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Combatting take-all of winter wheat in western Oregon

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Take-all disease of wheat is caused by the soil-borne fungus *Gaeumannomyces graminis* var. *tritici* (*Ggt*), which infects the roots, crown, and basal stem of plants. Take-all is common in western Oregon whenever consecutive crops of wheat are grown. Grain yield may be reduced by as much as 50 percent in second or third crops of winter wheat.

Symptoms are most obvious near heading and include stunting or uneven growth, poor tillering, blackened roots and crowns, premature ripening, and white heads with few kernels. Root systems of severely infected plants may be sparse, brittle, and exhibiting black lesions that extend to the crown and basal stem.

There are no economically effective fungicides and no varieties exhibit resistance to take-all. Where take-all is anticipated, disease control in winter wheat requires implementing specific soil and crop management practices beginning with planting and extending through early summer.

This publication identifies factors that influence the severity of take-all and recommends management practices to minimize losses to the disease in western Oregon. Management suggestions in *Recommendations* are based on more than 10 years of research and have been successfully implemented by growers.

Few if any corrective measures are available after identifying a severe take-all infestation. Growers should assess the risk of take-all and adopt a package of management practices to minimize yield losses when the risk of disease is high. *Disease development and management* provides data and details about management practices to slow take-all development and minimize yield losses.

Disease development and management

Soil temperature, soil water content, and soil and crop management practices influence take-all disease and associated yield losses in western Oregon. While weather conditions cannot be controlled, there

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are a number of management practices that can slow disease development and maintain grain yield. These include cropping history and rotation, weed control, stubble management, planting date, soil pH and liming, fall and spring fertilization, and control of other diseases. Management practices interact with environmental conditions, and each other, to determine the severity of take-all and the magnitude of yield loss. Since one or more of these factors may govern disease severity, we cannot always predict which factors will be most important in any given year.

Cropping history and rotation

Crop rotation is the best way to control take-all. The pathogen persists in infected host debris, which serves as the primary source of inoculum for infection of subsequent wheat crops. Survival of the fungus in the absence of a host is poor. A 1-year break from wheat or barley is usually sufficient to reduce the take-all risk to an insignificant level. Suitable break crops include oats, corn, beans, vegetables, oilseed crops, and annual legumes for seed.

The highest risk of take-all occurs when wheat is planted in consecutive years. Disease severity and yield loss can be substantial in second, third, and fourth wheat crops, with the worst take-all usually occurring in the third consecutive crop. Take-all becomes less severe, and yields usually increase, with the fifth or sixth successive wheat crop. This occurs because of a natural increase in soil microorganisms antagonistic to the pathogen—a phenomenon known as "take-all decline," which persists only so long as wheat is grown continuously.

Some growers have been caught off-guard by crop rotations that appear to be low-risk and yet unexpectedly develop severe take-all. One such rotation is winter wheat–sweet corn–winter wheat, in which volunteer wheat from the first crop is allowed to over-winter as a cover crop.

The 5-month break when corn is grown is insufficient to reduce the inoculum potential of the infested residue. The severity of take-all in the second crop of wheat can be comparable to that seen in second or third crops of continuous wheat.

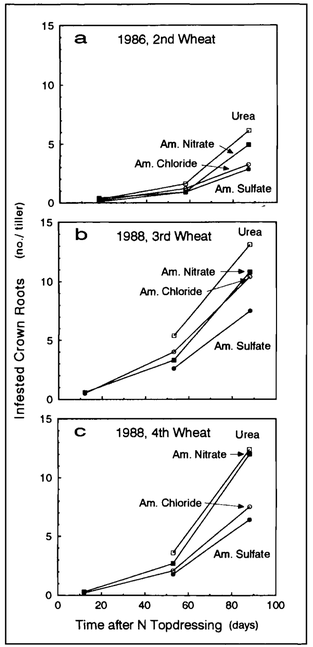

Figure 1.—*Severity of take-all as influenced by time after spring topdressing with urea, ammonium nitrate, ammonium chloride or ammonium sulfate on: (a) 2nd-year wheat in 1986, (b) 3rd-year wheat in 1988, and (c) 4th-year wheat in 1988. Nitrogen fertilizers were topdressed on March 1, + or – 7 days.*

Weed control and stubble management

The take-all fungus (*Ggt*) invades wheatgrass and quackgrass (*Agropyron* spp.), bromegrass (*Bromus* spp.) and bentgrass (*Agrostis* spp.), as well as wheat and barley. Like volunteer wheat or barley, grassy weeds can harbor the pathogen. These weeds may contribute to unexpected disease outbreaks when first-year wheat follows a legume crop infested with host grasses. Killing grassy hosts with tillage or herbicides within a few months of planting wheat may not reduce the risk of take-all since *Ggt* persists in host debris. We recommend advance, long-term control of grassy hosts for rotations including wheat.

Chopping stubble followed by plowing to a depth of 8 inches buries and reduces the size of host crop residues that serve as the primary inoculum source for subsequent crops. This delays or minimizes seedling infection and increases the probability that other control measures will slow disease progress. The impact of minimum-till or no-till on take-all has not been studied in western Oregon. However, data from other regions suggest a higher risk of take-all with reduced tillage.

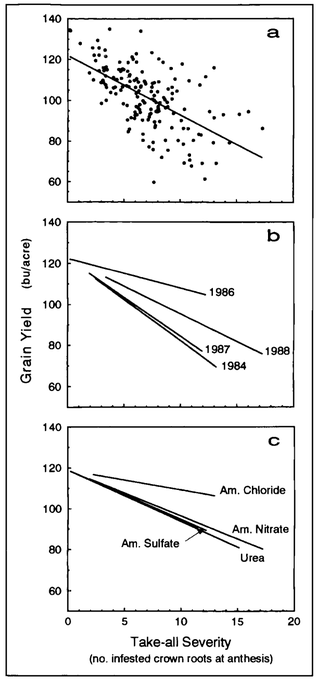

Figure 2.—*Winter wheat grain yield as influenced by the number of take-all infested crown roots at anthesis: (a) seven experiments in four seasons; (b) by year for ammonium nitrate, ammonium sulfate and urea treatments; and (c) by N fertilizer in 1986-88.*

Take-all development

Roots become infected as they grow through soil near infested debris and are colonized superficially before being penetrated by the fungus. Infection can occur throughout the growing season and is favored by moist soils having temperatures of 50 to 68° F. These conditions prevail for much of the growing season in western Oregon. Autumn and early-spring root infections are most likely to progress to the crown. Diseased crown roots usually increase exponentially from late February through late May in western Oregon.

Figure 1 illustrates this increase in disease severity. It shows that seasonal environment, nitrogen (N) fertilizer source, and number of years in wheat all affect the rate of disease development.

These results demonstrate the importance of adopting take-all control management practices far in advance of symptom development in any given year. At the time that N fertilizer should be topdressed in the spring for maximum benefit (Feekes Stage 5; approx. March 1), few if any crown roots are infected, and you cannot predict whether take-all will be mild (*e.g.*, 1986) or severe (*e.g.*, 1988).

Figure 1 also illustrates that the late-February choice of N fertilizer can make nearly a two-fold difference in the severity of take-all in late May. For example, 88 days after spring fertilization in 1988, plants fertilized with urea or ammonium nitrate had an average of 12 infected crown roots per tiller as compared to an average of 7 for plants fertilized with ammonium chloride or ammonium sulfate (figure 1**c**). Year-to-year rainfall and temperature differences and the choice of N fertilizer generally have greater effects on take-all severity than does the number of years wheat has been grown.

Yield loss to take-all

In western Oregon, the extent of crown-root infection at anthesis or flowering (late May) establishes the potential for take-all yield loss. Soils are generally dry enough by early June to arrest further development of the disease. Consequently, yield losses in any given year depend upon take-all severity at anthesis, weather conditions in June and July, and whether a chloride (Cl^-) containing fertilizer was applied in the spring.

These effects can be seen in Figure 2, illustrating the overall relationship between grain yield and disease severity at anthesis. It also shows the relationships for different seasons and different N fertilizers topdressed in late-February or early-March.

Figure 2**a** shows that for each take-all infested crown root per tiller, grain yield was reduced by 2.9 bu/acre on average. Thirty-five percent of the variability in grain yield in seven experiments over four crop-years was explained by the number of take-all infested crown roots at anthesis.

Up to 59 percent of the variability in grain yield was explained by taking seasonal variability (figure 2**b**) and N fertilizer source (figure 2**c**) into consideration. Regression lines in Fig. 2**b** show that maximum take-all severity was less in 1986 and 1987 than in 1984 and 1988.

Despite the similarity in maximum disease severity in 1986 and 1987, grain yield losses to take-all were much greater in 1987 (–3.8 bu/acre per infected root) than in 1986 (–1.5 bu/acre per infected root), probably because of higher summer temperatures and greater water stress on plants in 1987.

Similarly, figure 2**c** (and figure 1) shows that take-all severity was greater with urea and ammonium nitrate fertilizers than with ammonium chloride and ammonium sulfate fertilizers. Figure 2**c** also shows that yield losses to take-all were less when the crop was topdressed with a chloride containing fertilizer (–1.0 bu/acre per infected root) as compared to N fertilizers without chloride (–2.4 bu/acre per infected root). Apparently, chloride-fertilized plants have an increased tolerance to take-all.

Soil pH and liming

Increasing the pH of moderately acid soils through liming generally increases the severity of take-all and reduces grain yield (Table 1). Other management practices such as application of ammonium-N (NH_4^+) plus chloride in the spring are more effective in controlling take-all when soil pH is near 5.5.

In contrast, soils with pH 5.2 or less, especially those with low phosphorus (P) soil tests, may respond favorably to liming. Liming an acid, low-P Nonpareil soil (pH 5.2, 12 ppm P) increased yield of third-year wheat from 30 to 64 bu/acre and decreased the percentage of whiteheads (a symptom of take-all) from 63 to 14 percent. When pH-sensitive crops are grown in rotation with two or more years of wheat, lime should be applied after the last wheat crop is harvested.

Planting date

On well-drained valley-floor soils, delaying planting until late October can reduce early take-all infection of seedlings and increase grain yield, especially if other disease control measures are practiced (table 2). Be careful, however, because of the risk of fall rains. *Do not* delay planting on valley-floor soils with reduced drainage or on hill soils. A survey of 126 growers reporting results from 495 fields showed that planting after October 12 reduced yields by 14 to 26 bu/acre on hill or poorly-drained soils.

Fertilizer management

Nutrient deficiencies at any time during the growing season will increase the severity of take-all. Ensuring that N, P, sulfur (S), and potassium (K) are adequate at planting

Table 1.—*Liming (soil pH) and N fertilizer effects on winter wheat grain yield on moderately acid soils with a high risk of take-all.*

	Soil pH†			Soil pH‡		Soil pH¶	
Spring N source	5.5	6.0	6.2	5.5	6.5	5.5	6.0
	- - - - - - - - - - - - bu/acre - - - - - - - - - - - -						
Ammonium nitrate	n.a.	n.a.	n.a.	n.a.	n.a.	93	70
Ammonium sulfate	67	60	61	52	57	112	94
Ammonium chloride	85	75	65	70	56	114	96
LSD (P=0.05)		10		9		5	

† 'Hyslop' planted 27 Oct. 1977 on Willamette soil topdressed with 120 lb N/acre in spring 1978.
‡ 'Hill 81' planted 3 Nov. 1982 on Woodburn soil topdressed with 120 lb N/acre on March 15, 1983.
¶ 'Hill 81' planted 20 Oct. 1983 on Woodburn soil topdressed with 160 lb N/acre on March 6, 1984.

Table 2.—*Planting date and nitrogen source effects on winter wheat grain yield on two well drained soils with a high risk of take-all.*

	Willamette sl†		Woodburn sl‡	
Spring N source	4 Oct.	27 Oct.	15 Oct.	25 Oct.
	- - - - - - - - - -		bu/acre	- - - - - - - - - -
Ammonium sulfate	43	65	58	60
Ammonium chloride	56	76	67	80
LSD (P=0.05)	8	4	9	9

† 'Hyslop' winter wheat topdressed with 120 lb N/acre in spring of 1978.
‡ 'Stephens' winter wheat topdressed with 120 lb N/acre on March 16, 1981.

Table 3.—*Spring-topdressed N fertilizer effects on grain yield in 19 experiments.*

	Year of harvest (number of experiments)								
Spring N source†	1978 (2)	1980 (3)	1981 (3)	1982 (1)	1983 (1)	1984 (4)	1986 (2)	1988 (2)	1989 (1)
	- -	- -	- -	- -	-bu/acre‡	- -	- -	- -	- -
Urea	n.a.	n.a.	n.a.	n.a.	n.a.	111a	93a	86a	144ab
Am. Nitrate	n.a.	n.a.	n.a.	n.a.	85a	109b	94ab	93b	141ab
Am. Sulfate	54a	88a	66a	52a	106b	111a	99b	98b	138a
Am. Chloride¶	66b	107b	80b	70b	106b	111a	107c	116c	151b

† Topdressed at rates of 120 (1978, 1980, 1981), 125 (1983) or 160 lb N/acre (1984-89) by Feekes Stages 4 to 7.
‡ Within-column means followed by the same letter are not siginificantly different at P = 0.05. (For instance, 138a and 151b are not significantly different than 141ab, but they are signficantly different than each other.)
¶ Experimentally equivalent to ammonium sulfate (21-0-0) plus KCl (0-0-60) to supply at least 100 lb (Cl/acre.

Recommendations

Few if any corrective measures are available after identifying a severe take-all infestation. The following recommendations will minimize yield loss to take-all when successive wheat crops are planted for less than 5 years. Refer to "Disease Development and Management" for details, explanations, and data about management practices that slow take-all development and minimize yield loss.

Pre-plant management

Liming — A soil pH of 5.5 is desirable for combatting take-all. Apply lime only if the soil pH is 5.2 or less.

Stubble — Chop stubble and plow deeply to bury the inoculum.

Planting

Planting date — On well-drained valley-floor soils, delay planting until late October if possible. *Do not* delay planting beyond mid-October on hill soils or valley-floor soils with reduced drainage. For more information on wheat production on poorly drained soils, read FS 269, *Growing Winter Wheat on Poorly Drained Soil.*

Fertilization — Band 20 to 30 lb N/acre in ammonium form, 30 to 50 lb P_2O_5/acre, and 10 to 15 lb S/acre. Apply 25 to 30 lb K_2O/acre if a soil test indicates the need for K.

Growing season

Fertilization — Apply 140 to 180 lb N/acre as ammonium sulfate plus 100 lb Cl/acre as KCl before Feekes growth stage 5. Alternatively, apply 40 lb N/acre and 100 lb Cl/acre at late tillering (Feekes 4; mid-Feb.) and the remaining N within 3 to 4 weeks, but before jointing (Feekes 6). For more information on spring fertilization of wheat see FG 9, *Winter Wheat (Western Oregon).*

Weed Control — Control weeds to minimize competition with wheat for nutrients and moisture.

Disease Control — Control leaf diseases such as septoria and other root diseases by using resistant cultivars or fungicides to ensure maximum benefit from other aspects of this management plan to reduce yield loss from take-all. Read and follow fungicide label directions.

is especially important. Do this by banding N-P-S or N-P-K-S fertilizers with the seed when the risk of take-all is high.

Apply nitrogen in the ammonium form (NH_4^+), rather than as nitrate (NO_3^-), because NH_4^--N uptake reduces rhizosphere pH and favors growth of microorganisms antagonistic to the take-all fungus. Routinely apply P since P deficient plants are more susceptible to take-all, and infected seedlings have poorly functioning root systems.

When take-all is present, wheat will respond to banded P fertilizer on soils where no response would be expected in the absence of take-all. For example, grain yield increased from 56 to 65 bu/acre (LSD @ 5% = 7.3) when P was banded with the seed on a Willamette soil testing 125 ppm P. Sulfur is more often deficient for wheat in western Oregon than is K and should be routinely applied at planting.

As figures 1 and 2**c** show, spring-topdressed N fertilizers can influence the severity of take-all and, thus, grain yield (Table 3 on the preceding page). Yields are generally higher with ammonium chloride than with ammonium nitrate or urea. Ammonium sulfate (21-0-0) was common to all experiments and was assigned a relative value of 100 percent in calculating average relative yield for each N fertilizer.

On average, grain yield with ammonium nitrate (34-0-0) or urea (45-0-0) was slightly less (94 to 96 percent) than with ammonium sulfate. Fertilization with ammonium chloride, as compared to ammonium sulfate, significantly increased grain yield in seven of nine growing seasons for an average relative yield of 115 percent.

This compares favorably with results of a survey of 126 growers who reported average responses to chloride of 18 percent or 12 bu/acre. In research trials, test weight of wheat fertilized with ammonium chloride (59.7 lb/bu) was consistently higher than test weight of wheat fertilized with other N fertilizers (58.7 lb/bu).

Because ammonium chloride is no longer available in western Oregon, use ammonium sulfate *plus* potassium chloride (KCl) to supply ammonium-N and chloride. For comparable yield and test weight responses, sufficient KCl to supply at least 100 lb Cl/acre should be topdressed with ammonium sulfate. Ammonium-N and chloride should be applied by Feekes Growth Stage 5 if you are making only a single fertilizer application.

Control of other diseases

The effectiveness of crop and soil management to minimize yield losses to take-all is reduced when other plant diseases threaten the wheat crop. Common diseases that may need further control measures include strawbreaker foot rot caused by *Pseudocercosporella herpotrichoides* and septoria leaf and glume blotches caused by *Septoria tritici* and *S. nodorum*. Plants infested with take-all are commonly much more susceptible to Septoria.

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Goetze, N.R., M. Stoltz, and T.L. Jackson. 1981. *Growing winter wheat on poorly drained soil.* Oregon State University Extension Service, Fact Sheet 269. Corvallis, OR. No charge.

Hart, J., N.W. Christensen, T.L. Jackson, R. Karow, and W.E. Kronstad. 1989. *Winter Wheat (Western Oregon - West of Cascades).* Oregon State University Extension Service, Fertilizer Guide 9. Corvallis, OR. No charge.

Further reading

Asher, M.J.C., and P.J. Shipton (eds.). 1981. *Biology and Control of Take-all.* Academic Press Inc., New York.

Christensen, N.W., and M. Brett. 1985. *Chloride and liming effects on soil nitrogen form and take-all of wheat.* Agron. J. 77:157-163.

Christensen, N.W., M.A. Brett, and J.M. Hart. 1989. *Yield of take-all infested winter wheat as influenced by inhibiting nitrification with dicyandiamide.* Commun. in Soil Sci. Plant Anal., 20(19&20), 2137-2148.

Christensen, N.W., M.A. Brett, J.M. Hart, and D.M Weller. 1990. *Disease dynamics and yield of wheat as affected by take-all, N sources and fluorescent Pseudomonas.* Transactions, 14th International Congress of Soil Science, Vol. III:10-15, Kyoto, Japan, 12-18 Aug. 1990.

Christensen, N.W., R.L. Powelson, and M. Brett. 1987. *Epidemiology of wheat take-all as influenced by soil pH and temporal changes in inorganic soil N.* Plant and Soil, 98:221-230.

Christensen, N.W., T. Jackson, and R. Powelson. 1982. *Suppression of take-all root rot and stripe rust diseases of wheat with chloride fertilizers.* p. 111-116. *In* A. Scaife (ed.) Proc. 9th Int. Plant Nutrition Colloquium, Warwick, UK. 22-27 Aug. Warwick University, UK.

Christensen, N.W., R. Taylor, T.L. Jackson, and B. Mitchell. 1981. *Chloride effects on water potentials and yield of winter wheat infected with take-all root rot.* Agron. J. 73:1053-1058.

Mason, R., T.L. Jackson, and L.D. Calvin. 1991. *Supplementing experimental results with survey data.* J. Prod. Agric. 4:272-277.

Taylor, R., T. Jackson, R. Powelson, and N. Christensen. 1983. *Chloride, nitrogen form, lime, and planting date effects of take-all root rot of winter wheat.* Plant Dis. 67:1116-1120.

Wiese, M.V. 1987. *Compendium of wheat diseases*, 2nd edition. APS Press, St. Paul, MN.

The authors acknowledge the contributions of the late Thomas L. Jackson. For over 30 years, Dr. Jackson promoted Oregon agriculture through practical scientific endeavors as professor of soil science at Oregon State University. In 1976, Dr. Jackson observed that wheat plots fertilized with ammonium chloride were less affected by take-all than were plots fertilized with other nitrogen sources. This observation was the starting point for research that developed the management program described in this publication. This publication replaces FS 250.

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