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EFFECTS OF BROILER LITTER AND GIN TRASH ON BLACK ROOT OF COTTON

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Abstract

Cotton in some poorly-drained Atlantic Coastal Plain Flatwoods soils is susceptible to black root (an abiotic disease). Those soils have greater concentrations of total salts and Cl than upland coastal plain soils. Affected cotton has black roots, mottled leaves, S-Shaped petioles, and flowers with a protruding stamen that retains little pollen. When the disease is severe, plant growth, development, and lint yield are limited. Applications of broiler litter (manure + bedding) are effective in increasing lint yield in affected soils, but inorganic fertilizers are not. The objectives of studies reported here were to determine the length of time an application of broiler litter is effective, to elucidate the effective ingredient in litter, and to determine if other amendments are effective. Field research at four locations indicated that an application of 4 tons of broiler litter/acre is effective in maintaining yield for 2 years (crops). Field research also indicated that an application of 6 ton of well decomposed gin trash increased lint yield in the current year, even though gin trash did not appear effective in a greenhouse experiment. Increasing irrigation water salt and chloride concentrations decreased cotton growth and boll weight in the greenhouse. Broiler litter and leachate from broiler litter greatly increased growth, boll weight and boll count, while gin trash, broiler feed, and cow manure had some positive effects. Inorganic ammonium-N and nitrate-N did not diminish black root or affect growth or yield of cotton. The "active" ingredient in broiler litter was shown to be in the manure not in the pine shaving bedding material. It is in a water soluble fraction of the litter and appears to have its origin in broiler feed. Black root remains a disease with an unclear cause and one practical solution (broiler litter). At the present time, the best practical recommendation is to apply 3 to 4 tons of broiler litter/acre every 2 years to fields in the flatwoods that have a history of black root. The reason that broiler litter is effective remains unknown.

Introduction

Cotton in the some poorly drained Atlantic Coastal Plain Flatwoods soils is susceptible to black root (an abiotic disease, associated with soils containing concentrations of total salts and Cl greater than in upland coastal plain soils (Table 1). Affected cotton has black roots, mottled leaves, S-shape petioles and flowers with a protruding stamen that retains little pollen. When the disease is severe, little or no lint yield is obtained (Table 2). Literature indicates that established cotton is tolerant of high concentrations of salts and chlorides, but fairly intolerant in the seedling stage. Tan and Shen (1993) indicated that Cl concentration of 100 to 200 ppm can injure seedling cotton plants. However, Neither salts nor Cl per se have been proved to cause black root in cotton. Applications of broiler litter (manure + bedding) were effective in correction of the malady. Field research in 2000-2001 indicated responses averaging 507 and 678 pounds of lint/acre for applications of 2 and 4 tons of litter/acre, respectively. Mean leaf N concentration in June 2001 was 5.3 ppm for control plots and 4.5 ppm for plots that had received either rate of broiler litter. High N concentrations in leaves of cotton receiving no broiler litter provided some suggestion that N assimilation may be interfered with in plants affected by black root. Residual broiler litter from an application made to the previous crop also appeared to be effective in one experiment in 2001 (Table 3). Neither high rates of N, P, K, nor applications of Cu, Zn, B, or Mo were effective (Tables 2 and 3). The objectives of this research were to determine the length of time that a single application of broiler litter is effective in alleviating black root, to determine if gin trash could alleviate black root, and to determine the ingredient(s) in broiler litter responsible for its effectiveness in alleviating black root symptom and increasing lint yield.

Materials and Methods

Experiments were conducted in fields affected by black root and in a greenhouse employing soil from a Taylor Farm field that was greatly affected by black root. Data from all experiments were submitted to analysis of variance and means were separated by Fisher's Protected LSD (p =0.05).

Field Experiments

Small plot experiments were conducted at four locations in the flatwoods in 2002. All had four replications and were fertilized with commercial inorganic fertilizers according to University of Georgia recommendations from soil tests. No broiler litter was applied to plots that received broiler litter in 2000 and 2001. However, adjacent plots received either 2 or 4 ton/acre in 2002 and the control plots that never received broiler litter were maintained. Other plots received 6 ton/acre of gin trash (Table 4). Leaf and root samples were obtained at first flower and analyzed for N, C, S, P, K, Ca, Mg, Zn, Cu, and Cl. Due to exceptional soil moisture in the harvest season, we estimated lint yield by counting bolls and hand picking and weighing 10 representative bolls/10 ft. of row.

Greenhouse Experiments

Greenhouse studies were conducted from October 2001 to May 2002. For all experiments we filled 2 gal. pots with equal weights of soil from the control (no amendment) plots from the Taylor Farm (Table 1). We planted six DPL 33B seeds in each plot and thinned the stand to three upon establishment. Twelve hours of light and 80° F was maintained in all greenhouse experiments. Except where noted otherwise, all pots were fertilized on a biweekly schedule and the total fertilization, accomplished in 8 weeks, amounted to double the rate of the fertilizer recommended by soil test.

The objective of the first study was to determine the effects of added NaCl on black root symptoms and to determine if the form of N supplied had any effect. In this experiment, the base fertilizer included no N. The main treatments were irrigation solutions of 0, 50, and 100 μ molar NaCl (Table 5) and the subtreatments were four inorganic N sources and broiler litter (Table 6). The broiler litter was mixed with the soil 2 weeks prior to seeding at an equivalent rate of 4 ton/acre; a rate that supplies approximately 136 lb available N/acre. The inorganic N sources were applied in 4 equal doses of solutions at 2, 4, 6, and 8 weeks following emergence. Plant top and root weights were obtained at 8 weeks following emergence. Total soluble salts, Mehlich-1 extractable Na and 0.1M $NaNO_3$ -extractable Cl concentrations were made on soil samples collected in each pot at the termination of the experiment.

The objective of the second experiment was to determine if the ingredient associated with alleviation of black root was in the broiler manure or in the pine sawdust bedding material. Equivalent weights of 6 ton/acre of litter and pine sawdust were applied (Table 7). Plant top and root dry weights were determined at 8weeks following emergence.

In a third experiment, the objectives were to determine if cow manure and gin trash had any effect on elimination of black root, to determine if the "active" ingredient in broiler litter was in broiler feed and if it is water soluble, and to determine if leaching or autoclaving soil prior to seeding helps alleviate the detrimental effects of black root. In this experiment the amendments were made at 6 ton/acre equivalent rates (Table 8). The leachate from broiler litter was obtained from the leaching, with tap water, the equivalent of 6 ton broiler litter/acre. The leachate was applied in 4 equal applications at 2, 4, 6, and 8 weeks following emergence. Boll counts and top, root, and boll dry weights were obtained at physiological maturity.

Results and Discussion

Field Experiments

Lint yield responded well to broiler litter applications in 2002 as in previous years (Table 4). When no amendment was supplied, mean yield at 4 locations was 374 lb lint/acre, with a range from 0 to 741 lb lint/acre. Two tons of litter/acre increased lint yield by greater than 200 lb, but not significantly at the Kent Farm. Four ton of broiler litter significantly increased lint yield at all locations, with a mean increase of 402 lb/acre. Gin trash application did not increase lint yield at the Kent Farm, but 6 ton/acre resulted in increased at the other farms. Mean increase from 6 ton gin trash was 227 lb lint/acre. Responses to broiler litter applications prior to 2002 were of particular interest in the 2002 research. Application of 2 ton broiler litter in 2001increased lint yield at three Farms, but not at the Kent Farm. Mean increase due to 2 ton of litter in 2001 was 271 lb lint/acre. The application of 4 ton of broiler litter/acre in 2001 increased yield at all Farms by a mean of 388 lb lint/acre. Broiler litter applied at either 2 or 4 ton/acre in 2000 had no effect on lint yield in 2002 at the Kent Farm. It appears that black root can be controlled well by 4 ton/acre applications of broiler litter every other year. In this research the effect was not diminished until the third year following application. Heavy applications of well- decomposed gin trash also appear to have some merit for increasing yield in black root-affected fields. Application of 6 ton/acre had some positive effect, but not as great an effect as 4 ton of broiler litter. Research is needed to determine if greater rates of gin trash could be substituted for broiler litter applications.

Greenhouse Experiments

Soil from the Taylor Farm had a chloride concentration greater than 100 ppm (Table 5). Tan and Shen (1993) indicated that such concentrations can harm seedling cotton. Increasing salts, by irrigating the pots with NaCl solutions resulted in greatly decreased boll weight/pot. Because there was no interaction between irrigation salt concentrations and the form of N supplied and because of the great detrimental effect of salt or chloride, top and root dry weights for only the 0 μ molar salt treatment are provided in Table 6. Application of 6 ton equivalent of broiler litter resulted in approximately 8 times more dry weight than when either no N was applied or N was supplied as ammonium, nitrate or ammonium nitrate. These data suggest that application of inorganic N is not effective in these soils and the black root problem can not be corrected by changes in the N form used in commercial fertilizers. Previous studies indicated that plant N concentrations are less in plants in plants receiving broiler litter, possibly suggesting that N assimilation is inhibited without broiler litter and that broiler litter enhances N assimilation.

In a separate experiment , it was shown that the positive top and root growth responses from broiler litter are due to the manure and not from the sawdust bedding material (Table 7).

Increases in plant growth and yield were recorded due to broiler litter, leachate from broiler litter, and cow manure in a greenhouse study (Table 8). There also was some indication that broiler feed was beneficial as an amendment. Leaching or autoclaving soil prior to seeding or applying gin trash did not increase growth. Only broiler litter and the leachate from broiler litter increased boll dry weight and boll count significantly. No bolls were produced for any of the other treatments. Data from this experiment indicate that the ingredient in broiler litter that is active in reducing the effects of black root is water soluble and that the ingredient is likely also in cow manure and broiler feed. The lack of any response following a thorough leaching of the soil suggests that salts or chloride may not be the cause of low yield. Likewise microbiological effects do not appear to be the cause of cotton failure, as autoclaving the soil prior to seeding had no effect.

Reference

Tan, N. X. and J. X. Shen. 1993. A study on the effect of Cl on the growth and development of cotton. Soil Fertil. (in Chinese) 2:1-3. from Xu et al. 2000. Advances in chloride nutrition, p 97-150 *In* Sparks, D. L. (ed) Advances in Agronomy 68, Academic Press, San Diego, CA.

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Table 1. Chloride concentrations and total chlorides to a depth of 36 inches in soils that have a history of black root.

		Chloride	
Farm	**County**	**Mean ppm**	**Total lb/acre**
Rentz	Appling	58	522
Altman	Appling	58	522
Williams	Jeff Davis	44	396
Taylor	Cook	72	648
Kent	Berrien	52	468

Table 2. Lint yields in field experiments as affected by broiler litter and foliar nutrients in 2001.

	Treatment				
Farm	**Control**	**2 T litter/A**	**4 T litter/A**	**0.5 lb Cu/A**	**1.0 lb Zn/A**
	---------------------------------lb lint/acre-----------------------------------				
Rentz	481 b[a]	1062 a	1236 a	537 b	438 b
Altman	722 cd	1257 b	1692 a	909 c	604 d
Williams	658 b	1096 a	1115 a	653 b	468 b
Taylor	0 b	838 a	972 a	247 b	165 b
Kent	595 b	738 ab	832 a	593 b	513 b
Mean	491 C[b]	998 B	1169 A	588 C	438 C

[a] Farm values in a row followed by a common lower case letter are not different by Fisher's Protected LSD (p=0.05).
[b] Mean values in the last row followed by a common upper case letter are not different by Fisher's Protected LSD (p=0.05).

Table 3. Lint yields in 2001 as affected by residual broiler litter (applied in 2000), 10-10-10, and foliar B at the Kent Farm.

Treatment					
Control	**2 T litter/A**	**4 T litter/A**	**700 lb 10-10-10 A**	**1400 lb 10-10-10 A**	**0.5 lb B/A**
----------lb lint/acre----------					
595 b [a]	701ab	956 a	531 bc	462 bc	363 c

[a] Values followed by a common letter are not different by Fisher's Protected LSD (p=0.05).

Table 4. Lint yields in field experiments as affected by broiler litter (BL) and gin trash applied in 2002 and by residual broiler litter, applied in 2000 and 2001.

	Farm				
Treatment/acre	**Rentz**	**Williams**	**Taylor**	**Kent**	**Mean**
	----------lb lint/acre----------				
Control	342 b [a]	741 b	000 b	413 cd	374 c
2 ton BL in 2002	nt[b]	nt	nt	632 abc	
4 ton Bl in 2002	912 a	884 a	579 a	729 a	776 a
2 ton gin trash in 2002	nt	nt	nt	456 bcd	
4 ton gin trash in 2002	nt	nt	nt	478 abcd	
6 ton gin trash in 2002	715 a	830 a	351 a	509 abcd	601 b
2 ton BL in 2001	760 a	869 a	443 a	509 abcd	645 ab
4 ton BL in 2001	945 a	884 a	529 a	688 ab	762 a
2 ton Bl in 2000	nt	nt	nt	357 d	
4 ton BL in 2000	nt	nt	nt	543 abcd	

[a] Values in a column followed by a common letter are not different by Fisher's Protected LSD (p=0.05).
[b] Treatments were not applied.

Table 5. Effect of salt additions on total dissolved salts (TDS), Mehlich-1 extractable Na, 0.1 M extractable Cl, and cotton boll weight in the greenhouse using soil from the Taylor Farm.

NaCl solution	**TDS**	**Na**	**Cl**	**Boll weight**
μ Molar	------mg/kg------			g/pot
0	343 c [a]	191 c	102 c	14.36 a
50	1191 b	1078 b	536 b	6.31 b
100	3192 a	2814 a	1429 a	0.00 c

[a] All values in column are different by Fisher's Protected LSD (p=0.05).

Table 6. Effect of nitrogen source on cotton growth in the greenhouse using soil from the Taylor farm.

Nitrogen source [a]	**Top weight**	**Root weight**
	------g/pot------	
None	3.1 b [b]	0.3 b
Ammonium	2.8 b	0.3 b
Nitrate	3.2 b	0.3 b
Ammonium nitrate	3.3 b	0.3 b
Broiler litter	24.4 a	2.4 a

[a] N rate for inorganic sources was 136 lb/acre and was equal to the shot-term available of N in the 4 ton/acre broiler litter application.
[b] Values in a column followed by a common letter are not different by Fisher's Protected LSD (p=0.05).

Table 7. Effects of 6 ton broiler litter/acre and 6 ton bedding material/acre on growth of cotton in the greenhouse using soil from the Taylor Farm.

Amendment	Top weight	Root weight
	--------------g/pot------------	
Sawdust	0.6 b [a]	0.05 b
Manure and sawdust	4.1 a	0.26 a

[a] Values in a column followed by a common letter are not different by Fisher's Protected LSD (p=0.05).

Table 8. Effect of several amendments on plant and boll weights of cotton grown in the greenhouse using the Taylor farm soil.

Amendment [a] or Treatment	Top dry weight	Root dry weight	Boll dry weight	Boll count
	--------------------g/pot---------------			number/pot
Control	4 c [b]	0.4 c	0 b	0 b
Broiler litter	48 ab	3.9 ab	43 a	13 a
Leachate from broiler litter [c]	62 a	4.6 a	60 a	17 a
Cow manure	58 a	4.6 a	7 b	4 b
Gin trash	6 c	0.4 c	0 b	0 b
Broiler feed	22 bc	1.8 bc	17 b	5 b
Leached soil	4 c	0.4 c	0 b	0 b
Autoclaved soil	10 c	0.9 c	0 b	0 b

[a] Amendments incorporated into soil at rate equivalent to 6 ton/acre.
[b] Values in a column followed by a common letter are the same by Fisher's Protected LSD (p=0.05).
[c] Leachate from 6 ton/acre equivalent of broiler litter.