Development of oats that don't rust even in wet years, varieties of other grains and plants that are disease-resistant, seed-treatment methods that insure better crops—all mean money in the farmer's pocket.

6. Winning the Fight Against Plant Diseases

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TODAY IOWA FARMERS PLANT OATS THAT ARE RUST RE-sistant, potatoes that are certified disease free, seed corn that has been protected from root rot and seedling blight. They grow relatively little barley and wheat, knowing how often these are attacked by disease. They know that sick plants, like sick animals, mean a loss for the farmer. Yet a century ago the idea that plants could have disease was looked upon by many as a wild and fantastic dream.

The pioneer settling the prairie was looking for an opportunity to establish himself and his family on this new and uncropped land. Food and money were primary. Self-sufficiency was all-important. A farmer had to raise corn, oats, and barley for his livestock; potatoes, fruit, and vegetables for his family; cash crops like flax and watermelons if possible.

But as the years passed, plant diseases helped decide what crops would be grown. Wheat, once a standby, faded to minor importance with passing years. Many years the yield was high, but occasional losses from scab and rust, as well as heavy rains at harvest, made it undependable. Flax wilted and died. Barley was subject to a host of diseases that finally drove it from Iowa. But corn was a staple that always paid out. It seemed to stay healthy while plants on all sides were stricken by disease. That was one reason that Iowa became a corn-growing state.

Early in Iowa history, when science first began talking about fungi and parasites on plants, it didn't make sense. Farmers knew the weather had something to do with rust and rots. Those plants might have been dying as a direct result of heavy rains or hot sunshine even without the fungi. But in recent times when science has developed watermelons and flax that don't wilt, oats that don't rust even in wet weather, and chemicals that keep away the smuts, things look different. In rust years the new Clinton oats yield double the varieties once used. They mean money in the farmer's pocket. That is something he can understand.

In 1850 and the years following, when Iowa farmers watched their newly-planted apple orchards shrivel and die, when they saw dark patches appear on the leaves and the blossoms wilt and turn brown, they couldn't understand what was happening. Insects weren't eating those leaves—there wasn't a bug or a grasshopper in sight. There hadn't been a fire either, yet the ends of the branches looked brown and scorched. As late as the seventies they couldn't explain it.

There were writers who thought a tiny invisible insect bored its way into the tree. Others blamed the sunshine after a rain. In Garden Grove one citizen insisted the apple crop was destroyed by blood poisoning. The trees were caught by an early frost, he wrote, the vessels burst, the liquids in the tree fermented, and when the leaves appeared, the tree succumbed to the poison.

Hoping to save the orchards with magical cures, some placed bones under the trees. A few recommended that iron filings and scales be sprinkled on the ground. Only a handful suspected that fire blight, apple scab, and cedar apple rust were contagious diseases of plants, like smallpox and measles of human beings.

But across the Atlantic in the early 1850's a German scientist, de Bary, was thinking seriously about plant diseases. Many of them, he discovered, were caused by tiny plants, the fungi, that lived on the trees, shrubs, and grain. Fungi didn't have leaves to make their own living, so they got their food from a plant that made its own. Out of this discovery grew the whole study of plant diseases.

But it takes a long time for a scientific discovery to work its way out of the laboratory and into the hands of the common man. As late as 1888 orchardists in Iowa sneered at the idea that trees could "be killed by some mysterious bacteria floating around in the air." The buzzards, they said scornfully, never come until after the body is dead.

When farmers first discovered that you couldn't grow fruit trees easily in Iowa, they weren't too worried. If apples wouldn't grow on that rich black soil, almost everything else would. Each year the corn stood straight and tall and the wheat and oats produced high yields.

Prices in 1855 and 1856 were high. It was the time of the Crimean War, and with Russia cut off from the western European markets the Iowa farmer harvested a big crop of wheat and sold it at high prices to western Europe. Continuous rains at harvest destroyed a large part of the crop in 1857. Wheat prices dropped with the end of the war, but hopeful farmers still increased the acreage of wheat. In three years it more than doubled.

RUST STRIKES WHEAT

They planted nearly eight hundred thousand acres of wheat in Iowa in 1868 and watched it grow tall, sturdy, and green. Then disaster struck. Black stem rust shriveled the green stalks and turned them black. It cut that crop to four bushels per acre. On more than twice the land planted to wheat three years before, farmers harvested just over half the crop. It was the beginning of the end for wheat in Iowa.

All over the state except in Van Buren and Woodbury counties the wheat crop failed. And with the wheat, rust also took the oats. Rust extended throughout the wheat-growing country—Ohio, Indiana, Illinois, Missouri, and Iowa.

Wild stories spread. In Davis County one farmer insisted he had lost three horses by turning them into a badly rusted field of oats. The Democratic *Clarion* warned of a mysterious deadly poison in the rust.

Most farmers believed their wheat was "running out." The wheat deteriorated, they decided, as it was planted year after year, so they brought in new seed. Still there were losses, sometimes heavy. As farmers wondered "why," some began to gaze in suspicion at the barberries so often growing near rusted grains.

The common barberry bush was first introduced into Iowa in the early 1850's. Everybody liked that shrub. It was beautiful, and it grew well on the rich Iowa soils. Before long it was widespread in the state, growing wild in the fields where birds had spread the seeds.

The suspicion grew, however, until barberries attracted attention for reasons other than their beauty and usefulness. More and more observers noticed that wheat and oats near the bushes turned black with rust. They saw that single bushes growing wild in the fields were surrounded year after year by large patches of rusted grain. Then they knew the barberry would have to go.

Yet it wasn't until 1918, some sixty-five years after barberries entered Iowa, that farmers and the men working with them set out seriously to destroy the bushes. This was true though de Bary in Germany had proved fifty years before that rust lived a part of its life on the barberry, and scientists had known for many years the role that barberries played in black stem rust.

It seemed that rust lived over winter in the stubbles. But it couldn't cause any trouble to the wheat in the spring until it had spread first to the barberries and then back to the grain. Surely without those bushes, then, there could be no rust.

On this cue, throughout the wheat-growing area, agricultural experiment stations inaugurated an all-out campaign to destroy the bushes. School children were recruited to find them. Magazine articles were written, pamphlets were circulated, and "Eradicate the Barberry" posters were displayed in prominent places. Workers combed the areas to hunt out the bushes and kill them. Yet when all the barberries were gone from a field, rust remained. Where did it come from?

Scientists, having looked at the ground, decided to search the air for the tiny seedlike spores that spread the disease from wheat to wheat, from oats to oats, and from barberry bushes to both of them.

They flew in planes over the wheat, oats, and barley area and found those tiny spores floating in the air as high as 7,000 feet above the ground. That meant the rust could travel from south to north as the crops ripened from Texas to North Dakota and Canada. It meant that rust was too widespread to stamp out. So they set out to find a new wheat, a new oats that wouldn't rust.

Wheat in Iowa had to be spring wheat, for it was used as a rotation crop with corn, and corn was still standing at the time winter wheat should be planted. After experimentation, scientists found a few wheat varieties that were better than the old, but spring wheat never became dependable. Besides black stem rust, there were orange leaf rust and scab to strike it down. Iowa farmers turned to other grains.

Early in Iowa history, farmers had preferred oats to barley. To be sure, barley was a more profitable crop, but oats made excellent horse feed, and in the days before tractors it was important that horses be well fed. Later barley became less dependable than wheat and oats. It was susceptible not only to black stem rust, but to scab, blight, and smut. Barley was grown, like other crops, on fields where corn had been planted before. And the scab lived over winter on the cornstalks and was ready to strike the barley in the spring. In dry years Iowa could grow barley, but when conditions were right for corn, the barley crop failed. In the end, barley virtually left Iowa.

OAT CROPS SUCCUMB

Oats were always important in Iowa. Since 1890 they have ranked second only to corn in grain acreage. Yet at the close of the last century it looked as if oats would follow wheat and barley, and Iowa would be left wondering what to plant on the land where you didn't plant corn. Crown rust grew as orange specks on the leaves of oats. When harvesters saw clouds of dust following their machines, they knew the dust was the tiny seedlike spores of crown rust.

Farmers didn't have a great fear of crown rust. It was a common belief that rust was of no danger unless it turned black. Yet in 1907, 50 per cent of the oat crop was swept away by crown rust. Since that time there have been other losses as high as 20 per cent. The rust occurred all over Iowa, wherever oats were grown.

In his experiments in Germany, the scientist de Bary had noticed in 1866 that crown rust spent a part of its life on buckthorn just as black stem rust grew on barberries. But in the 1880's when farmers first realized the dangers of barberry bushes, many of them had turned to the buckthorn, not realizing that the buckthorn did for crown rust what barberries had done for the black stem rust. It was 1900 before farmers in Iowa realized you couldn't grow oats in a field surrounded by a buckthorn hedge. But it was more than the buckthorn that was spreading crown rust. Scientists saw that it also spread from south to north in showers of spores carried each year by the wind.

If oats were to be grown in Iowa, it meant a new variety must be found, a kind that would be strong enough to withstand the common oat ills of rust, smut, blight, and scab.

The Iowa Agricultural Experiment Station decided to do something about the oat situation. Its researchers began looking for a new oat. The Iowa State College agronomists collected varieties of oats from distant lands, seeking parent stock for plants with stiffer straw and greater yield. Might there not be found among these varieties or even individual plants which could withstand the rusts? Botanist S. M. Dietz initiated the trials, and H. C. Murphy, also a botanist, and L. C. Burnett, the oat specialist of the Experiment Station, continued the work. The plants were subjected to the disease, and those that remained healthy were carefully selected and multiplied.

Oats breeding at Iowa State College began to attract national attention, for the new varieties were shown distinctly better than the old. Through selection and breeding, rust- and smut-resistant varieties were produced and were widely adopted. Yet every time the problem seemed solved, a new race of rust would develop that would attack the grain.

Breeding new varieties of oats wasn't easy, for oats are self-pollinated. That means that each tiny flower must be opened and the pollination made by hand—a very slow and tedious process.

Without being perfect, the new cross, Clinton oats, in 1945 certainly seemed to be the answer to an oat-grower's prayer. The straw, so stiff that it would hold a blackbird or a sparrow, could stand in the field until it was dead ripe without a sign of weakness. That meant the oats might be combined. The oats had a higher test weight, plumper kernels, and thinner hulls than the old varieties. And for yield, here, too, it excelled.

Previous to the development of Clinton the problem of disease resistance in oats seemed solved by new varieties, Boone, Tama, Control, Vicland, and others. They were resistant to smut and rust, and enabled the American farmers to produce many extra bushels of badly needed grain during the World War II period. In 1945, a little-known parasite, Helminthosporium, became widespread on the seed and prevented maximum yield. Fortunately Clinton was not susceptible, hence the plant breeder had reserves to throw into this campaign against oat diseases.

Without a doubt the victory over diseases in oats will stand as a landmark in American agriculture. But the work is not finished. Plant pathologists are still on the lookout for the appearance of new races of rust that may arise to trouble the oat farmer. Breeding for disease resistance is work that goes on forever.

BUNT ON WHEAT

There had been troubles other than the rusts with the cereals. There was loose and covered smut on oats, stinking smut or bunt on wheat. For many years before Iowa was settled, treatments for some of these diseases had been known and commonly used in some areas of the world. But as always, the gap between the farm and the laboratory was wide.

For centuries some farmers in all sections of the world treated seed wheat with chemicals containing copper, like copper carbonate and blue vitriol. As late as 1914, many had no idea why they used them. They only knew that their fathers and grandfathers had treated their wheat—it made a better crop that way.

What the copper really did was to stop the growth of fungus that caused stinking smut, or bunt, on wheat. Stinking smut smelled like rotting fish; it changed wheat kernels to a mass of smut balls, and dwarfed the plants.

Bunt had been known for more than two thousand years, and the secret of its control, like so many other scientific discoveries, had come to light purely by accident.

Seed treatment had begun in the middle of the Seventeenth Century with a shipwreck off the coast of England. The ship had been loaded with wheat, and when some of the wheat seeds were salvaged from the salt water and planted, they were found to be relatively free from the smut that was raising havoc with the crop. Experimentation started there. By 1752 a French farmer, Tillet, had proved that copper would check the bunt.

Yet in 1863 when an Iowa farmer in Pottawattamie County claimed to control it with blue vitriol, the idea was considered crazy by some. It was much later that seed treatment became understood by the average man. With advances in science came new, modern ways to treat seed. Sulphur, ammonia, formaldehyde, copper, and finally new chemicals containing mercury were used.

With the new chemicals there was no need of soaking the wheat. They came in the form of a dust that would stick to but wouldn't kill the seed, as formaldehyde so often had done. The first of the new mercury chemicals had come out of Germany after World War I. Later others were discovered, including some developed at Iowa State College by C. S. Reddy.

There was another kind of smut on wheat that wasn't controlled so easily. Loose smut grew on the inside of the kernels. To kill that fungus something had to reach inside and poison it without killing the seed. In 1888 a scientist in Denmark found that soaking the wheat in hot water for half a day would solve the problem. But the water mustn't be too hot, for the seed was only a little stronger than the fungus. It took care to kill one without injuring the other. In spite of the fact that a preventive for the smuts is known, Iowa, even in modern times, suffers a loss averaging about 1 per cent of the wheat crop from loose and covered smut. The loss would be much greater, did not a great percentage of farmers treat their seed. The smuts were a grave problem in the history of Iowa agriculture, but they were much outweighed by the greater problem of rust.

FIGHTING CORN DISEASES

Corn had been considered invincible for many years. Few farmers thought that treating this crop could be valuable. To be sure, root rot and seedling blight, as well as smut, took their toll in corn year after year. But the loss was small compared with that caused by epidemics of rust in the cereals. Most farmers never thought of corn diseases other than smut, and even the scientists who made plant diseases their business didn't realize that those diseases were important until the World War I years. They decided then that good corn crops would be even better if root rot and seedling blight were wiped out. To do this they recommended treating seed corn with the new chemicals containing mercury.

Seed treatment meant, too, that corn could be planted early without danger of rotting in the field. It gave it a longer growing season. Later, hybrids came to cut disease even further. The hybrid seed was harvested early and dried quickly. There was no time for the disease to get started in the kernel. The new seed wasn't picked from the crib helter-skelter like much of the old seed corn. It had to meet rigid requirements. Hybrid seed treated chemically meant a corn that was healthy and protected from disease already in the soil.

Seed treatment had cut the loss from root rot and seedling blight, but what could be done for smut? Not much, it seemed. Pathologists recommend that farmers plant corn only once in three years on the same land. But in a Cornbelt state that isn't often enough. Burning the cornstalks would destroy the smut, but at the same time it would destroy the land. Spraying with Bordeaux mixture would control it, but spraying was far too expensive. Average losses from smut in Iowa have ranged from 1 to 9 per cent in the days since World War I. The only answer seems to be a corn that won't smut, and no such corn has yet been found.

POTATOES

A hundred years ago when Iowa was just being settled, farmers had to be self-sufficient. Their food came from the soil. Potatoes were one of the mainstays of the pioneer's diet. But once again disease stepped in to mix things up for the farmer. In 1865 and 1866, growers in parts of Iowa noticed that their tubers were rotting. They blamed the rot on the weather, as farmers for centuries before them had done with all plant diseases. To be sure, the weather was at fault—when the weather was right for the fungi and for insects that helped to spread disease. They grew faster than the plants they lived on. That spelled death for the crops.

From an all-time high of 170,285 acres of potatoes in the nineties, Iowa's production dropped to an all-time low of 44,000 acres in 1930. One of the greatest reasons for the drop was potato disease. Rot wasn't the only disease on potatoes. There was scab that dried up the surface of the potato and produced ugly scabby spots. There were also blight, black leg, black scurf, and dry rots.

Another group of diseases baffled farmer and scientist alike. They were the viruses. On potatoes they caused leaf wilt, mosaic, and spindle sprout. And no matter how powerful his microscope, nobody could see the viruses. Like scab, they were carried in seed potatoes. They were carried, too, by insects and weeds.

The virus spread like measles. If any potatoes growing together were affected by the viruses, it wasn't long before they all were diseased. Farmers found that if they planted potatoes in Iowa, saved some for seed and planted them the next year, their yield was low. They said the potatoes were "running out" from using the same stock year after year. When they imported seed from the northern states, the crop was better. It was better because there was less disease in the north where the weather was cooler and insects were fewer.

Treating seed potatoes with hot water for four hours would do much in control. So would treating with formaldehyde for four hours. I. E. Melhus at Iowa State College put those two ideas together. If hot water and cold formaldehyde would both control potato maladies, what about hot formaldehyde? That should be much faster for treatment and therefore less expensive and more convenient. It was. A solution of one part of formaldehyde in 125 parts of hot water was the answer. It did for potatoes in one minute what it had taken four hours to do before in whipping the fungi.

During the last decade agricultural experiment stations in the cool northern states—Maine, the Dakotas, Minnesota—and the mountain regions of Colorado have co-operated with those in Iowa as well as other states farther south where potato diseases are prevalent. They have set up a standard for freedom from disease. Northern-grown potatoes meeting the standard are certified disease free, and the farmer who buys this seed and treats it with hot water or hot formaldehyde as a further precaution has a good chance for growing healthy potatoes.

FLAX

When Iowa was new, a farmer could break a plot of prairie land, plant it to flax and pay for his farm in one year. But it always took new land. When there was no more prairie, there was no more flax. The land became infested with a fungus that grew into the ends of the roots and kept water from reaching the body of the plant.

But in the twenties from North Dakota there came a new flax that wouldn't wilt. Fields had been found where less than 5 per cent of the flax grew and matured seed. Here the healthy seeds had been collected, and planted on the same ground that was infested with the wilt fungus. Year after year the flax was planted, the best seeds saved and replanted. In the end only the plants that could take it survived. From these seeds a sturdy crop was grown, and it didn't wilt.

But something else was wrong with flax. When the seedlings were very young, a fungus in the soil would grow into the plant just below the soil line. That area would die, and the plant would fall to the ground. Scientists in Iowa discovered that this disease, called "damping off," could be prevented by treating the flax seed before it was planted. That, with the new flax that wouldn't wilt, meant that farmers all over America could grow flax again.

MELONS

Southeastern Iowa soil had been ideal for watermelon growing. In 1900 watermelons grew on five thousand acres of the sandy loam in that district. Much of that land had been mortgaged and many of the farms lost. The new owners of the land weren't either using or renting it, and they were too far away to know what was happening to their newly acquired property.

When farmers saw their melons wilt, therefore, in a soil infested with disease, a few furtively planted test plots on the nearby foreclosed land that was lying idle. If the test plot proved successful, they planted the land to watermelons, reaped a highly profitable crop, paid for their own farms. And the donors of the watermelon crop were never the wiser. But eventually new land ran out, and by 1926 the watermelon acreage had dropped to one-tenth its all-time high.

To combat watermelon wilt, plant breeders in Iowa gathered seeds from all over the world—China, Africa, Japan, Yugoslavia. They crossed the plants until by 1939 they had developed a super melon, Dixie Hybrid, that brought watermelons back to Iowa.

So it has been with nearly every crop grown in Iowa. For a time it has flourished. Then when the diseases that parasitize the crop have become well established, the yield has been cut—not greatly in some cases, but enough to warrant investigation, and development of a preventive or cure. In the case of oats, corn, potatoes, watermelons, and many garden crops like cucumbers and tomatoes, a great deal has been done to solve the problem.

No longer do farmers watch with dread and despair their crops "running out." Nor do they try magical cures for plant troubles. Instead they see a plant disease as it is—something that may be prevented through research for its causes and application by the farmer of the results of research. For after all, the research is worth nothing except as it is put to use by the practical farmer.

In the case of crops like wheat and barley, as well as those where greater progress has been made, the search continues.