Grape Entomology Research and Demonstration in Arkansas and Missouri
Department of Entomology
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Projects titled, "Demonstration & verification of best management practices for wine grape production in Ozark Mountain region," and "Survey and control of aerial and root grape phylloxera."

Demonstration Sites. In 2006, we placed a Spectrum WatchDog weather station in 2 vineyards in Arkansas and 5 vineyards in Missouri including Purdy, MO (new site for 2006). Weather station data was downloaded and files emailed to Donn Johnson monthly to allow him to run the predictive models. These data were used to run Spec7 Pro™ disease models to determine the daily risk of black rot, botrytis, downy mildew and powdery mildew (http://comp.uark.edu/~dtjohnso/Disease 06). These disease risk outputs for the Purdy, MO site will be compared to levels of grape disease recorded in the fungicide efficacy study block conducted by Keith Striegler and Turner Sutton. Growers in two vineyards in Arkansas and four in Missouri recorded insect trap catch weekly from early April to harvest. Management recommendations, trap data and graphs of predicted daily disease risk were placed on the Fruit IPM website as needed or when available: http://comp.uark.edu/~dtjohnso/.

Donn Johnson and Barbara Lewis made presentations on pest and disease management at grape tailgate meetings in Arkansas and Missouri. Specifically, we discussed timing and efficacy of insecticide sprays for grape berry moth and grape phylloxera, how to use the Spectrum WatchDog weather station and distributed handouts of graphs from the disease models that noted daily risk for each grape disease. Numbers of growers attending each tailgate meeting were: 30, 20 and 10 growers, respectively, on 4 April, 23 May and 25 July at Crown Valley Winery in Ste. Genevieve, MO; 20, 20 and 8 growers, respectively, on 5 April, 24 May and 26 July at St. James Winery in St. James, MO; 20, 20 and 15 growers, respectively, on 5 April, 24 May and 26 July at Stone Hill Winery in Hermann, MO; 20, 15 and 15 growers, respectively, on 6 April, 25 May and 27 July at Les Bourgeois Winery in Rocheport, MO; and 30 growers each on 20 March, 15 May and 17 July at Wiederkehr Winery in Altus and Gay Vineyard in Hindsville, AR. Some growers inspected 100 to 300 clusters during each generation of grape berry moth to determine the proportion of clusters damaged by grape berry moth. No demonstration vineyard experienced more than 2% damaged clusters (threshold).

Grape Berry Moth (GBM). The mean season total catch of GBM in pheromone traps in vineyards varied considerably relative to risk (increased with percentage of vineyard adjacent to woods) as follows: in Missouri at Ste. Genevieve (25.5 moths = low risk); Hermann (112.5 = high risk site); Rocheport (23 = low-moderate risk); St. James (180 = high risk by shed and 176.5 = moderate to high risk by tower), and Arkansas at Hindsville (75.7 = high risk and only 14.3 = low risk and all caught before placement of mating disruption ties on 1 June). All vineyards reported less than 1% cluster damage due to feeding by GBM larvae. No GBM damage was observed in the three mating disruption blocks in Hindsville, AR. Daily maximum and minimum temperature and rainfall data for select grape growing counties in Missouri (http://agebb.missouri.edu/weather/stations/) and daily maximum and minimum temperatures for grape growing zones in Arkansas (http://www.aragriculture.org/weather/download.asp) were used to generate graphs of cumulative degree-days for GBM (developmental base 47.14°F and upper threshold of 93°F). Each graph noted predicted periods of grape berry moth hatch (spray periods) for each generation in each grape-growing county in Arkansas and Missouri. This information was available on the Arkansas/Missouri Fruit IPM website at: http://comp.uark.edu/~dtjohnso/. This site also had specific vineyard trap catch data and management recommendations.

Grape Root Borer (GRB). Season total pheromone trap catches more than doubled from 2005 to 2006. In Missouri vineyards in Ste. Genevieve there were 31 and 65 GRB moths/trap in 2005 and 2006, respectively, in Hermann there were 11 and 130 and in St. James there were 8 and 34 compared to 5 and 33 in Hindsville, AR. Survey of 100+ vines/vineyard in late August resulted in low GRB pupal skin counts in Missouri - Ste. Genevieve (4 skins), St. James (1), Rocheport (0), and in Arkansas - Altus (1) and Hindsville (0).

Grape Phylloxera (GP). In 2006 on a 'Norton' block in Purdy, MO we demonstrated that the currently recommended rates of insecticides, Danitol and Assail, were effective against foliar GP. We also began to develop a protocol to determine the economic threshold of GP on various grape cultivars. This spray timing/efficacy study was a RCB design, 3 replicated plots each with 4-vines. Treatment sprays were applied with a Solo backpack sprayer on 11 May at the start of crawler activity (mean of 4.0 crawlers/leaf and 132.8 eggs/leaf gall). Some plots received a second spray on 25 May when crawlers were still present (mean of 5.6 crawlers/leaf and only 25.5 eggs/gall). Admire Pro was applied as a soil drench only on 11 May. On 16 June, we counted the number of galled shoots/vine in each treatment plot. Treatments of Danitol and Assail, applied either once or twice, provided significantly fewer GP-infested shoots/vine than did the experimental compound (E), Admire or the check (Table 1). Compound E provided significantly fewer galled shoots/vine than did either Admire Pro or the check which were similar. Thus, one spray of Danitol or Assail timed at the start of GP crawler emergence provided excellent control of foliar GP. The grower accidentally sprayed this block with Danitol on 8 July to prevent damage from Japanese beetles and green June beetles. This spray put a stop to new gall formation in the block. Thus, the untreated check plots only increased from 10.8 galled shoots/vine on 16 June to 15.6 on 24 July.

We plan to repeat this test in 2007, but Admire Pro will be irrigated into the soil in late October 2006 to ensure this material translocates in the plant before GP activity in April 2007.

This summer, we started to conduct several additional studies of GP in the Ozarks. From late May on, we collected 20 galled leaves from both ‘Vignoles’ and ‘Norton’ blocks in Purdy, MO. We quantified the number of galls/leaf, eggs/gall and crawlers/leaf to note time period for each generation.

In Arkansas, we began to dig up grape roots of different cultivars (own-rooted and on rootstocks), described root architecture, counted the number of GP-induced nodosities on 20 bunches of feeder roots and noted absence/presence of root GP. The purpose is to start comparing intensity of root GP infestations on a variety of cultivars and rootstocks that are adapted to the Ozarks.

We are developing a protocol to determine the economic threshold of foliar GP on various cultivars. This involved artificially infesting susceptible ‘Norton’ vines with different levels of foliar GP during first crawler period on 11 May. On 0, 1, 2, 4, 8 or 16 leaves/vine, we rolled a leaf around a leaf disk and tied it. Each leaf disk contained a GP gall with several hundred eggs and crawlers. As noted above, the grower sprayed Danitol in this block on 8 July which killed most GP in the galls. In spite of this, on 24 July we noted significant differences ($F = 97.8$; $df = 5, 1$; $P < .0001$) due to treatment number of galls added/vine in the number of galled shoots/treatment vine (in parentheses): 0 (7 c), 1 (5.2 d), 2 (6.6 c), 4 (10.4 a), 8 (8.5 b) or 16 (9.7 a). Next year, we will infest ‘Vignoles’ because it is more GP susceptible and more likely to be damaged economically. Also, test plots will be enlarged to 4 vines by 4 rows with Danitol sprayed buffer vines around each plot to minimize additional crawler movement to test plots.

Table 1. Insecticide control of foliar grape phylloxera in ‘Norton’ grapes in Purdy, MO (2006).

	# galled shoots/vine	
Treatment	**16 June**	**24 July**
Check	10.8a[b]	15.7 a
Admire Pro - once[a]	10.03a	8.8 b
E - once	6.8b	6.5 bc
E - twice	4.8b	6.4 bc
Assail - once	1.8c	7.3 b
Assail - twice	0.3c	2.0 d
Danitol - once	0.2c	2.9 cd
Danitol - twice	0.08c	1.3 d

[a] Once = sprayed on 11 May; Twice = sprayed on 11 and 25 May
[b] $LSD_{0.05}$ = 2.6 (Waller-Duncan K-ratio t Test)

Green June Beetle (GJB). The flight of GJB in the Ozarks was observed from late June to late August. The overall GJB population in 2006 was higher and more widespread than in 2005 as evidenced by the fact that most fruit growers from Altus, AR to Purdy, MO applied insecticide spray to minimize GJB damage to ripe fruit. In 2006, we obtained funding to collect and identify semiochemicals produced by GJB adults. To detect a broader range of volatiles, we used a SPME fiber (50/30 carboxen/DVB/PDMS fiber from Supelco, Bellefonte, Pennsylvania) to collect headspace volatiles for 30 min from GJB adults feeding on ripe nectarine, apple and peach. We inserted SPME fiber sample for 30 sec in either a Shimadzu GC/MS (UA Mass Spectrometer Laboratory, Fayetteville, Arkansas) or a Varian Chrompack CP-3800 GC/MS (USDA Dale Bumpers National Rice Research Center, Stuttgart, Arkansas) with injection temperature at 200°C, initial oven temperature = 50°C for 1 min, ramp rate of 10°C/min to 280°C and hold 4 min. Table 2 lists the headspace compounds produced by GJB adults feeding on ripe fruit as identified by GC/MS analysis.

Lopez et al. (1) achieved the greatest attraction of GJB adults by using a five component floral odor mixture called Mix-M that contained: phenylacetaldehyde; limonene; 2-phenylethanol; methyl salicylate; and methyl-2-methoxybenzoate. They noted that phenylacetaldehyde alone will attract significant numbers of GJB but it attracts more when mixed with phenylethanol. These two compounds were reported to be generated by microbes fermenting fruit to 2-phenylethyl alcohol which oxidizes into phenylacetaldehyde (2, 3). So far, neither phenylethanol nor phenylacetaldehyde were found in odors from fruit feeding GJB adults analyzed by GC/MS.

Bartelt and Hossain (4) identified a similar set of volatiles as by us, except no mention of cyclohexanecarboxylic acid, from 1- to 7-day fermented peach juice and overripe peach: acetaldehyde (800 ng odor released/min); ethanol (63,000); methyl acetate (220); 1-propanol (31); ethyl acetate (270); 2-methyl-1-propanol (150); propyl acetate (4); 3-methyl-1-butanol (330); 2-methyl-1-butanol (92); 2-methylpropyl acetate (2); 3-methylbutyl acetate (9); ethyl hexanoate (9); Z-3-hexenyl acetate (2); methyl octanoate (1); and ethyl octanoate (15). Fungus beetles, *Carpophilus davidsoni* Dobson (Family: Nitidulidae), were similarly attracted to either a synthetic mixture modeled after fermenting peach juice (listed above) or a mixture of an aqueous and an oil solution: water + acetaldehyde + ethanol + 2-methyl-1-propanol + 3-methyl-1-butanol + 2-methyl-1-butanol and oil + ethyl acetate + 3-methyl-1-butanol + ethyl hexanoate + Z-3-hexenyl acetate + ethyl octanoate. An aqueous mixture of ethanol (main component) and minor constituents of acetaldehyde, 3 higher alcohols (2-methyl-1-propanol, 3-methyl-1-butanol and 2-methyl-1-butanol) and ethyl acetate attracted fungus beetles in a wind tunnel bioassay.

Table 2. GC/MS analyses identified several compounds in the headspace of field collected green June beetle adults feeding on ripe nectarine or apple.

Compound	***Retention Time (min.)***
Acetaldehyde	1.36
ethanol	1.65
acetic acid	2.4
propanoic acid	2.6
ethyl acetate	3.3
3-methyl-1-butanol (isoamyl alcohol)	2.9
butanoic acid	3.4
2-hexaen-1-ol	3.6
3-methyl butanoic acid	4.2
3-methyl-butyl acetate (isoamyl acetate)	4.66
hexanoic acid (caproic acid)	4.74
cyclohexanecarboxylic acid	9.9 to 10.5
2-phenylethyl acetate	12.9

It was hypothesized that a lure charged with both the Mix-M floral odor mixture and a mixture of volatiles produced by fermenting peach plus cyclohexanecarboxylic acid would improve trap catch of GJB adults.

In 2005 in Hindsville, AR, we compared two mixtures for attractiveness to GJB adults. TRE#8706 was a mixtures designed after Mix-M that contained: 0.82 gm phenylacetaldehyde; 0.84 gm (R)(+) limonene; 0.79 gm 2-phenylethanol; 0.36 gm methyl salicylate; and 0.7 gm methyl-2-methoxybenzoate. TRE#9722 was our GJB headspace volatile mixture that contained: 2.79 gm (R)(+) limonene; 0.25 gm 2-phenylethanol; 0.42 gm methyl salicylate; and 0.04 gm methyl-2-methoxybenzoate. Both mixtures were provided by Trécé Inc., Adair, OK. The lower funnel opening of several yellow Japanese beetle (JB) Jumbo traps was enlarged to accommodate GJB adults. These modified JB traps were placed in a field adjacent to a grape planting containing ripe fruit. Each trap was baited with a Trécé floral lure cup dispenser containing 3.5 ml of either mixture TRE#8607 or TRE#9722. Traps were arranged in a RCB design with three replicates. From 15 July to 1 September 2005, a total of 1,298 GJB were captured in the TRE#8607 baited trap compared to 178 GJB in traps baited with TRE#9722. Thus, something was missing from our GJB mixture TRE#9722.

In 2006, we compared a series of odor mixtures for attractiveness to GJBs. All tests were conducted in a field adjacent to a planting of ripe nectarines and peaches in Bethel Heights, AR. Traps were arranged in a RCB design with two or more replicates. Brown, 25 ml bottles were filled with 4 ml of a mixture, not capped and hung by a wire inside the trap capture pail.

Table 3. By date, different odor mixtures affect mean number of green June beetle adults captured in traps near a planting of ripe nectarines in Bethel Heights, AR in 2006

Mixture	***Number beetles/trap***
July 20	
Mix-M + Nitidulid	278.0 A **(total)**
Mix-M	147.5 B
Nitidulid	0.5 C
GJB + Nitidulid	0.0 C
Check	0.5 C
July 24	
Mix-M + Nitidulid	322.0 A **(males)**
GJB feed on peach	79.5 AB
Check	0.0 B
July 24	
Mix-M + Nitidulid	355.0 A **(females)**
GJB feed on peach	49.0 B
Check	0.0 B
July 24	
Mix-M + Nitidulid	800.5 A **(total)**
Mix-M	580.5 A
GJB feed on peach	131.0 B
Check	0.0 B
August 1	
Mix-M + Nitidulid	828.0 A **(total)**
Mix-M	645.5 AB
GJB feed on peach	137.0 B
August 8	
Mix-M	326.0 A **(total)**
Mix-M + Nitidulid	234.0 AB
GJB feed on peach	209.5 AB
500X GJB	146.0 B
GJB	113.0 B
August 15	
Mix-M	295.0 A **(total)**
Mix-M + Nitidulid	198.0 B
GJB feed on peach	139.0 BC
500X GJB	113.0 C
GJB	98.0 C

Nitidulid mixture had both an aqueous and oil mixture: 50 ml water + 11.4 ml ethanol + 38.5 ul acetaldehyde + 3.1 ul 2-methyl-1-propanol + 6.87 ul 3-methyl-1-butanol (isoamyl alcohol) + 1.36 ul 2-methyl-1-butanol; and 50 ml mineral oil + 0.066 ul ethyl acetate + 0.0115 ul ethyl caprylate (ethyl octanoate) + 0.0115 ul ethyl caproate (ethyl hexanoate) (described by Bartelt and Hossain, 4).

GJB mixture also had both an aqueous and oil mixture: 50 ml water + 36.7 ul phenylacetaldehyde + 36.7 ul 2-phenyl ethanol + 36.1 ul benzyl alcohol + 40.3 ul hexanoic acid; and 50 ml mineral oil + 42.8 ul 3-methyl-butyl acetate (isoamyl acetate) + 36.3 ul cyclohexanecarboxylic acid (see Table 2).

500X GJB mixture was modified to include 500-fold mixture of ingredients: 100 ml ethanol + 1ml acetaldehyde + 1 ml ethyl acetate + 1 ml 3-methyl-1-butanol (isoamyl alcohol) + 1 ml cyclohexanecarboxylic acid + 1 ml 3-methyl-butyl acetate (isoamyl acetate) + 1 ml hexanoic acid + 1 ml 2-phenyl ethanol + 1 ml 2-phenylethyl acetate + 1 ml phenylacetaldehyde.

The addition of the Nitidulid mixture to Mix-M significantly increased the GJB trap capture compared to Mix-M alone for most sample dates (Table 3). Both these mixtures captured significantly more beetles than did the natural attractant of GJB feeding on ripe fruit or the 500X mixture of peach volatiles which was similar to the natural attractant.

Japanese beetle (JB). In 2005 in NW Arkansas, adult JB flight occurred from 1 June to mid August in Springdale, AR. Season total counts of adults/JB Jumbo trap in Arkansas were 91,394 JB/trap in rural Elkins; 86,364 JB in the Springdale vineyard; 62,663 JB in urban Fayetteville; 45,852 JB in UA-Fayetteville Farm; 33,100 JB in the Hindsville vineyard; 55 JB in rural Berryville whereas in Missouri counts were 3,868 JB in Ste. Genevieve; 12 in Purdy; and 0 in St. James, Hermann and Rocheport.

In 2006, adult JB flight occurred from 1 June and ended in mid August in Fayetteville, AR. Season total counts of adults/JB Jumbo trap were 131,879 JB in rural Elkins (a third more than 2005); 67,284 JB in urban Fayetteville; and 31,823 JB in the Hindsville vineyard. In addition, we glued 14 JB yellow funnels with floral/pheromone dual baits to tops of 3 gallon plastic storage boxes. Traps were placed 200 ft apart on the north perimeter of the UA-Fayetteville Organic Fruit Farm. These traps mass trapped a total of 484,274 JB. This trapping significantly reduced foliar damage to the organically managed small fruits, grapes and apple trees compared to a block of commercial apples several hundred feet further east.

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Demonstration and verification of best management practices for wine grape production in Ozark Mountain region. Missouri Wine Advisory Board and USDA/CSREES Viticulture Consortium-East. $145,226 ($50,000) for 2005-2008.

Survey and control of aerial and root grape phylloxera on grape cultivars and rootstocks in the Ozark Mountain region. Missouri Wine Advisory Board. $10,299 for 2006.

Control and survey of aerial and root grape phylloxera on grape cultivars and rootstocks in the Ozark Mountain Region. USDA/CSREES Viticulture Consortium-East. $8,200 in 2006.

Identify semiochemicals produced by green June beetles. Agricultural Experiment Station Research Incentive Program - Faculty Research Enhancement. $9,932 for 2006.

Publications or Newsletters or Presentations: None

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