OSSES TO WHEAT

What to Look For
and
Where to Find It

Being one of a series of articles in relation to crops, their common diseases, and insect pests to which they are subject

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WHEAT

This indispensable world-supporting cereal—its nature and special characteristics.

"Now a wise man is one who understands himself well enough to make due allowance for unseen moods and varieties, never concluding that a thing is thus, or thus, because just now it bears that look."

—*Bushnell.*

INTRODUCTORY

Wheat is one of the oldest food-producing crops with which we are familiar. For hundreds of years its culture and production have been known to and depended upon by mankind.

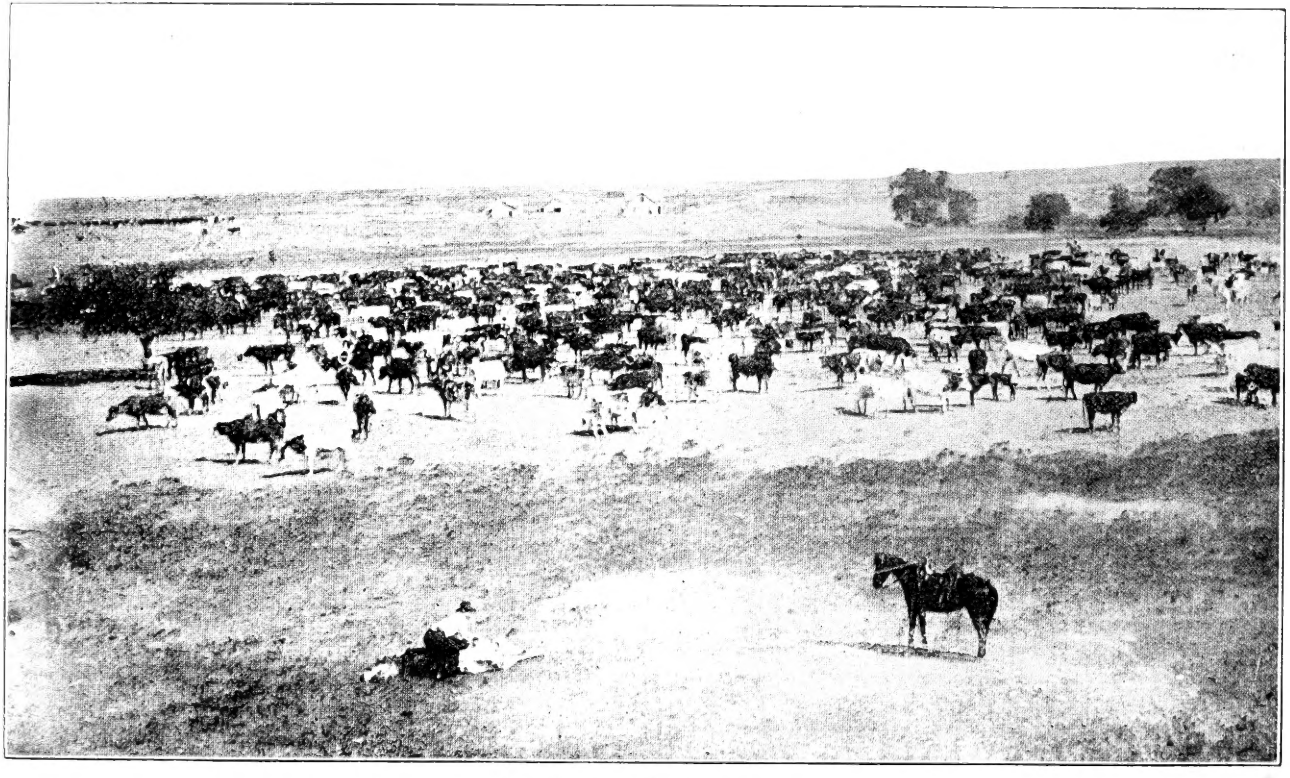
The nourishing food derived from this cereal is practically indispensable and has been the staff of life for generations. It tided the "cave-man" over when his trusty war club or his specially selected "rock missiles" failed to bring down a supply of meat and today it is still the most essential article of diet on the world's menu.

The origin of wheat is shrouded in the haze of antiquity, but most likely wheat is a development of certain wild grasses, the descendants of which are yet found in the old countries, for example, wild barley, wild emmer, and certain so-called wild wheats.

The earliest written documents refer to wheat, and many biblical references allude to yields of wheat beyond that hoped for by the average grower of today. In the time of Abraham and Isaac we find it recorded that Isaac sowed, and reaped an hundred fold, and, as it has been quite definitely established that the measure of grain sown then and that sown at the present time are identical, Isaac harvested the very satisfactory yield of 100 to 150 bushels per acre. The parable of the Sower refers to yields of thirty, sixty, and even an hundred fold, and Pliny and Varro refer to yields at Byzantium as one hundred and one hundred and fifty fold, or 150 to 200 bushels per acre. This almost incredible yield, nevertheless, is verified by various other testimonies.

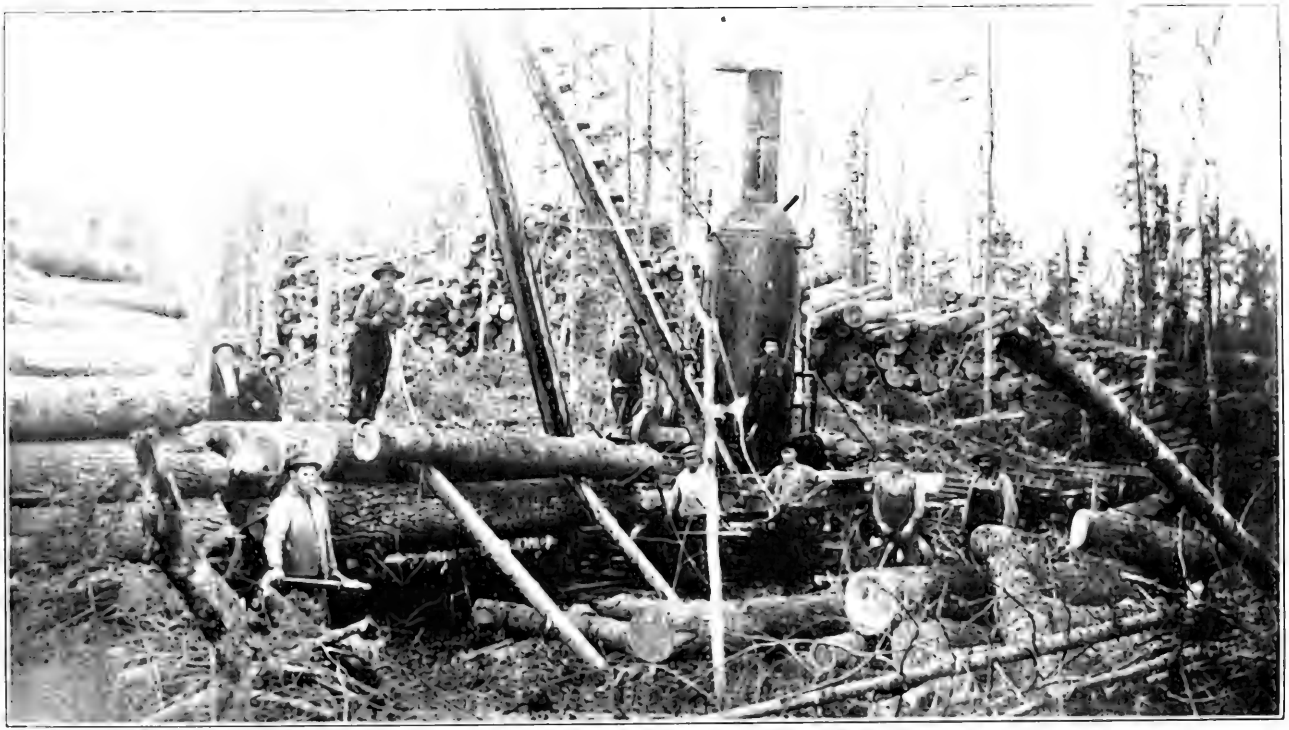
It would therefore seem that even with our knowledge of seed selection and soil bacteria and fungi, of which the ancients knew little, we are yet behind them in soil selection, testing and treating, crop rotation, seed-bed preparation, drainage, and general soil improvement.

Possibly this is because the American farmer, having been compelled to put forth so much effort in a fight against harmful insects and parasitic fungi, has not found time for the careful study given these topics by the ancients.



THE WEST OF YESTERDAY

THE WEST OF TODAY



FORMER BREEDING PLACES OF INSECTS

The forests with their dense foliage and extensive areas of underbrush were formerly the feeding-grounds and breeding-places of most of the noxious insects that now prey upon the grain crops. As the forests have been cleared and outfits such as this replaced with the plow and binder the insects have been forced to move on to the prairies and have often migrated far in their search for new foods.

None of the changes modern civilization has wrought upon the earth is more evident than the increased difficulty of saving crops from the ravages of noxious insects and parasitic fungi. Every crop has foes that often gather the greater portion of the harvest. "These enemies have come from the north and from the south, from the east and from the west, from Europe even and the islands of the sea, and in our own midst they have flocked from the forest to the field, deserting a wild plant for its cultivated congener or changing their habits to conform to a new environment."

The increase of pests is, in reality, but the natural result of changed conditions. Among the principal factors in support of such an assertion may be mentioned (1) the massing of crops in limited areas; (2) the facilities for transporting insects long distances by vessels and railways carrying agricultural crops; (3) the uncut weeds and grasses adjacent to crop fields, that serve as breeding-grounds, (4) the destruction of forests and the cultivation of prairies.

Authorities best able to judge estimate the annual loss in the United States due to these little pests at over half a billion dollars. In single states the damage is often frightful in extent.

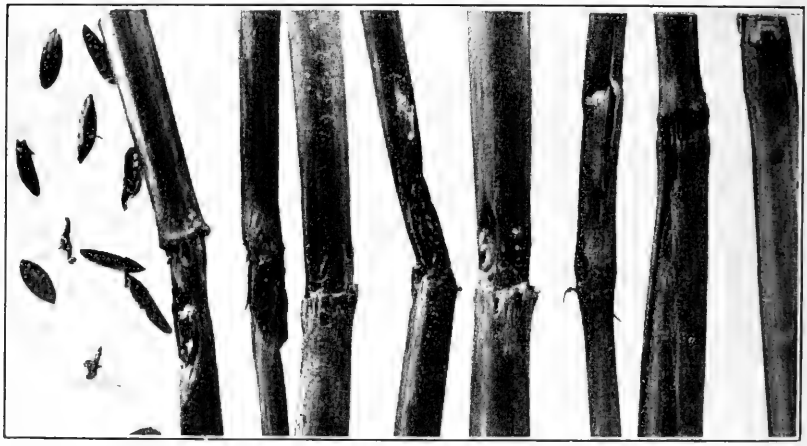
Fortunately, however, there is a silver lining to this dark cloud of insect injury. If these creatures have increased on every hand, knowledge of methods of controlling them has also increased with passing years.

PART ONE—ENEMY INSECTS

The Hessian Fly

This is one of the oldest and best-known insect pests of American agriculture. It has ranked as a destructive species for more than a century and has been identified everywhere that wheat is grown.

The adult is a small, two-winged, mosquito-like fly. The

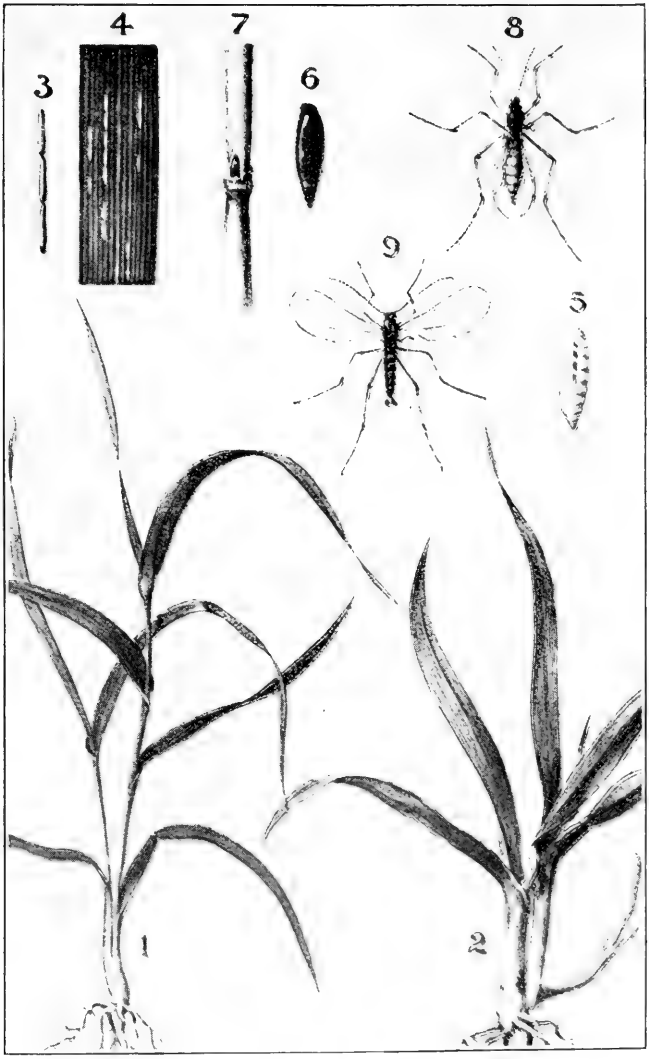


DAMAGE BY THE HESSIAN FLY

Straws in this condition do not require a hailstorm to break them down; a light wind is all that is necessary.

females of the species deposit their eggs on the upper surfaces of the wheat blades early in autumn. In a few days the larva hatches and descends the leaf to the base of the sheath, where it attaches itself, head downward, to the stalk, and proceeds to absorb the life sap of the plants. As the plant grows the larva becomes imbedded in the stalk, where it remains stationary. When full-grown (which occurs in three or four weeks from the time of hatching) the larva is a soft, white, footless maggot.

Its outer skin then becomes hard and brown, and separates from the rest of the body, although it still surrounds the latter, forming a sort of cocoon, or, as it is more correctly called, puparium, within which the insect

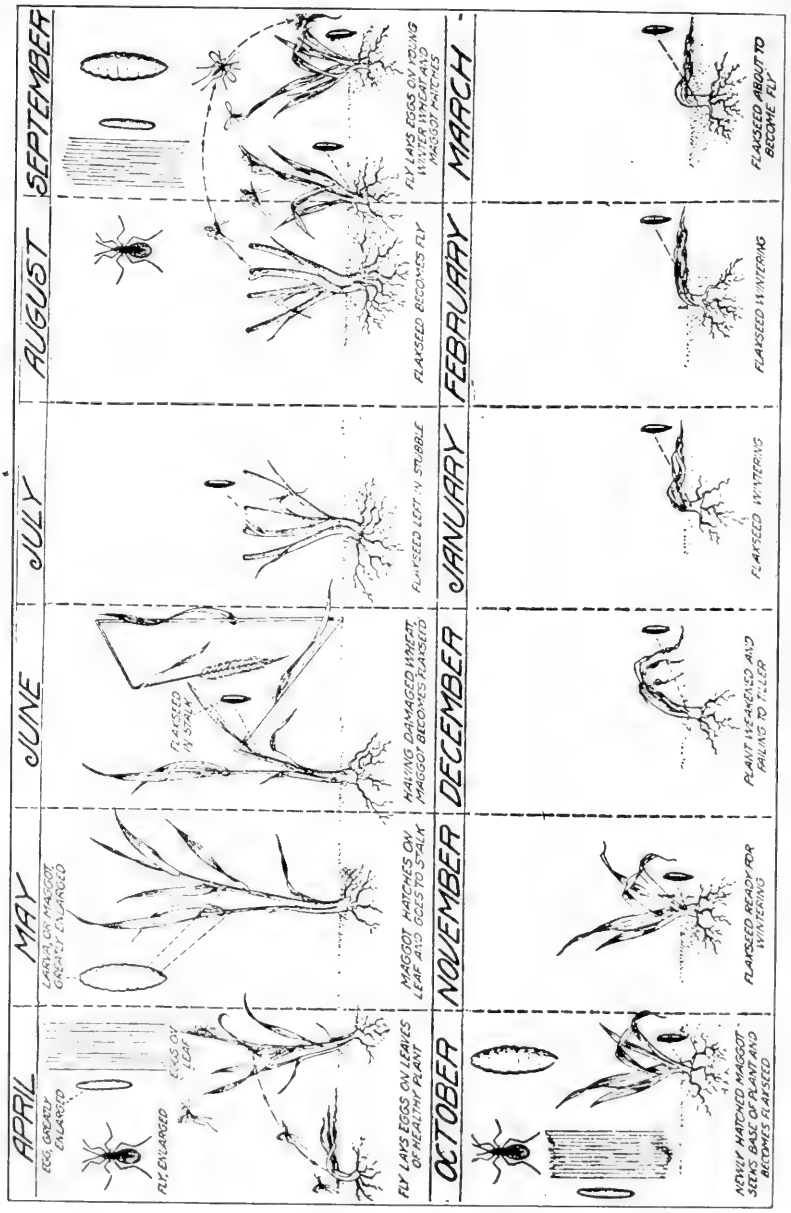


WHEAT AND THE HESSIAN FLY

Explanation of plate.

1. Healthy wheat plant. 2. Plant infested with larvae of Hessian fly. 3. Eggs of fly, greatly enlarged. 4. Eggs of fly on section of wheat blade. 5. Larvae of Hessian fly, enlarged. 6. Puparium or "flaxseed" of Hessian fly, enlarged. 7. Culm of straw removed to show "flaxseed" at the joint, about natural size. 8. Female Hessian fly, enlarged. 9. Male Hessian fly, enlarged.

changes to a pupa. This is the flaxseed stage. The winter is usually passed in this condition, and in spring the flies emerge from the flaxseeds to lay eggs for another brood.



THE LIFE OF THE HESSIAN FLY

The larvae of the young brood attack the young wheat plants just above the roots, between the stalk and sheathing base of the leaf. The spring generation, however, is formed a little higher up, and is usually found near the lowest point of the wheat, but may be variously located from below the ground line up to the third joint. The second generation completes its transformations before harvest, and there is often, at least as far north as latitude 40°, a third brood, which develops during summer in volunteer wheat. The chief damage, however, is done by the fall and spring broods.

Chinch Bug

There are two principal species of chinch bugs, one which breeds chiefly in wheat, and the other almost wholly in corn.

Passing the winter usually in clumps of bunch grass and similar clump-forming grasses, the chinch bugs begin to appear with the coming of warm weather, and continue to come out with uncertain rapidity, depending upon the weather, until all are in action. Cold days put a temporary halt to this migration, but it is resumed as soon as the temperature moderates. During the period of spring migration the bugs may travel considerable distances—just how far there are no conclusive data to show. Observation indicates that they make their way to the nearest wheat or barley field and that they do not travel farther than is necessary to secure a sufficient supply of food. Here, thrusting their beaks into the tissues of tender plants, they break their long winter fast.

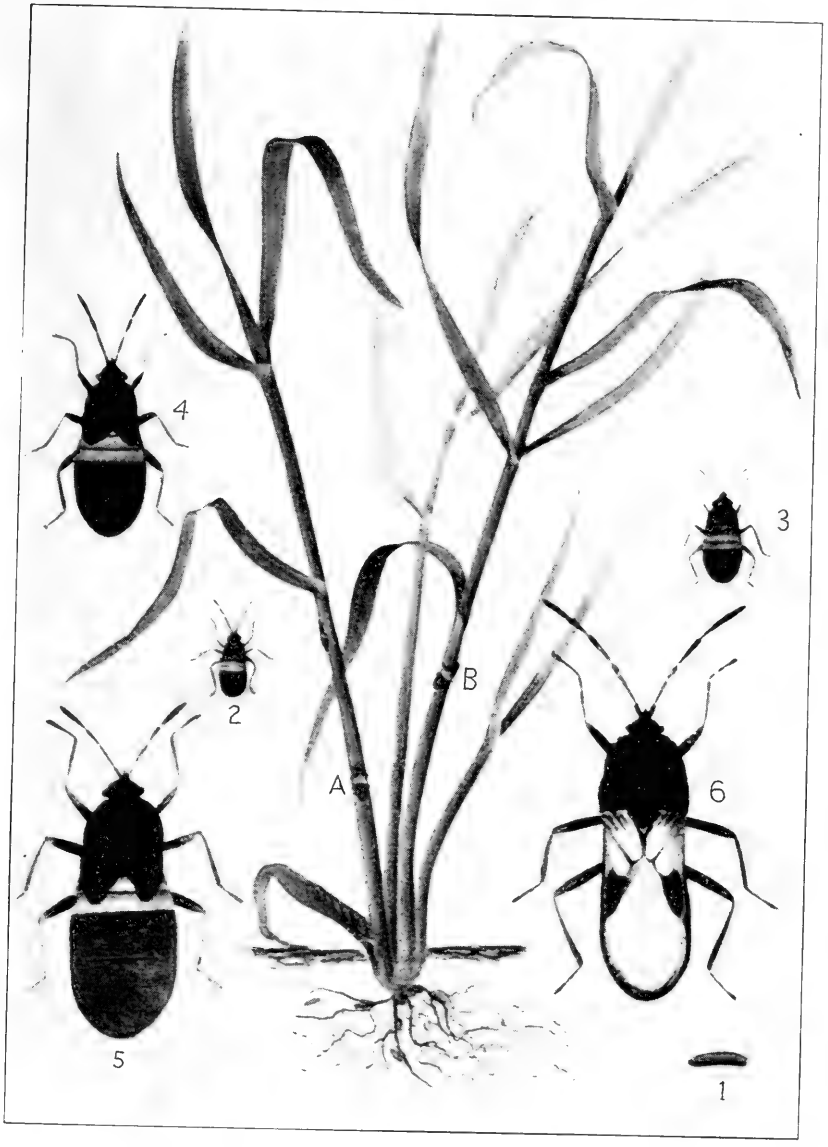
About three weeks after the first spring migration is noticed the eggs begin to appear. They are deposited in cracks and crevices of the ground, mainly on or near the stems and roots of the plants, but sometimes widely removed from all plants. They are also often thrust in directly between the leaf sheaths and stems of the plants. In fact, the location of the eggs appears to vary with any factor that affects the distribution of the bugs. Where the bugs find food plentiful and conditions to their liking, they congregate, and there the eggs are laid. The egg is a tiny, oval, reddish object about .03 inch long and one-fifth as wide.

WINTER QUARTERS OF THE CHINCH BUG

Clumps of red sedge grass in which over 6,000 chinch bugs were found hibernating during the winter.

One end is blunt and bears four small, rounded lumps near the center.

The dingy or grayish-black chinch bug is easily recognized by the fact that the white parts of its wings are so



THE CHINCH BUG.

1, Larva; 2, 3, 4, 5, and 6, various sizes, enlarged.
A and B. Showing bugs on stalks.

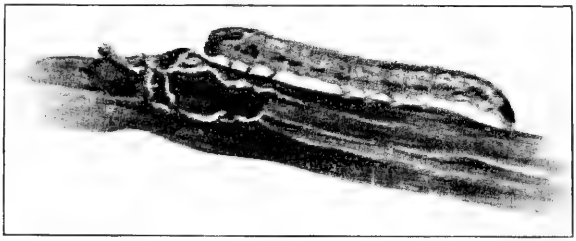
arranged that when the wings are folded it appears to be branded with a white **X**-shaped mark.

With the ripening of wheat, the chinch bugs, only a few of which have reached the adult stage, must seek food elsewhere or starve. If the grain fields are weedy and grassy, they obtain food from the grasses, but when compelled by hunger to leave, they transfer their activities to the nearest corn, cane, or millet field. The time of migration generally depends on the food supply, but begins when the wheat ripens or is cut. The bugs avoid traveling during the heat of the day, confining their movements to a few hours during the evening.

Where spring and winter wheat are grown in the same region, these bugs will more often destroy the former, probably because spring-grown grain is exposed for a longer time to pest attack before it is harvested.

The Small Stalk Borer

This well-known caterpillar, often called the heart-worm because of the character of the injury it does, may be at once identified by the peculiar break in the striping of the body at the middle. The caterpillar is about an inch long



THE SMALL STALK BORER.

when full grown. Its general color varies from purplish to whitish brown, according to age, and it is marked with five white stripes, one running down the middle of the back and two on each side. These side stripes are interrupted, being absent on the first segments of the abdomen, giving the larva the appearance of having been pinched or injured there. The stripes nearly vanish as the larva matures. The head and top of the neck and the leathery anal shield at the opposite end of the body are light reddish yellow with a black stripe on each side.

The presence of the stalk borer in a young stalk of grain is very clearly indicated by the wilting, breaking down, and death of the top and by the presence of a round hole in the side of the stalk. It infests a great variety of plants. The damage it does is most noticeable in early spring in blue grass by roadsides or around the borders of a field, its presence being indicated by the whitening of single heads of the grass while all the rest of the plant is green. At this time it is of small size and finds sufficient food within the grass stem. The furrow which it makes within the stem runs upward from the entrance opening and of course varies in size with the growth of the larva. Sometimes in leaving a stalk, the larva makes a new hole above that by which it entered, and in this way may injure in succession several different stalks and various kinds of plants. It is practically indifferent as to the kind of plants it feeds upon, the only necessary condition being a relatively thick stem, soft enough to allow it to enter and feed freely within. In the small grains and larger grasses, like oats, barley, and rye, it makes its presence manifest by killing or even cutting off the stem within, thus causing the head and the whole plant above the injury to turn white and eventually to dry up. The stalk borer is only one of several insects which produce this general effect, but the injury it does may be at once distinguished by the round hole which it leaves in the stem of the infested plant.

The stalk borer is found throughout the United States and Canada, east of the Rocky Mountains.

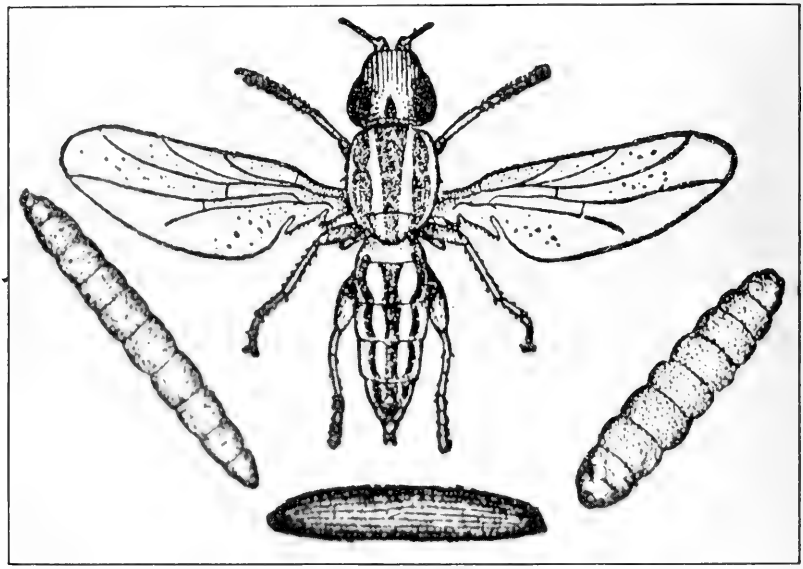
The caterpillar when full grown pupates, as a rule, within its last furrow, commonly below the opening at which it entered, seemingly as a precaution against destruction by the withering and breaking away of the upper part of the injured plant. The pupa is light mahogany brown and about three-fourths of an inch in length. From the pupa emerges the fawn-gray or mouse-colored moth.

There is but one brood a year, and by the end of June the caterpillars are over half grown. They have then nearly all left the grasses in which they made their start and entered the thicker-stemmed plants. They live in this stage until late in July, when reproduction begins.

The Wheat-Bulb Worm or Wheat-Stem Maggot

This insect has attracted attention only during comparatively recent years. Most wheat growers have never heard of it, and are therefore inclined to place the blame for its depredations on some other insect, or to assert that the damage sustained was caused by hail.

The adult is a handsome two-winged fly having two longitudinal yellowish stripes along its back. The females deposit eggs in the fall on the young wheat plants, usually



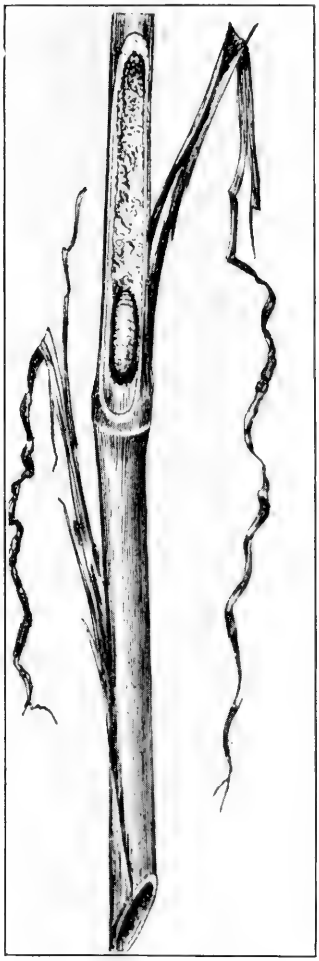
THE WHEAT BULB WORM GREATLY ENLARGED

one on a plant, and the eggs remain there through the winter, the young appearing in spring. They are then footless larvae, or worms which a fortnight later emerge as flies. After mating, the female flies of this second brood deposit eggs for larvae, which work into the straw just above the top joint, thus cutting off the sap supply from the heads, causing white heads or bald heads.

These heads often break over above the bulb exactly as if struck by a hailstone.

If the insects have left the plant and the grower still believes the damage is that caused by hail, the mass of finely chewed pulp left behind in the straw by the pests should be sufficiently convincing evidence to the contrary.

The work of these insects is somewhat different from that of the Hessian fly and the straw worm. In the case of the Hessian fly, the maggot is usually found between the third joint and the ground line, while the straw worm is



WHEAT-BULB WORM

Wheat straw showing the bulb worm.

found in the pithy tissues within the stem, and below the top joint. The wheat-stem maggot is always found just above the head joint on or in the stem.

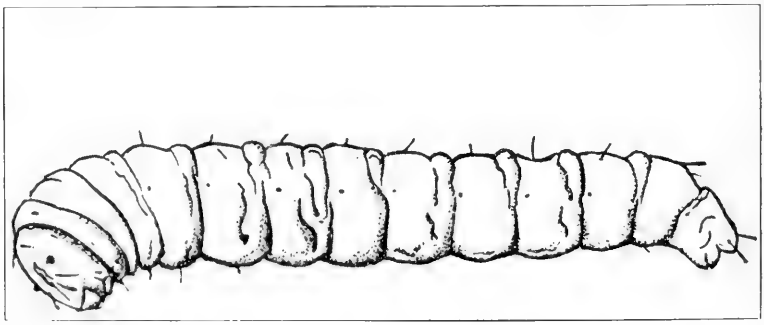
The larvae complete their metamorphosis during July, when they are on the wing as flies. Early in July eggs are

deposited by this third brood of flies on volunteer wheat, and the transformation of these is completed in time for the adults to lay their eggs in fall wheat. There are therefore three broods each season. This insect breeds in oats and various grasses as well as in wheat.

The Wheat-Straw Worm or Joint Worm

There are two generations of this insect annually, both of which are destructive. To the observer the adults look like shining black ants, some with, others without, wings; their legs are banded with yellow and they have red eyes. They are about ⅛ of an inch long, most of them being females and wingless. These females of the first generation deposit their eggs in young wheat plants when the stems of the plants extend but little above the surface of the ground.

The egg is placed in or just below the wheat head, and the larva, or worm, works within the stem, usually causing a slight enlargement. When the worm is fully grown it will be found in the crown of the plant, having eaten out and totally destroyed the embryonic head, its body occupying the cavity thus formed. The larva, or worm, is of a very light straw color, almost white, with brown jaws. In May, June, or July (depending on location) the larvae



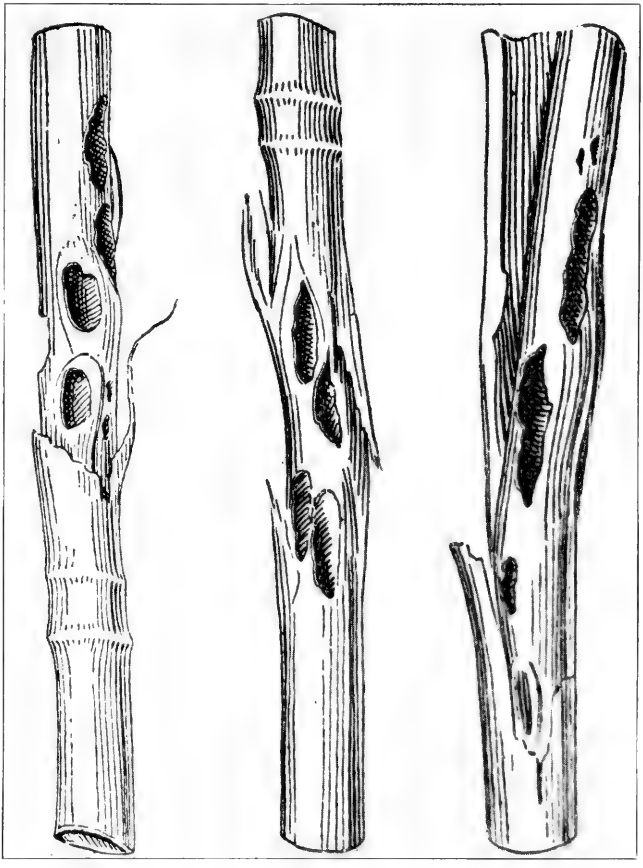
LARVA OF WHEAT-STRAW WORM, GREATLEY ENLARGED

become full grown and pass at once through a short pupal stage. The pupae are at first the same color as the larvae, later changing to a jet black.

In a few days the fully developed insect gnaws a circular hole through the stems and makes its way out, and this second adult deposits its eggs, usually in the second

joint below the head. The larvae from these eggs are the ones found in the plant and can be located in the straw always below the upper joint, generally above or below the second joint.

Both the work of the spring brood in fall wheat and that of the summer brood in spring and winter wheats are



WHEAT STRAWS INJURED BY STRAW WORM

so carried on that the planter does not know of his loss unless it amounts to a very large percentage of the crop, and then he may attribute it to some other cause.

The wheat-straw worm is capable of doing great injury to wheat crops in the West and Northwest. Its work is of such a nature that it passes unobserved unless an attack of unusual severity causes the farmer to scrutinize his fields

more closely than usual. Generally the injury is not noticed until about harvest time, when the stalks often begin to break over and many white heads appear in the field. This condition very closely resembles that of Hessian fly loss and is often confused therewith.

The wheat-straw worm is closely related to the wheat joint worm, and as their appearance, history, and life cycle and depredations are so nearly identical, they are usually considered as synonymous.

The Wheat Midge

This insect is often confused with the Hessian fly, to which it is closely related, but its operations are confined entirely to the wheat heads.

The adult is a yellow or orange-colored fly and lays its eggs in the wheat heads almost as soon as their protecting sheath unfolds. These eggs quickly hatch into footless maggots, which destroy the kernels as they are filling.

Becoming full grown within three weeks, they leave the wheat heads, entering the ground, where they pupate. Late-ripening wheats are most susceptible to injury from this source.

The wheat midge also breeds in barley, oats, and rye, but there is but one brood a year.

The Army Worm and Wheat-Head Army Worm

The army worm is hatched from eggs laid by a handsome brown moth which is about 1½ inches across the outstretched wings, and, when full grown, is a smooth, greenish or brownish striped caterpillar, something over an inch long. In this form it feeds on small grains and even grasses.

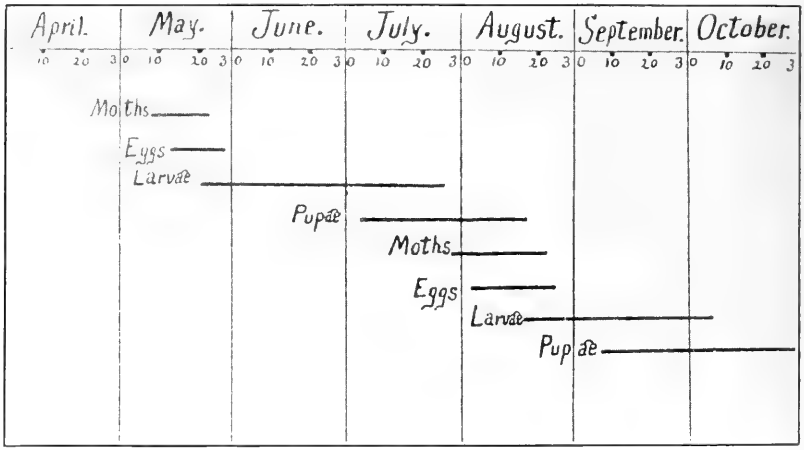
Ordinarily the army worms are unnoticed, as they remain concealed about the base of grain, where they feed undisturbed. They have many enemies with which to contend; otherwise they would, doubtless, be more destructive than at present. They are the prey of birds and parasites and are frequently the victims of a bacterial disease which sometimes almost sweeps them out of existence. In a season, however, when their natural enemies do not seriously attack them, they appear in countless armies, and the

THE ARMY WORM, WITH PUPAE, MOTH, AND EGG

destruction begins, all grains and grasses in their path being wholly devoured by them.

The name is derived from the caterpillars' habit of traveling in countless numbers, like an army on the march. They seldom go around an object, but crawl straight over, climbing houses, farm implements, standing automobiles, or any other obstruction. They were very numerous in western Kansas and Nebraska in 1918.

The wheat-head army worm is of the same general appearance as the well-known army worm, but the injury



LIFE CYCLE OF WHEAT-HEAD ARMY WORM

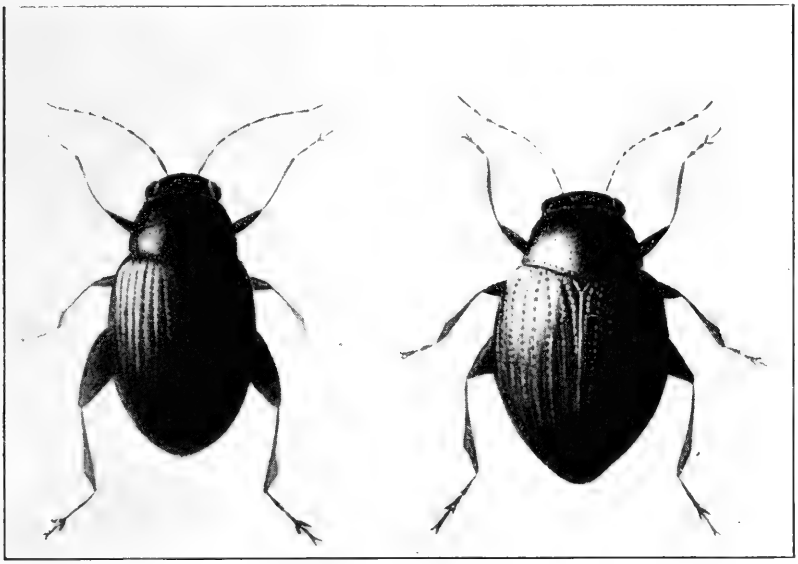
caused is different. The larvae gnaw into the heads of wheat, rye, and other small grains, timothy, and even some of the wild grasses, and are frequently found working in the head or resting on the stem just below it. They begin to feed at the bottom of the head and work upward, sometimes eating only one side, or even less than that, sometimes taking all but the stem. Badly injured fields appear dry and brown, and the denuded wheat heads are conspicuous, even at some little distance.

Flea Beetles

Of the several species of the beetle family, but one has been found that seriously injures small grain. This is

known as the flea beetle. It is about one-tenth of an inch long, oval, and plain brown. It feeds principally on grass and grain, but has done some serious injury to corn and has also damaged sugar-beets. Wheat and oats are its principal foods.

The species is generally distributed over the United States east of the Rocky Mountains, and is also reported from Montana, Utah, and California. The beetles do not eat holes in the leaves of the grain; they simply gnaw out the tissues from beneath, leaving the veins and upper sur-



THE FLEA BEETLE.
(Greatly enlarged)
Sometimes called the corn flea beetle. The injury it does in the Middle West is confined largely to the small grains, although it often bears the name of "corn flea beetle."

face untouched. The greatest damage they do is the severe injury to barley, the leaves of which they eat out in narrow channels. The larva breeds upon the roots of the plant. The worst injuries are done on low lands and near the winter shelters of the beetles. The beetles winter over and are abundant in May, when they pair. They generally lay their eggs by the first of July, but a new brood comes out in the latter part of the month, becoming abundant in August and continuing until the close of the season. The injury done to

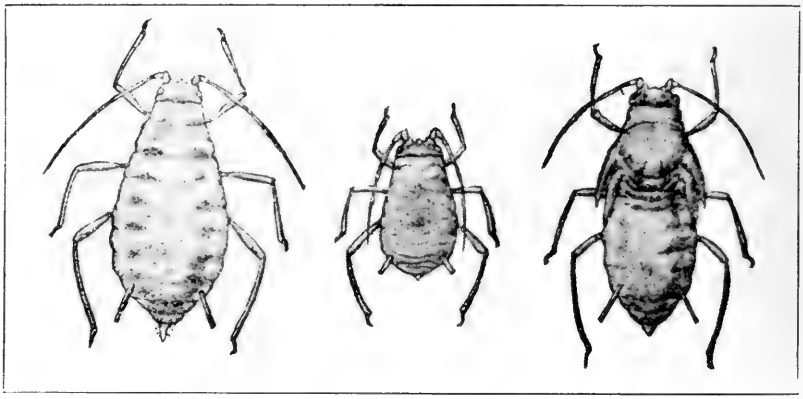
small grain is principally in early summer, shortly after the beetles come out of their winter quarters.

The Grain Aphis or Louse

There are two kinds of lice which occasionally cause considerable loss to grain, but their attacks have fortunately been infrequent. The names most commonly applied are "wheat louse," given to a brownish aphis, and "green bug," name being derived from the color.

The Wheat Louse

This is a small brownish insect, with or without wings, which, when present, can be found in countless numbers on



THE WHEAT LOUSE
(Greatly enlarged)
These are either brown or green

wheat, oats, and other plants. It is a sucking insect, having a pointed beak which is inserted into the plant, and it lives upon the sap of the stalk, leaves, or embryonic head. As the grain ripens, the louse deserts it for greener, more succulent vegetation.

It brings forth living young and is most prolific. It is estimated that one louse may become the progenitor of millions between spring and autumn. Were it not for the countless natural enemies that devour them, they would constitute a most alarming menace. No other means of preventing them from overrunning the fields every year has been discovered.

The Green Bug

In some localities wheat has frequently been damaged to such an extent as to make growing it unprofitable.

When wheat is green and beginning to cover the ground, the infestation by green bugs generally becomes conspicuous in "spots," i. e., small areas from 2 or 3 feet to 50 or 100 feet in diameter where the plants will begin to turn yellow. Death of the plants generally begins at the center of these circles and extends outward. Sometimes the "spots" become confluent, and meet each other. Such conditions as the coming together of these spots indicate that the planted crop will not be successful, and some other planting should be substituted. After the seed bed is prepared, any other crop except barley, rye, or oats may be safe.

The green bugs in an infested field are most numerous around the border of the "spots." They leave the dying plants and move out to the edge of the green wheat.

One week is the average time required for the green bug to become full grown. At this age it begins to bring forth its young alive. The average tenure of life, in summer, is thirty-six days.

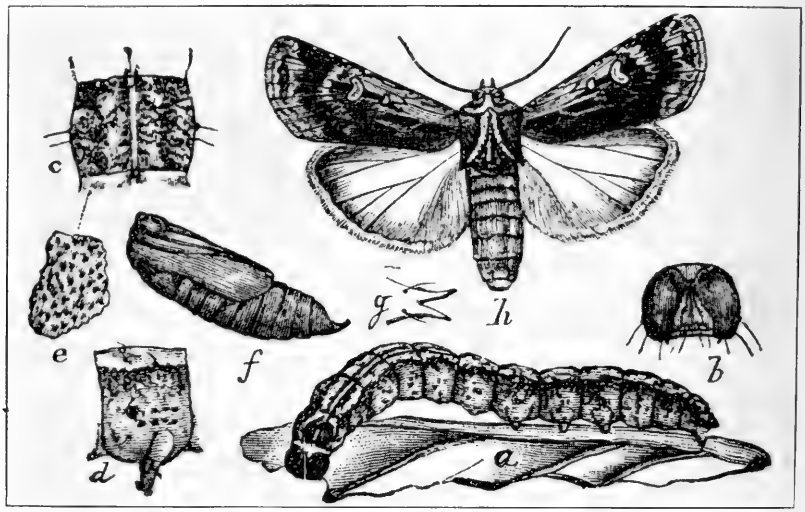
Some Ways of Identifying the Green Bug

Examine wheat for small green lice. If they are found congregated in large numbers, ten to fifteen on a single leaf of wheat, it is almost safe to conclude that the depredator is the green bug.

Look for the winged forms of the lice. Four wings will be present, and when not in action will have the upper edges together, while the lower edges will be each side of the body in the shape of an ordinary gable roof. Remove and examine one of the front wings closely. Observe a large vein extending from the base of the wing to near the tip end. From this vein four narrow veins arise. One of them is definitely **Y**-shaped in the green bug. The two branches of the "**Y**" extend to the outer margin of the wing. With nearly all other plant lice found on small grains, there are three branches to the "**Y**" instead of two.

Cut-Worms

Cut-worms attack wheat, oats, barley, and rye, as well as corn, and the appearance of injury is much the same in all these grains. Stalks sometimes are eaten only so far through that they do not fall, but only lean over. The heads



GRANULATED CUTWORM

Showing: a, larva; f, pupa; h, adult moth; and b, c, d, e, g, details of structure.

on these stalks do not fill, and the stalk comes loose at the ground line when it is touched.

Full-grown cut-worms are about $1\frac{1}{2}$ inches long and dull in color. They do their work at night. If the injury done by them is recent, they may be found near the roots of the plant, asleep; otherwise they have moved on to other fields.

PART TWO—DISEASES

Disease Enemies

In addition to the more commonly known disease enemies of wheat, such as rusts, smuts, blights, etc., there have been discovered in the soil various fungi which attack wheat and cause a serious loss. As these discoveries have been more recent, they are likely to be less well known, and considerable space (proportionately) is therefore given to, and a careful study is respectfully directed to "wheat sickness" and its various subdivisions.

Wheat Sickness

Constant culture of wheat on the same lands brings about wheat sickness—wheat-sick soil. This condition, with wheat-sick seed, is a principal cause of deterioration in grain.

The fungi attack the roots of the wheat, leaves, stems, and young developing grain, producing many visible evidences of a crop damage. These parasites are carried in various ways from fields afar, and frequently are transmitted from crop to crop by means of the seed, crop rubbish, etc. They may attack a crop directly by way of the soil, or through wind-blown or water-carried spores. They are believed to be the chief cause of failure of wheat to stool properly, causing the plants to live almost wholly upon the surface of the soil, even though the land is deeply and well worked. The following features are directly noticeable: wilting and blighting of embryos and plantlets in the first leaf; tip-burn and sun-scald of young plants at stooling time; blighting of side-stool at shot-leaf period; blackfoot or creosote-colored stems below ground line; incomplete filling of upper head parts; shriveled grains; black-pointed grains; purplish or pink grains; white-bellied grains; piebald grains; bleached and blistered grains.

Lack of filling is due not to bad climatic conditions or lack of fertility in the soil, but to fungi which blight the roots and prevent seeds from being properly filled at head-

WHEAT-SICK SOIL

This field has been sown to wheat eight years in succession. This is about the finish. Crop rotation would have told a different story.

ing time. The parasites penetrate into all parts of the straw and into seeds of such heads before the seeds are matured.

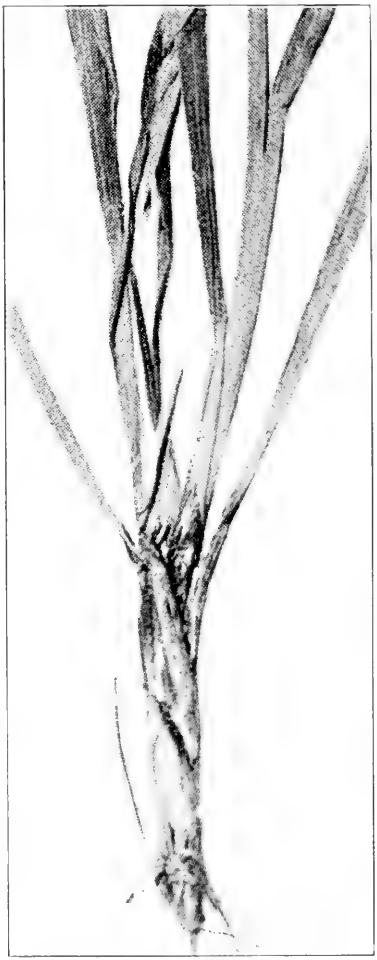
Even virgin or new lands remaining in the wheat belt unplowed, though they represent select areas when plowed and sowed to wheat, cannot now, as in the earlier days, be

CONTRASTS

Three blighted and three properly filled heads of fife wheat. Many such typically blighted heads are found on wheat-sick soils regardless of tillage or soil fertility.

relied upon to produce the quality of wheat formerly produced on immediately adjacent lands. Those lands are certainly as fertile as the adjacent areas broken in the early days of wheat culture, hence there is but one reason for the decreased productiveness. The present new lands are subject to wheat diseases caused by fungi which are carried in poor seed, dust, and dirt from old fields adjacent, by soil washed from higher land to the lower, by the hoofs of animals, and by various farm implements to which they have adhered.

On areas where wheat has been grown continuously there is a tendency for the crop at first to produce a heavy outburst of foliage and to show great unevenness of growth throughout the field, even though no unevenness of ground or peculiarities of chemical constituents, of drain-



INFECTED WHEAT STALK

Typical wheat stalk showing wheat-sick infection.

age, or of methods of culture may be observed. Some sections may yield fifteen to twenty-five bushels per acre, while fields immediately adjoining, of the same day's seeding, may scarcely be fit to harvest. Straw often varies in height on

such areas from a few inches to a foot or more, and shows great variation in color and texture throughout the season.

The stems apparently have no life and often crumple up in patches, sometimes several acres in extent, with apparently hardy grain growing immediately adjacent. Farmers sometimes attribute this to hail damage, but are not able to explain why their loss is so "spotted." Where the trouble extends to the entire field an expert's task is more difficult, but wheat-sick grain falls in all directions, and often breaks down into the roots, while hailed grain is uniformly broken over in one direction. The ashy color of the straw, the tendency to root above the ground, the lack of stooling, and the fungus-infected root system prove the true cause of the damage.

Where the grain does not actually break over in such fields it is generally uneven as to grade and likely to be shrivelled and of light weight and off in color, even though the greatest care is taken in harvesting.

Experiments and observations have demonstrated that old soils are either affected in large spots or are wheat-sick over entire fields.

Formerly considered merely as molds or simple decay forms, the fungi—which infest the land to such an extent as to make profitable wheat farming under present conditions in many cases impossible—have finally been identified as the cause of wheat sickness, wheat-sick soil, crinkle-joint, and other injuries of like nature.

The extent of the damage caused by them is governed mainly by the different soils and by climatic and cropping conditions, but they persist in their destruction in any soil adapted to wheat.

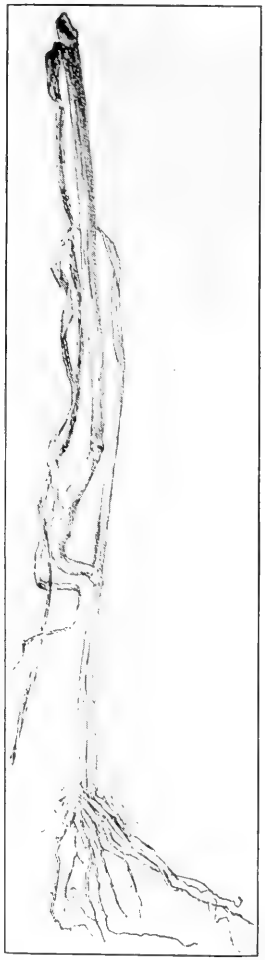
They exist in decay forms on roots, stubble, straw, and in manures, and even penetrate the berry itself. They have therefore become world-wide in distribution.

Owing to the varied forms in which these fungi appear and because of their insidious attacks on all parts of the wheat plant—from the root system to the ripened berry—numerous local names have been incorrectly applied by growers, and even by various authorities, to disease conditions which it is now definitely known are due to fungus attack. A number of these misused terms may still be en-

countered, such as root-rot, head-scald, stem-blight, and others, all of which, on final analysis, will be found to refer to what may be generally termed "wheat sickness."

Crinkle Joint, or Break-Over Disease

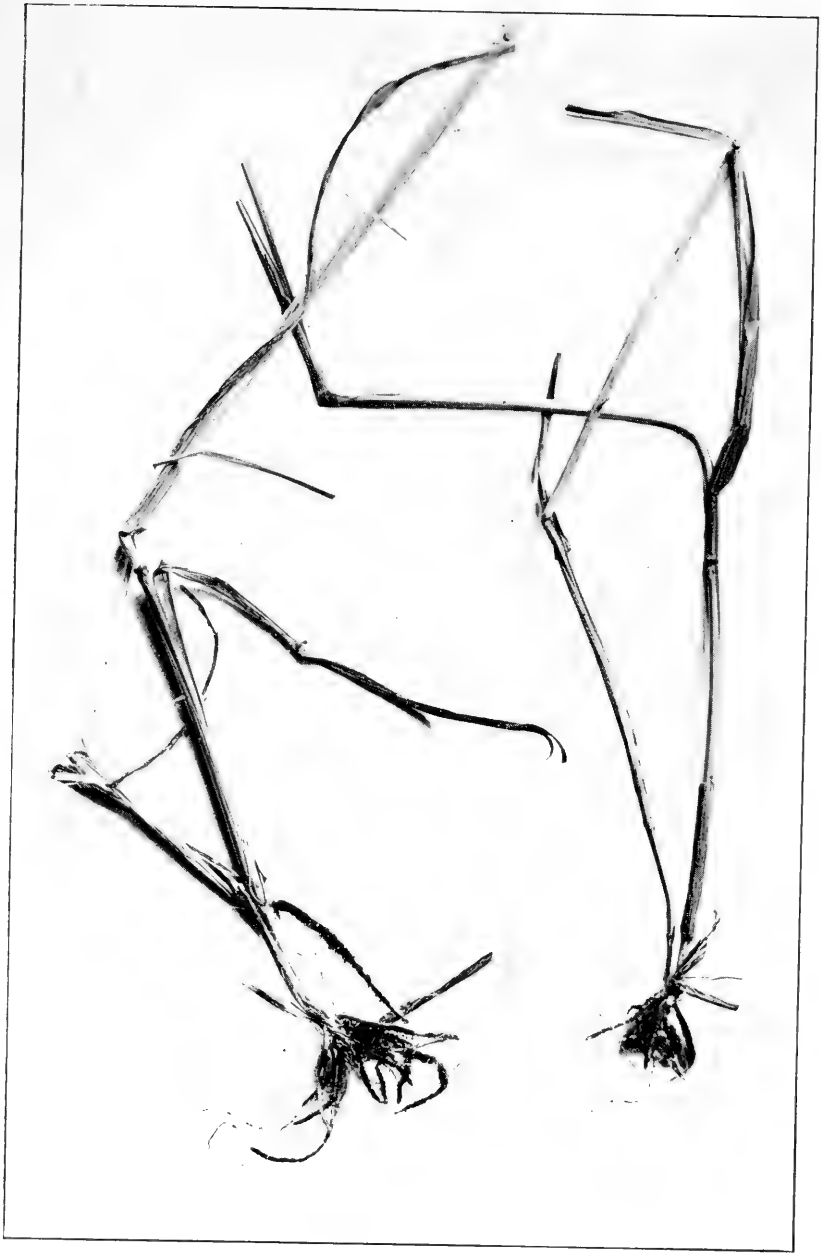
This is not an insect trouble, as many have supposed, but fungus infection associated with weather conditions.



CRINKLE-JOINT

Deformed stalk of wheat commonly termed crinkle joint.

When wet weather follows a drouth during the early growth of the straw, trouble is very pronounced on wheat-sick soils



CRINKLE-JOINT

Crinkle-joint or break-over disease is not an insect trouble, as many growers have believed, but a fungus infection associated with weather conditions.

CRINKLE-JOINT

Typical straws showing break-over disease and peculiarities of the roots associated with lack of stooling. Notice the tendency to form roots above the ground line—to re-root. This is due to the fact that the lower roots are blighted off by disease.

or in fields on which disease-bearing seed is used. Large swellings occur on the straw above the second joint, and blighted stools at the base of plants. The straw often breaks over, becoming crooked, then starts a deformed joint, much like an elbow in a stovepipe, and climbs up toward the sun eventually to mature its head, which, however, is often only partly filled. From 30 per cent to 60 per cent of the grain in some fields has been affected by this disease in recent years.

The break in the straw is generally at a uniform height, being just above the second joint from the ground, the elbow forming at the third joint.

As the break usually occurs during a high wind or rainstorm, hail losses are frequently reported, but as the recuperative elbow forms almost at once it is comparatively easy to establish the fact that the damage is not due to hail.

Careless Farming
Practices that Increase Wheat Sickness

1. *Careless Seed Selection and Failure to Disinfect the Grain before Seeding.*

All wheat seed in these affected areas should be carefully graded and disinfected.

2. *Using Too Much Seed.*

A healthy plant every three inches in the drill row is sufficient. Poor, disease-infected, shrivelled seeds, thickly drilled, soon spoil the best of soils for wheat. They fill the land with root diseases which spread most rapidly along the drill row in thickly seeded grain. Strong roots and heavy grain are not possible in too thickly sown fields.

3. *Lack of Intelligent Rotation of Crops.*

Rotation purifies the soil. Soil purification means soil disinfection. To eliminate the wheat-sick fungi, crops which are not related to wheat, such as corn, alfalfa, potatoes, and flax—in other words, crops on which the wheat fungi cannot exist should be planted.

4. *Improper Use of Manures.*

Wheat land should not be fertilized with fresh manures containing wheat or barley straw, as the fungi live in manure for three or four years. Stable manures should be composted, if possible, but even composted manure should not be placed on wheat-sick soils with the hope of increasing the wheat yield. Only careful rotation or other disinfection will destroy the fungi.

5. *Careless Preparation of Seed Bed.*

A loose ashy seed bed is an ideal spreading ground for fungi. A firmly compacted one into which air and water penetrate slowly and in which seeds lie evenly is best. A firm soil tends to prevent a rapid spread of fungi which may be present because of internally diseased seeds.

Rusts

Rusts are among the most common as well as among the most destructive of fungous diseases. They attack the cereals and grasses of fields, the fruit trees of orchards, and even the ornamental plants of the garden, causing, in periods specially conducive to their growth, enormous financial losses. Rusts are with us every year; we may not notice them so much during certain dry seasons, but not a

EFFECT OF BLACK RUST ON WHEAT

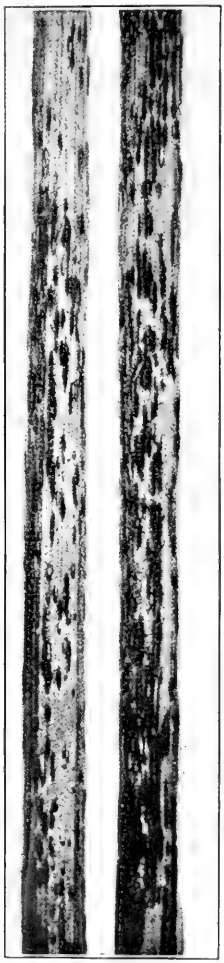
Crop totally destroyed. Except that straws are lodged in a tangled mass, it closely resembles a hail damage.

year passes without the disease being present on grain and other plants to a greater or less extent.

A wet spring, followed by warm, moist weather, presents just the conditions the rust needs for its rapid growth and spread. The weather known as "muggy," caused by showers with heat spells following and by heavy dews, results in a heavy, more or less succulent growth of the wheat plant, which thus becomes particularly susceptible to

the entrance and rapid growth of the rust parasite. Every planter should know what smut looks like to the naked eye, for it is usually so conspicuous as to attract the attention of even a casual observer.

Nearly everyone whose crops have been devastated by

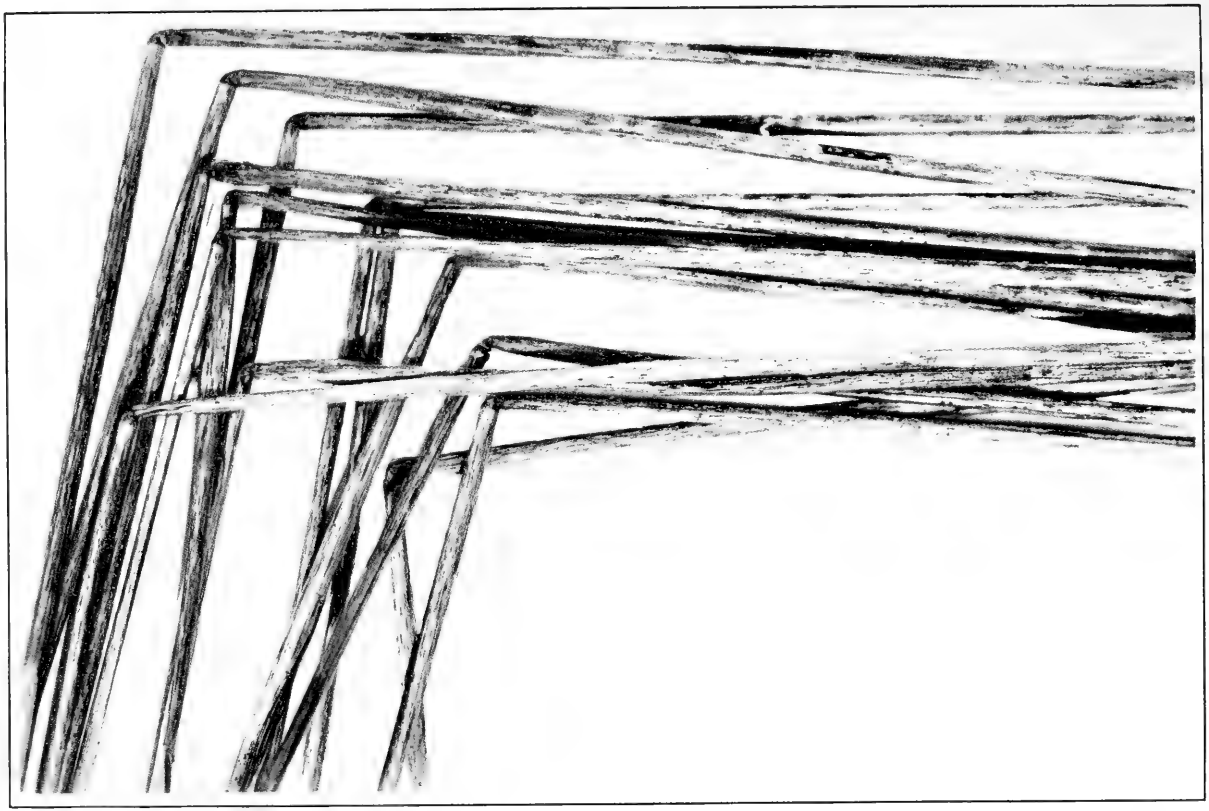


STEM RUST

Stems of wheat showing black clusters of spores of "stem rust" or "black rust."

these diseases dreads particularly what is commonly called "stem rust," or "black rust," since it is to this species that the greater losses are attributed.

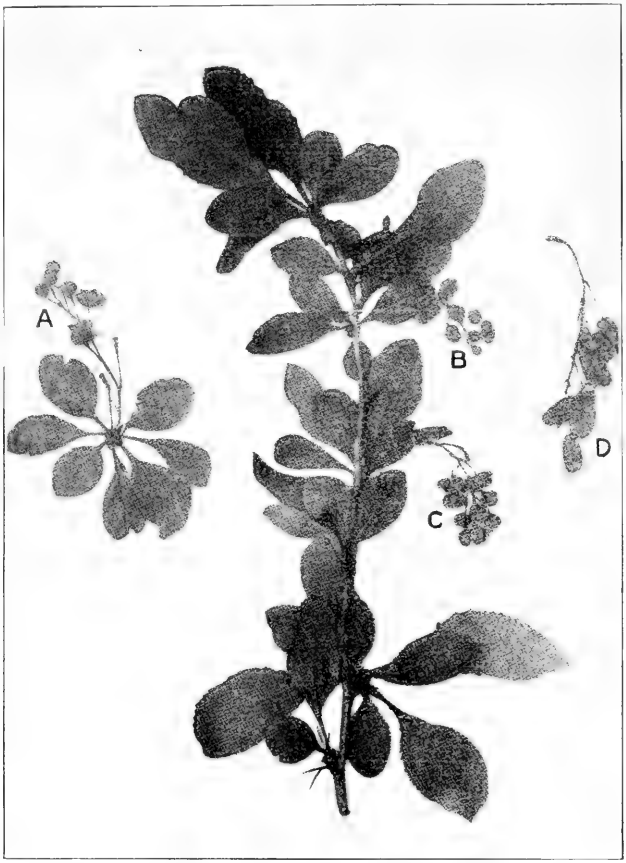
Proper drainage will help greatly to keep down wheat



RUST-RUINED GRAIN

Break occurs at joint which appears to have been "eaten away." Rust markings are very prominent on these straws.

rust. As long as the surface keeps fairly dry, rust spores cannot adhere to and infect wheat plants. In well-drained, sandy soil, such as is found about Aberdeen, S. D., for instance, rust has a poorer chance than in the bottom lands of the Sioux Valley, the Red River Valley, the Missouri



RUST BREEDS ON THE BARBERRY BUSH

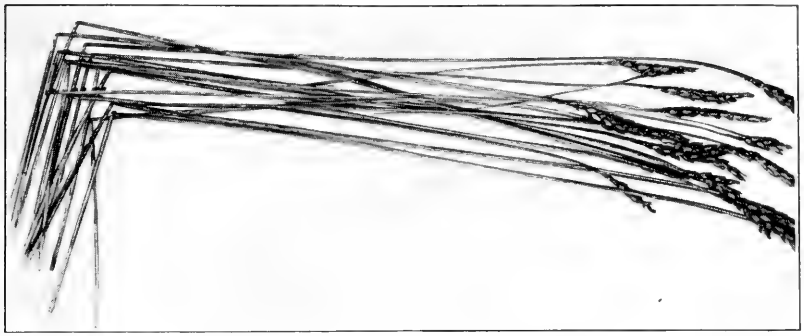
Branches of the barberry bush, bearing cluster cups of the black or stem rust of wheat. Its elimination will lessen this enormous loss to our wheat crops. A, B, C, and D are the rust bearing clusters.

Valley, or in low lands such as the gently rolling sections of North Dakota.

Rust eats into the joints of the wheat, occasionally causing entire fields to break over at the joints. This situation is sometimes attributed to hail damage, but as hail never eats out the joint nor breaks a stalk at its normally

strongest point, that theory of the misinformed should be easily refuted.

As the heads of rusted wheat at first glance sometimes



EFFECTS OF RUST ON WHEAT.
No grain whatever in these heads.

appear to be at least partly filled, that condition may be very misleading as respects a real loss caused by hail.

Red or orange rust is more frequently encountered than is black rust, and is ordinarily much less destructive. It is plainly visible on the plant, as its reddish color easily identifies it. On walking through a slightly infected field, it will be found that one's clothing is noticeably colored with this rust.

Smuts of Wheat

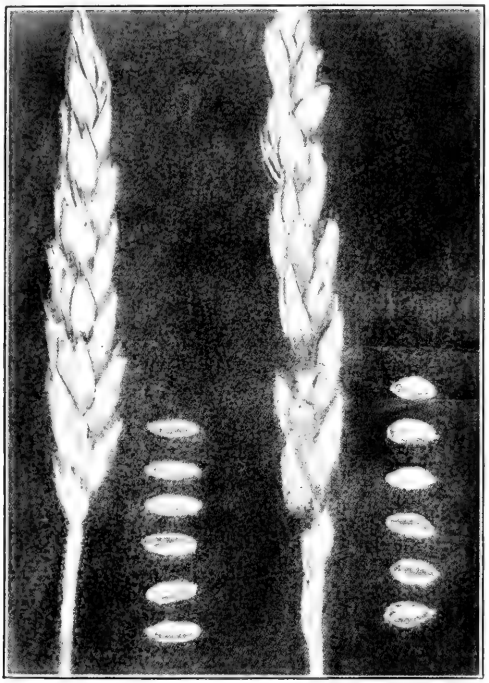
There are two common smuts of wheat. The loose smut is sometimes called "blackheads," and the covered smut is called "bunt" or "stinking smut."

Stinking Smut

Stinking smut forms a hard smut-mass—the smut-ball—where each kernel ought to be. These smut-balls remain inside the sheath, in the same position that the kernels would occupy if the head were healthy. The chaff on smutted heads is usually lighter in color and spreads farther apart than in healthy heads. The smut has a distinct odor, like that of decaying fish.

The smut-mass, then, is hard and must be broken up before the spores can be very widely scattered. This breaking is done in the handling of the grain in the field, or at

threshing time. The spores adhere to the outside of the kernels and remain there all winter. When the grain germinates in the spring, the spores also germinate, the smut



STINKING SMUT

Healthy head, and diseased head with smut balls removed.

entering the stem-tip after it comes out of the kernel. It lives in and grows with the developing berry until shortly before harvest time, when it produces smut-balls where the kernels should be.

Loose Smut

Of the two wheat smuts, the loose smut usually appears earlier in the season. It turns the entire wheat head, including the chaff, into a powdery mass, which is soon blown away by the wind, leaving only the bare stalk with a little clinging smut-dust.

This takes place at the time the grain is in flower. The

smut dust lodges in the sheath and sends out a germ-thread which enters into the young wheat kernel and remains there without changing the appearance of the wheat.

The next spring, when the grain germinates, the smut-

LOOSE SMUT

Heads have turned to a fine powdery mass of smut and blown away.

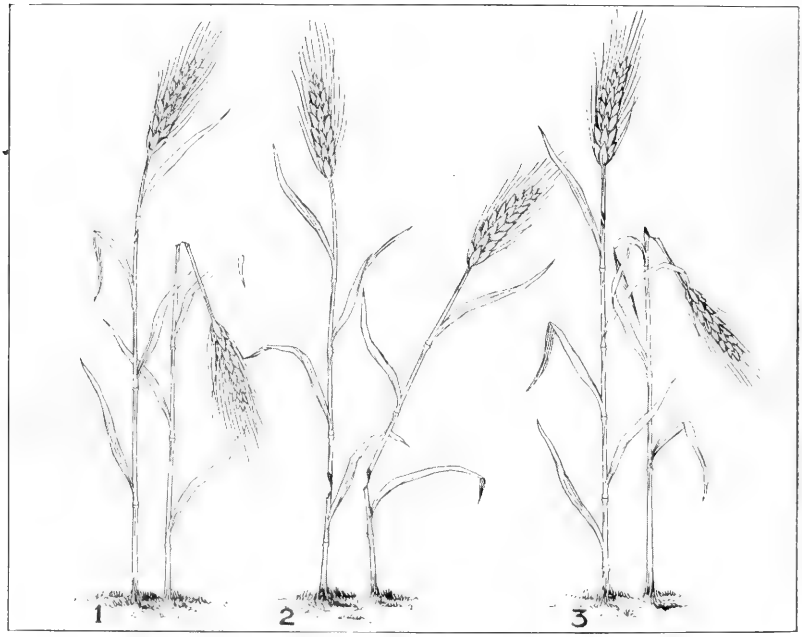
threads in the kernel begin to grow also, invading the stem-tip even before it pushes out of the kernel, growing along inside this stem-growing point, and, at heading-out-time, again changing the head into a mass of smut-powder.

PART THREE — CONTRIBUTING CAUSES

Knowledge of the elementary principles of scientific farming is essential to the successful conduct of any business which deals with farming or husbandry.

Grasshopper, Jack Rabbit and Gopher Loss

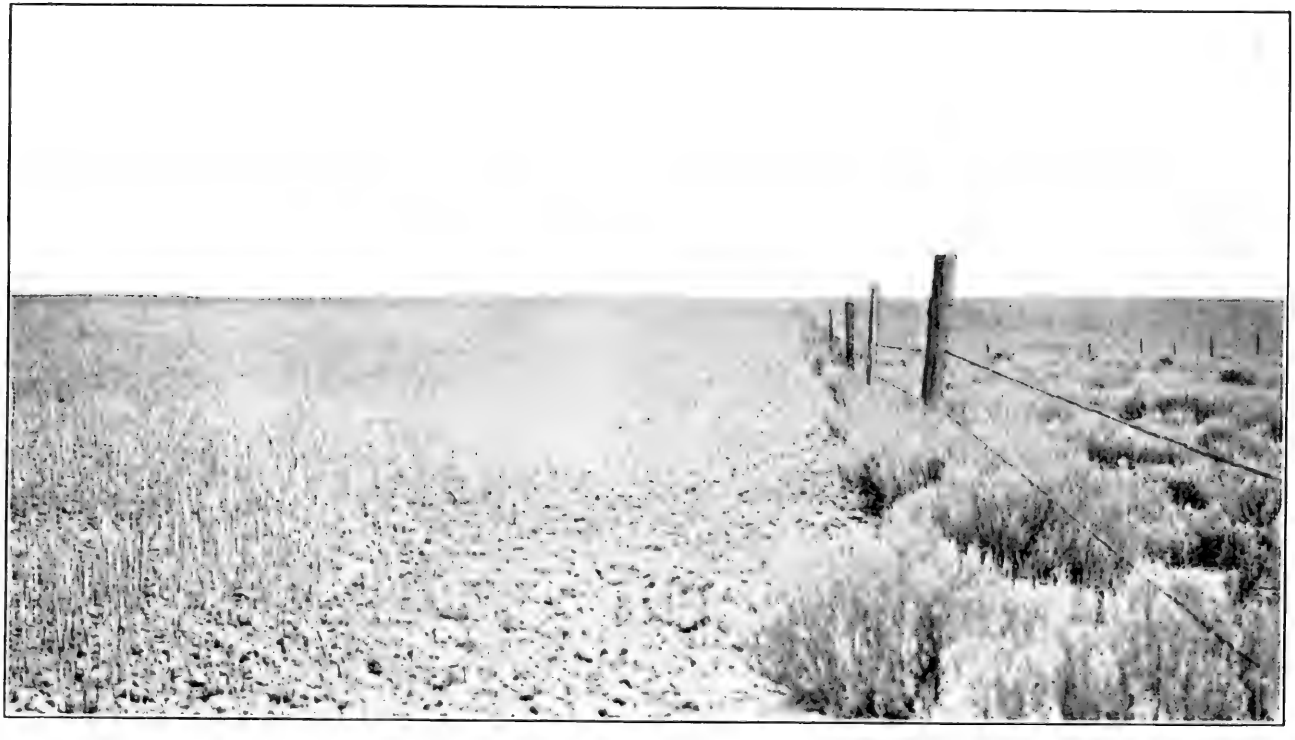
There are three quite common causes for hail-loss claims in some sections each season, namely—grasshoppers, jack rabbits, and gophers, or ground squirrels.



WHEAT DAMAGE

1. Grasshopper damage. 2. Gopher or ground squirrel damage. 3. Jack rabbit damage to wheat.

Each of these pests eats the heads of the grain from the stalks. Since an ordinary hailstorm will only break it and leave the head hanging, the grower can be shown the fallacy of his hail-loss argument. The grasshopper severs the head, leaving a finely serrated edge. The gopher, or ground



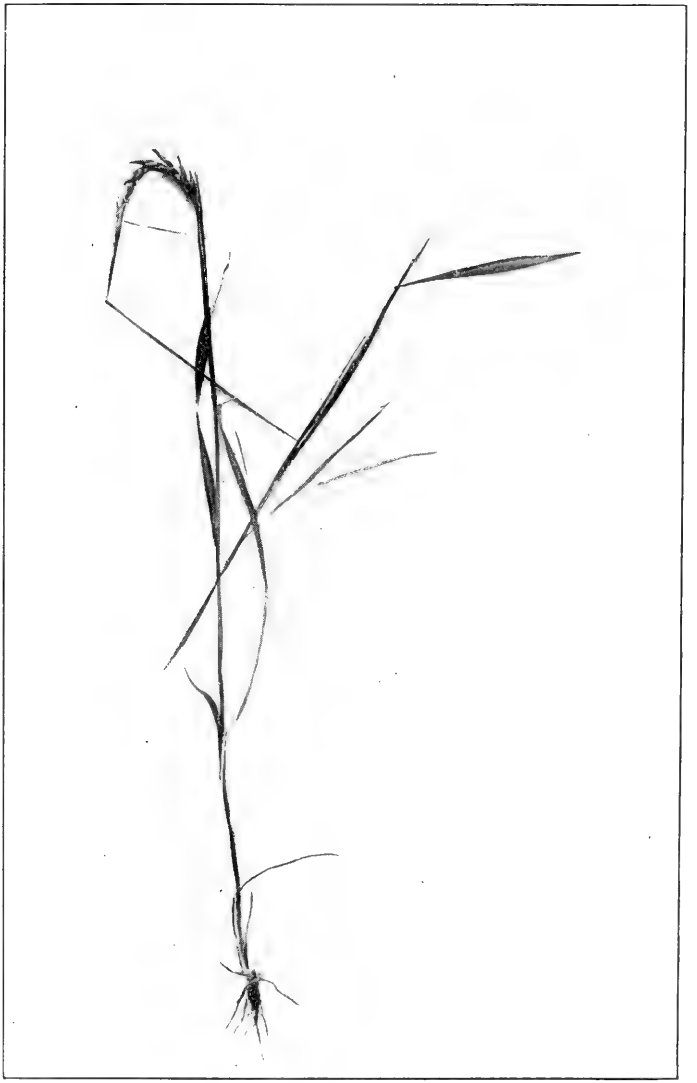
WHEAT FIELD DESTROYED BY GRASSHOPPERS

squirrel, elects to chew up one side for a half an inch to an inch, slivering the stalk before he finally nips it through. The jack rabbit with his sharp front teeth makes a clean diagonal cut usually above the head joint.

To overcome the argument that such condition does not constitute a hail loss and to show anyone how hard grain can be hit without severing the head from the stalk, it is only necessary to throw a good-sized stone down a grain row. This usually topples over several heads, but leaves them hanging to the stalk and the spurious contention on that point is promptly cut short.

Kinked Heads

In certain species of wheat the beards of the heading grain are often held temporarily by the slowly unfolding foot, which causes the heads to come out sideways, as shown in the accompanying illustration. This disorder is often attributed to hail damage, the farmer asserting that the hail has hit the boot and tightened up the sheath so that it does not open properly. This assertion is incorrect, as can be demonstrated; for in a few days these heads straighten up and fill as completely as others in the field that did not come out in such manner.



KINKED HEAD.

"Shatter Loss"

Beardless grain shatters much more easily than bearded wheat. Wind or rain will often cause a considerable "shatter loss," and many spurious hail claims are reported from this cause. A small hail damage to the stalk

MACARONI WHEAT HEADS MARCUS WHEAT HEADS

Bearded grain is less subject to shatter loss than are the unprotected beardless heads.

and a heavy shattering of the grain from the head cannot consistently be charged to loss by hail. Marcus wheat is most subject to shatter, while macaroni is least affected.

Wherever possible a compromise of loss suffered by the two grains will give a very good estimate as to the actual loss caused by hail.

Seed Selection and Seed-Bed Preparation

"Nature gave the principle of germination to seed, the rest of agriculture was left for man to discover."

The chief reasons for low production of wheat are:

1. The use of poor seed.
2. The failure to prepare the soil properly.
3. The fungus-laden, wheat-sick, or impoverished condition of the soil, due to continued wheat planting.
4. Improper application of fertilizers.

Too often the planter sows home-grown seed, without properly screening it, on poorly prepared ground of the average fertility of his acreage; or perhaps he may make a careful selection of seed, removing the foul weed seeds, and then fail to disinfect it properly, further infesting his land with the various fungi that cause wheat-sickness.

In wheat-sick areas or where the seed is badly smut-infected, thorough disinfection and careful grading of seed are absolutely necessary.

Even though seed is carefully selected, properly screened, and disinfected, there may still be failure due to one of two causes: Either the seed is drilled into a fungus-infested soil, there to become the food for various bacteria instead of food for man as intended; or, if the land is free from infection, the planter may have failed to prepare his seed bed properly.

The result of an improperly prepared seed bed was most forcefully illustrated in Custer County, Nebraska, in June, 1918. In a certain township visited by a light hail-storm some twenty-odd farmers reported damage to their winter wheat.

As the adjacent losses did not exceed 10 per cent, it occasioned some surprise to find upon inspection of one of the fields that the wheat there was damaged at least 35 per cent. Its condition was plainly noticeable, even from a distance, the plants having the same general appearance as though they had suffered from a severe hailstorm. A closer inspection, however, told a different story.

This farmer had carefully cleaned his seed, for which he had originally paid a fancy price and which doubtless was worth the price paid. So far he had proceeded carefully, but he had plowed the field to a depth of eight inches, and

A BASIS ON WHICH CLAIMS ARE FREQUENTLY MADE

Wheat on poorly prepared soil does not "stool" properly. This grain just beginning to head is so thin and weak that it does not even shade the ground. The stalks are too weak to hold up the heads and fall over as the grain ripens.

had neglected to work the soil into a firm seed bed, the result of which neglect cost a third of the prospective crop yield. The soil was altogether too loose, allowing the moisture to escape. In fields adjoining, the wheat had practically recovered following the hailstorm, but his steadily failed. The adjustment was concluded on a basis of 7 per cent damage by hail.

A carelessly prepared seed bed will not hold moisture, and, even under normal conditions, will not retain a sufficient quantity properly to mature a crop. If the unusual drain caused by hailed grain—which needs more than the ordinary amount of moisture to aid it in recuperating—is added, the deficiencies become immediately apparent.

A proper seed bed is one which is firmly compacted, as water and air must penetrate slowly to nourish the root system properly. To make a uniform growth, the seed must be drilled in at an even depth. Unless the field has been carefully and solidly worked down, all clods broken up and air pockets and loose ashy areas eliminated, the compress drills now in use will inevitably force in some of the seeds much deeper than they should be for proper germination.

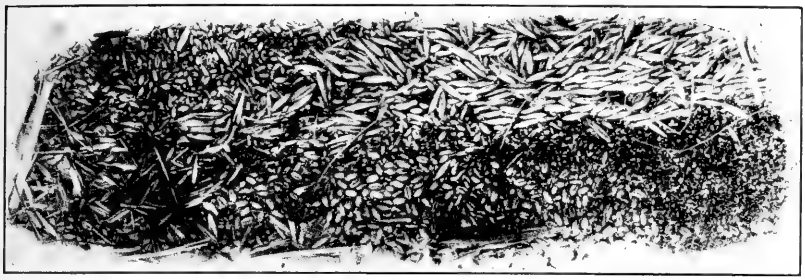
A loose, rough surface is an indication of air pockets below. A seed bed so prepared cannot properly germinate all seed, develop a sturdy root system, stool its plants, or sufficiently nourish them at any stage of their growth.

The careful selection and proper treatment of seed wheat have an important bearing on final results, for each particular variety of wheat has its own susceptibility to disease and its own peculiar period of ripening, each of which features may have a very definite and peculiar influence on the crop in a particular neighborhood. If farmers hope to escape the destructive influence of wheat diseases, it is necessary for most of them in a given neighborhood to agree to grow a single variety in order to get uniformity of growth with reference to maturity. When several varieties are grown in the same community, some are sure to be destruc-

tively attacked by disease, and from such attacks great injuries come to surrounding fields, which ordinarily would not be so affected. For example, a variety which rusts badly and matures early is likely to be most destructive to surrounding wheat which matures later, even though the later variety may be of a type much more resistant to rust. Winter-wheat growing is antagonistic to spring-wheat production in the same region.

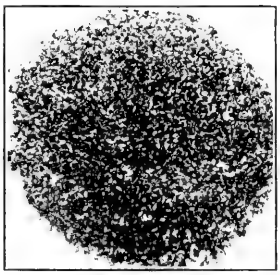
Wheat does not "run out," as is often asserted. It is generally the farmer who runs out by failure to clean and disinfect his wheat properly, to keep up the fertility and purity of his soil, and to prepare the seed bed properly.

The careless farmer sows his wheat fields with a mixture of this sort.

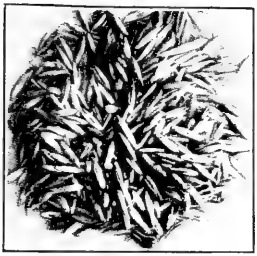


But the careful farmer removes

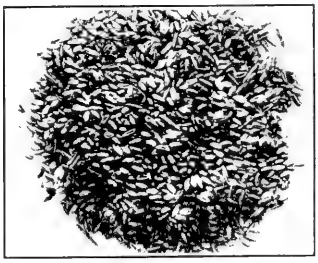
The chaff.



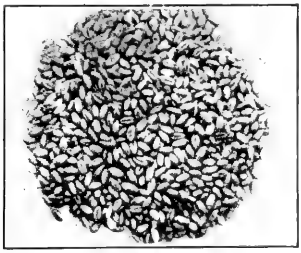
The Dirt.



The extraneous grains.



And the small grains of wheat.



Sowing only the large uniform berries.

This is Seed Selection.

SUMMARY OF LOSSES TO WHEAT WHAT TO LOOK FOR AND WHERE TO FIND THEM

LOSS TO THE HEADS

NATURE OF DAMAGE	CAUSED BY	LOOK FOR	WHERE FOUND	APPEARANCE OF LOSS
White Heads	Hessian Fly	Pupa or Flaxseed stage	In straw from underground to 3rd joint	White shriveled heads.
	Straw Worm, 2nd stage	Larva (Worm)	In straw, usually just above or below 2nd joint from head	White heads, Straw broken or very weak.
	Bulb Worm	Larva (Worm)	In straw above top or head joint	Heads white and unfilled.
	Stalk Borer	Larva (Worm)	In stalk, usually near ground	Straw tunneled. Head white. Stalk dying.
	Wheat Midge	Footless Maggot The maggot quickly changes to a fly and then leaves the plant	In chaff of heads	The maggots blast each kernel separately and if attack not severe, head will be partly filled.
	Wheat-Head Army Worm	Larva (Worm)	On head	Chaff of kernel eaten away.
	Wheat Louse (Green Bug)	Brown or Green Lice	On plants or head	White shriveled heads.
	Fungus Attack (Wheat Sickness)	Mildew and Fungi Spots	At base of head and throughout chaff and kernels	Closely resembles insect damage.
Smut Heads	Hard or Stinking Fungi Spores	Smut-filled Kernels	Heads only	Kernels and Heads appear nearly normal. Kernels, however, filled with smut.
Loose	Fungi Spores	Smutted Head	Heads only	A loose black powdery mass where head should be or a bare stalk with smut spores clinging to it.
Unfilled Heads	Black Rust	Rust Spores	On stem and heads	Heads often appear nearly normal but are unfilled.
	Wheat Sickness	Fungi spores cause ashy straw. Insufficient root system. Lack of stooling	From root to head	Shriveled, discolored or blighted grains.
	Drought or Hot Winds	Burned appearance	Entire plant	Grains shriveled and light.
Grain shattered out	Wind or Rain	Overripe Grain		Closely resembles hail damage.
Entire lack of Heads	Straw Worms, First Stage	Space in head where worm has been	In embryo where head should have been	Stalk headless and unhealthy appearance.
	Wheat Sickness	Fungus attack	Roots or stems	Sick plant, not enough vitality to mature head.
Kinked Head	Sheath holding beard just as it comes from head	Head coming out sideways		Head comes out sideways but later straightens.

SUMMARY OF LOSSES TO WHEAT—Continued.

	NATURE OF DAMAGE	CAUSED BY	LOOK FOR	WHERE FOUND	APPEARANCE OF LOSS
LOSS TO STALKS	Stalk Breaking	Hessian Fly	Larva or Pupa stage—(Worm) or Flaxseed	From ground line to 3rd joint from ground	Stalk weakened and breaks over. Evidence of work inside stalk at point of breaking.
		Straw Worm, 2nd stage	Larva (Worm)	In Straw near 2nd joint from top	Tunnels burrowed in stem. Head white.
		Bulb Worm	Larva (Worm)	In Straw above top joint	Break just above joint. Head white. Sap flow clogged.
		Chinch Bug	Bugs of various sizes	On Stalks	Sap sucked from stalk causing it to wither and fall.
		Stalk Borer	Larva (Worm)	Usually near ground	Burrowed Stem.
		Army Worm	Larva (Worm)	On any part of plant	When numerous enough to destroy they are very evident.
		Cut Worm	Larva (Worm)	At base of plant	Plant cut off at ground line.
		Fungi (Wheat Sickness)	Evidence of Fungus Spores	From root to head	Ashy, weak Straw. Poor heads. Insufficient root system. Absence of stools.
		Crinkle - Joint or Break-over Disease	Misformed, broken, and swollen Joints	Break over at 2nd joint above ground. 3rd joint enlarged and misformed.	Stalk breaks over then starts to grow up again at deformed 3rd joint. Head often only partly filled.
		Gophers	Chewed place on Straw	Near ground line	Stalk chewed up one side for about one inch, then breaks over.
		Jack Rabbits	Head nipped off	Near top of stalk	As if cut off with knife.
		Grasshopper	Serrated edges of broken Crain	From ground to head	Severed stalk. Edges irregular.
	*	Green Bug or Wheat Louse	Green or Brown Lice	On any part of plant, usually at junction of leaf and Stalk	Grain turns brown or yellow in spots. If attack bad, will cause break of Stalk.
LOSS TO JOINTS	Enlarged	Joint Worm	Larva (Worm)	Near 2nd joint from top	Joint enlarged.
		Bulb Worm	Larva (Worm)	Near 1st joint from top	Joint enlarged.
		Wheat Sickness	Crinkle-Joint	At 2nd and 3rd joint from ground	3rd Joint enlarged, 2nd broken over.
	Shriveled	Black Rust	Rust Spores	On all parts of plant	Joint shrinks, plant falls over.
		Wheat Sickness	Wheat-sick indications	On all parts of plant	Joint shrinks, plant falls over.
LOSS TO LEAVES	Yellow, discolored or missing	Flea Beetles	Small Brown Beetle	On under side of leaves	Center vein of leaf eaten or grooved.
		Green Bug, Wheat Louse	Green or Brown Louse	On leaves usually near Stalk	Yellow leaves, heads often turning white.
		Chinch Bug	Bugs of various sizes	All over plant	Stalks being sapped. Leaves drying up.
		Wheat Sickness	Wheat-sick indications	All over plant	Yellow leaves, weak ribs. No life to plant.

CLIMATIC OR POOR FARMING CONDITIONS ARE FIRST EVIDENCED BY THE WILTING LEAVES

* Improper growth of Young Grain—Yellow, Weak, etc. MAY BE CAUSED BY HESSIAN FLY, CHINCH BUG, WHEAT SICKNESS, OR BY POOR FARMING OR CLIMATIC CONDITIONS. BEST TO DEFER SUCH ADJUSTMENTS UNTIL JOINTING TIME AT LEAST.

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Education is that training
which fits for the duties
of life.