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Effect of Crop Rotation on Take-all Root Rot of Wheat

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Beginning in the 1970s wheat:soybean double cropping became a favored row crop farming system in the Southeast. As wheat production increased, take-all root rot, caused by *Gaeumannomyces graminis* var. *tritici*, became a serious problem where wheat was grown for three or more consecutive years. Crop rotation is the main method to manage take-all. Research showed that fallow or oats in place of wheat were the only alternatives to wheat. Barley and rye are only mildly affected by the disease, but they maintain the fungus at a level that results in serious take-all damage when wheat is planted the next season. Soybeans maintain the fungus at a high level also. Sorghum as a summer crop reduced take-all in the following wheat crop. A project was started in 1994 to investigate alternative rotational crops in the wheat:soybean system that would contribute to control of take-all and provide a profitable and sustainable farming system. As part of an interdisciplinary approach, twelve long-term rotation sequences were established in replicated plots at the Southwest Branch Station at Plains. A winter rye cover crop killed in early March or canola were alternatives to wheat. Pearl millet for grain was grown in some rotations as an alternative to soybeans.

Plots showing rotations with wheat, canola and rye (left center). Healthy wheat at right. Wheat stunted and poorly tillered because of take-all (left).

Healthy wheat on right with dense stand and normal development of heads. Wheat with take-all on left. The number of tillers is reduced and many have died because water cannot move upward from rotted roots. Weeds are growing in area thinned by take-all.

Methods

Soil was infested with the take-all fungus at the start of the project to simulate continuous wheat production that resulted in a buildup of severe take-all. Plots were 1200 sq ft. Wheat was planted in early November and harvested in late May. Wheat samples were removed from random locations in plots and rated for root rot at late milk to early dough stage (early May) when symptoms were most severe. The number of tillers per meter of row was counted about two weeks before harvest. Grain yield components were determined from grain harvested from a 1000 sq ft area of each plot.

Results and Discussion

Results from the second year of the study are summarized here. Take-all caused severe damage and reduction in yield in rotations with continuous wheat. However, a one-year rotation with canola resulted in about a 50% reduction in root disease severity score compared with continuous wheat. Results from assays of take-all damage on wheat seedlings grown in soil collected from the field plots was similar. Wheat grain yield, test weight, and 1,000 kernel weight in rotations with canola were the same as yields from control plots where no take-all occurred. All yield components were greatly reduced in continuous wheat because of take-all damage (Table 1). Comparison of continuous wheat with soybeans or pearl millet as the summer crop did not show any differences in wheat yield components the first year. In the second season grain yield did not differ significantly, but test weight and 1,000 kernel weight were higher following millet (Table 1).

The study is now beginning its third year. Results similar to the first two seasons will be needed to draw firm conclusions. However, the results for rotation with canola are encouraging. A one year rotation with canola may be sufficient to reduce take-all damage to a low level. Canola has the potential to be a more profitable winter crop than oats or rye cover crop. More data are needed to determine if pearl millet can reduce take-all when planted in place of soybeans.

Table 1. Yield components and disease incidence and severity for Savannah wheat in response to crop rotation and take-all root rot. Plains, GA 1995-96

Rotation	Yield bu/A	Test weight lb/bu	1,000 kernel weight (g)	No. tillers per m	% infected plants	Disease severity (0-4)[‘]
1. W-S-W["]	3.9 b[*]	42.4 c	15.1 b	23 c	100 a	3.6 a
9. W-M-W	8.0 b	47.2 b	19.3 b	28 c	99 a	2.6 ab
10. W-M-R	-	-	-	-	59 b	0.6 c
11. R-M-R	-	-	-	-	46 b	0.5 c
3. C-S-W	46.8 a	55.4 a	27.6 a	61 a	72 ab	1.4 bc
8. C-M-W	41.8 a	56.0 a	29.2 a	54 a	54 b	1.2 bc
Control 1[’]	47.9 a	56.2 a	30.1 a	50 ab	13 c	0.1 d
Control 2[’]	44.5 a	55.6 a	27.9 a	47 b	9 c	0.1 d

" C = canola, M = pearl millet, S = soybean, and W = wheat. Canola and wheat are fall-planted crops; Pearl millet and soybean are summer crops.

* Means in columns followed by the same letter are not significantly different according to Duncan's New Multiple Range Test (P = 0.05).

’ 1 = Rotation 8 noninculated control; 2 = rotation 11 noninoculated control

‘ 0 = no disease; 4 = plants dead.

Disease Management for Wheat-Soybean Doublecropping Systems in the Southeast

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Wheat-soybean doublecropping became a major component of conservation tillage systems in the Southeast in the 1970s. Wheat is fall-planted after deep tillage followed by no-till planted soybeans as the summer crop. Reduced tillage retains wheat stubble on the soil surface, whereas incorporation of stubble into soil promotes breakdown of organic matter. Many pathogens survive in straw and root debris from the previous crop as long as the debris remains intact. A major concern was that leaving stubble on the surface maintained high populations of pathogens and concentrated them where the plants of the next crop emerged. Our conclusions about the effects of doublecropping and conservation tillage on wheat production in the Southeast are that reduced tillage has not caused a significant increase in diseases, but the lack of crop rotation as a result of continuous doublecropping has contributed significantly to disease problems.

The most important disease that developed from continuous doublecropping of wheat was take-all root rot. The causal fungus invades roots and crowns and eventually rots the base of the stem. As a result, infected plants wilt and die suddenly after flowering. Therefore, yield loss in affected areas is 100%. The fungus spreads only through movement of infested debris in soil. Therefore, the disease usually occurs in patches in the field. Conservation tillage did not result in a buildup of crop debris in the soil compared with conventional tillage. Because conventional tillage moved infested debris more, take-all was worse in conventionally tilled fields. Where wheat is grown as the only crop each year, such as in the western U.S. and Europe, take-all reaches a peak after several years then declines due to antagonistic microorganisms. In doublecropping systems with soybeans, this decline does not occur. Sorghum as the summer crop reduced take-all in a subsequent wheat crop compared with soybean as the summer crop. The difference is probably due to changes in soil populations of fungi and bacteria antagonistic to the take-all fungus. Barley and rye roots become infected with take-all, but the damage is much less than on wheat. The disease may not be noticeable on these crops. Our research has shown that if a field with take-all is planted to barley or rye, then planted again to wheat the next year, take-all is just as severe as when wheat is planted continuously. Although barley and rye are not damaged much, the fungus is able to maintain itself at a high enough level to severely damage wheat the next season. Oats is not infected by the strain of the fungus that infects other small grains. Therefore, it is the only small grain that can be planted between wheat crops to reduce take-all. We are investigating other rotations which include canola and grain pearl millet in place of wheat and soybeans for management of disease and insects of all the crops.

Wheat spindle steak mosaic virus was found for the first time in the southern U.S. as a result of continuous doublecropping of highly susceptible cultivars for three or more years. In replicated tests yield was reduced as much as 64% and test weight was below commercially acceptable levels. The disease is transmitted to roots by a soilborne fungus. The spread of the disease is similar to take-all. Crop rotation and planting resistant cultivars effectively control the disease.

Studies were conducted over three years to determine if increased populations of volunteer wheat in no-till planted soybeans affected severity of leaf and glume blotch and take-all in the next wheat crop. The fungi that cause both diseases survive on volunteers during the summer, but this did not result in greater disease or yield loss in a following wheat crop. Therefore, wheat volunteers at populations which do not compete with soybeans do not have to be eliminated.

Leaf rust and powdery mildew have not been affected by conservation tillage because they are not as dependent on crop debris for survival as other pathogens. Fusarium scab and Rhizoctonia bare patch diseases have increased in importance in other parts of the U.S. when conservation tillage was introduced for wheat production, but they have not increased in the Southeast.

In contrast to the situation with wheat diseases in conservation tillage systems, southern stem canker of soybean became more severe in no tillage than in conventional tillage. Disease severity was higher in a wheat-soybean doublecropping system than in a soybean-fallow system, but yield was not affected by cropping system. The disease can increase from a very low level to epidemic level in one year. Yield loss for susceptible cultivars is much greater under no tillage than for resistant cultivars. Therefore, crop rotation and resistant cultivars are important management strategies for control of stem canker.

Reference

Cunfer, B.M., and Rothrock, C.S. 1994. The influence of conservation tillage and double cropping practices on diseases of wheat in Georgia. Georgia Agricultural Experiment Stations Research Bulletin No. 418. 18 pp.

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