of the body is adorned with a pair of large filaments or "saw-tooth" spines. Adults are strong fliers and can migrate over long distances. Nymphs are wingless and are confined to the lower part of plant stems and remain protected by the dense upper canopy of the alfalfa plant. The TCAH has a wide host range, and is able to feed and reproduce on a variety of crops. Both adults and nymphs insert their mouth parts into the alfalfa plant to extract plant sap. Female TCAH will deposit a majority of eggs into the alfalfa plant near the soil line in clusters averaging 6.20 (±4.51) and can lay as many as 100 eggs in an alfalfa field over several weeks. Eggs hatch in ≈58 d between 16.1 and 18.3°C. The TCAH usually overwinter as adults, but some eggs may also survive. There are 3-4 generations per year in southern California. The hopper population often starts building to its highest level during July, August, and September. The insect may remain abundant in October and November until the onset of cooler weather reduces the population.
Damage

Mechanical wounding during feeding by TCAH, and/or ovipositing by adult females causes girdling of stems and sometimes the leaf petioles which appears as a characteristic circular ring of necrotic tissue. Stem girdling retards plant growth by interfering with the plant's ability to translocate materials to portions of the plant above the point of girdling. Girdled stems are weakened and prone to breakage or lodging. Once alfalfa has lodged it becomes difficult to harvest and lodged areas that remain in the field can harbor greater hopper populations compared to stubble alfalfa. The reduction of translocated water and nutrients to the leaves above the girdle reduces chlorophyll production. Anthocyanins become the dominant pigment in the leaf resulting in the leaves turning a reddish-purple color. If TCAH populations remain untreated (10-12 adults/180° sweep) they can significantly reduce alfalfa hay yield and quality.

Management of three-cornered alfalfa tree hopper in Alfalfa

Overwintering TCAH adults and newly hatched nymphs can be found in weedy margins (i.e. vetch) of alfalfa fields in the early spring. Destroying these areas will reduce TCAH populations that later migrate into alfalfa fields. Although the economic injury level for TCAH in alfalfa has yet to be determined, monitoring of populations in the field is important. Sweep net sampling is useful for monitoring PLH populations (see above) but would only capture TCAH adults since a majority of the TCAH nymphs remain low on the alfalfa plant in the crown. Sweep net sampling is the recommended method for quantifying TCAH adults. The use of ground cloth sampling or beet net sampling is best if you want to quantify both TCAH adults and nymphs. Once a control action is justified then appropriate insecticides should be selected to effectively manage TCAH, and avoid injuries to field-workers, and non-target organisms (e.g., natural enemies, pollinators, birds and fish). Timing of insecticidal sprays for management of this insect is critical. Early spring alfalfa stubble applications of insecticide made after the first cutting has been shown as a viable option to manage TCAH populations long term. Biological control of TCAH does occur in alfalfa and is generally limited to the first 3 nymphal instars which remain inactive lower on the alfalfa plants. Adult TCAH escape predation for the most part due to their activity and heavy sclerotization which nymphs lack.
Immature Insect Key

Note: This key includes only the immature insect species that are most commonly found in alfalfa in California.

Use this key to identify an immature insect. The various stages of immature insects found in California alfalfa may be difficult to identify due to similar appearance and can be easily confused with other insects. Not all of the immature insect species found in alfalfa are agricultural pests. External morphological features are used here to identify individuals to the correct insect order and/or family.

The provided drawings are enlargements of typical immature insects that can be found in alfalfa showing a number of morphological features important for proper identification.

Lepidoptera (butterflies & Moths) larva

Diptera (flower flies) larva

Coleoptera (beetles) larva
1. Look at the immature insect with a 10x hand lens to see the important characters that distinguish the immature insects included in this key.
2. On each page of the key, follow the arrow that best matches the character of the immature insect you’re trying to identify.

The general dichotomous key below will help you in identifying which major insect group your immature larvae may belong to.

![Key to Larvae Diagram]

Key to Larvae

Head Capsule

- Has head capsule
- No head capsule

Diptera

Prolegs present

Lepidoptera

Prolegs absent

Coleoptera

![Diptera Image]

![Lepidoptera Image]

![Coleoptera Image]
Begin Detailed Key

Follow the description that best describes the immature insect.

Does the body have a hardened head capsule?

Yes

No

Go to page 6

Does the body have prolegs on abdomen and anal region?

Yes

Body possesses prolegs

Based on the key characteristics, the immature insect is likely to belong to the lepidoptera

Yes

Body does not possess prolegs

No

Go to page 4
From page 3 "Body does not possess prolegs"

Does the body have thoracic legs near the head?

Yes

No

Go to page 6

Does the head have large "sickle" shaped mouthparts?

Yes

No

Go to page 5

Go to page 5
Based on the key characteristics, the immature insect is likely to belong to the coleoptera. Ladybird beetle

Note: Ladybird beetles and their larvae are important predators of aphids, mealybugs, scale insects and spider mites. Larvae are \( \approx \) one centimeter long and are often referred to as “aphid alligators”. They are often black or bluish and spotted or banded with bright colors.
From page 3 “Does the body have a hardened head capsule?”

&

From page 4 “Does the body have thoracic legs near the head?”

Does the body possesses a hardened head capsule and is legless?

Yes

Body possesses a head and possesses no legs (legless)

No

Body possesses no visible head and possesses no legs (legless)

Based on the key characteristics, the immature insect is likely to belong to the Coleoptera. Alfalfa or Egyptian alfalfa weevil

Note: The alfalfa and Egyptian alfalfa weevil are identical-looking weevils infesting alfalfa in California. They are distinguished by their biology and distribution in the state. The alfalfa weevil is an annual pest in alfalfa districts east of the Sierra Nevada mountains and in the northernmost counties of California. In most other areas of California, it has been displaced by the Egyptian alfalfa weevil, which is a far more serious pest in California.

Based on the key characteristics, the immature insect is likely to belong to the Diptera. Flower fly

Note: About 950 species of flower flies in North America with many species predacious on aphids. There are 9 species of flower flies that are common in California. Predation by flower fly larvae can decimate small aphid colonies in a matter of days.