Comparison of Baited and Unbaited Traps for Monitoring Plum Curculios in Apple Orchards

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In the Summer 1998 issue of *Fruit Notes*, we presented two articles describing results of 1998 tests in which we evaluated responses of plum curculio (PC) adults to several different types of unbaited traps in commercial and unsprayed orchards. Here, we report on 1999 tests in which we evaluated not only unbaited but also baited versions of the same types of traps tested in 1998 as well as a new trap type called a circle trap.

Materials & Methods

In eight commercial orchards, we evaluated three types of traps: (a) black pyramid traps (24 inches wide at base x 48 inches tall) placed on the ground next to apple tree trunks, (b) black cylinder traps (3 inches diameter x 12 inches tall) fixed vertically onto horizontal branches within apple tree canopies, and (c) aluminum-screen "circle" traps (developed in Oklahoma for pecan weevils) and wrapped tightly around ascending tree limbs, designed to intercept PC adults walking upward. Traps were placed in six blocks of apple trees in each orchard. Each block consisted of seven perimeter trees. Each tree (save one) contained one unbaited and one baited trap of the above types. The bait consisted of a combination of one polyethylene vial containing limonene and two polyethylene vials containing ethyl isovalerate (components of host fruit odor found to be attractive to PCs in 1998 studies) plus one rubber septum impregnated with grandisoic acid (attractive male-produced pheromone of PC). Vials were attached to the exterior of traps at mid height, and the septum was placed inside the inverted wire-screen funnel (boll weevil trap top) that capped each trap and captured responding PCs. All traps were deployed at bloom and were examined for captured PCs every 3 to 4 days for 6 weeks thereafter. At each trap examination, 15 fruit on each of the seven trees per block were examined for PC oviposition scars. All blocks received two grower-applied sprays of azinphosmethyl to control PC.

In three small unsprayed orchards, we evaluated unbaited and baited pyramid and cylinder traps as well as clear Plexiglas squares (2 feet x 2 feet) fastened vertically 5 feet above ground to wooden poles seated in the ground. One side of each Plexiglas square was coated with Tangletrap to capture alighting PCs. Plexiglas traps were positioned with sticky-side facing woods either 6 feet from the edge of woods or 1 foot outside of perimeter foliage of apple trees. Traps were placed in four blocks of apple trees in each orchard. Each block consisted of six perimeter trees. Each tree contained one unbaited and one baited trap (above type bait) of each trap type. Each block in two of the orchards also received one unbaited and one baited clear Plexiglas trap placed at the edge of woods. All traps were emplaced at bloom. Every 3 to 4 days thereafter for 6 weeks, traps were examined for captured PCs, and fruit were examined for PC scars. No insecticide was applied to any of the blocks.

Results

In commercial orchards, significantly more (about three-times more) total PCs were captured by pyramid traps than by cylinder traps, with circle traps capturing no PCs (Figure 1). There was no significant difference in captures between unbaited and baited traps of any type (Figure 1). Disappointingly, none of the three types of baited or unbaited traps yielded captures whose amount or phenology (pattern of occurrence over time) reflected even in a very minimal way the amount or phenology of egglaying injury to fruit caused by PC. If there were a perfect relationship between trap captures and injury, then the statistical indicator of such a relationship (called r) would have a value of 1.00. Here, the r value describing the relationship between

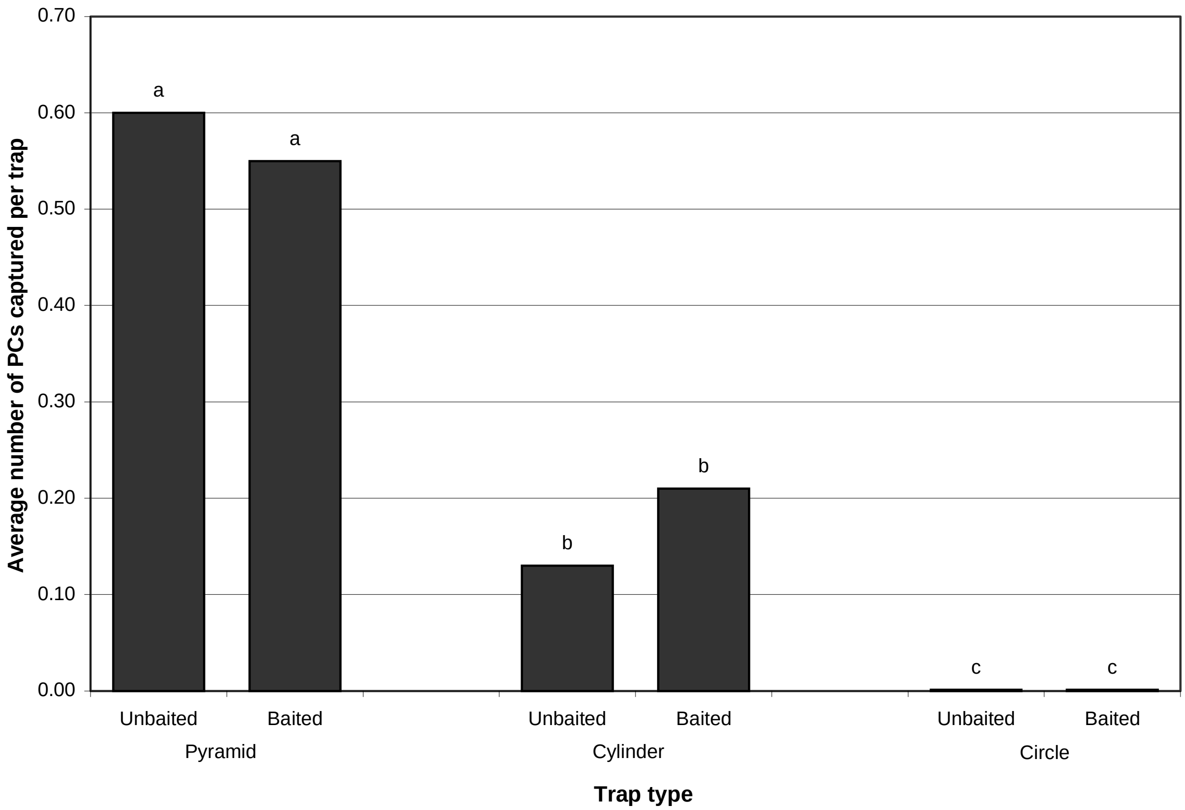

Figure 1. Captures of plum curculios on unbaited and baited pyramid, cylender, or circle traps in commercial orchards. Bars not superscribed by the same letter are significantly different at odds of 19 to 1.

abundance of PCs in traps and amount of injury never exceeded 0.37 for any type of unbaited or baited trap, and the r value describing the relationship between time of capture of PCs in traps and time of injury did not exceed 0.24 for any type of unbaited or baited traps.

In unsprayed orchards, significantly more (about eight times more) PCs were captured by pyramid traps than by cylinder traps, with clear Plexiglas traps positioned next to apple trees capturing slightly, but not significantly, more PCs than cylinder traps (Figure 2). Captures by unbaited versus baited traps did not differ significantly among any of these three trap types (Figure 2). However, baited clear Plexiglas traps placed at the edge of woods captured significantly more PCs (about 14 times more) than similarly positioned unbaited traps (Figure 2). In contrast to above findings in commercial orchards, r values describing the relationship between abundance of PCs in traps and amount of injury ranged between 0.75-0.89 for unbaited and baited pyramid and clear Plexiglas traps placed next to perimeter apple trees. Less encouraging, however, were r values describing relationship between time of capture of PCs in traps and time of injury, which did not exceed 0.22 for any type of unbaited or baited trap.

Conclusions

Perhaps the most encouraging finding from this study was the positive response of PCs to baited sticky clear Plexiglas traps placed next to woods. In the future, a simpler and more attractive version of this type of baited trap could be very useful for monitoring the beginning, peak and (most importantly) the end of immigration of overwintering PCs from woods or hedgerows into orchards.

The reason why odor bait significantly enhanced PC captures by clear Plexiglas traps near woods but not captures by any of the various types of traps placed adjacent to, beneath or within canopies of perimeter apple trees is uncertain but could be related to use of too high a dose of ethyl isovalerate, one of the odors used a component of the bait. The extra high dose used here turned out to be about six times greater than the medium dose found to be attractive in subsequent tests (see following article) and, at close range for PCs

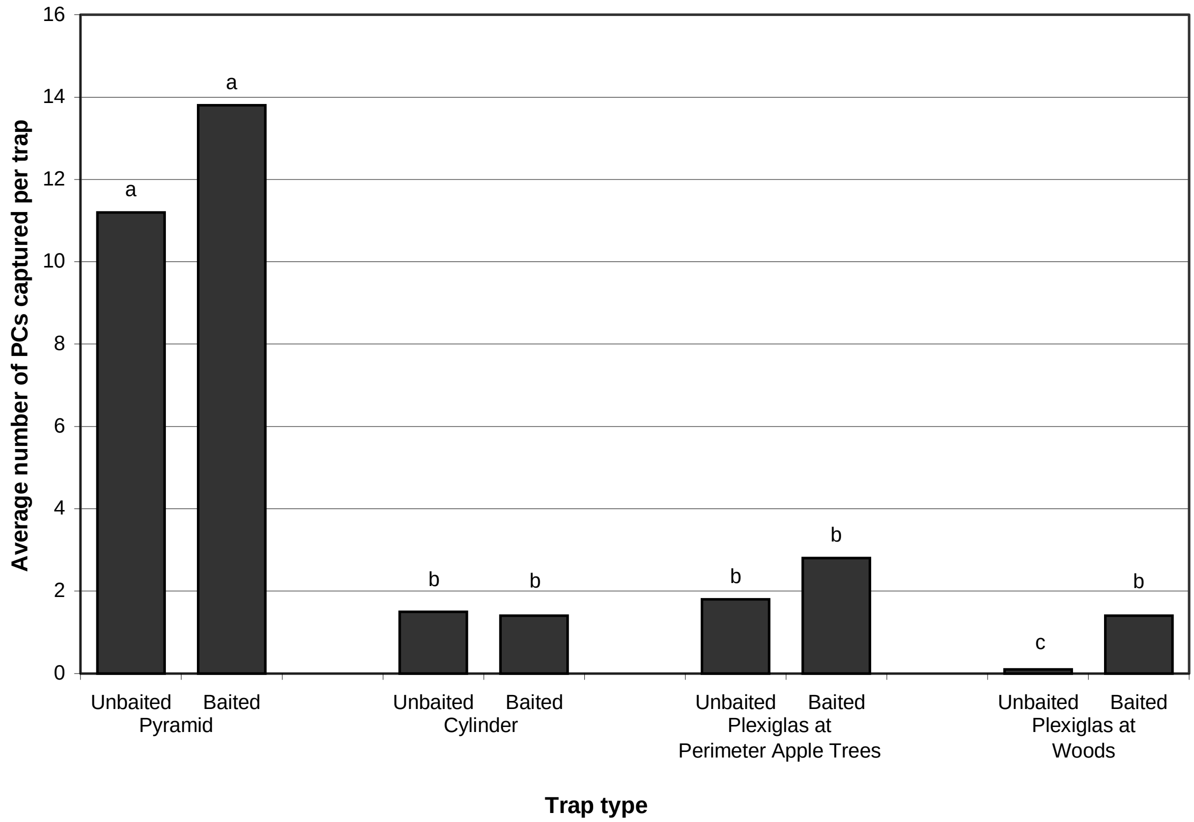

Figure 2. Captures of plum curculios on unbaited and baited pyramid, cylinder, or clear Plexiglas traps in unsprayed orchards. Bars not superscribed by the same letter are significantly different at odds of 19 to 1.

crawling toward pyramid, cylinder, or circle traps, could have negated attractiveness of limonene and/or grandisoic acid.

None of the unbaited or baited traps placed adjacent to, beneath, or within apple tree canopies represented improvement over traps tested in 1998 in terms of ability of trap captures to reflect the time of occurrence of PC injury to fruit. It is of little value to spend more time and effort to deploy PC traps in association with apple trees if one can not realize a principal benefit of doing so: being able to predict time periods when PC injury is most likely to occur based on increases in captured PCs. Further research is needed to achieve this benefit.

Acknowledgements

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Fruit Odors Are More Attractive than Conspecific Odors to Adult Plum Curculios

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Many species of weevils are attracted to host plant odors and to weevil-produced aggregation and/or sex pheromones. In many cases, when host plant odors and pheromones are deployed in combination, weevil attraction is greater than to either odor type alone. Plum curculios (PCs) have been shown to be attracted to host fruit odors and to a male-produced aggregation pheromone, grandisoic acid, identified in PCs by Eller and Bartelt of Illinois, but little is known about the level of PC attraction to a combination of host fruit and pheromonal odors.

Successful monitoring systems deploying both host plant and pheromonal odors have been created for several species of weevils. Although a reliable monitoring system for detecting adult PC entry into orchards from overwintering sites does not exist, the deployment of attractive odors such as those from host fruit and/or pheromone in conjunction with a trap that is also visually attractive to adult PCs could prove to be successful.

In the1998 Winter issue of *Fruit Notes*, we presented preliminary results from bioassays conducted in large Plexiglas arenas designed to assess PC attraction not only to fruit odors but also to odors emitted by other PCs. Here we provide more detailed results of PC attraction to fruit odors, odors emitted by other PCs, synthetic grandisoic acid, and fruit odors combined with odors emitted by other PCs or with synthetic grandisoic acid.

Materials & Methods

Large clear Plexiglas arenas with dimensions of 24x24x12 inches and Plexiglas lids were used as still-air arenas for the following experiments. Source materials to be tested as emitting potentially attractive odors were placed in small cotton bags hung in the upper corners (one per corner) of each arena.

Either ten male or ten female PCs starved for 24 hours and chilled 30 minutes prior to testing were released into the center of an arena at the beginning of darkness. Numbers of PCs that crawled to within one-half inch of an odor source held inside a cotton bag were recorded every 10 minutes for 1 hour. Each trial was repeated at least eight times, each time rotating the position of cotton bags containing odor sources.

Treatments tested as potentially emitting attractive odors included five freshly picked wild plums, five male or female PCs, synthetic grandisoic acid impregnated into small rubber septa (at a low and a high dose of 0.03 ug and 3.00 ug, respectively), or five wild plums in combination with five male PCs, five female PCs, grandisoic acid at a low or high dose, or a green fruit worm (GFW) larva. A GFW was used to simulate plums that had been fed upon by a non-PC insect because we wanted to learn if odor released from plums that were being fed upon by PCs and/or odor from PCs that were feeding on plums was attractive to other PCs.

The total number of PC responders to a particular odor treatment was tallied over the six 10-minute intervals for each of the four treatments to provide a total response score for each treatment for every experiment. Results presented here reflect the mean number of PCs attracted to each treatment over all total response scores.

Results

Male Responses to Females. In Arena One (Table 1), males did not respond to the odor of females alone compared to controls, but in Arena Two, males responded to odor of females held with plums in signifi-

Table 1. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which female PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Females*	*Control 1*	*Control 2*	*Control 3*
	0.9 a	1.0 a	0.5 a	0.4 a
Two	*5 Females*	*5 Plums*	*5 Females + 5 plums*	*Control 1*
	0.2 b	2.4 b	14.3 a	0.4 b
Three	*5 Females + 5 plums*	*Control 1*	*5 Males + 5 plums*	*Control 2*
	14.2 a	0.4 c	6.4 b	0.1 c
Four	*5 Females + 5 plums*	*Control 1*	*1 GFW + 5 plums*	*Control 2*
	14.8 a	0.7 c	8.0 b	0.6 c

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 2. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which male PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Males*	*Control 1*	*Control 2*	*Control 3*
	0.9 a	0.4 a	0.8 a	0.5 a
Two	*5 Males*	*5 Plums*	*5 Males + 5 plums*	*Control 1*
	0.2 c	5.2 b	11.3 a	0.3 c
Three	*5 Males + 5 plums*	*Control 1*	*1 GFW + 5 plums*	*Control 2*
	11.1 a	0.2 b	8.1 a	0.5 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

cantly greater numbers than to females alone or plums alone. Males also responded to odor of females held with plums in significantly greater numbers than to males held with plums or a GFW held with plums in Arenas Three and Four, respectively.

Male Responses to Males. In Arena One (Table 2), males did not respond to odor of males alone compared to controls, but in Arena Two, males responded to odor of males held with plums in significantly greater numbers than to males alone or plums alone. In Arena Three, males responded in statistically similar numbers to odor of males held with plums and to a GFW held with plums.

Female Responses to Females. In Arena One (Table 3), females responded in significantly greater numbers to females alone compared to controls. Comparisons in Arena Two of odors of females alone, plums alone, and females held with plums yielded statistically similar responses to plums alone and females held with plums, though responses to females held with

Table 3. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which female PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Females*	*Control 1*	*Control 2*	*Control 3*
	3.3 a	0.3 b	0.0 b	0.8 b
Two	*5 Females*	*5 Plums*	*5 Females + 5 plums*	*Control 1*
	0.6 b	4.2 ab	6.7 a	0.7 b
Three	*5 Females + 5 plums*	*Control 1*	*5 Males + 5 plums*	*Control 2*
	7.2 a	0.3 b	6.6 a	0.9 b
Four	*5 Females + 5 plums*	*Control 1*	*1 GFW + 5 plums*	*Control 2*
	12.6 a	0.4 b	12.3 a	0.9 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 4. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which male PC odors were included in at least one treatment per arena.

Arena	**Treatments**			
One	*5 Males*	*Control 1*	*Control 2*	*Control 3*
	3.1 a	0.3 b	0.1 b	0.4 b
Two	*5 Males*	*5 Plums*	*5 Males + 5 plums*	*Control 1*
	0.9 b	7.0 a	7.6 a	0.7 b
Three	*5 Males + 5 plums*	*Control 1*	*1 GFW + 5 plums*	*Control 2*
	14.6 a	1.1 b	6.6 a	0.0 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

plums were significantly greater than to females alone. Females also responded in statistically equal numbers to odor of females held with plums compared to males held with plums and to a GFW held with plums in Arenas Three and Four, respectively.

Female Responses to Males. In Arena One (Table 4), females responded in significantly greater numbers to males alone compared to controls. Comparisons in Arena Two of odors of males alone, plums alone, and males held with plums yielded statistically similar responses of females to plums alone and females held with plums and significantly greater responses to both than to males alone. Females also responded in statistically similar numbers to odor of males held with plums and to a GFW held with plums in Arena Three.

Male Responses to Grandisoic Acid. Males did not respond to odor of grandisoic acid at either a low or high dose in Arenas One and Two, respectively (Table 5). Statistically similar responses were recorded for males to plums alone and to grandisoic acid held

Table 5. Mean numbers of male PCs moving to within 1/2 inch or onto cotton bags of each treatment in which odor of grandisoic acid, either low (l) or high (h) dose, was included in at least one treatment per arena.

Arena	**Treatments**			
One	*Grandisoic acid (l)* 2.0 a	*Control 1* 1.8 a	*Control 2* 1.9 a	*Control 3* 2.9 a
Two	*Grandisoic acid (h)* 1.3 a	*Control 1* 2.1 a	*Control 2* 2.3 a	*Control 3* 1.4 a
Three	*Grandisoic acid (l)* 1.1 b	*5 Plums* 10.0 a	*Grandisoic acid (l) + 5 plums* 10.5 a	*Control 1* 0.5 b
Four	*Grandisoic acid (h)* 1.0 b	*5 Plums* 5.9 a	*Grandisoic acid (h) + 5 plums* 7.3 a	*Control 1* 1.5 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

Table 6. Mean numbers of female PCs moving to within 1/2 inch or onto cotton bags of each treatment in which odor of grandisoic acid, either low (l) or high (h) dose, was included in at least one treatment per arena.

Arena	**Treatments**			
One	*Grandisoic acid (l)* 3.5 a	*Control 1* 0.9 b	*Control 2* 0.6 b	*Control 3* 0.6 b
Two	*Grandisoic acid (h)* 2.0 a	*Control 1* 1.6 a	*Control 2* 1.8 a	*Control 3* 1.9 a
Three	*Grandisoic acid (l)* 1.8 b	*5 Plums* 11.0 a	*Grandisoic acid (l) + 5 plums* 5.6 ab	*Control 1* 2.3 b
Four	*Grandisoic acid (h)* 1.9 b	*5 Plums* 5.9 a	*Grandisoic acid (h) + 5 plums* 7.9 a	*Control 1* 2.1 b

* Means within rows not followed by the same letter are significantly different at odds of 19:1.

with plums at both the low and high dose in Arenas Three and Four, respectively.

Female Responses to Grandisoic Acid. Females responded in significantly greater numbers to grandisoic acid than to controls at a low dose in Arena One but not at a high dose in Arena Two (Table 6). Statistically equal responses were recorded for females to plums alone and grandisoic acid held with plums at both a low or high dose in Arenas Three and Four, respectively.

Conclusions

We conclude that females produce an odor that is attractive to males, but attraction occurs only when females are feeding on plums. Although females were attracted to males alone and synthetic grandisoic acid alone in significantly greater numbers than to controls, these responses were quickly lost when host fruit odor was included. Both males and females were equally attracted to odors of males feeding on plums and synthetic grandisoic acid held with plums when compared to plums alone, indicating that attraction to host fruit odor was not enhanced by the presence of male-produced or synthetic pheromonal odor. However, synthetic grandisoic acid impregnated into rubber septa may not have been very attractive due to chemical binding to septa but could be more attractive if formulated differently. In general, our studies revealed that fruit-based odors are the most attractive to PCs and that only minor contributions are made by addition of conspecific odors or grandisoic acid. Therefore, we conclude that attractive fruit-based volatiles should be the main additive to an attractive visual trap to create a successful monitoring system for PCs.

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Several Host-odor Compounds are Attractive to Plum Curculio Adults

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As revealed in the preceding two articles, traps developed for monitoring plum curculio (PC) adults in commercial orchards are unlikely to succeed unless baited with powerful attractive odor, the most promising type being attractive host fruit odor. To date, 56 compounds have been identified as components of odor of plum or apple fruit at the most attractive stage to PC (2 weeks after bloom). In the Summer 1998 issue of *Fruit Notes*, we presented results of 1998 tests evaluating 16 of these 56 compounds. Two were found to be attractive to PC: limonene and ethyl isovalerate. Here, we describe results of 1999 tests in which 30 of the 56 host-odor compounds (including the 16 compounds of 1998) were evaluated in field tests for attractiveness to PC.

Materials & Methods

Of the 56 compounds, 46 were identified in the laboratory by Larry Phelan in Ohio and 10 were identified in the laboratory of Sylvia Dorn in Switzerland. We chose to evaluate the 30 compounds that were most readily available from a commercial source (Aldrich Chemical Company) and least expensive to purchase (less than $5.00 per gram).

Each compound was introduced into a 2-dram polyethylene vial and assessed at three different rates of odor release, so as to create a low, moderate, or high dose of odor concentration in the surrounding air. Release rates were varied either by adding mineral oil to the contents of a vial to reduce release rate or drilling small holes in a vial just beneath the cap to increase release rate. Intended release rates for each compound were 3, 12, and 48 milligrams of odor per day, but it was not always possible to achieve intended precision with each compound.

Compounds were assayed in association with yellow-green boll weevil traps placed on the ground beneath perimeters of unsprayed apple tree canopies in Massachusetts and Ohio. PCs frequently drop from host tree canopies to the ground and thus may encounter odor from a nearby baited trap. Each trap was baited either with two vials containing the same compound at the same release rate or two empty vials. Vials were suspended vertically by wire attached to the base of the screen funnel top of the trap. Over a 7-week period from early May to late June, 360 traps were deployed in Ohio and another 360 in Massachusetts for compound evaluation. Traps were examined for captured PCs and rotated in position daily or every other day.

To measure attractiveness of a particular release rate of a particular compound, a Response Index (RI) was created by subtracting the number of PCs responding to an unbaited control trap (C) from the number responding to a baited trap (BT), dividing by the total number of PCs captured by the C and BT traps and multiplying by 100. Thus RI = [(BT-C)/(BT+C)] x 100. The greater the RI, the more attractive the compound at that release rate.

Results

Results (Table 1) show that 13 of the 30 compounds had RI values of 32 or greater (= minimum RI value for statistical significance) at the most attractive release rate. In descending order of attractiveness, these were E-2- hexenal (RI=90), hexyl acetate (67), decanal (64), limonene (64), geranyl propionate (59), 1-

Table 1. Response index (RI) of plum curculio adults to 30 host fruit odor compounds evaluated at three different release rates. For each compound, only that release rate which yielded the highest RI value of all (either from Massachusetts or Ohio) is given.

Compound	Release rate	RI*
Benzaldehyde	Low	46
Benzonitrile	Medium	-7
Benzothiazole	High	27
Benzyl Alcohol	Low	44
Decanal	Low	64
Ethyl Acetate	High	13
Ethyl Butyrate	Medium	4
Ethyl Isovalerate	Medium	40
Geranyl propionate	Medium	59
1-Hexanol	Medium	13
2-Hexanol	High	32
3-Hexanol	Medium	4
2-Hexanone	Medium	4
3-Hexanone	High	13
E-2-Hexenal	Medium	90
Hexyl Acetate	High	67
3-Hydroxy-2-butanone	High	27
Isopropyl acetate	Low	20
Limonene	Medium	64
Linalool	High	13
3-Methyl-1-butanone	Medium	-7
2-Methyl-3-buten-2-ol	Medium	13
1-Pentanol	Medium	59
2-Pentanol	High	35
3-Pentanol	Medium	4
1-Penten-3-ol	High	4
Phenylacetaldehyde	High	32
2-Phenylethanol	Low	20
2-Propanol	Medium	32
E-2-Nonenal	Medium	0

* RI values of 32 or greater are significantly different from zero at odds of 17 to 1.

pentanol (59), benzaldehyde (46), benzyl alcohol (44), ethyl isovalerate (40), 2-pentanol (35), 2-hexanol (32), phenylacetaldehyde (32), and 2-propanol (32).

Conclusions

These results strongly confirm previously-reported attractiveness of limonene and moderately confirm previously-reported attractiveness of ethyl isovalerate. In addition, five other compounds not among the 16 compounds tested in 1998 were found to be notably attractive here (RI value of 40 or greater): benzyl alcohol, decanal, geranyl propionate, hexyl acetate, and 1-pentanol. Also, two compounds that were among the 16 tested in 1998, but not found to be attractive then, were attractive here (perhaps because of a more favorable release rate here): benzaaldehyde and E-2-hexenal. These findings offer promise that one or more of these attractive compounds alone (or together in a blend) at an appropriate release rate can be applied to visual traps to substantially enhance capture of PCs.

Acknowledgements

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Evaluation of Kaolin Clay (Surround™) for Control of Plum Curculio

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Developing an effective trap for monitoring plum curculio (PC) in orchards would provide a means for determining the need and time to apply an insecticide treatment for controlling this pest. The question then arises of what insecticide to use. For the past 30 or more years, azinphosmethyl and phosmet have been the recommended materials against PC. Conceivably, new regulations under the Food Quality Protection Act may seriously compromise future use of these and other insecticides in orchards.

Therefore, in 1999 we decided to evaluate a new material, called Surround™, as a candidate for controlling PC. It consists entirely of particles of white kaolin clay, the same clay in fact that is used in porcelain pottery. Research to date by Michael Glenn and Gary Puterka of USDA's Appalachian Fruit research Laboratory in Kearneysville, West Virginia suggests that insects contacting foliage or fruit sprayed with an aqueous solution of Surround are not killed but instead are repelled. Apparently, the clay particles are very annoying to insects walking on treated surfaces and cause them to seek food and egglaying sites elsewhere.

Our 1999 tests of Surround against PC consisted of a small-scale trial conducted in a commercial orchard and preliminary trials conducted in the laboratory.

Materials & Methods

The orchard trial was carried out at the Prokopy Orchard in Conway using six rows of Liberty trees, each with five trees per row. Every other row was sprayed twice with Surround: once on May 31 (one week after petal fall) and again on June 8. Surround was applied at the recommended rate: 50 pounds per 100 gallons water, along with a manufacturer-provided adjuvant at 1 pound per 100 gallons water. Remaining rows were sprayed once (May 31) with phosmet at the recommended rate: 1 pound of 70WP per 100 gallons water. A single perimeter tree in another row did not receive any insecticide against PC and served as an untreated control. No PC injury was observed in samples of fruit taken prior to insecticide application. On June 17 (just before June drop), ten fruit were sampled for curculio injury on each treated or untreated tree. Only 1/6 inch of rain fell between May 31 and June 17.

The laboratory trials involved caging PC adults singly with either (a) one untreated apple or one apple sprayed with Surround and adjuvant at above rate (termed a no-choice test), or (b) one untreated apple together with one Surround-treated apple (termed a choice test). These trials were conducted in August using adults that emerged from pupae about 2 weeks before testing and were starved for 1 day before testing. Apples were examined 24, 48, and 120 hours after initial exposure for feeding punctures made by adults (young adults, as used here, are unable to lay eggs).

Results

Results of the orchard trial showed that averages

Table 1. Percent apples injured by plum curculio adults in commercial orchard trees receiving two applications of Surround, one application of phosmet, or no treatment.

Treatment	Number of trees	Injured apples per tree (%)
Surround	15	6.0
Phosmet	15	3.3
Untreated	1	30.0

Table 2. Number of punctures in apples made by newly-emerged plum curculio adults confined singly in laboratory cages with either one Surround-treated apple together with one untreated apple (choice test) or one Surround-treated apple alone vs. one untreated apple alone (no-choice test).

			Mean no. punctures per fruit after		
Test	Apples	Number of replications	24 hours	48 hours	120 hours
Choice	Treated	36	0.0	0.0	0.0
	Untreated	36	1.7	2.8	4.7
No choice	Treated	36	0.4	0.8	1.8
	Untreated	36	1.7	3.3	5.8

of 3.3, 6.0, and 30.0% of sampled fruit were injured by PCs on phosmet-treated, Surround-treated, and untreated trees, respectively (Table 1). Results of laboratory trials showed that in choice tests, where adults could choose to feed on either an untreated or a Surround-treated apple, all feeding occurred on untreated apples (Table 2). However, in no-choice tests, where adults remained hungry if they did not feed on the lone type of apple provided, punctures on Surround-treated fruit reached about one-fourth the number on untreated fruit 24 and 48 hours after trials began and reached about one-third the number on untreated fruit after 120 hours.

Conclusions

Our combined findings suggest that Surround has definite potential as a material for preventing PC injury. In the orchard trial, two sprays of Surround were about half as effective as one spray of phosmet in preventing curculio injury. In laboratory trials, Surround was completely effective in deterring feeding by PCs on treated apples under conditions where untreated apples were nearby but was less effective in the absence of accessible untreated apples. These results indicate, therefore, that unless coverage of foliage and fruit by Surround is complete over space and continuous over time, Surround may not be able afford total protection against injury by PCs. A possible scenario for future control of PC could involve treatment of the great majority of trees in an orchard block with Surround coupled with placement of odor-baited visual traps at untreated trees to capture deterred but still-foraging adults.

As a final note, a new wettable-powder formulation of Surround has been developed that is reported to have greater residual effectiveness after rainfall than the formulation used in our 1999 tests. This new formulation is now officially registered for use on apples. After an application of Surround, the foliage and fruit are covered with a thin layer of white clay particles, giving the tree a white appearance. Rather than being a drawback, this is said to improve fruit color and fruit size.

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Food Quality Protection Act: An Update, February 2000

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Although the Food Quality Protection Act of 1996 requires that the EPA review all active ingredients currently registered, the spotlight continues to focus on the organophosphate (OP) class of compounds. These materials, the majority of which are insecticides, are labeled for a wide variety of uses including agricultural, veterinary, residential, and structural. EPA must first assess the aggregate risk to human health posed by these compounds on an individual basis by considering all potential routes of exposure. Cumulative assessment of the OP's as a group will be conducted at a later date.

To date, only two (azinphos methyl and methyl parathion) of the five active ingredients most commonly used in commercial tree fruit production have completed the EPA's six-step initial review process culminating in risk management recommendations. The balance (chlorpyriphos, dimethoate, and phosmet) is currently under active review. Discussions of two materials with only limited usage in tree fruits (diazinon and malathion) have only recently been initiated. The following is a summary EPA's findings and actions as of February 21, 2000.

Azinphos methyl – The initial review of azinphos methyl (Guthion, Sniper) was completed on August 2, 1999. As registered at that time, EPA concluded that azinphos methyl posed an unacceptable dietary risk to children ages 1 to 6 years, risks of concern to agricultural workers, and unacceptable ecological risks. To mitigate occupational and environmental concerns, the registrants volunteered to amend their labels by agreeing to delete the use of azinphos methyl on cotton in Louisiana and east of the Mississippi River on sugarcane, ornamentals (except for nursery stock), Christmas trees, shade trees, and forest trees.

The majority of label amendments effecting tree-fruit production were made prior to the 1999 growing season as the registrants were aware of EPA's concerns prior to the final decision and acted accordingly. Additional changes for the upcoming season include a reduction in total amount of product allowed per acre per season from 12 to 9 pounds, a variable preharvest interval dependent on late-season application rates, and a prohibition on application by fixed-wing aircraft.

Methyl parathion – The revised risk assessment for methyl parathion (Penncap-M) also was made public in early August 1999. Although not widely used in the Northeast, methyl parathion has historically been applied to approximately 20% of the apple acreage and nearly 50% of the peach acreage in the U.S. EPA indicated their primary concern was acute dietary risk to children, a portion of the population specifically addressed by the FQPA.

In order to reduce the risk to this sensitive subpopulation, EPA accepted the registrant's voluntary cancellation of all children's food uses including fruit (apples, peaches, pears, grapes, nectarines, cherries, and plums), carrots, succulent peas, succulent beans, and tomatoes effective December 31, 1999. Additional food uses have been cancelled as well as non-food uses such as ornamentals, nursery stock, grasses grown for seed, and mosquito control.

Phosmet – Phosmet (Imidan) has reached a critical point in the review process. EPA's revised risk assessment was released and a technical briefing was held in Pasco, WA on February 10. This event officially began the 60-day public-comment period for submitting risk-mitigation proposals. The revised risk assessment indicated that acute dietary risk was **not** an issue, as phosmet accounted for an average of only 5% of the "risk cup" for all sub-groups. EPA also indicated that exposure to handlers (mixer/loader/applicators) could be managed satisfactorily with increased personal protective equipment and engineering controls such as closed loading systems and enclosed cabs.

However, EPA voiced concern for post application workers who may contact residues. Current information indicates that, depending on the rate used, acceptable margins of exposure may not be met until 37 to 52 days after application. Re-entry intervals of this magnitude would virtually eliminate phosmet as a pest-management option for many crops. The registrant and other meeting participants raised objections to some of the assumptions EPA used to compile the worker exposure assessment and presented information as to how the assessment could be refined further during the risk-mitigation phase.

Occupational exposure is regulated under FIFRA (Federal Insecticide, Fungicide and Rodenticide Act), **not FQPA**. As such, EPA is obligated to consider the benefits of a particular material when assessing its risk. Attendees reiterated to the EPA panel the importance of phosmet in existing IPM programs, its relatively low acute toxicity, its low impact on many beneficial species, the lack of viable alternative pest-management options, and the uncertain effects of potential replacement products on the crop ecosystems for consideration in determining the re-entry interval. EPA should release their risk-management recommendations by late May to early June.

Dimethoate – Dimethoate (Cygon) is currently in phase five of the review process since the release of the revised risk assessment and technical briefing in mid December. As with methyl parathion, this material has not been an important tool for producers in the Northeast but according to USDA surveys, dimethoate is applied to 35% of the total U.S. apple acreage and is labeled for approximately 40 other food crops.

Despite its widespread usage, EPA is not concerned with aggregate risk from diet or drinking water. Worker exposure and ecological issues seem to be their main concern. The registrants, U.S. Apple Association, and EPA currently are discussing methods to reduce this risk in tree fruits by utilizing increased the requirement for personal protective equipment, decreasing the maximum seasonal rates per acre, and lengthening reentry intervals for high contact activities such as hand thinning, summer pruning, and harvesting.

Chlorpyrifos – Chlorpyrifos (Lorsban) is somewhat in limbo in stage four of the review process. The public-comment period following the preliminary risk assessment ended December 27, and EPA currently is reviewing any new information that may have been put forth in preparation for releasing their revised risk assessment. No date has yet been set for the technical briefing, but it should occur sometime in late March. After that event, there will be another 60-day public-comment period, and then EPA will have up to 60 additional days to compile the final risk-mitigation proposal.

Diazinon and malathion – Both of these materials have just begun the review process. EPA has shared their first-tier risk assessments with the registrants for error comments only. Preliminary risk assessments have yet to be released for public review.

It is clear that EPA is making deliberate progress in implementing the legislation passed in August 1996. Initial review of the OP's should be completed by the third quarter of this year. The focus will then shift to the next two priority groups of pesticides: carbamates (Benlate, Topsin, Sevin, Lannate, Vydate) and potential carcinogens (Captan, mancozeb, Polyram), many of which are prominently used in commercial fruit production.

To date, with a few notable exceptions, dietary issues have played a secondary role to worker-exposure concerns in assessing the OP's. This may change in the future as EPA looks at cumulative risks associated with materials that have similar modes of action. In September 1999, the Scientific Advisory Panel agreed with EPA's intention to group certain carbamate pesticides with the OP's when assessing cumulative risk. Placing more materials in the same "risk cup" could reduce substantially the number of labeled uses that could be retained and still satisfy the requirements of the FQPA. Cumulative risk assessments have not been a part of the registration process in the past, and EPA has been working on the protocols needed to carry out this aspect of the legislation concurrent with their initial reviews of individual compounds.

It is uncertain how the FQPA will ultimately affect commercial agriculture, but it undoubtedly will change our pesticide-usage patterns. With the increased restriction on uses of older compounds, we must strive to keep up with the introduction of new and innovative pest-management options. Change is the only constant.

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