Arthropod pest management during and at the end of strawberry production season

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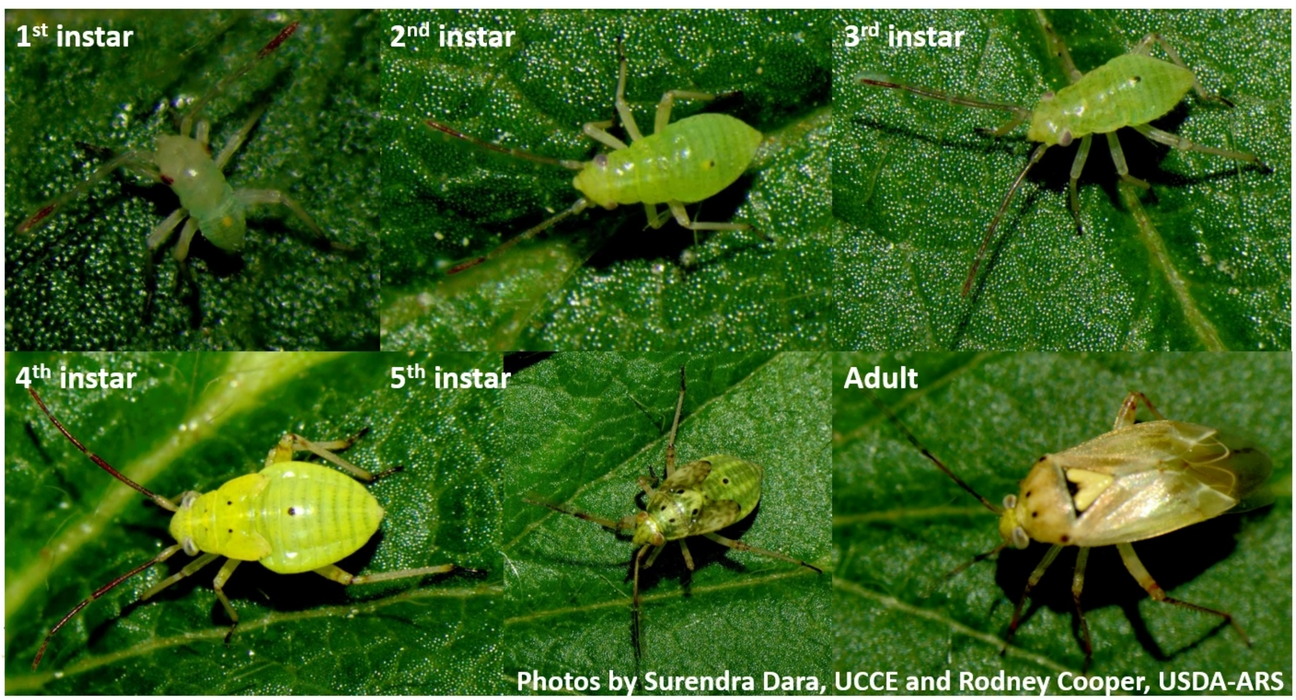
Lygus bug or the western tarnished plant bug, *Lygus hesperus* is a major pest of strawberries in California (Zalom et al. 2014). Lygus bug has a wide host range that includes more than 100 species of cultivated crops and wild host plants (Scott, 1977; Fye, 1980 and 1982; Mueller et al., 2005) that include cultivated crops such as alfalfa, broccoli, celery, cauliflower, grapes, strawberries, and tomatoes on the California Central Coast. Additionally, ornamental and vegetable crops in greenhouses or home gardens along with weedy hosts from Chenopodiacae, Compositae, and Cruciferae in vast uncultivated landscapes offer a continuous food supply for lygus bug throughout the year. Warmer and dryer conditions as experienced in the recent years can also contribute to increased lygus bug problems. Milder winters fail to bring down overwintering populations and drought conditions dry out wild hosts early in spring forcing lygus bugs to migrate to cultivated crops. Under these circumstances, timely monitoring and implementation of appropriate management practices is necessary to limit damage and spread of lygus bugs to other crops. Vegetable crops such as celery are reported to have an increased risk of lygus bug damage in recent years (Dara, 2015a).

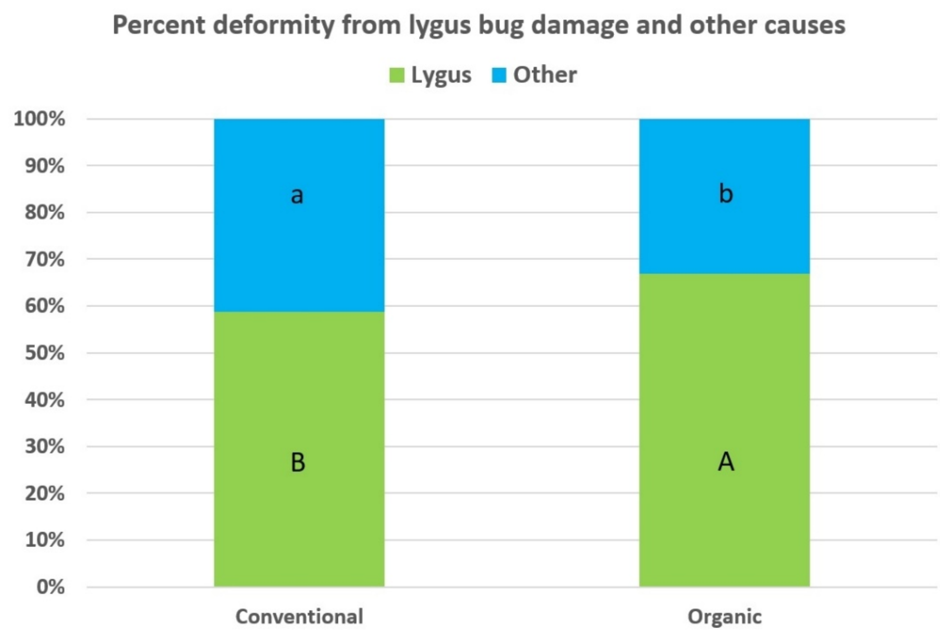


Damage

Lygus bugs primarily feed on inflorescence and developing seeds. They can also feed on foliage by sucking plant sap, but seeds which are rich in protein and lipids are important for the reproductive success of lygus bugs. Depending on the crop and crop stage, lygus damage can result in bud and flower loss, blemishes on seeds, necrotic spots on stems, or deformity of the fruit. In strawberries, fruit deformity caused by lygus bug renders fresh berries unmarketable. However, nearly 1/3 of the fruit deformity in strawberries is caused by factors other than lygus bug (Dara, 2015b). Regularly monitor the fields and make treatment decisions based on lygus numbers. Fruit deformity can also be caused by temperature extremities, poor pollination, genetic, and other factors.

Fruit deformity to due lygus bug damage

Deformity due to poor pollination, genetic, environmental, and other factors



Lygus-related deformity was 59% in conventional and 67% in organic strawberries

Management

Lygus bugs typically move into strawberry or other cultivated crops from weedy hosts in the wild habitats in April. However, seasonal weather conditions can alter these typical patterns. In a typical fall planting of strawberries, three generations of lygus bugs can be seen. But summer-plantings, extended season for fall-plantings, or early planting of fall strawberries make the crop available almost throughout the year. Improper management of lygus or any pest can lead to increased problems in crops where the pest is not usually a problem.

While UC IPM guidelines provide details of lygus bug management in strawberries and celery, here are some important points for managing lygus bug in strawberries during and at the end of the fruit production season:

Biological control:

- Several species of predatory and parasitic arthropods provide natural control of lygus bug. Big-eyed bug (*Geocoris* spp.), damsel bug (*Nabis* spp.), minute pirate bug (*Orius tristicolor*), and multiple species of spiders are among the predacious arthropods. Parasitic wasps that attach eggs (*Anaphes iole*) and nymphs (*Peristenus relictus*) are commonly found in strawberries. Conserving natural enemies by providing flowering hosts as refuges and selecting chemicals that are less harmful can contribute to biological control.

Egg parasitoid, *Anaphes iole*

Nymphal parasitoid, *Peristenus stygicus*

Lygus adult killed by *Beauveria bassiana*

Minute pirate bug, big-eyed bug, assassin bug, and spider (UC IPM)

Cultural control:

- Manage weeds near and around strawberry fields that serve as sources of lygus bug infestations.
- Some studies suggest growing strips of alfalfa or flowering hosts that attract lygus bugs and managing them with pesticides or vacuuming. This practice requires close monitoring to prevent dispersal of lygus bugs to strawberries.

Chemical control and biopesticides:

- A variety of chemicals that belong to different mode of action groups are registered for lygus bug in strawberries. Select appropriate label rates to obtain desired control. Using surfactants and proper application techniques can improve control efficacy.
- Rotate chemicals from different mode of action groups to reduce the risk of resistance development.
- Use appropriate materials for appropriate life stages of the pest. For example, an insect growth regulator like novaluron (Rimon) is effective against nymphal stages. To control a mixed population of nymphs and adults, novaluron can be used with other insecticides. Botanical insect growth regulator like azadirachtin (e.g., AzaGuard, Debug Turbo, Molt-X, and Neemix), which also has insecticidal properties, can be used with chemical pesticides. Microbial pesticides based on insect pathogenic fungi such as *Beauveria bassiana* (BotaniGard), *Isaria fumosorosea* (Pfr-97), and *Metarhizium brunneum* (Met52) in combination with azadirachtin or chemical pesticides can also be used as a part of the lygus IPM program.

Mechanical control:

- Bug vacuums can help remove lygus bugs from strawberry plants. They are typically run twice a week at a speed of 2 mph. Improved design and increased number of passes each time can enhance the control efficacy. Vacuums may not be effective in removing all life stages of lygus bugs and may also remove beneficial arthropods.

Control specific to end of the season:

- Do not neglect managing lygus until the end of the fruit production. Negligence can lead to the spread of the pest to neighboring fields requiring aggressive management practices. Such a situation that demands additional pesticide applications can lead to insecticide resistance in the long run.
- Some growers indicated that sulfuric acid applied as soil amendment at the end of the season helped in controlling lygus bugs. This practice is, however, not recommended for lygus management.

IPM strategies:

Several IPM studies in the Santa Maria area with a focus on lygus bug management provide information on effective chemical and non-chemical options. Check http://ucanr.edu/strawberries-vegetables for details.

Highlights of 2015 study:

This study was conducted at Sundance Berry Farms in 2015 using 12 treatments that contained botanical, chemical, mechanical, and microbial control options. Treatments were administered on 26 August, 2 and 9 September, 2015 using a tractor-mounted sprayer. A spray volume of 100 gpa was used for pesticide treatments. Each treatment had six 75' long (4 row) beds and four replications distributed in a randomized complete block design. Before the first treatment and 6 days after each treatment, 20 random plants from the middle two beds in each plant were sampled for insect pests and beneficial arthropods. Number of young and old nymphs, and adult lygus bugs, thrips, adult whiteflies, big-eyed bugs, minute pirate bugs, lace wings, damsel bugs, ladybeetles, parasitic wasps, predatory thrips, predatory midge larvae, and spiders were counted from each sample plant. Data were subjected to ANOVA and significant means were separated using Tukey's HSD test.

Chemical pesticides: Pyrethrins (formulations proprietary and Brigade, IRAC mode of action group 3A – sodium channel modulators), neonicotinoids [(formulation Assail 70 WP, IRAC group 4A), sulfoximines (formulation Sequoia, IRAC group 4C), and butenolides (formulation Sivanto, IRAC group 4D) – all of them are nocotinic acetylcholine receptor competitive modulators], flonicamid (formulation Beleaf 50 SG, IRAC group 9C – modulators of chordotonal organs), and benzoylureas (formulation Rimon 0.83 EC, IRAC group 15 – inhibitors of chitin biosynthesis).

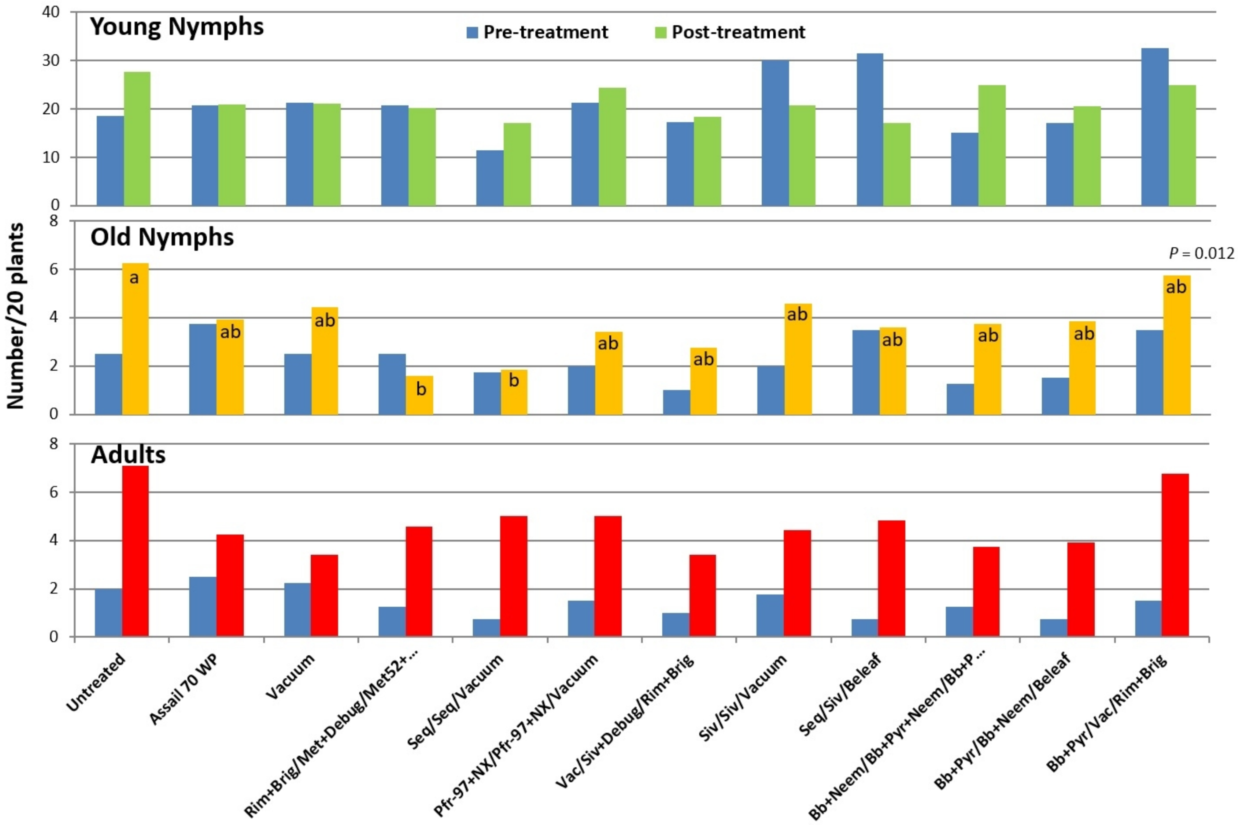
Botanical pesticide: Azadirachtin (formulations cold pressed neem, Neemix, AzaGuard, and Debug Turbo), which is an insecticide, insect growth regulator, antifeedant, and a repellent. Three new formulations of the entomopathogenic fungus, *Beauveria bassiana* used in this study included cold pressed neem (at 37.5 or 75 ppm) and/or natural pyrethrum (0.5 or 0.75%).

Entomopathogenic fungi: *Beauveria bassiana* (XPECTRO – *B. bassiana* + pyretrum 0.75%; XPULSE – *B. bassiana* + cold pressed neem 75 ppm; and XCEDE – *B. bassiana* + cold pressed neem 37.5 ppm + pyrethrum 0.5%), *Isaria fumosorosea* (Pfr-97), and *Metarhizium brunneum* (Met 52 EC)

Mechanical: Vacuuming twice a week at one pass each time at 2 mph.

	1st application (Rate/acre)	2nd application (Rate/acre)	3rd application (Rate/acre)
1	Untreated	Untreated	Untreated
2	Assail 70 WP (3 oz) **4A***	Assail 70 WP (3 oz) **4A**	Assail 70 WP (3 oz) **4A**
3	Vacuum	Vacuum	Vacuum
4	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**	Met52 EC(16 fl oz) + Debug Turbo (104 fl oz)	Met52 EC (16 fl oz) + AzaGuard (16 fl oz)
5	Sequoia (4.5 oz) **4C**	Sequoia (4.5 oz) **4C**	Vacuum
6	Pfr-97 (2 lb) + Neemix (9 fl oz)	Pfr-97 (2 lb) + Neemix (9 fl oz)	Vacuum
7	Vacuum	Sivanto (14 fl oz) **4D** + Debug Turbo (104 fl oz)	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**
8	Sivanto (14 fl oz) **4D**	Sivanto (14 fl oz) **4D**	Vacuum
9	Sequoia (4.5 oz) **4C**	Sivanto (14 fl oz) **4D**	Beleaf 50 SG (2.8 oz) **9C**
10	*B. bassiana*+neem (1qrt)	*B. bassiana*+pyrethrum **3A**+neem (1qrt)	*B. bassiana*+pyrethrum **3A** (1qrt)
11	*B. bassiana*+pyrethrum **3A** (1qrt)	*B. bassiana*+neem (1qrt)	Beleaf 50 SG (2.8 oz) **9C**
12	*B. bassiana*+pyrethrum **3A** (1qrt)	Vacuum	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**

*IRAC mode of action group



Lygus numbers before and after treatments (above) and percent change after 3 treatments (below)

Rank	% Change	I Spray	II Spray	III Spray
I	-28.9	Sequoia (4.5 oz) **4C***	Sivanto (14 fl oz) **4D**	Beleaf 50 SG (2.8 oz) **9C**
II	-12.1	Sivanto (14 fl oz) **4D**	Sivanto (14 fl oz) **4D**	Vacuum
III	0.0	*B. bassiana*+pyrethrum **3A** (1qrt)	Vacuum	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**
IV	7.8	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**	Met52 EC(16 fl oz) + Debug Turbo (104 fl oz)	Met52 EC (16 fl oz) + AzaGuard (16 fl oz)
V	8.0	Assail 70 WP (3 oz) **4A**	Assail 70 WP (3 oz) **4A**	Assail 70 WP (3 oz) **4A**
VI	11.5	Vacuum	Vacuum	Vacuum
VII	27.3	Vacuum	Sivanto (14 fl oz) **4D** + Debug Turbo (104 fl oz)	Rimon 0.83 EC (12 fl oz) **15** + Brigade (16 oz) **3A**
VIII	32.7	Pfr-97 (2 lb) + Neemix (9 fl oz)	Pfr-97 (2 lb) + Neemix (9 fl oz)	Vacuum
IX	46.8	*B. bassiana*+pyrethrum **3A** (1qrt)	*B. bassiana*+neem (1qrt)	Beleaf 50 SG (2.8 oz) **9C**
X	70.8	Sequoia (4.5 oz) **4C**	Sequoia (4.5 oz) **4C**	Vacuum
XI	78.3	Untreated	Untreated	Untreated
XII	85.7	*B. bassiana*+neem (1qrt)	*B. bassiana*+pyrethrum **3A** +neem (1qrt)	*B. bassiana*+pyrethrum **3A** (1qrt)

*Mode of action group

Efficacy of individual products or vacuuming:

The table below shows the number of times each treatment was used in the study and the percent change in nymphs and adult lygus bugs. While some products are effective in reducing lygus populations, care should be taken to avoid overuse. Choosing a variety of options and using them in combinations and rotations is important for a good IPM strategy.

Treatment/Vacuum	Number times administered	Mean % Change Compared to the Previous Counts				
		1–3 Nymphs	4–5 Nymphs	Adults	All Nymphs	All Stages
Untreated	3	23.85	46.66	90.93	25.49	31.95
Assail 70 WP	3	-1.04	-4.97	71.17	-2.35	3.00
Vacuum	8	27.43	16.07	61.93	21.08	23.98
Rimon + Brigade	3	-26.92	-34.92	74.05	-29.18	-18.83
Sequoia	3	-15.03	26.46	163.25	-10.43	-2.83
Sivanto	3	11.90	53.94	158.87	11.44	24.11
Beleaf	2	-34.04	-66.82	-24.09	-39.92	-37.20
Pfr-97 + Neemix	2	-0.36	55.59	129.76	2.69	11.13
B. bassiana + Neem	2	32.37	136.67	147.14	41.73	48.81
B. bassiana + Pyrethrum	3	12.76	65.00	133.33	15.25	21.59
Met52 + Debug Turbo	1	14.04	-50.00	133.33	4.48	19.74
Met52 + AzaGuard	1	86.15	-20.00	19.05	78.57	64.84
Sivanto + Debug Turbo	1	-10.71	0.00	0.00	-9.28	-8.41
B. bassiana + Pyrethrum + Neem	1	9.09	25.00	33.33	11.54	13.27

Efficacy of treatments on western flower thrips and greenhouse whitefly populations

Treatment	Western Flower Thrips						Greenhouse Whiteflies					
	Pre-treat.	Post I Treat.	Post II Treat.	Post III Treat.	Post-treat. Avg.	% Change	Pre-treat.	Post I Treat.	Post II Treat.	Post III Treat.	Post-treat. Avg.	% Change
1	7.00	15.75	13.25	12.25	13.75	96.43	0.25	1.00	0.25	1.75	1.00	300.00
2	9.00	21.00	13.25	13.50	15.92	76.85	0.25	0.25	1.25	0.50	0.67	166.67
3	4.75	20.50	15.50	15.75	17.25	263.16	0.75	1.25	0.75	0.75	0.92	22.22
4	18.25	12.25	8.25	11.50	10.67	-41.55	0.50	0.25	0.25	0.50	0.33	-33.33
5	5.50	17.75	14.75	18.25	16.92	207.58	0.00	0.25	0.00	0.50	0.25	-
6	13.25	18.50	15.25	13.50	15.75	18.87	0.00	1.00	0.25	1.00	0.75	-
7	5.50	14.25	11.75	6.25	10.75	95.45	0.75	0.00	0.00	0.00	0.00	-100.00
8	9.75	12.50	11.75	10.50	11.58	18.80	0.25	0.00	0.00	0.25	0.08	-66.67
9	7.25	14.50	13.75	16.75	15.00	106.90	0.25	1.00	0.00	0.25	0.42	66.67
10	16.50	16.50	10.25	11.75	12.83	-22.22	0.25	1.25	0.00	0.25	0.50	100.00
11	6.00	17.00	8.75	10.25	12.00	100.00	0.00	1.25	0.50	0.75	0.83	-
12	9.75	18.00	9.00	14.50	13.83	41.88	0.00	0.25	0.00	1.00	0.42	-

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