**Final report to the Unified Grant Management for Viticulture and Enology 2012**

**Project Title:** Characterization of Seasonal Brown Marmorated Stink Bug Damage to Grapes in Western Production areas (Prop no. 2013-1367).

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## 1. Summary:

Exposure to BMSB feeding at low pest levels and short feeding periods resulted in numerically lower crop levels, and statistical differences in berry weights compared to control treatments. Mean crop levels at these slight BMSB exposures was 15% lower than the untreated control treatments. These findings support previous literature that indicates that fruiting bodies abscise when exposed to BMSB during the early developmental stages of fruit. Combined impacts on crop quality were more pronounced in BMSB treatments before harvest. We believe that our findings may be impacted by seasonally favorable conditions. We produced a bilingual online and in-print informational factsheet that can be used by growers and in extension outreach activities on BMSB in addition to a website and reporting system.

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**4. Principal Investigators:** Vaughn Walton, OSU Horticultural Entomologist, Department of Horticulture, Oregon State University, Corvallis, Oregon, Tel. 541 740 4149, waltonv@hort.oregonstate.edu

**Cooperators:** Chris Hedstrom, MS Student, OSU Horticulture, Department of Horticulture, Oregon State University, Corvallis, Oregon

**5. Objectives:**

1. Characterize Seasonal Brown Marmorated Stink Bug Damage to Grapes.
2. Produce Identification Sheet and potential economic impacts due to damage and deliver extension outreach through established outreach programming in Oregon.

Justification:

Brown marmorated stink bug (*Halyomorpha halys*, Hemiptera: Pentatomidae, BMSB) is a new invasive species in the United States, and more recently the Pacific Northwest. Known BMSB hosts include many commercial crops, such as winegrapes, cherries, hazelnuts, peaches, apples, pears, blueberries, raspberries, corn and soybeans.

In 2010, Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys* (Stål), populations

increased dramatically in the mid-Atlantic production regions and caused unprecedented damage to many specialty crops. Damage in commercial tree fruit orchards reached critical levels, with some growers experiencing 100% crop losses. Extensive damage and crop losses were also reported for peppers, tomato, sweet corn, cane berries and grapes. Since its initial discovery, surveys conducted in the US identified a number of specialty crop hosts for BMSB. Among them, hazelnut (Molnar, pers. comm.), apple, plum, peach, pear, pecan, grape and cherry were identified (Bernon 2004, Nielsen and Hamilton 2009). BMSB is an invasive pest of Asian origin that was first identified in Allentown, PA in 2001 (Hoebeke and Carter 2003) and Portland, Oregon in 2004 (ODA). It is now firmly established in Oregon's Willamette Valley. This pest is currently established from the Portland Metropolitan area and found in patchy locations throughout the Willamette Valley to Corvallis, and is rapidly expanding its range in Oregon. These regions include most of the intensified high value agricultural areas in Oregon.

The reported work is a first step to characterize the damage that BMSB can cause in winegrapes. OSU is part of a USDA-SCRI grant to conduct research on this pest, with funds allocated to improve trapping, survey work, determination of biology and generation time, and rapidly accelerate biological control in order to strategically manage the spread of this pest in Western Production areas. Important unfunded research areas include characterization of damage to three cultivars of winegrapes in the Willamette Valley as a model for western production areas. This initial knowledge will help growers to better determine the impact that this pest will have on winegrape crop level and quality, and will help growers to optimize future IPM strategies against BMSB.

## 6. Summary of Major Research Accomplishments and Results by Objective

**1. Characterize Seasonal Brown Marmorated Stink Bug Damage to Grapes.**

Materials and Methods: Our proposed exclusion methods were refined after consultation with the national commodity workgroup for BMSB in order to represent the most realistic field conditions and BMSB pressure in newly established regions. Exclusion techniques and time periods were therefore adapted to include established developmental rates and temperature thresholds (Nielsen et al. 2008) during spring. We used ten closed-off sleeve field-feeding cages per treatment (60 cm long, 30 cm wide, mesh diam. 0.5mm, with an opening securely closed with a plastic zip-tie around the stem of a single Pinot Noir grape cluster) for one control and two treatment levels (zero, one and two male adult BMSB in each of the feeding cages). Insects were allowed to feed for one week for each of three discrete feeding periods, for a total of 70 cages. When adults were unavailable, pre-adult nymphs were used. For data analysis all exposure periods were grouped into three periods, *pre-pea size* (before 23 July 2012), *pre-véraison* (before 25 August 2012) and *pre-harvest* (before 28 September 2012) in order to determine when the majority of damage due to BMSB feeding may be visible.

Exclusion cages were placed over a single cluster at the start of each experimental period. After a week of exposure to the clusters, insects were removed and exclusion-feeding cages were resealed to prevent any further or unintended feeding damage after each experimental feeding period.

Impact of BMSB exposure are classified in two categories i.e. *crop levels* and *crop quality* Mean cluster weight and berries per cluster as well as injury to fruit were recorded in each of the categories for each of the growth periods including:

i. *Crop levels*

a. Mean cluster weight
b. Mean number of berries per cluster
c. Mean weight of berries

ii. *Crop quality*

a. Mean number of dropped berries at harvest. All berries that dropped off the cluster before or at harvest when collecting the feeding cages due to berry stem compromise.
b. Mean number of BMSB punctures per cluster.
c. Mean number of discolored berries per cluster. Discolored berries were berries that showed abnormal coloration compared to the relevant cultivar at harvest.
d. Mean number of raisin berries per cluster.

Mean percentage of the sum of compromised berries per cluster (sum of a-d).

*Statistical Analysis*: Data was analyzed using analysis of variance (ANOVA; Statsoft 2005) combining data for all treatment and all control plots. This data was analyzed by looking at date-specific damage and overall seasonal trends. Separation tests were performed using Fishers' LSD.

Results: All cultivars displayed statistically similar response to BMSB feeding and damage is therefore presented as a summary.

i. *Crop levels*

Mean berry weights were significantly different in BMSB feeding treatments $F(3, 66) = 1.27$, $p=0.06$ (90% confidence level, Table 1). Fishers' LSD separation displayed significantly higher berry weights when they were exposed to BMSB feeding during the pre-pea period. Numerically lower impacts were found during pre-véraison and pre-harvest compared to the untreated control. Numerically lower cluster weights were found in clusters exposed during all three feeding periods compared to the untreated control. The feeding period during which cluster weights were numerically least reduced was during pre-harvest. The number of berries per cluster was similarly numerically impacted for each of the three feeding periods compared to the untreated control.

**Table 1. Mean measured crop levels (±SEM) for three BMSB feeding periods in the Willamette Valley during 2012. Statistical differences are indicated by different letters (Fishers LSD, at 90% confidence level).**

| Treatment | Cluster weight (g) | Berries/cluster | Berry weight (g) |
|---|---|---|---|
| Untreated Control | 106.9±8.6 | 80.1±5.4 | 0.76±0.02 a |
| Pre-pea | 89.0±8.0 | 73.5±5.5 | 0.85±0.03 b |
| Pre-véraison | 86.7±6.7 | 70.9±4.6 | 0.83±0.02 ab |
| Pre-harvest | 99.5±6.7 | 79.9±5.5 | 0.81±0.04 ab |

ii. *Crop quality*

Compromised berries in BMSB treatments were significantly different $F(3, 66) = 1.52$, $p=0.045$ (95% confidence level, Table 2). Separation highlighted significant differences in mean sum % compromised berries/cluster during the pre-harvest period. Numerically higher numbers of punctures, discolored berries/cluster and raison berries/cluster were found in clusters exposed during all three feeding periods compared to the untreated

control. During this period, 15.7% damaged berries were recorded, which was significantly different from the untreated control.

**Table 2. Mean measured crop quality parameters per cluster (±SEM) for three BMSB feeding periods in the Willamette Valley during 2012. Statistical differences are indicated by different letters (Fishers LSD).**

| Treatment | Dropped berries | Feeding punctures | Discolored berries | Raison berries | Mean sum % compromised berries |
|---|---|---|---|---|---|
| Untreated | 1.6±0.5 | 0.2±0.1 | 0.3±0.1 | 4.4±1.3 | 3.8±2.4 a |
| Control | | | | | |
| Pre-pea | 7.6±5.5 | 2.6±1.1 | 5.6±0.3 | 12.1±5.4 | 9.5±7.3 ab |
| Pre-véraison | 1.7±0.6 | 6.0±4.8 | 5.1±4.8 | 12.5±5.1 | 12.3±8 ab |
| Pre-harvest | 1.7±0.6 | 3.4±1.6 | 1.1±0.4 | 8.6±1.6 | 15.7±12 b |

**2. Produce identification sheet and potential economic impacts due to damage and deliver extension outreach through established outreach programming in Oregon.**

Materials and Methods: Outreach, education and evaluation with farmers, land owners and stakeholders were accomplished and focused on four aspects: a) explanation of damage, b) extension of additional information gathered during the trial on the development of sustainable control options outside of this grant focus area, c) professional to professional extension of results to cooperators on the east and west coast, as well as global outreach through peer-reviewed publication of results. An annual field day for growers was held in Milton-Freewater during 2012. Additional field days are planned for 2013 in the Willamette Valley.

**Results:** Our deliverable output documents from this work included a color symptomological brochure reviewed by outside experts and produced at the Oregon State Extension office in both English and Spanish (OSU Extension Publication EM 9054 and

EM 9054-S, Fig. 1). The handout indicates various types of damage to fruits, vegetables, and nuts. It also includes photographs of the insect's life cycle and features on the adults used for positive identification. Photographs of insects that occur in the Willamette Valley which are often mistaken for BMSB are provided, with text indicating key differences. This document is available online and in print to growers and stakeholders via the Oregon State University Extension Services website (Hedstrom et al, 2013, http://extension.oregonstate.edu/catalog/).

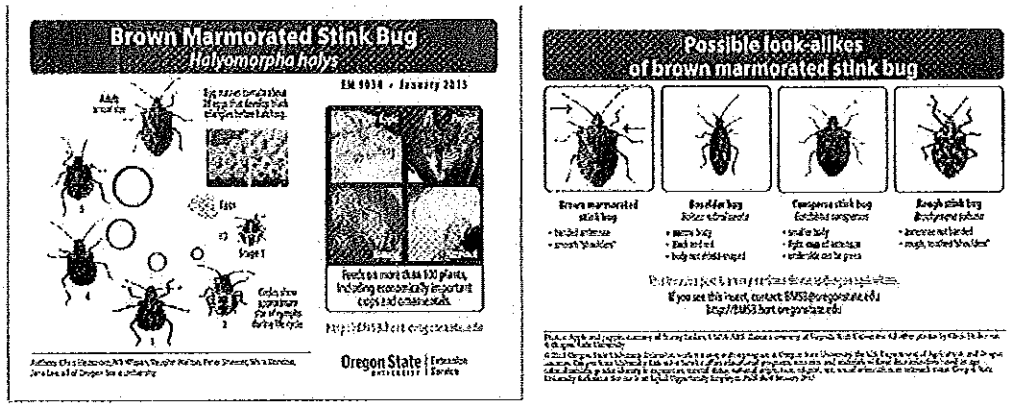


**Fig. 1: Informational handout highlighting identification, life cycle, and economic crop injury of *Halyomorpha halys*, brown marmorated stink bug, published by Oregon State University Extension Services January 2013 as EM 9054 and EM 9054-S in English and Spanish.**

In addition we have created a BMSB website (http://horticulture.oregonstate.edu/group/brown-marmorated-stink-bug-oregon) which includes the newest information on this pest as it becomes available on a national level.

## Discussion

We exposed grape clusters to BMSB during three distinct periods and were able to determine that early exposure to BMSB resulted in numerically lower cluster weight and number of berries per cluster as opposed to later exposure and the untreated control. Berries were significantly heavier in treatments where clusters were exposed to BMSB during the pre-pea stage. Percent compromised berries were significantly more during pre-harvest compared to the untreated control.

We exposed low numbers of BMSB for short periods to grape clusters in order to get the most realistic figures of damage in early BMSB population explosion cycles. Despite the low exposure periods, it appears that BMSB could cause serious economic impact to the wine industry as a whole.

Though crop levels in treated vines were not statistically different to control treatments, these treatments resulted in a mean of 14% crop weight reduction. Industry wide, this reduction in crop weight may equate to approximately $11 million in crop value (Oregon Agricultural Statistics fact sheet 2012). More concerning is the fact that these results were recorded for short exposure periods (7 days), and relatively low exposures to BMSB (1-2 bugs/cluster) during any of the highlighted exposure periods before harvest. Our initial data support literature that suggest that feeding of stinkbugs during the early development of fruiting bodies may result in abscission of these tissues, potentially resulting in a reduction of crop levels (McPherson and McPherson, 2000.).

During 2012, BMSB feeding punctures in berries did not result in secondary impacts as found in East Coast vineyards (D. Pfeiffer, Virginia Tech, Pers Comm). Secondary impact

due to increased disease pressure may be facilitated by BMSB feeding punctures during wetter growing seasons. The 2012 season in Oregon's Willamette Valley had virtually no precipitation (~ 0.11 mm during July through September 2012; NOAA 2012). Low precipitation may have resulted in lower disease pressure and less impact due to BMSB feeding during 2012.

In our study we summed the total percentage of compromised berries. Our data suggest that quality of grapes may be negatively impacted. The impact of compromised berries on wine quality was not determined in this study. We believe that additional trials are needed in order to confirm trends observed during 2012. We also believe that the increased awareness of the pest by wine growers and the general public will result in more rapid tracking and management of this invasive pest in Oregon.

Our symptomological handout is available online and in print in addition to a BMSB website which allows reporting and updates regarding the spread, economic impact and progress to control BMSB.

**7. Outside Presentations of Research**

We have created a statewide BMSB website and online available BMSB ID sheet. Our information were presented at regional and national producer and peer meetings in addition to mass media. See results section of objective 2 for relevant materials and website information used in outreach to the industry. For additional publication details, see literature-cited section.

**8. Research Success Statements:**

Our work is the first information available to our knowledge that characterized and quantifies winegrape damage due to BMSB exposure. This information helps us to put a dollar amount to the possible risk that winegrape growers can experience when winegrapes are exposed to BMSB. We have created in-print and online resources as well as a BMSB reporting email, informing growers of identifying characteristics of this pest.

**9. Funds Status:**

We have received a portion of the budgeted funds as negotiated with OWB. This final report satisfies the requirements by OWB to release final payment of the requested funds. We have currently exhausted funds as budgeted for in the grant application.

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