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Controlling Diseases and Insects on Ornamental Trees

Michigan State University Extension Service

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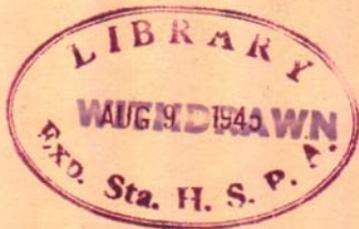
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*Controlling*  
DISEASES AND INSECTS  
ON  
ORNAMENTAL TREES

Prepared by  
Departments of Botany and Plant Pathology, Entomology,  
and Horticulture



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## QUANTITIES OF COMMON INSECTICIDES REQUIRED FOR SMALL AMOUNTS OF SPRAYS BASED ON GENERALLY ACCEPTED FORMULAS

MATERIALS	1 GALLON	3 GALLONS	100 GALLONS
Calcium arsenate	3½ tablespoons	11 tablespoons or ¾ cup	4 pounds
Lead arsenate	3 tablespoons	9 tablespoons or ½ cup	4 pounds
Derris powder (4-percent rotenone)	5 tablespoons	1 cup	5 pounds

These quantities are based on standard measuring cups and spoons level full.

### EQUIVALENT QUANTITIES OF LIQUID MATERIALS WHEN MIXED BY PARTS

DILUTIONS				
WATER	1-400	1-800	1-1000	1-1600
100 gallons	1 quart	1 pint	1½ cup	½ pint, 1 cup
25 gallons	1 cup	½ cup	⅔ cup	¼ cup
5 gallons	3 tablespoons	5 teaspoons	4 teaspoons	2½ teaspoons
1 gallon	2 teaspoons	1 teaspoon	¾ teaspoon	½ teaspoon

These quantities are based on standard measuring cups and spoons level full.

Approximate equivalents for use in measuring liquid insecticides and fungicides.

3 teaspoons = 1 tablespoon

16 tablespoons = 1 cup

1 pint = 2 cups

2 tablespoons = 1 fluid ounce

16 fluid ounces = 1 pint or pound

8 pints = 1 gallon

### APPROXIMATELY EQUIVALENT QUANTITIES OF DRY INSECTICIDAL MATERIALS FOR VARIOUS QUANTITIES OF WATER

WATER	QUANTITIES OF MATERIALS					
100 gallons	1 pound	2 pounds	3 pounds	4 pounds	5 pounds	6 pounds
25 gallons	4 ounces	8 ounces	12 ounces	1 pound	1 pound, 4 ounces	1 pound, 8 ounces
5 gallons	4 tablespoons	8 tablespoons	¾ cup	1 cup	4 ounces	5 ounces
1 gallon	2 teaspoons	4 teaspoons	7 teaspoons	3 tablespoons	4 tablespoons	5 tablespoons

The number of tablespoons per ounce of dry fungicides and insecticides varies so greatly that it is impossible to give accurate measures in teaspoons, tablespoons, or cups. 5-6 tablespoons equal approximately one ounce at different rates. The amounts given in teaspoons, tablespoons, and cups are the averages of a number of materials. If there is any information on the package as to dosage for small amounts of spray, follow manufacturer's directions. If there are no accompanying directions for mixing small quantities, use the table above.

# Control of Diseases and Insects on Ornamental Trees

By C. E. WILDON, and E. J. RASMUSSEN, Department of Horticulture; RAY HUTSON and E. I. McDANIEL, Department of Entomology; and F. C. STRONG, Department of Botany and Plant Pathology

There is no effort in this bulletin to catalog all the diseases and insects which may affect ornamental trees. Descriptions of the pests and their injuries are as brief as possible. Presentation of treatments is also streamlined. The control methods suggested are those which have been successful with readily available materials and machinery.

The presentation of information is by alphabetical arrangement of host plants. As a usual thing treatment is indicated in the description of the pest, with fuller descriptions as to dosage, dilutions, mixing, etc., on pages 21-28.

There are several general considerations in spraying which must be kept in mind at all times. The more important are:

1. Do not spray with a summer oil when the temperature is 80° F. or above or when there are indications such a condition may develop.
2. Do not apply any spray when the temperature is 85° F. or above. Nicotine and other sprays directed solely at aphids are possible exceptions.
3. Do not apply dormant oil sprays when there is danger of the spray freezing before it dries.
4. Be certain to have a perfect emulsion and that the spray hose does not contain a concentrated dose when starting the application of oil.
5. PDB in cottonseed oil should not be applied during the summer months when there is danger of the temperature going above 80° F., for any prolonged period.
6. Lead and calcium arsenates are interchangeable for all situations requiring arsenates in this bulletin. See (10), page 24.
7. When the insect or disease cannot be identified, send insect samples to Entomology Department, and disease samples to Botany Department, Michigan State College.

Many insecticides and fungicides have a tendency to stain wood, painted surfaces, or stone. This must be taken into consideration when spraying ornamental plantings in cities. If a structure is thoroughly wetted before and thoroughly washed down after an application, the damage caused by stains will be lessened.

NOTE: Control recommendations described in this bulletin are given code numbers in parentheses. The numbers refer to detailed information in the last part of the bulletin.

INSECTS AND DISEASES	CHARACTERISTICS AND CONTROL
	<b>ARBOR - VITAE (Thuja)</b>
	See Cedar.
	<b>BIRCH (Betula)</b>
Imported birch leafminer. . .	Blotch mines on terminal leaves of young trees and water sprouts. Two broods, Mid-June and late August. <b>Use nicotine sulfate 1-800 and soap (13)*.</b>
Bronze birch borer. . . . .	Trees attacked from top. Spiral ridges on bark of branches and trunks. <b>Maintain vigor of trees. Use arsenate (10) in May or early June.</b>
Birch leaf skeletonizer. . . . .	Skeletonized foliage in late summer. <b>Use lead arsenate (10). Coat under sides of leaves in late July.</b>
	<b>CATALPA</b>
Catalpa mealy bug. . . . .	Cottony excretions on bark, axils of twigs and foliage. Two or three generations. <b>Use nicotine sulfate 1 to 800, plus ½ gallon summer oil (13, 18) or sulfated alcohol (31).</b> (Spray must be applied with pressure and volume.)
Catalpa Sphinx. . . . .	Trees defoliated by greenish or brownish caterpillar, 2¼ inches long. Two broods appear in June and August or September. <b>Hand pick. Use lead arsenate (10).</b>
Leaf spots. . . . .	Mostly circular brown spots. <b>Sanitation (38). Spray (1) or (3) 3 times at 14-day intervals beginning when leaves start.</b>
Wilt. . . . .	Sudden wilting of leaves, followed by death of affected branches. Cause unknown. <b>Remove affected branches and burn. Fertilize (39) and water tree (33).</b>

\*Control recommendations throughout this bulletin are given code numbers in parentheses. The numbers refer to detailed information in the last part of the bulletin. An index to host plants and control materials can be found on the inside back cover.

**CEDAR, WHITE AND RED**  
(Thuja, Chamaecyparis and Juniperus)

Red spider.....	Attacks arbor-vitae, causing foliage to turn gray or bronze—usually in July or August. <b>Spray with glue (19) or bill-poster's paste (16) or rotenone (15) or DN (17).</b>
Spruce mite.....	Common on Juniper. Bronzed or off-colored foliage. Presence of mites, eggs, and webbing. <b>Rotenone (15) or bill-poster's paste (16) or glue (19) in mid-summer or DN (17) or 2 percent summer oil (18) in early spring or late fall.</b>
Aphids.....	Accumulations of honeydew usually accompanied by sooty fungus. <b>Use nicotine sulfate 1-800 and soap (13). To remove the honeydew, wash tree with a sulfated alcohol (31).</b>
Juniper scale.....	A circular grayish-white shield with a yellow center, on foliage; attacks Juniper. <b>Spray in early spring with 2-percent summer oil (18) or with sulfated alcohol (31) in mid-summer.</b>
Juniper webworm.....	Needles webbed together, forming a nest 2 to 3 inches long and usually containing small, greenish caterpillars. <b>Spray when larvae are active, with lead arsenate (10) plus 1 pint, 40-percent nicotine sulfate to 100 gallons spray. (This spray is only effective when applied with pressure.)</b>
Rusts.....	Small, woody galls on twigs of Junipers which develop gelatinous orange horns in April or May. <b>Do not grow red cedar within 500 feet of hawthorn or native flowering apples unless there is foliage screen between. Use wettable sulfur (5) in July and August. Use Bordeaux mixture 180 (2) on Junipers when horns first appear on galls late in April; use a second application in 7 days.</b>
Twig blight.....	Twigs and branches killed back. <b>Prune out and burn affected branches. Spray (1) when disease is prevalent.</b>
Winter drying.....	See Pines.

## INSECTS AND DISEASES

## CHARACTERISTICS AND CONTROL

CHERRY, FLOWERING (*Prunus cerasus*)

San Jose scale.....	Circular grayish shield 1-16-inch in diameter on trunks and branches. <b>Use dormant lime-sulfur (4) or 3-percent dormant oil (23).</b>
Pear slug.....	Leaves skeletonized by slug-like larvae. <b>Use lead arsenate (10) in the early spring, or spray, when present, with nicotine sulfate 1-800 plus soap (13), or dust with rotenone (12).</b>
Peachtree borer.....	Masses of gum and frass about bases of trees. <b>Remove by hand.</b>
Oriental fruit worm.....	Tender terminal growths mined by larvae. <b>No control.</b>
Tent caterpillar.....	Large tents containing caterpillars formed in axils of branches in early spring. <b>Destroy nests. Use lead arsenate (10) when caterpillars are young.</b>
Flatheaded apple tree borer	See Maple.
Leaf spot.....	Circular brown spots which later drop out, leaving holes in leaves. Leaves also turn yellow and drop. <b>Four sprays at 14-day intervals, beginning at petal-fall (3).</b>
Witches'-broom.....	Dwarfing and deformation of branches, producing small, compact, broom-like growths. <b>Use dormant lime-sulfur spray (4). Cut out and burn brooms.</b>
Powdery mildew.....	White moldy growth over leaf surfaces. <b>Dusting with sulfur (8) will prevent appearance and will check spread after it appears.</b>

**CHESTNUT, AMERICAN (Castanea)**

Blight..... Leaves wilt, turn brown, and remain on branches after cankers have girdled and killed the branches. Trees eventually die. **No control.**

**CRAB, FLOWERING (Pyrus)**

Mealy bug..... Cottony excretion on bark, in axils of twigs, on branches and on foliage. Two or three generations each year. **Use nicotine sulfate 1 to 800 (13) plus ½ gallon summer oil.** (Spray must be applied with pressure and volume.)

Roundheaded apple tree borer See Cotoneaster.

Flatheaded apple tree borer Flat legless grub tunneling under bark, often girdling transplants. **Protect trees with crepe paper (37) or paint opening to tunnels with PDB in cottonseed oil (25) or inject carbon disulfide (24) and plug entrance.**

Aphids..... Woolly aphids congregating on trunk and limbs. **Use nicotine sulfate (13) and oil, same as for mealy bug.**

Oystershell scale..... See Cotoneaster.

San Jose scale..... See Cotoneaster.

European red mite..... Rusty brown foliage and small foliage in mid-summer. Reddish pinpoint eggs on bark and smaller twigs in fall and winter. **Use dormant 3-percent oil (23).**

## INSECTS AND DISEASES

## CHARACTERISTICS AND CONTROL

## CRAB, FLOWERING (Pyrus)—Con.

Leafhopper.....	Several species. They remove sap from the leaves, causing a white, stippled appearance or curl the terminal leaves of the new growth. Use nicotine sulfate 1-800 (13) plus $\frac{1}{2}$ gallon summer oil, same as for mealy bug.
Cankerworms.....	See Elm.
Tent caterpillar.....	See Cherry.
Tussock moth.....	See Horsechestnut.
Fall webworm.....	See Poplar.
Pearleaf blister mite.....	See Mountain Ash.
Clover mite.....	Reddish eggs on bark and twigs in fall and winter. Seldom a problem on trees in Michigan during summer. Use dormant oil 3-percent (23).
Red-humped caterpillar....	Gregarious caterpillars feeding on foliage in mid-summer. Head and hump on fourth abdominal segment bright red, rear of abdomen humped. Hand pick; use lead arsenate (10).
Green aphids.....	Several species. Use nicotine sulfate 1-800 (13), plus soap.
Red spider.....	Infests undersides of leaves, causing off-colored un-thrifty appearance. Sometimes mites and eggs present protected by webbing. Use rotenone (12) or bill-poster's paste (16), or rotenone and turkey red oil (15).

Leaf spots . . . . .	Brown to blackish spots on leaves. <b>Apply three sprays (1) or (3) or (5) at 14-day intervals, beginning when flower buds are in the pink.</b>
Fire blight . . . . .	Sudden withering of new twig growth, flowers blighted, hold-over cankers on branches and trunk. <b>Prune off blighted branches 6 inches below visible extension of disease. Sterilize pruning tools after each cut (32). Treat hold-over cankers (36).</b>
Crown gall . . . . .	Woody galls on roots. Use clean, healthy trees. <b>If galls are removed before planting, dip roots in disinfectant (34).</b>
Rust . . . . .	Yellow spots on leaves. Twigs sometimes affected and become swollen. Fruit also may be attacked. <b>Spray with (1) or (3) at seven-day intervals, beginning last week of April and continuing to June 1.</b>

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**ELM (Ulmus)**

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Cankerworm . . . . .	Measuring worms defoliating trees in early spring. <b>Apply lead arsenate (10) when leaves are a quarter grown.</b>
Elmleaf beetle . . . . .	Bronzed striped beetles $\frac{1}{4}$ inch long, defoliating trees. Two broods, first brood when leaves are one-fourth grown, second about third week in August. <b>Lead arsenate (10) 4 pounds with sticker (18) to 100 gallons in spring, when leaves are a quarter grown and again in mid-summer, if present.</b>
Woolly aphid . . . . .	Rolled and distorted leaves contain aphids covered with cottony excretions. <b>Use nicotine sulfate and soap (13) before leaves curl.</b>

INSECTS AND DISEASES	CHARACTERISTICS AND CONTROL
<b>ELM (<i>Ulmus</i>)—Con.</b>	
European elm scale . . . . .	Soft-bodied chocolate-brown scales surrounded with a fringe of white wax. On trunks and limbs. One generation each year. Young, late in June. <b>Use dormant oil 3-percent (23) or nicotine sulfate and soap (13) when young crawl.</b>
Elm bark beetles . . . . .	Short brood chambers under bark, girdled trunks or limbs. Mature trees attacked. <b>Maintain vigor of trees. No control.</b>
Tussock moth . . . . .	See Horsechestnut.
Leaf spots . . . . .	Small, brown to black, areas on leaves. <b>Sanitation (38). Spray with (1) or (3) or (5) three times at 14-day intervals beginning when leaves first start.</b>
Dutch elm disease . . . . .	Wilting of leaves, dying of entire branches. Tree dies in short time. <b>No control. Remove and burn affected tree or cut up and store wood inside to avoid infestation by bark beetles which carry casual fungus to healthy trees. Send 6 six-inch length pieces from dying, but not dead branches to Botany Department, Michigan State College, East Lansing. NOT KNOWN TO BE PRESENT IN MICHIGAN TO DATE.</b>
Phloem necrosis . . . . .	Wilting and dying of branches. Tree soon succumbs. <b>No control. Remove and burn affected trees. Not likely to appear in Michigan.</b>
Wilts, Verticillium and Dothiorella	Similar symptoms to foregoing two diseases. <b>Remove dead and dying branches. Sterilize tools between cuts (32). Fertilize (39) and water (33). Send samples from dying branches to Botany Department, Michigan State College, East Lansing for diagnosis.</b>

Slime flux..... Continuous or intermittent oozing of sap from wounds or cracks in trunk or branches. Accumulation of sap soon becomes foul-smelling and may kill bark beneath. **No control. May cease in time. Wash off accumulated slime occasionally with water.**

**HACKBERRY (Celtis)**

Aphids..... Aphids infesting leaves. **Use nicotine sulfate 1-800, plus soap (13), or pyrethrum (14) as a dust or spray.**

Witches'-broom..... Deformed terminal growths, often developing broom-like growth. **Remove deformities as soon as they appear. Use dormant lime sulfur (4).**

Chlorosis..... Leaves become yellowish-green, especially between veins. **Have soil tested. Usually requires treatment to make it more acid in reaction (40).**

**HAWTHORN (Crataegus)**

Hawthorn lace bug..... Faded foliage with black specks on undersides of leaves. Presence of lace bug 1/8 inch long. **Use nicotine sulfate 1-400 and soap (13), or nicotine sulfate with special spreader (30), or rotenone (15).**

Roundheaded apple tree borer..... Tunnels in trunks near ground level. Quantities of excelsior-like sawdust. Two-year life cycle. Adults in early summer. **Paint wounds with PDB in cottonseed oil in fall or spring (25) or inject carbon disulfide (24).**

Spotted apple tree borer... Work and life history similar to that of round-headed apple tree borer but activity restricted to limbs and larger branches. **Clean wounds and paint with PDB in cottonseed oil (25) in fall or spring.**

INSECTS AND DISEASES	CHARACTERISTICS AND CONTROL
<b>HAWTHORN (Crataegus)—Con.</b>	
Flatheaded apple tree borer	See Maple.
Thorn-limb borer . . . . .	Swellings on twigs and branches about 1 inch long with longitudinal scars. Twigs break at point of injury. Adults in June. <b>Remove and burn infested twigs.</b>
Leaf blight . . . . .	Small, angular, reddish-brown to black spots. Susceptible trees such as "Paul's Scarlet Thorn" often defoliated by August. <b>Three sprays of (1) or (3) or (5) at 14-day intervals, beginning when flower buds are in the pink. Sanitation (38).</b>
Rust . . . . .	Orange spots on leaves. <b>Avoid growing near red cedars, or dwarf junipers in Northern Michigan. See crab, flowering for spray control.</b>
<b>HICKORY (Carya)</b>	
Hickorybark beetle . . . . .	Vertical galleries about an inch long in the inner bark and sapwood with smaller tunnels radiating out at right angles. Usually mature trees. <b>Maintain vigor of trees. Remove and burn infested trees before adults emerge.</b>
Hickory-gall aphid . . . . .	Globular galls on stems and new shoots. Cause deformed growth. <b>Use nicotine sulfate 1-800 plus soap (13).</b>
Fall webworm . . . . .	See Poplar.
Tussock moths . . . . .	See Horsechestnut.
Walnut caterpillars . . . . .	See Walnut.
Leaf spots . . . . .	Small to large, circular to angular brown, dead areas on leaves. <b>Sanitation (38). Spray (1) three times at 14-day intervals beginning as soon as leaves start.</b>

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HORSECHESTNUT (*Aesculus*)

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- Tussock moth..... Tussock-bearing caterpillars 1½ inches long defoliating trees. Weathered cocoons on trunk or branches in winter. **Hand-pick** fall and winter, or spray with lead arsenate (10) before caterpillars are ½ inch long.
- Leaf blotch..... Large irregular brown areas. **Sanitation** (38). **Spray** with (1) or (3) or (5) three times at 14-day intervals, beginning when leaves start.
- Leaf scorch..... Edges, tips and between veins of leaflets become brown. **Evidence of soil moisture deficiency.** **Water** (33).
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JUNIPER (*Juniperus*)

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See Cedar.

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LINDEN (*Tilia*)

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- Aphid..... See Maple.
- Leaf miner..... Leaf miner and skeletonizer defoliating trees in August or early September. **Use lead arsenate (10) in July.**
- Sooty mold..... See Maple.
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## INSECTS AND DISEASES

## CHARACTERISTICS AND CONTROL

LOCUST, BLACK (*Robinia*)

Leaf miner.....	Blister-like galls or skeletonized leaves in mid-summer. Use lead arsenate (10) as soon as leaves develop full size.
Silver-spotted skipper.....	Leaflets fastened together forming a nest. Use lead arsenate (10) before nest has formed. Hand-pick.
Locust borer.....	Accumulation of sawdust on trunk and about base of tree in June and July. Use PDB in cottonseed oil (25) in spring.

MAPLE (*Acer*)

Bladder gall.....	Small globular galls on upper surface of leaves. No control required. Responds to dormant lime-sulfur (4).
Flatheaded apple tree borer	Flat, legless, flat-headed grub excavating cavities under bark—often girdles young trees. To prevent borers, wrap trunk with crepe paper impregnated with asphalt (37). To kill borers in trunk, paint with PDB and cottonseed oil (25) or inject carbon disulfide (24).
Sugar maple borer.....	Dead limbs among leafy branches. Mutilation of trunks and larger limbs. Check spring and summer for borers and treat with PDB in cottonseed oil (25) or inject carbon disulfide (24).
Aphids.....	Small, greenish aphids on undersides of the leaves of Norway maples. Dropping of leaves and accumulation of honeydew. Wash with water under pressure. Use nicotine sulfate 1-800 plus soap (13).

Cottony maple scale.....	Cottony masses protruding from brown scales on twigs in June. <b>Use dormant lime-sulfur (4).</b>
Tar spot.....	Black, tar-like spots on leaves. <b>Sanitation (38). Spray with (1) or (3) or (5) three times at 14-day intervals, beginning when leaves start.</b>
Leaf spots.....	Brown areas on leaf surfaces, sometimes on veins. <b>Spray as for tar spot.</b>
Leaf scorch.....	Brown, dead areas along edges of leaves and between the veins. Evidence of soil moisture deficiency. <b>Water (33).</b>
Wilt.....	Leaves wilt, curl and dry. Whole branches die. In spring dead branches killed in winter become evident. Disease spreads to entire tree. <b>Remove and burn dead and dying branches. Sterilize pruning tools between cuts (32). Fertilize (39) and water affected trees (33).</b>
Sooty mold.....	Black, sooty mold covering leaves and sometimes twigs and branches. Follows aphid attacks. <b>Control aphids.</b>

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**MOUNTAIN ASH (Sorbus)**

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San Jose scale.....	See Cherry.
Pear-leaf blister mite.....	Brownish blisters on undersides of leaves. Defoliates trees. <b>Use dormant lime-sulfur (4), or dormant oil (23).</b>
Shot-hole borer.....	Galleries under bark, often girdling trunks, limbs, or twigs. Beetles emerge through holes in bark. <b>Maintain vigor of trees. No other control. Remove and burn infested trees.</b>

MOUNTAIN ASH (*Sorbus*)—Con.

Fire blight .....	Sudden dying back of growing tips. Cracked bark on larger branches and trunk are hold-over cankers. <b>Prune out blighted branches, cutting at least a foot below farthest extension of disease and burn. Sterilize pruning tools between cuts (32). Treat hold-over cankers (36).</b>
Canker .....	Sunken oval areas on branches and trunk. Stem girdled, killing part above. <b>Cut off affected branches and burn, or if on trunk, treat (35).</b>
Rust .....	Orange spots on leaves. Avoid growing near red cedars, or dwarf junipers in northern Michigan. <b>See Crab, Flowering, for spray control.</b>

OAK (*Quercus*)

Twig pruner .....	Small, clean-cut twigs on ground in mid-summer or dead twigs clinging to tree. <b>Collect and burn fallen twigs.</b>
June beetles .....	Trees defoliated at night, in spring by brown beetles. <b>Lead arsenate (10) just before leaves become full grown.</b>
Flatheaded apple tree borer	See Maple.
Red-humped caterpillar....	See Crab, Flowering.
Oak galls .....	Many conspicuous galls. Many kinds made by different insects. Usually unimportant. <b>No control required.</b>

Leaf miners .....	Several species. <b>Remove fallen leaves in fall (38). No control.</b>
Fall webworm .....	See Poplar.
Leaf blight .....	Brown areas at leaf tips and on veins. Twigs killed back occasionally. Appears in spring and early summer. <b>Sanitation (38). Spray with (1) or (3) or (5) three times at 14-day intervals, beginning when leaves start.</b>
Leaf scorch .....	Brown areas along edges and between veins of leaves. Drought conditions. <b>Water (33).</b>
Chlorosis .....	Yellowish-green coloration especially between veins. Soil too alkaline. <b>Have soil tested (40).</b>

#### PINE (Pinus)

Sawflies .....	Several species. Larvae gregarious. Defoliate trees early spring and mid-summer. <b>Lead arsenate (10) before growth starts. Pyrethrum (14), or rotenone (12), or nicotine sulfate (13), when larvae are present.</b>
European pine shoot moth.	Terminals tunneled by larvae in late spring deforming trees and producing characteristic stag-horn growth. <b>Fixed nicotine (13a) or derris or cube (5% rotenone), 3 pounds per 100 gallons plus 1/2 gallon summer oil (18) the last week in June and repeat in 10 days. (Apply with pressure).</b>
Pine bark beetle .....	Short brood chambers with numerous larval galleries under bark. Adults emerge through holes in the bark. <b>Maintain vigor of tree. No control.</b>
Pine needle scale .....	Elongated white shield scales on foliage. Off color foliage. Growth stunted. <b>Use dormant oil 3 percent (23) in the spring.</b>

INSECTS AND DISEASES	CHARACTERISTICS AND CONTROL
<b>PINE (Pinus)—Con.</b>	
Pine bark aphid . . . . .	White cottony masses on bark, trunk or limbs. <b>Wash with water under pressure in mid-summer. Use dormant oil 3 percent (23) in the spring.</b>
Spittle bug . . . . .	Masses of froth or spittle on twigs in early spring. <b>Rotenone (15).</b>
Blister rust . . . . .	<b>WHITE PINE ONLY.</b> Cankers on branches and trunk. Girdles stem killing parts beyond. Tree killed. <b>Do not grow white pine within 900 feet of currants or gooseberries, nor within one mile of black currants.</b>
Needle scorch . . . . .	<b>ALL PINES.</b> Terminal half or more of needles turn brown. Drought conditions in summer or sometimes in spring. Severe drought injury resembles winter drying. <b>Water (33) in summer and also in autumn before soil freezes.</b>
Winter drying . . . . .	<b>ALL CONIFERS.</b> Foliage turns brown in March or April. Trees during first few years after planting often suffer when planted in exposed or in sunny, sheltered locations if their root systems do not extend below the frost line. <b>Soak soil with water before ground freezes in autumn. Mulching reduces depth to which frost penetrates. Use only old, well-rotted mulch.</b>
Needle rust . . . . .	<b>RED PINE.</b> Tiny, pale yellow blisters on needles in June. Disease also affects goldenrod and wild aster. May stunt young pine. <b>No control feasible.</b>
Twig blight . . . . .	<b>AUSTRIAN, SCOTCH, MUGHO PINES.</b> Twigs killed back at tip and turn brown. <b>Prune off diseased tips. Spray with (1) or (3) at 10-day intervals in spring when new growth is developing.</b>

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POPLAR (*Populus*)

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- Mottled willow borer..... See Willow.
- Poplar sawfly..... Orange-yellowish larvae with black spots. Gregarious. Double brooded. Defoliate trees. Use lead arsenate (10) before larvae appear. Apply contact sprays or dust such as nicotine sulfate (13) or pyrethrum (14) or rotenone (12) when larvae are present.
- Fall webworm..... Gregarious, hairy caterpillars feeding within webs. Nests terminal in mid-summer. Trim out nests while small. Use lead arsenate (10).
- Oystershell scale..... Brownish shields resembling minute oystershells on trunk and branches. Use DN dormant (21).
- Leaf spots..... Small, brown areas on leaves. Sanitation (38). Sprays usually not considered necessary.
- Cankers..... Dead oval area on branches and trunk, sunken or with cracks at margins. Branches die. Tree becomes scraggy in appearance. Dormant spray (4) aids in checking spread of disease. Almost useless to attempt cutting out cankers.
- Wetwood wilt..... Wilting of leaves and dying of branches. Tree soon dies. No control. Remove and burn tree to avoid spread of disease.

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SPRUCE (*Picea*)

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- Spruce mite..... Foliage grayish or with bronzed cast. Spray with glue (19), or bill-poster's paste (16), or rotenone (12), or DN foliage (17), or rotenone-turkey red oil (15) in summer.
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INSECTS AND DISEASES	CHARACTERISTICS AND CONTROL
<b>SPRUCE (Picea)—Con.</b>	
Spruce cone gall aphid.....	Pineapple-shaped galls at the bases of new growths. Adults late July or August. <b>Use dormant oil (23) in spring or nicotine sulfate 1-800 and soap (13) when aphids are on the foliage. Remove and destroy the galls in July before they open.</b>
Spruce tortrix.....	Lower inside branches with nests made by several needles matted together. Contain larvae and pupae. <b>Use lead arsenate (10) and nicotine sulfate 1-800 plus summer oil ½ gallon.</b> (See juniper webworm under Cedar.)
Spruce sawfly.....	Masses of dark green larvae with dark, longitudinal stripes. Defoliate trees. (See pine sawflies).
Spruce budworm.....	Terminal nests of several leaves, giving a reddish or brownish cast. <b>Spray early in spring with lead arsenate (10) to cover terminal growth.</b>
<b>SYCAMORE (Platanus)</b>	
Lace bug.....	Tiny insects with lace-like wings and sucking mouthparts feeding on under sides of leaves. <b>Use nicotine sulfate 1-800 and soap (13).</b>
Tussock moth.....	See Horsechestnut.
Leaf and twig blight.....	Large, brown, dead, areas along veins. Leaves fall. Twigs killed in spring and leaves shrivel, appearing as if frost-killed. <b>Sanitation (38). Spray with (1) or (3) three times at 14-day intervals beginning when leaves start. Prune out affected branches in young tree.</b>

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WALNUT (*Juglans*)

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Bud moth.....	Terminal leaves and shoots webbed together. New growth killed or is stunted. <b>Use lead arsenate (10) in early June.</b>
Caterpillars.....	Trees defoliated August or September by gregarious nest building hairy caterpillars. <b>Trim out nests when small. Spray with lead arsenate (10) in July or early August.</b>
Walnut scale.....	Circular light, grayish, scale about 1/8 inch in diameter. <b>Use DN dormant (21) or lime-sulfur dormant (4).</b>
Oystershell scale.....	See Poplar.
Leaf spot.....	Small circular to angular brown, dead, areas on leaves. Abundant late in season. Common cause of early autumnal defoliation. <b>Spray with (1) or (3) or (5) three times at 14-day intervals beginning when leaves start. Sanitation (38).</b>
Canker.....	Small to large oval sunken areas with callus-ridge border on big branches and main stem. Often open wounds from rotting of exposed wood. <b>Remove affected branches or cut out cankers (35).</b>

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WILLOW (*Salix*)

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Spotted leaf beetle.....	Reddish black-spotted beetles about 1/4-inch long defoliating trees in mid-summer. <b>Use lead arsenate (10) when larvae first appear.</b>
Tent caterpillar.....	See Cherry.
Mottled willow borer.....	Swollen galls and knotty growths on limbs and branches splitting bark. Adult in late summer. <b>PDB in cottonseed oil (25) in spring.</b>

WILLOW (*Salix*)—Con.

Cone gall.....	Terminal grayish-brown cone-shaped galls about one inch long. <b>No control required.</b>
Oystershell scale.....	See Poplar.
Poplar sawfly.....	See Poplar.
Aphid.....	Quantities of honeydew dripping from trees in late summer. Presence of large, black aphids. <b>Use nicotine sulfate 1-800 and soap (13).</b>
Fall webworm.....	See Poplar.
Willow scab.....	Leaf and twig blight. Not reported in Michigan to date. May occur and will cause considerable injury. <b>Spray with (1) or (3) three times at 14-day intervals, beginning when leaves first start.</b>
Canker.....	Oval sunken areas on branches and main stem. May girdle branch of stem killing part beyond. <b>Cut out cankers (35).</b>
Crown gall.....	Woody galls on branches as well as roots. <b>Remove and burn young trees. Older trees may survive without great injury.</b>
Rust.....	Tiny orange and black, raised spots on leaves. <b>Sanitation (38).</b>

## Spraying and Dusting Materials

Spraying and dusting materials can be divided into three groups according to the purposes for which they are used. (A) Fungicides, materials used to control diseases; (B) insecticides, materials used to control insects; (C) accessory materials, materials used as spreaders, stickers, and correctives.

### FUNGICIDES

In general, spraying and dusting materials used to control diseases contain either copper, sulfur, or mercury.

### SPRAYING MATERIALS

1. **\*Bordeaux mixture**—Bordeaux mixture is a mixture of copper sulfate and lime. The formula for bordeaux varies in the amount of copper sulfate and lime, depending upon the disease to be controlled. The formula 4-6-50 is in common use for the control of diseases on ornamental trees and shrubs. In a formula for bordeaux, the first figure always signifies the amount of copper sulfate in pounds, the second figure the amount of hydrated spray lime in pounds, and the third figure the amount of water in gallons.

\*Control measures throughout the preceding portion of this bulletin are given code numbers in parentheses. These numbers refer to corresponding numbers on this and following pages.

Copper sulfate appears on the market in two forms: (1) the crystal form used for spraying purposes, (2) the monohydrated form for dusting purposes. The crystal form is obtainable in three grades based on particle size. These grades are referred to by the trade as (a) powdered, (b) snow, and (c) small and large crystals. The powdered and snow grades are recommended for convenience in the preparation of bordeaux. Only fresh hydrated lime prepared for spraying purposes should be used in the preparation of bordeaux. Agricultural or mason's lime is not satisfactory.

To make 4-6-50 bordeaux:

1. Fill the tank about  $\frac{2}{3}$  full with water.
2. Have agitator in operation.
3. Make the 6 pounds of spray lime into a thin paste and wash through a strainer.
4. Dissolve the 4 pounds of copper sulfate in 2 to 3 gallons of water and add it slowly to the lime solution.
5. Add water to make 50 gallons.
6. Allow 3 to 4 minutes for the copper sulfate and lime to react before using. Bordeaux should be used soon after mixing. Keep agitator in operation until the mixture is sprayed out.

2. **Bordeaux mixture 180**—This is a special formula for spraying red cedars bearing cedar-apple rust galls in the spring. Prepare a 6-6-50 bordeaux as outlined in section 1 and add 1 pound monocalcium arsenite, 4 pounds zinc arsenite, and 1 pint of fish oil. (1½ pounds of soybean flour may be substituted for the fish oil.)

3. **Proprietary copper compound**—Proprietary copper compounds are manufactured copper fungicides containing copper in a relatively low soluble form. They are sold under various trade names. A partial list of these materials listed alphabetically includes Basicop, Bordow, Cupro K, COCS, Oxobordeaux, Spraycop, Tennessee 26, Tennessee 34, and Tri Basic. Proprietary copper materials can be used as substitutes for bordeaux to control several plant diseases. They are less injurious to plants, vary in copper content, and should be used according to manufacturer's recommendations.

4. **Lime-sulfur**—Lime-sulfur contains sulfur combined with lime, and these products are known as calcium polysulfides.

Lime-sulfur can be obtained in both the liquid and dry forms.

Liquid lime-sulfur is both an insecticide and a fungicide. It can be used to control certain scale insects and some diseases in the dormant period, and to control certain plant diseases in the growing period. For dormant use, add 1 gallon of concentrated liquid lime-sulfur to 7 gallons of water. The usual dilution for the

control of plant diseases in the growing period is 1 gallon to 40 to 50 gallons of water. Dry lime-sulfur can be substituted for liquid lime-sulfur when used as a fungicide. In general, 1 pound of dry lime-sulfur is equal to 1 quart of liquid lime-sulfur.

5. **Wettable sulfurs**—Wettable sulfurs contain finely divided particles of elemental sulfur to which a wetting agent has been added. They can be obtained in both the dry and paste forms. Wettable sulfurs are sold under various trade names. A partial list of wettable sulfurs includes Dritomic, Flotation Paste, Flotox, Kolofog, Magnetic, Mike, Sulfix, Sulforon, 3 M, Linco. They vary in sulfur content and particle size. The products containing the largest amount of sulfur and the smallest sized particles are the most effective. In general, the amount of the dry forms to use is 1 to 1½ pounds to 20 gallons of water or 5 to 8 pounds to 100 gallons of water. Wettable sulfurs are protective fungicides and the plants must be kept covered during infection periods if good control is to be obtained.

6. **Mercury compounds**—Mercury compounds are used principally for seed, bulb and turf treatment. They are sold under tradenames and should be used according to manufacturer's recommendations.

7. **Organic fungicides**—Within the past few years new materials have been appearing on the market. Two of these materials show promise of controlling certain plant diseases. Ferric dimethyldithiocarbamate (Fer-

mate) and disodium ethylene bisdithiocarbamate (Dithane). These materials should be used according to manufacturer's directions.

#### DUSTING MATERIALS

8. **Sulfur dusts**—Sulfur dusts contain finely divided particles of elemental sulfur to which a conditioner has been added to make them flow readily. They are usually high in sulfur content, and can be used as straight sulfur dusts or diluted with other materials.

9. **Copper dusts**—Two kinds of copper dusts are available as fungicides: (a) monohydrated copper sulfate-lime dust and (b) proprietary copper dusts. The monohydrated copper sulfate-lime dust is usually prepared by mixing 20 parts by weight of monohydrated copper sulfate and 80 parts of fresh hydrated spraying lime and is known as a 20-80 copper-lime dust. The proprietary copper dusts are prepared by mixing a proprietary copper material with talc or some other inert material for a diluent. The proportion of proprietary copper compound to the diluent varies with the proprietary copper compound and the disease to be controlled. In general, the dust should contain 5 to 7 percent metallic copper. For example, a 5-percent metallic copper dust prepared from a proprietary copper compound containing 25-percent metallic copper and talc would contain 4 pounds of the copper compound and 16 pounds of talc.

#### INSECTICIDES

Materials used to control insects can be divided into three groups: (a) Stomach poisons—those used to control leaf-eating insects, such as caterpillars, beetles, and slugs; (b) contact insecticides—those used to control sucking insects such as mites, aphids, and leafhoppers; and (c) fumigants—materials which control insects by giving off poisonous gases.

#### STOMACH POISONS

Stomach poisons in general use contain arsenic, fluorine, or rotenone.

10. **Lead arsenate**—Lead arsenate is the most commonly used stomach poison because it is effective and causes less injury to plants than other kinds of arsenicals. It is compatible with fungicides, contact insecticides, and many stickers, spreaders, etc.

RECOMMENDED MATERIALS	AMOUNT TO USE	
	FOR 1 GALLON OF SPRAY	FOR 100 GALLONS OF SPRAY
Lead arsenate.....	2-3 tablespoons	3 pounds
Summer oil.....	.....	1 quart
Milk.....	½ cup	

Calcium arsenate can be substituted for lead arsenate as a stomach poison but is not so desirable because of the danger of arsenical injury to plants.

**11. Fluorine compounds**—Fluorine compounds are sold under various trade names. They are not used to any extent on ornamental trees or shrubs.

**12. Rotenone**—Rotenone is a compound found in the roots of derris and cube as well as other tropical plants. It can be used as a stomach poison and as a contact insecticide. It can be purchased in powdered form or as a liquid formulation. There are a number of proprietary rotenone-containing materials on the market. They should be used according to manufacturer's recommendations. Rotenone is non-poisonous to warm-blooded animals.

#### CONTACT INSECTICIDES

**13. Nicotine sulfate 40%**—This contact spray is used with soap or other alkaline activating agents. Standard dilutions are 1 pint, plus 4 to 6 pounds of soap in 100 gallons of spray or 1 teaspoonful to 1 gallon of warm soapsuds.

Nicotine sulfate is also used with summer oils at the rate of 1 pint with 100 gallons of spray. Read section 18.

**13a. Fixed nicotine**—Nicotine in combination with bentonite and other materials is factory-processed and sold as fixed nicotine. 3 pounds fixed nicotine plus 2

quarts of summer oil constitute an excellent material for combating various small caterpillars, since nicotine in this form does not volatilize rapidly and remains effective for a comparatively long period.

**14. Pyrethrum**—Pyrethrum is a product prepared from the flower heads and stalks of certain plants of the Chrysanthemum family. It can be used to control aphids and leafhoppers and, when combined with the wetting agent, mannitan monolaurate, will kill rose chafer. Pyrethrum is also effective as a dust against many insects. It is sold under various trade names and should be used according to manufacturer's recommendations. It is harmless to warm-blooded animals.

**15. Rotenone**—See rotenone under stomach poisons. Rotenone-containing sprays are recommended for the control of mites, thrips, aphids, and other soft-bodied insects. The following mixture is effective for mites:

RECOMMENDED MATERIALS	AMOUNT TO USE	
	FOR 3 GALLONS OF SPRAY	FOR 50 GALLONS OF SPRAY
Rotenone powder containing 4-percent rotenone	4½ tablespoons	10 ounces
Sulfonated castor oil (Turkey red oil).....	12 tablespoons	1 pint

To prepare a rotenone-containing spray:

1. Add about  $\frac{2}{3}$  of the water to the spray tank.
2. Add the sulfonated castor oil to the water and agitate.
3. Make the powder into a thin paste with water and add to the oil and water mixture.
4. Add water to make the required amount of spray. Keep well agitated. Two or more applications should be made at 10-day intervals.

**16. Bill-poster's paste**—The usual recommendation is 1 pound of the paste plus 1 quart of skim milk to 25 gallons of water. Best results are obtained when applied at 400 to 500 pounds pressure.

**17. Dicyclohexylamine salt of dinitro-ortho cyclohexylphenol (DN-111)**—DN-111 is a specific for mites on foliage. It can be applied in sprays with lead arsenate and wettable sulfurs. It is incompatible with oils and alkalis.

**18. Summer oils**—Summer oils are light chemically treated oils of approximately 70-80 viscosity by the Saybolt test. They are sold under trade names ready for dilution with water and are commonly applied at the rate of  $\frac{1}{2}$  or 1 gallon per 100 gallons of spray. A partial list, alphabetically arranged, includes Casco, Medina, Orthol-K, Summer Mulsion, Superla, Verdol, and Volck. They are sometimes used as spreader-stickers with other sprays, usually at the rate of 1 or 2 quarts per 100 gallons of spray. Many plants will not tolerate oils. Oils are incompatible with sulfur. Read section 13.

**19. Glue**—Glue (flake) dissolved in a small amount of warm water and strained into the sprayer is excellent for controlling mites on rare or valuable evergreens. Twelve ounces of glue in 5 gallons of water is a convenient amount to prepare for small operations. A teaspoon of kerosene will reduce foaming. Glue, 15 pounds and 1 pint kerosene are necessary for 100 gallons of spray. Wash the sprayer after using.

**20. Dichloro-diphenyl-trichloroethane, DDT**—This material commonly known as DDT is a very specific poison and, when available will be a valuable addition to the group of residual contact insecticides. It is not soluble in water and requires special preparation; therefore, when using the material it will be necessary to be certain as to the formulation. Apparently DDT will control leafhoppers, tarnished plant bugs, four-lined leaf bug, and flea beetles.

It also kills certain beneficial insects such as bees, and the U. S. Public Health Service is investigating the health hazards involved. This agency advises caution in the use of the material until more is known concerning its effect on man and other warm-blooded animals.

#### INSECTICIDES FOR DORMANT USE

The materials recommended for dormant use must be applied only while the trees are strictly dormant.

21. **DN dormant**—DN dormant sprays are sold with different percentages of DN and it is necessary to follow the manufacturer's directions. 1¼ pounds of 40-percent DN compound, or 1 pound of 50-percent DN compound per 100 gallons are required for aphid control. Where a 40-percent DN is used, 7½ pounds are required for each 100 gallons of water when applied to control oystershell scale since about 3 pounds of actual DN is required to get a commercial kill.

22. **Lime-sulfur**—See Section 4.

23. **Dormant oils**—Dormant oils used for control of scales and mites are made from lubricating oils of slightly more than 100 viscosity (Saybolt at 100° F.) and 60-70 percent unsulfonated residue. A partial list of brand names for dormant oils includes Casco Dormant, Dendrol, Dormoil, Emulso, Kleenup Ready Mix, Peninsula, Stanolind, and Sunoco. There are probably others. When using commercial dormant oils, follow manufacturer's directions. Consult Extension Bulletin 154 for directions on home-made emulsions. This may be worth while when spraying large areas.

#### FUMIGANTS

24. **Carbon disulfide**—If only a few trees are to be treated, borers can be killed by injecting a few drops of carbon disulfide into the tunnels and plugging the openings with mud or grafting wax. **Carbon disulfide is inflammable and explosive.**

25. **Paradichlorobenzene in cottonseed oil**—Dissolve PDB at the rate of 1 pound in 2 quarts cottonseed oil and apply with a brush over injured areas in early spring or late fall to control borers. PDB may be dissolved at the rate 2 pounds in 1 gallon of commercial miscible oil such as Dendrol, Sunoco, etc., diluted with 30 gallons of water and applied to the infested areas as a spray.

#### ACCESSORY MATERIALS

Hydrated lime is the only form of lime generally available for spraying and dusting purposes in Michigan.

26. **Lime**—Lime used for spraying and dusting should be one prepared for this purpose. Masons' hydrate or agricultural lime is not satisfactory. Only fresh lime should be used. Freshly hydrated lime should be satisfactory for 10 to 12 weeks if stored in a dry place and not exposed to the air.

27. **Zinc sulfate-lime mixture**—The flake form of zinc sulfate containing 25-percent zinc is the form recommended for spraying purposes.

A 4-4-100 zinc sulfate-lime mixture is recommended to prevent arsenical injury to peach and plum trees.

The zinc sulfate-lime mixture is prepared as follows:

1. Begin filling the spray tank with water.
2. With the agitator running, add the required amount of zinc sulfate previously dissolved in water to the tank. Fill tank to about 2/3 full.

3. Wash the required amount of lime through the strainer or prepare it as a thin paste and pour into the tank.
4. Finish filling the tank and agitate a few minutes before adding the lead arsenate. If a fungicide is necessary it should be added after the lead arsenate.

28. **Soybean flour**—Soybean flour is used as a sticker and spreader with several materials. A special grade of flour is available for spraying purposes. In general, it should be used at the rate of 1 ounce to 25 gallons or  $\frac{1}{4}$  pound to 100 gallons of spray. A good method of adding it to the spray mixture is to prepare it as a thin paste before adding it to the spray solution in the tank.

29. **Soaps**—The most important uses of soap or soap-like compounds are for wetting and activating agents with nicotine sulfate. One-half pound of soap flakes, or 1 pound of ordinary laundry soap, or 1 ounce of Dreft is generally recommended to 25 gallons of spray.

30. **Commercial spreaders and stickers**—A large number of spreaders and stickers have been developed for use with specific materials. Very commonly these spreaders and stickers are satisfactory when used for the purpose for which they were made. Often they work poorly if not used in just the way intended. When using commercial spreaders and stickers, read all directions carefully and follow them.

31. Several sulfated alcohols are sold as spreaders, activators, and extenders. Of these, Dreft, Drene, Duponal ME, Orvus WA, etc., or the Dupont sticker-spreader can be used to remove honeydew soot and sooty mold from foliage. They are recommended at 4 ounces per 100 gallons and best results follow where the spray is applied with pressure. The trees should be rinsed with water to remove the material within 24 hours after application. Dilute any accumulation of sulfated alcohol on the grass to prevent burning.

These materials in themselves have certain insecticidal actions.

#### SUPPLEMENTARY MEASURES

32. **Disinfecting pruning tools**—Dip in formalin 1 part in 10 parts of water or in a solution of corrosive sublimate (mercuric chloride) 1 to 500. Corrosive sublimate tablets can be purchased at a drug store and used to make up required quantities. Corrosive sublimate is corrosive to metals and should be mixed only in stone or glass containers. **Corrosive sublimate is very poisonous when taken internally.** Care should be taken to store it out of reach of children.

33. **Watering trees or shrubs**—To water trees in the summer, soak the soil to a depth of about 2 feet by slow application of water through a porous hose or by sprinklers. Such waterings should not be made oftener than at 2-week intervals.

34. **Disinfecting roots for crown gall**—Dip roots of young trees suspected of being contaminated with the crown gall organism in a strong bordeaux mixture made by pouring a solution of copper sulfate, 1½ pounds in 1 gallon of water into another gallon of water containing 3 pounds of hydrated lime.

35. **Canker treatment**—Cut the bark away well back from the edge of the canker, leaving an oval-shaped wound with pointed tips at the upper and lower ends. Paint over with asphalt or with a good wound dressing.

36. **Treating for fire blight**—The bacteria overwinter in hold-over cankers. The most effective time to treat cankers is during the dormant season. At this time the bark should be removed for 3 inches above and below and one inch around the sides of any visible signs of the canker.

37. **Wrapping as a protection against borers**—Crepe wrapping paper consists of two layers of crepe paper cemented together with asphalt. It can be purchased in rolls 4 to 6 inches wide and several hundred feet long and is recommended for the protection of transplanted trees. Wrap the trees before borers have laid their eggs in the bark. Overlap the paper to form a complete barrier and tie in place with loops of binder twine (binder twine will break before it girdles a tree).

38. **Sanitation**—Sanitation is simply good house-keeping, and its practice will aid materially in insect and disease control. The collection, removal, and burning of dead leaves, and other plant parts which may harbor fungi or bacilli causing disease will aid in the control of most diseases. In some cases it is the only means of keeping diseases in check. Many injurious insects which over-winter in the shelter afforded by plant litter will be destroyed at the same time.

39. **Fertilizing trees**—General recommendations for **deciduous trees** is the application in the spring of a complete, commercial fertilizer of about a 10-8-6 formula at the rate of 3 pounds per inch of diameter of the tree through soil auger holes bored 15 inches into the soil and located most abundantly out under the limits of branch spread. Enough holes should be bored to allow ¼ pound of fertilizer to each hole.

For **conifers**, apply about ¼ pound of the fertilizer mentioned above per inch of trunk diameter.

Applications should be made every second or third year.

In cases of suspected fertility deficiencies consult your county agricultural agent.

40. **Soil testing**—To determine if soil is too alkaline, test with Soiltext. Excess alkalinity can be neutralized by applications of ammonium sulfate, aluminum sulfate or sulfur.

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