Effect of Twelve Crop Rotation Sequences on Take-all of Wheat

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ABSTRACT

Twelve double cropping sequences were established over a three year period which included wheat, rye, or canola as the fall-planted crop and soybean or pearl millet as the summer crop. *Gaeumannonmyces graminis* var. *tritici* was incorporated into soil prior to planting the first season's crop. Data were collected each season for incidence and severity of take-all and wheat yield components. Twice each year soil was collected from plots within each rotation. Wheat seedlings were grown in the soil in growth chambers. Take-all was severe in rotations with continuous wheat each year. Soybean or pearl millet had little effect on reducing take-all severity or yield loss in a subsequent wheat crop. A one year rotation with canola significantly reduced take-all incidence and severity. At the end of the second season, grain yield was similar to that in control plots with no take-all. Results from the third year of the study confirmed the results of the previous season. Results from seedling assays in growth chambers were similar to results from the field. Canola, a new winter cash crop in the Southeast, can be a valuable rotational crop for management of take-all in wheat. This research was funded by the Southern Region USDA Sustainable Agriculture Research and Education Program.

Introduction

Beginning in the 1970s wheat:soybean double cropping became a favored farming system in the Southeast. Wheat is fall-planted and soybean is planted with minimum tillage in early June. Take-all became a serious problem where wheat was grown for three or more years. Fallow or oats were the only crop rotation alternatives to wheat. Barley and rye grown for grain are only mildly affected, but they maintain *Gaeumannomyces graminis var. tritici* (Ggt) at a level that results in serious take-all damage when wheat is planted the next season (1). Sorghum as a summer crop reduced take-all in the following wheat crop, whereas soybean did not (2). A project was started in 1994 to investigate alternative rotational crops in the wheat:soybean system that would contribute to management of take-all and provide a sustainable farming system. Twelve rotation sequences were established at Plains, GA (Table 1). A winter rye cover crop killed in early March or canola were alternatives to wheat and pearl millet for grain was an alternative to soybean during the summer cycle.

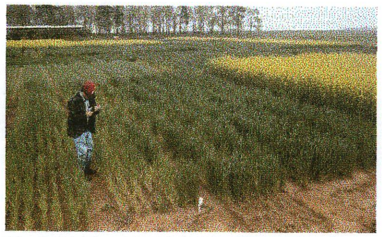
Methods

Soil was infested with Ggt at the start of the project to simulate continuous wheat with severe take-all. The twelve doublecrop rotations were planted in a randomized complete block with four replications (Table 1). Each plot was 1200 sq. ft. Wheat was planted in November and harvested in May. Number of tillers per m of row was counted and wheat tillers from random locations in plots were rated for root rot at late milk to early dough stage when symptoms were most severe. Grain yield components were determined; controls were harvested from a noninfested portion of eight plots. Twice each year soil was collected from each plot. Wheat seedlings were grown in this soil for 10 weeks at 18 C in growth chambers until take-all symptoms were moderate to severe in the continuous wheat treatments. Seedlings were rated for take-all incidence and severity. The results were compared to disease ratings from the field.

Table 1. Doublecropping rotation sequences

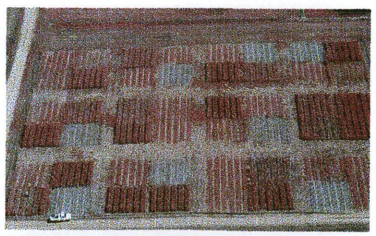
Rotation	1994-95	1995-96	1996-97
1	WS	WS	WS
2	CS	CM	CS
3	CS	WM	CM
4	CM	CS	WM
5	WS	CS	WM
6	RS	CM	WS
7	WS	CM	WS
8	CM	WM	WS
9	WM	WM	WM
10	WM	RS	CS
11	CS	WM	CS
12	RM	RS	WM

W=Wheat S=Soybean C=Canola
R=Rye M=Pearl Millet



Wheat plots at early heading stage showing stunting due to take-all. Canola is flowering in nearby plots.

Plot with continuous wheat:soybean rotation showing severe take-all damage. The portion of the plot on the right has little take-all damage because the soil was not infested with Ggt.



Aerial infrared photograph of all four replications of the test. Healthy wheat is deep red. Take-all areas within plots are dark. Wheat plots with intense red color show the effect of the canola rotation the previous year. The plot in the lower left is the same plot pictured on the left. Light red plots are canola. Grey plots are rye which has been killed.

Results

Take-all caused severe damage and reduction in yield in rotations with continuous wheat each year (Fig 1). A one-year rotation with canola resulted in 28-57% decrease in disease incidence and about a 50% reduction in disease severity compared with continuous wheat over two seasons. Wheat grain yield and number of tillers per m were the same following canola as in the control where very little take-all occurred both years (Fig 1). Test weight in rotations with canola and the control was the same both years and significantly higher than continuous wheat. Thousand kernel weight was greater in treatments following canola than those with continuous wheat in 1996 only (see Table in handout).

Test weight and 1,000 kernel weight were higher in the continuous wheat:millet rotation than continuous wheat:soybean in the second season, but millet did not reduce take-all incidence or severity and had no effect on grain yield either season compared with the control (Fig 2).

In 1997, rotation 12 with two previous years of rye cover crop had tillers per m row and grain yield which was the same as the control and significantly greater than the continuous wheat rotations. Disease incidence and severity did not differ from continuous wheat (see Table in handout).

Ratings of take-all damage on wheat seedlings grown in soil collected from field plots were similar to disease incidence and severity in the field. The results demonstrated the reduction in take-all when canola was part of the rotation (Table 2).

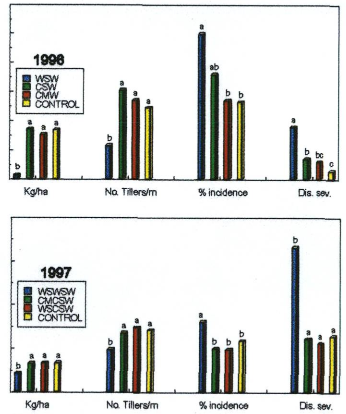


Fig1. Yield components and take-all damage in the continuous wheat:soybean rotation compared with two rotations in which canola was planted prior to wheat and the noninfested control. Canola reduced take-all damage so it was the same as the control. Data values are in the Tables in the handout.

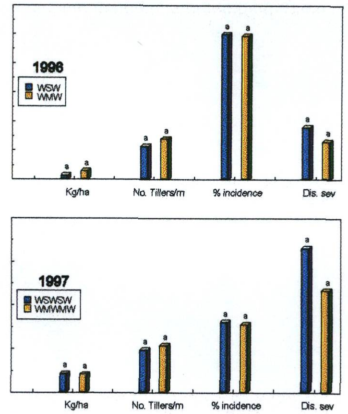


Fig2. Yield components and take-all damage in the continuous wheat:soybean rotation compared with continuous wheat:pearl millet. Take-all damage was the same in both rotations. Data values are in the Tables in the handout.

Table 2. Incidence and severity of take-all root rot on wheat seedlings grown in soil from plots with twelve crop rotation sequences. Plains, GA. 1994-96

Rotation		% plants with take-all	Disease severity (0-4)[x]	Rotation		% plants with take-all	Disease severity (0-4)
1	Wheat[y]	88 a	1.6 b	7	Wheat	99 a	1.7 a
	Soybean	96 a	1.6 b		Soybean	98 a	2.0 a
	Wheat	100 a	3.3 a		Canola	65 b	0.7 b
	Soybean	48 b	0.8 c		Millet	6 c	0.1 c
2	Canola	17 b	0.2 b	8	Canola	35 b	0.5 b
	Soybean	22 b	0.1 b		Millet	36 b	0.6 b
	Canola	60 a	0.7 a		Wheat	75 a	1.5 a
	Millet	1 c	0.01 b		Millet	34 b	0.5 b
3	Canola	29 b	0.4 b	9	Wheat	99 a	1.9 b
	Soybean	25 b	0.3 b		Millet	100 a	1.9 b
	Wheat	80 a	1.7 a		Wheat	100 a	3.2 a
	Millet	26 b	0.3 b		Millet	44 b	0.6 c
4	Canola	37 a	0.6 a	10	Wheat	78 a	1.3 b
	Millet	34 a	0.3 a		Millet	90 a	1.6 b
	Canola	41 a	0.4 a		Rye	100 a	2.7 a
	Soybean	7 b	0.1 a		Soybean	35 b	0.5 c
5	Wheat	100 a	1.9 a	11	Canola	16 b	0.2 b
	Soybean	69 a	1.7 a		Soybean	22 b	1.1 a
	Canola	79 a	1.1 a		Wheat	88 a	1.9 a
	Soybean	0 b	0.0 b		Millet	23 b	0.3 b
6	Rye	73 a	1.2 a	12	Rye	53 a	0.9 b
	Soybean	76 a	1.3 a		Millet	55 a	0.6 b
	Canola	30 b	0.3 b		Rye	95 a	2.5 a
	Millet	1 c	0.02 b		Soybean	20 b	0.3 b

[x] 0 = no disease, 4 = >75% of root system diseased.
[y] Soil collected from plots of the four crops in each group in March 14, 1995 (first line); August 30, 1995 (second line); April 18, 1996 (third line); and September 19, 1996 (fourth line).

Conclusions

A one year rotation with canola is sufficient to control take-all. The mode of Ggt suppression was not investigated, but glucosinolate compounds released by canola roots may play a role. Canola has the potential to be a more profitable winter crop than oats or rye cover crop. Pearl millet fits well into the rotation system, but it has no effect on take-all when planted in place of soybean. Sorghum is the only summer crop in doublecrop rotations in the Southeast known to suppress take-all (2). Two years of a rye cover crop resulted in tiller counts and yield the same as the control, but take-all incidence and severity was the same as in continuous wheat. A rye cover crop still maintains Ggt at a significant level. Therefore, its use for long-term management of take-all is questionable.

References

1. Rothrock, C. S., and Cunfer, B. M. 1991. Influence of small grain rotations on take-all in a subsequent wheat crop. Plant Dis. 75:1050-1052.

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This research was funded in part by the Southern Region USDA Sustainable Agriculture Research and Education program. Presented at the APS Annual Meeting, August 9-13, 1997, Rochester, NY. (Phytopathology 87:S21)

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In 1997, rotation 12 with two previous years of rye cover crop had tillers per m row and grain yield which was the same as the control and significantly greater than the continuous wheat rotations. Disease incidence and severity did not differ from continuous wheat (Table 3).

Ratings of take-all damage on wheat seedlings grown in soil collected from field plots were similar to disease incidence and severity in the field. The results demonstrated the reduction in take-all when canola was part of the rotation (Table 4).

Conclusions

A one year rotation with canola is sufficient to control take-all. The mode of Ggt suppression was not investigated, but glucosinolate compounds released by canola roots may play a role. Canola has the potential to be a more profitable winter crop than oats or rye cover crop. Pearl millet fits well into the rotation system, but it has no effect on take-all when planted in place of soybean. Sorghum is the only summer crop in doublecrop rotations in the Southeast known to suppress take-all (2). Two years of a rye cover crop resulted in tiller counts and yield the same as the control, but take-all incidence and severity were the same as in continuous wheat. A rye cover crop still maintains Ggt at a significant level. Therefore, its use for long-term management of take-all is questionable.

References

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9	WM	WM	WM
10	WM	RS	CS
11	CS	WM	CS
12	RM	RS	WM

W = Wheat S = Soybean C = Canola
R = Rye M = Pearl Millet

Table 2. Yield components of Savannah wheat in response to crop rotation and take-all root rot. SARE. 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)[z]
1 WSW[w]	3.9 b[x]	42.4 c	15.1 b	23 c	100 a	3.6 a
3 CSW	46.8 a	55.4 a	27.6 a	61 a	72 ab	1.4 bc
8 CMW	41.8 a	56.0 a	29.2 a	54 a	54 b	1.2 bc
9 WMW	8.0 b	47.2 b	19.3 b	28 c	99 a	2.6 ab
10 WMR					59 b	0.6 c
12 RMR					46 b	0.5 c
Control[y]	46.2 a	55.9 a	29.0 a	48 ab	11 c	0.1 d

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

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

[y] Rotation 8 and 11 noninculated control

[z] 0= no disease; 4=plants dead

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Table 3. Yield components and disease incidence and severity for Savannah wheat in response to crop rotation and take-all root rot. Plains, GA 1996-97

Rotation	Yield bu/A	Test weight lb/bu	1,000 kernel weight (g)	No. tillers per m	% infected plants	Disease severity (0-4)[z]
1 WSWSW[w]	29.5 b[x]	58.4 d	33.5 ab	49 b	81 a	1.66 a
4 CMCSW	45.1 a	59.7 abc	34.1 ab	68 a	50 b	0.61 cd
5 WSCSW	45.9 a	59.8 ab	32.3 b	74 a	49 b	0.56 d
6 RSCMW	44.5 a	60.2 a	35.7 ab	70 a	64 ab	0.86 bcd
7 WSCMW	42.3 a	60.2 a	35.8 ab	69 a	62 ab	0.79 bcd
8 CMWMW	27.1 b	56.0 a	34.3 ab	49 b	63 ab	1.10 bcd
9 WMWMW	28.4 b	47.2 b	34.2 ab	54 b	78 a	1.17 abc
12 RMRSW	41.1 a	58.6 cd	33.1 ab	69 a	80 a	1.22 ab
Control [y]	45.9 a	60.2 a	35.2 a	71 a	59 ab	0.64bcd

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

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

y Harvested from noninculated portion of plots in rotations 4 and 6

z 0 = no disease; 4 = plants dead.

Savannwh4.97

Table 4. Incidence and severity of take-all root rot on wheat seedlings grown in soil from plots with twelve crop rotation sequences. Plains, GA. 1994-96

Rotation	% plants with take-all	Disease severity (0-4)[x]	Rotation	% plants with take-all	Disease severity (0-4)
1 Wheat[y]	88 a	1.6 b	7 Wheat	99 a	1.7 a
Soybean	98 a	1.6 b	Soybean	98 a	2.0 a
Wheat	100 a	3.3 a	Canola	65 b	0.7 b
Soybean	48 b	0.8 c	Millet	6 c	0.1 c
2 Canola	17 b	0.2 b	8 Canola	35 b	0.5 b
Soybean	22 b	0.1 b	Millet	36 b	0.6 b
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Soybean	7 b	0.1 a	Soybean	35 b	0.5 c
5 Wheat	100 a	1.9 a	11 Canola	16 b	0.2 b
Soybean	89 a	1.7 a	Soybean	22 b	1.1 a
Canola	79 a	1.1 a	Wheat	86 a	1.9 a
Soybean	0 b	0.0 b	Millet	23 b	0.3 b
6 Rye	73 a	1.2 a	12 Rye	53 a	0.9 b
Soybean	76 a	1.3 a	Millet	55 a	0.6 b
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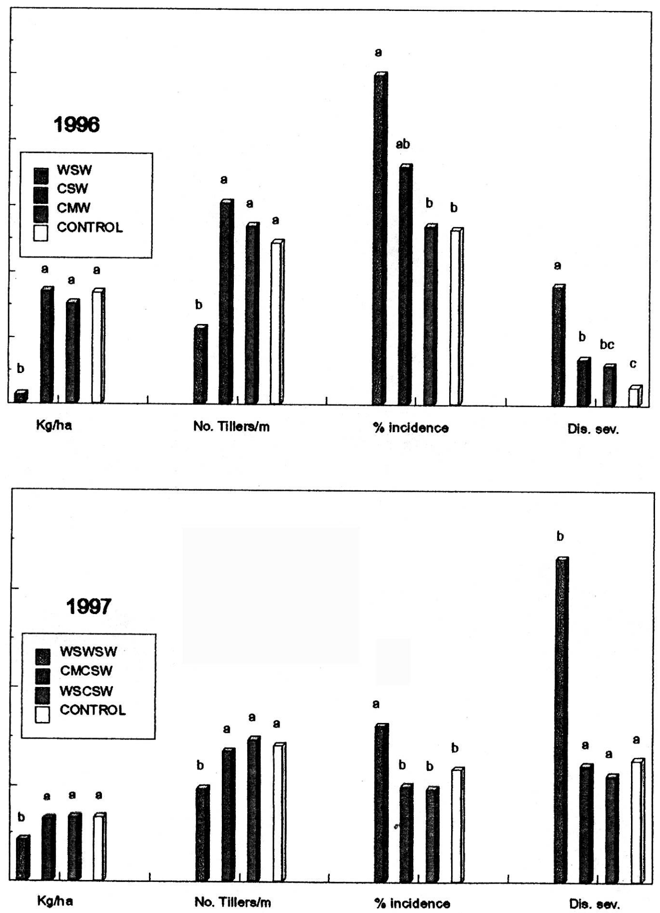

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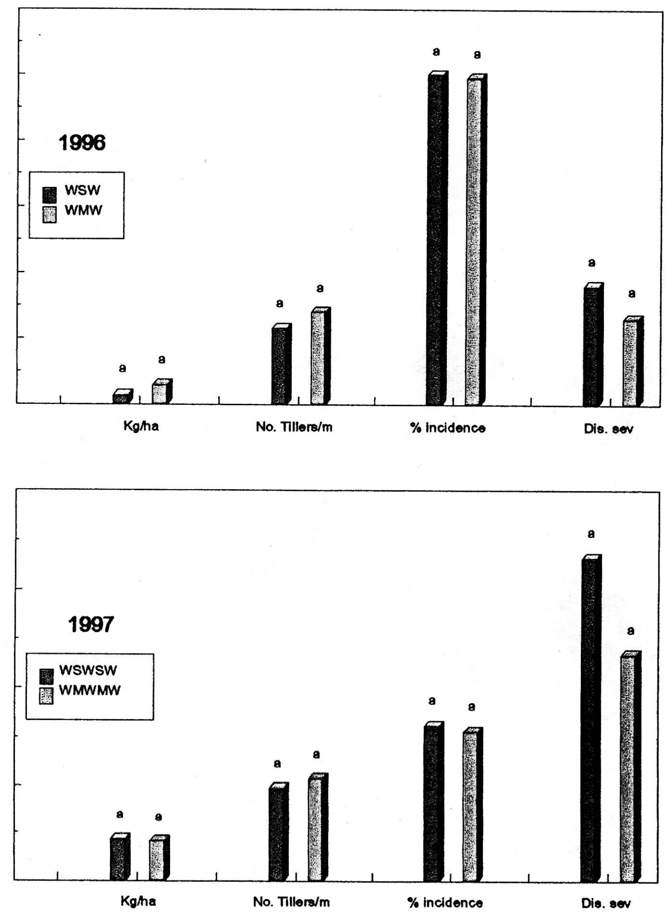

Fig2. Yield components and take-all damage in the continuous wheat:soybean rotation compared with continuous wheat:pearl millet. Take-all damage was the same in both rotations. Data values are in the Tables in the handout.