CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
SPECIALTY CROP BLOCK GRANT PROGRAM
PROGRESS REPORT

PROJECT INFORMATION				
USDA PROJECT NUMBER:	59			
RECIPIENT ORGANIZATION NAME:	California Department of Food and Agriculture			
PROJECT TITLE:	Biological Control of Brown Marmorated Strink Bug, Halyomorphpa Halys (Pentatomidae)			
CDFA GRANT NUMBER:	SCB16059			
RECIPIENT'S PROJECT CONTACT				
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PROJECT REPORT				
ANNUAL REPORT TYPE:	2nd Annual Report			
REPORTING PERIOD:	**START DATE:**	10/1/17	**END DATE:**	9/30/18

ACCOMPLISHMENTS

OCTOBER 2017 – MARCH 2018

The estimated total percentage of work completed on this project …….. 60%

#	Objective	Activity and Accomplishment
1	Objective 1: Complete host specificity testing for *T. japonicus*, a novel, two millimeters in length parasitoid from China that attacks the eggs of Brown Marmorated Stink Bug (BMSB).	Host testing was completed and was reported on in previous reports.
2	Objective 2: Survey California for egg parasitoids attacking BMSB	Northern California: Although the BMSB average trap catch dropped slightly in northern California over the last 3 years, from 0.77 per trap per date in 2016 to 0.24 in 2017, its population statewide continued to expand. BMSB has been found to be established in 15 counties, up from 10 reported in fall of 2016. In northern California, a total of 513 sentinel egg cards were placed in the field. In most locations the team attached cards to both the tree trunk and one of its leaves. Egg parasitism averaged 3.5 percent for cards on tree trunks and 13 percent when placed on a leaf. BMSB were far more likely to lay their eggs on leaves than the bark of the tree, and these parasitoids appeared to search leaves far more readily

#	Objective	Activity and Accomplishment
		than the trunks of trees. The target parasitoid *Trissolcus japonicus* was never found to attack these eggs. In addition to inland locations with known BMSB populations, cards were placed on the northern California border shared with Oregon. *Trissolcus japonicus* was actively released and established in the southern part of Oregon. The sentinel cards were also deployed in the San Jose area, an area with a high BMSB population and near areas of high commerce where BMSB eggs originating from China (and parasitoids) were more likely to be present. The native parasitoids emerging from sentinel egg cards were two species of chalcids, *Anastatus* sp. and *Ooencyrtus*, and three species of scelionids, *T. euschisti*, *T. hullensis*, and *T. brochymenea*. Most of the emerging parasitoids were *T. euschisti*. Southern California: BMSB was established in two southern California counties, Los Angeles and Orange. Traps captures were consistently relatively low, compared to the situation on the east coast, with less than 100 adults per field season for all sites beginning in 2014. However, BMSB had noticeably been spreading within established Southern California counties and this was clear from field collections and compiled reports from the public. Approximately 312 egg cards were deployed in the field across sites in Los Angeles, Fresno and Madera. There was evidence of limited predation and parasitism at these sites. Recovered parasitoids were identified, with a primary focus on *Trissolcus* sp. Presently, *T. euschisti* was recovered and some *Anastatus* sp. as well. The goal will be to combine pooled sentinel card California datasets to provide stakeholders with greater perspective of the

#	Objective	Activity and Accomplishment
		natural enemies that could be used to enhance biological control practices at the orchard/field level.

APRIL – SEPTEMBER 2018

The estimated total percentage of work completed on this project …….. 80%

#	Objective	Activity and Accomplishment
1	Objective 1: Complete host specificity testing for *T. japonicus*, a novel, two millimeters in length parasitoid from China that attacks the eggs of BMSB.	A total of 452 replicates were completed as part of the safety testing of the BMSB parasitoid, *Trissolcus japonicus*. These efforts accounted for more than 12,000 stink bug eggs. Dissections of stink bug eggs that did not yield successful emergences (either parasitoids or nymphs) were completed. These data were compiled for analyses with results and conclusions. Preliminary results indicated seven of ten non-BMSB stink bugs from California were parasitized by *T. japonicus*, in no-choice tests, but levels of egg parasitism were always higher on host BMSB eggs.
2	Objective 2: Survey California for egg parasitoids attacking BMSB	Northern California: A total of 564 sentinel cards with BMSB eggs were placed at 54 locations in the Northern California region over 5 months, May through September 2018. Cameras were placed at six of these locations to conduct time-lapse imaging of predation over a continuous 72-hours. These images helped to identify the predators and parasitoids attacking the sentinel eggs. Between the imaging and sentinel eggs the tam will be able to identify what was removing the eggs. This was the first attempt to identify what natural enemies could potentially feed on these eggs. Conservation of the more important predators will likely be considered for pest management programs. The team will also identify parasitoids emerging from the same eggs, of which one could be *Trissolcus japonicus*, the self-introduced parasitoid from China known to specialize on BMSB. If *Trissolcus japonicus* is found in southern

#	Objective	Activity and Accomplishment
		or northern California, this would be the first record for the state and entire southwestern United States. Furthermore, the detection of *Trissolcus japonicus* in the field would expedite efforts to release this natural enemy for BMSB control in the northern San Joaquin Valley where feeding damage from BMSB populations have been recorded in commercial almond and peach orchards. Southern California: More than 500 sentinel egg cards consisting of BMSB and non-BMSB eggs were deployed in southern California during 2018 to monitor egg parasitoid activity. Several *Trissolcus*-like parasitoids were recovered from sites within Los Angeles County, the first county where BMSB established in southern California. Data from these sentinel cards were still in the process of being collected and pertained to levels of predation by generalist natural enemies (e.g. spider, lacewings larvae) and successful parasitism by specialized stink bug egg parasitoids. Parasitoids still needed to be identified, but once this portion has been completed the team can determine if the BMSB-parasitoid, *Trissolcus japonicus*, is already present in California.

CHALLENGES AND DEVELOPMENTS

OCTOBER 2017 – MARCH 2018

Challenge	Corrective Action and/or Project Change
Not applicable.	

Positive Development	Project Change
Not applicable.	

APRIL – SEPTEMBER 2018

Challenge	Corrective Action and/or Project Change
Dissections of stink bug egg masses took longer than anticipated due to their small size and fragility of non-BMSB host eggs and limited microscope space.	Another workstation space was also created which will facilitated the dissection process. With this corrective action, no-choice and choice dissections were recently completed. These data were in the process of being primed for statistical analyses.
One of the original BMSB monitoring field sites in Sherman Oaks (Los Angeles County), which had a large infestation of BMSB, was sold off and was no longer accessible. Consequently, a new site needed to be identified.	Three new stink bug monitoring field sites in Long Beach near the Port of Los Angeles were added. The presence of BMSB and parasitoids that attack sentinel BMSB eggs in these areas was confirmed, thus adding new detection information on the spread of BMSB in southern California.

Positive Development	Project Change
This year the team deployed both pyramid and sticky panel traps during spring-summer months in southern California field sites. This transition allowed the team to detect BMSB in new areas where previous monitoring efforts with only pyramid traps yielded inconclusive results on the presence of BMSB.	Given the proven BMSB-detection efficacy of sticky panel traps (in comparison to the pyramid traps used in previous years) in southern California, the team deployed panel traps in Fresno County. BMSB was detected in that region as early as June 2018. These results confirmed that BMSB had established in the interior of the San Joaquin Valley. Specialty crop stakeholder groups in the region have been alerted of this new development at conference meetings, through published articles, and by updating the BMSB distribution map on-line (webpage supported by the Center for Invasive Species Research Center at the University of California, Riverside).

OUTCOME AND INDICATOR RESULTS TO DATE

OCTOBER 2017 – MARCH 2018

Outcome and Indicator	Quantifiable Results
Outcome 4: Enhance the competitiveness of specialty crops through greater capacity of sustainable practices of specialty crop production resulting in increased yield,	The results showed that there was a serious lack of natural control of BMSB eggs by resident parasitoids in northern and southern California which only attacked from

Outcome and Indicator	Quantifiable Results
reduced inputs, increased efficiency, increased economic return, and/or conservation of resources. Indicator 2: Adoption of best practices and technologies resulting in increased yields, reduced inputs, increased efficiency, increased economic return, and conservation of resources.	somewhere between 3.5 percent and 13 percent of eggs. Predation of egg masses was as high as 26 percent, but that was recorded from egg masses placed on trunks. In 2017 the team found only 8 percent of sentinel eggs placed on leaves had been attacked by predators. Much higher levels of biological control will be needed to provide significant control in urban and farm landscapes, highlighting the need for importing and releasing *Trissolcus japonicus*, known to prefer BMSB eggs over most other non-target host eggs. Unusually warm summers likely helped curb the buildup of BMSB in California, but that will not help during years with closer to normal temperatures, especially near coastal areas and foothills, and production areas of northern California. Pest and egg parasitoid field surveys and the completion of safety testing results were a major accomplishment for securing future *Trissolcus japonicus* release permits and implementing a classical biological control program. The adoption of cost-saving biocontrol practices by stakeholder industries has been projected to secure economic returns for growers. Cost-effective field liberation of *Trissolcus japonicus* could occur by deploying *Trissolcus japonicus* -parasitized BMSB egg masses in the field using the sentinel card methods validated in California by the project team. Monitoring traps could also be used to confirm the presence of BMSB in the field. These pest and beneficial insect monitoring practices have been communicated through publications, webpages, and presentations, Information has been well-received by California agriculture stakeholders (pest control advisers, crop advisers, and industry leaders).

Outcome and Indicator	Quantifiable Results
Outcome 5: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems. Indicator 8: 46,000 growers/producers that gained knowledge about science-based tools through outreach and education programs.	Total views from the University of California, Riverside Web Page from January 2017 to March 2018 were 3,910 for BMSB English version and 98 for the Spanish version which was launched toward the end of the reporting period. During this reporting period, four publications and one online outreach article were extended to stakeholders. The publications discussed the implications of BMSB feeding on specialty crops and efforts to provide sustainable pest control solutions and maintain competitive California production: • Lara et al. 2017; DOI: 10.1093/jisesa/iex084 • Lara et al. 2018; DOI: 10.1080/00779962.2018.1438758 • Lara et al. 2018; CAPCA Adviser (volume 31, pg. 44-48) (publication distributed to 4668 subscribers) • Lara et al. 2018; CISR (in Spanish) • Western Farm Press Article (January 2018) Presentations: • Heteroptera Symposium, Monterey, California. April 2017 (200 attendees). • Portland, OR, April 2017 (100 attendees). • Western Regional Biological Control Working Group, Anza Borego Springs, California. October 2017 (60 attendees). • California Food Processors annual meeting, Stockton, California. November 2017, (50 attendees). • Lara, J.R., C. Pickett and M.S. Hoddle. Progress of BMSB biocontrol research in California. ESA 65th Annual Meeting. Denver, CO. November 7, 2017. (50 attendees).

Outcome and Indicator	Quantifiable Results
	• Lara, J.R., C. Pickett and M.S. Hoddle. Developing a biological control program for BMSB. 101th Pacific Branch, ESA Annual Meeting. Portland, OR. April 2017 (35 attendees).

APRIL – SEPTEMBER 2018

Outcome and Indicator	Quantifiable Results
Outcome 4: Enhance the competitiveness of specialty crops through greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources. Indicator 2: Adoption of best practices and technologies resulting in increased yields, reduced inputs, increased efficiency, increased economic return, and conservation of resources.	Current data from field-deployed sentinel egg cards and wild egg masses showed that only a small percentage of BMSB eggs (roughly <1%) were attacked by egg parasitoids. The baseline levels of BMSB-mortality caused by these resident parasitoid species (yet to be identified), was not enough to manage BMSB populations in California, especially since the distribution and severity of BMSB infestations (from urban to agricultural areas) had expanded each year. The findings from this project underscored the need to introduce effective BMSB natural enemies like *Trissolcus japonicus*. These results along with those from safety testing evaluations (Objective 1) were expected to facilitate efforts to secure *Trissolcus japonicus* field release permits.
Outcome 5: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems. Indicator 8: 46,000 growers/producers that gained knowledge about science-based tools through outreach and education programs.	The project team updated the University of California, Riverside website to describe progress to date in both English and in Spanish. The English version was accessed 1,462 times over the last six months, and the was Spanish version, 45 times. A paper was recently published in an industry magazine, the California Association of Pest Control Advisors for Pest Control Advisors, that covered results and problems growers may encounter with respect to BMSB: Trouble Comes in Pairs: Invasive Stink Bugs in California.

Outcome and Indicator	Quantifiable Results
	Several presentations were given by the project team: • Lara, J.R. Pacific Branch Entomological Society of America Meeting in Reno, NV in April of 2018. • Lara, J.R., C. Pickett, and M.S. Hoddle. Who's got the funk? Brown marmorated stink bug (BMSB) in California. California Association of Pest Control Advisers Meeting. Fresno, California. September 13, 2018 (150 attendees). • Lara, J.R., C. Pickett, and M.S. Hoddle. What's the big stink? Brown marmorated stink bug (BMSB) in California. California Association of Pest Control Advisers Meeting. San Diego, California. September 12, 2018 (140 attendees). • Lara, J.R., C. Pickett, and M.S. Hoddle. A new pest threat for California? Biology and management of brown marmorated stink bug. California Association of Pest Control Advisers Meeting. Simi Valley, California. August 16, 2018 (100 attendees). • Lara, J.R., C. Pickett and M.S. Hoddle. Prospects and challenges: safety testing with samurai wasp for classical biological control of brown marmorated stink bug in California. 102nd Pacific Branch ESA Annual Meeting. Reno, NV. June 13, 2018 (35 attendees). • Lara, J.R., C. Pickett and M.S. Hoddle. Biological control of brown marmorated stink bug in California. 102nd Pacific Branch ESA Annual Meeting. Reno, NV. June 12, 2018 (40 attendees). • Lara, J.R., C. Pickett and M.S. Hoddle. Update on BMSB in California. E.&J. Gallo Winery Insecticide and Fertilizer Update Meeting. Fresno, California. May 4, 2018 (50 attendees).

DISCUSSION OF ACTIVITIES PERFORMED (IF NEEDED)

OCTOBER 2017 – MARCH 2018

No additional information.

APRIL – SEPTEMBER 2018

No additional information.

UPCOMING ACTIVITIES

OCTOBER 2017 – MARCH 2018

No information provided at this time.

APRIL – SEPTEMBER 2018

Activity	Anticipated Completion
Publication of recommended BMSB management guidelines intended for an audience of specialty crop stakeholders in California.	Dec. 2018
Analysis of safety testing data and preparation of manuscript for publication in a peer-reviewed journal.	Jan. 2019
Analysis of survey studies, including imaging of sentinel egg predation.	Mar. 2019

FEDERAL EXPENDITURES

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$78,940.00	$74,852.65
Fringe Benefits	$38,633.00	$37,390.90
Travel	$7,724.00	$7,687.05
Equipment	$0.00	$0.00
Supplies	$5,329.00	$5,013.42
Contractual	$311,239.00	$291,495.95
Other	$300.00	$300.00
Direct Costs Sub-Total	$442,165.00	$416,739.97
Indirect Costs	$0.00	$0.00
Total Federal Costs	**$442,165.00**	**$416,739.97**

Percentage of total federal funds expended to date ……..…94%

PROGRAM INCOME

Source/Nature (i.e., registration fees)	Amount Approved in Budget	Actual Amount Earned
Not applicable.	$0.00	$0.00
	$0.00	$0.00
	$0.00	$0.00
Total Program Income Earned	**$0.00**	**$0.00**