Soybean Disease Management

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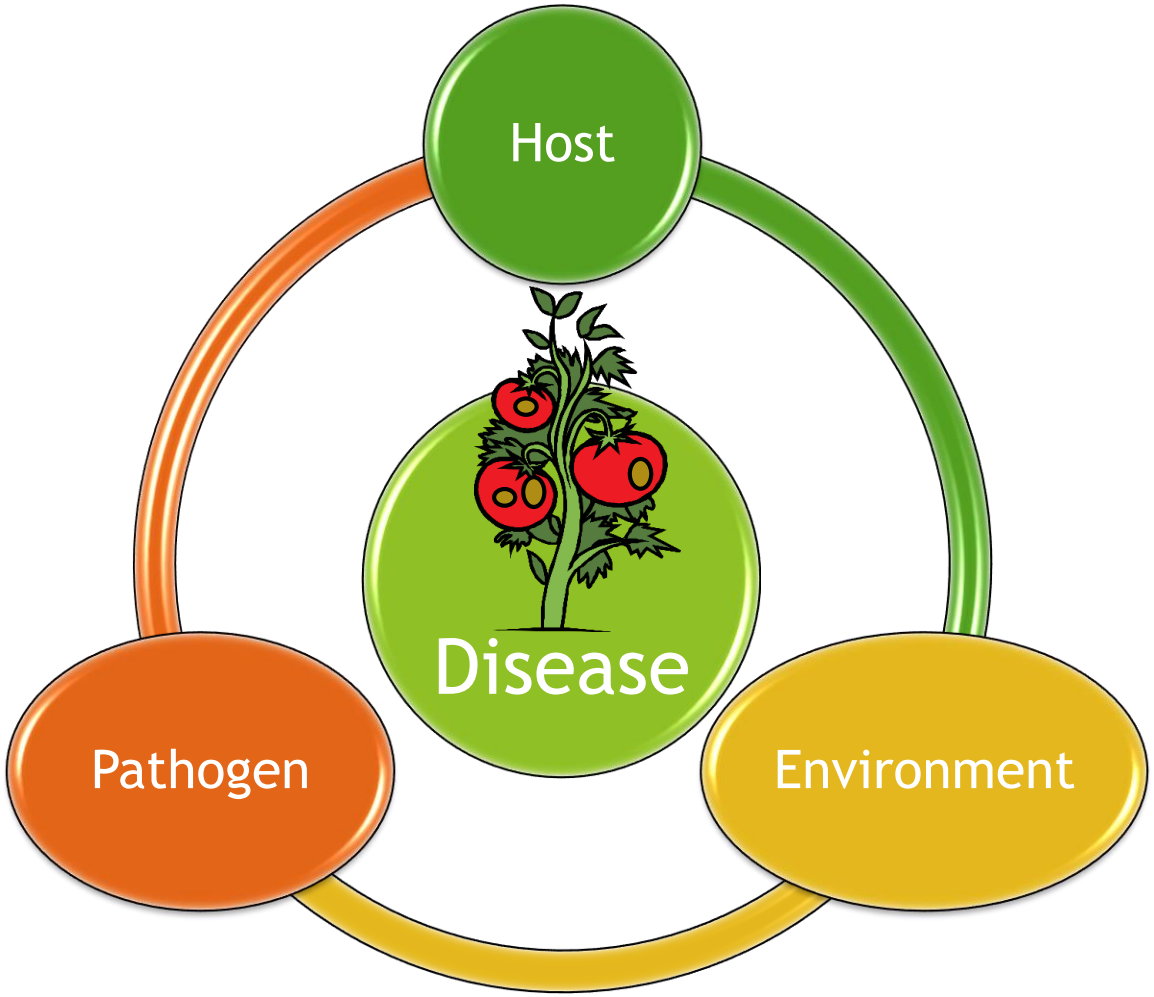
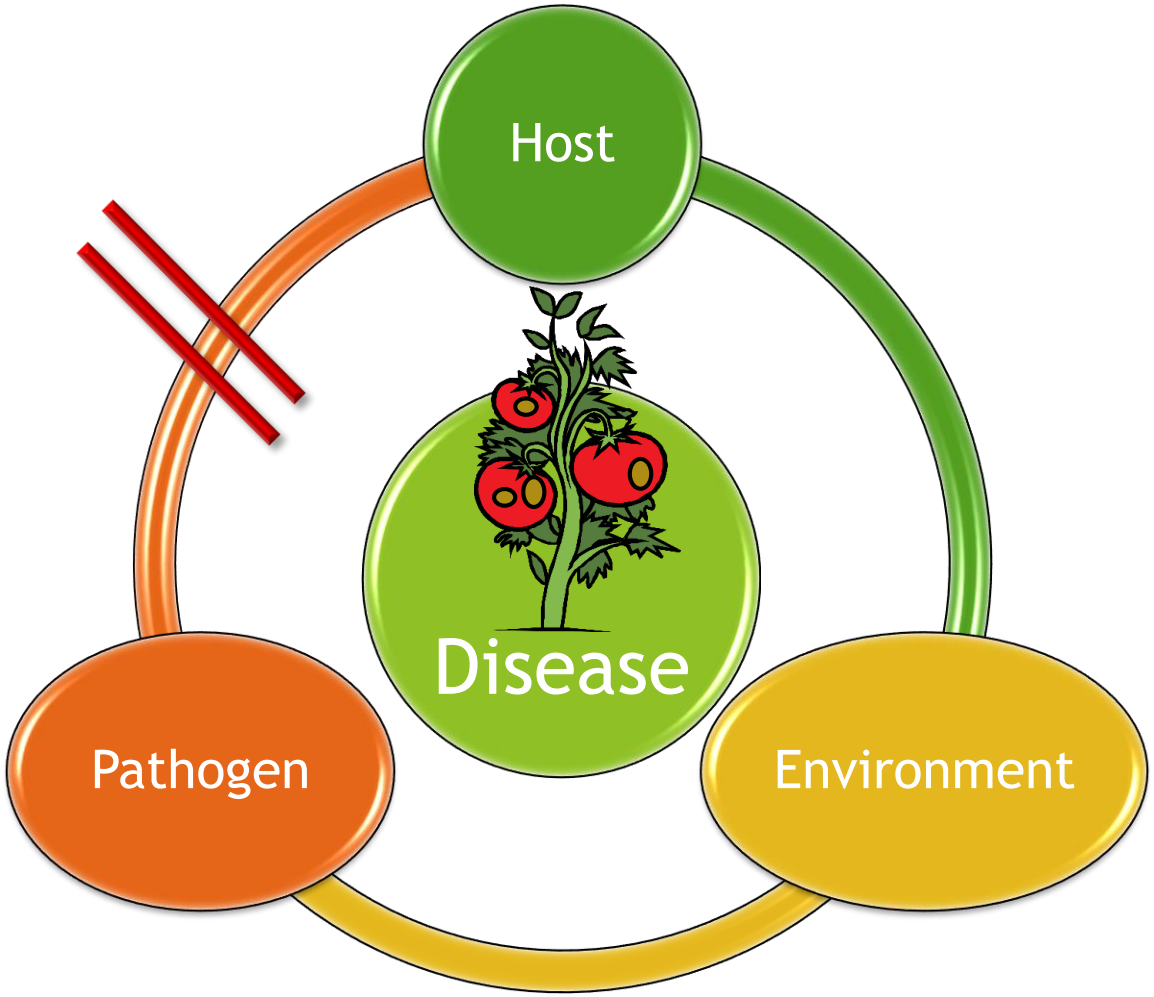
Disease Triangle



Disease Management

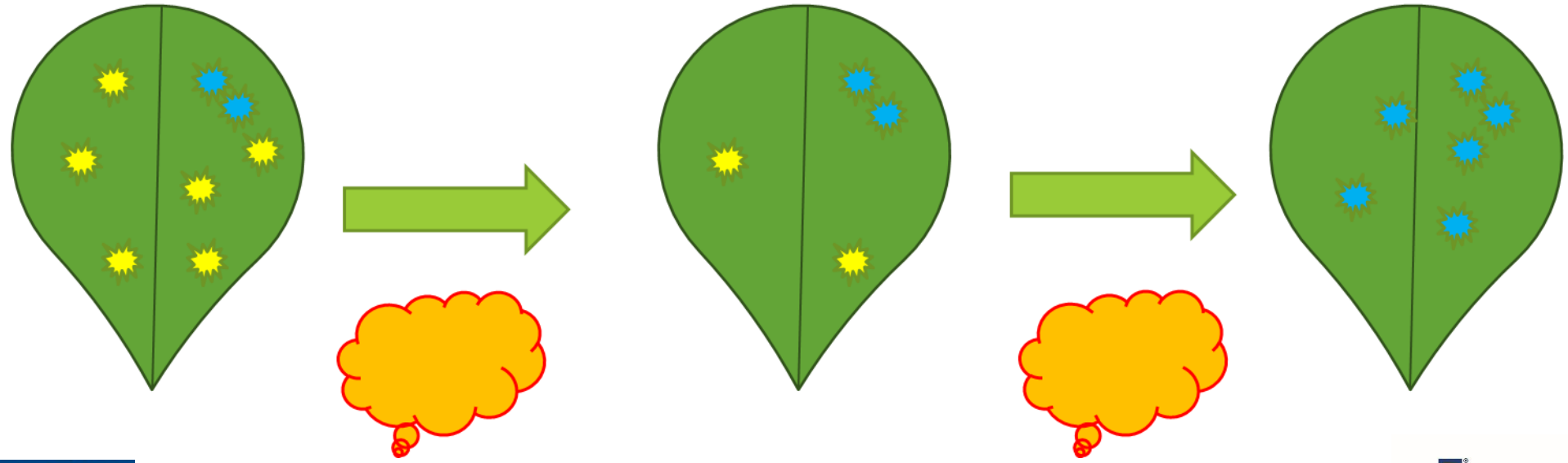


Management Limitations

- Cost
- Effect of management on other agronomic practices
- Pesticide resistance**
- Host resistance/pesticide availability

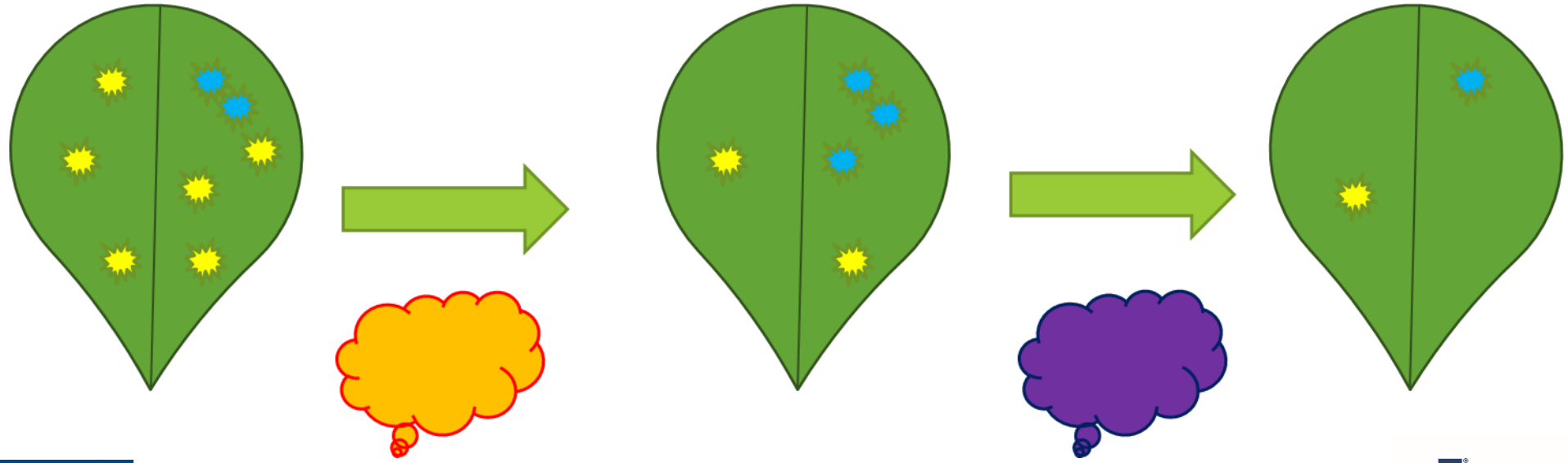
Pesticide Resistance

- Two major mechanisms
  - Selection of resistant organisms over susceptible
  - Sub-lethal doses selecting for/inducing mutations over time



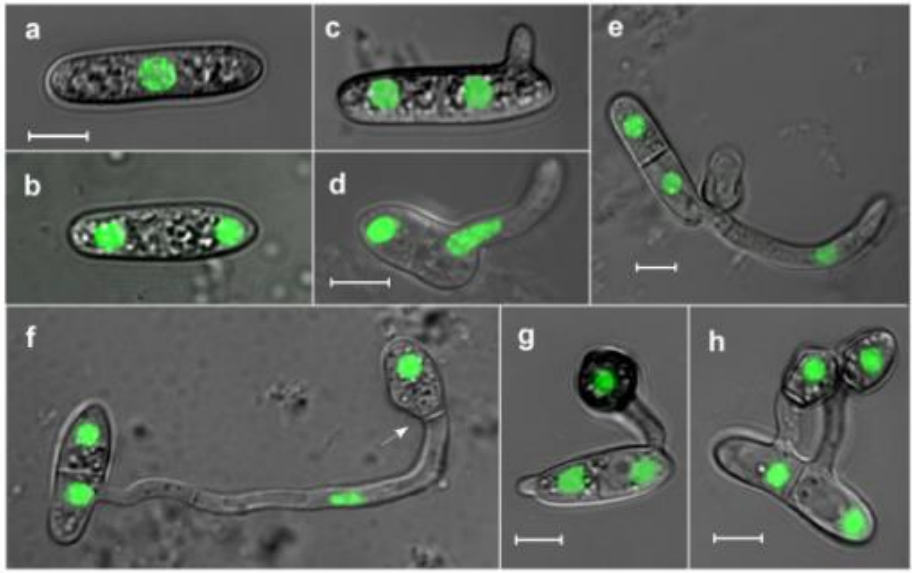
Pesticide Resistance Management

- Rotation of chemistries
- Mixed modes of action products



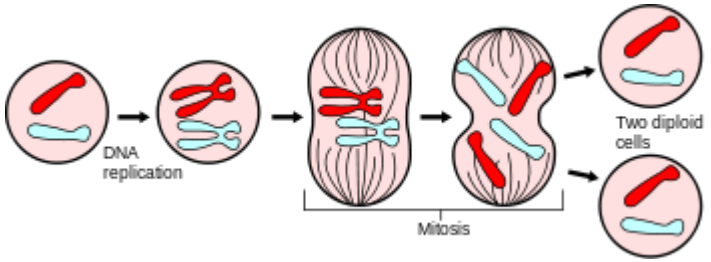
Fungicide Classes

- Group 11
  - Strobilurins/QoI (Quinone Outside Inhibitors)
  - Prevent spore germination and cell respiration
  - Examples: azoxystrobin (Quadris), picoxystrobin (Aproach)
- Group 3
  - DMI/Triazole
  - Demethylation inhibitor that prevents sterol production (important for cell membranes)
  - Examples: propiconazole (Tilt), prothioconazole (Proline)



Fungicide Classes

- Group 1
  - Thiophanates
  - Binds to tubulin, thereby blocking mitosis
  - Example: Thiophanate-methyl
- Group 7
  - SDHI
  - Block succinate dehydrogenase, inhibiting respiration
  - Examples: Boscalid (Endura), Fluopyram (Velum/Luna)



Fungicide Selection

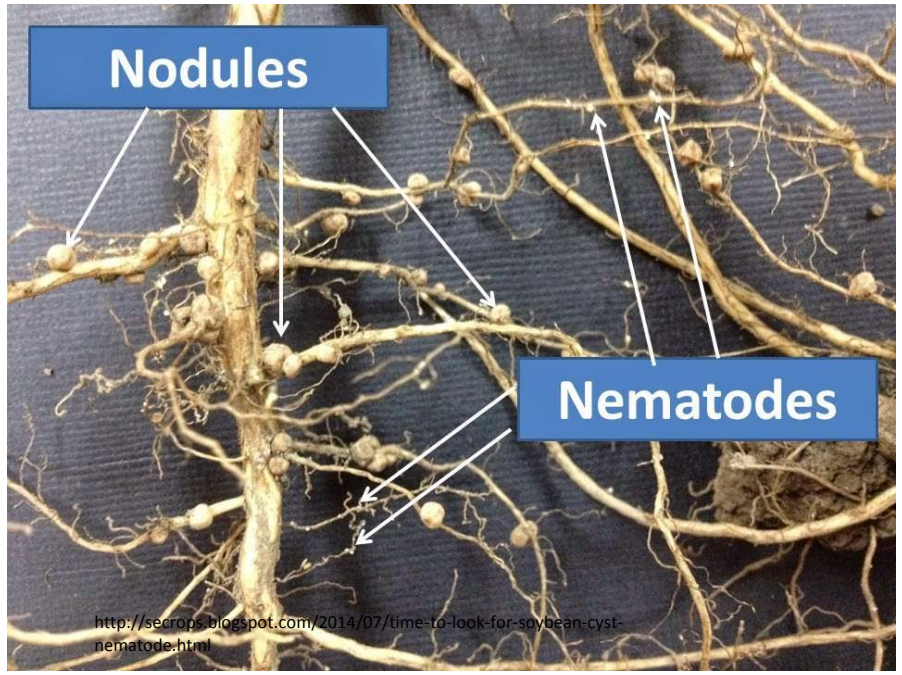
https://soybeans.ces.ncsu.edu/wp-content/uploads/2018/07/Soybean-Fungicide-efficacy-table_2018.pdf?fwd=no

Fungicide(s)				Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight[2]	Frogeye leaf spot[3]	*Phomopsis/ Diaporthe* (Pod and stem blight)	Soybean rust	Target spot	White mold[4]	Harvest restriction[5]
Class	Active ingredient (%)	Product/Trade name	Rate/A (fl oz)										
Qol Strobilurins Group 11	Azoxystrobin 22.9%	Quadris 2.08 SC Multiple Generics[6]	6.0 - 15.5	VG	VG	G	P	P	U	G-VG	P-F	P	14 days
	Fluoxastrobin 40.3%	Aftershock 480 SC Evito 480 SC	2.0 – 5.7	VG	G	G	P	P	U	U	U	NL	R5 (beginning seed) 30 days
	Picoxystrobin	Aproach 2.08 SC	6.0 -12.0	VG	G	G	P	P	U	G	U	G-VG[10]	14 days
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 - 12.0	VG	VG	G	P	P	U	VG	P-F	NL	21 days
DMI Triazoles Group 3	Cyproconazole 8.9%	Alto 100SL	2.75 – 5.5	U	U	VG	F	F	U	VG	U	NL	30 days
	Flutriafol 11.8%	Topguard 1.04 SC	7.0 – 14.0	U	VG	VG	P-G	VG	U	VG-E	P	F	21 days
	Propiconazole 41.8%	Tilt 3.6 EC Multiple Generics[6]	4.0 - 6.0	P	VG	G	NL	F	NL	VG	U	NL	R5 (beginning seed)
	Prothioconazole 41.0%	Proline 480 SC[7]	2.5-5.0	NL	NL	NL	NL	G-VG	NL	VG	U	F	21 days
	Tetraconazole 20.5%	Domark 230 ME	4.0 – 5.0	NL	VG	VG	P-G	G-VG	U	VG-E	P	F	R5 (beginning seed)
Thiophanates Group 1	Thiophanate-methyl	Topsin-M Multiple Generics	10.0 – 20.0	U	U	U	F	VG	U	G	U	F	21 days

Disease Management

Nematodes of NC

- Most Prevalent Soybean Nematodes
  - Soybean Cyst (32%)
  - Root Knot (32%)
  - Stunt (83%)
  - Sting (88%)
  - Lesion (51%)



http://secrops.blogspot.com/2014/07/time-to-look-for-soybean-cyst-nematode.html

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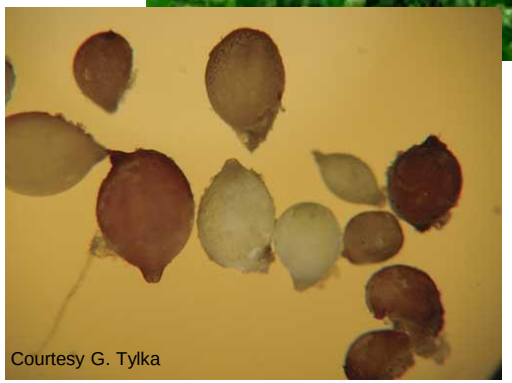
Soybean Cyst Nematode

- *Heterodera glycines*
- May cause irregular patches of stunted or yellow soybeans
  - Often mistaken for damage from nutrient deficiencies, herbicide injury, or other diseases
  - Yield losses of up to 30% are possible with no above-ground symptoms
- Infected roots are dwarfed or stunted, and may have adult female nematodes or cysts

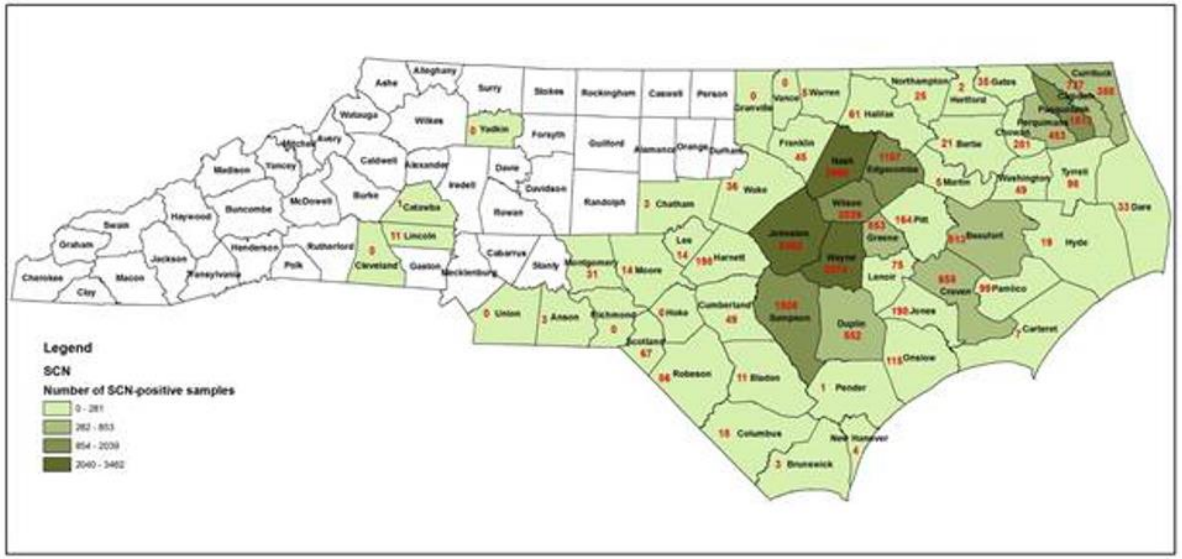


Courtesy G. Tylka

Courtesy R.D. Riggs

Soybean Cyst Distribution

Number of SCN Positive Samples



Average SCN Population Level

Weimin Ye, NCDA 2014-2017 Survey

Soybean Cyst Nematode

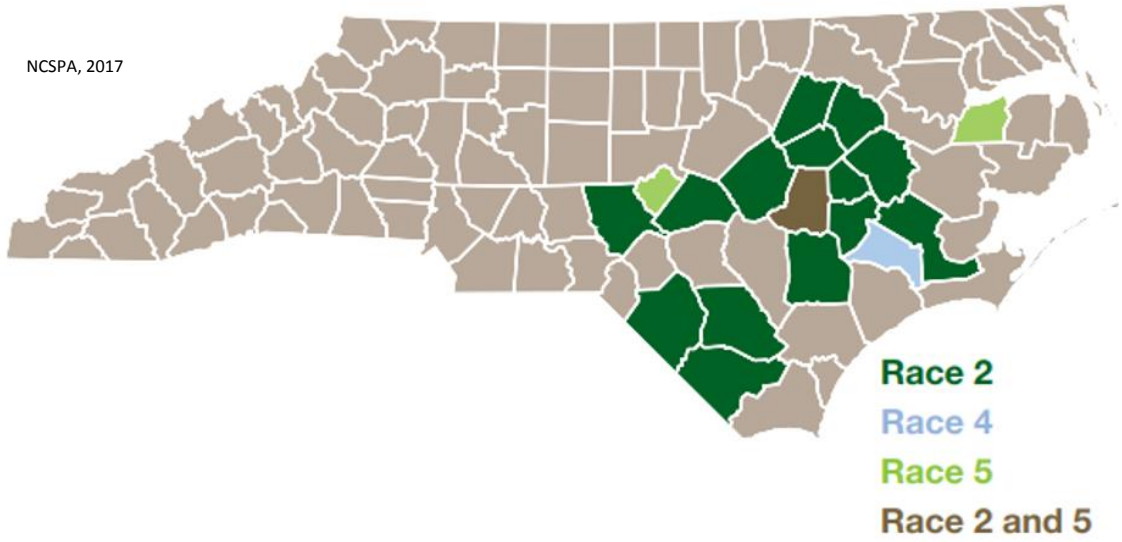
- Host Resistance
  - Sixteen different races of SCN/7 different HG Types
  - Races 2 (87%), 4 (10%), and 5 (3%) dominant in 18 counties

Variety	Growth Habit	Maturity Group	Maturity Date	Resistance Shatter	Resistance Lodge	Resistance Nematodes	Herbicide Ready	Height (in.)	Seed Size	Flower	Pub.	Co
HBK RY5421	Det	V	Oct 5-9	Exec	Fair		RR	39-43	Medium	Purple	Gray	
HBK RY5521	Det	V	Oct 6-10	Exec	Good		RR	32-36	Medium	Purple	Gray	
HBK RY7523	Det	VII	Oct 26-30	Good	Good	Ri	RR	36-40	Medium	Purple	Tawny	
Hutcheson	Det	V	Oct 6-10	Good	Good			31-35	Medium	White	Gray	
Jake	Det	V	Oct 5-9	Good	Good	C1,2,3,5,14R		32-36	Medium	Purple	Tawny	
JTN-5203	Det	V	Oct 4-8	Exec	Good	C2,3,5,14		30-34	Small	White	Gray	
JTN-5303	Det	V	Oct 5-9	Good	Exec	C2,3,5,14		27-31	Medium	White	Tawny	
JTN-5503	Det	V	Oct 5-9	Good	Good	C2,3,5,14		31-35	Medium	White	Tawny	
LC 4713S	InDet	IV	Sep 28-Oct 2	Good	Good	C3,14	STS,LL	31-35	Medium	Purple	Gray	
LL 396N	InDet	III	Sep 20-24	Good	Good		LL	33-37	Medium	White	Tawny	

TABLE 1
Type indicator foods and type indicator soybean lines used in the hypothetical "HS type test" and the SCN HG type test, respectively.

"HS type test" indicator food	Index number	HG type test indicator soybean line
dairy	#1	PI 548402 (Peking)
peanuts	#2	PI 88788
wheat	#3	PI 90763
shellfish	#4	PI 437654
	#5	PI 209332
	#6	PI 89772
	#7	PI 548316 (Cloud)

NCSPA, 2017



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SCN Resistant Soybean Varieties

Commercially Available

- Resistance to SCN 2, 4, and 5
  - Fowler (C1,2,3,5,14)
  - Jake (C1,2,3,5,14R)
  - JTN-5503 (C2,3,5,14)
  - N7003CN (C1,2,3,4,5,14)
  - Osage (C2,3,14)
  - P52T86R (C1,2,3,5,14)

Information from the Soybean Varieties in NC Guide:

https://soybeans.ces.ncsu.edu/wp-content/uploads/2017/02/2016-OVT-Variety-Characteristics.pdf?fwd=no

Soybean Cyst Nematode

- Crop Rotation
  - Not always feasible, but encouraged where possible
  - Rotations with non-legume crops are good option for dealing with SCN

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Preferred	Non-host crop	Resistant variety	Non-host crop	Susceptible variety	Repeat cycle	
Optional	Non-host crop	Resistant variety	Susceptible variety	Repeat Cycle		
Preferred	Non-host crop	Non-host crop	Soybean	Repeat cycle		
Optional	Non-host crop	Soybean Group V or earlier	Non-host crop	Soybean Group V or earlier	Non-host crop	Repeat cycle

Root Knot Nematode

- *Meloidogyne* spp.
  - Five different species in NC
- Infections are characterized by reduced vigor, stunting, wilt, and chlorosis
- Roots appear deformed, have galls
  - Soybean nodules can be removed whereas galls are permanently in the tissues

Root Knot Nematode Management

- Field Crops Management
  - Rotation with non-host
  - Resistant variety selection
  - Potentially seed treatments or non-fumigant alternatives

Hosts of Root Knot Nematode Species Found in North Carolina

M. incognita	*M. arenaria*	*M. javanica*	*M. hapla*	**M. enterolobii*
Soybean	Soybean	Soybean	Soybean	Soybean
Cotton	Peanut	Cotton	Peanut	Cotton
Tobacco	Tobacco	Tobacco	Tobacco	Tobacco
Corn	Corn	Corn		Sweet Potato
Sweet Potato	Sweet Potato	Sweet Potato		

RKN Resistant Soybean Varieties

Commercially Available

- 32RY55
- 34RY75
- 39RY57
- 5N550R2
- 95M82
- AG4835
- AG5535
- AG5732
- AG5935
- AG6536
- AG6732
- AG6834
- AG6931
- AG7231
- AG7535
- AG7934
- AGS 767 RR
- AGS 787 RR
- AGS 828 RR
- AGS Woodruff
- Armor 43-R43
- Armor 49-C3
- Armor 55-R22
- Armor 61-R14
- Cheraw
- DB5416R
- DB7213RR
- Ellis
- Halo 5:26
- HBK LL4850
- HBK RY7523
- LL 6314S
- Ozark
- P 5226 RYS
- P 5333 RY
- P 5414 LLS
- P 5555 RY
- P 5610 RY
- P 5752 RY
- P 5960 LL
- P 6215 RY
- P 6710 RY
- P 7215 RYS
- P 7310 RY
- P48T53R
- P49T80R
- P50T64R
- P54T94R
- P67T29R3
- P74T38X
- P76T54R2
- Paul
- REV 56R63
- REV 57R21
- REV 73A74
- S40RY25
- S52RY75
- S55-Q3
- S56-G6
- S56RY84
- S61RY93
- S65RY73
- S67RY25
- S69RY34
- S72RS36
- S74-M3
- S74RY15
- S77RY85
- S77-T7
- S78-G6
- S79RY05
- SH 4115 LL
- SH 4715 LL
- SH 5912 LL
- SH 6215 LL/STS
- SH 7116 LL/STS
- SS 5215NS R2
- SS 5511N R2
- SS 5615N R2
- SS 7215NS R2
- USG 75B75R
- USB 75J45R
- USG 75J90R
- USG 76G15LS
- USG 76J45R
- USG 76S22R
- USG 76S90R
- USG 77J25RS
- USG 77S40R

Varieties in black have M. incognita resistance
Varieties in red have both M. incognita and M. arenaria resistance
Varieties in green have M. arenaria resistance
Information from the Soybean Varieties in NC Guide: https://soybeans.ces.ncsu.edu/wp-content/uploads/2017/02/2016-OVT-Variety-Characteristics.pdf?fwd=no

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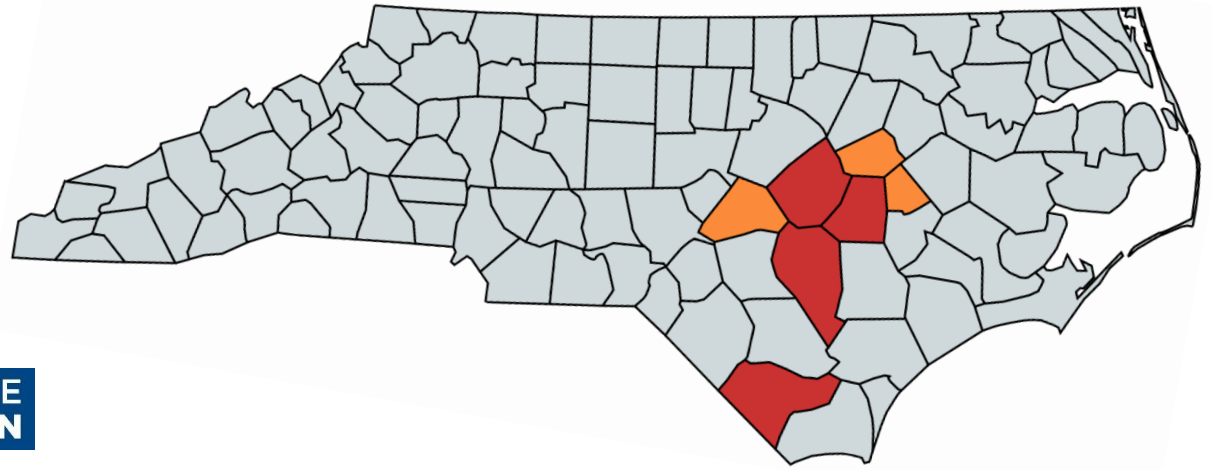
Meloidogyne enterolobii

- Originally identified on Pacara Pod trees in China
  - Found in NC in 2011
- Wide host range (screening crops and weed species in greenhouse)
- More aggressive than other RKN species in NC
- Spreading to new counties (3 more confirmed)
  - Presently conducting a survey to determine actual distribution



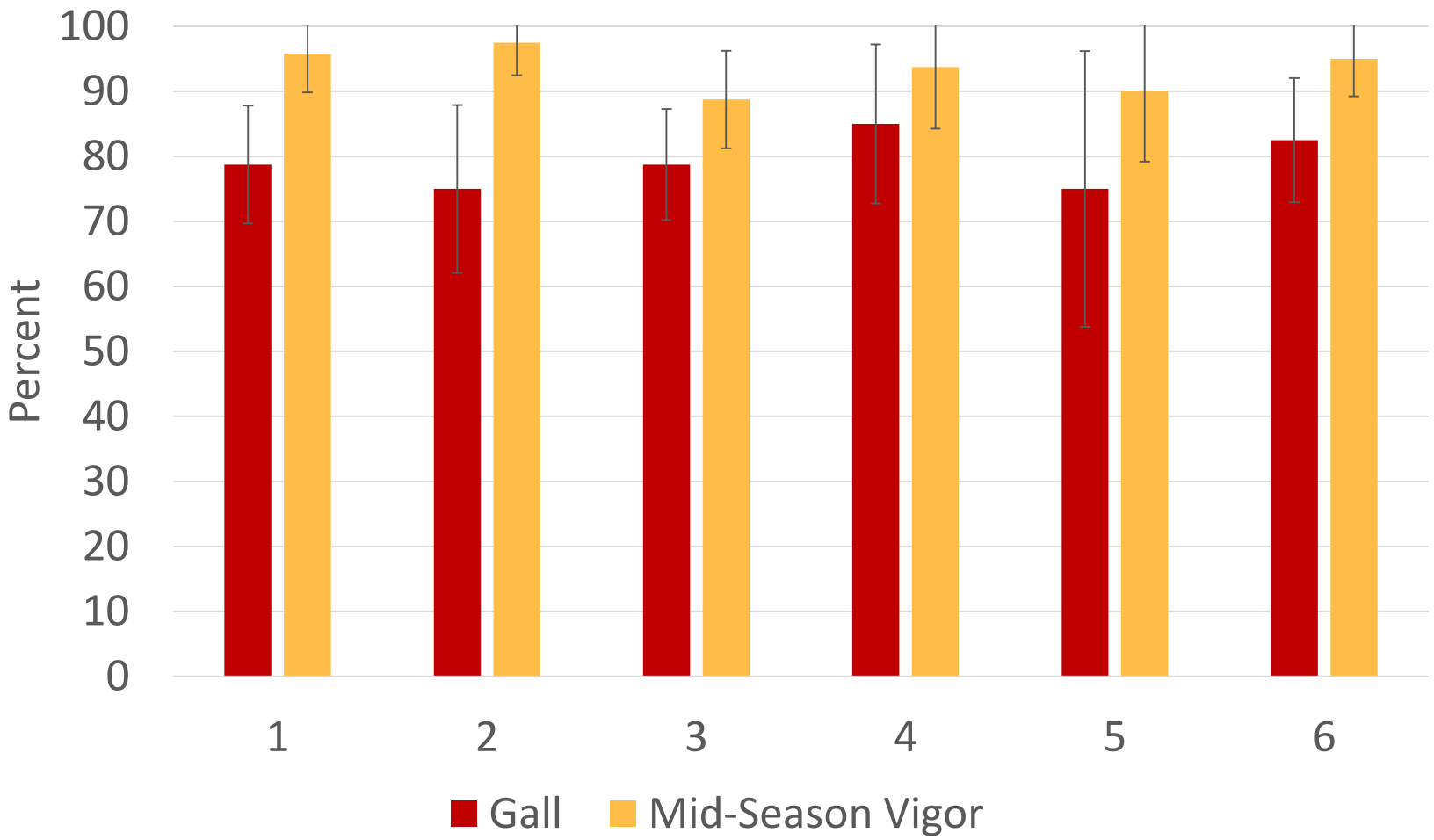
2017 Trials

- Seed Treatments in Soybean
  - *M. incognita* (Hyde)
  - *M. enterolobii* (Johnston)
- Experimental seed treatment at Sandhills Research Station
  - Moderate-high pressure SCN

Soybean Nematode Trial

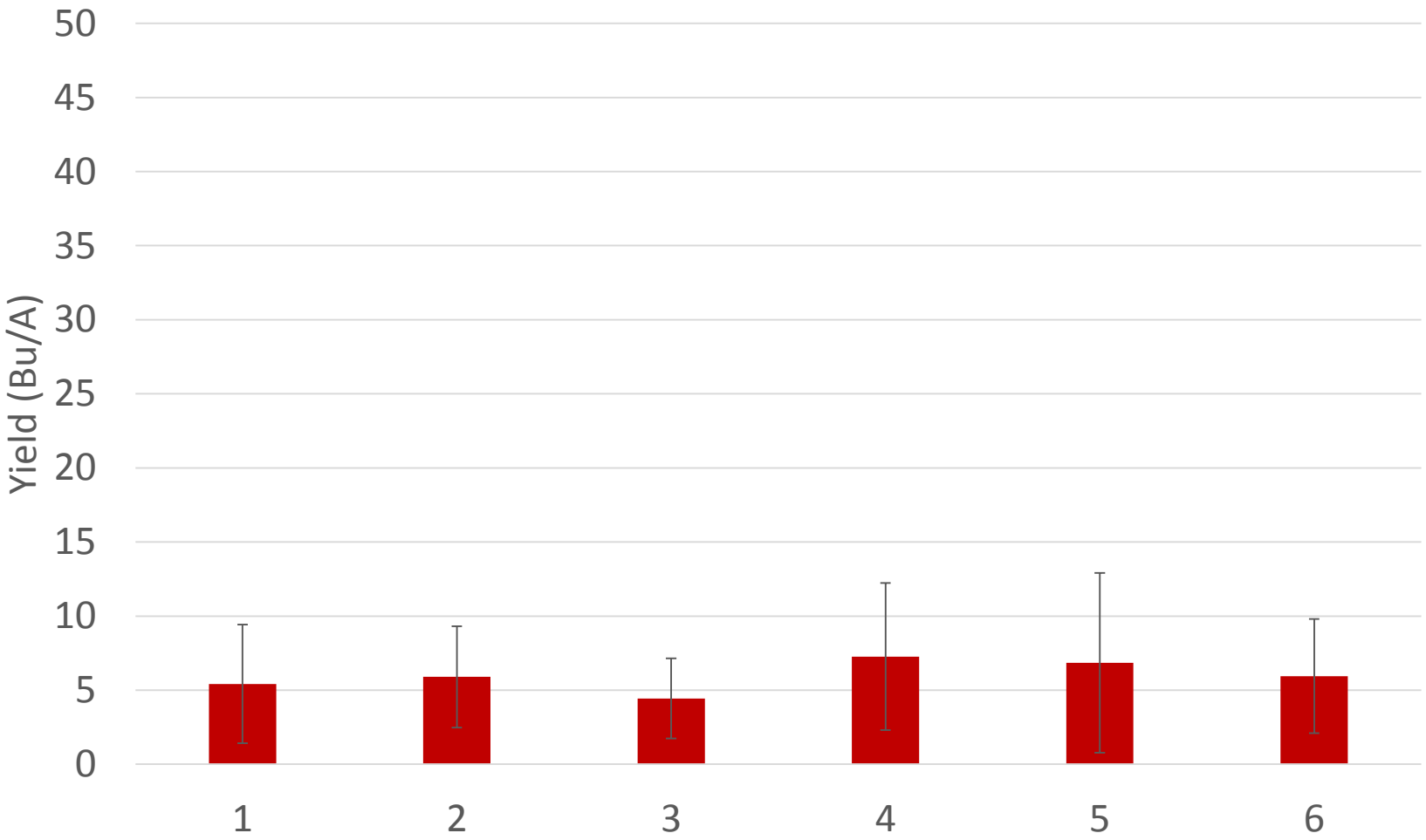
- Assessed seed treatments to manage nematodes in Soybean
- Selected two field sites
  - Hyde County (*M. incognita,* high pressure)
  - Johnston County (*M. enterolobii,* previous test site for sweet potato)
- Seed Treatments
  1. Gaucho (Imidacloprid, no-nematicide)
  2. Avicta (Abamectin)
  3. Clariva (*Pasteuria nishizawae*)
  4. Gaucho/Fluopyram (Imidacloprid and Fluopyram)
  5. Poncho/Votivo (Clothianidin and *Bacillus firmus*)
  6. Poncho/Votivo/Fluopyram (Clothianidin, *Bacillus firmus,* Fluopyram)

Hyde County-*M. incognita*



	Seed Treatment
1	Gaucho (Imidacloprid)
2	Avicta (Abamectin)
3	Clariva (*Pasteuria nishizawae*)
4	Gaucho/Fluopyram (Imidacloprid and Fluopyram)
5	Poncho/Votivo (Clothianidin and *Bacillus firmus*)
6	Poncho/Votivo/Fluopyram (Clothianidin, *Bacillus firmus,* Fluopyram)

Hyde County-*M. incognita*

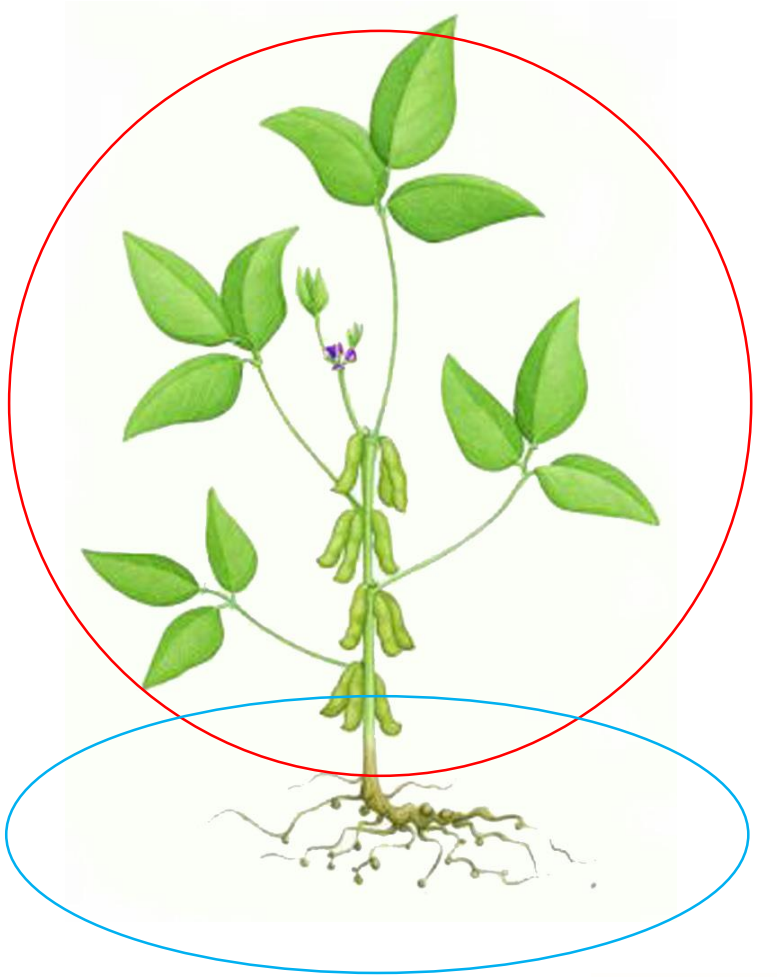


	Seed Treatment
1	Gaucho (Imidacloprid)
2	Avicta (Abamectin)
3	Clariva (*Pasteuria nishizawae*)
4	Gaucho/Fluopyram (Imidacloprid and Fluopyram)
5	Poncho/Votivo (Clothianidin and *Bacillus firmus*)
6	Poncho/Votivo/Fluopyram (Clothianidin, *Bacillus firmus,* Fluopyram)

*No difference when comparing paired plots

Fungal Diseases

- Seedling Diseases
- Root/Stem Rots
  - White Mold
  - Fusarium
  - Stem Canker
  - Phytophthora Root Rot
- Foliar Diseases
  - Frogeye Leaf Spot
  - Cercospora Blight
  - Soybean Rust



Root and Seed Rots

- Reduces stand and yield potential early in the season
- Caused by several different organisms
  - *Phytophthora sojae*
  - *Pythium* spp.
  - *Rhizoctonia* spp.
  - *Fusarium oxysporum*
- Favored by wet soils
  - *Phytopthora* and *Rhizoctonia* favored by warm soils
  - *Fusarium* and *Pythium* favored by cool soils

Root and Seed Rots

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Root and Seed Rots

- Improve drainage as much as possible
- Reduce plant stress and early season damages
  - Opportunistic pathogens colonize slow-emerging and damaged roots
  - Nematodes
- Delay planting until soils are warm (>55° F)
- Seed Treatments
  - Depends on pathogen

Seed Treatments

https://soybeans.ces.ncsu.edu/wp-content/uploads/2018/07/2018-Soybean-Seed-Treatment-Fungicide-Efficacy-Table.pdf?fwd=no

Table 8-1. Fungicide efficacy for the control of soybean seedling diseases.

Fungicide active ingredient	*Pythium* sp.[1.]	Phytophthora root rot	*Rhizoctonia* sp.	*Fusarium* sp.[1,3]	Sudden death syndrome (SDS) (*Fusarium virguliforme*)	*Phomopsis* sp.
Azoxystrobin	P-G	NS	VG	F-G	NR	P
Carboxin	U	U	G	U	NR	U
Chloroneb	U	P	E	P	NR	P
Ethaboxam	E	E	U	U	U	U
Fludioxonil	NR	NR	G	F-VG	NR	G
Fluopyram	NR	NR	NR	NR	VG	NR
Fluxapyroxad	U	U	E	G	NR	G
Ipconazole	P	NR	F-G	F-E	NR	G
Mefenoxam	E[2]	E	NR	NR	NR	NR
Metalaxyl	E[2]	E	NR	NR	NR	NR
PCNB	NR	NR	G	U	NR	G

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White Mold

- *Sclerotinia* spp.
- Not as problematic in NC
  - Requires several freeze-thaw events for fruiting bodies to form
- Fungicides may help reduce incidence
- Tillage practices

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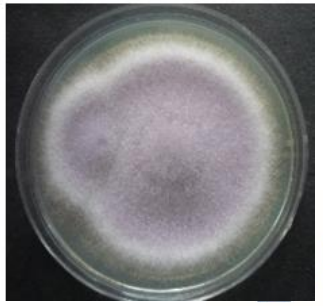
Fusarium Wilt and Sudden Death Syndrome

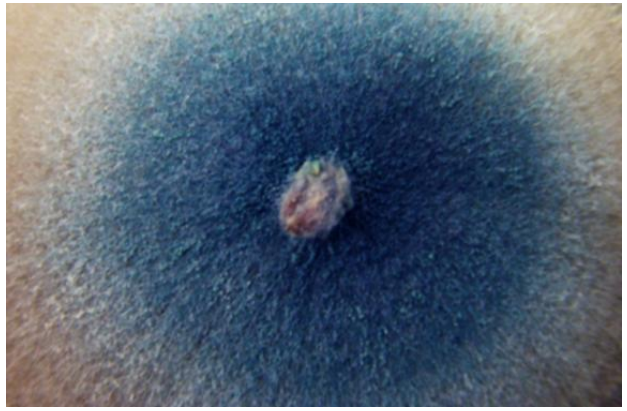
Fusarium virguliforme

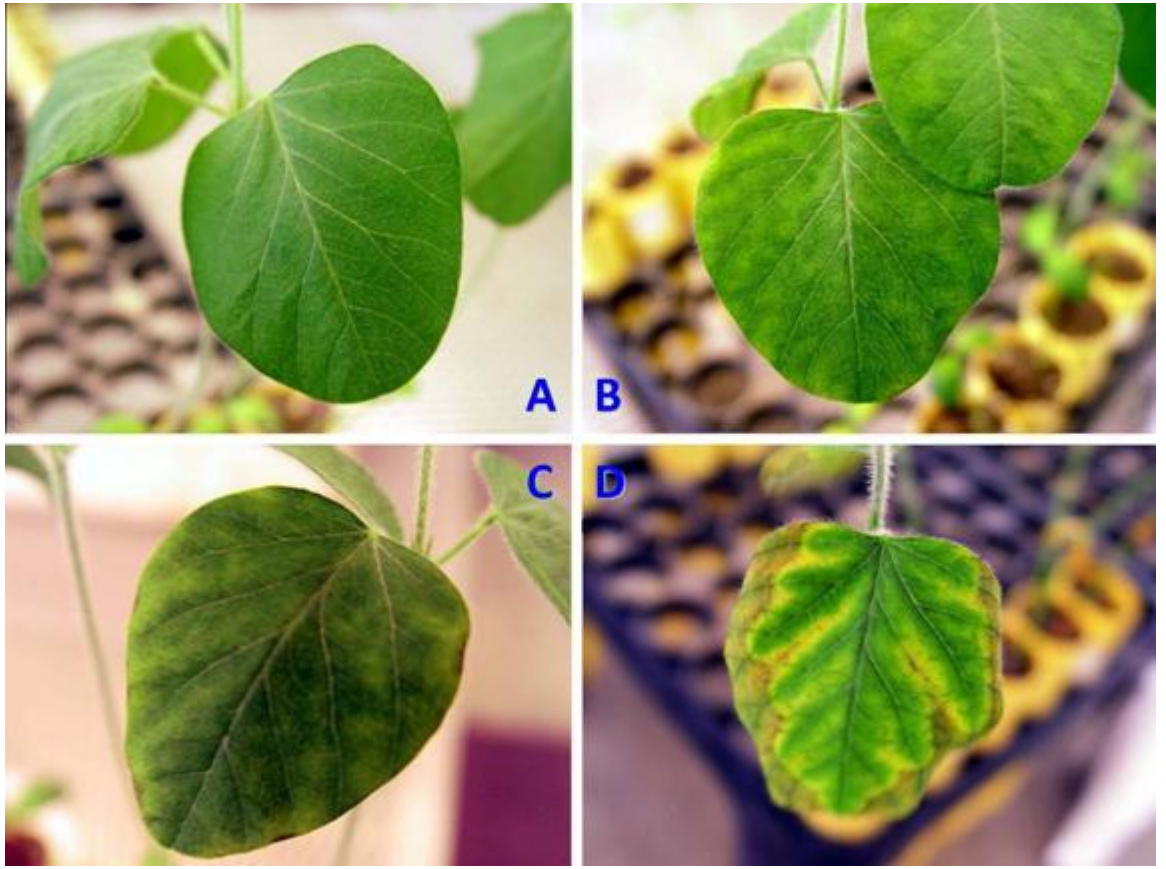
Fusarium oxysporum



Fusarium Wilt and Sudden Death Syndrome

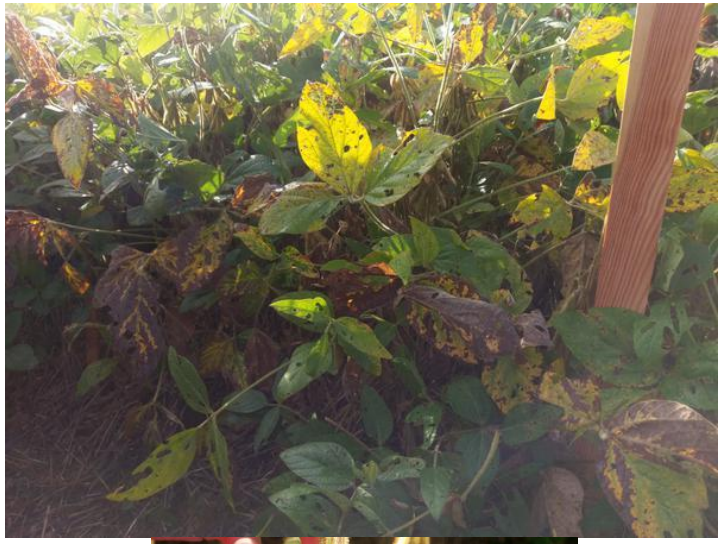
- Management focused on limited damage to roots
  - Seedlings and injured plants most affected
  - Root knot nematode or SCN damages increase disease
  - Improve soil drainage and limit water stress where possible





Stem Canker

- *Diaporthe phaseolorum*
- Easily confused with *Phytopthora*
  - Lesions from first node versus roots up
- Management
  - Variety selection
  - Tillage practices
  - Chemical applications not effective in reducing disease



Phytophthora root rot

- *Phytophthora sojina*
- Favored by wet conditions at any point in the growing season
- Early season management
  - Seed treatments
- Late season management
  - Chemical treatments not economical (Ridomil)
  - Reduce flooding as much as possible

Frogeye Leaf Spot

- *Cercospora sojina*
- Survives in infested crop residues that infect the next growing season
- More severe in continuous soybean production
- Favored by humid/wet conditions

Frogeye Leaf Spot

- Management
  - Resistant Varieties
  - Fungicides

Table 8-2. Efficacy of foliar fungicides for the control of foliar soybean diseases[1].

Class	Active ingredient (%)	Product / Trade name	Rate/A (fl oz)	Aerial web blight	Anthracnose	Brown spot	Cercospora leaf blight[2]	Frogeye leaf spot[3]	*Phomopsis / Diaporthe* (Pod and stem blight)	Soybean rust	White mold[4]	Ha res
Qol Strobilurins Group 11	Azoxystrobin 22.9%	Quadris 2.08 SC Multiple Generics[6]	6.0 - 15.5	VG	VG	G	P	P	U	G-VG	P	14
	Fluoxastrobin 40.3%	Aftershock 480 SC Evito 480 SC	2.0 – 5.7	VG	G	G	P	P	U	U	NL	R5 be se 30
	Picoxystrobin	Aproach 2.08 SC	6.0 -12.0	VG	G	G	P	P	U	G	G-VG[9]	14
	Pyraclostrobin 23.6%	Headline 2.09 EC/SC	6.0 - 12.0	VG	VG	G	P	P	U	VG	NL	21
DMI Triazoles Group 3	Cyproconazole 8.9%	Alto 100SL	2.75 – 5.5	U	U	VG	F	F	U	VG	NL	30
	Flutriafol 11.8%	Topguard 1.04 SC	7.0 – 14.0	U	VG	VG	P-G	VG	U	VG-E	F	21

Soybean Varieties in North Carolina

with at least moderate resistance to Frogeye Leafspot (FLS), southern Stem Canker (SC), or Sudden Death Syndrome (SDS).

Variety	FLS	SC	SDS
32RY39	X		X
32RY55	X	X	X
33LL58	X	X	X
34RY75	X		
36RY68	X		
37RY47		X	X
39RY57	X		
41RH22	X		X
4203R2			X
4402R2	X	X	X
444NR	X		X
44RE02	X		
4501R2	X	X	X
4602R2	X	X	X
46B3RR	X	X	X
46C6RR	X		X
47LD08	X		
47RC32	X		
48LD80	X		
48RD00	X		
4990.RC	X		

Frogeye Leaf Spot

- Fungicide Resistance in NC
  - Found in every county sampled thus far
  - Shameless plug: Send me FLS!
- Managing Resistance
  - Use combination fungicides or avoid solo strobilurin
  - If making multiple applications, rotate chemistry groups

Cercospora Blight

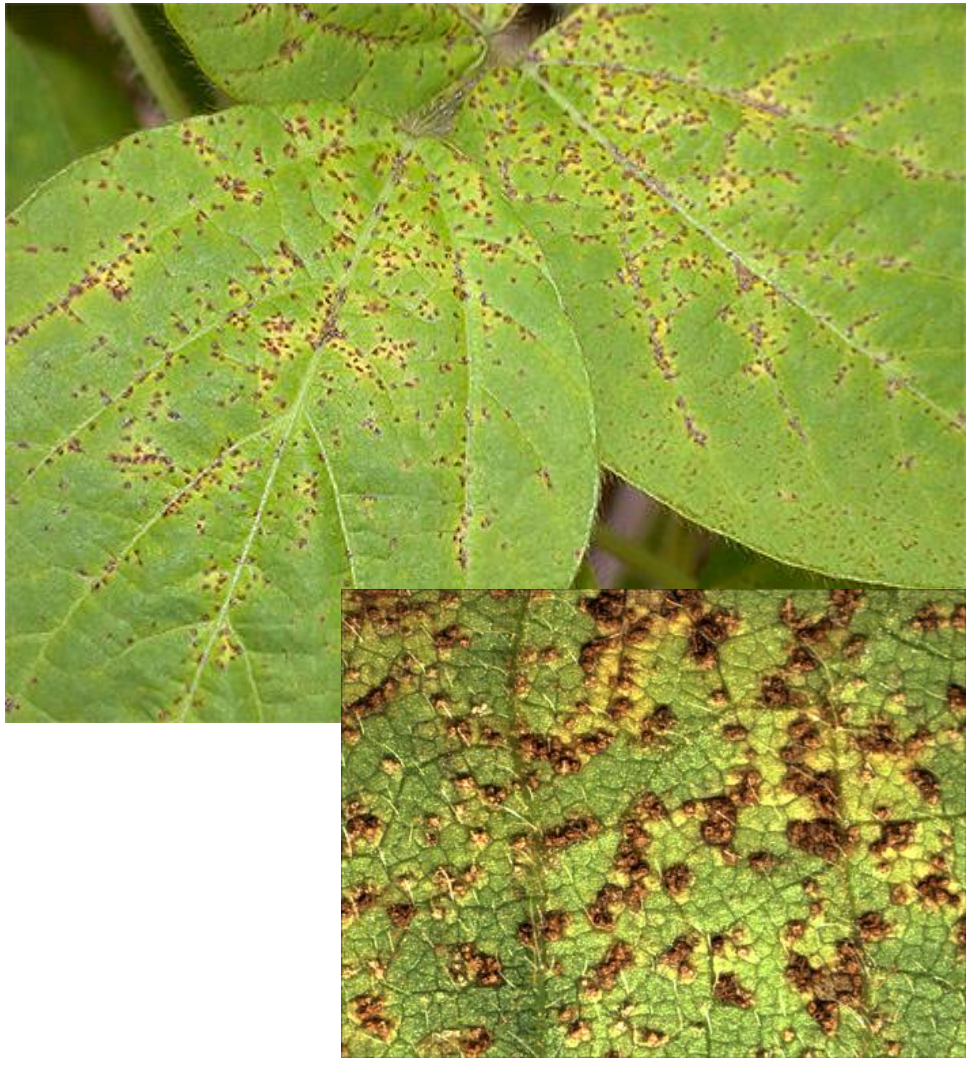
- *Cercospora kikuchii*
- Favored by humid/wet conditions
- Survives in overwintering debris
- More severe in continuous soybean
  - Can defoliate plants prematurely

Cercospora Blight

- Management
  - Improve airflow by avoiding excessively dense planting
  - Improve soil drainage where possible
  - Certified, disease-free seed
  - *Fungicides do not economically reduce seed infection*

Soybean Rust

- Not typically a concern for NC
  - Observed in 258 counties in 10 states in 2017
  - Observed in 2 States in 2018
- Fungicide applications only recommended if found within 100 miles of soybeans between R3 and R5
  - Will make announcements when found in neighboring states on soybeans



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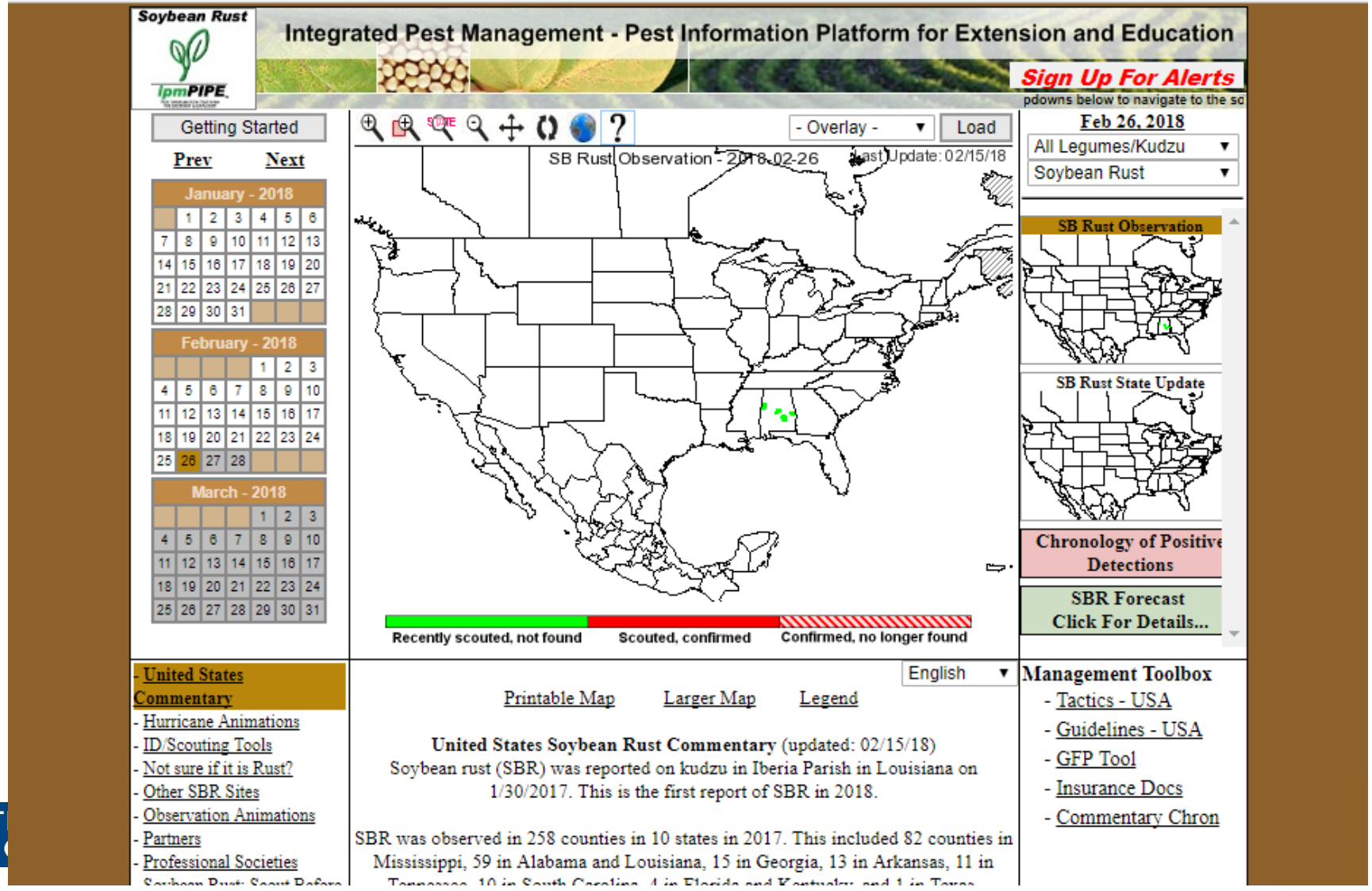
Soybean Rust PIPE



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Questions

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Website: https://fieldcropspathology.wordpress.ncsu.edu/

NCSU Tobacco and Field Crops Pathology

@FieldCropsPath

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