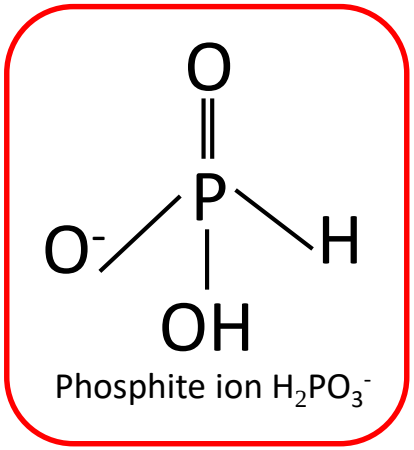


Phosphite ion $H_2PO_3^-$

Update on Phosphite Residues in Pecan

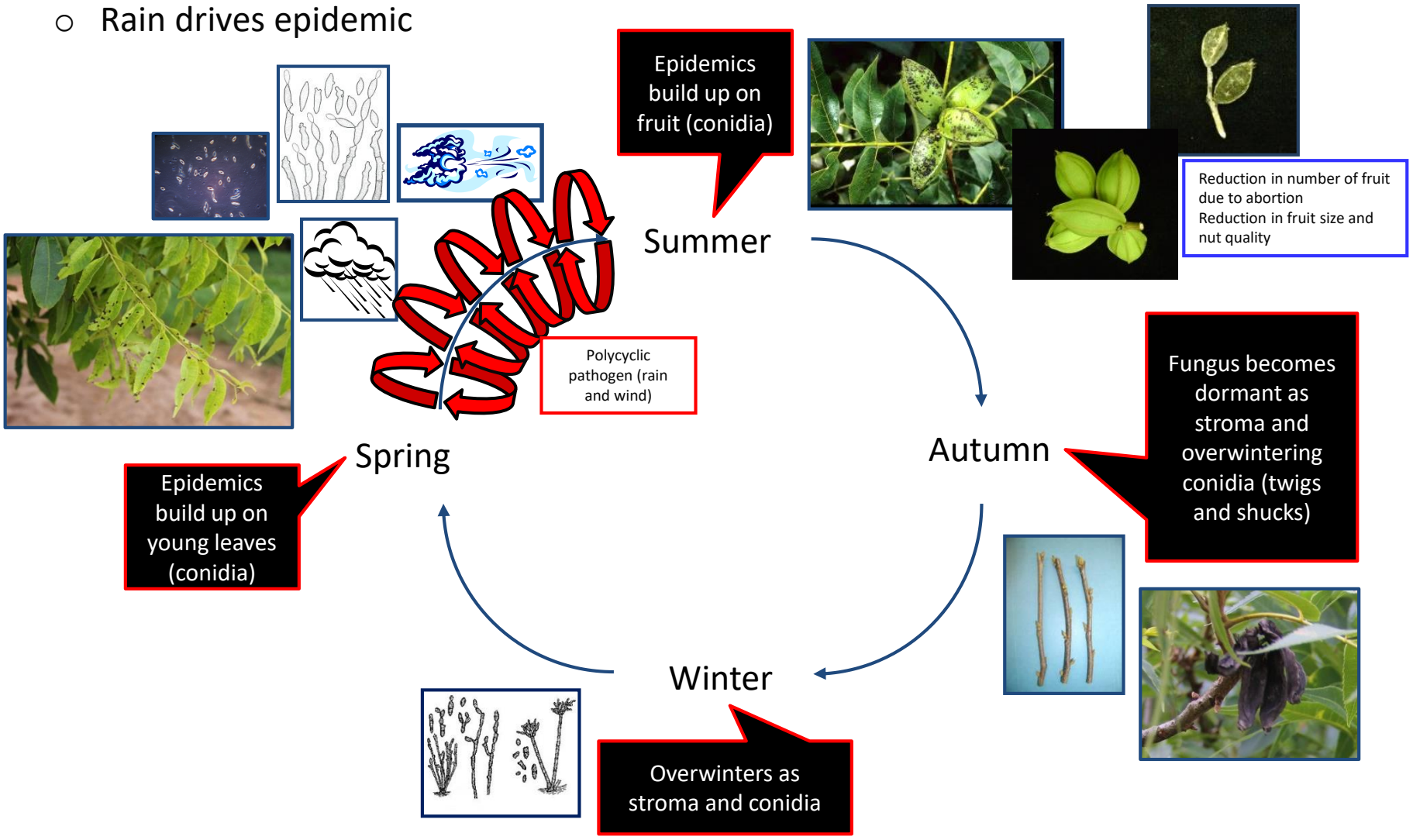


Clive H. Bock and Tim B. Brenneman

USDA-ARS-SEFTNRL, Byron, GA
University of Georgia, Tifton, GA

Pecan scab (*Venturia effusa*)

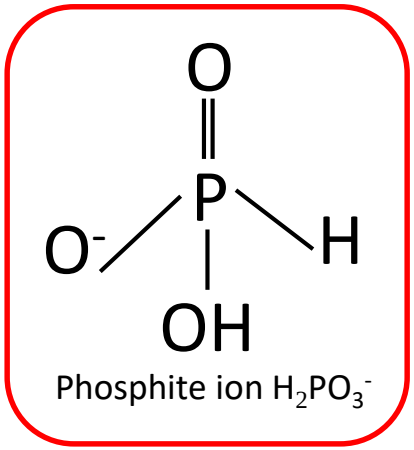
- Can cause 100% yield loss in susceptible cultivars
- Lifecycle of *V. effusa*
- Rain drives epidemic



Phosphite fungicides

What is phosphite?

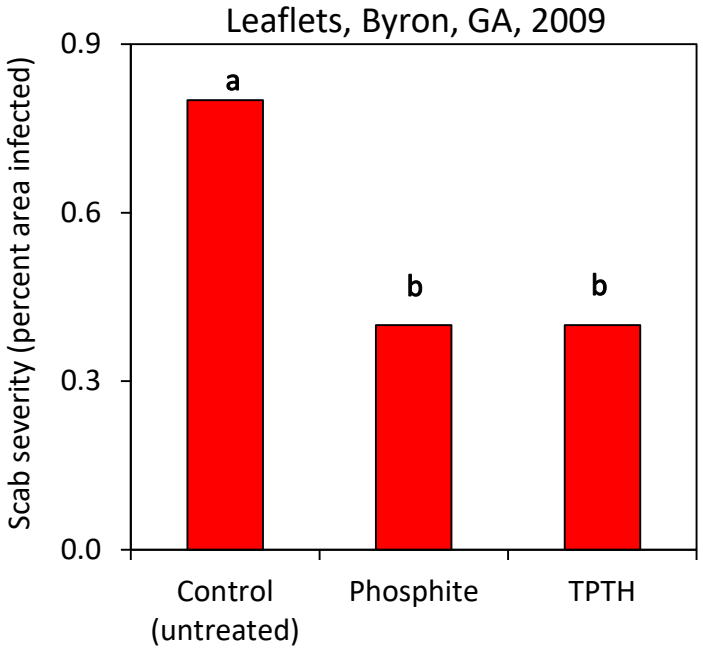
- Phosphites ($H_2PO_3^-$) (phosphonates) are salts of phosphorous acid [$HPO(OH)_2$]
- Not a phosphate (HPO_4^{2-}), which are important in plant nutrition
- The phosphite ion ($H_2PO_3^-$) is readily absorbed in plants
- Phosphite travels systemically in both the xylem and phloem
- Formulated with a cation (most often an alkali metal, Na, K, Al, NH_4) and is sold both in fungicide and nutritional packages for use in agriculture

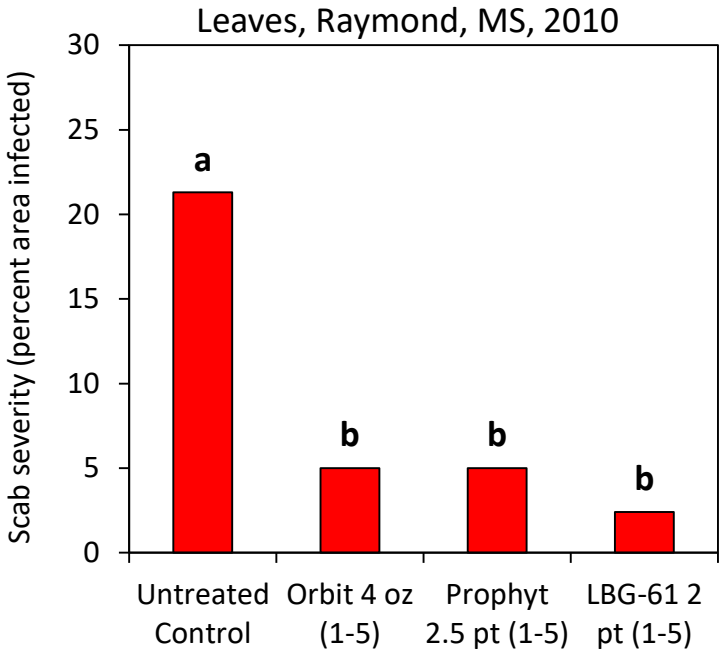


Phosphite ion $H_2PO_3^-$

Phosphites are effective on foliage

- In multiple experiments phosphites have been shown to effectively reduce scab on foliage when compared to other industry standard fungicides
- But generally results were less efficacious on fruits at the low rates initially recommended





- Fungicide treatments: Potassium phosphite (Prophyt, 36 fl oz/100 gallons) or triphnyl tin hydroxide (TPTH) (Super Tin 4L, 12 fl oz/100 gallons). Applications made biweekly. Prepollination - end of July
- Scab severity assessed visually on foliage . Data was analyzed using General linear modeling with Tukey's means separation (P = 0.05)

Bock, C.H., Brenneman, T.B., Hotchkiss, M.W. and Wood, B.W. Evaluation of a phosphite fungicide to control pecan scab in the southeastern USA. Crop Protection 36: 58-64. 2012.

- Fungicide treatments (5 applications): Orbit 4 oz (1-5), Prophyt 2.5 pt (1-5), LBG-61 2 pt (1-5)
- Scab severity assessed visually. Data was analyzed using ANOVA with means separation an LSD test (P = 0.05).

Ingram, D.M. 2011 Evaluation of products for control of scab in pecans, 2010. Plant Disease Management Reports 5:STF007

Phosphite usage: recommendations

- Phosphites are applied as both single chemistry applications and tank mixes
- There is much information we do not have, but current usage recommendations are:
  - **Prepollintation** applications (every 10-14 days from bud-break to nut-set)

2018/19 spray guide

phosphorous acid Phostrol ProPhyt FungiPhite Reliant	33	 2-5 pt 2-3 pt 2-3 pt 4 pt	4 H/ –	See info below: MOA Group 33.
phosphorous acid + tebuconazole Viathon	33 + 3	2-2.5 pt	12 H/ 0 D	See info below: MOA Group 33. See info below: MOA Group 3.

  - **Postpollintation** applications (every 10-21 days from nut-set to shell hardening)

2018 spray guide

phosphorous acid Phostrol ProPhyt Viathon FungiPhite Reliant	33	 2-5 pt 2-3 pt 2 pt 2-3 pt 4 pt	4 H/ –	See info below: MOA Group 33.
phosphorous acid + tebuconazole Viathon	33 + 3	2-2.5 pt	12 H/ 0 D	See info below: MOA Group 33. See info below: MOA Group 3.

2019 spray guide

phosphorous acid Kphite 7LP Phostrol ProPhyt Viathon FungiPhite Reliant	33	highest label rate	4 H/ –
phosphorous acid + tebuconazole Viathon	33 + 3	2-2.5 pt	12 H/ 0 D

MOA Group 33: Resistance risk is low. For best control apply in 100 gpa by ground. Do not apply in consecutive applications. Three to five applications are generally recommended. Check labels for potential limitations on maximum number of applications or amount of active ingredient allowed per season. Do not use when there is a phosphate deficiency.

Brock, J., and Brenneman, T.B. 2018. Pecan Disease Control. p9-13. In: 2018 Commercial Pecan Spray Guide. L. Wells (Ed.). University of Georgia Extension. Bulletin 841. 22 p.

Rates of phosphite: experiment procedures (Byron)

- Cv. Desirable, 30 y old trees ~60 ft
- 5 applications in 2015 (24 April, 19 May, 19 June, 9 and 30 July)
- 6 applications in 2016 (27 April, 11 and 27 May, 21 June, 13 July and 10 August)
- Applied using a Durand-Wayland 3210
- 100 gallons per acre at 2 mph
- 4 replicate trees of each treatment, foliage and fruit sampled and assessed for scab, fruit weigh recorded
- Analyzed using a general linear model with Tukey's means separation ($\alpha = 0.05$)

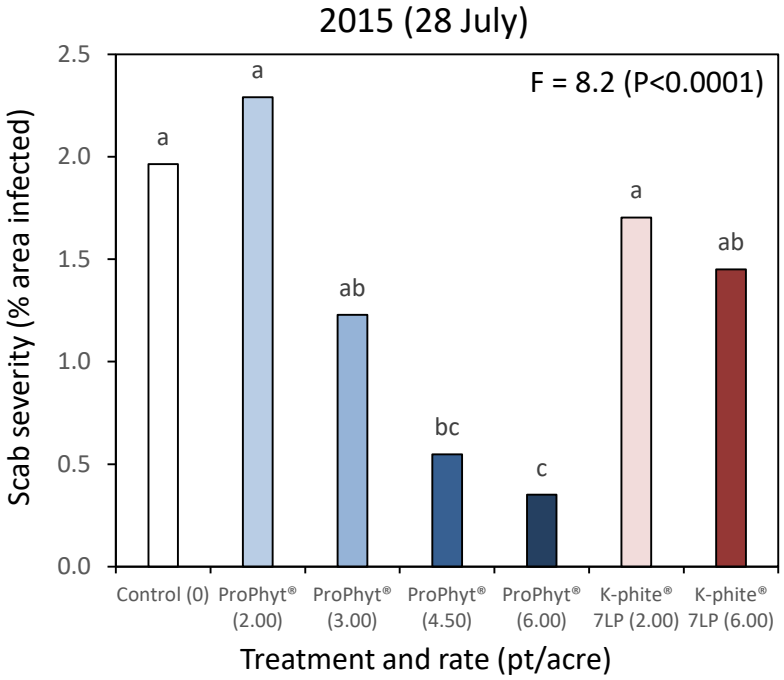
Fungicide [a]	Phosphonate salt	Proportion of phosphonate salts in product	Weight (Kg/L) of phosphorous acid	Recommended rate (label)		Rates applied	
				Liter/ ha	Pints/ acre	Liter/ ha	Pints/ acre
Control	0	0.0%	0.00	0.0		0.0	0.0
ProPhyt®	Mono- and di-basic potassium	54.5%[b]	0.50	2.3-5.9	2.0-5.0	2.3	2.0
						3.5	3.0
						5.3	4.5[b]
						7.0	6.0
K-phite® 7LP	Mono- and di-basic potassium	56.0%	0.53	2.3-7.0	2.0-6.0	2.3	2.0
						7.0	6.0

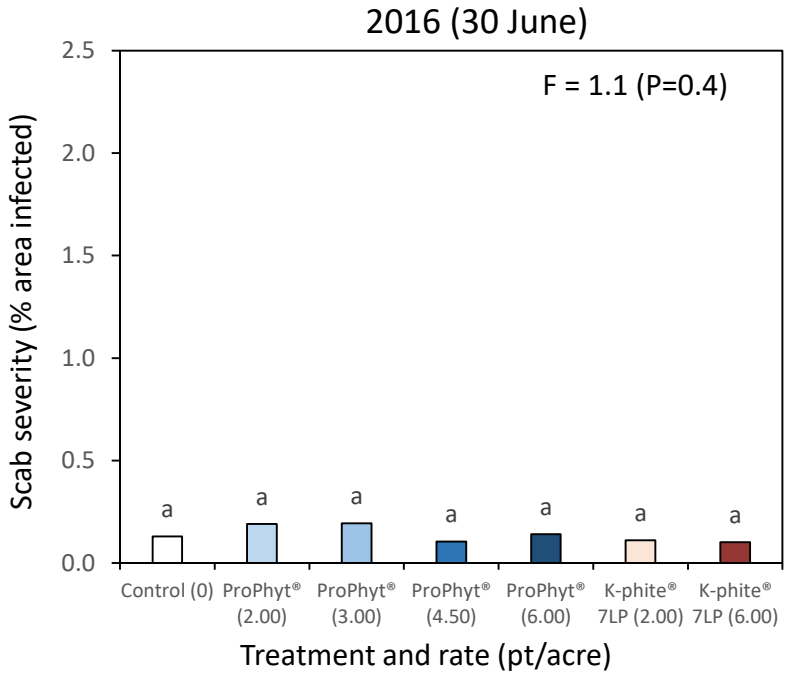
[a] Manufacturers are as follows: K-phite® 7LP (Plant Food Systems, Zellwood, FL), ProPhyt® (Helena Chemical Company, Collierville, TN)
[b] Labelled high rate of Prophyt® is 5.9 L/ha (5.0 pints/acre).

Effect of rate of phosphites for scab control (Byron)

Severity on leaflets (% area scabbed)

- Higher concentrations of phosphite reduce scab more on foliage
- In 2016, scab severity was low early in the season
- No phytotoxicity observed at 6 pnts/acre



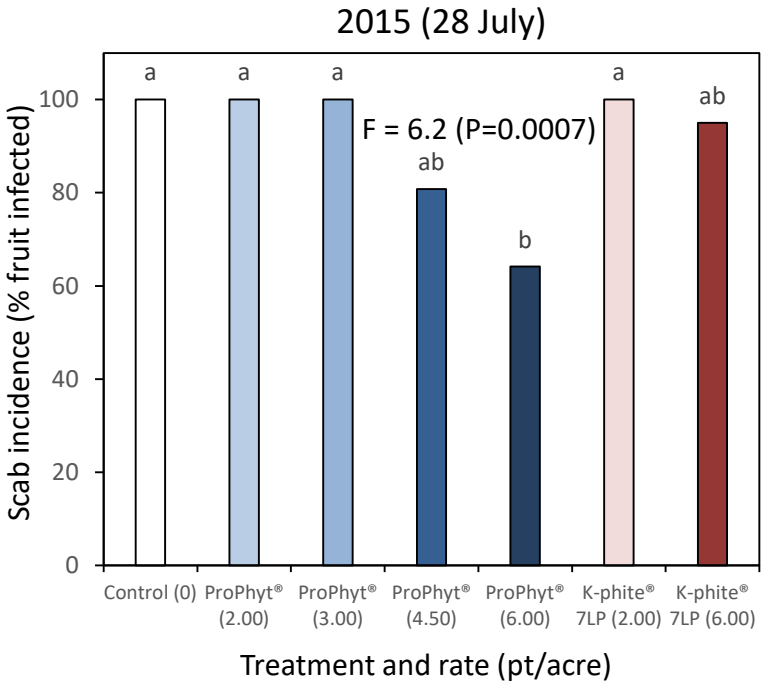


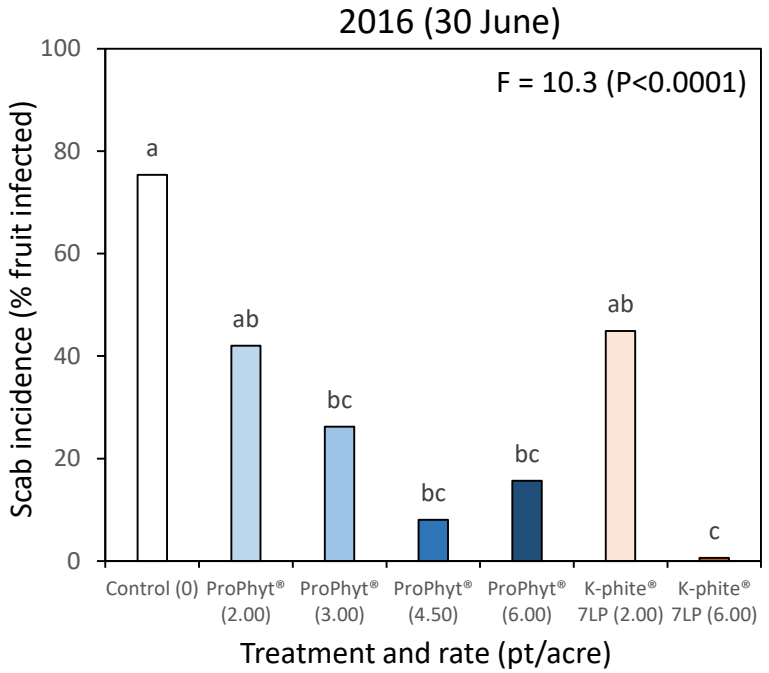
Different letters indicate means are significantly different ($\alpha = 0.05$)

Effect of rate of phosphites for scab control (Byron)

Immature fruit – incidence of scab (% fruit scabbed)

- Higher concentrations of phosphite reduce scab more on fruit
- In 2016, incidence of scab was lower early in the season





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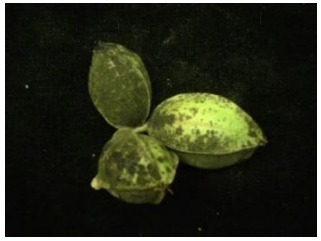
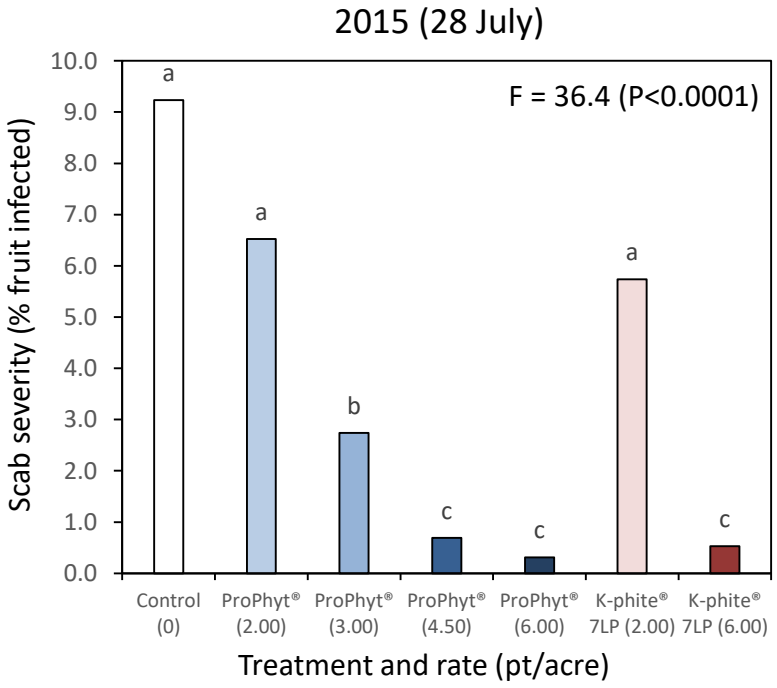
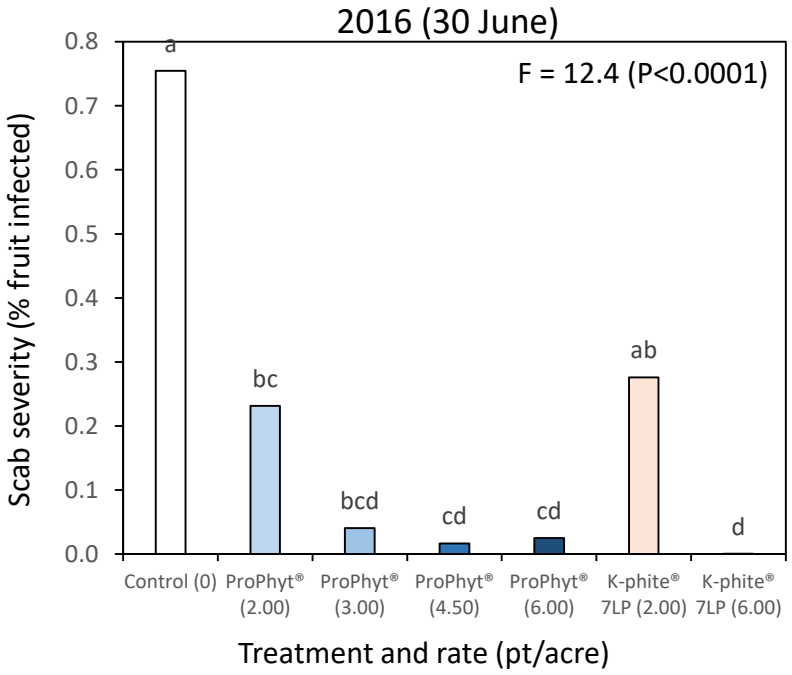
Effect of rate of phosphites for scab control (Byron)



Immature fruit – severity of scab (% area scabbed)

- Higher concentrations of phosphite reduce severity of scab more on fruit
- In 2016, scab severity was lower early in the season





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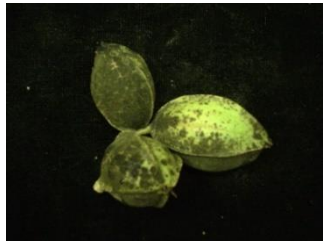
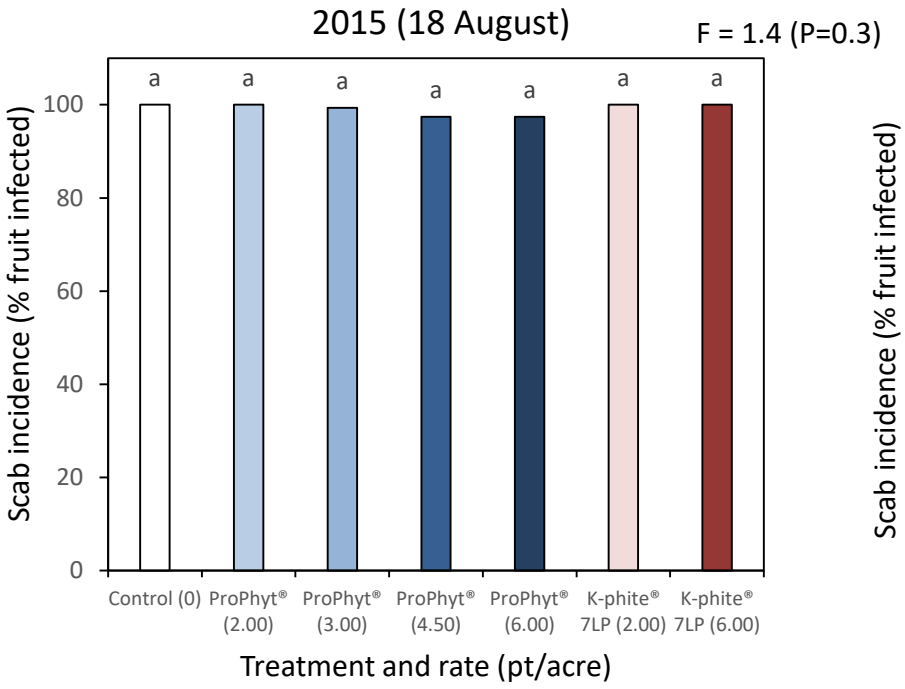
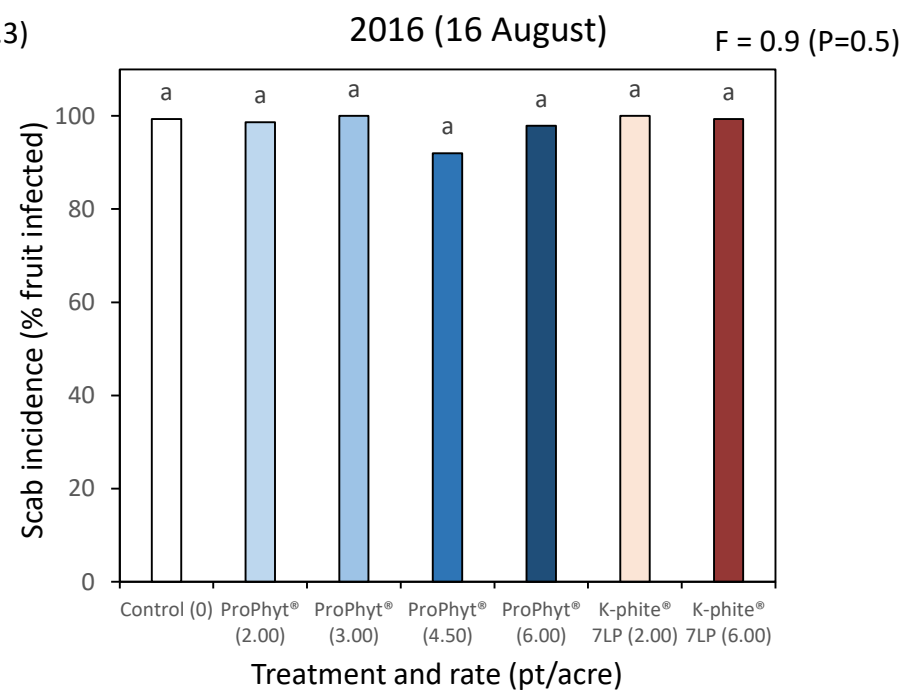
Effect of rate of phosphites for scab control (Byron)



Mature fruit – incidence of scab (% fruit scabbed)

- By mid-late August incidence was high in both years on all treatments



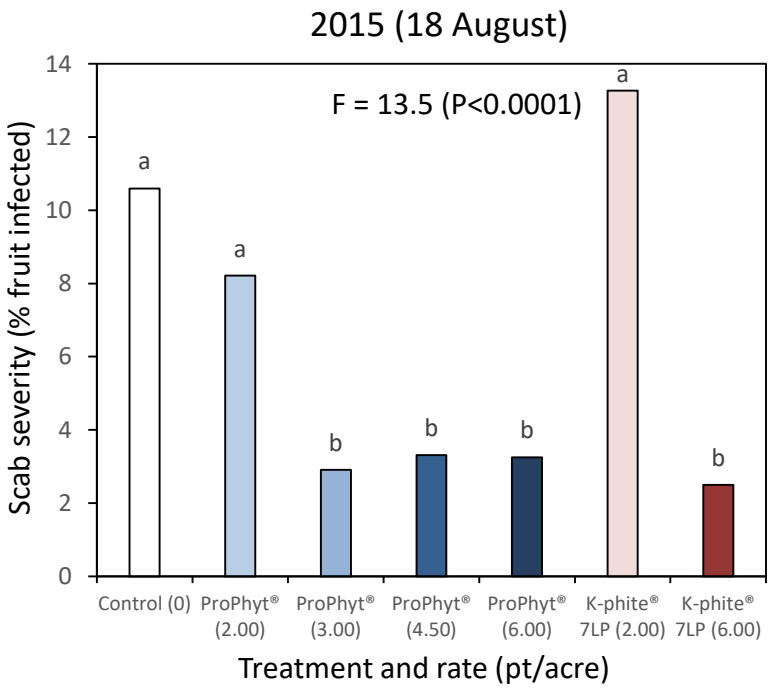


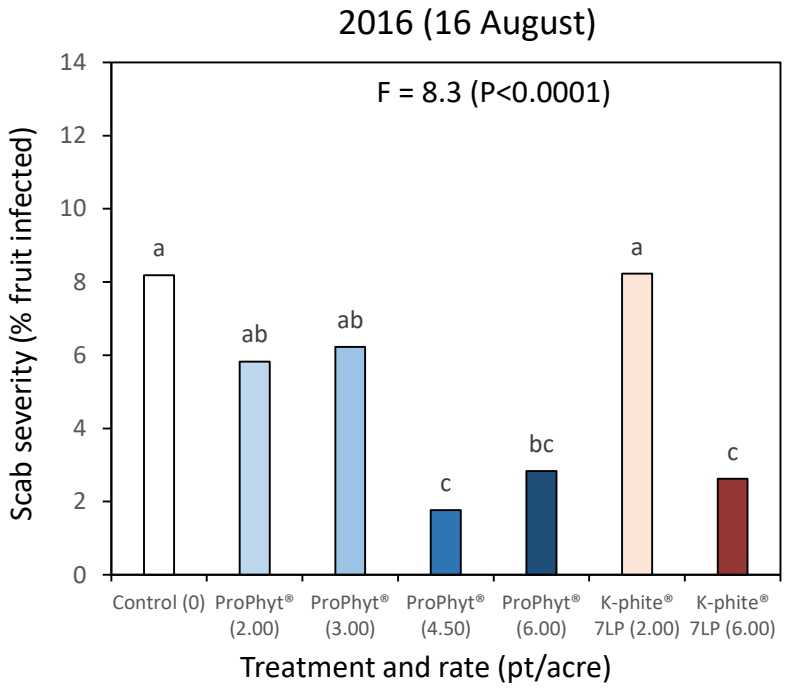
Different letters indicate means are significantly different ($\alpha = 0.05$)

Effect of rate of phosphites for scab control (Byron)

Mature fruit – severity of scab (% area scabbed)

- Higher concentrations of phosphite reduce severity of scab more on fruit
- In 2016, slightly lower scab severity on the control later in the season





Different letters indicate means are significantly different ($\alpha = 0.05$)

Rates of Phosphite: experiment procedures (Ty Ty)

- Cvs. Desirable and Wichita, individual terminals treated with hand pump sprayer
- Applications in 2017 (11 April, and every 14 +/-1 day to 15 August)
- Applications in 2018 (13 April, and every 14 +/-1 day to 17 August)
- Equivalent of 100 gpa
- Foliage and fruit sampled and assessed for scab (9 replicates for each tretament)
- Analyzed using a general linear model with Tukey's means separation ($\alpha = 0.05$)

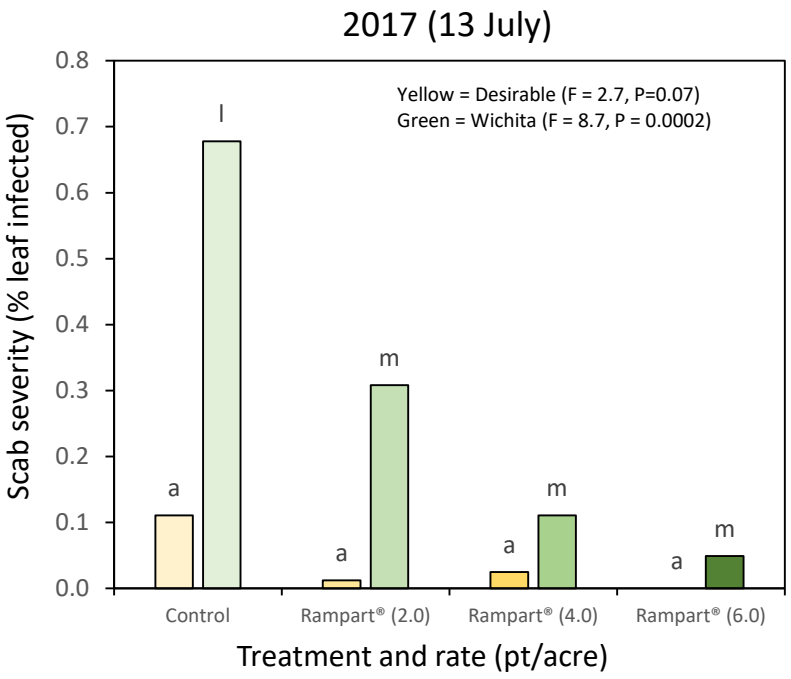
Fungicide [a]	Phosphonate salt	Proportion of phosphonate salts in product	Weight (Kg/L) of phosphorous acid	Recommended rate (label) Liter/ ha	Rates applied	
					Liter/ ha	Pints/ acre
Control	0	0.0%	0.00	0.0	0.0	0.0
Rampart®	Mono- and di-basic potassium	53.0%	0.47	3.0-8.0	2.3	2.0
					4.7	4.0
					7.0	6.0

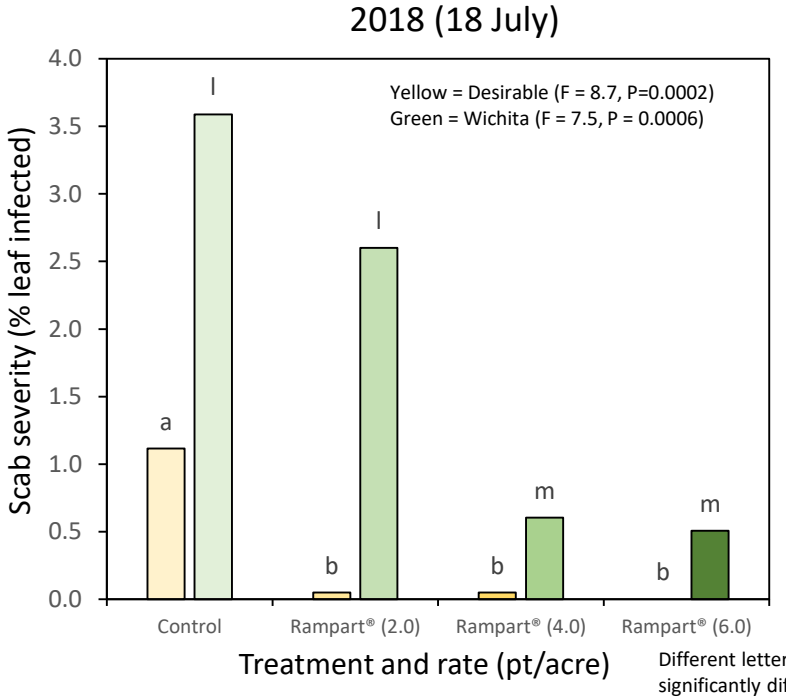
[a] Manufacturers are as follows: K-phite® 7LP (Plant Food Systems, Zellwood, FL), ProPhyt® (Helena Chemical Company, Collierville, TN)
[b] Labelled high rate of Prophyt® is 5.9 L/ha (5.0 pints/acre).

Effect of rate of phosphites for scab control (Ty Ty)

Severity on leaves (% area scabbed)

- On both cvs severity was significantly reduced by higher rates of the phosphite product
- In some cases difference were numeric but the trend consistent
- No phytotoxicity observed at 6 pnts/acre





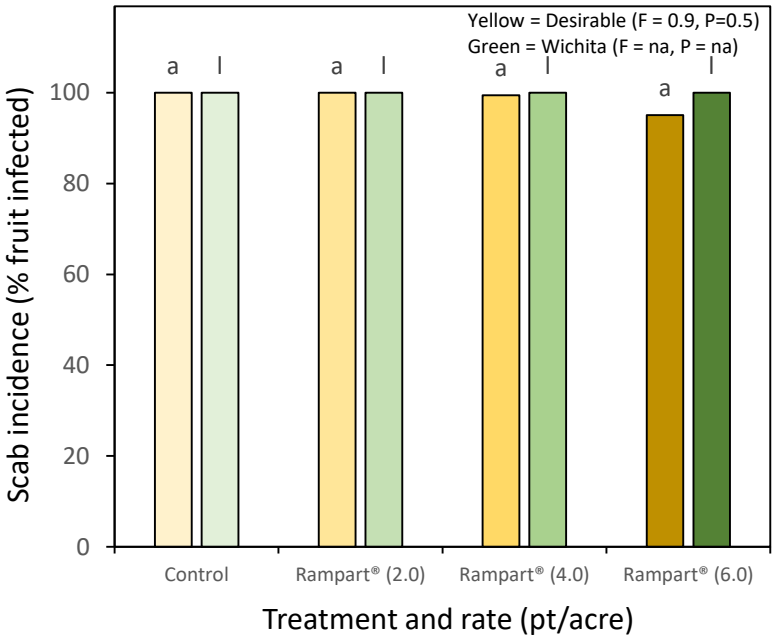
Different letters indicate means are significantly different ($\alpha = 0.05$)

Effect of rate of phosphites for scab control (Ty Ty)

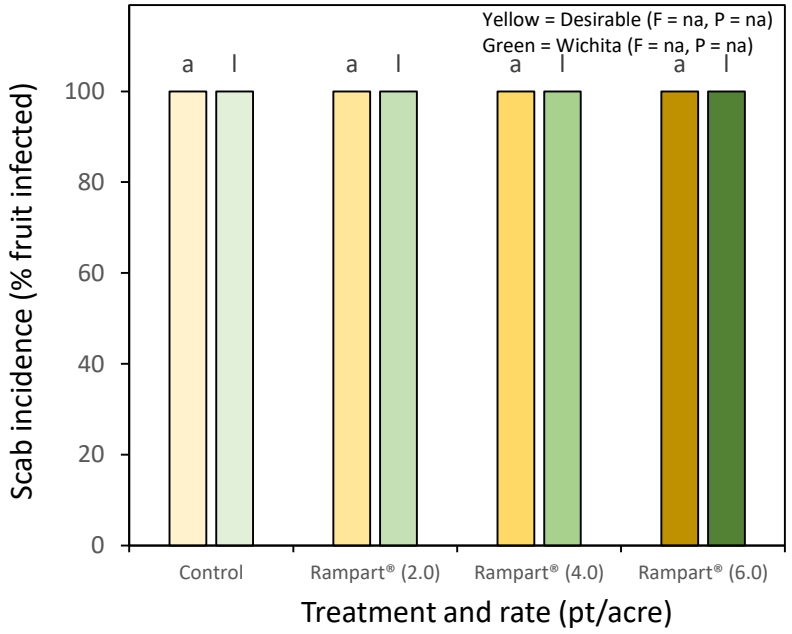
Mature fruit – incidence of scab (% fruit scabbed)

- Incidence of scabbed fruit was high on both cvs. There was no significant difference among rates of phosphite product

2017 (26 August)



2018 (31 August)



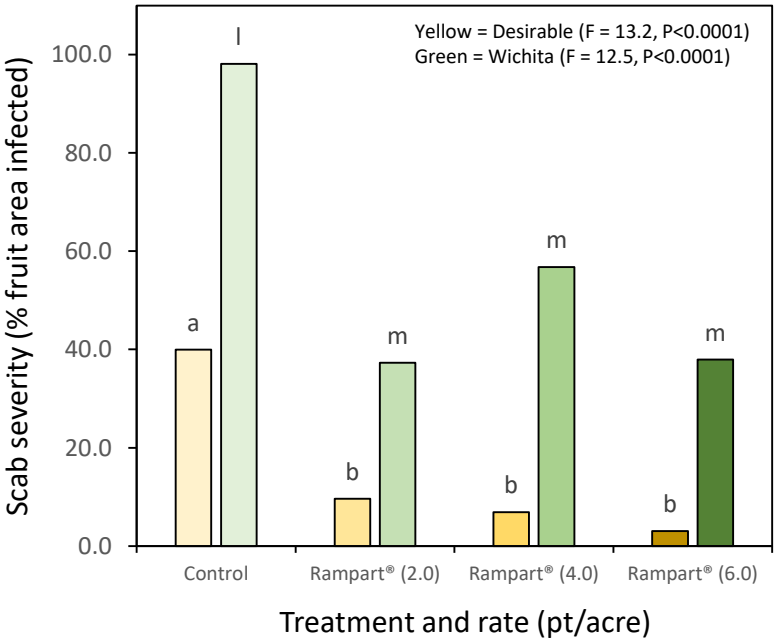
Different letters indicate means are significantly different ($\alpha = 0.05$)

Effect of rate of phosphites for scab control (Ty Ty)

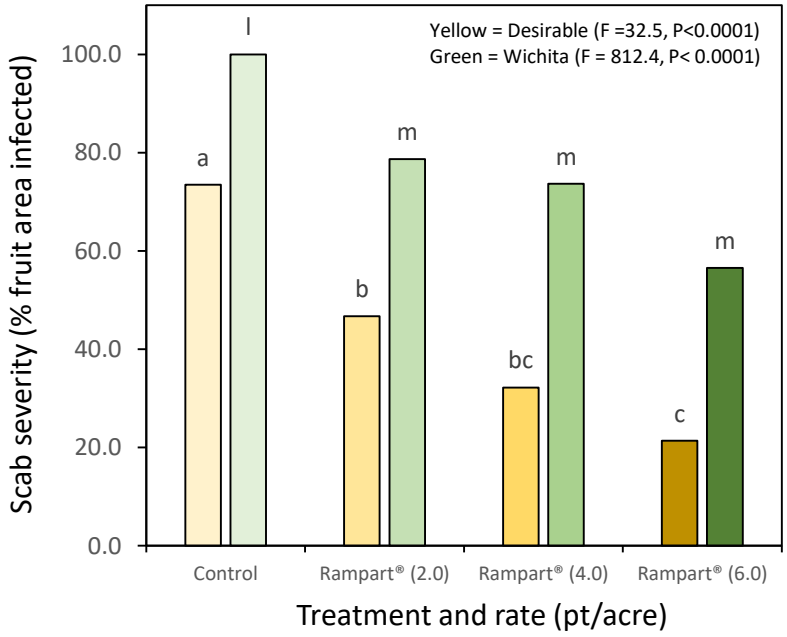
Mature fruit – severity of scab (% area scabbed)

- Most often there was significantly or numerically less severe scab on fruit of trees sprayed with higher rates of phosphite product

2017 (26 August)



2018 (31 August)



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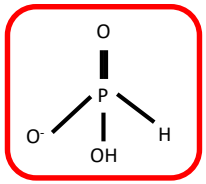
Residues, MRLs, EU rulings and other nut crops in relation to pecan



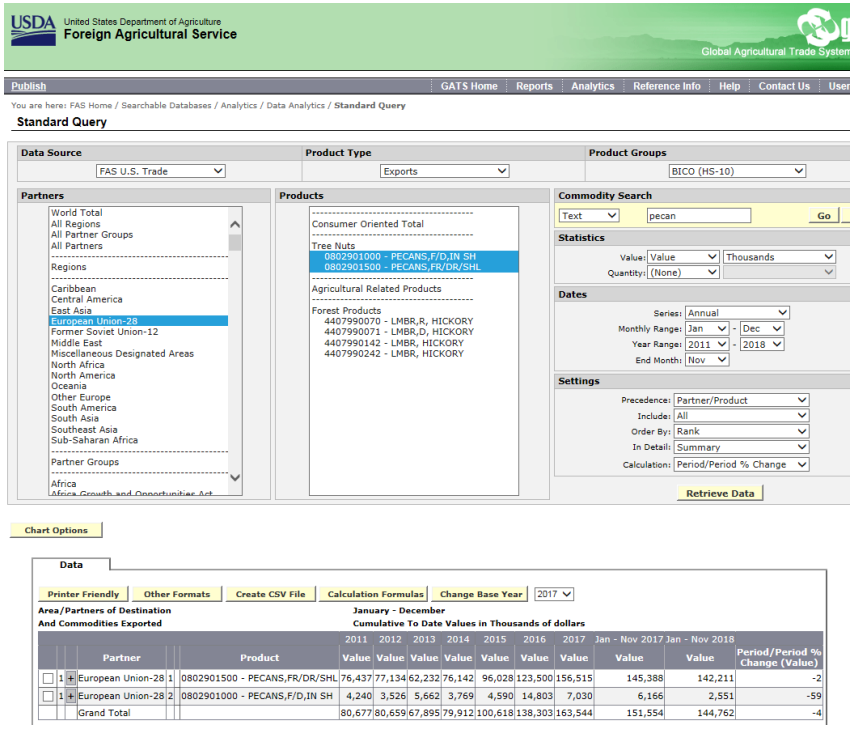
Phosphite ion
$H_2PO_3^-$

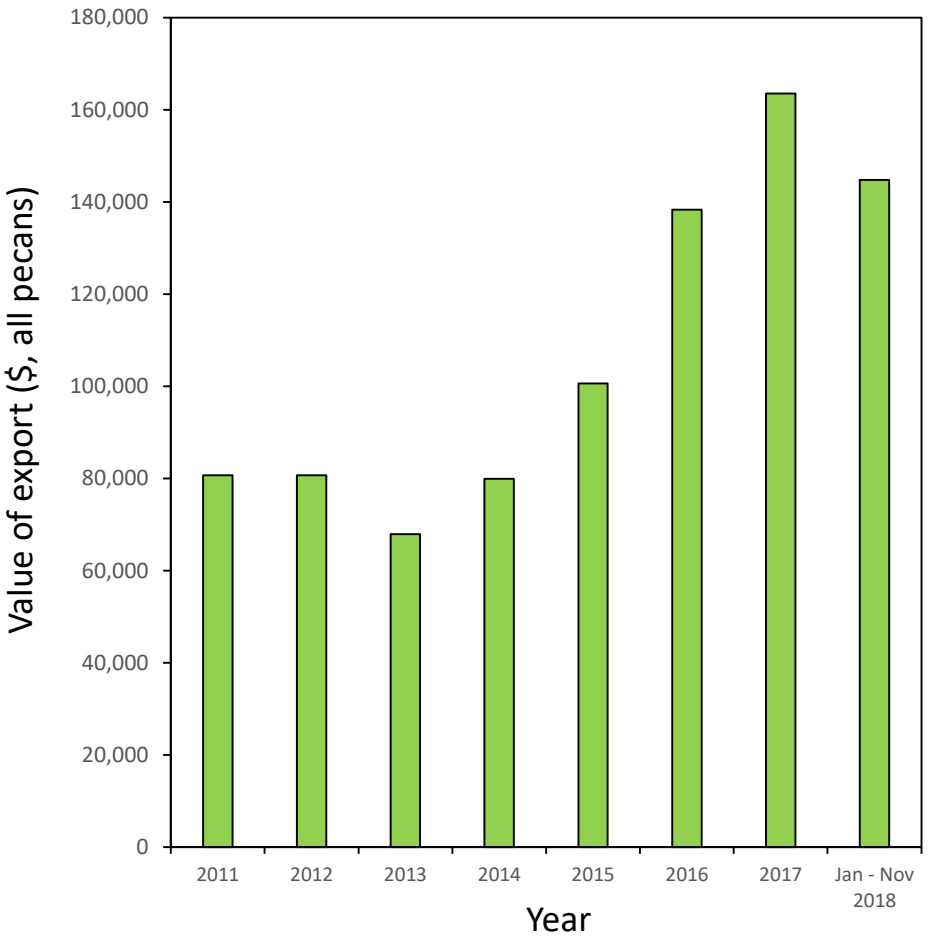
- Phosphite has VERY low animal toxicity
- In 2013 the EU changed the designation of phosphites as both fertilizer and pesticide to only pesticide, thus defaulting phosphites to a 2 ppm MRL
- They provided a temporary MRL of 75 ppm to nut and other crops to 31 December 2015 to allow time for producer industries to respond
- In September 2015, the US tree nut industry submitted a package based on IR-4 phosphite residue testing (*which did not include pecan data, but pecan was a stated nut in the documentation*) for the EU to determine a final import tolerance to replace the temporary MRL
- A permanent MRL was finally ratified on 5 June 2018 and set at 500 ppm
- Here in the Southeast, we use phosphite differently to pecan and other nut crops grown out West (from TX to CA)
- We need residue data for pecan to confirm it is within EU limits, and also determine how usage in the Southeast impacts residue

Exports of pecans to the EU

- Valuable export market
- Increasing in size as a market for pecans

United States Department of Agriculture
Foreign Agricultural Service





https://apps.fas.usda.gov/Gats/default.aspx

Phosphite residues

- Cvs. Pawnee and Caddo in 2016 and 2017
- Two experiments: (i) spray timing, and (ii) spray number effects on residues
- Applied using a Durand-Wayland 3210 (100 gallons per acre at 2 mph). Phosphites (ProPhyt®, Helena Chemical Company, Collierville, TN was applied at 3.51 L/ha (1.5 Q per acre). Contains 54.5% potassium phosphite, and has a phosphorous acid equivalent of 34.3% (equating to 503.3 g/L [4.2 lb/gallon]).
- 2-3 replicate trees of each treatment, foliage and fruit sampled
- Phosphite residue in nutmeats analyzed using
- Analyzed using a general linear model with Tukey's means separation ($\alpha = 0.05$), and by regression analysis

Spray number experiments

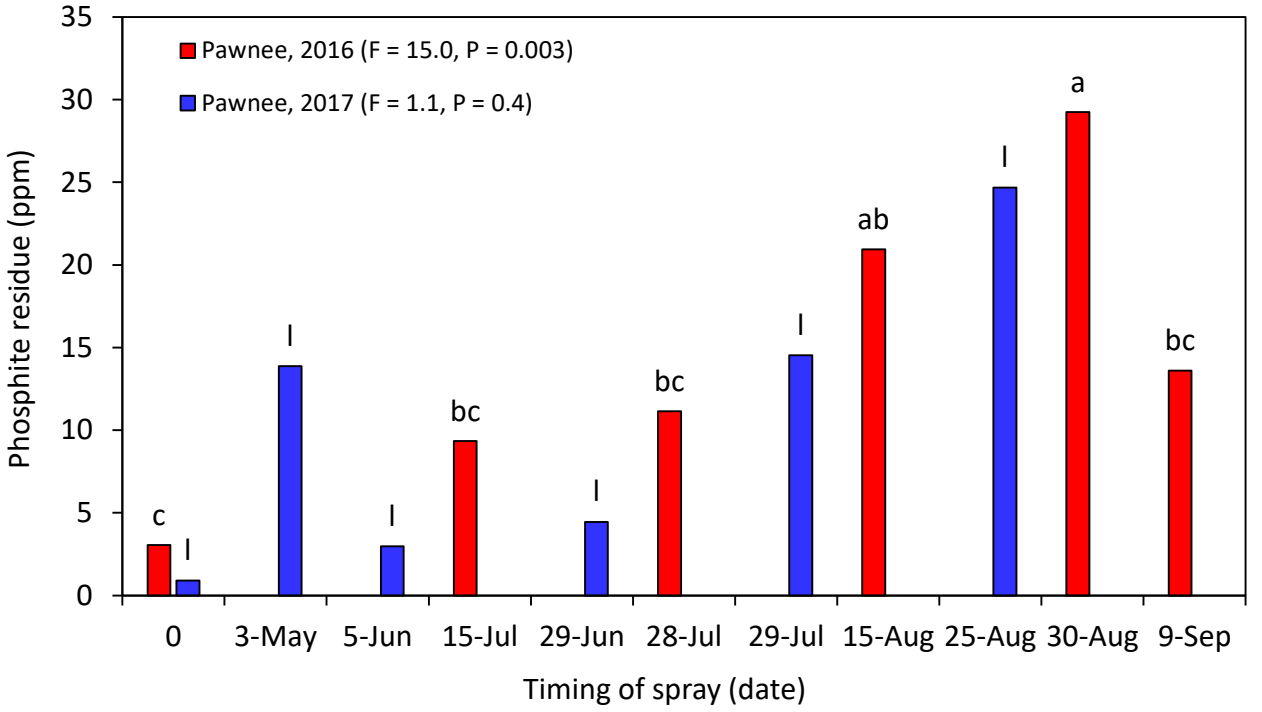
Year	Cultivar	No. of sprays	Spray dates
2016	'Pawnee'	0	0
	(GB)	1	15 Jul
		2	15 Jul, 15 Aug,
		3	15 Jul, 28 Jul, 15 Aug
		4	15 Jul, 28 Jul, 15 Aug, 30 Aug
		5	15 Jul, 28 Jul, 15 Aug, 30 Aug, 9 Sep
2017	'Pawnee'	0	0
	(GB)	1	3 May
		2	3 May, 24 May
		3	3 May, 24 May, 5 Jun
		4	3 May, 24 May, 5 Jun, 15 Jun
		5	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun,
		6	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul
		7	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul
		8	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul, 15 Aug
		9	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul, 11 Aug, 25 Aug
	'Caddo'	0	0
		1	3 May
		3	3 May, 24 May, 5 Jun
		5	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun,
		7	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul
		8	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul, 15 Aug
		9	3 May, 24 May, 5 Jun, 15 Jun, 29 Jun, 14 Jul, 29 Jul, 11 Aug, 25 Aug

Spray timing experiments

Year	Cultivar	Spray date
2016	'Pawnee'	0
	(GB)	15 Jul
		28 Jul
		15 Aug
		30 Aug
		9 Sep
2017	'Pawnee'	0
	(GB)	3 May
		5 Jun
		29 Jun
		29 Jul
		25 Aug

Phosphite residues: spray timing

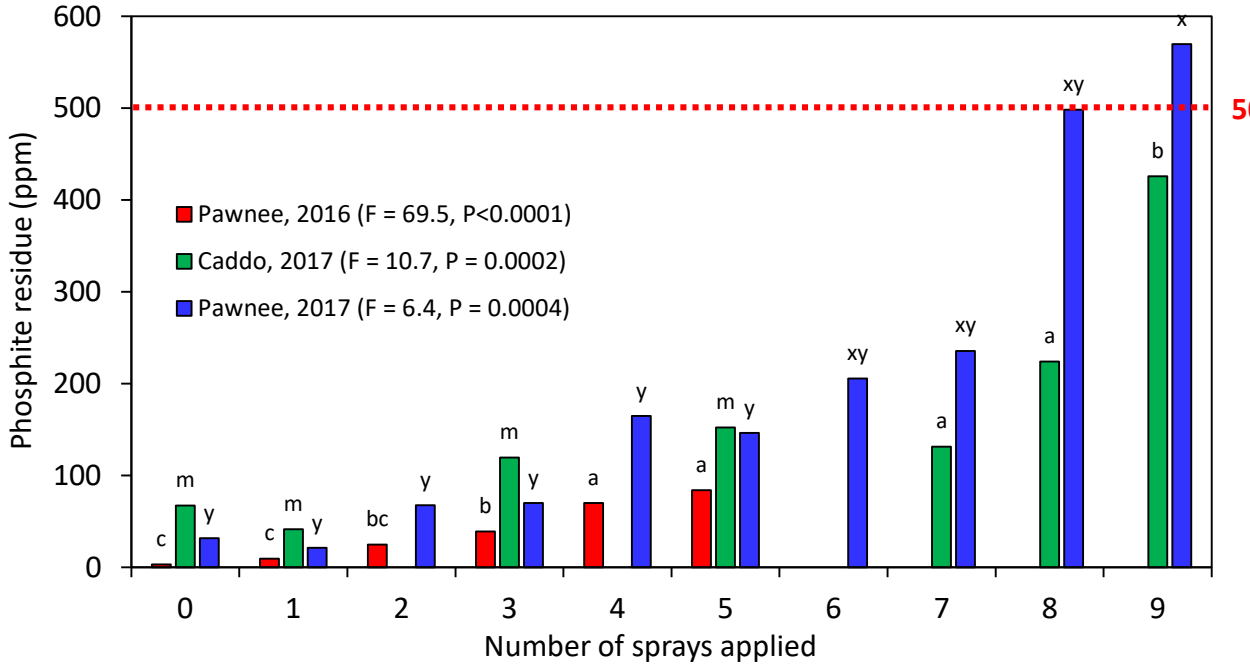
- In 2016 there was a small effect of the date of application of phosphite on nutmeat residue level (3.05 to 29.25 ppm)
- In 2017 there was no discernible effect of the date of application on phosphite on nutmeat residue level (0.9 to 24.67 ppm) – but there was a numeric trend for higher residue later



Different letters indicate means are significantly different (α = 0.05)

Phosphite residues: number of sprays applied in season

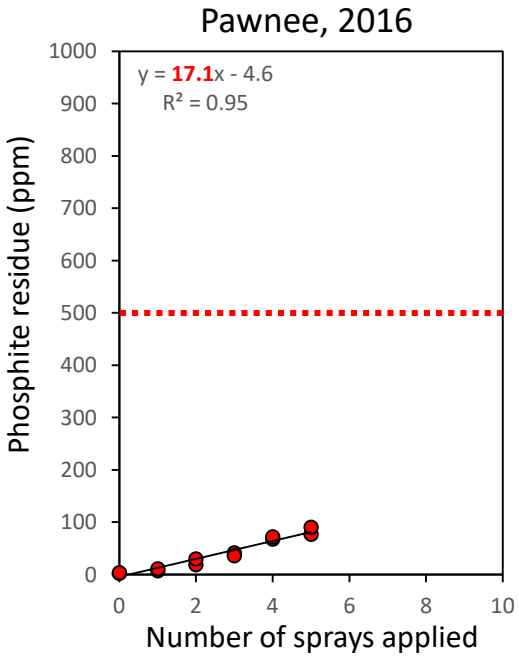
- More sprays result in a higher residue in pecan nutmeats
- Most often there is tree to tree variability within a treatment. Might phosphite residue vary within a tree canopy?
- 3-5 sprays are recommended in GA spray guide. Highly unlikely this will lead to >500 ppm EU limit
- >6 sprays may lead to a risk, but probably up to 7 are safe at 1.5 Q (3 pints/acre)

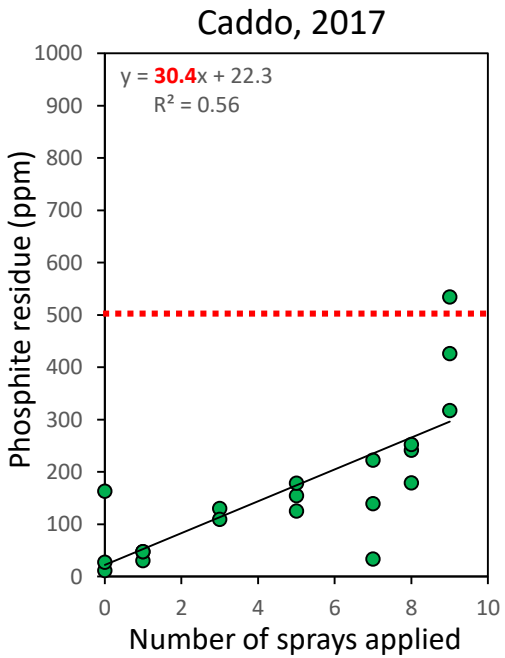


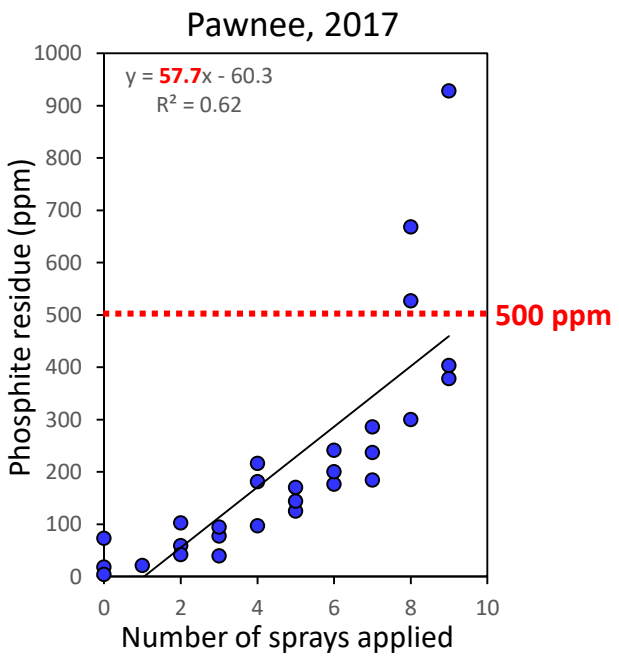
Different letters indicate means are significantly different (α = 0.05)

Phosphite residues – number of sprays applied in season

- There was a linear relationship between number of phosphite applications in a season and the final residue level
- A few individual samples from trees exceeded 500 ppm
- Depending on season, we determined ~17 to ~58 ppm/spray application
- UGA recommendation are for 5 or fewer sprays per season – well within the safety limit
- But we do not know about season to season build up, or the effect of rate



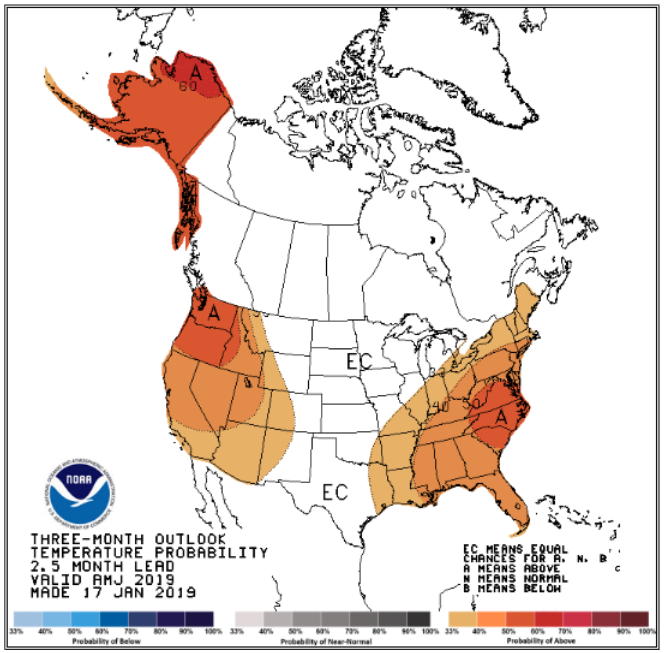


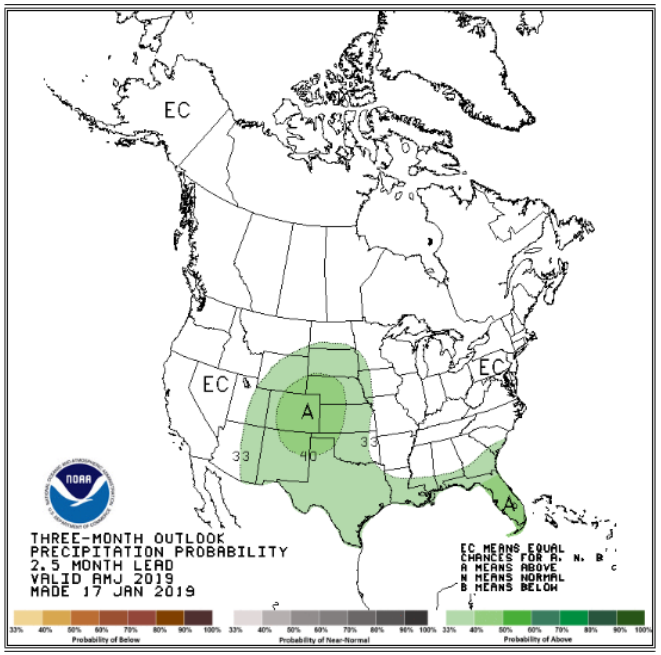


Finally, what does the season hold for weather?

- ❑ April-May-June 2019
- ❑ Probability to be hotter for the first three months of the season (and beyond)
- ❑ Some probability of being slightly wetter early in the season
- ❑ So scab is likely to be at least average in intensity

https://www.cpc.ncep.noaa.gov/products/predictions/long_range/



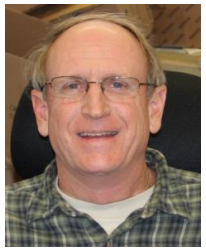


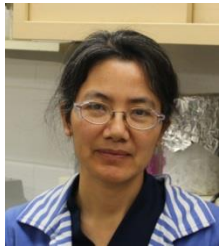
Summary

- ❑ Phosphites are a valuable chemistry in our toolbox against scab
- ❑ Phosphites at higher rates are efficacious on leaves and fruit
- ❑ We have robust data on 6 pnts/acre
- ❑ No phytotoxicity at 6 pnts/acre
- ❑ Phosphite residues may be an issue in pecan if >7 sprays are applied (effects of rate and season carry-over have not been established)
- ❑ In 2019 we should be prepared for at least an average scab year

Acknowledgements

- Thanks to the pathology team at the USDA-ARS-SEFTNRL:


Dr. Mike Hotchkiss


Minling Zhang


Wanda Evans

…..and many short-term employees who have worked with the group (Jason Shipp, Sue Burrell, Sarah Morril, Andrew Hudgens and Kaylee Carlson), and Dr. Bruce Wood

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Thank you

Questions?