Crop Profile for Apple in Missouri

Prepared: November, 2001

Summary

The Missouri Apple Crop Profile was developed from surveys and interviews with key apple growers who manage approximately one-tenth of the production acreage in the state. Other information was gleaned from Extension Fruit Specialists at the University of Missouri and Southwest Missouri State University. The third key information source was from pesticide usage data obtained from USDA and the North Central Pest Management Center.

Apple production in Missouri is scattered throughout the Ozarks region of Southern Missouri and along the "bluff" hills bordering the Missouri River in central Missouri. The largest producer in the state manages approximately 500 acres of apples, with several growers managing 50 to 150 acres. Other growers have considerably smaller operations, which average from 5 to 10 acres. The apple operations located in southwest and central Missouri are coupled with production of other fruit, primarily peach.

General Production Information

- Missouri ranks 20th in the commercial apple production.
- Missouri produces 0.44% of the total United States apple crop.
- In 1999, 46 million pounds of apples, valued at $8.11 million was produced on approximately 3,500 acres. The 5-year average production was 41.2 million pounds valued at $7.51million/year.
- All apples produced in Missouri are for fresh market or juice. The majority of the crop is marketed through wholesale channels and sold locally.

Cultural Practices

The Crop Profile/PMSP database, including this document, is supported by USDA NIFA.

In Missouri, apples are grown in a wide range of soil types. Optimal production is achieved in soils that are deep (2 to 3 feet or more), light textured (sandy loams to clay loams), well-drained and at pHs between 6.0 to 6.5. Apples are planted on sloping land, generally bluffs and ridges, for adequate airflow, drainage and protection from spring frosts. The majority of the apple crop is grown without irrigation.

All apple cultivars are bud-grafted on to adapted rootstocks. Almost all the acreage in Missouri is planted on MM111 or M7A rootstocks. The productive life of a apple orchard in Missouri ranges from 12 to 20 years. Generally, the first crop is harvested in the third year after young trees are planted. There is no general replant policy for replacing lost trees or orchards, but on average five percent of the trees are replaced each year.

Pruning is done by hand during the winter months starting in December and extending into April. Thinning is done by hand. Most growers apply nitrogen fertilizer annually in the spring in the form of ammonium nitrate. Most split the applications and apply 1/3 of the total amount in mid-March and apply the remainder after bloom when it is determined that a crop will be present. The larger growers will also apply foliar sprays containing nitrogen and various micronutrients at several times during the early season.

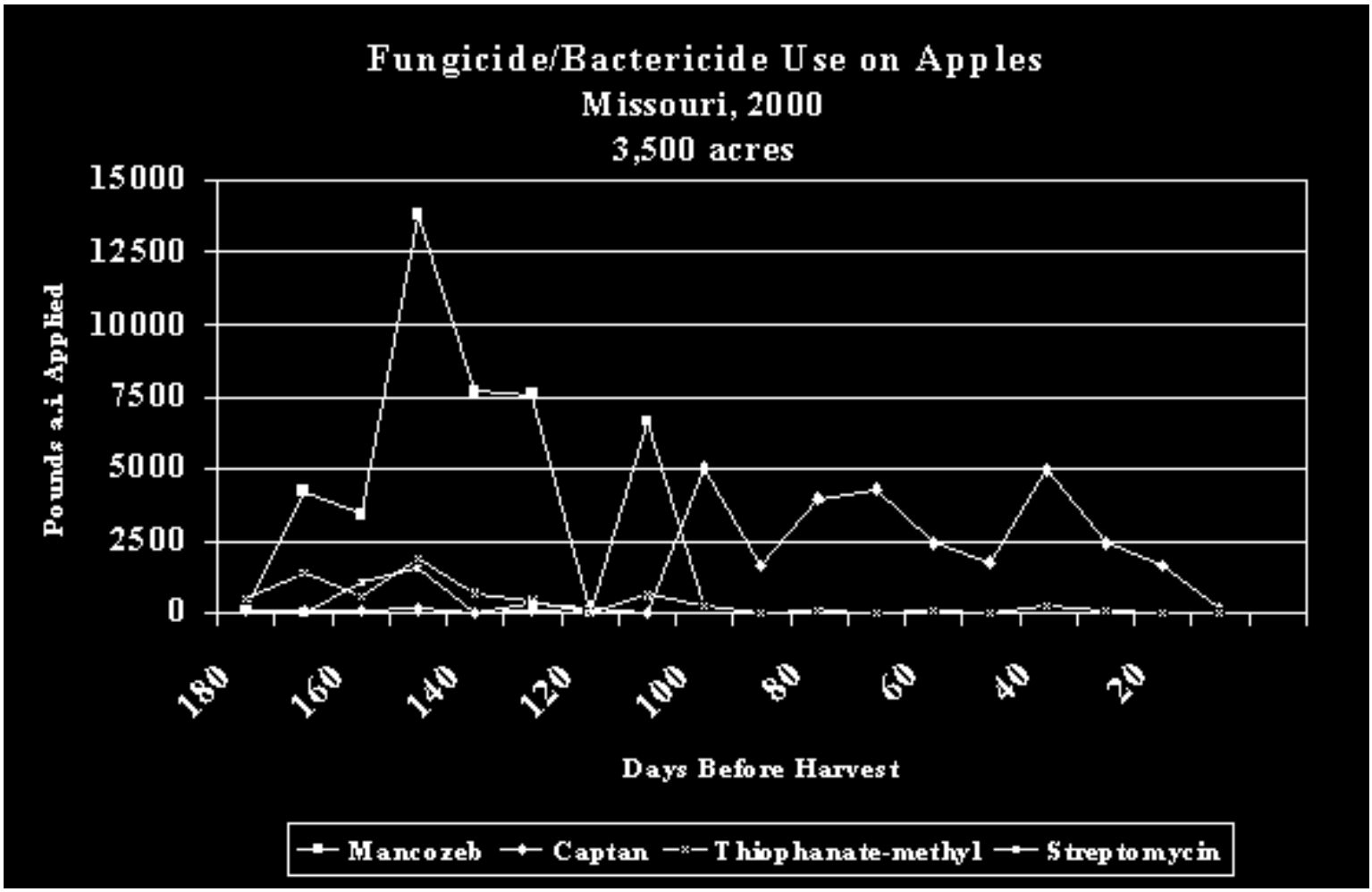
The determination of which apple varieties will be grown is based on harvest or ripening date so that growers will have a continuous crop of apples throughout the late summer and fall. Harvest usually begins with a few varieties producing a small crop by late August, but the bulk of the apple harvest runs from mid-September through October. Some of the varieties commonly grown include Golden Delicious, Johnathan, Red Delicious, Gala, Fugi, Red Rome, Ozark Gold, EarliGold, IdaRed, Cortland, Empire, Winesap, Jonalicious, Rome Beauty, LuraRed, Blushing Golden, Granny Smith, Freedom, and Braeburn, Individual growers reported as many twenty three different apple varieties in their orchards.

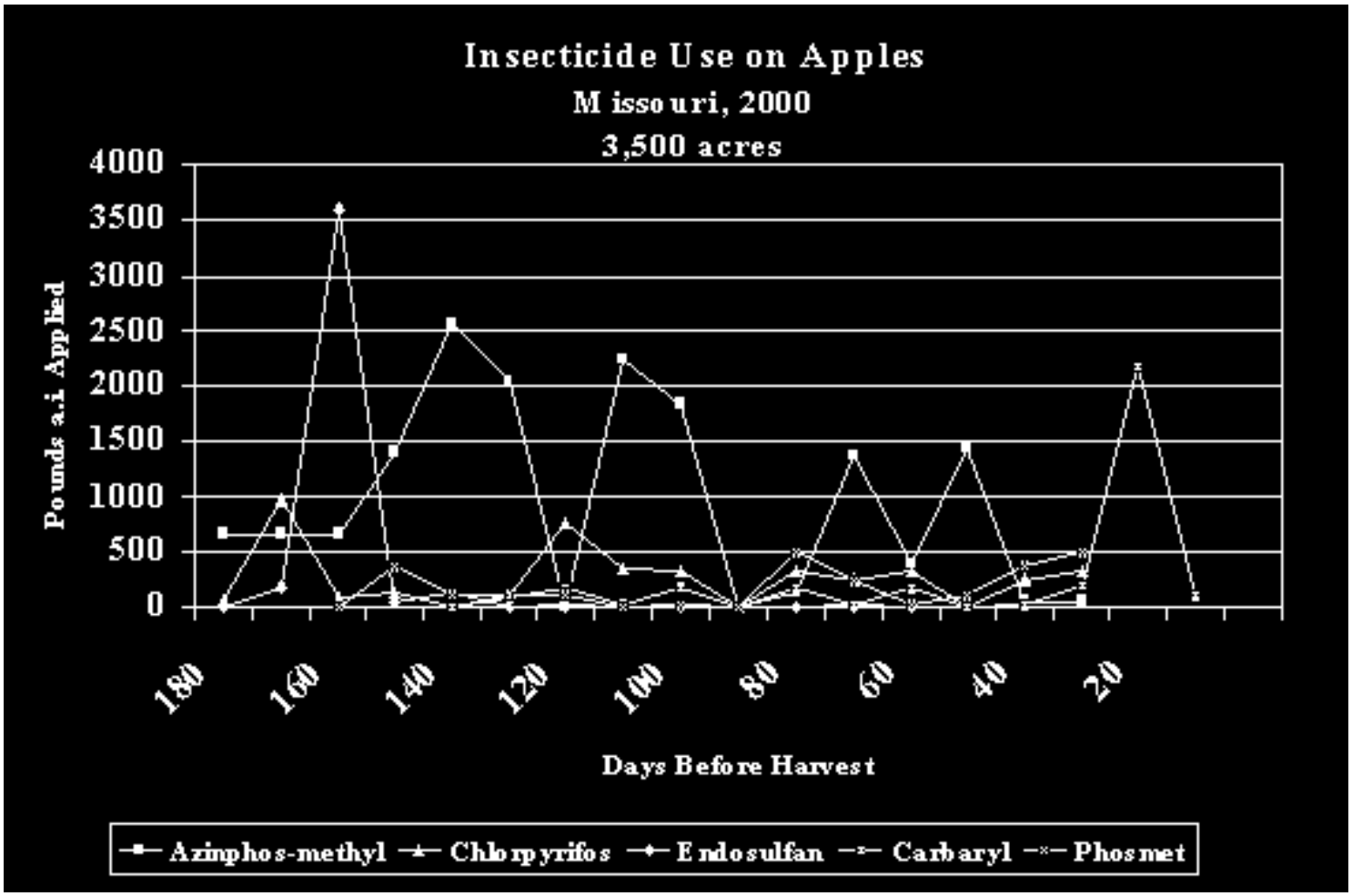
The most limiting factor affecting apple production in Missouri is the occurrence of spring frosts in southeast and southwest Missouri and winter freezes in north-central Missouri. The most damaging freezes usually occur in the late fall when below zero temperatures immediately follow a period of abnormally warm temperatures and the trees have not been exposed to adequate "hardening" to cold temperatures. Winter temperatures below -20^0 F may kill dormant fruit buds. A full crop is expected four out of five years, a partial crop one out of five years. Complete crop failure may occur once every 15 years.

Pest Management in Apples

Apples cannot be commercially grown unless a wide variety of insect, disease and weed pests are controlled. Four key insect pests, codling moth, mites, San Jose scale and plum curculio cause economic losses in apple unless populations are kept below economic injury levels. The key diseases are apple scab, fire blight, cedar apple rust and powdery mildew. Apple scab and fire blight are the primary economically limiting diseases of apples for Missouri growers. Flyspeck and sooty blotch are secondary diseases that affect fruit quality if not controlled during mid and late-season. Growers expect yield losses from diseases to occur every year if left uncontrolled. Annual and perennial weeds (grasses and broadleaves) must be managed to reduce competition for water and nutrients, and to remove overwintering sites for insects and

diseases. A brief synopsis that includes the biology of and the type of damage caused by each these key and secondary pests of apples is listed below.





Insect Pests

Codling Moth (*Grapholitha molesta*)

The larvae of this small, 3/8 inch moth damage apples by chewing their way into the center of the fruit. "Frass" or fecal matter is pushed out through the side of the fruit skin or the calyx end. In addition, wounds caused by the larvae promote the development of fruit rotting fungi. The most economic damage is caused by the second and third generations.

Codling moth overwinters as a fully developed larva which pupates in early spring during bloom. The first generation moths, which emerge in late April or early May, lay their scale-like eggs singly on developing fruit or adjacent leaves or stems just after sundown each night. Upon hatching, the larva enters into the calyx end or side of the fruit, then tunnels to the center where it feeds and develops. Larval development is completed in about three to five weeks. The fully developed larva exits the fruit to pupate in a thick silken cocoon on the tree bark or other protected areas in the orchard canopy.

European Red Mite (*Panonychus ulmi*)

Damage to apples is caused by mites withdrawing plant sap and chlorophyll form leaves. Feeding injury becomes visible as leaf bronzing by mid- to late July, due to mite build-up on leaves. When these conditions occur, serious injury to the current season's fruit crop is expressed by poor color fruit or a reduction in fruit size and quality. If damage becomes extensive due to lack of management, the next season's crop will be reduced due to a reduction in the number of fruit buds. The earlier in the season that mite population reach the economic injury level, the greater the potential for loss.

Eggs that overwinter are laid in roughened bark around the bases of buds and spurs. Eggs begin to hatch in the spring around the tight cluster stage. Newly hatched mite larvae crawl onto the unfolding leaves and begin feeding. Development form egg to adult may be accomplished in one to three weeks depending on temperature. There may be as many as six to eight overlapping generations per season. Summer eggs are laid on the underside of leaves.

This mite would be relegated to the role of secondary pest of apples were it not for the suppression of predatory mites, lady beetles, and banded thrips from insecticide sprays needed to control codling moth and other pests. In particular, growers are advised to avoid the use of pyrethroid insecticides to mitigate problems with this pest. In Missouri, the organophosphate insecticide, azinphos-methyl, is preferred by growers because many predatory insects have developed a tolerance to this chemical and it is highly efficacious on codling moth.

San Jose Scale (*Quadraspidiotus pericosus*)

Damage to apples is caused by the crawler stage which feeds on limbs, leaves, and fruit, causing red, spotted areas. Infested leaves usually drop, and limbs lose vigor and die. Infested fruit will have an undesirable finish due to the red, spotted appearance caused by scale presence and feeding.

Three life stages are important in managing this insect pest. The adult female is yellow and lives under a protective gray, round, and flattened scale-like cap. This protective cap at maturity is about 1/20 inch in diameter. The male is tiny, yellow, two-winged and gnat-like. The crawlers are orange-yellow and oval, with six legs.

San Jose scale overwinter as a nymph under a scale on tree limbs and resumes feeding when sap begins to flow in the tree. Adult males emerge about mid-May and seek out wingless females. After mating the crawlers emerge about one month later. These crawlers seek out and locate a suitable site on the tree to insert its mouthpart into the tree and then it secretes the waxy shell that is characteristic of this insect pest. There are two or more generations pre year.

Plum Curculio (*Conotrachelus nenuphar*)

Damage from surface feeding and egg laying by the adult 1/4-inch long, dark brown snout beetle causes

scarring or misshaping of the fruit by harvest. Feeding by larvae may cause premature fruit drop. The adult beetle overwinters in ground litter or soil. They migrate into orchards each spring and the first signs of fruit damage coincide with the onset of 60ºF nighttime temperatures. Eggs are laid on crescent-shaped flaps cut in the skin of young fruit. When larvae are fully developed, they leave the infested fruit, drop to the ground, and pupate one to two inches below the surface. There is only one generation per season.

Secondary Insect Pests

Several insect pests may cause economic losses on a sporadic basis, but are managed by insecticide and miticide applications to control key insect pests. These secondary pests include spotted tentiform leafminer, rosy apple aphid, tarnished plant bug, red-banded leafroller, white apple leafminer, green apple aphid, oblique-banded leafroller, apple maggot, and Japanese beetle.

Diseases

Apple Scab (*Venturia inequalis*)

This fungal disease is the most significant disease problem encountered by Missouri apple growers. Total crop loss can occur if this disease is not managed. Infection of and lesion development on leaves and fruit causes reduced fruit quality and quantity and reduces tree vigor and subsequent crops.

The key to successful apple scab management is to prevent primary infections from ascospores. During the winter and early spring, the pathogen develops in fallen leaves that were infected the previous season. Microscopic fruiting structures form in these decaying fallen leaf tissue and the ascospores are produced in the structures. These spores mature in early spring about the time that the new season's leaves begin to emerge. With minimal rainfall that wets the orchard floor for at least 30 minutes, the ascospores are discharged and carried by air currents to newly emerging leaves and blossoms. In general, maximum ascospore discharge and maximum leaf and fruit susceptibility to infection occur between tight cluster and ten days after petal fall. Discharge of ascospores may continue up to two weeks after petal fall, but the majority are released by first cover.

Infections by ascospores prior to tight cluster create the potential for the greatest losses because the lesions that develop from these initial infections produce copious amounts of secondary spores called conidia just as the leaves and fruit reach maximum susceptibility to further infections. Thus, if the ascospores are prevented from establishing infections early in the season, further scab control is unnecessary. However, if scab lesions become established in the orchard from ascospores, then the grower must manage the secondary infections from conidia throughout the season. The number of conidia produced by just a few scab lesions is greater than the total number of ascospores produced in an entire

acre of leaf litter in most commercial orchards.

Fire Blight (*Erwinia amylovora*)

This bacterial disease can be highly destructive to apples and requires an integrated approach that combines cultural practices and judicious use of bactericides. Disease severity is highly influenced by variety and rootstock susceptibility, weather, and the amount of succulent tissue present. Infections of blossoms destroy fruit set, but more significantly, the bacteria may move systemically within the plant and kill shoot tips, branches, limbs and even the rootstock.

The pathogen overwinters in cankers on branches and trunks. In spring, the bacteria ooze from the canker margins and a re carried by splashing rain and insects (mainly bees) to blossoms. Spring storm events accompanied by hail and high winds often result in "explosive" outbreaks of fire blight within one to two weeks following the storm.

Cedar-apple Rust (*Gymnosporangium juniperie-virginianae*)

Infection of apple leaves and fruit originates from wind-blown spores that are produced on the alternate host, Eastern Red Cedar. Leaf spots develop on the upper leaf surfaces shortly after bloom. These lesions are pale yellow, then turn orange. Extensive leaf infection may cause early defoliation, which in turn weakens the tree. Fruit infections are most common near the blossom end. The lesions are similar in appearance to those produced on leaves, but are larger with a dark green border, and are up to 1/16-inch deep. Fruit tissue beneath the lesion is unaffected.

The fungus overwinters on its alternate host in reddish brown galls on cedar trees. With the concurrence of spring rains and trees breaking dormancy, these galls become bright orange due to the emergence of the gelantinous tendrils or "horns" from the gall. The spores that cause the infections on apples are produced from these "horns".

Fruit are most susceptible for two to three weeks starting at bloom; leaves are mnost susceptible when four to eight days old. Once release of the spores from the cedar galls has ceased, usually by second or third cover, there is no further infection of apple tissues.

Powdery Mildew (*Podosphaera leucotricha*)

While usually not as severe a disease problem as apple scab, on highly susceptible varieties, the disease may deform, stunt or kill twigs, leaves, blossoms and fruit. Infected fruit may become severely russeted. Gray to white felt-like patches occur on the leaves and on one-year-old twigs. Infected leaves are narrowed, crinkled, and folded lengthwise, and they become thickened.

The pathogen overwinters in vegetative or fruit buds infected the previous season. Infected terminals may have a silvery gray color, stunted growth, and a misshapen appearance and are more susceptible to winter

injury than are non-infected terminals. When buds break dormancy, the fungus resumes growth and colonizes developing shoots. These primary infections on vegetative shoots and blossoms reduce yields. Secondary infections which develop on leaves and buds prior to terminal bud set in midsummer may reduce the vigor of the tree. Young fruit become infected from about the pink stage of flower bud development up to one to three weeks after bloom. Fruit infections result in a web-like russeting on the mature fruit.

This pathogen is unique from apple scab in that leaf wetness is not required for the fungus to infect plant tissues. Because powdery mildew does not need this wetting period to develop, control measures are needed even during dry periods. The critical periods for control are from tight cluster to pink through first or second cover.

Secondary apple diseases

The summer diseases of apple, bitter rot, black rot, white rot, flyspeck and sooty blotch, have the potential to cause serious fruit losses, but are managed by the fungicides applied for control of scab, rust and mildew.

Disease Management

Apple diseases are managed primarily through suppression strategies but avoidance and prevention strategies are practiced on all acres because they enhance the efficacy of fungicide sprays. However, the use of fungicides/bactericides dominates the IPM tactics employed by Missouri growers with an average 15-17 applications applied to 100 percent of the acreage each season. Practically every in-season fungicide application is a mixture of two different fungicides with different modes of action. Growers are acutely aware of the problems that can arise from overuse of a single fungicide chemistry and therefore they combine chemical classes to target the appropriate diseases. Disease incidence in Missouri orchards, aside from weather conditions that favor the disease, is largely dependent variety susceptibility.

Prevention Strategy

Missouri growers recognize that orchard sanitation plays a critical role in disease management. Growers remove diseased branches during pruning and discard mummies during harvest operations. Orchards are mowed regularly to promote good air drainage and drying of foliage and to promote decay of plant residues that may harbor pathogens. Additionally, apple growers eradicate Eastern Red Cedar growing near orchards as they are the alternate host for rust.

Avoidance Strategy

Although crop rotation is not practiced it the traditional sense because apples are a perennial crop, once

an orchard is destroyed it will not be replanted to apples for three to four years.

Monitoring Strategy

Apples are not scouted in the traditional sense for disease management. However, many of the major apple producers in the state utilize the "Show-Me" disease forecasting system in Missouri to determine when fungicides should be applied.

Suppression Strategy

Fungicides dominate the IPM tactics used to suppress diseases. Mancozeb and Captan are the key fungicides used for disease control; mancozeb is applied early in the season due to its 77 day PHI, whereupon growers switch to captan beginning with the first or second cover spray. Growers more commonly combine fungicides with different modes of action to prevent or delay the buildup of disease-resistant biotypes.

Chemical controls:

Captan (Captan 50WP) is applied to 100% of the acreage for control of scab and the summer diseases. It is applied at an average rate of 1.77 lbs. a.i. per acre. The PHI is greater than the labeled zero day interval. The number of applications varies from three to six times during the season. Captan is used in combination with benomyl or thiophanate methyl to reduce the development of resistance strains of scab. Captan is the primary late season fungicide on apples due to the 77 day PHI for the EBDC fungicides.

Mancozeb (Mancozeb, Dithane, Manzate) is applied to 99% of the apple acreage for control of scab, rust and the summer diseases. It is applied at an average rate of 2.29 lbs a.i. per acres which is less than the maximum labeled use rate of 3 lbs a.i. per acre. Prior to bloom mancozeb may be applied at up to 6 lbs a. i. per acre but only one 22-acre producer in the 2000 survey used this rate. The number of applications varies from three to six times during the season. In Missouri, mancozeb applications are terminated about 100 days prior to harvest and replaced by captan.

Thiophanate methyl (Topsin-M 70WSB) is applied to 95% of the acres for control of scab, rust and secondary diseases. It is applied at an average rate of 0.54 lbs. a.i. per acre. The PHI is greater than the labeled zero day interval. This fungicide is typically applied three to five times through the season. One to two applications are made before the first cover and several applications are made in the successive coverage sprays. Use during the cover sprays is largely dependent upon the prevalence of wet weather. Growers prefer to use this during periods of wet weather because of the greater protection imparted due to systemic properties of the chemical. Thiophanate methyl use is greater than chemicals with similar properties because of its low cost and previous problems with plant phytotoxicities from benomyl applications. Because this fungicide is also subject to the development of scab resistance, it is often combined with captan or mancozeb.

Myclobutanil (Nova 40 WP) is applied to 80% of the apple acreage for control of scab, rust and powdery mildew. The sterol-inhibitor fungicide is applied at an average rate of 0.08 pounds a.i. per acre. Up to two applications are generally made per season but some growers who do not apply captan or mancozeb may apply from six to 14 applications of Nova in a season.

Sulfur (various formulations) is applied to 62% of the acreage at a rate of 8 lbs per acre. This fungicide is applied at tight cluster in combination with another scab fungicide for control of scab and powdery mildew.

Streptomycin is applied to 100% of the apple acreage for control of fire blight. One or two applications per season are applied during bloom at an average rate of 0.77 lbs. a. i. per acre.

Benomyl (Benlate 50 WP) is applied to 18% of the apple acreage for control of scab, powdery mildew and the summer diseases. It is applied at an average use rate of 0.19 lb. a.i. per acre. Benlate was voluntarily cancelled by the registrant in 2001 and will be replaced by Topsin M.

Integrated Pest Management Strategies

Insect Pest Management

Insect pests in apples are managed primarily through suppression strategies. The use of insecticides and miticides dominates the IPM tactics employed by Missouri growers. An average 11 insecticide/miticide applications are applied to 100 percent of the acreage each season. The use of pheromones and mating disruption to monitor and control codling moth is increasing but still used on less than 5% of the acreage. Growers are aware of the problems that can arise from overuse of a single chemistry and therefore they rotate chemical classes to target the appropriate pest.

Prevention Strategy

The planting of insect-free transplants and field sanitation practices that remove alternate hosts and reduce overwintering sites are practiced on 100% of the acres. Where practicable, Eastern Red Cedars are removed for up to two miles from orchards to reduce the amount of rust spores available for infection.

Avoidance Strategy

No avoidance tactics are used to control insect pests in Missouri apples.

Monitoring Strategy

Pheromone monitoring: The use of pheromone traps to monitor adult emergence and peak flights of the

codling moth to time spray applications, is encouraged and practiced by approximately **xx** percent of the growers.

Mating disruption: No insect pests are managed through mating disruption in Missouri apple orchards.

Suppression Strategy

The insecticides included in the sprays that are applied at pink, petal fall, shuck split and some of the earlier cover sprays are primarily chosen for

Because of the concern for resistance development and the propensity of the synthetic pyrethroids to encourage mite populations, growers rotate chemical classes in these sprays. Choices for effective codling moth control become limited as harvest approaches because of pre-harvest intervals and concern for mite outbreaks.

Chemical Controls:

Superior Oil (various products and formulations) is applied to 99% of the acres at various rates (depending on the product) for control of San Jose scale, European red mite. Growers generally make one to two applications per season from dormant to green tip. Two formulations are used on apples in Missouri: Superior Oil and Sunspray Ultra-Fine Spray Oil. Superior Oil, applied at an average rate of 12.10 lbs a.i. per acre, accounts for 95% of the petroleum distillates used on apples. Sunspray Ultra-Fine is applied at an average rate of 17.50 lbs a.i. per acre.

Azinphosmethyl (Guthion 50%WP) is applied on approximately 97% of the acres for control of codling moth . It is applied at the average rate of 0.77 lbs a.i. per acre with a typical PHI of 21 days. The number of applications per season ranges from two to eight with an average of 4.5 applications per season. The relatively long PHI limits late-season use against codling moth despite excellent control of this pest. Thus, carbaryl is generally applied prior to harvest for late-season insect control. Loss of this product would leave less efficacious materials and products that are toxic to mite predators.

Chlorpyrifos (Lorsban 50W, 4E) is applied to 78% of apple acres for control of scale, aphids and leafhoppers. The 4E formulation is applied with oil from green tip to pink at an average rate of 0.40 lbs a. i. per acre. The 50 WP formulation is applied prebloom at1.66 lbs a.i. per acre.

Endosulfan (Thiodan 50% WP or 3 EC) is applied to 73% of the acres for control of leafminers, tarnished plant bug and leafhoppers. It is applied at the average rate of 1.44 lbs a.i. per acre. The labeled PHI of 21-30 days is readily observed as use of endosulfan is limited to early season sprays some 145 days prior to harvest.

Carbaryl (Sevin XLR Plus, 50W, 80S) is applied to about 67% of the acres for control of apple maggot, leafhoppers, and Japanese beetle. The XLR Plus formulation, which accounts for 69% of the carbaryl applied, is applied at an average rate of 1.0 lbs a.i. per acre. The labeled PHI of three days is observed. Growers typically include this in the last cover spray before harvest. Growers are aware the toxic properties of carbaryl to bees and do nit use it during bloom. Carbaryl is typically applied one to three times per season but one surveyed grower applied it eight times in a season.

Phosmet (Imidan 70WP) is applied on approximately 13% of the acreage for control of codling moth. It is applied at an average rate of 1.67 lbs a.i. per acre which is slightly below labeled rates. The labeled PHI of 14 days is observed. The number of applications varies with apple variety but ranges from three to seven times per season. Growers generally will use phosmet to specifically target codling moth because of efficacy, pre-harvest interval and compatibility with mite predators. Growers also prefer spraying this instead of other chemicals due to safety reasons.

Miticides (Kelthane, Vendex, Agri-mek) are applied to 32% of the apple acreage. Generally one or two applications are made with summer cover sprays, but as many as four applications per season may be applied.

Weeds

A broad number of annual and perennial grasses and broadleaf weed species must be managed in apple orchards. Some key annual and perennial grass weeds include crabgrass, fall panicum, barnyardgrass, and fescue. Some key annual broadleaf weeds include pigweeds, nettles, wild garlic, and lambsquarter. Some perennial broadleaf weeds include trumpet creeper and bindweeds. Noxious weeds such as johnsongrass and musk thistle require periodic control.

Post Harvest Pests

Because most of the crop is immediately sold on the fresh market, there are few serious post-harvest problems. Use of post harvest fungicides is not common among Missouri growers.

Weed Management

In general, management of weeds is accomplished through a burndown application of herbicide after

bloom, spot treatments of weed infestations as needed through the growing season and mowing. The burndown treatment includes a contact herbicide to kill existing vegetation and a pre-emergent herbicide to provide residual control of grass and broadleaf weeds. It is applied in a strip (widths vary with operation) to either side of the trees. The areas between rows of trees (alleys) are typically sodded, most often with fescue, and all orchards receive frequent mowing of the alleys and trimming weeds around trunk of trees to minimize competition.

Prevention Strategy

Missouri growers recognize that orchard sanitation plays a role in the management of weeds and other pests. Orchards are mowed regularly for weed control and to promote good air drainage and drying of foliage and to promote decay of plant residues that may harbor pathogens.

Avoidance Strategy

None for weeds

Monitoring Strategy

Scouting for weeds is practiced in an arbitrary manner as part of a grower's overall orchard management program. Perennial and noxious weeds are identified and removed as required.

Suppression Strategy

Approximately 95% of orchards are treated with herbicides to suppress weed competition in orchards. Karmex and Roundup are the key herbicides used. Paraquat, simazine, oryzalin and glufosinate are applied to relatively few acres.

Chemical:

Diuron (Karmex DF) is applied to 67 % of acres by ground at an average rate of 1.75 lbs. a.i. per acre. This herbicide is the primary product applied for pre-emergence control of grass and broadleaves in spring applications.

Glyphosate (Roundup Ultra) is applied to 91% acres by ground at an average rate of 0.63 lb. a.i. per acre. It is typically applied in spot applications once or twice during the season..

Table 1. Pre-harvest and Restricted Entry Intervals, and Strengths and Weaknesses of Critical Pesticides on Apples in Missouri

Insecticides (I) Fungicides (F) Bactericide (B)	PHI (days)	REI (hrs)	Strengths	Weaknesses
azinphosmethyl (I)	14-21	48	safe for predatory mites; excellent control of Codling moth	21 day PHI limits effectiveness for Codling moth
phosmet (I)	7	24	excellent control of Codling moth; worker safety	
endosulfan (I)	21-30	24	excellent control of leafhoppers; early season control of key insect pests	not used late season
chlorpyrifos (I)	prebloom	24	excellent control of scale	maximum one app./season
pyrethroids (I)	7-21	12	excellent control of early season insects	promotes mite infestations
carbaryl (I)	3	12	last cover spray	toxic to bees and mite predators
captan (F)	0	24	#1 late-season fungicide; excellent for resistance management; economical	not effective on rust and powdery mildew
sulfur (F)	0	24	economical;	phytotoxic when hot and humid; not effective on rust and summer diseases
mancozeb (F)	77	24	#1 early-season fungicide; economical; excellent for resistance management; excellent control of scab, rust and summer diseases	maximum use rates of 3 lbs/app and 21 lbs/season; not effective on powdery mildew
thiophanate-methyl (F)	0	12	excellent in tank-mix with other fungicides	overuse promotes resistant biotypes, cannot use alone; not effective on rust
myclobutanil (F)	14	24	systemic and curative; excellent control of scab, rust and powdery mildew	not effective on summer diseases
streptomycin (B)	21	12	cheap and effective control of susceptible biotypes when applied at bloom	must be applied weekly during bloom. Resistant biotypes have been problematic in Missouri

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References

1. Bessin, R.T., P. S. McManus, G. R. Brown, J. G. Strange, eds. 1998. Midwest Tree Fruit Pest Management Handbook.

2. Commercial Tree Fruit Spray Guide: Missouri, 2001. MP-651. University Extension, University of Missouri and Southwest Missouri State University.

3. Missouri Agricultural Statistical Service. 1995-2000. Missouri Farm Facts. Missouri Department of Agriculture and United States Department of Agriculture.

4. National Agriculture Statistical Service. 1999. 1999 Census of Agriculture.

5. Pesticide Use Surveys: Missouri, 1990 and 2000. Apples, Peaches, Grapes, Cotton and Rice. Pesticide Impact Assessment Program, USDA.