Oregon Agricultural Experiment Station

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BOTANICAL DEPARTMENT.

Plant Diseases: Their Cause and Prevention.

MOSES CRAIG, Botanist.

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Plant Diseases:

THEIR CAUSE AND PREVENTION.

Though there is much literature on this subject, it is scattered through so many botanical books, magazines and experiment station bulletins as to be inaccessible to most Oregon farmers, who lack the time and means, as well as the books, necessary for the study of vegetable pathology. A desire on their part for more information is shown by the many letters of inquiry received by this department during the past year.

PURPOSE OF THE BULLETIN.

The object of this bulletin is to present to Oregon farmers, in a condensed and popular form, what is now known about the most important diseases attacking cultivated plants. Fortunately many morbid conditions destructive in other states have as yet caused little damage here, but new diseases are gradually coming in and agriculturists should be able to recognize them and apply proper remedies in time to prevent their gaining a foot-hold in the state.*

The methods of treatment here given are those that have been found most beneficial in other states but whether they will prove so here and what modifications are necessary can only be determined by a careful series of experiments which, contrary to what many persons suppose, will require several years for their completion.

*Our purpose may be misunderstood by some who think that only the direct results of technical experimentation should be included in experiment station bulletins. To such the writer would say that while he partially agrees with them he thinks some general information on this subject is now needed in the state and hopes that the bulletin will prove serviceable as an introduction to investigations the results of which will be published, from time to time by this department.
ENEMIES TO AGRICULTURE.

A successful agriculturist must not only know the conditions affecting plant growth but be able to recognize the enemies of his crops and protect the plants from them. Weeds, insects, and fungous diseases are his worst enemies, and some knowledge of their nature and habits is necessary to successfully combat them. It is evident that the more thorough his knowledge of plant diseases the more effective will be the means employed to destroy them.

Three questions regarding these diseases are of great importance to the husbandman, namely: What causes them? How, and to what extent, do they injure plants? How shall he best prevent this injury?

CAUSES OF DISEASE.

Plants live and are healthy only while repair and waste are properly balanced. When loss becomes greater than gain the plant dies from old age (maturity), from failure of food supply (starvation and suffocation), or from morbid conditions caused by an injury (disease).

Plant diseases are produced in various ways: by fungi; by insect injury; by something in the environment of the plant, or by a combination of these causes, so it is often difficult to determine their exact cause. Insects frequently weaken plants by wounding the leaves or bark, then fungi attack them and complete the injury already begun. Sometimes necessary food elements are absent. So to secure the best results the Entomologist, Horticulturist and Chemist must work hand-in-hand with the Botanist in devising remedies.

ETIOLAION.

Some diseases are due to weakness or imperfect nutrition of the plants caused by improper or insufficient nourishment which destroys their verdure making them pale and sickly.

This blanching, or etiolation as it is called, usually comes from overshadowing the plants, if this is the cause when again exposed to sunlight they will recover their normal color. Celery and plants grown in dark rooms or under the shade of trees are familiar examples. This disease which is often aggravated by cold, uncongenial weather and bad drainage predisposes the plant to fungus attacks.

Paleness may also result from poverty of the soil, from excessive moisture and from the depredations of insects in the roots or stem, consuming the plant food in the sap. This starves the leaf-cells rendering them unsusceptible to the action of light. If the debilitating cause is not removed the blanched leaves soon wither and droop or shrivel up and drop off according to the extent of injury.

Chlorosis is a palid condition of plants exposed to direct sunlight. The best remedy is watering them with a weak solution of green vitriol.

DEPOLLATION.

When growing leaves are injured by insects or noxious vapors, growth of the margins being arrested, they become curled and crumpled.

† M. T. Masters, Plant life on the Farm, 1884, pp. 114-15.
‖ B. D. Halsted, N. J. Experiment Station, Rep. 1892, pp. 298 and 303.
Ⅰ Wm. Rhind. Vegetable Kingdom, 1855, p. 132.
Sunburn and fungi often cause irregular brown patches of decayed tissue which may spread and gradually involve the whole leaf.

If from these or other causes a tree loses its foliage in early summer its growth will be stunted as owing to impaired nutrition a thin layer of wood is formed that season and probably the next also. Vigorous plants may produce a second crop of leaves later in the season but this will be at the expense of next year's buds, as nutritive material in the crude sap sent up by the roots must be elaborated and returned for the use of the plant.

EFFECTS OF FROST.

Other causes of plant debility are too rapid growth and sudden changes of temperature.

High temperatures usually cause wilting, water being given off from the leaves more rapidly than it is absorbed by the roots.* This may be prevented by shading or watering the plants before the cells lose their necessary fullness and the sap ceases to flow readily. Low temperatures disturb the leaf functions and chlorophyll being imperfectly formed, give the plant a yellow tinge as in frosted wheat. Occasionally the sap freezes in

* H. M. Ward, Timber and its diseases, 1889, p. 244.
* G. L. Goodale, Physiological Botany, 1885, p. 277.
the cells rupturing their walls and causing death, the leaves then become limp and blackened. When plants are frosted the fluid contents of the cells escape and freeze in the intercellular spaces, arresting all vital functions. If gradually thawed, the water may be re-absorbed and life action resumed.

**SUN SCALD.**

Light spring frosts and chilling winds often damage green, immature wood of fall growth or young growing shoots and buds so slightly as to be unnoticed at the time but still cause a withered or blighted appearance, called sunscald, later in the season. The bark begins to crack and peel off, the inner bark dies and the branches, sometimes the whole tree, die. Sometimes the bark rots off near the ground where it was surrounded by snow during the winter, thus killing the tree the second season. This may be prevented by wrapping the trunk or branches with coarse cloth.

The best remedy is to have the wood fully matured before winter sets in. Avoid the application of rich manures late in the season, and root-prune by plowing around the trees about the middle or last of August to check a late growth of branches.

**DECAY AND DEATH.**

Death may be sudden and complete as in trees broken by the wind or struck by lightning; or it may be partial and gradual when caused by fungal attacks, dust, exposure to noxious vapors, or loss of leaves. Decay may begin in the roots, in the stem, in the intermediate collar, or in the leaf-cells.

Death of the roots from decay, exposure to the air, drought, or ravages of insects larvae, mice, gophers, etc. produces effects similar to those given under etiolation. Injuries to the leaves and stem are given under the effects of frost, sun-scald, and parasitic fungi.

When small branches are bent or partially broken the parts will reunite on being properly secured in their natural positions, provided the limbs are not crushed.

**KEEP YOUR PLANTS HEALTHY.**

Remember always that plants do not succumb to disease until they have in some way become weakened, so when they present a sickly appearance seek for the causes of weakness, remove them, if possible, and then apply preventive or curative treatment according to the nature of the case. Prevention is the best and cheapest remedy.

Pay attention to the general health of your plants, see that they are not overcrowded, that they have a suitable soil, neither too wet nor too dry, and one containing the food elements necessary for their best development. See also that their vitality is not sapped by the ravages of insects and fungi which always cause the most injury to the weakest plants.

**AVOID INSECT INJURY.**

There are a large number of diseases caused wholly or in part by insects but as the Entomologist exercises perpetual jurisdiction over them, few are mentioned here. Those desiring further information are referred to him and to bulletins number 3, 5, 10, 14, 18, and 25 of this Station.

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2 M. T. Masters, Plant life on the Farm, 1884, pp. 64-5.
4 Wm. Rhind, Vegetable Kingdom, 1835, p. 35.
The serious injuries caused by scale-insects or bark-lice (Coccidae) are frequently mistaken for fungous diseases which they occasionally resemble, but careful scrutiny under a hand-lens will usually dispel all doubt.

ERINOSE.

The name erinose is now used to designate a leaf disease caused by a minute spider (acarid) but formerly thought to be a fungus. The appearance of the affected grape leaves is similar to that caused by the downy mildew from which it may be readily distinguished under a microscope. Thus examined the spots are seen to be composed of shining hair-like growths with enlarged tips quite unlike the branched fungus.

**FIG. 3.** Lower surface of grape leaf attacked by Erinose.

**FIG. 4.** Cross section of leaf through one of the galls showing the hairs a formed from elongated epidermal cells, two of the animals b b and one of the eggs c.

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Erinose usually appears in early summer as small, white, raised spots scattered over the lower surface of the leaves; these soon enlarge and become a dark reddish-brown color. Leaves attacked when young do not attain normal size and if badly infested become curled with the convex side uppermost. This disease rarely makes much difference in the crop and when necessary the multiplication of the insect may be checked by repeated applications of sulphur to the young shoots.†

MOSS COVERED TREES.

Mosses and lichens though not parasitic often cover trees impeding the circulation of air and hastening decay by retaining water about the branches. When enveloping young shoots, they intercept light and interfere with the development of wood and the production of foliage.‡ In early spring, before the buds open, spray the trees with lye which will not only kill the lichens growing on the trees but also destroy the many fungus spores lodging on them and on the branches.§

PARASITIC FUNGI.

As most plant diseases are due directly or indirectly to attacks of fungi, it is necessary to know something about them. They are minute flowerless plants destitute of the green coloring matter called chlorophyll and thus unable to assimilate food for themselves. There are two kinds, saprophytes those that live on dead organic matter, and parasites those that draw nourishment from living plants called their hosts.|| The common mushroom is a saprophyte while corn smut and apple scab are parasites.

Scientists formerly thought that the vegetable parasite was a diseased condition of the host itself; for example, that the rust of wheat was only the degenerated cell tissue of the wheat plant. Though much study is still needed to disclose the best methods of preventing the growth and development of fungi, botanists now know that they are the descendants of pre-existing forms; that they begin their growth outside of the host-plant and gain entrance by penetrating the membranes or through the stomates.¶

Their mycelia ("vegetative system") usually grow within the body of their host but some like the "Surface Mildews" grow on the outside sending small fibers called haustoria into the tissues of their host through which they pass, abstracting food much like roots through the soil.†† In naming fungi the fruit (consisting of spores which are analogous to seeds) is made the basis of classification as the reproductive system is more diversified than the vegetative one ‡‡ and the differences are more readily described.

USE OF FUNGI.

The only use of fungi seems to be in checking the growth of noxious plants by closing their stomates ("breathing pores") thus choking them to

‡ J. D. Hooker, Descriptive and Analytical Botany, 1872, p. 948.
§ Wm. B. Atwood, Va. Ex. Station, June 1892, Bull No. 17, p. 64.
|| Bennett and Murray, Cryptogamic Botany, 1888, pp. 316-17.
‡ Periosporiaceae.
death as in the black-rust on Pin-weed and Skunk-weed. They thus do much toward destroying the many weeds found in the gardens and orchards of the state. If they confined themselves to weeds alone all would be well but they seem to prefer the more delicate, richly fed and juicy cultivated plants which they eagerly attack. So we cannot depend on these parasites as weed-killers. The poor host becomes weakened and appears taller, slenderer and paler than the healthy plants. The result of a fungus attack is either total destruction of the plant or an abnormal development and distortion of the affected parts as in the plum-wart, plum-pockets, or the club-foot of cabbage.

FIG. 5 Powdery mildew of gooseberry. 1. Mycelium with conidiophores a and conidia b in rows, as found on the leaf surface. 2. Pycnidia discharging spores. 4. A young perithecium. 6. Ripe perithecium with appendages. It has been broken open and the spore sac (ascus) is escaping. 7. A spore sac showing the eight spores. U. S. Dept. of Agr. Rep. 1887, P. 385.

3 Puccinia Giliae, Hark? on Gilia integerrima, Stead and G. squarrosa, H. & A. These are new hosts, so far as I am able to ascertain with the limited literature at my command. The fungus proved very destructive to these weeds during the summers of 1892-3 causing large patches of them to turn yellow and die long before the summer was over.

Of the many examples of damage done by fungi, two must suffice.

Prof. Harwood says: 'A low estimate of the loss in Michigan this year from Oat Smut is over one million dollars. Dr. Sturtevant gives the annual loss in central New York as 9½ per cent, which he considers a fair average for the eastern United States.

Dr. Burrill estimates the damage annually caused in Illinois by Wheat Rust at more than 530,000 bushels valued at $175,000. Prof. H. L. Bolley says: 'In Indiana it amounts to from $300,000 to $500,000 annually and for the United States at least one per cent, or more than $4,102,000.'

PREVENTION OF FUNGUS ATTACKS.

Though the damage caused by plant diseases in the United States amounts annually to several millions of dollars, people see their crops injured or destroyed without attempting to prevent the injury, thinking it inevitable, when, by a little effort and at slight cost, most of these diseases could be prevented and the harvest correspondingly increased. For example:

Prof. Swingle says: "The net gain from universal seed-treatment of oats in the United States during the decade ending 1890 would have been more

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† T. J. Burrill, I. c. Art 111 part 1, P. 145.
than $1,624,570. And Prof. Kellerman tells us* that "The yield of oats when treated with hot water is increased, not simply by an amount which equals the portion destroyed by smut, but by at least twice that amount" which would make a saving of $3,250,000 in this disease alone. A fair idea of the enormous annual loss can only be gained by adding up the damage occasioned by all the rusts, smuts, blights, mildews, moulds, etc., so prevalent in many places.

Since these fungi develop mostly within the tissues of their hosts, there is little possibility of saving a plant once really infected, for what would kill the parasite would probably kill or seriously injure the host also. Our chief object then is always preventive, that is, to protect the plant by a thorough application to its exposed surface of some preparation which shall, without injuring the plant, kill or prevent the germination of fungus spores that may alight upon it.†

SPRAYING MIXTURES.

A number of such preparations have been tested with good results and some of the more important formulas are given below. The basis of most fungicides is a solution of copper sulphate which is an ideal remedy being both cheap and effective. Oregon foliage is more readily injured than that of eastern states, so care should be taken not to have the solutions so strong as to burn the foliage. The strength of all mixtures should be suited to the severity of the disease, the condition of the plants and the locality.

pounds, water 22 gallons. Dissolve the powdered blue-stone in hot water, slake the lime in another pail, mix the solutions thoroughly, when cool, straining them through a coarse cloth and dilute to 22 gallons. Try a more dilute solution using fifty gallons of water, this cheaper and more easily applied mixture will probably prove as effective for many diseases.

2. Modified eau celeste: Sulphate of copper 1 pound, Sodium carbonate 2 pounds, strong aqua-ammonia 1½ pints, water 30 gallons. Dissolve the blue vitriol and washing soda separately in water and when cool carefully add the ammonia. Then dilute for use.

3. Ammoniacal copper carbonate: Into a large dish pour one quart of strong ammonia add three ounces of copper carbonate and stir rapidly. The clear liquid thus formed may be kept bottled till needed when it should be diluted to 22 gallons.

4. Liver of sulphur: Dissolve seven ounces of potassium sulphide in 22 gallons of water. A stronger solution used for soaking seed oats is made by dissolving one pound of the sulphide in 24 gallons of water.

5. Iron sulphate solution: Dissolve 5 pounds of green vitriol (copperas) in 22 gallons of water and use immediately.


7. Disinfecting solution for pruning knives: Take crude carbolic acid one pint; strong whale oil soap one gallon. Mix with two gallons of boiling water, let the mixture stand for 24 hours and then add 7 gallons of soft water.

8. Combined fungicide and insecticide: Add two ounces of Paris green or London purple to each 25 gallons of Bordeaux mixture. London purple must be used instead of Paris green in all fungicides containing ammonia. Mix 2 ounces of London purple with two ounces of lime and add to each 25 gallons of eau celeste.


Fig. 8. SPRAYING AN ORCHARD.

SPRAYING MACHINERY.

An expensive outfit is not necessary in order to protect your plants: the essentials are a double-acting force-pump, a barrel or other receptacle for the mixture, and a nozzle which will throw a very fine spray for a long distance. The pump should be mounted on a barrel and placed in a cart so as to be readily moved about in the orchard and vineyard.

In small orchards, vineyards, or gardens knapsack sprayers are often convenient and with a Vermorel nozzle which throws a fine fog-like spray do good work.

Success and economy in spraying depend largely on the nozzle used, and the ability to place the spray just where it is needed is the great object to be attained. The Nixon or Climax nozzle is said to be the best for tall trees as it throws a strong spray for a long distance, but both this and the above are effective and give good results. The Nixon Nozzle and Machine Co., Dayton O.; the field Force-pump Co., Lockport, N.Y.; Mitchel, Lewis, Staver, and Co., Portland, Or., and
many other well known firms carry large stocks of reliable pumps and nozzles. For a fuller account of spraying machinery see the bulletins of this Station.*

**ECONOMY IN SPRAYING.**

Does spraying pay? Yes, when the work is well and carefully done. The trees or vines should be thoroughly wet so there will be a thin layer of the fungicide over the entire plant surface. Do not waste the mixtures by drenching the plants so the solution drops to the ground like rain covering the grass and poisoning stock that may be pastured in the orchard. Begin spraying early but never spray while the plants are in bloom. Spray early

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in the morning or late in the afternoon, if the day is hot, to avoid injury to the foliage.

It has been found by experiments in Ohio orchards that, at a cost less than 15 cents a tree, both insects and fungus diseases can be held in check and the value of the crop doubled which will more than pay the expense of spraying.† At Smyrna, Del. 1200 vines were sprayed five times with Bordeaux mixture for black rot at an expense of 3 cents a vine, giving a net saving of $62.60 per acre ‡ over the unsprayed vines. In another experiment the profit from treatment was 72 cents per vine.‡ Dr. Halsted says: ||

![FIG. 12. 2, Enlarged vertical section of diseased berry, showing epidermis and sub-epidermal tissue. Large numbers of conidia spores are developed beneath the epidermis a which they rupture and escape b.](image)

![FIG. 13. 4, Mature "summer spores" (conidia.)](image)

"In a poor season it pays to spray in order to save as much of the product as possible and in years of abundance it is likewise profitable, that the product may be increased in attractiveness and thereby catch the eye of the purchaser." ¶

When a diseased plant is too far gone to be saved by spraying, prompt measures should always be taken to prevent infection the following season of healthy neighboring plants, of the same kind, by carefully cutting off and burning all affected parts which may harbor fungus spores during the winter.

**NEED OF CO-OPERATION.**

Thoroughness is the secret of success and epidemic plant diseases cannot be successfully combated without the earnest co-operation of all living in an infected region, since one infested field or orchard is a breeding place.

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from which the germs of disease are wafted over the neighborhood. The most perfect co-operation is that enforced by law. The New Jersey Experiment Station has power to destroy crops infested with new or dangerous fungi and the state reimburses the owners.* California and Washington have appointed inspectors of fruit-pests with power to quarantine plants and fruit packages believed to contain disease germs liable to spread contagion.† Many other states have effective laws for the suppression of fungus diseases and are rigorously enforcing them.

NEED OF LEGISLATIVE ACTION.

Why can not Oregon follow their example? Our fruit is naturally better than theirs, † owing to advantages of soil and climate § and will if kept free from scab and blight continue to bring higher prices in the market. Why do we now see so many scabby apples, blighted pears, and rotting peaches? Simply because some fruit growers are as yet too ignorant or too slothful to keep their orchards free from these pests and thus furnish breeding grounds from which the germs of disease are scattered broadcast

§See list of awards at World's Fair in Chicago, 1893.
through the state while their more thrifty neighbors are struggling to overcome the results of this negligence. If they are too short-sighted to avail themselves of profitable means of prevention they should not be permitted to injure the enlightened husbandman who sprays his trees.

Here is a good field for legislative action. Our present laws being insufficient the State Board of Horticulture has drafted a new law and amended the former one. Let us have these stricter and more effective laws compelling the immediate destruction of all diseased plants and fruit so the careful cultivator will no longer have to labor alone but all will work for the common good of the state and its productions.
FIG. 16. Healthy peach shoot. Reduced to 1/5 natural size.
FIG. 17. Downy mildew of the grape. 1. A "sporangia" (conidium), 3, same showing contents divided into zoospores, which are escaping. 5, a highly magnified zoospore showing the cilia by which the "living spore" moves about. 8, The same, having lost its hairs, pushing out a germ tube. 10, A group of fruit bearing filaments (conidiophores), which have grown out of the leaf through one of the "breathing pores" (stomates). U.S. Dept. of Agr. Rep. 1886, p. 136.

Having studied general methods of treatment, we will now consider briefly the more important diseases which attack cultivated plants.

**FOOT-ROT OF CABBAGE.**

The club-foot of cabbage, turnips and other Cruciferous plants is caused by a slime mould (*Plasmodiophora brassicae*, Wor.) which commences its rapid growth early in the life of the seedling causing the rootlets to become

* Limited space prevents many special references. Free use has been made of Experiment Station bulletins and reports of the U. S. Dept. of Agriculture, to which those desiring more detail are referred.
covered with smooth, spindle-shaped swellings whose flowing outline distinguishes them from the abrupt excrescences caused by insects. The older portions soon decay and new roots sent out above also become knotty and decayed giving off a very offensive odor.

Burn all diseased plants. Do not throw them on the manure pile over winter to be carefully sown in the spring, or leave them rotting in the fields to infect the soil and roots of next year’s plants. Set healthy plants in a new field and keep the soil free from mustard-like weeds which frequently spread the contagion. An alternation of crops, raising other than Cruciferous plants, for two or three years will reduce the disease. Lime applied to the soil is often beneficial. The leaf-spot of Horse Radish may be prevented by spraying with Bordeaux mixture.

DISEASES OF THE GRAPE. *

Powdery mildew (*Uncinula Spiralis*, B&C) attacks the leaves, young stems and fruit. Spray with potassium sulphide soon after the leaves start in spring and again just before blooming. Downy mildew (*Peronospora viticola*, D. By.) seldom injures the fruit directly. Spray with ammonical copper carbonate as soon as the first leaves are fully formed and repeat every two or three weeks until the berries begin to color. It is often well to spray once or twice after the fruit is harvested to insure perfect ripening of the wood. Black rot (*Physalospora Bidwellii*, Sacc) appears as livid brown spots on the berries. The spots increase covering the entire grape which soon loses its fullness and becomes dry, hard and shriveled to one-half or one-fourth its original size. Collect and burn in autumn all fallen berries and trimmings from diseased vines. Spray vines before the buds begin to swell with a strong solution of green vitriol. Soon after the buds open spray with dilute Bordeaux mixture and again just before the flowers open. When the berries are the size of peas spray with ammoniacal copper carbonate and again two weeks before the grapes are ripe.

ANTHRACNOSE OF BEAN.

On the pods large brown spots (*Glacosporium Lindemuthianum* Sacc.) are produced in the center of which spores, easily blown about by the wind.

FIG. 10. Powdery mildew of the grape. 1. Mycelium from surface of leaf showing two haustoria and three upright fruit bearing filaments in different stages of growth. Above are two mature "summer spores" one of which is represented as just detached from its support. These propagate the fungus through the summer and autumn. 2, Shows one germinating. U. S. Dept. of Agr. Rep. 1886, p. 136.

are formed. These infect other pods. Soon after the pods set spray with sulphide of potassium and repeat the operation when they are half or two-thirds grown, and again ten days later. Thin the plants, drain the soil,
and select a dry and airy site for the bean plot. Carefully burn all diseased pods and vines.

**DISEASES OF CURRANTS.**

**Anthracnose (Gleosporium ribis, M. & D.)** appears on the leaves in June as small dark brown spots which increase rapidly. The leaves turn yellow, begin falling before the middle of July and early in August the bushes are bare, the fruit also shrivels and drops off. Spray in June with Bordeaux mixture.* Leaf-spot (*Septoria ribis Desm.*) Early in June spray with Bordeaux mixture. In bad cases four or five applications should be made.

**DISEASES OF GOOSEBERRIES.**

For leaf-spot and anthracnose treat as above. Mildew, (*Sphaerothea mors-uvae, B & C*) first appears like cobwebs on the young half-grown leaves but soon becomes white and powdery. Then thin patches appear on the berries, spread and become dark colored finally producing spores. Manuring, mulching the roots, high culture and pruning are preventives. Dust the bushes with flour of sulphur as soon as the first leaves are formed, and repeat the operation every ten days during the rapid growth of canes. Try spraying with sulphide of potassium. (See grape.)

**DISEASES OF THE APPLE.**†

Scab (*Fusiladium dendriticum, Fckl.*) causes great damage as its attacks are persistent and heroic treatment is required to free an infested orchard. The scab forms dark, livid, velvety patches upon the surface of the leaves and fruit checking their growth; causing the fruit to become distorted and knotty, cracking the surface and rendering it unfit for market. The foliage is seldom seriously injured. Infection takes place both from the fungus wintering upon the twigs and from spores remaining on old leaves and decaying fruit which should be carefully removed.

Bitter rot or birds-eye rot (*Gleosporium fructigenum, Berk.*) occurs only on the fruit appearing as small circular spots of pale brown slightly sunken tissue with a smooth surface. These increase in size and soon become softened as the decay extends deeper into the apple. The fungus reproduces rapidly by means of spores borne on the diseased area. Hogs should be put in the orchard to destroy all infected fruit as it falls.

Brown rot appears on the leaves as small circular spots with a straw-colored centre. These rapidly enlarge and coalesce making large areas of diseased tissue. The diseased leaves remaining on the ground over winter are the chief source of infection and should be carefully raked up and burned.

Rust occurs on the foliage in early summer and may be distinguished by the circular orange-colored spots which sometimes coalesce, covering

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the leaf surface and eventually destroying it. The under side of the spot shows at maturity small cup-shaped bodies which bear spores. This rust is the summer stage of the Cedar-apple which grows on the Juniper and Cedar and from which alone infection is to be feared as spores borne on apple leaves will not reinfect them. Where practicable the Cedars should be cut down or the galls removed before the spores mature.† For twig blight see pear.

TREATMENT.

In early spring before the buds open spray trees with lye which will destroy the many fungus spores lodging on the branches. Just after the bloom has fallen spray with weak Bordeaux mixture. About 20 days later

spray again to prevent the brown rot which makes three attacks in a summer. About the middle of July spray with copper carbonate to prevent the bitter rot.

**DISEASES OF THE PEAR.**

Fire blight of pears, apples and quinces is caused by a minute germ (*Micrococcus amylivorus*, Burrill) which multiplies rapidly in the tissues of the plant whenever its vitality is lowered. The first cause is probably disease seed, then perhaps the seedlings are budded or grafted from blighted trees, at all events the bacteria are in the plant awaiting an opportunity to develop. The attack usually comes on rapidly as a sudden withering of the wood and bark preceeded by a blackening of the leaves, and may confine itself to one limb or rapidly involve the whole tree. It is often brought on by overcrowding or starving the trees and may then be averted by thinning them. If the land is damp or wet it should be drained thus lessening the danger of blight. Never crop an orchard when affected with blight.†

When a tree blights remove, and burn at once outside the orchard, every trace of diseased wood. Saw off the smaller branches about a foot below the least sign of disease, and dig out the spots on the trunk and larger limbs cutting deep enough to remove all discoloration. The knife and saw used in pruning should always be disinfected with carbolic acid before leaving each tree to avoid infecting the freshly cut healthy wood of the next tree. The exposed surfaces should be at once painted to exclude germs that may be floating in the air.

Pear rust (*Roestelia pirata*, Thax.) When the fruit is very small fine fungus threads grow through it distorting the pear and replacing the green color by orange. In these red patches small pimples appear, enlarge and produce short tubes containing an immense number of bright orange spores which fall out and are carried away by the wind at maturity. Later the distorted fruit hardens and falls to the ground or remains hanging to spread the disease. The only remedies are the axe and pruning knife. Destroy at once all diseased fruit, also Cedar apples to prevent their spores reaching healthy trees.

Leaf blight (*Entomosporium maculatum*, Tul.) appears on the leaves in June and July as small brown spots which spread rapidly discoloring the leaves stopping their growth and causing them to fall. It also causes the fruit to crack, and destroys tender twigs. Great injury is done to the seedlings in the nursery, the standard being weakened so that grafting will not succeed.§ Get a vigorous growth of trees before midsummer and spray with Bordeaux mixture. The first application should be made when the leaves are half grown and repeated every 3 or 4 weeks during the season.

Prof. Chester recommends¶ this solution for spraying: mix 3 ounces of copper carbonate with one pound of pulverized carbonate of ammonia, dissolve in 2 quarts of water and dilute to 50 gallons.

† J. J. Black, Cultivation of the Peach and Pear 1886, pp. 272, 281-85.
DISEASES OF THE QUINCE.

Fruit spot, (Entomosporium maculatum, Lev.) When quinces or pears are nearly grown small brown spots appear, which enlarge run together and turn black. The decay is superficial and the fruit though stunted can be used. The leaves become spotted and soon fall leaving the branches bare. Spray with copper carbonate or eau celeste. For leaf blight see pear.

DISEASES OF THE PLUM.

The spores of Plum wart (Plowrightia morbosa, Sacc.) germinate on the bark of plum and cherry trees, penetrate it, and feed upon the soft tissues of the branches. The growth of the fungus and that of the tree in its effort to overcome the injury causes the enlargement known as the black knot. Cut off and burn diseased branches. Cut out the young knots. Wet them thoroughly with linseed oil, turpentine or kerosene, taking care not to injure the sound wood. Make three applications during the summer.

Fruit rot: Spray with Bordeaux mixture or copper carbonate. (See Peach). For leaf-spot and blight see cherry. For mildew see apple.

Plum pockets (Exoascus pruni, Fckl.) distort the fruit and cause the tips of branches to swell and die. Remove and burn immediately all fallen and diseased fruit. Spray with Bordeaux mixture to prevent germination of spores.

DISEASES OF THE CHERRY.

The Shot hole fungus (Cylindrosporium padi, K.) penetrates the entire leaf but congregates in spots to produce spores. Here the tissue dies, becomes brittle and soon breaks away riddling the leaves which turn yellow and fall prematurely. Spray with Bordeaux mixture or ammoniacal copper carbonate about June 1st and every three weeks thereafter if the disease is bad. For fruit rot see peach. For black knot see plum. For mildew see apple. For Leaf blight spray with ammoniacal copper carbonate. (See pear).

DISEASES OF THE PEACH.

Of the many diseases affecting the peach—curl, yellows, rot, blight, mildew, etc.—none attack the trees until they have in some way become weakened so the weakening causes should be sought out and removed as the remedy will then prove more effective. Peaches need a light soil and equable climate. They are apt to become blighted on wet heavy soil when overcrowded and without sufficient nourishment. In such situations the rot (Monilia fructigena, Pers.) frequently does much damage by causing the fruit to lose its color and flavor, turn leather colored, and finally rot; rapidly destroying from $\frac{1}{2}$ to $\frac{3}{4}$ of the crop. The earlier thin skinned varieties are said to suffer most. The decaying peaches should be removed and burned immediately and not be allowed to remain on the trees over winter as they bear the spores from which young peaches are infected in the spring.

When this appears in the twigs it is called BLIGHT and the direct injury usually occurs near the point of attachment of the peach where the tissues are browned and killed by the parasite. Sometimes this and the mildew (Erysiphe sp.), which consists in a thin whitish covering over the leaves causing their decay and death, may be found together. Cut off and burn the
diseased branches. Spray with sulphide of potassium, or dust with sulphur. Bordeaux mixture will check the mildew. Prevent the disease from spreading by carefully examining the trees and if any rotted fruit and blighted twigs are found remove and burn them immediately. For leaf spot see cherry.

PEACH YELLOWS.

The peaches on diseased limbs or trees ripen prematurely, the sound fruit being only half grown. The fruit is red or purple-spotted without and streaked within. Soon diseased dwarfed growths, bearing red, yellow or white diminutive leaves, appear on the branches. These shoots tend to branch repeatedly. The disease usually appears in one branch gradually spreading till in two or three years the entire tree is diseased and dies, or it may languish dying from the extremities downward.

The cause of yellows is unknown. It has been attributed to sudden changes of temperature, to excessive rainfall, to an impoverished soil, to the effects of parasites, and by some to a germ. No remedy is known. Promptly remove and completely burn all diseased trees on the first appearance of yellows. Procure trees from localities free from the disease. When replanting many prefer to set trees in a new place. The peach is very sensitive to frost, and chilling winds render it more susceptible to attacks of curl-leaf (Taphrina deformans, Tul.) for which no remedy is known. Keep the trees as vigorous as possible. Destroy infected trees or at least remove and burn diseased parts.

STRAWBERRY LEAF-BLIGHT.

Blight (Sphaerella fragariae, Tul.) usually causes its greatest injury by attacking the new growth which appears after the fruit is harvested. The old leaves then contain countless spores which will infect the young growing foliage. To prevent this mow the plants with a scythe, rake up all the leaves, allow them to dry and then burn carefully. Some recommend renewing the settings annually and planting in deep well drained soil. Spray with ammonical copper carbonate every fortnight beginning the latter part of April. Four applications should be sufficient.

DISEASES OF THE ROSE.

Mildew (Sphaerotheca pannosa, Wallr.) often develops suddenly giving the foliage a misshapen, powdery appearance. Spray with potassium sulphide. Evaporate sulphur with due caution.

Black-spot (Actinomena rosae, Fr.) produces characteristic black spots on the leaves which become pale and soon fall. Gather up and burn the fallen leaves. Spray with copper carbonate.

DISEASES OF CELERY.

Leaf-blight (Cercospora api, Fr.) causes a peculiar yellowish appearance of the foliage which is soon ruined. Shelter the plants from the sun by cloth or lath screens. Destroy the old leaves and stems on which the fungus lives over winter. Spray the young seedlings with ammonical copper carbonate twice a week till they are removed from the seed bed and later if necessary. Dirt falling into the heart of the plant produces rot. The rust and bacterial disease can probably be checked by spraying. *

Lettuce Mildew (*Peronospora gangliformis*, D. By.) Good drainage and abundant sunlight are preventives. Evaporated sulphur carefully used is an effective remedy.

**DISEASES OF THE POTATO.**

Potato rot (*Phytophthora infestans*, D. By.) passes the winter as spores on the old vines and as mycelia in the tubers. Carefully examine all seed potatoes and reject those that are diseased. Burn the vines as soon as the crop has been dug. Do not raise two successive crops of potatoes in the same field. Spray the vines with Bordeaux mixture when half-grown, again when they are in bloom and once or twice afterwards.

Scab (*Oospora scabius*) may be prevented by planting healthy tubers in soil where diseased beets and potatoes have not grown. Soak the tubers $\frac{1}{2}$ hours in corrosive sublimate before planting.

**DISEASES OF THE TOMATO.**

Anthracnose (*Colletotrichum lycopersici*, C.) attacks the ripening tomato at the point where it has begun to color and spreads rapidly, causing much loss before the fruit can be marketed. It appears as sunken discolored spots with a dark centre, these increase in size, run together, cover a large portion of the decaying fruit and are surrounded by wrinkled, discolored skin. Spray the vines and young fruit early in the season with potassium sulphide.

In southern or field blight the leaves become yellowish and curled, the ends shrivel and droop, finally becoming dry and black. Gather and burn all diseased vines and fruit in the fall. Change the tomato patch to another field for two or three years.

**THE DODDERS.**

The dodders are leafless annual herbs with thread-like yellow stems rising from the ground and becoming parasitic on the bark of herbs and shrubs on which they twine and to which they adhere by means of suckers through which they draw juices from the plant. * The lower part of the stem then dies, but the threads develop until a circular patch of flax or alfalfa is covered by the dodder and becomes so weakened that it turns brown and dies.

Plant only pure seed and never save an infested crop for seed. Dodder seeds are similar to those of clover but can be separated by careful screening. If the meadow is slightly infested, mow and destroy the affected patches as soon as seen and if no plants are allowed to seed the crop may be saved. If, however, the meadow is full of dodder, plow up the flax or alfalfa and plant other crops for a few years when all the dodder seeds will have germinated and died for want of a suitable host on which to feed.

**ONION MOULD.**

Mould (*Peronospora schleideniana*, D. By.) appears as a grey velvety outgrowth on the upper part of the leaves in June and July causing them to become pallid and shrivel. The plants die when the bulbs are from $\frac{1}{2}$ to 1 inch in diameter. Never set bulbs from a diseased crop. Try spraying with Bordeaux mixture.

* Gray’s *Man. of Botany, 6th Ed. 1892, p. 371.*
FIG. 22. Smut of Indian corn. Portion of smutty ear; at the base are some sound grains (g); above them, the female flowers remain sterile (s), and the bracts (c, c) are swollen and made numerous by the fungus developed there and in the abortive ovaries. U. S. Dept. of Agr. Rep. 1887 p. 396.

GRAIN SMUT.

The smuts (Ustilaginoidea) are internal parasites developing entirely within the tissues of their hosts. Grain smut [Ustilago segetum, Pers.] appears on the fruiting heads of cereals completely replacing the seed and when ripe presents a characteristic mass of black spores. The seed coats burst open and the spores are scattered in all directions by the wind, lodging on the surrounding plants and soil. Fortunately, these cannot infect healthy neighboring plants. It is useless to attempt to save a plant once attacked but prevention is both cheap and effective. First, kill the adhering spores by soaking the grain, for a short time, before sowing in a solution of copper sulphate using one pound to 25 gallons of water. It may then be spread out to dry or dusted with plaster. Second, lessen the liability to smut by having healthy plants. Sow good ripe seed at the proper time on well prepared and drained land. Avoid animal manures as they are liable to contain smut spores.

WHEAT RUST.

Wheat rust *Puccinia graminis*, Pers.] is a good example of the rust group *Uredineae,* because its life-history shows four well marked stages.

I. In the spring clusters of small, yellow cups break through the outer covering of barberry leaves. They are filled with rounded masses which drop out and are carried away by the wind. This is the first or “cluster-cup” stage.

II. When these spores fall upon a wheat leaf they germinate and their root-like threads penetrate its tissues abstracting nourishment from the plant. In a few days the parasite has become sufficiently mature to form
large red spores which appear as reddish lines or spots upon the leaves and stems. This is the second or “red rust” stage.

III. Later in the season the same fungus which produced the red rust spores give off the spores of a black rust called “resting spores” because the fungus lives over winter in this form. This is the third or “black-rust” stage.

IV. In the spring these germinate on decaying straw, producing minute spores which fall upon the barberry leaves, producing cluster-cups and thus completing the cycle of their existence. One of these stages is sometimes skipped where the barberry is absent.*

Destroy wild barberry bushes [Oregon grape] in the fence corners. Plant wheat early. Select varieties that have hard flinty straw. Fertilize fields with potash and phosphates which produce a hard straw.†

Such is an imperfect account of the more important plant diseases and the author hopes it will subserve the purpose for which it was prepared. The general methods of treatment given will apply to most cases of disease. For some diseases there is an effective and practicable remedy while for others none has as yet been discovered but the Experiment Stations are now investigating this subject and let us hope they will find a cure for all the diseases that now trouble our farms and orchards.

ACKNOWLEDGEMENTS.

We take this opportunity to thank those who have aided the Station by sending specimens of plants growing in their vicinity and answering questions regarding their flora. It is through such friendly co-operation in Station work that the best results can be accomplished, as it is impossible for the Botanist to individually visit all portions of the State and make a study of the noxious weeds, injurious fungi, etc., without neglecting his classes at the College.

I desire to express my obligations to the U. S. Department of Agriculture for the electro-types used in this bulletin.

HOW TO SEND PLANTS FOR IDENTIFICATION.

Remember that the Experiment Station was established for your benefit so if you desire information concerning plants growing on your farm or about any plant disease write to us and your questions will be answered as fully as possible. Questions about plants should be accompanied by specimens, so we may know just what one is meant. The fragmentary or imperfect specimens often sent to botanists for identification are so annoying that it is necessary to state what is needed to correctly determine a plant.

The specimens should be complete, that is, they should include the flowers, fruit, leaves and if herbaceous a portion of the root; often the lower or root leaves are different from the stem leaves, so both should be sent. Of woody plants a shoot six or eight inches long bearing leaves and flowers accompanied by the fruit, if possible, will be sufficient. All specimens

* C. E. Bessy, Advanced Botany, 7th Ed. 1892, p. 316. C. B. Plowright, British Uredinae and Ustilaginae, 1888, p. 34.
should represent the typical form except when the object is to show some abnormal growth. Send plenty of material.

Plants may be preserved by placing them under pressure between sheets of newspaper immediately after gathering, changing the driers every day for four or five days, after which the specimens will keep indefinitely. Number them wrapping each species separately in old newspapers, and send in an unsealed package with your name and address, preceded by the word from, plainly written on the outside. The postage is one cent an ounce which must be fully prepaid or the package will not be forwarded. In the accompanying letter state the date and place of collection and whether the plant is considered medicinal, poisonous or weedy, with any other information you consider of interest.

Address all communications regarding plants to

MOSES CRAIG,
Experiment Station,
Corvallis, Or.