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 *Gaeumannomyces 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.

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Figure 1. Symptoms of take-all root disease on wheat plants. The crowns and lower stems show a shiny black discoloration and the roots are mostly destroyed.

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

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 included alfalfa as well as the other row crops. Because fertilizer 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 compared 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 percent or less (Figure 2). In 1983, the second year of this experiment, 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 percent 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 percent to 14 percent in the two-year sequences and by 1 percent to 7 percent in the three-year sequences (Figure 3). By contrast, yields in the continuous wheat plot were reduced by 60 percent in the third year (1984) and 23 percent in the fourth year (1985). In both these years a trace (less than 0.1 percent) of take-all was present in the external check plots.

The original plan was for a six-year study, in which all rotations would return to wheat for comparison in the final year (1988). Loss of funding for this site in 1986 meant that studies would be terminated after 1986, so all plots were brought back to wheat for the fifth-year crop. This meant that the three-year rotation plots went into a repeat wheat crop (see Table 1).

In 1986, the two-year rotation plots (WRWRW) were in their third wheat crop and had take-all incidences of 2 percent to 4 percent, higher than in their previous wheat crop but still much lower than incidence (21 percent) in the continuous wheat plots (Figure 2). Yields in the two-year rotations were reduced by 1 percent to 9 percent versus 27 percent in the continuous wheat (Figure 3).

A dramatic increase in take-all was noticed in the second successive wheat crop on the three-year rotation plots (WRRWW). 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 indicate 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 percent and 16 percent in these two plots (Figure 3).

Among the row crop rotations used in this trial, it appeared 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.

	Treatment (crop sequence)					
Year	1 WWWWW	2 WFWFW	3 WCWCW	4 WBWBW	5 WCFWW	6 WCBWW
1982	Spring durum	Spring durum	Spring durum	Spring durum	Spring durum	Spring durum
1983	Spring durum	Sunflower	Corn	Soybean	Corn	Corn
1984	Spring durum	Spring durum	Spring durum	Spring durum	Sunflower	Soybean
1985	Spring durum	Sunflower	Corn	Soybean	Spring durum	Spring durum
1986	Spring durum	Spring durum	Spring durum	Spring durum	Spring durum	Spring durum

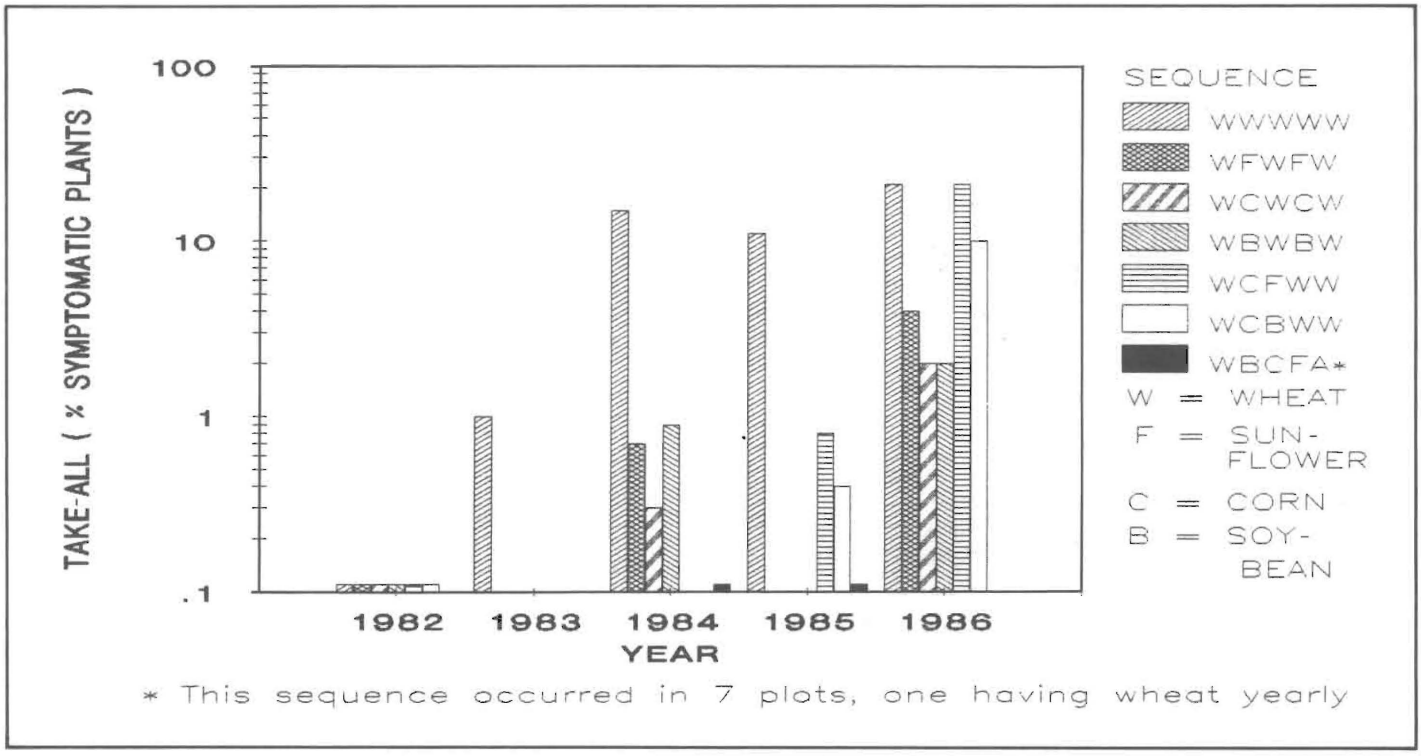

Figure 2. Effect of Seven Crop Rotations on Incidence of Take-All in Irrigated Durum Wheat.

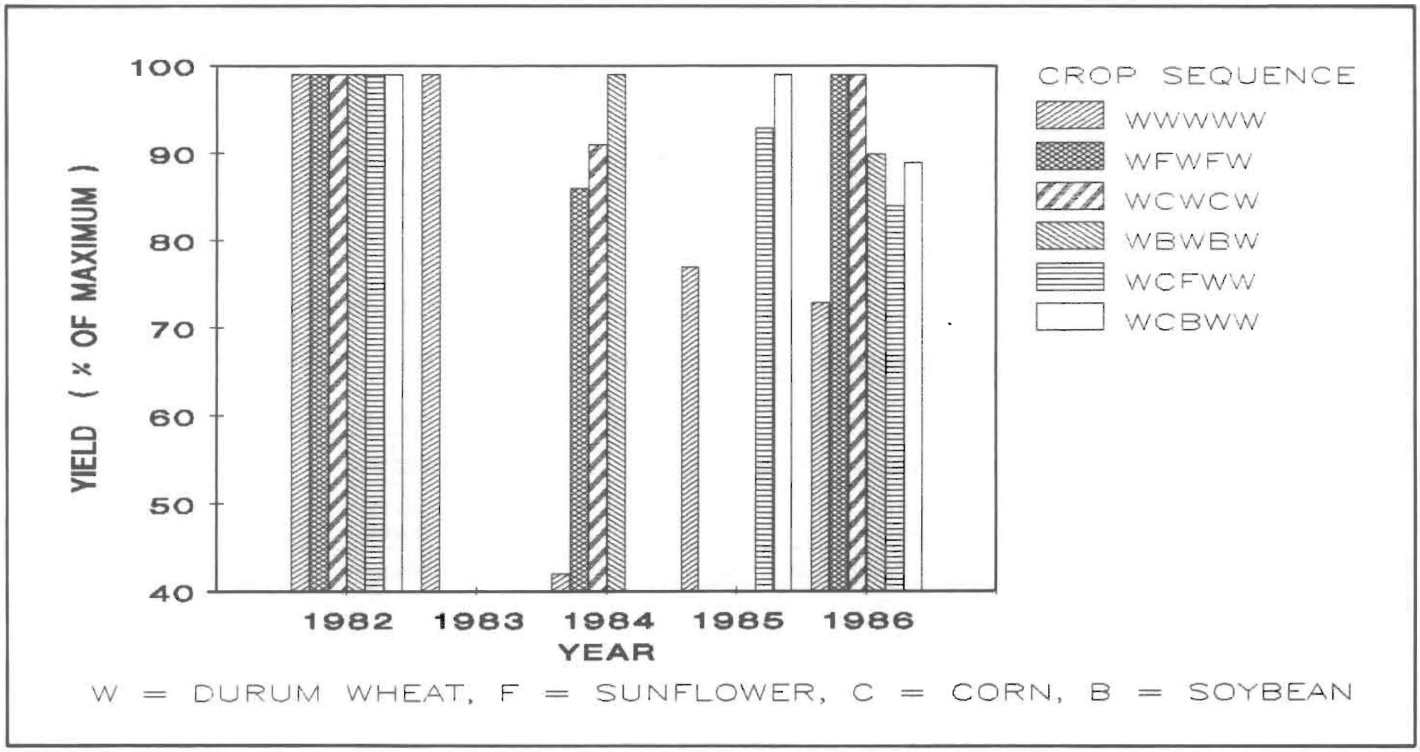

Figure 3. Yield of Irrigated Durum Wheat in Different Crop Rotations.

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.

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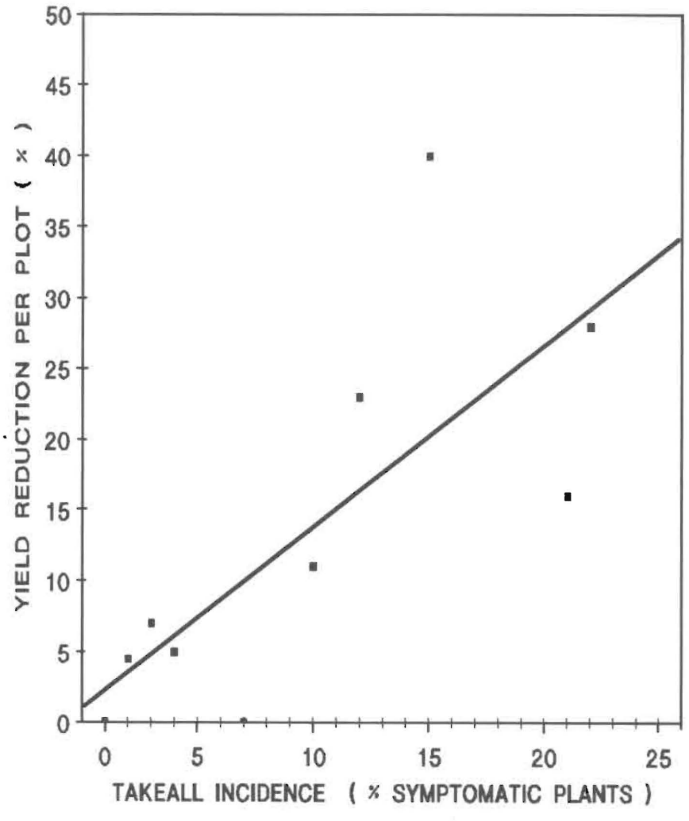

Figure 4. Relationship of Take-All incidence and Plot Yield Loss, 1986.

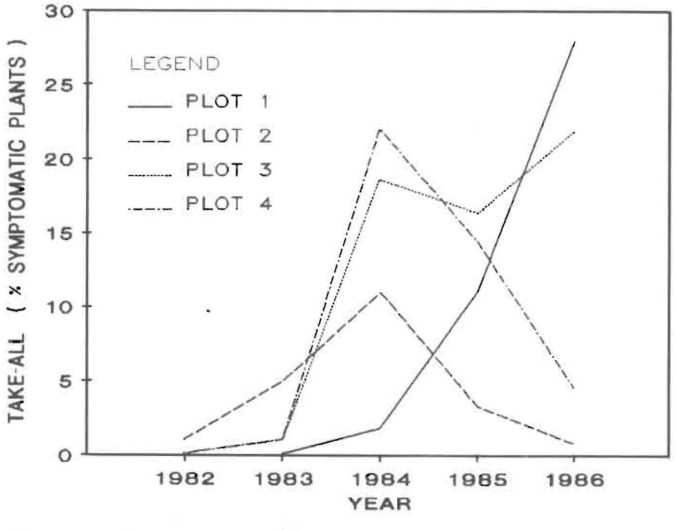

Figure 5. Take-All Decline in Individual Plots of Irrigated Durum Wheat Over Five Years.