COOPERATIVE EXTENSION SERVICE
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TOTAL QUALITY ASSURANCE

Apple Production

BEST MANAGEMENT PRACTICES

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Throughout history, apples have played an important and significant part in the diet of Americans. Fresh apples, apple cider, and other apple products are still favorites of people of all ages. Kentucky apple growers are able to provide flavorful, fresh apples and apple products directly to the consumer. New dietary recommendations that favor diets rich with fresh produce have Americans eating more fresh fruits and vegetables than the previous generation. There is also a push at the consumer level to reduce pesticide use for all crops. Growers share this concern and are finding ways of reducing pesticide use while maintaining quality and managing pest and disease risks.

In the United States, food-borne illnesses associated with fresh produce are on the rise. The safety of food is a concern shared by producers, processors, retailers, and consumers. This publication will outline the primary steps that can be taken at the grower level to lessen the chances of food-borne illness and reduce pesticide inputs. These are generally simple and easily implemented, and often include cost-saving measures. The benefit of added protection to the consumer makes these steps both desired and necessary.

Codling moth pheromone traps are used to determine the need for and timing of sprays.

IPM/Pesticide Use

Apple growers must watch costs in order to sustain their business. This is a fact of business for any entrepreneur. A major expense for apple producers is that of pesticides and the cost of application. However, a large number of insect, weed, and disease pests threaten orchards throughout the season. Because organic apple production is not feasible for commercial orchards in Kentucky, chemical pesticides are needed to produce high-quality fruit.

One way to manage pesticide costs is by adopting a program known as IPM, or Integrated Pest Management. IPM helps growers determine exactly when pesticide applications are needed. Generally, apple IPM in Kentucky can reduce the number of pesticide applications by about one-third on average when compared with a calendar-based program. IPM also ensures that pesticides are used effectively by timing sprays to have the greatest impact. Research has determined threshold levels for a number of pest species, and models have been developed to predict disease infection and insect emergence. Weather monitoring plays a key role in disease forecasting. Knowing when an infection will occur helps to determine when sprays are needed. Kentucky apple growers use pheromone traps, systematic tree sampling, and key weather factors to determine the emergence of key pests and disease events.

When pesticides are applied, certain practices can help to ensure that the product being sprayed does the job it was purchased to do. Something as simple as calibrating equipment periodically not only will ensure the proper rate of application, but also can avoid over-application. Some types of products perform well when applied as low-volume concentrate sprays, while others must be applied as higher-volume dilute sprays. There are different nozzles for different spray patterns. Choosing the correct one for the desired coverage will help to ensure that the product actually gets to where it is needed. Knowing the pest habits and how products perform also helps when choosing nozzles and spray volumes. Water-sensitive paper placed at different heights and positions in the trees can be used to determine whether spray coverage is satisfactory.

The water used in pesticide applications should be clean and free from any microbial or chemical contaminants. Checking the pH of the water is important, as this can affect the effectiveness of a pesticide. The pH of the water should be neutral to slightly acidic. Alkaline water can lead to the rapid breakdown of spray materials. If the pH is too high, a buffering agent can be added to the tank to adjust the pH to a more desirable level. It is important to use only pesticides that are labeled for the crop and pest needing control. Often the lowest recommended rate will perform as effectively as the higher rates, but at less expense.

Pesticide Resistance

Insects, disease organisms, and weeds may develop resistance to commonly used pesticides. This means the chemical becomes ineffective and another chemical must be found to control the particular pest. Effective alternative chemicals are not always available, so the main strategy to combat pest resistance is to prevent the resistance from occurring in the first place. In fact, one reason why IPM was developed was to fight pesticide resistance that was occurring in cotton production systems.

Pesticides have different *modes of action*, or means of killing the pests. Pesticides are divided into different classes depending on how they work. When a pesticide application is made, only a portion of the pest population is killed. Some of the surviving individuals may escape the application, but others may be genetically more resistant to the chemical. Initially the number of individuals with resistance is low. However, if the same type of chemical is used continuously, the number of resistant individuals may increase because they are not killed. These surviving individuals multiply, and some of their offspring may also have the genes for resistance. Their numbers grow, and at some point the population is said to have developed resistance to the particular chemical.

Insects and diseases are notorious for developing resistance. This is due to several factors. Generally, less time is required to develop resistance when a species has multiple generations per year and lots of offspring in each generation and when pesticides with the same mode of action are used repeatedly.

There are several practices that can help to delay or minimize the development of pesticide resistance:

- Alternate chemicals with different modes of action. This delays resistance development, as individuals resistant to one mode of action are usually not resistant to another.
- Reduce the number of applications and treat only when absolutely necessary as determined by IPM thresholds. This helps by limiting repeated exposure to the same type of chemical.
- Use labeled rates for pesticides and ensure proper coverage in the orchard to delay the development of resistance.

Cultural Practices—Sanitation (Orchard Cleanup)

There are some very simple ways of reducing future pest problems in the orchard. Generally, good cultural practices help to prevent the recurrence of pest problems and need to be used in advance of a pest problem. After the occurrence of a pest problem, a grower needs to determine what cultural practices can be used to reduce the chances of future problems and implement those practices. Examples of good cultural practices include:

- Remove and destroy fruit mummies. These are a source of fruit rot diseases.
- Chop fallen leaves finely with a flail mower to reduce scab inoculum.
- Remove branches from the orchard after pruning or chop them finely with a flail mower. These are sources of disease organisms that may cause future infection if left to rot in or close to the orchard.
- Remove, destroy, or bury piles of culled fruit, as these allow for the development of fruit pests and diseases.
- Remove and destroy abandoned fruit trees near the orchard.

Cultural Practices—Resistant Varieties

Apple cultivars resistant to scab and other diseases are available. Where such cultivars fit into a grower's planting and marketing scheme, they could reduce fungicide use.

Microbial Contamination

Microbes that affect food safety have always been with us. Changes in consumer habits, handling procedures, grower practices, and even in the microbe itself can contribute to an increase or decrease in the number of cases of food-borne illness. One such culprit is *E. coli* O157:H7. This is a new strain of a very common bacterium. More virulent than its predecessor, O157:H7 can cause problems where others would fail when ingested by people. This is because fewer individual bacteria are required for an illness to occur. Once started, the infection is notably difficult to control and more life threatening than that caused by other bacteria, even *Salmonella*. This bacterium has been shown to survive more than 4 months in water troughs; it can survive freezing and can readily survive in areas of low oxygen such as soils, water, and manure. O157:H7 has been found in the manure of cattle, deer, sheep, dogs, cats, horses, goats, and birds. These animals show no symptoms, and there is no way to tell if they carry the bacterium by looking at them.

Fruit can become contaminated with harmful bacteria when:

- Fruit fall to the ground.
- Fruit are contaminated with bird droppings.
- Manure washes or is blown onto fruit.
- Fruit are handled by workers with contaminated hands.
- Fruit come into contact with contaminated harvest equipment.
- Fruit come into contact with contaminated water.
- Fruit are contaminated in storage due to rodent or other animal activity.

Cultural Practices—Manure

Keeping harmful microbes off apples and out of apple cider is a multi-step process. Microbes can find their way to the final product in many ways, but there are also simple procedures to

lessen the chance that they will. Many harmful bacteria in addition to O157:H7 can be found in animal manure. Even if you do not treat your orchards with manure, that does not necessarily mean you are free from concern. Manure stored near orchards, fruit storage areas, production areas, or equipment can be blown in on the wind, carried through runoff after rain or irrigation, or find its way into creeks or ponds used for irrigation. If manure is applied to orchards, it should be aged or well rotted and not fresh. Manure should not be applied to perennial fruit crops after establishment. There should be a minimum 60- to 90-day period between manure application and harvest. Pets and livestock animals should not have access to orchards or water areas such as creeks or ponds that are used for irrigation. To the extent possible, wildlife should be excluded from these areas as well.

Equipment and Storage Facilities

Ladders, bins, refrigeration units, and other equipment should be power washed and sanitized prior to use. This is to ensure that any possible contamination via soil is removed. A chlorine solution of 200 ppm (parts per million) or 1 tablespoon of household bleach per gallon of water that is between 75° and 110°F can be used for sanitization. Cooler water reduces the pathogen-killing potential of chlorine. Keeping storage bins in full sun allows UV radiation to kill harmful organisms. Protect storage and enclosed work areas from pets, rodents, and birds. Trucks that are used to carry produce should be cleaned and not used to transport livestock or other animals.

Workers

Workers have the closest contact with the fruit, so it is important to safeguard against any produce contamination via the workers. Simple measures, such as providing access to restroom facilities, soap, single-use paper towels, and clean water at all times, may be all that are required to ensure no transmission of pathogens to the fruit. Instruct workers to wash their hands before and after eating, smoking, and using the restroom. Monitoring workers initially to ensure proper use of facilities may also be required in some situations. Occasionally a worker may become injured or ill. These workers should not be allowed to handle fruit for obvious reasons. During harvest, workers should be instructed not to carry or handle ladders by the rungs, as these are contaminated with soil from work shoes. The rungs may be painted a bright color as a reminder. Once bins are sanitized, workers should be instructed not to stand in the bins, as this can lead to soil/microbe produce contamination.

Harvest and Juicing

The practice of using fruit that have been picked up off the ground should not be allowed in cider production because it allows harmful microbes to enter the final product. Fruit that has had contact with the soil should not be used nor should fruit that has any severe bruising or other damage. It is not recommended that drops be used for pasteurized cider, as drops often have extremely high microbe populations, some of which are not killed by flash pasteurization. The tank used for sorting or culling apples should contain a 200-ppm chlorine solution, which should be changed regularly to ensure its ability to kill pathogens. Test strips can be purchased to test the chlorine level in the water and determine the need for adjusting chlorine. Apples should be rinsed and brushed prior to juicing. Research with tomatoes and peppers shows that placing warm produce in cold water can actually cause surface contaminants to be drawn into the product. These microbes cannot be killed with chlorine. The same holds true for apples. Keeping the water used for dumping, washing, and rinsing 10°F warmer than the produce not only helps to prevent this but also allows for the chlorine to act more efficiently. If a final wash is used, this water should be drinkable and should not have been recycled. This water may be recycled into dump tanks. Cooling apples quickly and keeping them refrigerated after harvest not only allows them to be kept longer, but also slows the growth of any harmful microbes present.

Cider Pasteurization

New regulatory requirements are in effect for cider producers. But cider pasteurization alone does not ensure that the final product will be high quality and free from harmful microbes. Good manufacturing practices need to be followed during the entire process to produce a high-quality product. All of the equipment needs to be sanitized prior to use and cleaned afterward. The only type of pasteurization that has been approved for cider is flash pasteurization. This provides the necessary 5-log reduction of the harmful bacteria. During the pasteurization processing, producers need to monitor the equipment to confirm that the cider is heated to the necessary temperatures. It is important to cool and handle the cider properly after pasteurization. Flash pasteurization reduces the level of contamination at one point in the production process, and producers need to ensure that the cider does not become contaminated after the pasteurization process.

An enclosed area is required for making cider, as this helps keep any wind-borne contaminants out of the process and allows for easier cleanup and protection of equipment. Cider containers need to be kept dust free and covered until used. After the cider is produced, it should be chilled and stored below 40°F to inhibit spoilage.

In large operations, it is a good idea to label cider containers with a lot number in case a recall is ever needed. Labelling may prevent having to recall an entire run, which can be very costly with large operations. Assigning lot labels can also help with record keeping.

After the juice is extracted, the pomace (juice extraction waste) should be removed and not allowed to remain in the facility overnight as this could be an attractant to rodents, insects, etc.

Many of these practices may already be in use; others take only minor adjustments to adopt. Keeping apples and apple cider safe, as well as keeping down costs, makes good sense.

Best Management Practices Checklist for Apple Producers

Pesticide Application Checklist:

- ☐ Calibrate spray equipment annually.
- ☐ Use proper pesticide rates according to the label.
- ☐ Use IPM guidelines to determine need for and timing of pesticide sprays.
- ☐ Use the correct volume of spray needed for the pest/pesticide.
- ☐ Select the appropriate nozzle to ensure proper coverage.
- ☐ Use water-sensitive paper to check spray coverage.
- ☐ Use clean water to dilute sprays.
- ☐ Make sure spray water pH is neutral to slightly acidic.

Resistance Management Checklist:

- ☐ Alternate chemicals with different modes of action to delay resistance.
- ☐ Reduce the number of sprays and treat only when necessary according to IPM thresholds.
- ☐ Use labeled rates for pesticides and ensure proper coverage in the orchard.

Cultural Pest Management Checklist:

- ☐ Remove and destroy fruit mummies and scabbed fruit.
- ☐ Prune trees to provide good air circulation and spray penetration.
- ☐ Finely chop or remove fallen leaves and tree prunings from the orchard.
- ☐ Remove, destroy, or bury piles of culled fruit.
- ☐ Remove and destroy abandoned fruit trees near the orchard.

Manure Management Checklist:

- ☐ Do not store manure near orchards.
- ☐ Make sure any manure applied to orchards is aged or well rotted.
- ☐ Allow a minimum 60- to 90-day period between manure application and harvest.
- ☐ Exclude pets, wild game, and grazing animals from orchards and water areas used for irrigation.

Harvesting Equipment Checklist:

- ☐ Sanitize ladders, bins, refrigeration units, trucks, and other equipment prior to use.
- ☐ Store bins in full sun prior to harvest to allow UV radiation to kill harmful organisms.
- ☐ Exclude pets, rodents, and birds from storage and enclosed work areas.
- ☐ Do not transport livestock or other animals on trucks that are used to carry produce.

Employee Checklist:

- ☐ Provide access to restroom facilities, soap, single-use paper towels, and clean water at all times.
- ☐ Instruct workers to wash hands before and after eating, smoking, and using the restroom.
- ☐ Monitor workers to ensure proper use of facilities.
- ☐ Do not allow injured or ill workers to handle fruit.
- ☐ Instruct harvest workers not to carry or handle ladders by the rungs.
- ☐ Paint ladder rungs a bright color as a reminder.
- ☐ Do not allow workers to stand in the bins.

Cider Checklist:

- ☐ Do not use dropped fruit to make non-pasteurized cider.
- ☐ Use only sound, high-quality fruit to make cider.
- ☐ After harvest, cool and refrigerate fruit.
- ☐ Wash fruit in a 200-ppm chlorine bath prior to juicing.
- ☐ Wash and brush fruit before juicing.

An automated weather station is used to record weather conditions and monitor disease and insect development.

Pasteurization checklist:

- ☐ Sanitize all equipment prior to use and clean it afterward.
- ☐ Produce cider in an enclosed area to keep out wind-borne contaminants.
- ☐ Keep containers free from dust during storage.
- ☐ Chill and store cider below 40°F to help protect against spoilage.
- ☐ Avoid cider contamination after pasteurization.
- ☐ Label containers with lot numbers and dates to aid removal in case of recall.
- ☐ Promptly remove juice-extraction waste from the facility to avoid attracting rodents and other pests.