Cereal Root-Rot Investigations and Control Factors

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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

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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 sur-
fact subject to irradiation and dry-
ing 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 burn-
ing 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 phos-
phorus and high in nitrogen, which
unbalanced condition favors the
fungi over the host (8). In North
Dakota, such brief trials on the ef-
eft of fertilizers, as were run in
1940, were mostly negative or
inconclusive. The grain (Thatcher
wheat) did show some increase fol-
lowing application of certain com-
plete garden fertilizers but there
was nothing of any immediate in-
terest in the results. At the Lan-
don station, root-rot was only
slightly reduced by the application
of phosphorus while other treat-
ments appeared to have no effect
on root-rot. Gleaney (2) recently
found evidence at Winnipeg that
phosphate deficiency acted detri-
tentially to the plant somewhat in-
dependent of Fusarium root-rot ac-
tivity.

Ground subject to root-rot is
often overworked and dressed down
too fine. It can be disked too early
and worked until it is subject to
blowing. With the top soil depleted
the land puddles easier and the re-
sulting collaring of the plant ap-
ppears 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 report-
ed by Sallans (3). In addition, the
weeds that follow root-rot-thinned
wheat may be carriers of root-rot
themselves. Pigeon grass for in-
stance is very subject to Pythium
damping-off and Russian thistle to
Rhizoctonia injury. Further study
is needed before the economic im-
portance of this phase of the prob-
lem 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
gasses. 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 Conserva-
tion 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. Infor-
mation on rotation and cropping
practices is sorely needed in connec-
tion with the grass root-rot prob-
lem.

Variatel resistance of cereals to
root-rots has not proven the pana-
acea that varietal resistance has in
some other crops. Cereals do not
show very marked resistance to the
common root-rots. In 1940 certain
wheat, Premier, Carleeds (Nord-
hougen), Merit, and Vesta all aver-
aged about 6 percent loss in the ex-
Experimental plots and could be classified 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 non-susceptible 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.

RECENT LITERATURE CITED


Northern Great Plains Field Station, Mandan, N. Dak.