

BULLETIN NO. 216

JUNE, 1948

Handbook of Plant Diseases And Their Control for Montana

by

H. E. Morris

Botanist

Montana Extension Service

and

M. M. Afanasiev

Assistant Botanist & Bacteriologist

Montana Agricultural Experiment Station

CONTENTS

Introduction	3				
Hosts					
page	page	page			
Alfalfa	4	Eggplant	12	Onion	16-17
Apple	5	Flax	12	Pea	18
Ash	5	Geranium	13	Peach	18
Aster	6	Gladiolus	13	Peony	19
Barberry	6	Gooseberry	13	Plum	19
Barley	6	Hollyhock	14	Poplar	19-20
Bean	7	Iris	14	Potato	20-21
Beets	8	Juniper	14	Rose	21
Blue Grass	8-9	Lawns	8-9	Russian Olive	22
Cabbage, etc.	9	Lettuce	15	Rye	22
Caragana	9	Lilac	15	Sorghum	22
Carnation	10	Maple	15	Strawberry	22
Cherry	10	Marigold	15	Sweet pea	22
Corn	10	Millet	16	Tomato	23
Cucumber	10	Muskmelon	16	Watermelon	23
Currant	11	(Canteloupe)		Wheat	24
Dahlia	11	Oats	16	Willow	24
Delphinium	11				
Damping-off					34-36
Seed Treatments					25-26
Soil Treatments					28-30
Fungicides					30-32
Winter Injury					32-33
Chlorosis					33-34
Stem and root rots					36

Montana Extension Service in Agriculture and Home Economics, J. C. Taylor, director.
 Montana State College and United States Department of Agriculture cooperating.
 Distributed in furtherance of Acts of Congress, May 8 and June 30, 1914.

Handbook of Plant Diseases And Their Control for Montana

The main purpose of this bulletin is to give a brief popular account of the nature and control methods for the important plant diseases of Montana. Much information has been secured as results of experimental research in the state, but control measures recommended in other states have been included also.

Diseases or failures of plants are due to a great variety of causes, and they occur to some extent in every field, orchard, nursery, home garden or storage house.

Some diseases are caused by definite parasites which can be fought with sprays, dusts and other devices. Virus diseases, the exact causes of which are unknown, are controlled generally by the use of disease-free stock. This is accomplished most readily by the use of a seed-plot and the elimination of the virus diseases by roguing. Other troubles arise from an unfavorable environment which may be difficult to diagnose or correct. The proper application of the recommended control measures for many plant diseases would prevent much of the annual loss from diseases in Montana.

The hosts are listed alphabetically and the principal diseases of each are briefly described with their recommended control measures. For greater accuracy and for reference, the scientific name of the casual organism is stated.

Alfalfa

Disease	Symptoms	Control Measures
Bacterial wilt <i>Phytomonas insidiosa</i> (McC) Bergey et al.	Dwarfed plant, small abnormal shaped leaves of pale green color. Plants gradually weaken and die. Yellow or brown color of wood of roots just under bark. Wilting of top growth under drought conditions.	Use of resistant varieties. Ladak and Cossack more resistant than Grimm. Hardiston and Orestan more resistant than Grimm. Ranger (composite of 8 strains) shows high degree of resistance.
Bacterial stem blight <i>Phytomonas medicaginis</i> (Sack.) Bergey et al.	Stems lesions in early stages, green water-soaked, often becoming yellow brown but finally blackening. Stripes are black, rarely girdling the stem. Clear bacterial exudate gives stems a shiny varnished appearance	None entirely satisfactory. Early cutting.
Leaf spot <i>Pseudopeziza medicaginis</i> (Lib.) Sacc.	Circular delimited spots rarely exceeding 4 mm. in diameter. Often spots very abundant. Occur late on first crop, or any time in mid-summer or autumn.	Cut crop when disease becomes severe. Variegated or common varieties somewhat resistant.
Leaf blotch <i>Pyrenopeziza medicaginis</i> (Lib.) Sacc.	Elongate blotches more or less restricted by veins, becoming yellow, finally brown to black. More prevalent on plants which stand long between cuttings.	Same as leaf spot.
Crown rot Physiological	Rotted and discolored, light to dark brown, chiefly in central part of root. Splits in roots often occurs. Plants dwarfed and weak.	Plants weakened by unfavorable environment, such as frost, pasturing too early or too late. Improve culture and care.
Alfalfa dodder <i>Cuscuta</i> spp.	Yellowish thread-like twining parasitic plant with small white flowers, winds around and attaches to alfalfa plant. When abundant alfalfa plants weaken and die. Dodder connected with ground only during seedling stage.	Plant clean seed, mow infested area, cover with straw and burn, rotate crops.

Apple

Disease	Symptoms	Control Measures
Fire blight <i>Erwinia amylovora</i> (Burrill) Com. S.A.B.	Dead leaves on tips of twigs or on fruiting spurs. Cankers on twigs, limbs, or main trunks.	Remove infected twigs during winter, cutting several inches below visible sign of disease. Cut out cankers on main trunk or larger limbs removing all diseased tissue. Paint with Bordeaux paint. After each cut, sterilize pruning instruments in formaldehyde 1 part in 25 parts of water.
Scab <i>Venturia inaequalis</i> (Cke) Wint.	Brown to black spots on leaves and fruit.	Lime sulphur 28°B. 1 gallon in 25 gallons water. Two or three applications. First (important) in the pink. Second— $\frac{1}{2}$ petals fallen. Third (if necessary) August or September.
Crown gall <i>Phytomonas tumefaciens</i> (S.&T.) Bergey et al.	Galls on the crowns and roots. Abundant development of fibrous roots. Affected trees usually not thrifty.	Healthy nursery stock.
Drought spot Die back Internal cork (Boron deficiency)	Light brown spots of dead corky tissue in region of core or in flesh. Superficial dead area on skin of fruit, later cracking. Fruit dwarfed, misshapen. Death of terminal shoots or spurs.	Application of 30 pounds of borax per acre preferably in fall.
Storage diseases Parasitic and Physiological	Spots and rots of various kinds, resulting in damaged tissue of the apple.	Store healthy fruit of good quality. Precool promptly. Maintain temperature from 30° to 36° F. Provide good ventilation.

Ash

Disease	Symptoms	Control Measures
Drought injury on leaves Physiological	Drying up of leaves which starts at the end and progresses inside along the veins until whole leaf is involved. Only a few or practically all of the leaves are affected.	Lack of moisture combined with extensive evaporation during hot weather is responsible for this trouble. Good watering will relieve the situation.

Aster (China)

Disease	Symptoms	Control Measures
Wilt <i>Fusarium conglutinans callistephi</i> Beach.	Drooping of lower leaves. Plant finally dies.	Plant wilt-resisting varieties.
Yellow virus	Stunting, yellowing, malformation and clustering of foliage.	Remove and burn infected plants as soon as discovered. Because leaf hoppers carry the disease, plants should be protected from them by wire screen.

Barberry

Disease	Symptoms	Control Measures
Black Stem Rust <i>Puccinia graminis</i> Pers.	Small orange yellow spots (cluster cups) on under surface of leaf of common barberry, small reddish spots on upper surface of leaves.	Destroy bushes. Growing common barberry prohibited by law. Japanese barberry immune.

Barley

Disease	Symptoms	Control Measures
Smut-loose <i>Ustilago nuda</i> (Jens.) K. and S.	Kernels replaced by a black smutty mass which blows away leaving naked stalk.	Hot water treatment, not recommended for general use. Use clean seed. Trebi resistant.
Smut-covered <i>Ustilago hordei</i> (Pers.) K. and S.	Smutty mass covered by whitish membrane at harvest time.	New Improved Ceresan. Trebi susceptible.
Stripe <i>Helminthosporium gramineum</i> Rabh.	Brown streaks or spots on leaves and stems.	Rotate crop. New Improved Ceresan.

Bean

Disease	Symptoms	Control Measures
Common bean mosaic Virus disease.	Leaves have a puckered, mottled appearance with light and dark green areas. Dark green areas often along the mid-vein. Leaves are often curled and cupped downward. Plants are stunted and mature late. Disease transmitted through seeds.	Plant certified seeds. Idaho selections of Great Northern beans U. I.-81, U. I.-123 and U. I.-15 are immune to this disease. All garden varieties are susceptible to common mosaic except Idaho Refugee and Wisconsin Refugee.
Root rots <i>Fusarium solani</i> var. <i>martii</i> (A. and W.) f. 3. Snyder	Tap and lateral roots show brick-red discoloration or streaks. Lateral roots decay. Plant shows stunting. Leaves turn yellow and die.	Crop rotations.
Rust <i>Uromyces appendiculatus</i> (Pers.) Lev.	Small reddish-brown to black pustules mostly on lower surfaces of leaves. Leaves shrivel and fall from the plant.	Avoid cultivation when leaves are wet. Do not overirrigate. Spraying or dusting is not practical.
Common blight <i>Phytomonas phaseoli</i> (EF S) Bergey et al.	Disease is systemic. Water-soaked spots or light green wilted areas on leaves, which, as they enlarge, become brown and brittle. Lesions have yellow border surrounded by pale green zone. Water-soaked dark-green streaks on stems and spots on pods which become reddish-brown in color. Those on pods often covered with yellow exudations. Girdling of the lower part of the stem. Disease transmitted through seeds.	Use disease-free seeds. Great Northern beans and Refugee varieties are somewhat resistant. In field, disease can be disseminated by dew, rain, hail, wind, insects and water. Avoid cultivation when beans are wet.
Halo blight <i>Phytomonas medicaginis</i> var. <i>phaseolicola</i> (Burk.) Bergey et al.	Disease is systemic. Small brown spots on leaves surrounded by chlorotic halo, mostly in cool weather. In hot weather numerous small angular lesions occur, entire leaf somewhat chlorotic. Water-soaked dark-green streaks on stems and spots on pods which dry and become reddish-brown. Lesions on pods covered with silvery crustation. Disease transmitted through seeds.	Use disease-free seeds. Great Northern beans are resistant. Garden beans are very susceptible. In field, disease can be disseminated by dew, rain, hail, wind, insects and water. Avoid cultivation when beans are wet.

Beets—Sugar or Garden

Disease	Symptoms	Control Measures
Seedling diseases or "black root" caused by different soil fungi	Diseased seedlings show a browning and blackening of the stem and roots. The killing of the seedlings varies from fairly rapid to very slow.	Beets are less susceptible to disease when soil is properly fertilized and in good physical condition. Less disease occurs if beets are planted after corn or potatoes than after alfalfa. Early planting and early cultivation. If diseases are serious, thinning should be delayed, preferably past 6-leaf stage.
Phosphate deficiency Physiological disease.	Light brown spots on edges of leaves and between veins in July or later. Color of the spots changes from light brown to black, spots coalesce and leaves may appear burned.	Fertilization of soil with sufficient phosphate fertilizer.
Nitrogen deficiency Physiological disease.	Yellowing of tops of sugar beets early in season.	Sufficient application of manure. Use of ammonium sulphate.
Curly Top virus	Small wart-like enlargements on lower surface, and inward curling of leaves. Pronounced venation, hairy roots, dwarfing.	Use resistant varieties of sugar beets. Good culture. Properly fertilized soil in good physical condition.

Blue-grass (Lawns)

Disease	Symptoms	Control Measures
Brown Patch <i>Rhizoctonia solani</i> Kuhn	Grass turns brown in summer during periods of hot weather. Spots roughly circular in outline. Acid soil favors disease. Attacks leaves mostly.	Apply mixture of two parts calomel and one part corrosive sublimate at rate of 2 to 3 oz. per 1,000 square feet as a spray, or mixed with soil. Trade names of mercurial fungicides are calo-clor, semesan, nu-green, curex pfizer's mixture. Follow printed instructions on container.
Dollar spot <i>Rhizoctonia</i> spp.	Similar to brown patch, but size of spots limited to 2-inch diameter. Leaves much bleached. Appear early in spring or late in fall. Attacks roots and stems.	Similar to brown patch.

Blue Grass (Lawns) (Continued)

Disease	Symptoms	Control Measures
Disease in general		Make conditions highly favorable for growth of grass. Use fertilizers (especially rich in nitrogen) liberally. Avoid close clipping by raising cutter-bar to cut at least 2 inches tall. Leave grass clippings on lawn as a mulch. Allow grass to become reasonably long in spring before the first mowing. Allow a good long growth before winter sets in. Give thorough irrigations when necessary.

Cabbage and Related Plants

Disease	Symptoms	Control Measures
Yellows Fusarium conglutinans Wr.	Yellowing of leaves, uniform or more often worse on one side, causing a lateral warping or curling of stem and leaves. Browning of vascular element of stem. Premature leaf dropping.	Sanitary measures. Crop rotations. Yellows resistant varieties of cabbage are now available and should be used in regions where disease is prevalent.
Wire Stem or Damping-Off Corticium vagum Berk. and Curt. also other fungi.	In young seedlings this disease causes damping-off. If attack is late or environment too unfavorable to permit killing of the young plant, th's disease produces wire stem.	Sanitation and rotation of the seed bed. Apply solution of corrosive sublimate (1-2000) 4 to 6 days after the plants are up, and repeat treatment at intervals of a week for 4 to 6 weeks.

Caragana

Disease	Symptoms	Control Measures
Root and crown rots. Different soil fungi.	Yellowing and wilting of leaves and drying up of branches on a part of the bush. Gradually all bush is involved. Finally plant dies.	Infection with rot producing fungi is facilitated by frost injury which occurred previously. Avoid heavy watering after Aug. 15 so that plants may mature before frost.

Carnation

Disease	Symptoms	Control Measures
Rust <i>Uromyces carophyllinus</i> (Schr.) Wint.	Chocolate-brown, dusty rust pustules on leaves. Leaves curl. Plant stunted.	Destroy badly affected plants. Keep foliage dry. Discard very susceptible varieties, if possible.
Wilt <i>Fusarium</i> spp.	Affected plants wilt, wither and die.	Remove and burn affected plants promptly. Propagate from healthy stock. Use new soil in cutting bench, or treat old soil (see soil treatments p. 28).

Cherry

Disease	Symptoms	Control Measures
Leaf spot <i>Cocomyces hemisphaerius</i> Higgins	Brown, more or less circular disease areas in leaves. Spots often fall from leaves giving shot-hole effect.	Bordeaux mixture 3-4-50 (1) petal fall, (2) 2 weeks later, (3) 2 weeks after 2, (4) after harvest.
Gummosis (Physiological)	Collection and hardening of sap in crotches or on trunks of trees.	Prevent injuries and improve cultural care.

Corn

Disease	Symptoms	Control Measures
Smut <i>Ustilago zea</i> (Beckm.) Ung.	Various sized smut masses or boils on ears, stalk, leaves and tassels. Early stages appear greenish, later black. Smut overwinters on corn refuse and in soil. Spores may be blown a considerable distance.	Crop rotation. Seed treatment not recommended. In small patches (diseased boils should be removed before they break open).

Cucumber

Disease	Symptoms	Control Measures
Bacterial Wilt <i>Erwinia tracheiphila</i> (EFS) Bergey et al.	Wilt first local on a few leaves followed by general wilting of plant. A white sticky ooze can be pressed from freshly cut stem.	Insect vector must be controlled up to vining. Rotenone dust is satisfactory. In greenhouses, beetle control by screening or fumigation.
Mosaic Virus disease.	Stunting of growth; mottling of leaves; V-shaped lesions on older leaves. Fruits are mottled and deformed.	Eradication of wild hosts and diseased cucumber plants. Control insects in greenhouses by fumigation and screening of ventilators.

Currant

Disease	Symptoms	Control Measures
Blister rust <i>Cronartium ribicola</i> F. de Waldh.	Small yellow rust pustules on under side of leaves. Severely infected leaves drop. Alternate hosts 5-leaved pines.	Do not grow cultivated black currant (<i>Ribes nigrum</i>). Cultivated red currants resistant.
Cane-blight <i>Botryosphaeria ribis</i> Grossenb. & Duggar	Leaves wilt and wither. Cane or branch die. Small diseased spots on canes.	Cut out and burn affected canes.
Powdery mildew <i>Sphaerotheca mors-uviae</i> (Schw.) B. & C.	White mildew on leaves and fruit.	Apply dusting sulphur or spray with 1% lime sulphur plus 6 pounds wettable sulphur in 100 gallons when disease first appears.

Dahlia

Disease	Symptoms	Control Measures
Mosaic virus	Plants bushy, dwarfed, with shortened shoots and malformed leaves. Leaves pale green, yellow bands along main veins. Tubers often abnormal in shape. Disease spread by insects.	Remove and destroy diseased plants and tubers. Control insects.

Delphiniums (Larkspur)

Disease	Symptoms	Control Measures
Mosaic virus	Plants stunted, dwarfed leaves yellow, malformed, streaked or mottled.	Destroy affected plants. Do not propagate from diseased plants.
Root rot (Disease complex)	Death and decay of root and basal part of stems. Top of plant light color, general wilt or blight.	Avoid too warm an exposure or too heavy soils. Do not use manure as a mulch. Use deep, well drained soil, of medium to high fertility, neutral or slightly alkaline.
Bacterial leaf-spot <i>Phytoponas delphinii</i> (E. F. Smith) Berney et al.	Irregular, tarry black spots on the leaves, sometimes on stems and buds. Deformed leaves. Prevalent during cool weather.	Destroy all above-ground parts in fall. Drench plant crowns with mercuric chloride solution 1-2000. Spring application of Bordeaux mixture. Propagate from resistant plants.

Eggplant

Disease	Symptoms	Control Measures
Wilt <i>Fusarium</i> spp. or <i>Verticillium</i> <i>alboatratum</i> R. and Ber.	Plants first show slight yellowing and stunting, followed by wilting and death. Vascular system of the plant is discolored.	Crop rotation.

Flax

Disease	Symptoms	Control Measures
Heat canker Physiological	Outside of stem killed at ground line. Plant withers and dies. Plants that survive may later break at point of injury.	Thick seeding, early sowing, drill rows north and south.
Pasmo <i>Phlyctaena</i> <i>linicola</i> Speg.	Diseased spots on seed leaves, later on true leaves. Brown lesions on all parts of stem. Plant very conspicuous with normal green color, mixed with brown diseased spots.	Rotate crops. Disinfect seed with New Improved Ceresan $\frac{1}{2}$ ounce to 1 bushel in a rotary or gravity treating machine. Argentine varieties very susceptible.
Wilt <i>Fusarium</i> lin H. L. Bolley.	May attack plant at any time. Causes preemergence loss. Older plants may become yellow, weak, wilted and finally die, roots decay. Plants easily pulled from ground.	Rotate crop. Sow seed early. Use thoroughly cleaned, plump seed. Treat seed with formaldehyde. Bison, Biwing, Redson, Koto—resistant. Redwing, Viking, Bolley Golden, Walsh, Renew, Rio, Buda—moderately resistant. Newland—susceptible.
Rust <i>Melampsora</i> <i>lini</i> (Pers.) Liev.	First appears as small yellow pustules on leaves. May attack any above-ground portion of plant. As plant matures pustules become black, fungus overwinters in black stage. All stages of this rust occur on flax plant. Cool, moist weather favors disease.	Thorough cleaning of seed, early sowing, crop rotation, removal or plowing under completely all flax refuse. Use of resistant varieties adapted to locality. Viking, Bolley Golden, Walsh, Renew, Newland, Rio, Buda—resistant. Bison, Redwing, Biwing, Redson, Koto—susceptible to moderately susceptible.

Geranium

Disease	Symptoms	Control Measures
Leaf curl Mosaic (Virus)	Small, irregular and chlorotic areas on ruffled and dwarf young leaves. More conspicuous in cool weather. Mottling of foliage with light green and dark green areas.	Propagate only from healthy stock. Destroy diseased plants. Control insects.
Cutting-stock rot (several fungi)	Soft, brown to black decay at or below soil line. Plants fail to root and die.	Propagate only from healthy stock. Sterilize soil in cutting bench. Some benefit by watering heavily with copper carbonate, 2 oz. stirred in 3 gallons of water, on 5 to 6 square feet of bench soil.

Gladiolus

Disease	Symptoms	Control Measures
Scab (neck rot) <i>Phytoponas marginata</i> (McC.) Bergey et al.	Burnt areas on husks leaving blackened margins around breaks on stored bulbs. Black spots on bulbs. Scabby and rough bulbs. Leaves decay at neck of plant. Organism lives in soil and on bulbs in storage.	Treat peeled bulbs just before planting with 2 percent solution of Semesan for 4 hours. Treatment also recommended for control of thrips on bulbs.
Rots	Black sunken decayed areas near base of bulb. Leaves turn yellow and decay near soil line.	No satisfactory control methods except discarding diseased bulbs.
Diseases in General		Use clean stock. Rotate gladiolus. Place on same ground only once in 4 or 5 years. Treat corms. Dig carefully, cure rapidly, store properly. Practice sanitation by burning withered bulbs and leaves after harvest.

Gooseberry

Mildew <i>Sphaerotheca mors-uvae</i> (Schw.) B&C	White patches of moldy appearance turning to dull brown on leaves, young stems and fruit.	Spray as buds are opening with Bordeaux mixture 4-4-50, lime sulphur 1-25 or liver of sulphur 1 oz. to 2 gallons. Liver of sulphur at 7 day intervals for 2 months.
--	---	---

Hollyhock

Disease	Symptoms	Control Measures
Rust <i>Puccinia malvacearum</i> Mont.	Orange brown to purplish brown spots on under surface of leaf. May occur on upper surface of leaf, stems and flower parts.	In fall, cut plants to ground and burn all plant parts. Eradicate common garden mallow. Apply dusting sulphur at 10-day intervals beginning when plants are 6 in. high. Select seed from rust resistant plants.

Iris

Disease	Symptoms	Control Measures
Leaf spot <i>Didymellina macrospora</i> Kleb.	Small brown spots with water-soaked margins, later becoming yellow. Old spot gray with red borders. Infected leaves die prematurely.	Remove and burn all diseased leaves in late fall. Bordeaux mixture 4-4-50 plus spreader when symptoms appear.
Mosaic virus	Streaking of foliage, light green areas alternating with the normal green. Premature death of leaves. Early blooming.	Discard infected rhizome.
Root rot (Several fungi)	Tips of leaves wither, basal portion becomes water-soaked, leaf and shoot collapse. Darkened areas on rhizome. Rhizome becomes soft and slimy with a strong odor.	Avoid heavy soils. Shallow planting, with upper half of rhizome above soil surface. Avoid overcrowding. Discard diseased rhizomes.
Diseases (general)		Remove all dead leaves and cut back tops in fall or early spring.

Juniper

Disease	Symptoms	Control Measures
Rust <i>Gymnosporangium</i> spp.	Small galls on small limbs. Jelly-like masses in spring when discharging spores.	Remove and destroy galls. Spray with Bordeaux mixture 4-4-50 in spring or use dusting sulphur 2 or 3 times at 3-week intervals.
Die-back	Dying of tips of smaller branches. Browning of tips or entire needles.	Improve growing conditions. Bordeaux mixture 4-4-50 in spring, and 2 or 3 additional applications at 3-week intervals.

Lettuce

Disease	Symptoms	Control Measures
Drop Sclerotinia libertiana Fuckel	A soft rot begins on stem near soil as a soft water-soaked spot which extends into the roots and head. Outer leaves at first appear wilted and finally fall. The parasite kills the leaves in succession until it reaches the heart of the plant, changing the tender inner leaves to a wet, slimy, decayed mass.	Rotate crops. Do not follow cabbage or celery with lettuce. Plant on low ridges and keep surface of soil dry by frequent cultivation. In the greenhouse, soil sterilization is the most important control measure.

Lilac

Disease	Symptoms	Control Measures
Bacterial Blight Phytomonas syringae (van Hall) Bergey et al.	Blackening of young growing tips. Brown to black spots on leaves. Infected areas typically black in color.	Prompt removal and destruction of diseased twigs. Spray young foliage with 2-2-50 Bordeaux mixture.

Maple

Disease	Symptoms	Control Measures
Leaf spots Different fungi.	Leaf spots are either large, brown in the center, and bordered by a red or purple zone, or they are small, light brown or whitish without a colored border.	Two or three applications of Bordeaux 4-4-50. Spraying must be begun before infection starts.

Marigold

Disease	Symptoms	Control Measures
Wilt Different soil organisms.	Plants (about 1 foot tall) suddenly wilt, death follows in a few days. Plant lifts easily from ground. Many roots dead or dying.	Treat a bushel of soil with 2½ tablespoons of formaldehyde + 6 tablespoons of water. Thoroughly mix, cover for 24 hours, aerate for 24 hours, then place in flats or pots and sow seed. Water freely. Transplant seedlings to soil that has been treated with formaldehyde 1 to 50 using ½ gallon per square foot. Aerate after treatment for 2 days before setting seedlings.

Millet

Disease	Symptoms	Control Measures
Kernel smut <i>Ustilago crameri</i> Korn.	Kernels replaced by "false kernels" of smut. Heads become dark brown.	Copper carbonate 52%, two ounces per bushel or formaldehyde solution 1 pint to 40 gallons of water for 1 hour.

Muskmelon (cantaloupe)

Disease	Symptoms	Control Measures
Bacterial wilt <i>Erwinia tracheiphila</i> (EFS) Bergey et al.	Same as cucumber.	Same as cucumber.

Oats

Disease	Symptoms	Control Measures
Smuts—covered <i>Ustilago levis</i> (K. and S.) Mag.	Smutted kernels appear about the same time as normal head. Smut masses may persist until threshing time or may blow away leaving naked stalk (loose smut).	New Improved Ceresan or formaldehyde. Bridger and Gopher varieties are resistant, Victory variety is susceptible. Treat seed with New Improved Ceresan or formaldehyde.
Sterility Physiological.	White, empty spikelets mostly near lower part of oat head.	Varieties vary greatly in susceptibility. Control measures unknown.

Onion

Disease	Symptoms	Control Measures
Smut <i>Urocystis cepulae</i> Frost	Brown to black elongated blisters form within the scales or leaves. Leaves thickened and curved downward. Blisters often break open exposing black powdery masses of spores. Most seedlings die while young; some persist and lesions occur on bulbs. Some seedlings outgrow disease.	Where crop is grown from seed, use formaldehyde-drip method. The disease may be avoided by use of transplants, slips, or sets.

Onion (Continued)

Disease	Symptoms	Control Measures
Fusarium Bulb Rot Fusarium spp.	Yellowing and dying back from tips of leaves in mid-season or later. Decay of roots. Semi-watery decay of bulbs, advancing from the base of the scales upward. Disease continues in storage and transit. Finally leaves dry and bulbs become shrivelled mummies.	Infection of plants is somewhat correlated with maggot injury. Careful sorting at harvest is recommended. Rotations.
Diseases primarily important in storage and transit		
1. Neck rot Botrytis spp.	Bulbs are infected through neck, sometimes through base or wounds. Tissue becomes watersoaked; bulbs decay and gradually become dry mummies.	Use of colored varieties. Thorough curing after harvest. Keep storage temperature slightly above 32° F.
2. Soft rot Erwinia carotovora (Jones) Bergey et al.	Starts at the neck and advances down one or more scales, with little or no progress from scale to scale. Slimy soft rot with sulphurous odor.	Proper harvesting and curing of bulbs. Keep storage well ventilated and slightly above 32° F.
3. Black mold Aspergillus niger Tiegh.	Black mold develops on outer scales and between scales in storage and transit. Heavy losses in Bermuda varieties.	Sanitation. Bulbs should be thoroughly dry before being shipped. Cold storage will hold disease in check.
4. Smudge Colletotrichum circinans (Berk.) Vogl.	Black smudgy spots on dry outer scales of white bulbs at harvest or later. Slow advance into inner fleshy scales. Premature sprouting in storage.	Colored varieties are highly resistant, white varieties are susceptible. Thorough curing and protection from rain after harvest.

Pea

Disease	Symptoms	Control Measures
Bacterial Blight <i>Phytoponas pisi</i> (Sackett) Bergey et al.	If the infection starts from the seed or if the plants are very small, the vine may be killed without producing a crop. Small water-soaked spots darkening with age on all above-ground parts of plants. White to cream colored exudations on the spots. Leaves yellow from base of plant toward top.	Use clean seed, preferably western grown. Disease is more prevalent after hail or dust storm. Mechanical injuries serve as entrance points for bacteria. Avoid cultivation when peas are wet.
Fusarium Wilt <i>Fusarium oxysporum</i> Schl.f. <i>pisi</i> (Linf.) Race 1 S. & H. and Near Wilt <i>F. oxysporum</i> Schl.f. <i>pisi</i> (Snyder) Race 2 S. & H.	Yellowing of lower leaves and stunted growth of the plant. Downward curling of the margins of the leaves. Infection takes place from the soil, through the roots, and the casual organism follows the water-conducting canals up to the stem and branches, thus preventing the passage of water to the stem and leaves. Wilting and dying of plants. Growth is retarded or entire plant is killed. Tap and other roots decay, new roots sometimes form above injury.	Early plantings of sweets usually benefited by seed treatment. Treat seed with Spergon 1.5 to 2 oz. per bu., or Semesan at 2.5 oz., plus graphite 1 oz., or red copper oxide 2.5 oz., plus graphite 1 oz. Alaskas and field peas sometimes benefited by seed treatment. Use wilt resistant varieties. Rotate crops. Avoid planting on poorly drained soils. A highly fertile soil decreases loss. Destroy old pea refuse around vining stacks especially. Varieties resistant to the near-wilt and common root rot are not available.
Common Root Rot <i>Aphanomyces euteiches</i> Drechs.	Whitish, powdery growth on the leaves, and less frequently on petioles, stems, pods. Leaves are yellowed and dwarfed.	Dust with dusting sulphur when disease first appears and in intervals of 10-14 days thereafter.

Peach

Disease	Symptoms	Control Measures
Leaf curl <i>Exoascus deformans</i> (Berk.) Fuckel.	Leaves are curled, thickened and distorted with whitish or pinkish surface on curled portions. Affected fruits are misshapen with smooth areas. Entire tree may be defoliated early in season.	Spraying should be made from a month to two weeks before buds open. Spraying after the buds begin to unfold gives little benefit. Bordeaux mixture 4-4-50 is preferred, but lime sulphur testing 28° B. (Baume), diluted 1 to 15 may be also used.

Peony

Disease	Symptoms	Control Measures
Blight <i>Botrytis</i> spp.	Young shoots turn black, decay at soil level and collapse. Young buds turn brown to black and fail to develop. Large, irregular, dark brown areas on leaves. Crown and roots sometimes affected.	Cut stalks just below ground level and burn them in the fall. Remove mulch early. Avoid crowding. Prompt removal of infected stalks. Sprinkle soil in and around plants lightly with corrosive sublimate 1-2000.
Stem rot <i>Sclerotinia sclerotiorum</i> (Lib.) Mass.	Sudden wilting and death of young shoots similar to blight. Black bodies (sclerotia) in center of rotted stems.	Similar to blight.

Plum (native)

Disease	Symptoms	Control Measures
Plum pockets (Bladder-plums) <i>Taphrina</i> spp.	When fruits are small ($\frac{1}{2}$ inch), small whitish spots appear, later fruits become greatly inflated and hollow.	Lime sulphur 28° B. 1 part, water 50 parts. Single application any time from a late dormant condition to the time when blossoms are in the pink. Spray also controls leaf gall mite.

Poplar

Disease	Symptoms	Control Measures
Rust <i>Melampsora</i> spp.	Underside of leaf covered with a dense layer of yellow, dusty fungus spores. Leaves sometimes drop.	Destroy fallen leaves, especially in late fall.
Canker Several fungi.	Cankers on branches and trunks. Infection generally through wounds. Small black pimple-like spots on diseased bark. Red exudate (spores) conspicuous during spore discharge July and August.	Select resistant varieties. Adopt recommended methods of culture. Paint cankers with white-lead paint to prevent spore spread. Cankered areas may be cut away and the exposed surface painted.

Poplar (Continued)

Disease	Symptoms	Control Measures
Chlorosis Physiological Iron deficiency.	General yellowing of leaves on a single branch or entire tree.	Spray with 1% solution of iron salts. Placement of ferric phosphate 5 gm. per inch diameter of tree in holes $\frac{3}{8}$ inch diameter bored in a spiral ring in trunk of tree. Remove dirt around tree, so as to expose, but not injure, the roots and add $\frac{1}{2}$ pound of iron sulphate spread evenly about the roots extending 4 feet or more from trunk of tree. Replace dirt and irrigate.

Potato

Disease	Symptoms	Control Measures
Scab <i>Actinomyces</i> seabies (Thax.) Gussow	Potato tubers show rough corky brown patches varying in size from small spots to areas over half an inch in size. Depth of lesions vary from superficial to $\frac{1}{4}$ of inch deep.	Clean soil. At least 5-year rotations. Treatment of seed tubers with formaldehyde. Netted Gem resistant.
Rhizoctonia <i>Rhizoctonia</i> solani Kuhn	Brown, dead lesions on underground stems, roots, stolons, sometimes girdling the part attacked. Black specks (sclerotia) on surface of tubers. Plants severely infected show rosetting, bunching and purpling of tops.	Clean soil. At least 5-year crop rotation. Treatment of seed tubers with corrosive sublimate.
Wilt <i>Fusarium</i> <i>oxysporum</i> Schlecht. f. 1 Wr. and F. solani (Mart) App. & Wr. var. <i>eumartii</i> (Carp.) Wr.	Mottling, yellowing and wilting of tops. Internal discoloration in stems, roots, stolons and browning of vascular ring in tubers.	Plant seed stock free from wilt. Rotations. Maintain a seed plot.
Mosaic Virus disease	Mottling and wrinkling of leaves, dwarfing of plants.	Plant seed stock free from mosaic. Seed plots. Seed selection in the field.

Potato (Continued)

Disease	Symptoms	Control Measures
Black leg <i>Erwinia carotovora</i> (Jones) Berkeley et al.	Rotting of tubers. Stems blackened at base, black streaks on aerial part of stems. Wilting and death of diseased portion of plant.	Plant seed stock free from disease. Treat seed stock. Use disinfectant on knives for cutting seed.
Ring-rot <i>Phytoponas sepedonica</i> (Spiekermann) Berkeley et al.	Yellow cheesy-like rotting of tuber mainly in vascular ring. Yellowing and wilting of leaves. In severe cases plant dies.	Plant seed stock free from disease. Treat seed stock. Use disinfectant on knives for cutting seed.

Rose

Disease	Symptoms	Control Measures
Black spot <i>Diplodcarpon rosae</i> Wolf.	Black, irregular circular spots with feathery margin on the leaves and also on the other parts of a plant. Several spots may occur on a single leaf; the tissue between the spots turns yellow, and the leaf falls prematurely. New leaves produced in late summer. Plant is weakened and subject to winter injury.	All fallen leaves should be burned in the fall. Canes should be cut back to three or four buds in the spring. Weekly applications of finely ground sulfur dust will hold the disease in check. In greenhouse, prevent excessive and rapid changes in temperature.
Powdery mildew <i>Sphaerotheca pannosa</i> (Wallr.) Lev. var. <i>rosae</i> Wor.	Young leaves show raised blister-like areas. Older leaves become covered with a white, powdery fungus growth, composed largely of colorless spores. Dwarfinng and distortion of growing tips. Thorns, stems and bloom stalks are also infected.	Weekly applications of dusting sulfur. In greenhouses, painting the steam pipes with a paste composed of equal parts of sulfur and lime mixed with water. Avoid excessive ventilation, syringing and sudden change in temperature.
Rust <i>Phragmidium</i> spp.	Orange-brown powdery spore masses on the under surface of the leaves. Later in the season pustules become dark brown. Young canes may also be infected.	All fallen leaves should be burned in the fall. A dormant spray of lime sulfur 1-9, severe spring pruning, a weekly application of dusting sulfur during the growing season will give a practical control.

MONTANA EXTENSION SERVICE

Russian Olive

Disease	Symptoms	Control Measures
Root and crown rots Different soil fungi.	See <i>Caragana</i> p. 9.	

Rye

Disease	Symptoms	Control Measures
Ergot <i>Claviceps purpurea</i> (Er.) Tul.	Yellowish drops of honeydew from infected flowers. When grain begins to ripen, hard, violet, horn-like body replaces kernel.	Crop rotation. Removal of ergotized bodies.

Sorghum

Disease	Symptoms	Control Measures
Kernel smut (loose or covered) <i>Sphacelotheca cruenta</i> (Kuhn) Potter <i>Sphacelotheca sorghi</i> (Link) Clinton	All normal kernels usually replaced by black smutty masses. Disease visible when head emerges from sheath. Disease overwinters on contaminated seed.	Copper carbonate (50%). 2 oz. per bushel in rotary machine. New Improved Ceresan $\frac{1}{2}$ oz. per bushel, treat 24 hrs. before planting. Leave treated seed in uncovered pile, or in loose burlap sacks. Sulphur dust 2 to 3 oz. per bushel.

Strawberry

Disease	Symptoms	Control Measures
Leaf spots Different fungi	Reddish, circular spots on leaves.	Bordeaux mixture 4-4-50 after harvest.
Yellows Virus, physiological or hereditary.	Foliage assumes yellowish color, either leaf margins or between the larger veins. Plants dwarfed, leaves small, production low. Causes: alkali, poor drainage, virus, heredity.	Avoid alkali and poorly drained soils. Plant healthy stock. Use selections which are free of heredity yellowing.

Sweet Pea

Root rot Different soil organisms.	Sudden flagging of leaves accompanied by general wilting and collapse of plant.	Treat soil with 6% formaldehyde dust at rate of 3 oz. per foot of row 12 in. wide and 6 in. deep immediately before planting. Treat seed 1 minute in 95% alcohol followed by 20 minutes in 1-1000 mercuric chloride. Give good culture care and water freely. Blue Bonnett somewhat resistant.
---------------------------------------	---	--

Tomato

Disease	Symptoms	Control Measures
Western yellow blight Virus disease.	Leaflets roll upwards, become thickened and crisp, light green or yellow in color with purpling of veins. Stems become hollow. Plants have erect and dwarfed appearance. Roots decay and plants die.	Use resistant varieties. Tomatoes should be planted some distance from beets, spinach, poppies, cucurbits, etc., which are also susceptible to the disease. This same disease causes curly top of sugar beets.
Wilt <i>Fusarium bulbigenum</i> var. <i>lycopersici</i> Wr. and R.	Vascular bundles of stem and roots are discolored. Yellowing and browning of lower leaves. The leaves die successively until the whole plant wilts and dies. Brown streaks inside the stems and petioles.	Certified seeds. Soil should be disinfected for use in hot beds and cold frames. Crop rotations. Disease resistant varieties—Illinois Pride, Illinois Baltimore, Early Baltimore, Marglobe. Susceptible varieties are Earliana, Bonny Best.
Bacterial canker or birdseye <i>Phytoponas michiganense</i> (EFS) Bergey et al.	Wilting of foliage, beginning with the lower leaves which turn brown and die. Setting of fruit is reduced. Stems and leaves become brittle. Birdseye spots develop on tomato fruits.	Use seeds from healthy plants. Soil should be disinfected for use in hot beds and cold frames. Crop rotation. Spraying plants with Bordeaux mixture as soon as disease appears. Remove side shoots by breaking off rather than pruning.

Watermelon

Disease	Symptoms	Control Measures
Bacterial wilt <i>Erwinia tracheiphila</i> (EFS) Bergey et al.	Same as cucumber.	Same as cucumber.
Fusarium wilt <i>Fusarium nivium</i> EFS.	Rot of seedlings before emergence, damping-off, and stunting of seedlings. In older plants wilt starts at tips of runners and gradually involves entire plant. Vascular bundles show brown discoloration. Cankers develop on roots.	Very long rotations. Resistant varieties. Conqueror, Iowa Belle and Iowa King are resistant.

MONTANA EXTENSION SERVICE

Wheat

Disease	Symptoms	Control Measures
Root rot Different soil organisms.	Lower part of stem discolored. Roots more or less rotted. Severe cases, straw ashy white, kernels small and shriveled.	Rotate crops. Treat seed with New Improved Ceresan or Copper Carbonate. Wheat planted after September 10 usually shows less disease.
Rust—Black stem rust <i>Puccinia graminis</i> Pers.	Red elongated spots on leaf sheaths and upper nodes. When wheat matures spots become black.	Early planting. Good seed bed. Thatcher and Pilot varieties are resistant. Marquis and Ceres are susceptible.
Rust, Leaf-rust <i>Puccinia rubigo-vera tritici</i> (Eriks. and Henn.) Carl.	Small circular spots mostly on leaf blade.	Very prevalent but damage not as severe as black stem rust. No satisfactory control.
Smut—Stinking or Bunt <i>Tilletia tritici</i> (Bjerk.) Wint. and <i>T. levis</i> Kuhn.	Normal kernels replaced by black smutty masses, usually has a foetid odor.	Treat seed with copper carbonate or New Improved Ceresan. Ceres variety susceptible. Yogo variety resistant.
Smut—Loose <i>Ustilago tritici</i> (Pers.) Jens.	Smutty mass appears at flowering time. Later smut is blown away leaving bare stalks.	Plant disease-free seed. Hot water treatment not recommended for general use.

Willow

Disease	Symptoms	Control Measures
Canker <i>Cytospora chrysosperma</i> (Pers.) Fr.	See Poplar p. 19	
Rust <i>Melampsora</i> spp.	Yellow pustules on the lower surface of leaves bearing spores of the fungus. Late in the summer the over-wintering spores are found in reddish-brown pustules.	Collecting and burning all dead leaves and branches which have fallen in late fall.

Seed Treatment

Many diseases of plants are caused by bacteria or fungi which are carried in, on, or with the seed or the other parts of plants used for propagation. To destroy these parasites and to give more or less protection to the young plant from other pathogenic organisms present in a soil, different seed, tuber, etc. treatments are used. Disinfected seed frequently gives a greater yield than non-disinfected seed. Seed treatments alone do not always control all diseases against which they are directed, therefore such additional practices as seed bed or field sanitation, rotation, destruction of weeds etc., may be necessary to obtain successful disease control.

Only a few special treatments, such as hot water, are effective in destroying seed-borne parasites that are lodged in the inner parts of the seed. The hot water treatment requires that the temperature be carefully regulated and even then the germination of the seed is sometimes injured. Since this treatment is very difficult it is probably better to obtain a new seed stock free of disease than to use the hot water treatment.

To destroy surface borne plant parasites, different chemical treatments are used. They may be used for a specific disease, or as a general purpose treatment for several diseases. Some of these chemicals as for example, formaldehyde, destroy pathogens on the surface of the seed, but the disinfectant has very little residual effect. Other types of chemicals, as for example different copper and mercury compounds, not only are effective against surface-borne parasites, but also have a residual effect, as they remain on the seed coat and retard the growth of fungi and bacteria in the soil, which under unfavorable conditions of growth may injure the young plant. Seed treatments are "wet" and "dry". Examples of the wet treatments are formaldehyde and copper sulphate dips. In dry treatments, different disinfecting dusts are used.

The following seed treatment chart lists the chemicals usually used for treating various kinds of seed. The amount used for the treatments are either given in the chart or they should be used according to the printed instructions on the container. Many of the chemicals are poisonous and for this reason treated seeds

should not be fed to animals. Small amounts of seed may be treated by shaking them with the chemical for several minutes in an ordinary fruit jar. For treating a large amount of seed use either manufactured machines or homemade rotary or gravity equipment.

A good dust mask, the filters of which should be changed daily, should be worn when large amounts of seed are treated.

Seed Treatment Chart

Crop	Treatment
Barley	New Improved Ceresan (5%) $\frac{1}{2}$ oz. per bushel of seed.
Beet Sugar or garden	Under certain conditions it is advisable to use Ceresan (2%) 3 to 4 oz. per 20 lbs. of seed. New Improved Ceresan (5%) 0.8 to 1.4 oz. per 20 lbs. of seed; or Red Copper Oxide—4 pounds per 100 pounds of seed, or 4 level teaspoonsfuls per pound of seed. Any excess of Red Copper Oxide dust should be screened off.
Cabbage	Corrosive sublimate—1 part to 1000 parts of water (1 oz. of corrosive sublimate to $7\frac{1}{2}$ gallons of water or 1 tablet ($7\frac{1}{2}$ grains) to 1 pint of water). Soak seed for 20 minutes, wash 15 minutes, dry. Semesan— $\frac{1}{2}$ level teaspoonful per pound of seed. Place the seed and the dust in a tight container and shake it for 3 to 5 minutes until all of seed is thoroughly covered. The excess dust should be screened off.
Corn	New Improved Semesan Jr., or Merko, or Barbak III—2 oz. per bushel of seed. A barrel mixer or rotary mixer of some type is need for this treatment.
Cucumber	Corrosive sublimate—1 to 1000 (see cabbage). Soak 5 minutes, wash 15 minutes, dry. Red Copper Oxide—1 level teaspoonful per pound of seed, or 1 pound to 100 pounds of seed. The seed and the dust should be mixed thoroughly in a tight container until all the seed is coated. Any excess dust should be screened off. The seed is usually treated with corrosive sublimate and then with Red Copper Oxide as a protectant.
Eggplant	Red Copper Oxide—same as cucumber. Semesan—same as cabbage.
Gladiolus	Treat corms by soaking in corrosive sublimate 1 to 1000 (see cabbage) for 5 hours.
Millet	New Improved Ceresan— $\frac{1}{2}$ oz. per bushel of seed. Copper carbonate 50%—2 oz. per bushel of seed.

Seed Treatment Chart (Continued)

Crop	Treatment
Muskmelon Cantaloupe	See cucumber.
Oats	New Improved Ceresan— $\frac{1}{2}$ oz. per bushel of seed. Formaldehyde spray treatment (dry)—mix 1 pint of commercial formaldehyde with 1 pint of water. Apply this mixture uniformly with a sprayer at the rate of 1 quart to 50 bushels of seed as it is being shoveled from one pile to another. Bin it or pile and cover with disinfected canvas or sacks for 4 to 8 hours. Sow immediately or run through fanning mill or otherwise expose to air before storing for any length of time.
Onion	Semesan (see cabbage). Formaldehyde drip method (for prevention of smut). In dry soil apply formaldehyde (1 pint to 16 gallons of water) in the furrow with the seed, using about 16 gallons per 3000 feet of row (about 200 gallons per acre). In wet soil use 1 pint to 10 gallons of water and apply 125 gallons per acre.
Pea	Semesan—(see cabbage). Red Copper Oxide— $2\frac{1}{2}$ oz. per each bushel of pea seed. To avoid seed injury and drill trouble add 1 oz. of powdered graphite to the $2\frac{1}{2}$ oz. of Red Copper Oxide and mix both with the seed. If sown by hand, graphite is not needed. Spergon—2 oz. per bushel of seed.
Potato	Send for the Circular No. 166 of the Montana Agricultural Experiment Station, "Potato Diseases in Montana and Their Control."
Rye	New Improved Ceresan— $\frac{1}{2}$ oz. per bushel of seed.
Sweet Pea	See Pea.
Sorghum	New Improved Ceresan— $\frac{1}{2}$ oz. per bushel of seed. Copper carbonate—2 oz. per bushel of seed. Sulphur dust— $2\frac{1}{2}$ oz. per bushel of seed.
Tomato	Corrosive sublimate—1 to 3000 solution (1 oz. to $22\frac{1}{2}$ gallons of water or 1 to 2000 solution (1 oz. to 15 gallons). Soak for 5 minutes, wash 15 minutes, dry. Red Copper Oxide—2 level teaspoonsfuls per pound of seed. Any excess dust should be screened off. New Improved Ceresan—dissolve 1 oz. in 9 gallons of water and use 1 gallon for each pound of seed treated. Soak for 5 minutes, then dry. Do not store in tight containers.
Watermelon	See cucumber.

Seed Treatment Chart (Continued)

Crop	Treatment
Wheat	<p>For bunt:</p> <ol style="list-style-type: none"> 1. Copper carbonate—50% metallic copper—2 oz. per bushel of cleaned seed; 20% metallic copper—3 to 4 oz. per bushel of cleaned seed. A rotary mixing machine should be used for this treatment. 2. New Improved Ceresan—½ oz. per bushel of wheat. Allow the treated grain to remain in sacks at least 24 hours before being sown. 3. Basic copper sulphate (about 50% of copper)—use 2 oz. per bushel of cleaned seed.

Soil Treatments For The Control Of Plant Diseases

Soil sterilization in greenhouses, hotbeds, in outdoor seedbeds, flowergardens, small nursery plots, etc., is often necessary in order to control certain soil-borne and root diseases. Unfortunately, soil sterilization is a rather expensive procedure and is applicable to limited areas.

Steam: In this method, live steam from a boiler is conducted into an inverted box which is moved about over the loosened soil. In another method drain tile or perforated-pipe, buried in the soil, may also be used to distribute the steam. Small quantities of soil may be sterilized in an autoclave. Soil should be saturated with water and kept in an autoclave for 3-4 hours at 15 pounds of pressure. Small quantities of soil may be also sterilized in an ordinary cooking oven. Soil should be saturated with water and kept in an oven at a temperature about 160°F. for 3 or 4 hours.

Electricity: Where steam is not available and electricity is cheap, electric sterilizers can be used for treating small quantities of soil for pots, flats, or seedbeds. The soil is usually heated at a temperature of about 160°F. for 3 or 4 hours.

Formaldehyde: This chemical has been used for many years as a drench, in which case a solution containing 1 gallon of commercial formaldehyde in 50 gallons of water is added to the spaded soil at the rate of 1 gallon to each square foot of soil surface. After application the soil should be covered for 1 to 2 days with paper or boards to prevent too rapid escape of the formaldehyde gas. After removal of the cover, the soil should be spaded several times and left to dry out for two weeks before being used. Recently

formaldehyde was used as dust and sprinkle types of applications. The dust (6%) is used at 1½ ounces per square foot and worked into the soil a day or so ahead of using. The sprinkle method is much the same except that ½ tablespoonful is applied in a little water to each square foot. Formaldehyde fumes are poisonous to the growing plants.

Acetic acid: This acid is cheaper than formaldehyde and in large, well ventilated greenhouses it can be used near beds where plants are growing without producing injury to these plants. One gallon of glacial acetic acid should be diluted in 99 gallons of water. One-half gallon of the diluted liquid is poured over each square foot of spaded soil. Seeds and plants should not be planted in this soil for 8 to 14 days after the treatment. Soil should be aerated during this period.

Chloropicrin (Larvacide): Liquid form of this chemical is used for sterilizing soil, especially against nematodes and certain fungi. It is used at the rate of about 1 pound to 140 square feet of soil surface and place at a depth of 6 or 8 inches in the soil in holes about 15 inches apart. After injection the holes should be immediately closed and surface of the soil watered to a depth of one inch. Best results with this treatment are obtained when treated soil is in a loose condition and has a moderate moisture content and treated at 60-85°F. or higher. Do not treat the soil with chloropicrin at a temperature below 45°F. Chloropicrin fumes are injurious to growing plants. Do not plant in treated soil until all traces of gas have disappeared. This requires 5 to 15 days depending on moisture and temperature of the soil.

In addition to the chemicals already mentioned, many other materials have been used for soil disinfection, but those already described appear to be ones which are generally recommended.

In conclusion all methods of soil sterilization are rather elaborate and relatively expensive. In some cases soil sterilization possibly could be avoided by the crop rotation, fallowing, planting resistant varieties or by supplying the soil with necessary fertilizers to produce healthy, vigorous plants which have a better chance to withstand the attack of a disease than weak, undernourished plants. Very often it is better to obtain fresh, disease-free

soil to replace soil in greenhouses or in small garden spots than to sterilize the same. But when really drastic measures are required for the suppression of plant diseases, soil sterilization is the only treatment which gives complete control of plant pathogens.

Fungicides

The most common fungicides used to control plant diseases contain some form of copper or sulphur. Compounds containing mercury or zinc and some other metals are also used.

Copper compounds: These compounds are used as foliage sprays, or dusts, seed treatments, seedling sprays, and soil treatments.

Copper Compounds

Bordeaux mixture: Almost the only fungicide used on vegetables is bordeaux mixture. It is also used to a considerable extent on trees and shrubs to control leaf spots, mildews, etc.

Bordeaux is made by mixing a solution of copper sulphate (blue vitriol) with milk of lime. In bordeaux formulas such as 4-4-50, 3-5-50, etc., the first figure means pounds of copper sulphate, the second figure pounds of lime, and the last figure gallons of water.

The recommended method for preparing bordeaux is to dissolve the copper sulphate in half the required amount of water, and the lime in half the required amount of water, and then pour the two solutions simultaneously into a third container, which may be the spray tank, barrel, etc. Wooden containers should be used in preparing bordeaux, as copper sulphate corrodes metals. A sky-blue solution will be the final result. Freshly slaked burned lime or hydrated lime may be used. Air-slaked lime is not satisfactory and should not be used.

For making small quantities of bordeaux, 4 ounces of copper sulphate, 4 ounces of hydrated lime and 3 gallons of water are required.

Calcium arsenate or lead arsenate in the amounts recommended may be added to the bordeaux mixture for the control of insects.

Prepared bordeaux mixtures are on the market, but in large quantities they are expensive as compared with the home mixed material. Bordeaux mixture deteriorates rapidly upon standing and should be used as soon as possible after it is prepared.

Copper lime dust made by thoroughly mixing 1 pound of monohydrated copper sulphate (snow) with 4 pounds of hydrated lime is frequently used instead of bordeaux.

Insoluble or fixed copper compounds are becoming widely used as fungicides for plants. They may not be as effective, in all cases, as bordeaux, but they cause less foliage injury and are more convenient to use. The trade names of some of these materials are cuprocide, metrox, copper-hydro "40", coposil, and basicop. Many of these compounds have not been thoroughly tested under Montana's conditions, therefore they should be used according to the instructions on the container and tested on a few plants and the results noted after two or three days before large numbers of plants are treated.

Copper carbonate and monohydrated copper sulphate are used chiefly for treating seed-wheat for smut.

Sulphur And Its Compounds

Sulphur: Dusting sulphur, a finely ground form (325 mesh), is used for the control of mildews, rusts and some foliage diseases. It is applied as a dust. **Wettable sulphur** is finely ground sulphur to which a wetting agent has been added. It gives a uniform suspension when added to water. It is usually used at the rate of 2 ounces to a gallon of water or 5 pounds to 50 gallons.

Lime sulphur is sold either in the wet or dry form. It is made by boiling together sulphur and lime. The lime sulphur solution commonly used in Montana tests 28°B and should be used at the rate of 1 gallon lime sulphur solution in 25 gallons of water for foliage sprays. For dormant sprays use 1 gallon lime sulphur in 6 to 9 gallons of water depending upon the purpose of the spray.

If dry lime sulphur is used, 4 pounds of the dry material should be substituted for 1 gallon of the liquid in the formulas.

Mercury Compounds

Corrosive sublimate is often used for treating tubers, bulbs, corms and seeds. It is used in a 1 to 1000 solution (1 tablet ($7\frac{1}{2}$ grains) in a pint of water or 1 ounce in $7\frac{1}{2}$ gallons of water). Sometimes a 1 to 2000 or a 1 to 3000 solution is recommended. The material is highly poisonous and it should be used in glass, earthenware or wooden containers. It corrodes metals.

Organic mercury compounds are mixed with inert materials for use as sprays, dips, etc. The trade names of some of them are new improved ceresan, semesan, semesan Jr., new improved semesan, sanoseed, nu-green, and perhaps others. They should be used according to the printed instructions on the container.

Spreaders, Stickers, etc.

Many materials have been used in sprays and dusts to give better covering properties. Some of those commonly used are ordinary wheat flour, $1\frac{1}{2}$ to 2 pounds to 50 gallons (make a thin paste of the flour before adding it to the spray material). Calcium caseinate is used at the rate of $\frac{1}{2}$ pound to 50 gallons, powdered skim milk at the same rate, or two quarts of sweet skimmed milk may be substituted for calcium caseinate. Glue and soap are sometimes used. Trade names of some of the spreaders or stickers are aresket, lethane, penetrol, kayso and numerous others.

Winter Injury

Cold injures plants usually under two conditions, by winter injury when the plants are in a dormant or semi-dormant condition, and by early or late frosts or freezes when the plants are in active growth.

Plants show winter injury in a variety of ways, such as blackened sapwood, injured or killed cambium, death of leaf or fruit buds, twigs, branches, injury to tap or side roots, or crown injury. A tree or shrub may develop full foliage in the spring and then suddenly die due to winter injury of its roots or the crown at or near the soil level. Mild, warm winter days that start sap circulation followed by a sudden drop in temperature usually causes

sun-scald or loosening of the bark on the south or southwest side of plants.

Late spring or early fall frosts may actually kill tender tissues or impair the quality of fruits, flowers and vegetables.

The main control measure to lessen winter injury is to provide conditions that will encourage the proper maturity of the plants before freezing weather occurs. Irrigation water should be withheld if necessary, cover crops should be planted to use excess water, excess plant foods, etc. Fertilizers containing considerable amounts of easily available plant food such as sodium nitrate, ammonium sulphate should be applied early in the season, good drainage should be provided, etc.

To largely prevent sun-scald, the trunk of young trees should be shaded by placing boards, shingles, etc., to cast a shadow on the south and southwest sides of the trees and older trees should have comparatively low heads so the trunk will be more or less shaded at all times.

Since winter injury in many instances is closely correlated with proper maturity of the plant, every effort should be made to regulate, insofar as practical, conditions to bring about this result.

Chlorosis

Chlorosis or the yellowing of the foliage of many plants may be due to several different causes. Plants affected with chlorosis are unthrifty in appearance and low in vigor, which makes them undesirable for ornamentals or for orchard purposes. Certain plants growing in soil containing a high content of lime may show chlorosis, due to a deficiency of iron. The iron in alkaline soil is unavailable to these plants. Yellowing of the foliage due to lack of iron usually appears in the young foliage near the tip of the branches. In severe cases all the foliage may become yellow. Trees, shrubs and herbaceous perennials may be affected.

The control method for correcting iron deficiency chlorosis is to supply iron in an available form.

(1) **Spray method:** The yellowed leaves should be thoroughly

sprayed with a solution containing 2 heaping teaspoonfuls of iron (ferrous) sulphate (green vitriol) in a quart of water to which one-fourth teaspoonful of glue is added as a sticking agent. Several applications at intervals of 10 to 14 days may be required.

(2) **The injection method** of applying iron salts has been used successfully in many trials. This method is as follows: A small hole ($\frac{1}{2}$ inch) is bored on a slant into the tree, and 1 gram of the iron salt, preferably iron citrate or iron phosphate, is put into the hole and the hole plugged with a close fitting wooden plug or grafting or sealing wax. For small trees 4 to 6 inches in diameter two or three holes are bored at equal intervals to a depth of 1 inch. For larger trees proportionally more holes are bored in a spiral ring around the trunk or branch. Approximately 1 gram of the iron salt is required for each inch diameter of the tree, using as many holes as are necessary.

(3) **The soil treatment** recommended as the most effective and permanent by the New Mexico Agricultural Experiment Station (Bulletin 264, June, 1939) consists of the application to the soil of barnyard manure and equal parts of iron and aluminum sulphate, used at the rate of 1 pound of the mixture to each inch of diameter of the plant. The materials should be applied uniformly beneath the spread of the branches,, commonly called the "drip" of the tree. The salts may be applied in a water solution or in holes 12-18 inches deep uniformly distributed around the tree.

Other causes of chlorosis are fungus and virus diseases, low temperatures, especially in early spring, excess of water, or lack of nitrogen, however, chlorosis caused by iron-deficiency is probably the most prevalent chlorosis in the state.

Damping-off Disease Of Seedlings Under Glass

The problem of obtaining a stand of ornamental or vegetable seedlings and of combating damping-off may mean the difference between profit and loss. All field, vegetable and ornamental crops are susceptible to certain diseases known as seedling blight or damping-off. This disease is caused by one or more species of soil-inhabiting fungi. These fungi frequently rot the germinating

seed and attack the tender stems of the survival seedlings at or near the soil level. Some damping-off fungi are carried into the soil on the seeds, a surface disinfectant will kill these organisms. Some damping-off fungi are present normally in the soil, ready to attack seeds or plants when environmental conditions are favorable. If seeds are covered with some fungicide, or if the soil is treated, considerable protection is afforded from soil-borne parasites. (See soil treatments p. 28 and see treatment chart p. 26)

Cultural practices often have a direct bearing on damping off, and recommended practices should be adopted. At least once a year the greenhouse should be thoroughly cleaned. All plants should be removed and the house thoroughly sprayed with formaldehyde (one pint in ten gallons of water) or copper sulphate (one pound in ten gallons of water).

Diseased plants should be disposed of preferably by burning or burying, or in such a manner that they will not continue to be a source of infection.

The recommended greenhouse practices for "flat" culture are:

(1) Using a soil-mix of a sandy nature to provide adequate drainage, and of medium to fair richness and preferably new soil
(2) disinfecting "flats" and immediate surroundings (3) controlling temperature and moisture correctly during the early stages of growth (4) using A-1 seed and planting in rows (5) disinfecting seed and treating soil as recommended (6) if damping-off appears it may be checked by spraying the seedlings (A) with Semesan, using one level tablespoon of Semesan in one gallon of water (1 oz. to 3 gal. water) at the rate of $1\frac{1}{2}$ quarts for each 10 square feet of medium to heavy soil, or one quart for each 10 square of lighter soil. A second or third application at intervals of 2 or 3 weeks may be necessary. Always keep the beds well ventilated. (B) Red copper oxide (1 oz. in 3 gallons water) may be used similar to Semesan. (C) Copper carbonate (1 oz. in $1\frac{1}{2}$ gallons water) using 1 pint to each square foot of surface may be used similar to Semesan. (7) Light is essential for best seedling growth, and effort should be made to furnish as much light as possible to the "flats". (8) Air circulation is of prime importance, and the flats

should be well ventilated at all times. (9) Watering should be carefully done, preferably in the morning and on bright days. In dull weather the plants should be kept comparatively dry, even on the verge of wilting. Since damping-off is closely correlated with moisture, careful attention to watering is of prime importance in damping-off control.

Stem And Root-rots

A general characteristic of stem and root-rots is a sudden wilting of a part or the entire plant. In a tree or shrub just a single branch or a main limb, or half the plant may be affected. In some cases the plant fails to leaf out in the spring. Upon careful examination some of the roots will show evidence of a disease condition. It is often difficult to distinguish between root-rots and killing of the roots due to winter injury.

There are several different fungi which cause rotting of the roots or stem at or below the soil line. The diseased plants usually show a decay of the affected tissue, and sometimes the fungus is visible as a whitish growth on the affected parts. These rots are quite common in garden or in ornamental plantings. Cultural methods are very important in controlling these rots. Crop rotation is very important, watering the plants only as often as necessary to maintain satisfactory growing conditions is advisable. Crowding of plants, which provides poor ventilation and retains a moist condition near the soil line, favors this type of disease. In a field, cover crops or manure should be plowed under early to allow complete decomposition before the succeeding crop is planted.

Beneficial treatment when known, is indicated under the respective hosts.