Lures, Mating Disruption and Mass Trapping of the Grape Root Borer

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Abstract

The grape root borer, *Vitacea polistiformis*, is a root pest of wine grapes and muscadine vines (*Vitis* spp.) that reduces yield over time and kills vines. Management tactics include soil mounding, laying landscape cloth under vines or applying a soil barrier of insecticide (chlorpyrifos). The Isonet-Z dispenser (Shin-Etsu Chemical Co. Tokyo, Japan) is a new sex pheromone blend of the leopard moth, *Zeuzera pyrina* (*Lepidoptera*: *Cossidae*) of 95% (E,Z)-2,13-octadecadien-1-ol-acetate (called E,Z-2,13-ODDA): 5% (E,Z)-3,13-octadecadien-1-ol-acetate (called E,Z-3,13-ODDA). Isonet-Z has the same major component as the grape root borer sex pheromone, a 99:1 blend of (E,Z)-2,13-ODDA and Z,Z-3,13-ODDA. This study compared attractiveness to grape root borer of two lures: Isonet-Z rope dispensers and grape root borer sex pheromone rubber septa lures. It also compared three densities of Isonet-Z dispensers per hectare to disrupt mating of grape root borer, and determined if grape root borer sex pheromone-baited green bucket traps at a density of 2.5 traps per ha would mass trap grape root borer. Traps baited with grape root borer sex pheromone lures captured significantly more grape root borer males than traps baited with an Isonet-Z dispenser of leopard moth pheromone. In Florida and Missouri, zero grape root borer moths were caught in grape root borer pheromone-baited traps set in muscadine or wine grape plantings with mating disruption treatments of 127, 370, 494 or 741 Isonet-Z dispensers per ha. In Missouri, more grape root borer moths were captured in wine grape plots with mass trapping at a density of 2.5 grape root borer pheromone-baited traps per ha than plots with mating disruption or untreated controls, and after two years mass trapping only 15% of vines were infested with larvae compared with 71% that had old root tunneling.

INTRODUCTION

The grape root borer, *Vitacea polistiformis*, is native to the eastern United States and is a key root pest of American and European bunch grapes (*Vitis labrusca* and *V. vinifera*) (Dutcher and All, 1979; Johnson et al., 1981, 1986, 1991) and muscadine (*V. rotundifolia*) (Liburd et al., 2004; Weihman and Liburd, 2006). The grape root borer completes its life cycle in 1 to 2 years, depending on the latitude (Snow et al., 1991). Many management tactics have been described for the grape root borer including: covering the base of vines with landscape cloth; monthly soil mounding under the vines to prevent adult emergence; a soil barrier of chlorpyrifos insecticide under the vines to kill larvae entering the soil; mating disruption with pheromones; and attract-and-kill (Weihman and Liburd, 2006; Sanders et al., 2011).

The main component of the grape root borer sex pheromone was identified as (E,Z)-2,13-octadecadien-1-ol acetate (E,Z-2,13-ODDA) (Schwarz et al., 1983). Snow et

al. (1987) reported traps baited with rubber septa charged with 1 mg of a blend of 99% E,Z-2,13-ODDA to 1% (Z,Z)-3,13-octadecadien-1-ol acetate (Z,Z-3,13-ODDA) were at least 3 times more attractive to grape root borer males than traps baited with 1 mg of 100% E,Z-2,13-ODDA or a blend of 99% E,Z-2,13-ODDA to 1% (E,Z)-3,13-octadecadien-1-ol acetate (E,Z-3,13-ODDA). The 99% E,Z-2,13-ODDA to 1% Z,Z-3,13-ODDA blend serves as the standard attractant in grape root borer monitoring traps.

In Europe, Isonet-Z is labeled for use in apples, pears, olives and black currents at a density of 298 dispensers per ha to disrupt mating of the leopard moth, *Zeuzera pyrina* and the currant clearwing moth, *Synanthedon tipuliformis*. Each Isonet-Z dispenser contains 0.7 mg of the leopard moth pheromone blend of 95% E,Z-2,13-ODDA to 5% E,Z-3,13-ODDA.

Mating disruption has been successful against grape root borer. Johnson et al. (1991) used twist-tie dispensers containing 40 mg of either 100% grape root borer component (E,Z)-2,13-ODDA or the 100% peach tree borer pheromone component (Z,Z)-3,13-ODDA each at a density of 247 dispensers per ha to significantly reduce grape root borer pupal skin counts in the third and fourth years of treatment. The two-component sex pheromone blend is prohibitively expensive to synthesize for commercial application. Therefore, Weihman and Liburd (2006) evaluated a commercially available Isonet-Z pheromone dispenser (which also contains E,Z-2,13-ODDA) at a rate of 254 per ha and reported no catch of grape root borer males in pheromone traps. They also caught significantly fewer grape root borer males in plots treated with 2,223 drops per ha of Last Call™ attract-and-kill gel containing the 99:1 grape root borer sex pheromone blend and pyrethrin.

It is unknown if mass trapping will significantly reduce subsequent generation counts of grape root borer males in traps and larvae in grape roots. The green bucket Unitrap Trap (Great Lakes IPM, Vestaburg, Michigan, USA) appears to be the best choice for mass trapping. Weimund and Liburd (2007) reported that the green bucket trap caught five times more grape root borers than the wing trap which was limited by surface area of the sticky liner.

The objectives of this study were to: 1) compare attractiveness of the leopard moth lure to the grape root borer lure; 2) determine if Isonet-Z dispensers disrupt grape root borer mating in Florida and Missouri; 3) evaluate mating disruption of grape root borer with placement of variable densities of Isonet-Z dispensers in Florida; and 4) determine if mass trapping reduces the number of grape root borers in subsequent generations.

MATERIALS AND METHODS

Lure Attraction

In 2011, the lure attraction experiment was set up at a farm in Lithia, Florida (27°45’13”N; 82°09’08”W). The experimental design was a randomized complete block with three treatments and three replicates. Pherocon VI delta traps (Trécé Inc., Adair, OK) or wing traps were hung on the top trellis wire and treatments included: 1) Pherocon VI delta traps baited with 1 mg grape root borer sex pheromone: 99% E,Z-2,13-octadecadien-1-ol acetate, 1% Z,Z-3,13-octadecadien-1-ol acetate (Great Lakes IPM, Vestaburg Michigan, USA); 2) Pherocon VI delta traps baited with Isonet-Z twist-tie dispenser each containing 70 mg of leopard moth sex pheromone: 95% E,Z-2,13-ODDA, 5% E,Z-3,13-ODDA (Shin Etsu Chemical Co., Tokyo, Japan); and 3) unbaited wing traps (Control) (Great lakes IPM, Vestaburg, Michigan).

Mating Disruption in Florida

In 2011, two commercial muscadine grape vineyards, one in Lithia, Florida and a second in Spring Hill, Florida (28°24’44”N; 82°29’32”W), each had the following experimental spatial arrangements and rates of Isonet-Z in four, 600 vine treatment plots (0.4 ha) with vines spaced about 3.7 m apart both within and between rows (Fig. 1): 1) 741 Isonet-Z pheromone dispensers per ha with a tie placed on every other vine;

2) 370 Isonet-Z dispensers per ha placed on every other vine in every other row; 3) 127 Isonet-Z dispensers per ha placed on all border vines around the plot; and 4) an untreated plot (control) without pheromone dispensers. Each treatment was separated from the other by a 50 m buffer zone on either side. Grape root borer male flight in each plot was monitored with 4 wing traps baited with grape root borer sex pheromone (Fig. 1); each trap representing a replicate for the particular treatment. Traps were checked once per week from 15 June 2011 until 30 August 2011 and the number of grape root borer males was recorded. Pheromone lures in traps were replaced every three weeks and sticky bottoms were replaced approximately every 2-3 weeks.

Mass Trapping and Mating Disruption in Missouri and Arkansas

The effectiveness of mass trapping and mating disruption against grape root borers were evaluated. Each green bucket trap was baited with grape root borer sex pheromone and a Hercon Vaportape (Hercon Environmental, Emigsville, PA) treated with 2,2-dichlorovinyl dimethyl phosphate to kill moths and minimize moth predation.

From mid-June to 31 August in 2007 to 2009, each grape treatment plot (6.5 ha) had 16 green bucket traps (2.5 traps per ha) to mass trap grape root borers in Hindsville (36°08'22"N; 93°49'58"W), and Bethel Heights (36°13'07"N; 94°05'02"W), Arkansas, and Hermann (38°40'18"N; 91°32'03"W) and Ste. Genevieve (37°46'47"N; 90°11'29"W), Missouri. A bucket trap was tied to the top trellis wire in every 20th row (rows 3 m apart) and spaced 66 m apart within that row. Grape vines were spaced 2.4 m apart within rows. Counts of grape root borer per green bucket trap were recorded in late-July and late-August when lures were replaced. Concurrently, the soil within 1 m of each of ten vines by each bucket trap was scanned and we recorded the number of pupal skins. On 11 June 2009, the 'Chardonel' plot in Ste. Genevieve, Missouri reported to have poor vigor was uprooted and the vines left in place for inspection for root damage. On 15 June 2009, row and vine position for each of 80 uprooted vines (ten vines spaced 30 m apart in eight rows), and numbers of grape root borer larvae and old tunnels per vine were recorded.

In 2011, we compared the efficacy of mating disruption and mass trapping in grape vine treatment plots in the Ste. Genevieve, Missouri vineyard where grape root borer trap counts were much higher than the three vineyards further west sampled from 2007 to 2009. Treatments (2 or 5 replicates) were set out on 17 June or 21 July 2011 (first flight was in mid-July) as follows: 1) mating disruption: 494 Isonet-Z dispensers per ha were tied to the top trellis wire every 6.7 m in each grape row with rows 3 m apart in plots of 2.4 ha and 3.2 ha; 2) mass trapping: 2.5 green bucket traps per ha were attached to the top trellis wire of every 20th row (rows 3 m apart) and spaced 66 m apart within that row in plots of 2, 2, 3.2, 3.2 and 4 ha; 3) untreated control in both a 2.4- and 3.2-ha plot. Treatment plots under mating disruption and untreated control each had four green bucket traps to estimate seasonal numbers of grape root borer males flying in each plot. Bucket trap counts of grape root borer males were recorded for all plots on 19 July and 24 August when trap lures were replaced, and 20 September.

Statistics

The number of grape root borer males captured per trap was compared across treatments using analysis of variance. Means were separated using Tukey's Studentized Range (HSD) test (α=0.05) (SAS Institute, 2003). Data were $\log_{10}(x+1)$ transformed to satisfy model assumptions. Untransformed means and standard errors are reported in the tables and figures.

RESULTS

Lure Attraction

In Florida, grape root borer sex pheromone-baited traps captured significantly more grape root borer males than traps baited with leopard moth pheromone dispensers

which was significantly different from unbaited traps in control plots on each sampling date (F=27.12; df=2,18; P<0.0001) (Fig. 2). No males were caught in the control treatment.

Mating Disruption

In Florida, no grape root borer moths were caught in the two vineyards each with three mating disruption plots treated with Isonet-Z dispensers at one of three rates: every other vine (741 dispensers per ha); every other vine of every other row (370 dispensers per ha); and on all border plants (127 dispensers per ha) around the 600 vine treatment plots (Fig. 3). However, bucket traps in both control treatment plots captured grape root borer males with higher total catch recorded throughout the sampling period in Lithia, Florida (Fig. 3A) than in Spring Hill, Florida where trap capture was zero until after early-August (Fig. 3B).

Mass Trapping and Mating Disruption in Missouri and Arkansas

Mass trapping with 16 bucket traps in 6.5 ha grape plots resulted in a variety of outcomes. For 2007, 2008 and 2009, respectively, trap counts in: Hermann, Missouri in the 'Vidal' grape plot dropped each year from 218 to 161 to 43 moths; Bethel Heights, Arkansas the counts in the 'Concord' grape plot dropped from 158 to 41 and leveled off at 39 moths; but in Hindsville, Arkansas, the counts in the 'Concord' grape plot increased from 3 to 7 and then jumped to 77 moths in 2009 (Fig. 4). In Ste. Genevieve, Missouri, the mass trapped 'Chardonel' grape plot had extremely high catches of 899 (2007) and 1361 (2008) grape root borer males. In 2009, the 6.5 ha plot of 'Chardonel' vines were dug and 80 roots inspected: 71% of roots had empty grape root borer tunnels (past damage); but only 15% of those infested vines had mature grape root borer larvae (presumably from eggs laid in 2007), and no smaller larvae (from eggs laid in 2008) (Fig. 5).

In 2011, in Ste. Genevieve, Missouri, season total counts of grape root borer males in bucket traps were: zero in two plots under mating disruption; 9 and 17 males in two untreated control plots; and counts varied from 11 to 103 males in bucket traps in the five plots under mass trapping (Table 1).

Mass trapping grape root borer males with 2.5 traps per ha baited with grape root borer sex pheromone took a total of 40 min per season or 7 min each month to set out and replace lures and vaportapes in each green bucket trap and remove and replace traps if flight still occurring at harvest to prevent damage to traps by the harvester. An approximate seasonal cost per ha for supplies for each tactic are as follows: $ 124 per ha (1 hour labor) to use mating disruption at a density of 127 Isonet-Z dispensers per ha; $ 163 per ha to apply the recommended rate of chlorpyrifos (3 kg Lorsban 75WDG per ha) as an insecticidal soil barrier to kill grape root borer larvae; and mass trap grape root borers using density of 2.5 traps per ha using three grape root borer sex pheromone lures per season (replaced monthly) in either a plastic wing trap at cost of $ 25 per ha or green bucket traps (last for 3 years) at cost of $ 44 per ha.

DISCUSSION

Isonet-Z dispensers were not as attractive to grape root borer as the grape root borer sex pheromone blend because the Isonet-Z-dispenser only has the major component (and in smaller quantities and lower percentage) of the grape root borer pheromone. In addition, the minor component in the Isonet-Z dispenser is completely different to that produced by the grape root borer female. If the pheromone blend is not a match to the natural blend, the response from the target pest (grape root borer males) is much lower (Snow et al., 1987). This decreased response of grape root borer males to Isonet-Z dispensers was shown in Sanders et al. (2011) and cited in Weihman and Liburd (2006). In addition to the attractiveness of the pheromone, the amount of pheromone used also affects mating disruption efficacy. The load rate of lure used for grape root borer is 1 mg of grape root borer pheromone, whereas each twist tie has about 0.7 mg of leopard moth

pheromone.

There were four spatial distributions and rates per ha used for placement of Isonet-Z pheromone dispensers in vineyards in Florida or Missouri including dispensers placed on: every other vine in row (740 per ha); spaced 6.7 m apart in each grape row (500 per ha); every other vine in every other row (370 per ha); or every vine around the vineyard perimeter (127 per ha). All four rates disrupted grape root borer mate-finding as noted by zero catch of grape root borer males in monitoring traps baited with the more attractive standard grape root borer blend. Weihman and Liburd (2006) had similar results using 635 Isonet-Z pheromone dispensers per ha. Our results indicate that the lowest rate of 127 dispensers per ha placed around the vineyard perimeter would be sufficient to disrupt grape root borer mating. Full vineyard plot tests need to be conducted to further compare efficacy against grape root borer of Isonet-Z dispensers placed either on every other vine in every other row (370 per ha) or on every vine around the vineyard perimeter (127 per ha) to the standard Lorsban (chlorpyrifos) treatment of soil under vines and to an untreated control vineyard.

Mass trapping grape root borer males with 2.5 traps per ha did reduce local trap catch of grape root borers in subsequent years in two plots, but did not eliminate all grape root borers from a plot area nor prevent all egg laying (Fig. 5). The mass trapping of 2,260 grape root borer males from the Ste. Genevieve 'Chardonel' plot may have reduced the root infestation by grape root borer larvae to only 15% compared with the 71% of roots with old tunneling. In addition, we did not find small one-year-old larvae in roots in 2009, indicating success by mass trapping the second year in 2008. In Lancaster, Pennsylvania, Keen (2006) used 81 bucket traps (27 of each color: green, yellow and white) in a 1 ha 'Chambourcin' plot presumably for mating disruption, but in reality he was mass trapping because total trap counts were: 239 grape root borer males in 2002 (2 traps); he then used the 81 traps to capture 224, 144 and 266 grape root borer males in 2003, 2004 and 2005, respectively. Given that the grape root borer has a three year larval life cycle in the northern portion of its range (Pennsylvania, New Jersey and Maryland), a majority of the moths captured in 2005 could have been from eggs laid in 2002 when only two traps were used.

Counts of grape root borer males mass trapped and pupal skins per 160 vines increase in vineyards as you travel east from Hindsville, Arkansas to Ste. Genevieve, Missouri. The pupal skin counts by location for 2007, 2008 and 2009 were as follows: all zeros in Hindsville, Arkansas; 7 in 2009 in Bethel Heights, Arkansas; 1, 0 and 0 in Hermann Missouri; and 12 and 32 skins in Ste. Genevieve. The extremely low grape root borer trap counts in 2007 and 2008 in the 'Concord' plot in Hindsville, Arkansas are partially attributed to site selection of a 44 ha vineyard (all <10 years old in 2007). Specifically, cow pasture borders three sides and a woodlot is 2 km to the north of this 'Concord' plot. The woodlot had wild grapes and other understory plants that were all removed in 2005 and 2006 to lessen the overwintering habitat for grape berry moths and grape root borers.

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Tables

Table 1. Sample date mean number per green bucket trap and season total number of male grape root borer moths captured where each trap was baited with 1 mg of grape root borer sex pheromone in grape vineyards under mating disruption with 494 Isonet-Z dispensers per ha, mass trapping using green bucket traps at a rate of 2.5 traps per ha, or untreated controls in Ste. Genevieve, MO (2011).

Treatment[1]	Cultivar (ha/# traps)	Mean number of grape root borer males per trap			Season total per plot
		19-Jul.	24-Aug.	20-Sep.	
Mating disruption	Chambourcin (2/4)	0	0	0	0
Mating disruption	Frontenac (2/4)	0	0	0	0
Mass trap	Chambourcin (2/16)	-[2]	1.3	0.1	22.0
Mass trap	Frontenac (2/4)	-[2]	2.5	0.3	11.0
Mass trap	Vignoles (3.2/8)	-[2]	8.5	0.4	71.0
Mass trap	Vignoles (3.2/8)	-[2]	5.7	0	102.0
Mass trap	Norton (4/10)	0.1	2.0	0	23.0
Control	Norton (2.4/4)	0.5	3.8	0	17.0
Control	Norton (3.2/4)	0.5	1.8	0	9.0

[1] Mating disruption and control plots each had four monitoring bucket traps.

[2] Pheromone-baited traps set out in vineyard on 21 July, the week that grape root borer flight began in Missouri.

Figures

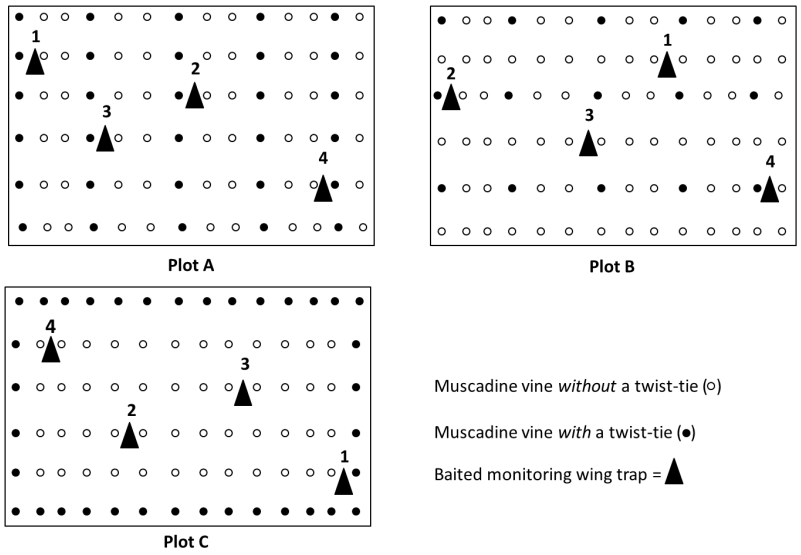

Fig. 1. Mating disruption treatment plots of 600 muscadine vines in Florida (2011). Plot A) 741 Isonet-Z Leopard moth pheromone dispensers per ha; Plot B) 370 Isonet-Z dispensers per ha; C) Isonet-Z dispensers on all border vines. The experiment also included two control plots with no dispensers.

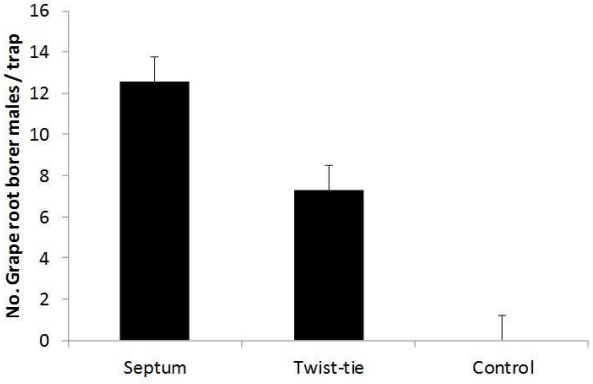

Fig. 2. Mean (±SE) number of grape root borer males captured in wing traps baited with either grape root borer pheromone (Septum) or leopard moth pheromone (Twist-tie), and an unbaited control trap in muscadine vineyards in Florida (2011). All three means were significantly different (P<0.0001) by Tukey's Studentized Range (HSD) test (α=0.05).

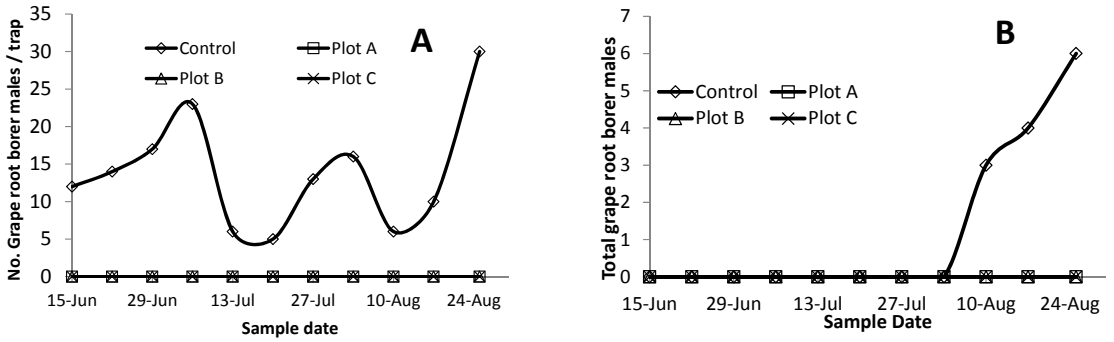

Fig. 3. Total trap capture of grape root borer males in wing traps baited with grape root borer pheromone in four mating disruption treatment plots in a muscadine vineyard in A) Lithia, Florida and B) Spring Hill, Florida (2011). Plot A: 741 Isonet-Z Leopard moth pheromone dispensers per ha; Plot B: 370 Isonet-Z Leopard moth pheromone dispensers per ha; Plot C: Isonet-Z Leopard moth pheromone dispensers on all border vines; Control with no dispensers.

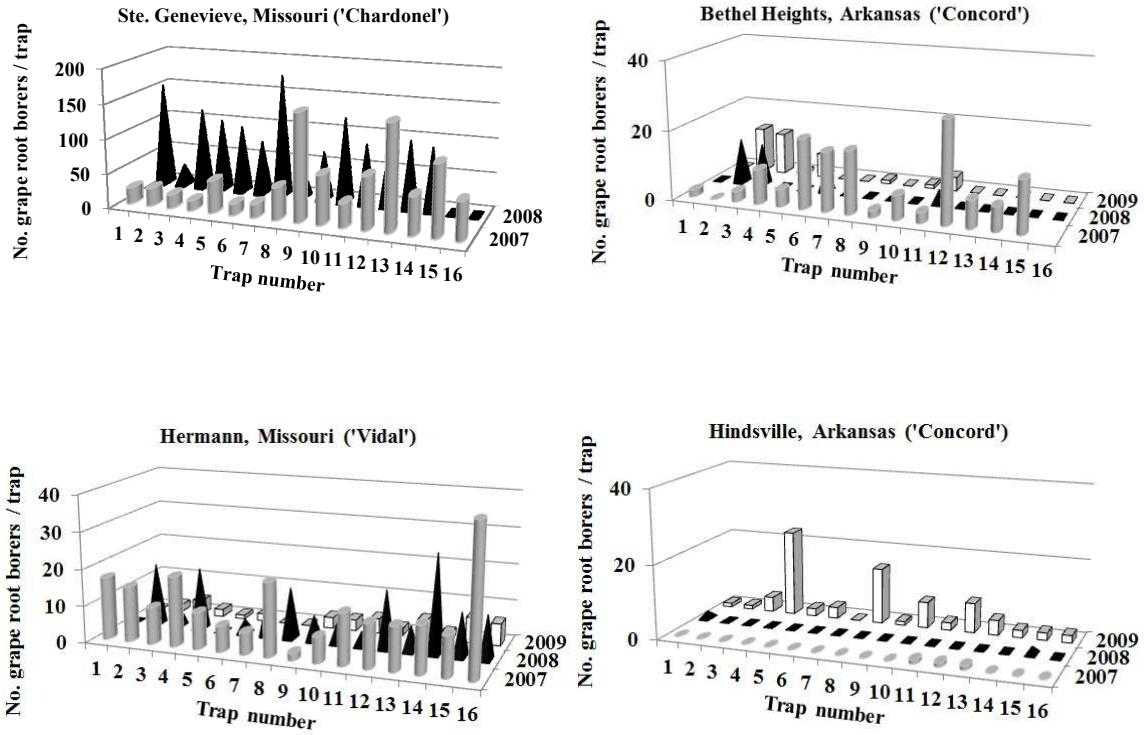

Fig. 4. Season totals (mid-June through August) of grape root borer males captured in green bucket traps baited with 1 mg grape root borer sex pheromone. Traps were placed at a density of 2.5 traps per ha in four 6.5 ha grape vineyard plots in either Arkansas or Missouri from 2007 to 2009. The Ste. Genevieve vineyard was removed in June 2009 due to poor vigor.

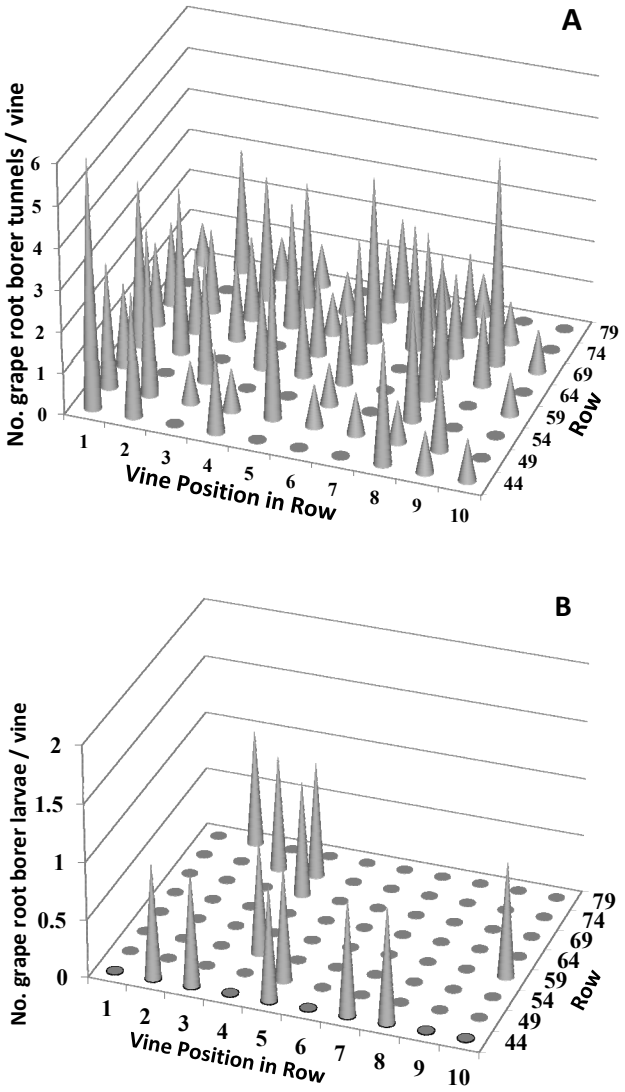

Fig. 5. 'Chardonel' grape vineyard (6 ha) in Ste Genevieve, Missouri in June 2009 showing: A) number of grape root borer tunnels; and B) number of grape root borer larvae in grape roots after mass trapping grape root borer moths in 2007 and 2008 with 2.5 grape root borer pheromone-baited bucket traps per ha.