ANC91-9

SECTION IV. PESTICIDE RESIDUES IN PEACH (*PRUNUS PERSICA* L. 'NEWHAVEN') FRUIT GROWN UNDER IPM AND CONVENTIONAL PEST CONTROL

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Received for .

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Cellular and Whole Plant Physiology

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Additional index words. IPM

Abbreviations: EPA, Environmental Protection Agency; GC, gas chromatography; Conventional, conventional level of chemical input; Moderate, moderate level of chemical input; Low low level of chemical input

Abstract. Six peach, *Prunus persica* orchards were established in 1990 and three distinct management strategies were employed that compared different levels of synthetic chemical input: a conventional system that utilized standard chemical control measures, a moderate level of chemical input that monitored pest populations for pesticide use and integration of nonchemical controls, and a low level of chemical input that further reduced by chemical inputs by employing additional IPM strategies and applying pesticides only as absolute necessity. Selected pesticide residues in the fruit and soil were determined for 1992 and 1993. For fruit harvested in 1992, there was no significant differences between the pesticide residues from the different orchards although there had been a distinct difference in the number of pesticide sprays each orchard received. In 1993, there was again a distinct difference in the pesticide sprays for each orchard with little difference in residues. The conventional orchards did have higher residues of the fungicide Captan than the Moderate or the Low orchards. Also, the conventional orchards had residues of chlorpyrifos of 0.08ppm which is above the EPA tolerance of 0.05ppm. The chlorpyrifos residues in the Moderate and Low orchards were below the EPA tolerance, 0.03ppm and 0.04ppm respectively. For the two management years of this study, few differences were

found in the pesticide residues of the different treatment orchards, however, the conventional orchards did have chlorpyrifos residues above EPA tolerances in 1993.

There is growing concern about the use of synthetic pesticides in the production of food crops. This has sparked considerable interest and study in the use of management practices that reduce chemical control measures and the utilize nonchemical strategies. Integrated pest management (IPM) incorporates the technologies of horticulture, entomology, plant pathology and other fields to maintain quality crop production while minimizing adverse environmental impact to the site as well as the crop itself.

Pressure has been mounting for peach producers to produce quality fresh fruit but at the same time meet the increasing consumer demand for fruit produced with a minimum of chemical input to the fruit and the orchard environment. The orchard manager must control a number of persistent insects and diseases to even produce a crop and maintain crop quality. With the advent of integrated pest management strategies (IPM) and new biological controls, there exist the possibility of producing the quality and quantity of fruit with reduced use of synthetic chemicals. However, these techniques require greater skill in orchard management and the production results of using these strategies exclusively even on a moderate scale in unknown. Also, the effects of reduced synthetic inputs on pesticide residues is also uncertain. It is the effect of residues that has become a major health concern, but not without controversy. The debate ranges from dramatic press headlines (Blume, 1987) to scientific review (CAST, 1990). The standards by which the EPA uses to establish health risks has also been called into question (Gold *et al.* 1992; Ames and Gold, 1990). The EPA has established pesticide residue tolerances for all synthetic chemicals registered for use in the U.S (Code of Federal Regulations, 1992). However, little is known concerning how employing reduced pesticide strategies will alter residues in the fruit. It is assumed residues would be reduced as a result of reduced chemical input but this is unknown.

This study was initiated to compare three levels of chemical input and integrated pest management strategies and to determine if reducing synthetic chemical input into the orchards will reduce the detectable pesticide residues in the fruit and soil.

Materials and Methods

Orchard Management Strategies. The establishment and management strategies of the orchards has been previously described in detail (Flore, *et al.* 1994) and will be briefly considered here. Six orchards of *Prunus persica* 'Newhaven' peaches were established in 1990. Treatments applied were conventional chemical input, moderate level of chemical input and low level of chemical input. The conventional treatment consisted of production practices typical of those used by peach producers in southwest Michigan. Specifically, that treatment had preplant fumigation, clean cultivation of the soil, broadcast application of fertilizer, scheduled insecticide sprays and herbicide sprays of paraquat and simazine, and dormant pruning. Pesticide sprays were utilized according to the spray guidelines issued by Michigan State University Cooperative Extension Service (Table 1). The moderate level of chemical input included a fescue ground cover, fertilizer application through drip irrigation lines, insect scouting for spray scheduling, application of sulfur in place of synthetic fungicide sprays, conventional herbicide sprays of simazine and paraquat, and dormant pruning. Scouting included monitoring the presence of Oriental fruit moth, tarnished plant bug, and peach tree borers with sticky boards and traps. Once treatment thresholds were exceeded a spray was made to control populations. The low level of chemical input included an endophytic rye ground cover for tarnished plant bug control, utilization of unconventional insect controls, insect scouting for spray scheduling, *Pseudomonas* control of nematodes, nitrogen fertilizer applied in the form of horse manure, application of sulfur in place of synthetic fungicide sprays, biological control of

nematodes, straw mulch in tree rows for weed control, no synthetic fertilizer application, and summer pruning. Insect controls included pheromone disruption for control of Oriental fruit moth by placing pheromone ties in the trees and effectively saturating the orchard environment and preventing adults from finding each other and mating. The amount of horse manure applied gave the equivalent amount of nitrogen per ha as the other fertilization methods.

Pesticide Extraction and Analysis. The pesticides were extracted according to procedures obtained from M. Zabik of the Pesticide Research Center at Michigan State University and were in accordance with EPA methodology: simazine was extracted from the soil using the procedure of Smith (1981) and polyclonal antibody kits obtained from Millipore Corp. (Bedford, MA); chlorpyrifos and azinphos methyl extracted from a procedure originally obtained from Shell (Modesto, CA); fenvalerate extracted based on a procedure originally obtained from DuPont (Wilmington, DL); iprodione, chlorothalonil and captan were extracted based upon the procedure of Liao, *et al.* (1991); elemental sulfur extracted on a procedure originally obtained from the EPA (Washington, DC). Triplicate samples were extracted from the 1992 fruit and duplicate samples extracted from the 1993 fruit and spiked samples were extracted every six samples.

Extracted samples were analyzed on a Hewlett Packard gas chromatograph with a 25m capillary DB-5 column set up with an electron capture detector. Injection was via a Hewlett Packard automatic injector. GC parameters were as follows: split injection mode, inlet temperature 240°; nitrogen carrier gas with a column head pressure of 12.9 psi, initial oven temperature of 180° for 20 minutes and then increasing at 10° per minute to 275° and holding at 275° for 5 minutes, detector temperature was 300°. Duplicates were run of each sample along with the spiked samples and pesticide standards obtained from ChemService (PA). A standard was delivered no less than every six samples. Standards that were run included the first degradation products of azinphos methyl and asana that are included in the EPA tolerance levels (Code of Federal Regulations, 1992). Retention times for the samples

were compared to retention times for the standards and the amount of pesticide in each sample calculated from the area of the detector response as measured by an integrator (Hewlett Packard). Recoveries of the extraction procedures were calculated based on the amount of pesticide found in the spiked samples.

Results

Orchard Management Strategies. The number of pesticide spray applications to each treatment orchard are given in Table 1 for 1992 and Table 2 for 1993. In 1992, the Conventional orchards received a total of 14 synthetic chemical sprays compared to 9 for the Moderate and 2 for the Low. In addition the Low orchards received 3 pesticide sprays that were applied only to the perimeter of the orchard, thus minimizing the amount of pesticide applied to the fruit. Also, the Moderate orchard was treated with 6 sprays of elemental sulfur and the Low was treated with 2 sulfur sprays. In 1993, the Conventional orchard received 16 spray applications of synthetic chemicals, the Moderate 6 spray applications and the Low 2 applications. Again, the Moderate orchard received 6 sprays of elemental sulfur while the Low received 2.

There were notable differences in fruit yield and fruit quality and these have been previously discussed (Flore *et al.*, 1994)

Pesticide Extraction and Analysis. The results from the pesticide extraction and analysis of the fruit are given in Tables 3 and 4. In 1993, Iprodione was detected in the Conventional (0.69ppm) but not in the Moderate or the Low as it was not applied to these orchards. No iprodione was detected in any of the 1993 fruit samples. Chlorothalonil, applied only to the Conventional was not detected in any of the samples except for detection of trace levels in the 1993 Conventional orchards. No captan was detected in 1992, but was detected in the two orchards it was applied to in 1993, 4.0ppm residue in the Conventional and 0.4ppm in the Moderate. While no chlorpyrifos was detected in 1992, it was detected in fruit from each orchard in 1993, and in the case of the Conventional it was

at 0.08ppm, exceeding the EPA tolerance of 0.05ppm. No azinphos methyl was detected in any of the samples analyzed for either year. Fenvalerate was detected in equal amounts in each treatment for both 1992 and 1993. Sulfur residues were highest in the Moderate as those orchards received the most sulfur spray applications.

Simazine residues in the soil were similar in 1992, the Conventional had 8.0ppb, the Moderate 22.3ppb and the Low 12.2ppb.

Recoveries for the extraction and analysis procedures ranged from 80-160% based on the data collected from the spiked samples.

Discussion

Distinctly different levels of pesticides were applied to each of the different treatment orchards. The large differences were due to the distinct management strategies employed for each. The Moderate orchards utilized a number of IPM techniques that eliminated the need for several of the synthetic chemical sprays. In particular, the use of sulfur as a fungicide markedly reduced the chemical input into those orchards. The fruit quantity and quality was comparable to the Conventional indicating that IPM strategies can control pest population and reduce chemical input into the orchard. The Low orchards utilized additional IPM strategies and used synthetic chemicals only if absolutely necessary to prevent damage to the entire crop. However, the Low orchards had a lower level of fruit free of insect and disease damage, 79% compared to the 95% for the Conventional. This demonstrates that a significant crop can be produced by drastically reducing chemical inputs but at present their is a tradeoff in quality and quantity.

There are obvious benefits to the producer and the consumer from producing fruit crops with reduced levels of synthetic chemicals. The producer may realize a net cost savings as a result of lower pesticide expenses, and the cummulative effect of pesticide

application to the orchard site is reduced. The consumer benefits from knowing that fewer pesticides have been added to their food and the environment as a whole.

There is considerable controversy over the health effects of reduced pesticide input into fruit production. It is assumed that lower chemical inputs will mean lower pesticide residues in the fruit. This study demonstrates that chemical inputs are not clearly reflected in the fruit residues, but reducing chemical inputs can reduce pesticide residues. The levels of fungicide residues were most markedly different as the fungicide applications among the orchards was most different. The Conventional orchards received the most fungicide applications and consequently had slightly higher residues, although the residues were not as different as one might expect considering the number of synthetic fungicide applications to the Conventional. In 1992, only iprodione was higher in the Conventional and in 1993 only captan was higher. Additionally, while fruit from the Low and Moderate orchards were low in synthetic fungicide residues, sulfur residues from those orchards was highest, although not significantly. The insecticide fenvalerate was detected in each orchard and there was no difference in the levels between the treatment orchards. In 1993, the level of chlorpyrifos in the Conventional orchards was higher than the EPA tolerance for peach fruit, but the residues detected in the other treatment orchards was close to the tolerance limit. Obviously, conventional pest management in Michigan can lead to fruit with excessive levels of pesticide residues as can poorly timed applications of pesticides in an IPM scheme. Therefore, implementation of IPM strategies is becoming a necessary pest management tool due to increased restriction on pesticide use, producer concern for the orchard environment and consumer preference. However, reduced synthetic chemical pesticide input does not necessarily mean lower residues in the fruit. The manager must take into consideration the timing of chemical application with respect to harvest as well as alternative pest control measures.

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Table 1. Pesticide applications made to peach orchards in 1992. Treatments are Conventional, conventional level of chemical pest management; Moderate, moderate level of chemical pest management; and Low, low level of chemical pest amangement.

	Pesticide (Rate•acre^{-1})*						
Treatment	Iprodione (2 lb.)	Chlorothalonil (4 pts)	Captan (1 lb)	Chlorpyrifos (3 lb)	AzinphosMethyl (3 lb)	Fenvalerate (8 oz)	Sulfur (15 lb)
Conventional	1	2	4	3	2	2	0
Moderate	0	0	0	2	4	1	6
Low	0	0	0	2**	2**	1**	2

* The Moderate level orchards received 2 benomyl applications.

** One of the chlorpyrifos sprays, the azinphosmethyl sprays and the fenvalerate spray were applied only to the perimeter trees of the Low level orchards.

Table 2. Pesticide applications made to peach orchards in 1993. Treatments are Conventional, conventional level of chemical pest management; Moderate, moderate level of chemical pest management; and Low, low level of chemical pest amangement.

	Pesticide (Rate•acre^{-1})*					
Treatment	Iprodione (2 lb.)	Chlorothalonil (4 pts)	Captan (6 lb)**	Chlorpyrifos (3 lb)	AzinphosMethyl (3 lb)	Fenvalerate (8 oz)
Conventional	1	3	4	4	2	2
Moderate	0	0	1	2	1	2
Low	0	0	0	1	1	3

* The Moderate level orchards received 6 sulfur and 2 benomyl applications and the Low level orchards received 2 sulfur applications.

** The Moderate level orchards were sprayed at a rate of 1 lb•acre^{-1} of captan.

Table 3. The effect of different levels of chemical pesticide input on pesticide residues of peach fruit in 1992. Treatments were Conventional, conventional chemical pesticide input level; Moderate, moderate level of chemcial pesticide input; Low, low level of chemical pesticide input. Values are the mean of triplicate extraction samples from two orchards of each treatment.

	Pesticide Residues (ppm)						
Treatment	Iprodione	Chlorothalonil	Captan	Chlorpyrifos	Azinphosmethyl	Fenvalerate	Sulfur
Conventional	0.69	0.00	0.0	0.00	0.0	1.16	18.0
Moderate	0.00	0.00	0.0	0.00	0.0	1.04	31.8
Low	0.00	0.00	0.0	0.00	0.0	0.88	22.2
EPA tolerance	20.0	0.50	50.0	0.05	2.0	10.0	–
MDL	0.01	0.50	0.4	0.01	0.19	0.90	5.0

Table 4. The effect of different levels of chemical pesticide input on pesticide residues of peach fruit in 1993. Treatments were Conventional, conventional chemical pesticide input level; Moderate, moderate level of chemcial pesticide input; Low, low level of chemical pesticide input. Values are the mean of triplicate extraction samples from two orchards of each treatment.

	Pesticide Residues (ppm)					
Treatment	Iprodione	Chlorothalonil	Captan	Chlorpyrifos	Azinphosmethyl	Fenvalerate
Conventional	0.00	0.03	4.0	0.08	0.0	0.02
Moderate	0.00	0.00	0.4	0.03	0.0	0.03
Low	0.00	0.00	0.0	0.04	0.0	0.01
EPA tolerance	20.0	0.50	50.0	0.05	2.0	10.0
MDL	0.09	0.04	1.3	0.01	0.38	0.02