In Short ■ by Thomas J. Stevens III and Richard L. Kilmer

Pesticide Residues on Fresh Tomatoes and Strawberries

The demand for pesticide-free food is growing (Eom; Lynch; Misra, Huang, and Ott) and health experts encourage us to increase the proportion of fruits and vegetables in our diet. However, news stories about the potential health risks associated with minute amounts of pesticide residues sometimes found in these foods dampen our enthusiasm. These concerns encouraged passage of the federal Food Quality Protection Act of 1996 that mandated a recertification of all pesticides within ten years. To help discover new ways of reducing pesticides on fruits and vegetables, we researched the tomato and strawberry industries in Florida. We wanted to find out where pesticides occur in the marketing channel and how pesticide residues are associated with grower production practices and grower attributes.

Residue differences between strawberries and tomatoes

On average, we found higher levels of pesticide residues on strawberries than on tomatoes. Cultural/botanical characteristics and differences in handling practices may account for these findings. For instance, tomatoes grow during the warmer seasons and have a smoother outside surface compared to strawberries. These characteristics facilitate the breakdown of pesticide residues and their removal by washing. From an economic standpoint, the marginal return to pesticide applications on strawberries may be greater because of their relatively high per acre value. Finally, because distributors usually do not wash strawberries prior to distribution, growers may apply fungicides shortly before harvest to lengthen the consumer/retailer shelf life.

Fungicides dominate pesticide residues found in Florida strawberries. At the grower, packer, and distributor stages, at least 89 percent of the samples had detectable fungicide residues (figure 1). By comparison, at most, 38 percent of strawberries at the grower, packer, and distributor stages had detectable insecticide levels.

Insecticides and miticides dominate pesticide residues found in tomatoes. We found detectable insecticide/miticide residues on 69 percent of the samples collected at the grower stage (figure 1). This proportion decreased to 36 percent at the distributor stage. Detectable pesticide residues found in tomatoes diminished as the product moved through the market channel. Washing and rinsing at the packing stage reduced residues. Tomato storage at warmer temperatures (near 60°F) further reduced residue levels because warm temperatures facilitate the breakdown of pesticides residues. In comparison, growers pack most strawberries into retail containers at harvest and refrigerate them shortly thereafter at temperatures slightly above freezing. No packers or distributors applied pesticides to strawberries or tomatoes.

Grower production practices and pesticide residues

Production practices directly and indirectly affect pest infestation and the resulting damage. They also affect residue levels. The form of fertilizer and the method of application influenced residue levels in strawberries and tomatoes. Fertilizer applied through the irrigation system lowered fungicide residues on both strawberries and tomatoes. Liquid and foliar fertilizer applications increased residues on tomatoes, while dry and foliar forms of fertilizer lowered residues on strawberries. Organic fertilizers contributed to higher insecticide residues in strawberries and higher fungicide residues in tomatoes.

Integrated pest management practices influenced insecticide residues in tomatoes. Beneficial insects, use of pheromone traps to monitor pests, and application of biological agents for pest control reduced residues. Counter to expectations, however, adjusting plant

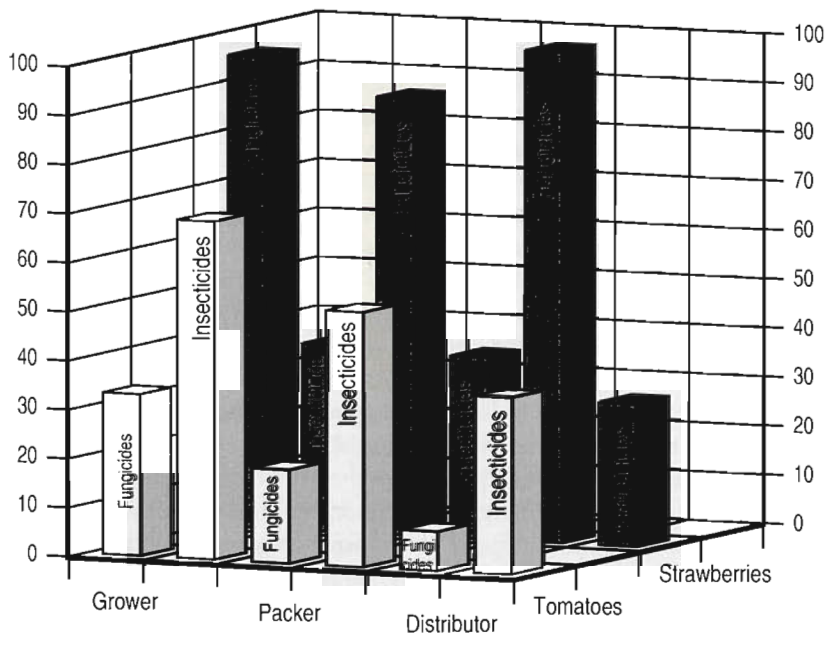

Figure 1. Percentage of strawberry and tomato samples with detectable pesticide residues at the grower, packer, and distributor market stages, October 1990 through June 1993

Description of the Data and Methods

For pesticide monitoring and enforcement purposes, a total of 321 samples of strawberries and tomatoes—approximately nine pesticides per sample—grown in Florida between 1990 and 1993 were obtained from grower fields, packing houses, and distributors by the Florida Department of Agricultural and Consumer Services. We acquired data on grower attributes and general production practices associated with these samples through personal interviews conducted by the Florida Agricultural Statistics Service.

We used linear regression analysis to evaluate the statistical relationships between grower attributes, general production practices, and pesticide residue levels. Because of significant inherent differences in the forms and treatment of insect versus disease infestations, we analyzed the residue levels separately for fungicides and insecticides (Stevens and Kilmer).

ing dates, soil testing for pests, and sprayer calibration were associated with higher residues. Instead of representing substitutes for chemical pest control activities, these last three activities may be indicators of the overall level of pest management intensity for a particular operation.

Residue levels varied with the type of irrigation technologies used to grow strawberries and tomatoes. Irrigation impacts the microenvironment, and thereby influences plant susceptibility to insects and diseases. Irrigation may also wash pesticides off the plants. Drip-irrigated strawberries and tomatoes had lower residues. Overhead irrigation was linked to higher insecticide residues but lower fungicide residues in strawberries. Overhead and microsprinkler irrigation technologies wet all or part of the plant, thus encouraging pest infestations—especially fungi. These same systems can wash residues off. Drip irrigation places water directly on the soil near the roots of the plant, thus keeping the foilage and fruit dry.

Growing season, plant spacing, and plant variety influenced residue levels. Tomatoes and strawberries with shorter growing seasons had higher residues. Insecticide residues on both commodities increased with the distance between plants. The greater spacing allows more coverage and increases the amount of residues on the fruit. Variety or cultivar influenced the occurrence of residues in strawberries. Selva and Chandler cultivars had higher fungicide residues but lower insecticide residues, compared to Oso Grande. SolarSet tomatoes had higher fungicide residues. Generally, any relationship between variety and residues is due to the level of genetic resistance to certain pathogens and insects and the accompanying need to use pesticides. Also, characteristics related to the timing of fruit set and maturity of different varieties influence pest infestations.

Strawberries grown on sandy loam and loam soils had lower residues than strawberries grown on sand-type soils. Tomato fields with sand-type soils had lower residues than those grown on sandy loam.

Grower attributes and pesticide residues

Grower attributes influenced pesticide residue levels. The decision-maker's education and the certification of employees in strawberry operations increased pesticide residues. Highly trained managers practice more intensive pest management.

Strawberry and tomato growers affiliated with downstream market stages had fewer residues. Improved coordination between the grower and packer stages reduced insecticide residues.

Implications for business and policy makers

We found insecticide and fungicide levels differed between strawberries and tomatoes, and at different stages of the marketing channel. Some of these differences occurred because of physiological differences between the two commodities. To a large extent, though, different production and handling practices caused these variations. Researchers, government agencies (including policy makers and outreach agencies), and private decision makers might focus on these production and handling practices to reduce pesticide applications and residues in a least-cost way. ◘

■ For more information

Eom, Y.S. "Consumers Respond to Information about Pesticide Residues." *Food Rev.* 15(October-December 1992):6–10.

Environmental Protection Agency, Food and Drug Administration, and U.S. Department of Agriculture. "Clinton Administration Proposes Strengthening the Nation's Pesticide and Food Safety Laws." Release No. 0815.93, Joint Release on Food Safety/Pesticides by EPA, FDA, USDA, 21 September 1993.

Kuchler, F., K. Ralston, L. Unnevehr, and R. Chandran. "Pesticide Residues: Reducing Dietary Risks." Washington DC: U.S. Department of Agriculture, ERS Agricultural Economic Report Number 728, January 1996.

Lynch, L. "Consumers Choose Lower Pesticide Use over Picture-Perfect Produce." *Food Rev.* 14(January-March 1991):9–11.

Misra, S.K., C.L. Huang, and S.L. Ott. "Consumer Willingness to Pay for Pesticide-Free Fresh Produce." *W. J. Agr. Econ.* 16(December 1991):218–27.

Stevens, T., and R.L. Kilmer. *Empirical Relationships Between Pesticide Residues, Producer Attributes, and Production Practices for Florida Grown Tomatoes and Strawberries.* Florida Agr. Exp. Sta. Res. Bull. No. 329, Gainesville FL, in press.

Stevens, T., and R. L. Kilmer. *A Descriptive and Comparative Analysis of Pesticide Residues Found in Florida Tomatoes and Strawberries.* Florida Ext. Bull. No. 331, Gainesville FL, in press.

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