Cereal Root-Rot Investigations and Control Factors[1]

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THE fungi which attack the roots of small grains in North Dakota are mainly of the so-called common root-rot group. In addition, certain root-browning fungi belonging to *Pythium* and related genera are present in this State and probably of considerable importance in some places. However, the common root-rots are very widespread and no particular area in the State is consistently free from their attack. The calculated reduction in yield in commercial fields from common root-rot varied, in 1940, from as low as mere trace to as high as 13.5 percent in one instance. Losses were frequently about 3 to 5 percent.

The common root-rots are believed to be due to a complex of fungi. The most prevalent of these are species of *Helminthosporium* and *Fusarium*. During years of relatively abundant spring-time soil moisture, species of *Fusarium* are sometimes more abundant than species of *Helminthosporium* in the roots of diseased grain. However, tests on the ability of these fungi to cause root-rot indicate that most of the local species of *Fusarium* are not very parasitic. In cooperation with W. L. Gordon, Pathologist, Dominion Laboratory at Winnipeg, Manitoba, it was determined that most of the species of *Fusarium* isolated from North Dakota grain and grass roots in 1940 were not ones commonly recognized as serious parasites. The important scab-producing species which are common farther south were virtually non-existent in the cool soil of early spring in North Dakota in 1940. It would appear from present evidence that *Helminthosporium* is a more serious problem in the common root-rot complex than *Fusarium* in this region.

Trials with local material indicates considerable variation in the ability of races of *Helminthosporium* to cause root-rot. Some cultures of this fungus when introduced into the soil at seeding time cause from 25 to 50 percent reduction in emergence while other cultures fail to inhibit the seedlings to any observable extent. These differences if they continue to hold true indicate that our control problem is greatly complicated.

In attempting to control root-rots it is important that control measures must be correlated with good agronomic practices. It is often lost sight of that reducing root-rot and yield at the same time does not appeal to the farmer. In some cases the balance between favoring the plant and inhibiting the root-rot-causing fungus is rather finely drawn and this is likely to be the case with most root-rot complexes. With our common root-rot, evidence shows that the fungi are favored by cool wet weather at or just after seeding which is followed by drought or near drought conditions. Seedlings with weakened roots show the effects of drought faster than plants with normal healthy roots. It is difficult to gauge where drought begins and root-rot ends. They more often go hand-in-hand. Drought conditions check the moisture-needing fungus, it is true, but it checks the root-rot-weakened roots sooner. Then, if at a later date, the drought is broken by late rains the attending fungi sometimes develop faster than the injured plant. It is very hard to determine just how much reduction in yield comes from these late season attacks. In 1940 this condition was particularly evident at Williston and to less extent at Fargo. It

[1] Cooperative investigations between the North Dakota Agricultural Experiment Station and the Divisions of Cereal Crops and Diseases, and Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

was concluded that the late season rains permitted the fungi to grow and kill the roots a short time before their normal maturity. The plants were thus required to make use of the food in their culms to mature their grain. The late season attack no doubt reduced yield slightly.

One of the symptoms of late season injury is pink roots, the oat plant being particularly susceptible. Pink root appears to be largely caused by *Fusarium oxysporum* which is generally believed to be a very weak parasite on cereals.

The amount of fungus threads and of spores in the soil is a distinctly important point in controlling common root-rot. The more parasitic fungus material (inoculum) there is in the soil, the greater the chance of infection. The common root-rot fungi build up this inoculum on dead host parts as has been determined by various workers and most recently and clearly by Tyner (7) [2]. Therefore, continued cropping to susceptible species of plants tends to increase the amount of inoculum in the soil. This increase appears to be fairly rapid for a few seasons after which other soil competitors appear to check the upward trend of infection. Plots seeded to wheat for generations may still yield fair crops. However, rotation appears to be of prime necessity as indicated by work in adjacent parts of Canada (1, 5). While we have but one year's results to record, these have been taken from plots of long standing in the State. The results are sufficiently erratic to show that much more study is needed and only a few points of interest will be mentioned. At Dickinson fall-plowed plots of Pilot wheat had as much as 35 percent root-rot while in spring-plowed plots the loss dropped to about 10 percent. Plots grown continuously to one crop were usually higher in percent of root-rot than ones in which less susceptible crops alternated. Legumes such as sweet clover starved or dried out the root-rot fungi but after a few seasons left the soil in a hard, "baked" (deflocculated) condition. There seems to be some evidence that some soil parasites, once they are re-established in soil of this condition, are able to attack plants which do not thrive in it. While some root-rots, notably *Ophiobolus graminis* (the take-all fungus, not present locally) prefer loose soil; and while nearly all can no doubt spread faster in loose soil, there does seem to be a factor in the reverse situation. Injury in deflocculated soil is in the form of lesions on the undersized roots and in a collar rot where the soil presses close against the culm base.

Corn is widely used in rotation with wheat in experimental plots on the stations throughout the State. Where the rotation involved only corn and wheat alternating the reaction was unfavorable but in three- and four-year rotations corn proved relatively satisfactory although the results were somewhat erratic. Based on the results from 1940 there did not appear to be much danger from scab-causing organisms following corn.

Root-rot in spring wheat following fallow was not very different from the amount and kinds of root-rot that followed corn. The *Helminthosporium* rot did not appear to be starved out by one year of fallow but we did not find much evidence that root-rot was increased by the use of fallow as has been believed by some. In this connection when oats followed fallow to be followed in turn by wheat root-rot was materially reduced. Since oats is only incidentally attacked by *Helminthosporium* it would appear that 2 years of starving was detrimental to the *Helminthosporium* inoculum. Where sorghum was introduced into this rotation the results were less favorable. It is possible that sorghum was carrying *Pythium* into the next crops. *Pythium* was isolated very frequently from cane, millets and maize in 1940 in North Dakota.

In tillage practice plots at Dickinson and at Langdon there were indications that duck foot fallowing slightly favored root-rot but at Mandan this was less evident. Plots plowed July 1st usually had less root-rot in the following wheat crops than ones plowed earlier in the year. This reduction is due

[2] The figures in parentheses refer to literature citations at the end of the article.

probably to the fact that much of next year's inoculum lies at or near the surface in the stubble and roots and the longer it lies near the surface subject to irradiation and drying winds the less there will be to plow or disc under. However, even if the stubble is allowed to lie until next seeding time there will still be a good crop of root-rot the next year. This was demonstrated in plots at McCanna this past season. Along this line one plot out of two at Mandan gave evidence that burning the trash might reduce root-rot.

Sarvis and Thysell have found that green manure crops are not yet profitable at Mandan (4). It was indicated at both the Dickinson and Mandan stations that root-rot was more severe in plots following green manure than otherwise. Sometimes this greater severity was very marked, sometimes less or not at all. Rye appeared to be the least desirable green manure crop but the leguminous crops were not very encouraging either.

Vanterpool in Saskatchewan found that *Pythium* root browning was favored by soil low in phosphorus and high in nitrogen, which unbalanced condition favors the fungi over the host (8). In North Dakota, such brief trials on the effect of fertilizers, as were run in 1940, were mostly negative or inconclusive. The grain (Thatcher wheat) did show some increase following application of certain complete garden fertilizers but there was nothing of any immediate interest in the results. At the Langdon station, root-rot was only slightly reduced by the application of phosphorus while other treatments appeared to have no effect on root-rot. Greaney (2) recently found evidence at Winnipeg that phosphate deficiency acted detrimentally to the plant somewhat independent of *Fusarium* root-rot activity.

Ground subject to root-rot is often overworked and dressed down too fine. It can be disced too early and worked until it is subject to blowing. With the top soil depleted the land puddles easier and the resulting collaring of the plant appears to favor the root-rot fungus. Reduction in stand from seedling blight favors weed growth. The weeds further choke out the grain reducing yield and favoring late-season root-rot. The weeds in turn serve as hosts for wire worm and after a severe root-rot infestation the grower may find himself with a crop of weeds, and then finally wire worms. Data relating in part to this cycle has recently been reported by Sallans (3). In addition, the weeds that follow root-rot-thinned wheat may be carriers of root-rot themselves. Pigeon grass for instance is very subject to *Pythium* damping-off and Russian thistle to *Rhizoctonia* injury. Further study is needed before the economic importance of this phase of the problem can be determined.

Grasses are now being used in rotation with cereal crops in some places in North Dakota. Some of the wheat grasses such as crested, western or slender, appear to have depressing effect on wheat crops that follow immediately after them. Most of the root-rot fungi that will attack wheat will attack these grasses. Whether it will be possible to work non-susceptible grasses into this picture will require time and study.

One of the stumbling blocks in the grass expansion program has been seedling blight. The South Dakota station and Soil Conservation Service, U. S. Department of Agriculture (Wayne Austin) have found that grass seedings in the vicinity of Brookings, S. Dak., have been consistently wiped out by root-rots. A less serious but all too heavy toll occurs in most places in North Dakota also. We are dealing with the same group of fungi that occur on cereals with the addition of a large number of races and some specialized species of fungi. Information on rotation and cropping practices is sorely needed in connection with the grass root-rot problem.

Varietal resistance of cereals to root-rots has not proven the panacea that varietal resistance has in some other crops. Cereals do not show very marked resistance to the common root-rots. In 1940 certain wheats, Premier, Carleeds (Nordhougen), Merit, and Vesta all averaged about 6 percent loss in the ex-

perimental plots and could be classed as moderately resistant. Several others such as Thatcher showed only slightly more root-rot while Pilot ran somewhat higher in apparent susceptibility. Among the more susceptible ones could be included Kubanka (variable however), Ceres, and the worst was Marquis. It might be added that Marquis, under Saskatchewan conditions, is found to be somewhat resistant. The susceptible varieties averaged about 8 to 9 percent loss or only about 50 percent more injury than the slightly or moderately resistant group. Susceptibility is no doubt tied up to a considerable extent with general adaptability of the variety to the area, although not infallibly. There is no strong evidence that durum wheats as a class are distinctly more susceptible than common wheats although there is a tendency for the poorest to be very poor and the best of them such as, this past year, Mindum to be intermediate in susceptibility.

Some of the hybrids of durum and emmer developed by Glenn Smith at the North Dakota Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture are moderately resistant.

In comparing date of maturity with relative resistance we find some slight suggestion that the earlier varieties are more resistant than the later ones. At least since Stoa (6) has shown that earliness is, in general, a desirable character under North Dakota conditions, it will be relatively safe to ignore the root-rot factor for the present in breeding for earliness and high yield.

In checking the average root-rot resistance of the standard wheat variety plots at Fargo, McCanna, Mandan, Langdon, Dickinson and Williston, there was close correlation between high yield as listed in Stoa's recent data (5) and resistance to root-rot.

In conclusion it is suggested that where root-rot is serious more crops be used that are resistant to root-rot such as oats; that good seed, treated with New Improved Ceresan be used; that the soil be protected against blowing and resulting loss of top-soil; and that excess root-rot trash and pigeon grass be avoided. More use of grass is very desirable with oats or some resistant crop to follow it for two seasons after breaking up the sod. Where nonsusceptible grasses are used, this would probably not be necessary. These practices, subject to local conditions, and the judgment of the grower, will aid in reducing the severest of root-rot losses to a more nominal figure.

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