Effect of Cropping Sequence on Take-All and Take-All Decline in Durum Wheat Under Irrigation

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Of the many diseases which affect wheat, the “take-all” root rot is among the potentially most harmful. Fortunately for North Dakota farmers, this disease has not been a major problem on dryland spring wheat and durum (5,7).

Take-all root rot is caused by the soilborne fungus Gaecumannomyces graminis v. tritici (commonly referred to as GGT). The take-all fungus survives in the soil on debris (roots, crowns, etc.) from previous infected crops (8). GGT infects young plants in the spring soon after planting and spreads slowly throughout the root system. No obvious symptoms appear until after heading, when severely infected plants die, leaving bleached empty “white heads.” If affected plants are pulled up, the roots are found to be destroyed and the stem bases and crowns are a shiny coal-black color. This blackening is diagnostic for take-all (Figure 1). Further general information about take-all under North Dakota conditions is found in two NDSU extension circulars (2,7) available from county agents or the NDSU bulletin room.

Take-all is worldwide in distribution but is more often a problem on winter than on spring wheats (8). The causal fungus (GGT) is present throughout the northern Great Plains of the U.S. and Canada, but reports of epidemics of take-all are rare in dryland spring wheat in North Dakota and adjacent areas (4,6).

Irrigated spring wheat is one environment in North Dakota where take-all epidemics regularly occur. Severe losses in some fields of irrigated spring wheat have been noted in North Dakota during the past decade, with the greatest take-all incidence where wheat was grown for several successive years. Stack (6) documented losses of up to 45 percent under field conditions in irrigated wheat in North Dakota. Take-all has rarely been found on wheat crops grown as an occasional break rotation in irrigated crops of corn, alfalfa or soybeans.

Crop rotation is known to be effective in controlling root diseases in dryland wheat but little is known about the value of rotation in irrigated wheat under North Dakota conditions. The purpose of the present study was to determine how rapidly take-all would build up in spring wheat grown on newly irrigated land, and to see whether different rotation crops would influence take-all development.

A second purpose was to see if a phenomenon called take-all decline (TAD) (1,8) would develop. In more humid regions of the world where take-all regularly occurs, the TAD phenomenon is often observed (1,3,4). In such places, when wheat is planted continuously take-all soon appears and builds up to high levels after a few years. If wheat continues to be grown the level of take-all begins to drop. This disease reduction is TAD. Take-all never disappears completely in TAD but it often is slight enough to be of minor concern. TAD is believed to be caused by soil bacteria antagonistic to the take-all fungus; it represents an example of naturally-occurring biological disease control. It was not known if TAD could occur in irrigated spring durum.

METHODS

To test the effects of cropping sequence on buildup of take-all in irrigated durum wheat, a study was set up in 1982 at a newly established research station near Karlsruhe in north central North Dakota on a site never previously irrigated. Six crop rotations were established within the study area in a randomized block design with four replicates and

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individual plots 3.5 x 14 m. The rotation crops included
corn, sunflower and soybean. Plots were set for continuous
wheat (WWWWW), three two-year rotations (WRWRW)
and two three-year rotations (WRRWW) where W = spring
durum wheat and R = row crop (F = sunflower, C = corn,
B = soybean) (Table 1).

Other irrigated durum wheat plots at this same site which
were part of a different experiment were rated for take-all as
an external check. In that experiment, wheat was planted
each year on ground never previously used for irrigated
wheat, barley or oats. The extended rotation of this plot in­
cluded alfalfa as well as the other row crops. Because fertil­
erizer rates and irrigation amounts differed from the take-all
trial, yields here were not comparable.

Natural rainfall during April through July varied from
5.85 to 12.87 inches during the years of this study (1982 to
1986). This was supplemented by irrigation during the May
to July cropping period to bring available water to about
17.5 inches. The supplemental irrigation was applied by
overhead sprinkler to all plots.

Presence of take-all was determined by visual evaluation
of plots when the grain was in early dough stage but plants
were still green. Incidence of plants showing symptoms of
take-all (stunting or death and blackening of stem base,
Figure 1) was determined by counting at least 1,000 plants
in each plot. Representative samples of symptomatic plants
were microscopically examined for signs of the casual
fungus, and isolations were made to confirm presence of
GGT. Yields were taken using a plot combine. Yields were
taken among treatments by scoring the highest yield as
100 percent and all others as percentages of the highest.

RESULTS

All rotation treatments were planted to spring durum
wheat in 1982. This land had never before been irrigated
and it was not known if take-all would appear in the first
season. When take-all counts were made on these plots, a
few scattered individual plants or small groups of plants
were symptomatic but the incidence of take-all was 0.1 per­
cent or less (Figure 2). In 1983, the second year of this ex­
periment, only the continuous wheat rotation was planted to
durum wheat. Take-all in that crop was about 1 percent.
In the wheat in the external irrigated check plots, no take-all
was observed in either 1982 or 1983.

In 1984 the two-year rotations returned to wheat and in
1985 the three-year rotations returned to wheat (Table 1).
Take-all in the second wheat crop after the various row
crops was 0.3 percent to 0.9 percent, compared to 15 per­
cent and 11 percent take-all, respectively, for the third and
fourth years of the continuous wheat (Figure 2). Yields of
wheat following row crop rotations were reduced by 9 per­
cent to 14 percent in the two-year sequences and by 1 per­
cent to 7 percent in the three-year sequences (Figure 3).

A dramatic increase in take-all was noticed in the second
sucessive wheat crop on the three-year rotation plots (WR­
WWRW). Take-all incidence increased from approximately
0.5 percent to 10 percent in the WCBWW sequence plot
and from approximately 0.9 percent to 21 percent in the
WCRWW sequence plot. This dramatic increase would in­
dicate the necessity of crop rotations when planting small
grains under irrigation and of avoiding two consecutive
years of small grain. The take-all incidence in the two-year
rotation remained lower than the second consecutive year
of wheat in the WCBWW and WCFWW sequences. Take­
all incidence was 10 percent in the WCBWW sequence plot
and 21 percent in the WCFWW plot, the same level as the
continuous wheat (Figure 2); yields were reduced by 9 per­
cent and 16 percent in these two plots (Figure 3).

Among the row crop rotations used in this trial, it ap­
peared that corn in a two-year rotation or corn-soybean in a

Table 1. Irrigated crop sequences used in take-all study at Karlsruhe, N.D., 1982-1986.

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment (crop sequence)</th>
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<tbody>
<tr>
<td></td>
<td>1 WWWW</td>
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<tr>
<td>1982</td>
<td>Spring durum</td>
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<tr>
<td>1983</td>
<td>Spring durum</td>
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<td>1984</td>
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<td>1985</td>
<td>Spring durum</td>
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<td>1986</td>
<td>Spring durum</td>
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Figure 2. Effect of Seven Crop Rotations on Incidence of Take-All in Irrigated Durum Wheat.

Figure 3. Yield of Irrigated Durum Wheat in Different Crop Rotations.
three-year rotation were slightly more effective in slowing take-all buildup than was sunflower or sunflower in combination with corn (Figure 2).

Separate records of incidence of take-all and yield reduction were kept for several of the individual plots in this study. These are presented graphically in Figure 4. Yield losses of the magnitude found in this study are similar to those reported due to take-all in other regions (8).

Emergence of take-all decline (TAD) was not apparent when average disease incidence for treatments was examined (Figure 2); however, when incidences of continuous wheat in individual plots were considered separately, the development of TAD was seen (Figure 5). Plots 2, 3 and 4 of continuous wheat had some take-all in the first year and high incidence (10 percent to 20 percent) by the third. Take-all in plots 2 and 4 then rapidly declined while plot 3 leveled off. In contrast, plot 1 of continuous wheat had no take-all in 1982 and very little in 1983 or 1984. No evidence of TAD was seen in any of the plots with wheat-row crop sequences.

CONCLUSIONS

When wheat is grown continuously under irrigation, take-all can reach high levels very quickly (within three seasons), even on land not previously used for irrigated crops.

Row crop rotations slow this buildup of take-all but it remains unclear whether this effect can last more than a few rotation cycles.

A four-year rotation of two years wheat following two years row crop will have more take-all than one using the same crops in an alternating year sequence.

Sunflowers in a rotation with irrigated wheat may be less effective as a break to slow take-all buildup than corn or soybeans.

Take-all decline (TAD) does occur in continuously cropped irrigated spring wheat, possibly as soon as after four or five successive crops.

LITERATURE CITED