REPORT OF THE COTTONSEED TREATMENT COMMITTEE FOR 2019

H. M. Kelly
R. Guyer
S. Pate
WTREC – The University of Tennessee Institute of Agriculture
Jackson, TN
T. W. Allen
T. Wilkerson
Delta Research and Extension Center - Mississippi State University
Stoneville, MS
P. D. Colyer
LSU AgCenter
Bossier City, LA
T. Isakeit
Texas A&M University
College Station, TX
R. C. Kemerait
University of Georgia
Tifton, GA
K. S. Lawrence
Auburn University
Auburn, AL
H. L. Mehl
Tidewater Ag Res & Ext Ctr - Virginia Tech
Suffolk, VA
P. Price
LSU AgCenter - Northeast Region
Winnsboro, LA
A. Rojas
University of Arkansas
Fayetteville, AR
L. Thiessen
North Carolina State University
Raleigh, NC
T. Wheeler
Texas A&M AgriLife Research
Lubbock, TX

Abstract

The 2019 National Cottonseed Treatment Program evaluated cotton seedling survival for a number of fungicide seed treatment combinations over diverse environmental conditions and populations of cotton seedling pathogens. Eleven fungicide seed treatments were nominated by chemical industry representatives for evaluation in 2019, along with 4 control-check treatments.

All seed treatment fungicides, except the metalaxyl-only treatment, improved stands of cotton compared to a non-treated control across all 12 locations. Data across all locations indicate the nominated treatments 9 (Apron XL, Maxim, Rally, and Vibrance CST [lower rate]) and 14 (Allegiance FL, Evergol Prime, Fluoxastrobin FS 480, Evergol Extend, Proline 480 SC, and Spera) protected the greatest number of seedlings. Although, treatments that best protected seedlings varied by location and only at 50% of the locations (6 locations: AL, AR, LA1, TN, TX1, TX2) did treatments significantly improve stand over the check(s). In addition to treatments 9 and 12, treatments 5 (myclobutanil, metalaxyl, and fludioxonil), 7 (pyraclostrobin, fluxapyroxad, metalaxyl, and myclobutanil), 10 (Apron XL, Maxim, Rally, and Vibrance CST [higher rate]), and 12 (metalaxyl, penflufen, fluoxastrobin, prothioconazole, and myclobutanil), significantly protected stand over check(s) within at least one location.

Isolations of *Fusarium* spp. were the greatest, with an average isolation rate at 92% and only the AL and AR locations having less than 90%, although many of the species of *Fusarium* isolated may be non-pathogenic. *Thielaviopsis basicola* isolations had the greatest range from 0 to 100% (with 48% average), while *Pythium* spp. isolations ranged from 0 to 67% (26% average). *Rhizoctonia solani* was isolated from soil from every location, at relatively high levels with the number of propagules/100 cm^3 ranging from 12.2 to 33.1 (26.8 average). The varied levels of pathogen isolations generally explain the stand response to fungicide treatments. For example, the TX2 location had high levels of *Pythium* spp. (40% isolation frequency) and relatively lower *R. solani* levels (24.5 propagules/100 cm^3) which aligns with the non-treated check and penflufen-only treatments (no protection from *Pythium* spp.) having the lowest stand establishment and the metalaxyl-only treatment (protection from *Pythium* spp.) having significantly greater stand establishment. These regional studies confirm the importance of IPM strategies for seedling diseases, the value of fungicide seed treatments, and the continued improvement of seed treatment chemistries as well as increased knowledge regarding soilborne pathogens.

Introduction

The National Cottonseed Treatment Program evaluates cotton seedling survival for a number of fungicide seed treatment combinations that are nominated by chemical industry representatives over diverse environmental conditions and populations of cotton seedling pathogens. Unfortunately, neither of the historical standard fungicide treatments, Vitavax-PCNB + Allegiance nor RTU Baytan-Thiram + Allegiance, were able to be included in the 2019 trials, but a new standard was evaluated beginning in 2018 and in 2019 that included Alleigance + EverGol Prime + Spera + Proline. A non-treated control (insecticide –only) was included to assess efficacy of the fungicide treatments and seedling disease pressure. Allegiance (metalaxyl-only) and EverGol Prime (penflufen-only) were also included to aid in determining the importance of *Pythium* spp. and *Rhizoctonia solani*, respectively. Disease ratings and pathogen isolations for seedlings and soil populations of selected soilborne genera were conducted by collecting seedlings and soil from the nontreated control plots at each location. Soil temperature and plant development data were also collected for each location included in the 2019 National Cottonseed Treatment Program.

Materials and Methods

Fungicide treatment

Acid-delinted seed of *Gossypium hirsutum* L. cv 'DP 1522 B2XF' were provided by Monsanto, St. Louis. Fungicide treatments were mixed with Color Coat Red (1 oz/cwt) and Gaucho 600 (16 oz/cwt) (Bayer Crop Science) in a total slurry rate of 30 oz/cwt (i.e. the amount of water added to each treatment was adjusted to have a 30 oz/cwt slurry). Water, Gaucho 600, and dye also were applied to the non-treated check at the same rate. Treatments were applied to the cottonseed while the seed mixed in a Kobalt 4-cu ft 0.5-HP Cement Mixer (model # SGY-CM1) used as a Liquid Seed Treater. When two or more fungicides were applied, the fungicides were mixed and applied in a single application. The technical information for the fungicide treatments is provided in Table 1. Seed germination was evaluated for all treated and non-treated seed by rolling seed in moistened germination paper and incubating for 3 days at 30ºC.

Field experiments

Twelve field trials were conducted by 12 cooperators across the U.S. Cotton Belt (Table 2). Each location utilized a randomized complete block experimental design, with the number of replications ranging from 3 to 5. The stand counts used in the analyses were taken from 28 to 41 days after planting, averaging 32 days after planting. A soil sample and ~100 seedlings were collected from plots containing non-treated seed and were collected from 28 to 41 days after planting, averaging 32 days after planting. Soil and seedlings were placed in insulated packages with refrigerated cool packs and mailed overnight to the West Tennessee Research and Education Center for processing. A subsample of soil from each location was sent to Dr. T. L. Kirkpatrick, Southwest Research and Extension Center, Hope, Arkansas, for determination of populations of plant parasitic nematodes. Soil moisture and temperature data were obtained from WaterScout SM100 soil moisture and external temperature sensors connected to WatchDog 1200 micro stations (Spectrum Technologies, Aurora, IL), or the nearest weather station (National Weather Service) (see Table 2).

Isolations

Seedlings were evaluated for growth by recording the number of nodes from five arbitrarily selected seedlings and the aboveground portions of all seedlings were removed and discarded. Seedlings were then rinsed for 20 minutes in running tap water. Approximately 50 seedlings were rated for disease symptoms. The hypocotyl disease severity index

was 1=no symptoms, 2=few pinpoint lesions or diffuse discolored areas, 3=distinct necrotic lesion, 4=girdling lesion, and 5=seedling dead. The root disease index was 1=no symptoms, 2=1-10% of the root system discolored, 3=11-25% of the root system discolored, 4=26-50% of the root system discolored, 5=51-75% of the root system discolored, and 6>75% of the root system discolored.

Of the 100 seedlings sampled from nontreated plots, 60 were rinsed under tap water for 20 minutes to dislodge soil debris. A subset of twenty seedlings were plated onto *Pythium* selective media, P_5ARP (Jeffers and Martin, 1986), and *Fusarium* selective media, MGA (Castellá et al., 1997). The remaining 20 were surface sterilized by immersion for 1.5 min in 10% NaClO, blotted dry with a sterile paper towel, and plated onto *Thielaviopsis* selective media, TB-CEN (Specht and Griffin, 1985). Plates were either incubated for 3-5 days (MGA) or 7-14 days (P_5ARP and TB-CEN) at ~23°C prior to screening for colonies. Seedlings originally plated onto TB-CEN were transferred to P_5ARP (10 seedlings) and MGA (10 seedlings) to supplement the respective sample sizes.

The remaining 40 seedlings were divided into 2 groups of 20 (see Table 4) for analysis using double antibody sandwich (DAS) enzyme-linked immunosorbent-assay (ELISA) kits from Neogen (Lansing, MI) and Loewe (Sauerlach, Germany) to detect presence of *Pythium* spp. and *Rhizoctonia solani*. Extracts of seedlings were prepared for analysis by dicing 0.1-0.15g of tissue per sample with a razorblade, placing it into a mortar with liquid nitrogen for 1 min to flash-freeze, and grinding it with a pestle before loading it into a 2 ml vial with 1-1.5 ml of general extract buffer (Neogen) and centrifuging for 2 min at 14,000 rpm (Centrifuge 5425, Eppendorf, Hamburg, Germany). The resulting supernatant was frozen at -20°C until testing. A total of 2 replications were tested per sample. Test wells were prepared according to manufacturer instructions and read using a spectrophotometer (Accuskan FC, Fisher Scientific, Hampton, NH) set at 405 or 620 nm, depending on the pathogen kit instructions.

Soil samples evaluated for populations of *R. solani* were screened using the toothpick-baiting method (Paulitz and Schroeder, 2005). Nine toothpicks were baited per sample and populations were quantified on the *Rhizoctonia*-selective media, TSM (Spurlock et al., 2011).

Pathogenicity Assay

The *Pythium* pathogenicity assay developed by Zhang and Yang (2000) for soybean and corn was modified for cotton as follows. *Pythium* isolates were taken from initial seedling plantings onto P_5ARP and saved in long term storage via freezing on filter paper. Two isolates per location were then selected at random to be screened for pathogenicity. For each isolate, there were two replications. Each isolate was plated onto 1% Water agar to grow out at room temperature for 7 days. After 7 days, 10 black cottonseeds were placed towards the outer edge of each plate containing a *Pythium* isolate and incubated at 16°C for 7-8 days. Seeds were sterilized before plating by submersion in a 1% bleach solution for 3 minutes, and then rinsing with running tap water for 5 minutes. After 7-8 days, the plates were moved to room temperature for an additional 2 days to allow for additional mycelial growth and possible seed germination. During each pathogenicity assay, 10 sterilized seeds were plated on 1% water agar and incubated at room temperature as a germination control.

After the completion of each assay, data was collected on the seedling germination rate for each isolate. A scale of 0-4 was used to determine the pathogenicity of each isolate, where 0=seed germinated without visible infection, 1=germinated with light discoloration on roots, 2=germinated with short severely discolored roots, 3=died after germination, and 4=died before germination.

Statistics

Data were analyzed with JMP 14 Pro (SAS Institute Inc., Cary NC). Percent stand was analyzed across locations using Mixed Model – Tukey HSD means separation with alpha = 0.05 and by location using the Fit Model – Standard Least Squares procedure – Tukey HSD means separation with alpha = 0.1. The Pearson product-moment correlation method was used to examine the relationship among soil temperature, early season growth (nodes), percent stand, disease hypocotyl and root ratings, pathogen isolation frequency, and soil populations over locations.

Table 1. Fungicides, formulations, and active ingredients in the 2019 National Cottonseed Treatment Program

No.[Y]	Common or registered name[Z]	Formulation	Active ingredient (%)	Rate oz/cwt	Target Pathogen
1	Gaucho 600	F	Imidacloprid (47.8)	12.8	*No target*
2	ALLEGIANCE FL	F	Metalaxyl (28.35)	1.5	*Pythium*
3	EVERGOL PRIME	F	Penflufen (22.7)	0.64	*R. solani*
4	SPERA 240FS	F	Myclobutanil (22.37)	1.85	*R.solani, T. basicola*
	PROLINE 480 SC	F	Prothioconazole (41.0)	0.16	*R.solani, Fusarium*
	EVERGOL PRIME	F	Penflufen (22.7)	0.32	*R. solani*
	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
5	Albaugh Premium fungicide	F	Myclobutanil (63.34), Metalaxyl (30.25), Fludioxonil (3.78)	5	*Pythium, R. solani, T. basicola, Fusarium*
6	BAS500 F	F	Pyraclostrobin (90.2)	1.54	
	BAS700 F	F	Fluxapyroxad	0.94	
	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.96	*R.solani, T. basicola*
7	BAS500 F	F	Pyraclostrobin (90.2)	3.07	
	BAS700 F	F	Fluxapyroxad	0.94	
	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.96	*R.solani, T. basicola*
8	BAS500 F	F	Pyraclostrobin (90.2)	1.54	
	BAS700 F	F	Fluxapyroxad	0.94	
	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.96	*R.solani, T. basicola*
	COPeO PRIME	F	Fluopyram (48.4)	5.97	*Nematodes*
9	APRON XL	F	Mefenoxam (33.3)	0.5	*Pythium*
	MAXIM 4FS	F	Fludioxonil (40.3)	0.08	*R.solani, Fusarium*
	RALLY 40WSP	WP	Myclobutanil (40)	0.84	*T.basicola*
	VIBRANCE CST	F	Mefenoxam (6.71), Azoxystrobin (6.71), Sedaxane (3.13), Fludioxonil (1.12)	3.06	*Pythium, R. solani, Fusarium*
10	APRON XL	F	Mefenoxam (33.3)	0.5	*Pythium*
	MAXIM 4FS	F	Fludioxonil (40.3)	0.08	*R.solani, Fusarium*
	RALLY 40WSP	WP	Myclobutanil (40)	0.84	*T.basicola*
	VIBRANCE CST	F	Mefenoxam (6.71), Azoxystrobin (6.71), Sedaxane (3.13), Fludioxonil (1.12)	4.08	*Pythium, R. solani, Fusarium*
11	KABINA ST	F	Penthiopyrad (40)	0.87	*R. solani*
	SPERA 240FS	F	Myclobutanil (22.37)	1.8	*R.solani, T. basicola*
	ALLEGIANCE FL	F	Metalaxyl (28.35)	1.5	*Pythium*
	MAXIM 4FS	F	Fludioxonil (40.3)	0.16	*R.solani, Fusarium*
12	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	EVERGOL PRIME	F	Penflufen (22.7)	0.33	*R. solani*
	FLUOXASTROBIN FS480	F	Fluoxastrobin (40.3)	0.38	*Pythium, R. solani*
	PROLINE 480 SC	F	Prothioconazole (41.0)	0.16	*R.solani, Fusarium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.8	*R.solani, T. basicola*
13	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	EVERGOL PRIME	F	Penflufen (22.7)	0.64	*R. solani*
	FLUOXASTROBIN FS480	F	Fluoxastrobin (40.3)	0.38	*Pythium, R. solani*
	PROLINE 480 SC	F	Prothioconazole (41.0)	0.16	*R.solani, Fusarium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.8	*R.solani, T. basicola*
14	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	EVERGOL PRIME	F	Penflufen (22.7)	0.33	*R. solani*

	FLUOXASTROBIN FS480	F	Fluoxastrobin (40.3)	0.38	*Pythium, R. solani*
	PFL+TFS FS308 (EVERGOL XTEND)	F	Penflufen (14.26), Trifloxystrobin (14.26)	1	*R. solani*
	PROLINE 480 SC	F	Prothioconazole (41.0)	0.16	*R.solani, Fusarium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.8	*R.solani, T. basicola*
15	ALLEGIANCE FL	F	Metalaxyl (28.35)	0.75	*Pythium*
	EVERGOL ENERGY	F	Prothioconazole(07.18), Penflufen (3.59), Metalaxyl (5.74)	1	*R. solani*
	EVERGOL PRIME	F	Penflufen (22.7)	0.33	*R. solani*
	FLUOXASTROBIN FS480	F	Fluoxastrobin (40.3)	0.38	*Pythium, R. solani*
	PROLINE 480 SC	F	Prothioconazole (41.0)	0.16	*R.solani, Fusarium*
	SPERA 240FS	F	Myclobutanil (22.37)	1.8	R.solani, T. basicola

[Y]All treatments included GAUCHO 600, Flowable, Imidacloprid (48.7%), 16 oz/cwt.
[Z]Registered chemical name, all capital letters.

Table 2. List of cooperators and procedures for locations in the 2019 National Cottonseed Treatment Program

			Date								
Cooperator	Location	Site ID	Planted	Sampled	Counted	Seed planted/ft	Length row counted/plot	Seed planted/row length counted	Soil temp.[V]	Soil moisture[X]	Avg. % stand[Z]
Kathy Lawrence	Auburn, AL	AL	4/17	5/22	5/22	4	25	100	22 (18)[W]	--[Y]	38 g
Alejandro Rojas	Fayetteville, AR	AR	5/29	7/1	7/1	5	50	250	27(21)	6(4)	83 a
Robert Kemerait	Tifton, GA	GA	4/4	5/15	5/15	3	25	75	27(21)[W]	--[Y]	78 ab
Trey Price	Winnsboro, LA	LA1	4/16	5/14	5/14	5	20	100	19(14)[W]	--[Y]	77 bc
Patrick Colyer	Bossier City, LA	LA2	4/17	5/20	5/20	4	25	100	19(16)[W]	--[Y]	55 ef
Tessie Wilkerson, Tom Allen	Stoneville, MS	MS1	4/24	5/28	5/22	4	70	280	24(23)[W]	--[Y]	70 d
Tessie Wilkerson, Tom Allen	Stoneville, MS	MS2	6/10	7/12	7/11	4	70	280	27(24)	--[Y]	84 a
Lindsey Thiessen	Raleigh, NC	NC	5/9	6/6	6/6	4	40	160	23(14)	5(3)	56 e
Heather Kelly	Jackson, TN	TN	4/23	5/23	5/22	4	60	240	20(19)[W]	--[Y]	80 ab
Thomas Isakeit	Snook, TX	TX1	5/15	6/13	6/13	4	25	100	26(22)[W]	--[Y]	51 f
Terry Wheeler	Lubbock, TX	TX2	5/6	6/5	6/3	4	36	144	20(16)[W]	--[Y]	34 g
Hillary Mehl	Suffolk, VA	VA	5/8	6/12	6/12	4	60	240	22(17)	15(12)	72 cd

[V]Mean (Minimum) soil temp. (°C); 3-day average following planting.
[W]Weather data collected from National Weather Service weather station.
[X]Mean (Minimum) soil moisture (%VWC).
[Y]Information not available.
[Z]Percent stand based on plants counted 30 days after planting across all treatments.

Results and Discussion

For the 12 locations in the 2019 National Cottonseed Treatment Program, location, treatment, and their interaction (location x treatment) significantly affected stand counts ($P \leq 0.01$). Hence, the significant interaction suggests treatment response was dependent on the environment and/or pathogen pressure for a particular location, which is expected. All treated and nontreated seed had ≥ 90% germination, ranging from 73 to 97%. Treatment 8 germination was not correct as it was 50%, yet percent emergence at field sites was not different than other nominated treatments; it was therefore not included in the analysis.

There was a significant treatment response at 6 of the 12 locations regarding percent stand establishment (Table 3). Percent stand ranged from 34 to 84% with MS2, AR, TN, GA, LA1, VA, and MS1 having ≥ 70% and NC, LA2, TX1, AL, and TX2 having significantly lower stands ranging from 34 to 56%. The Allegiance treatment increased stands compared to the nontreated control and Evergol Prime at TX2 site, indicating *Pythium* spp. was limiting stand establishment at this location in 2019. In contrast, at TX1 site, the allegiance treatment had the lowest stand indicating low pressure of *Pythium* spp. and higher pressure of other true fungal pathogens. At the LA1 site all treatments had significantly greater stands compared to the non-treated check, but treatments were not significantly different from one another at this location. Outside of the LA1 site, nominated treatments that increased stand over the non-treated check at individual locations included treatments 5, 7, 8, 10, 12, and 14 (Table 3).

Seedling development across the locations at the time of disease assessment and isolation ranged from 1.6 nodes to 6.0 nodes with an average of 3. nodes (Table 4). Hypocotyl disease indices ranged from 1.7 (AR and LA2) to 2.8 (TX2), averaging 2.1 across all locations. Root disease indices ranged from 2.5 (TX1) to 5.3 (GA), averaging 3.9 across all locations. *T. basicola* was isolated from seedlings at 10 of the 12 locations with isolation frequencies ranging from 20 to 100%, averaging 48%. *Fusarium* spp. were detected at all sites using selective media and had ≥90% isolation frequency at all sites except AL (63%) and AR (67%). Similar to results from 2018, the high levels of *Fusarium* spp. detected yet lack of stand response at all sites suggest many of the identifications were of non-pathogenic species. Therefore, consideration is needed to develop a similar pathogenicity assay for species of *Fusarium* as the one used for species of *Pythium*. *Rhizoctonia solani* was detected in soil screened from all 12 sites, ranging from 27.4 to 33.1 propagules/100 cm3 of soil, averaging 26.8. It was not detected from seedlings using ELISA from all sites, with *R. solani* detected in only 5 of the 9 sites with isolation frequency ranging from 5 (AR) to 80% (GA), averaging 16%. While the ELISA from seedlings is a more reliable estimation of *R. solani* impact on stands than soil isolations, additional evaluation of the *R. solani* ELISA method is needed to have more confidence in its results.

Pythium spp. were isolated on selective media from seedlings from all except the MS2 location, ranging in isolation frequency from 13% (LA1 and TX1) to 67% (AR), averaging 26% across locations (Table 4). The isolation frequencies of *Pythium* spp. from ELISA were not as high, where 6 sites did not have detection and isolation frequencies ranged from 5 to 35%, averaging 9% across locations. The isolation frequencies from selective media in 2019 were improved from 2018 using a pathogen identification guide that was developed, although were still higher compared to isolation frequencies from ELISA. Additional investigation is needed to understand the lack of congruency between the *Pythium* isolation frequencies from selective media and ELISA. Two possible explanations are that different seedlings as well as different numbers of seedlings were used for both methods, and a greater number of seedlings might need to be incorporated in the ELISA method. Additionally, while TX1 had one of the lowest isolation frequencies of *Pythium* spp., the 2 isolates tested from that location had the greatest pathogenicity (Figure 1). Pathogenicity of species of *Pythium* spp. ranged from 1 to 3.7, averaging 2.3 across all isolates tested.

Early-season growth (nodes) was negatively correlated with root index, correlation coefficient = -0.60 (P=0.04), as seedlings were larger less root discoloration was observed. Similarly, there was a trend for stand establishment for non-treated checks to increase with early-season growth (nodes), correlation coefficient = 0.57 (P=0.05), as can be expected. Isolation frequency of *Pythium* spp. and *Fusarium* spp. were negatively correlated, correlation coefficient = -0.70 (P=0.01), which could indicate competition between these pathogens in colonizing seedlings. Only *T. basicola* isolation frequencies were negatively correlated with minimum soil temperatures the first 3 days after planting, correlation coefficient = -0.60 (P=0.04) and weakly with early-season growth (nodes), correlation coefficient = -0.54 (P=.07), as with smaller seedlings and minimum soil temperature decreased *T. basicola* isolation increased. Additionally, there was a similar trend with hypocotyl index increasing with lower average temperatures the first 3 days after planting, correlation coefficient = -0.54 (P=0.07).

Table 3. Cotton seedling stands for locations of the 2019 National Cottonseed Treatment Program

No.[Y]	Plant Stand %[Z]																			
	AL		AR		GA	LA1		LA2	MS1	MS2	NC	TN		TX1		TX2		VA	Mean	
1	31	b	79	ab	64	52	c	46	55	83	42	71	c	40	bc	26	b	73	54	d
2	34	ab	81	ab	72	72	ab	49	63	82	52	74	bc	29	c	41	a	75	59	cd
3	32	ab	74	b	76	71	b	56	66	84	59	78	abc	42	bc	26	b	70	60	bc
4	35	ab	81	ab	84	80	ab	61	74	83	55	78	abc	55	ab	38	ab	77	66	ab
5	39	ab	81	ab	75	81	ab	53	76	81	63	85	a	45	abc	39	ab	75	65	abc
6	40	ab	74	b	82	77	ab	56	79	88	53	82	ab	55	ab	33	ab	69	64	abc
7	44	a	80	ab	71	78	ab	53	71	85	65	83	ab	50	ab	33	ab	75	64	abc
8	39	ab	80	ab	75	80	ab	60	70	82	59	83	a	57	ab	33	ab	72	65	abc
9	43	ab	95	ab	75	83	ab	58	72	83	57	82	ab	57	ab	32	ab	72	68	abc
10	37	ab	84	ab	75	82	ab	58	73	83	53	86	a	57	ab	31	ab	71	66	abc
11	36	ab	81	ab	94	81	ab	49	79	81	57	83	ab	49	ab	37	ab	76	67	abc
12	35	ab	85	ab	80	82	ab	60	76	82	51	83	ab	63	a	35	ab	71	68	abc
13	40	ab	90	ab	73	75	ab	51	77	85	56	80	abc	49	abc	35	ab	75	67	abc
14	42	ab	89	ab	82	82	ab	57	71	89	67	81	ab	64	a	39	ab	69	71	a
15	42	ab	85	ab	88	79	ab	60	56	87	58	80	abc	51	ab	35	ab	67	67	abc
Average	38		83		78	77		55	70	84	56	80		51		34		72	65	
COV	0.11		0.07		0.10	0.10		0.08	0.11	0.03	0.11	0.05		0.18		0.13		0.04	0.06	
P>F	0.04		0.07		ns	<0.0001		ns	ns	ns	ns	0.0004		<0.0001		0.03		ns	<0.0001	

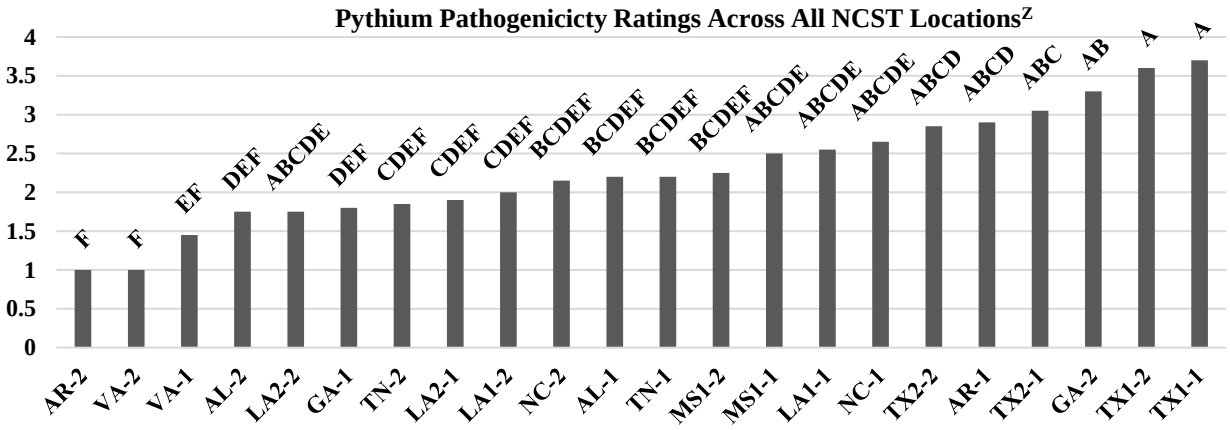
[Y]See Table 1 for treatment details.

[Z]Data were analyzed with JMP 14 Pro (SAS Institute Inc., Cary NC), values with the same letter within a column are not significantly different, where percent stand was analyzed across locations using Mixed Model – Tukey HSD means separation with alpha = 0.05 and by location using the Fit Model – Standard Least Squares procedure – Tukey HSD means separation with alpha = 0.1.

Table 4. Disease ratings and isolation frequencies of seedling pathogen groups for the 2019 National Cottonseed Treatment Program locations

		Dis. index		Isolation frequency (%)						
Location	Nodes[S]	Hyp[T]	Root[U]	*Pythium* spp.		*T. basicola*[V]	*Fusarium* spp.[V]	*R. solani*		Avg. % Stand[Y]
AL*	2.6	2.1	4.2	37[V]	0[W]	100	63	32.4[X]	20[W]	38 g
AR*	5.4	1.7	4	67	25	35	67	27.4	5	83 a
GA	2.8	1.8	5.3	27	35	60	100	31	80	78 ab
LA1*	1.6	2.4	4.4	13	10	55	100	25.2	15	77 bc
LA2	3.8	1.7	4.5	30	15	50	93	32.4	25	55 ef
MS1	3.8	2.3	3.9	27	15	0	90	12.2	0	70 d
MS2	5.6	1.9	3.4	0	0	0	100	25.2	0	84 a
NC	4.8	2.2	3	7	0	95	100	32.4	--[Z]	56 e
TN*	3	2.2	4.9	17	5	90	90	14.4	0	80 ab
TX1*	3.8	1.8	2.5	13	0	20	100	33.1	0	51 f
TX2*	2.6	2.8	4	40	0	65	97	24.5	--[Z]	34 g
VA	6	2	2.9	30	0	--[Z]	100	31.7	--[Z]	72 cd
Avg	3.8	2.1	3.9	26	8.75	48	92	26.8	16.1	65

[S]Nodes based on five seedlings per location.
[T]Hypocotyl index; 1=no symptoms, 2=few pinpoint lesions or diffuse discolored areas, 3=distinct necrotic lesion, 4=girdling lesion, and 5=seedling dead.
[U]Root index; 1=no symptoms, 2=1-10% of the root system discolored, 3=11-25% of the root system discolored, 4=26-50% of the root system discolored, 5=51-75% of the root system discolored, and 6>75% of the root system discolored.
[V]Isolation frequency from selective media is based on 20-30 seedlings per location and reported as a percentage.
[W]Detection by ELISA from 15-20 seedlings per location and reported as a percentage.
[X]Soil populations from toothpick baiting method reported in no. propagules/100 cm^3.
[Y]Percent stand based on plants counted 30 days after planting across all treatments.
[Z]Information not available.



[Z]Bars with the same letter are nor significantly different at $P \leq 0.05$.
Figure 1. Pathogenicity results from randomly selected isolates from locations in 2019.

Disclaimer

This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation by the University of Tennessee Institute of Agriculture nor does it imply registration under FIFRA.

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