Spray coverage in pecan trees - results of spray deposition tests

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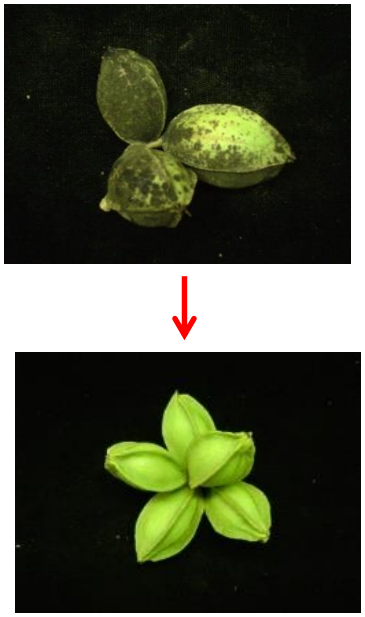
Why interest in spray coverage from an air-blast sprayer?

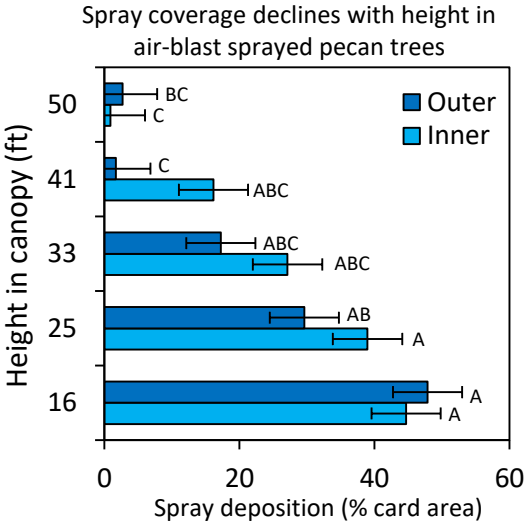
- It may not be uniform with height
- Non-uniform coverage may affect disease (and pest) control
- Various factors may affect coverage including volume, speed or use of a volute
- These factors can influence:
  - Management operation costs (time, labor and equipment taken)
  - Quantity and quality of yield (due to overall treatment efficacy)
- Both of which affect profitability

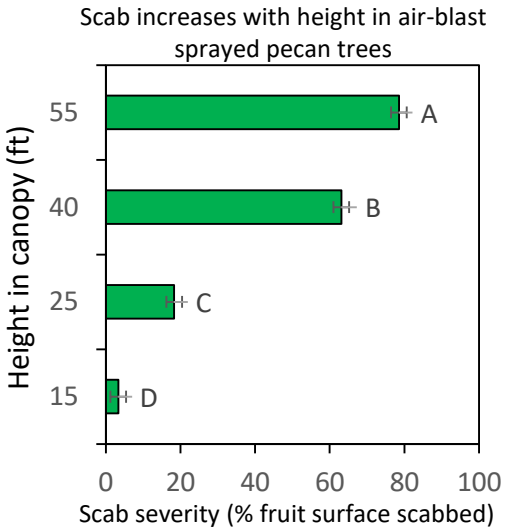
Spray coverage looks impressive when using an air-blast sprayer – appearing to easily reach the tops of tall trees (>25 m)

What do we know about air-blast spray coverage in pecan?

- Spray declines with height (Sumner, 2004; Reilly et al., 2007; Bock et al., 2015)
- In air-blast sprayed trees scab increases with height (Bock et al., 2013; Bock et al., 2017) – and the fruit higher in the canopy are smaller (Bock et al., 2018)
- Thus control of scab and other diseases in taller trees is challenging
- But we have virtually no knowledge of the effects of volume, speed or volutes in redistributing spray or controlling disease







Bock, C.H., Hotchkiss, M.W., Cottrell, T.E. and Wood, B.W. 2015. The effect of sample height on spray coverage in mature pecan trees. Plant Dis. 99: 916-925.

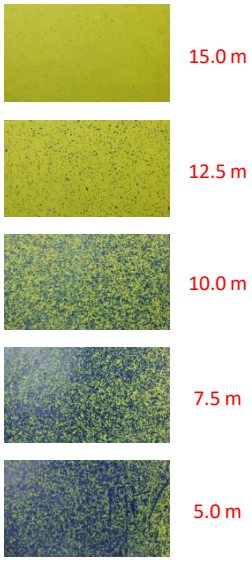
Bock, C. H., Hotchkiss, M. W., Brenneman, T. B., Stevenson, K. L., Goff, W. D., Smith, M. W., Wells, L., and Wood, B. W. Severity of scab and its effect on fruit weight in mechanically hedge-pruned and topped pecan trees. Plant Disease 101: 785-793. 2017.

Objectives

1. Get an insight into the effects and interactions between speed, volume and use of a volute in redistributing spray in tall pecan trees

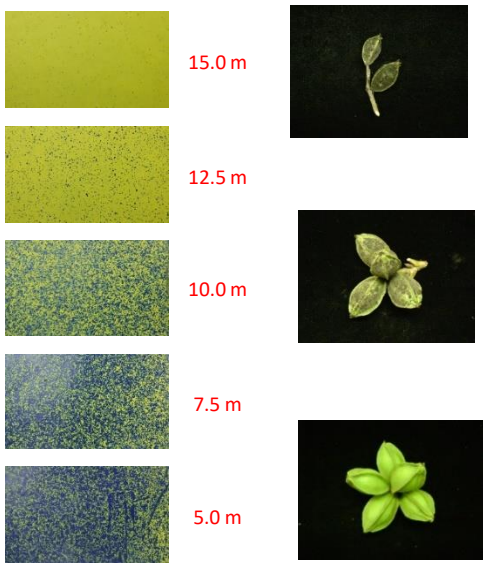
   Possible combinations are clearly limitless - we chose to compare 50, 100 and 200 GPA at 1.5 and 2.0 mph (without a volute), and 50 and 100 GPA at 1.5 and 2.0 mph (with a volute)

2. Perform experiments to compare how the different treatments affect control of scab in tall pecan trees (preliminary results)



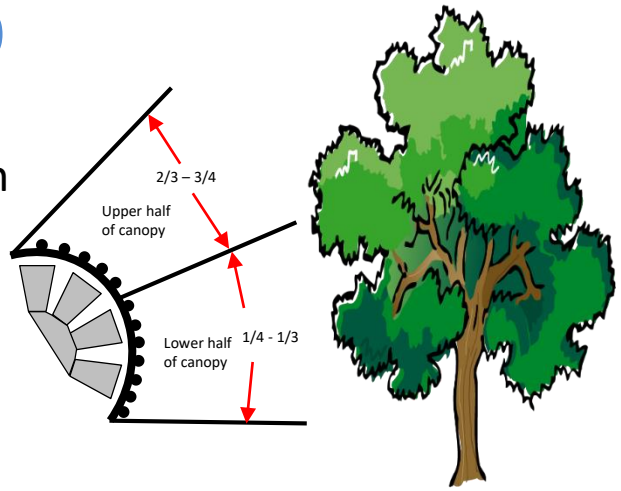
Spray deposition in tall pecan trees

- Performed at the USDA-ARS Southeast Fruit and Tree Nut Research Laboratory, Byron, GA in an orchard of mature cv. Schley (~80 ft trees)
- Volume and tractor speed were varied. Volume was 50, 100 or 200 gpa, each at 1.5 and 2.0 mph. Volute treatment at 50 and 100 GPA, each at 1.5 and 2.0 mph was included.
- Experiment design was a split plot (main plot = treatments (volute, speed and volume), sub-plot = height). 3 replicates/treatment, 3 repeat experiments
- Data were analyzed using standard statistical procedures:
  - A generalized linear mixed model with fixed and random effects and a Tukey-Kramer post hoc means separation of main effects and simple effects of interactions [$\alpha = 0.05$]



Sprayer set up

- 70-80 ft cv. Schley trees (scab control experiments also in cv. Desirable)
- Spacing 60 ft between rows
- Sprayer set up to deliver a range of volumes at different speeds



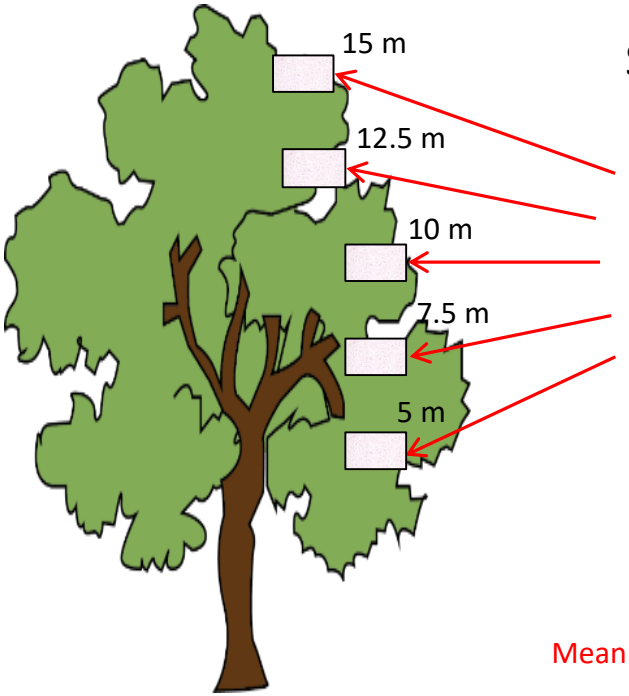
Nozzle number	50 GPA@ 1.5 mph		50 GPA@ 2.0 mph		100 GPA@ 1.5 mph		100 GPA@ 2.0 mph		200 GPA@ 1.5 mph		200 GPA@ 2.0 mph		V50 GPA@ 1.5 mph		V50 GPA@ 2.0 mph		V100 GPA@ 1.5 mph		V100 GPA@ 2.0 mph	
	GPM		GPM		GPM		GPM		GPM		GPM		GPM		GPM		GPM		GPM	
	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R
1	1.20	X	1.68	X	1.20	X	1.68	X	1.20	1.20	1.68	1.68	1.15		1.15		1.15		1.15	
2	X	X	X	X	1.20	X	1.68	X	1.20	1.20	1.68	1.68	X		1.15		1.15		1.15	1.15
3	1.20	X	1.68	X	1.20	X	1.68	X	1.20	1.20	1.68	1.68	1.15		1.15		1.15		1.15	
4	X	X	X	X	1.20	X	1.68	X	1.20	1.20	1.68	1.68	X		X		1.15		1.15	1.15
5	1.20	X	X	X	1.20	X	1.68	X	1.20	1.20	1.68	1.68	1.15		1.15		1.15		1.15	
6	X	X	0.54	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	0.29	X	0.29	X	0.29	0.29	0.29	0.29
7	0.44	X	0.54	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	X	X	X	X	0.29	X	0.29	0.29
8	X	X	0.54	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	0.29	X	0.29	X	0.29	0.29	0.29	0.29
9	0.44	X	X	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	X	X	0.29	X	0.29	X	0.29	0.29
10	X	X	0.54	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	0.29	X	0.29	X	0.29	0.29	0.29	0.29
11	0.44	X	0.54	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	X	X	X	X	0.29	X	0.29	0.29
12	X	X	X	X	0.44	X	0.54	X	0.44	0.44	0.54	0.54	0.29	X	0.29	X	0.29	0.29	0.29	X
13	X	X	X	X	X	X	X	X	0.44	0.44	0.54	0.54	X	X	X	X	0.29	X	0.29	
GPM upper 2/3	3.60		3.90		6.0		8.4		12.0		16.80		3.45		4.6		5.75		8.05	
GPM lower 1/3	1.32		2.16		3.08		3.78		6.16		8.12		1.16		1.45		3.48		4.06	
Total	4.92		6.06		9.08		12.18		18.16		24.36		4.61		6.05		9.23		12.11	
GPA	54.66		50.50		100.88		101.50		201.77		203.00		51.22		50.42		102.55		100.90	

Volume = nozzle and swirl plate
1.68 GPM = D8-45
1.15 GPM = D6-45,
1.20 GPM = D5-35
0.54 GPM = D4-25
0.44 GPM = D3-45
0.29 GPM = D2-25

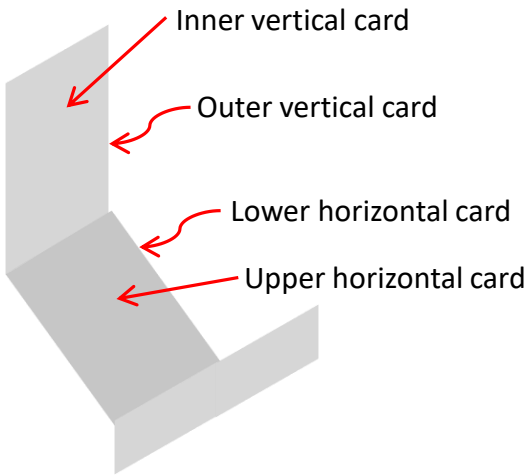
Blue shading indicates the spray nozzles directed to the upper half of the tree (2/3 spray volume)

Spray deposition in tall pecan trees – sampling spray deposition

- 2015: cv. Schley, 70-80 ft tall trees
- Three replicate trees, 5 heights, 5 card positions per height
- Sprayed with water containing Vision Pink dye
- Cards recovered from tree after spray application
- Coverage quantified using image analysis

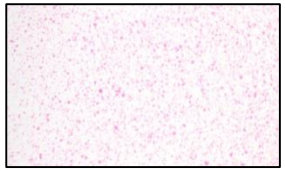


Spray deposition assessment



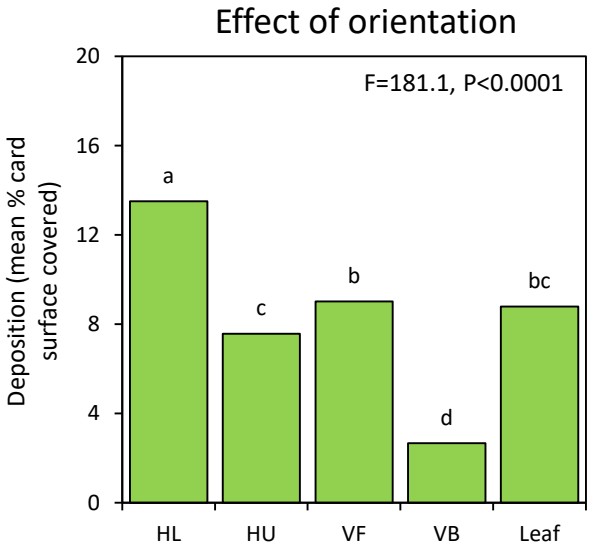
- Five card positions at each height:
  - Horizontal Lower
  - Horizontal Upper
  - Vertical Front
  - Vertical Back
  - Leaf – attached to a terminal to mimic a leaf

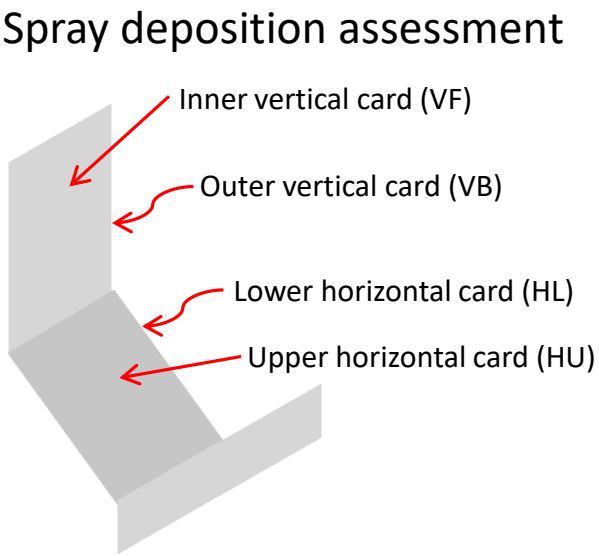
Kromekote card support frame attached to branch at sample location
One additional card attached to foliage to simulate 'leaf coverage'

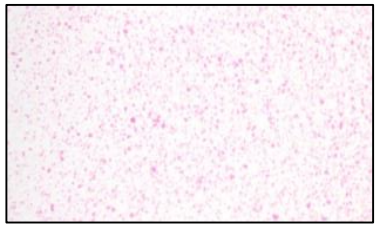


Mean date of all 5 card positions per height is presented

Did card orientation influence deposition?





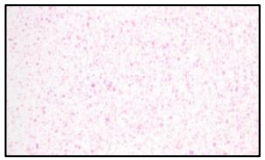


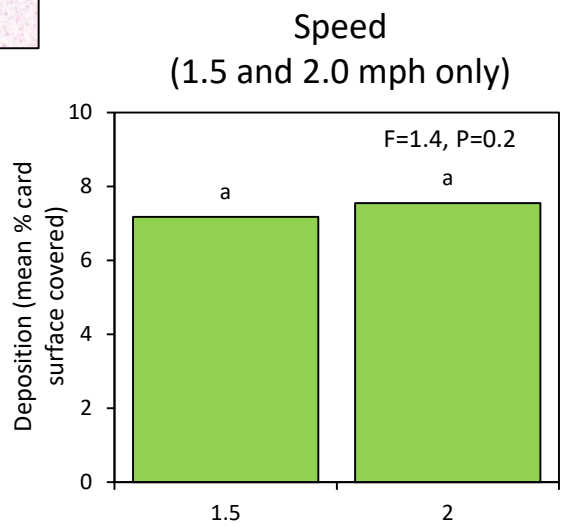
Mean date of all 5 card positions per height is presented

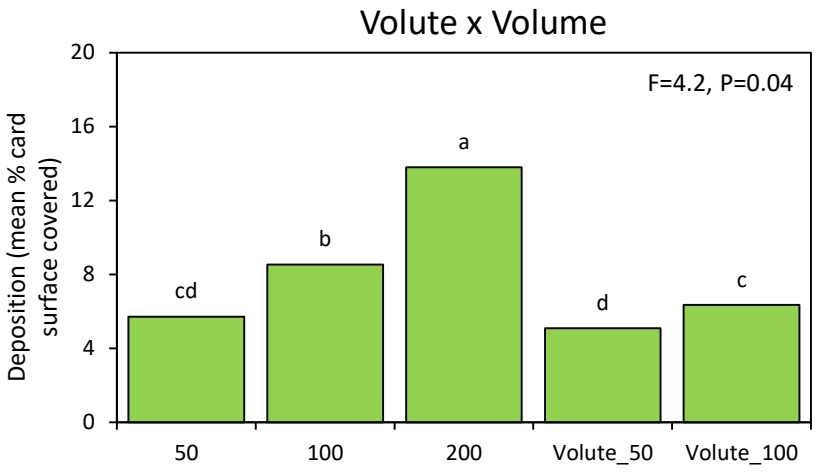
- Overall the greatest spray coverage was observed on the lower horizonal cards
- Least was observed on the vertical back oriented cards
- Some plant parts, eg, fruit, may have sides that receive suboptimal coverage due to orientation (especially higher in the canopy where the terminals are not jostled as much)
- Cards positioned to mimic leaves received intermediate spray coverage

Different letters indicate significant difference between means according to the post hoc Tukey-Kramer test (α=0.5)

Did speed, volume and volute influence deposition (overall)?



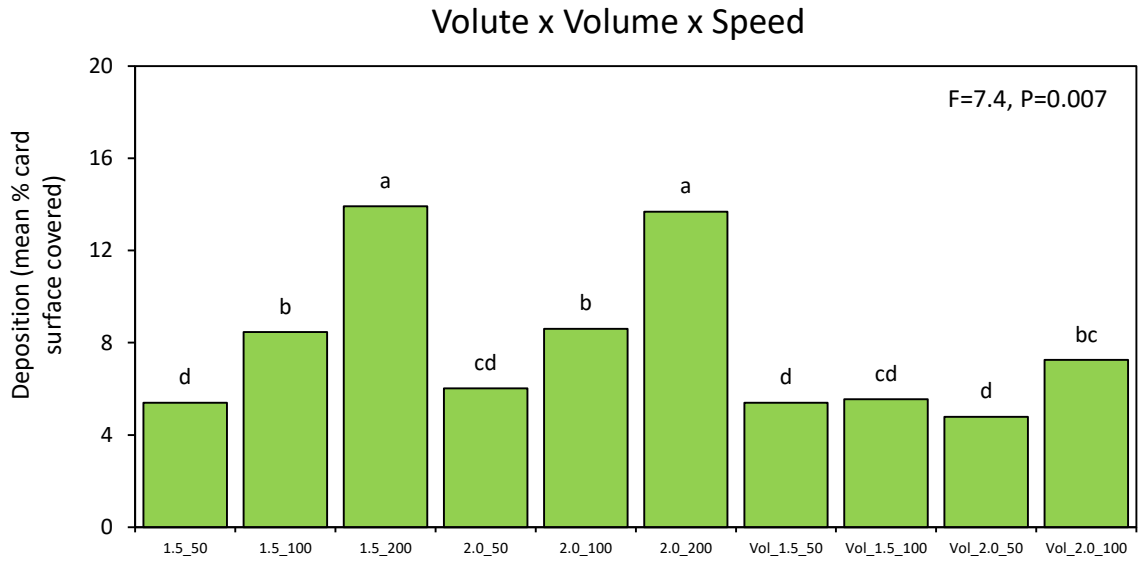




- Overall, there was no difference between 1.5 and 2.0 mph (but bigger differences in speed may well affect deposition dramatically)
- Overall, use of the volute resulted in lower coverage (but that comparison is a little unfair as there was no 200 GPA test for the volute)
- Greater volume without a volute results in more coverage
- Similar coverage at 50 GPA with or without a volute, but coverage was greater without a volute at 100 GPA
- It may be that the bulk of the volute spray was depositing at heights >15 m and due to inability to sample higher, we did not get those data points

Different letters indicate significant difference between means according to the post hoc Tukey-Kramer test (α=0.5)

Did the Volute x Volume x Speed interaction influence deposition?

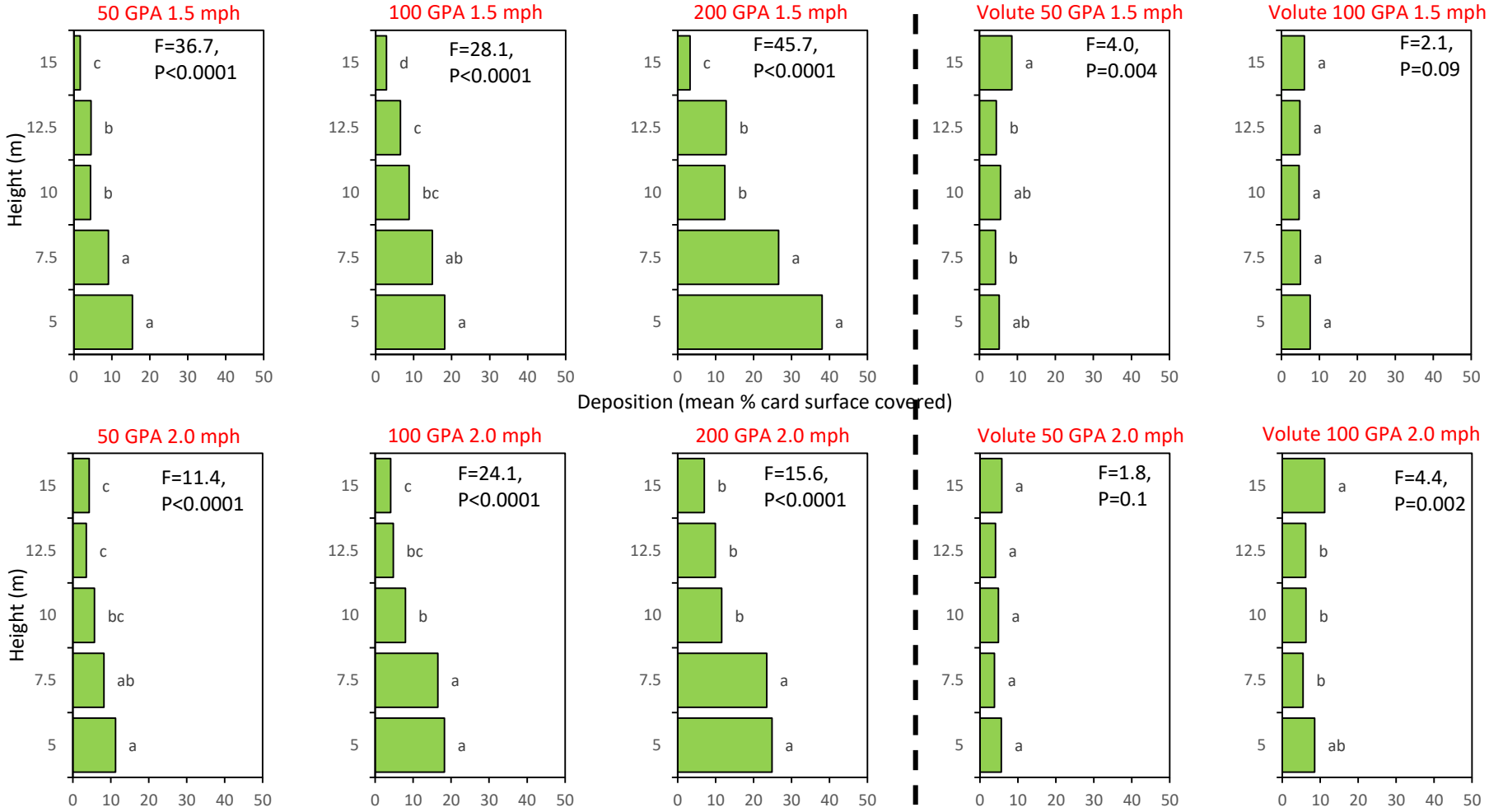


- It is valid to compare the "Volute x Volume x Speed" interaction - this was the treatment applied to each tree (it comprised the treatments at the main plot level)
- Clearly with no volute there is more spray deposition at higher volumes without a volute (speed had little effect)
- Overall the volute caused a slight reduction in deposition at 50 and 100 GPA

Different letters indicate significant difference between means according to the post hoc Tukey-Kramer test (α=0.5)

How did height affect spray treatment (Volute x Volume x Speed)?

- Height has major impact on deposition regardless of volume (except with volutes)
- Use of a volute resulted in less deposition low in canopy, but as much or more at 15 m (did not quantify at greater heights)



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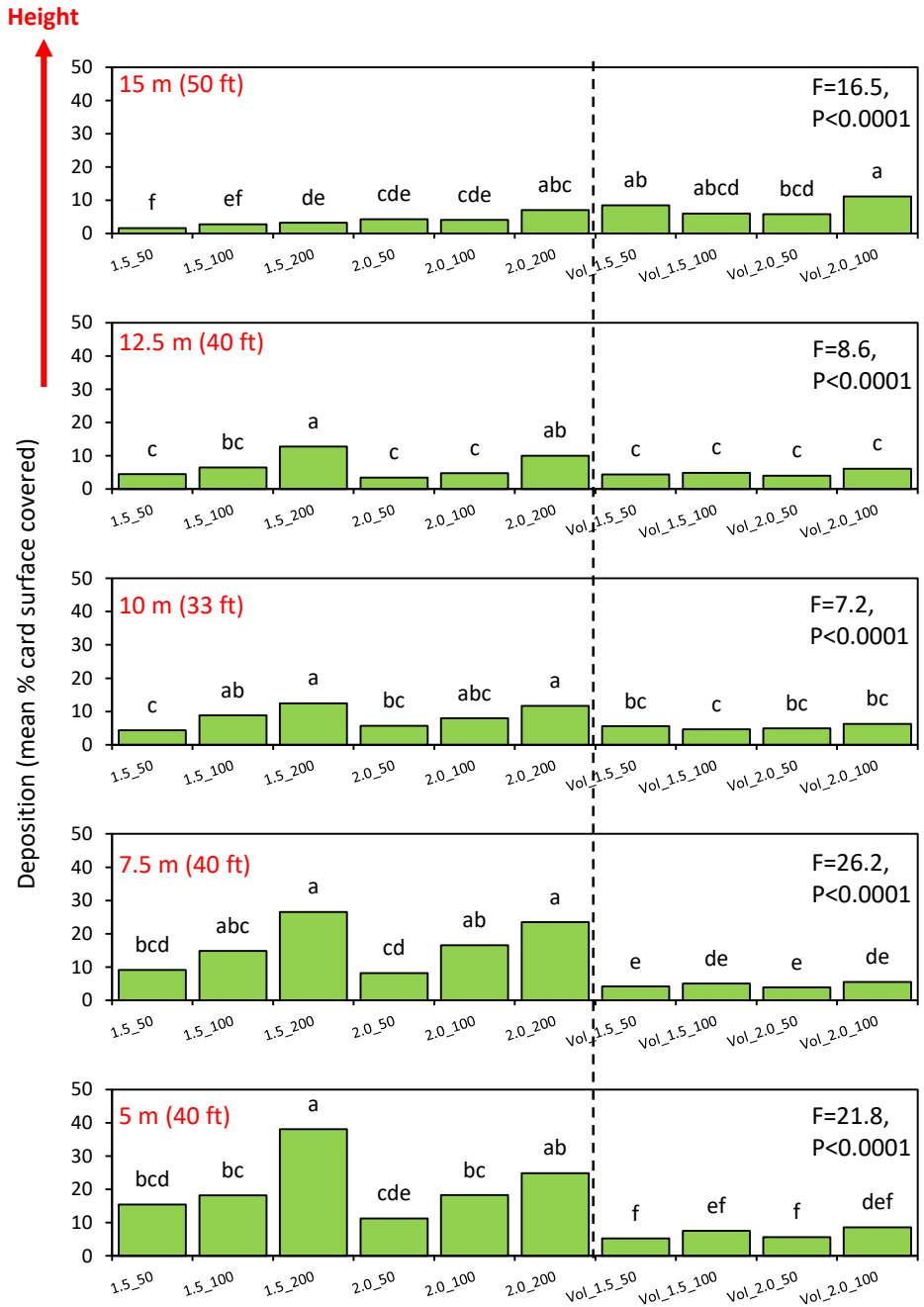

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How did treatment (Volute x Volume x Speed) affect deposition at different heights?

- Up to 15 m greater volumes resulted in more deposition (no volute)
- But deposition declined above 10 m, less effect of volume (50 to 200 GPA)
- Speed had a negligible effect (1.5 or 2.0 mph)
- Volutes had little effect except to reduce deposition at lower heights (slightly higher deposition at 15 m = max height tested?)
- Mean coverage was similarly low at all heights when using a volute
- Volumes >100 GPA may be beneficial when using volutes?

Scab control using different volumes, speeds or a volute

Experiment plan and design

- Repeated 5x (2015 - 2019) at the USDA-ARS Southeast Fruit and Tree Nut Research Laboratory, Byron, GA. Orchards of mature cv. Schley or cv Desirable (60 to 80 ft trees)
- Fungicide spray volume/tractor speed were 50, 100 or 200 GPA each at 1.5 and 2.0 mph (or a subset of these). Volute at 50 and 100 GPA, each at 1.5 and 2.0 mph was included in some experiments (2015 - 2017)
- 3 to 5 replicates of each treatment
- Fungicide was applied using a Durand-Wayland A3210 air-blast sprayer at approximately 2-3 week with attention to weather:
  - Prophyt (3 pt/acre), Quilt (28 fl oz/acre), Prophyt (3 pt/acre), Absolute (7 fl oz/acre), Elast (50 fl oz/acre), QuadrisTop (12 fl oz/acre), Supertin (12 fl oz/acre), Elast (50 fl oz/acre) and SuperTin (12 fl oz/acre)
- Experiment design was a split plot (main plot = treatment, sub-plot = height)
- Trees were assessed for leaf and fruit scab and weight at 3 or 5 heights in the canopy (depending on experiment)
- Data were analyzed using standard statistical procedures:
  - A generalized linear mixed model with fixed and random effects and a Tukey-Kramer post hoc means separation of main effects and simple effects of interactions [$\alpha = 0.05$]

Scab control using different volumes, speeds or a volute

Experiment years, spray dates and assessment dates

2015: cv. Schley, 70-80 ft

Spray applications (8): 27 Apr, 12 May, 28 May, 11 Jun, 26 Jun, 13 Jul, 4 Aug, 18 Aug

Assessments: Foliage/early fruit = 2 Jul; late fruit/fruit weight = 12 Aug

2016: cv. Schley, 70-80 ft

Spray applications (7): 20 Apr, 9 May, 25 May, 9 Jun, 5 July, 27 Jul, 15 Aug

Assessment: Foliage/early fruit = 8 Jul; late fruit/fruit weight = 1 Sep

2017 (2 experiments): cv. Desirable 55-60 ft/cv. Schley, 70-80 ft

Spray applications (8): 26 Apr, 10 May, 31 May, 22 Jun, 11 Jul, 28 Jul, 11 Aug, 28 Aug

Assessment: Foliage/early fruit = 19 Jul/28 Jun; late fruit/fruit weight = 21 Sep/5 Sep

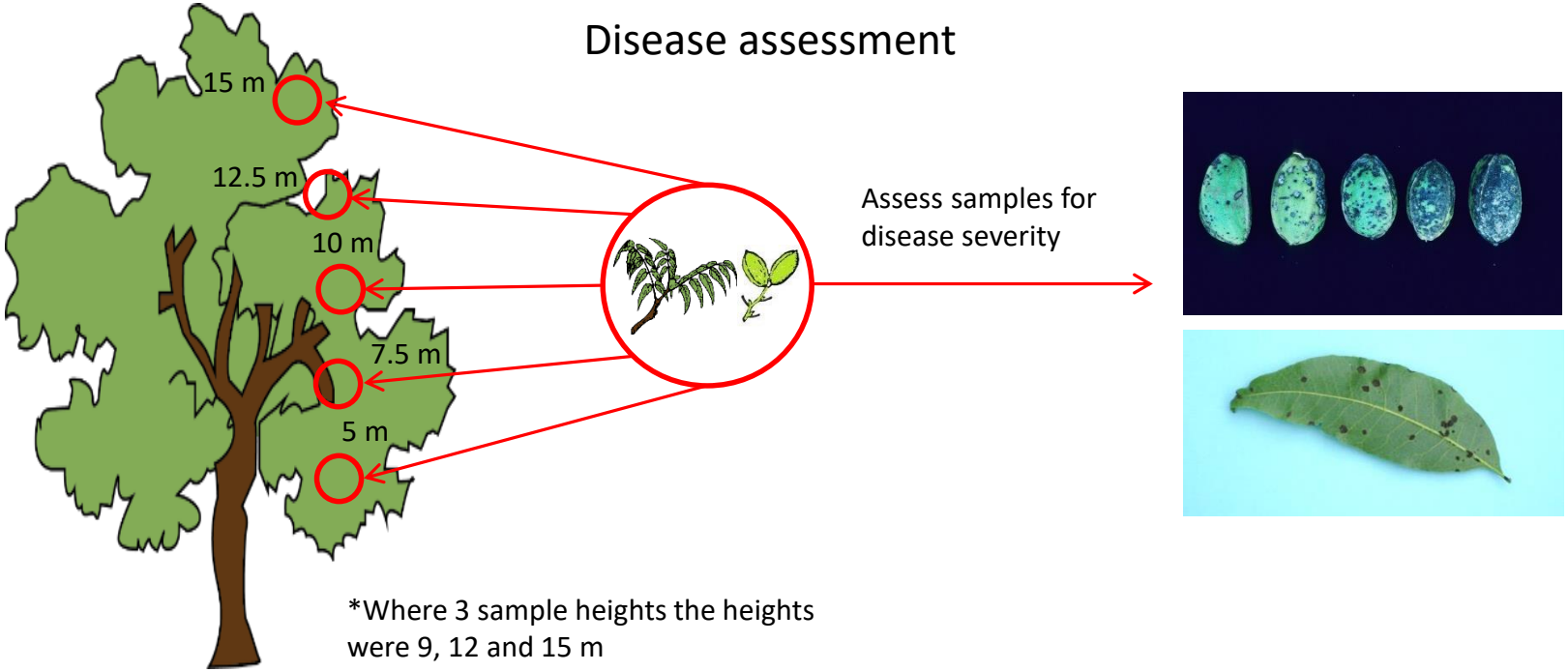
2019: cv. Desirable, 55-60 ft

Spray applications (9): 16 Apr, 30 Apr, 14 May, 28 May, 4 Jun, 18 Jun, 3 Jul, 15 Jul, 30 Jul

Assessments: Foliage/early fruit = 10 Jul; late fruit/fruit weight = 18 Sep.

Scab control in tall pecan trees – sampling foliage and fruit

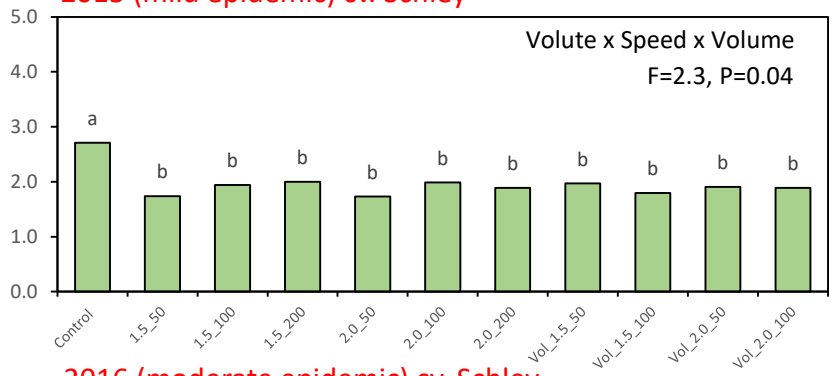
- ❑ Cv. Schley or Desirable trees
- ❑ 3 to 8 replicate trees, 3 to 5 sample heights*
- ❑ Used a hydraulic lift to collect samples
- ❑ 10 to 20 leaves or fruit collected per sample height
- ❑ Assessed visually for incidence and severity of scab



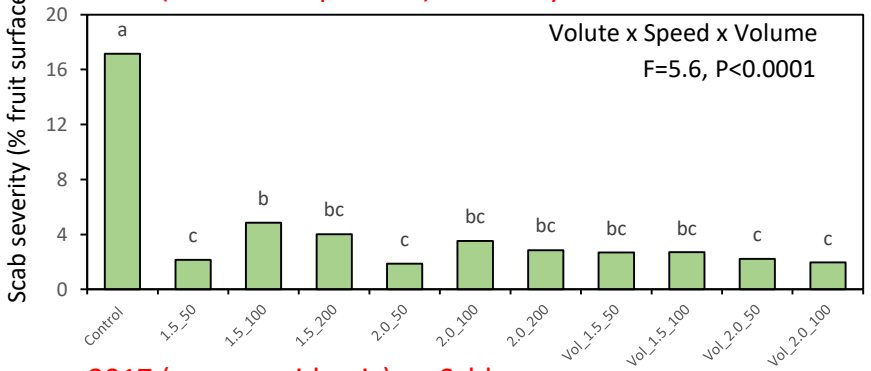
*Where 3 sample heights the heights were 9, 12 and 15 m

Treatment effects (Volute x Volume x Speed) reducing scab

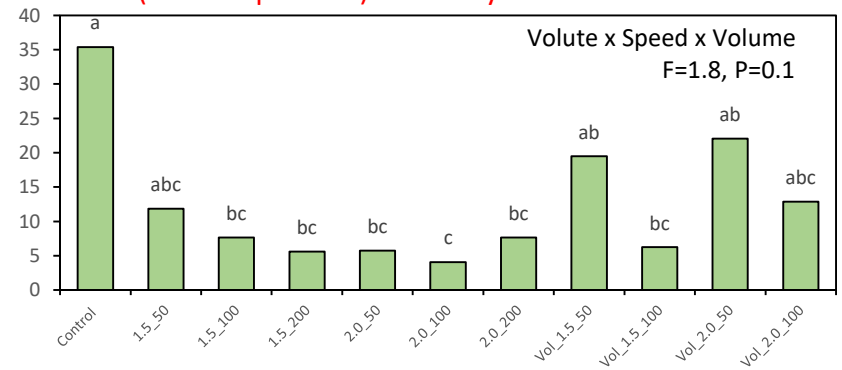
2015 (mild epidemic) cv. Schley



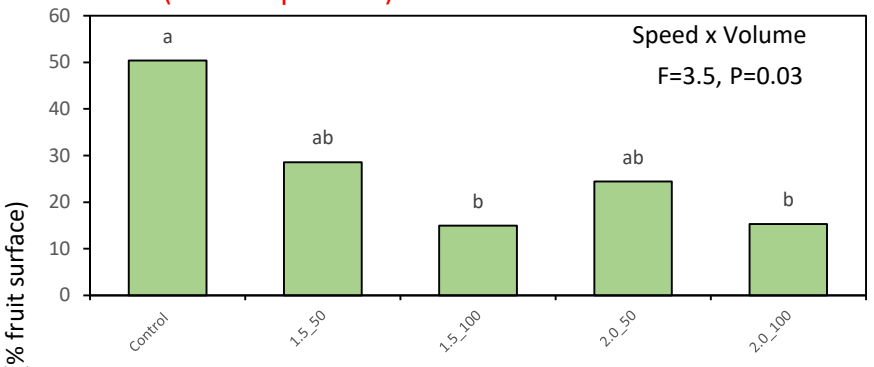
2016 (moderate epidemic) cv. Schley



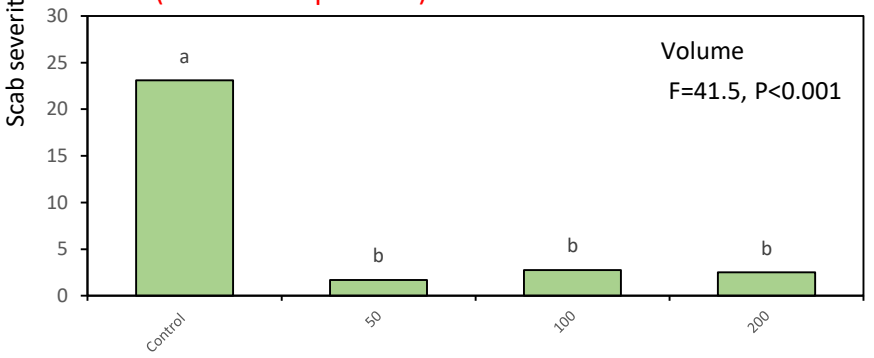
2017 (severe epidemic) cv. Schley



2017 (severe epidemic) cv. Desirable



2019 (moderate epidemic) cv. Desirable



- No single treatment was consistently superior – varied with season (rain, scab epidemic intensity?)
- Volute at 50 GPA resulted in poor control in severe epidemic years (Schley/Desirable, 2017)
- Without a volute, 50 GPA at 1.5 or 2.0 mph was as effective as higher volumes in 2015, 2016, 2017 (S and D) and 2019.
- Numeric differences may indicate trends?

Summary

- Volume at 50, 100 and 200 GPA affects spray deposition (but what about concentration of active ingredient?)
- Speed at 1.5 and 2.0 mph had little effect on deposition
- Volutes reduced overall deposition low in the canopy (some evidence of more coverage high? Samples needed at heights >15 m)
- Height affects spray deposition for all treatments (even 200 GPA had low deposition >12.5 m)
- Preliminary results and analysis indicated little effect of spray volume/speed on disease control at 50, 100 or 200 GPA at 1.5 or 2.0 mph (some evidence of season effects?)



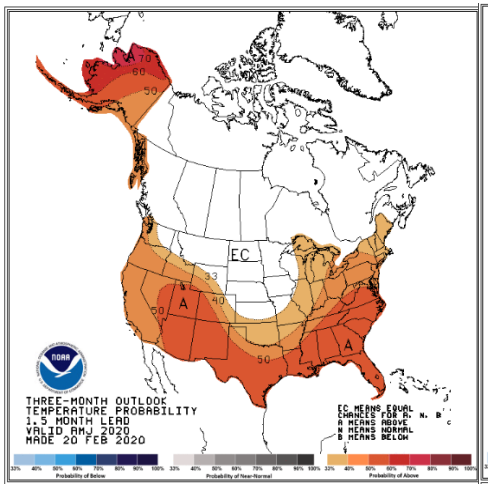
Finally, what does the season hold for weather?

- ❑ April-May-June 2020 and June-July-August 2020
- ❑ Probability to be hotter for the first six 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 going into the season

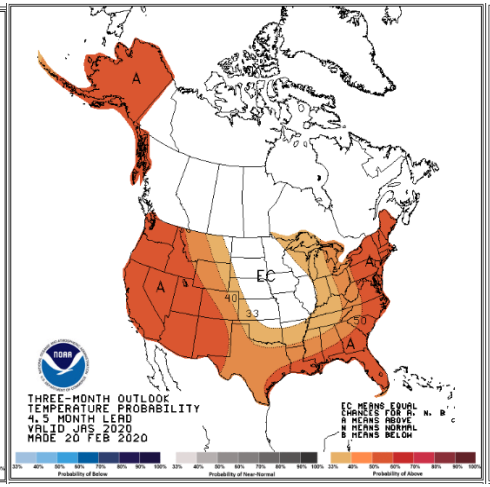
https://www.cpc.ncep.noaa.gov/products/predictions/long_range/

Temperature

April-May-June 2020

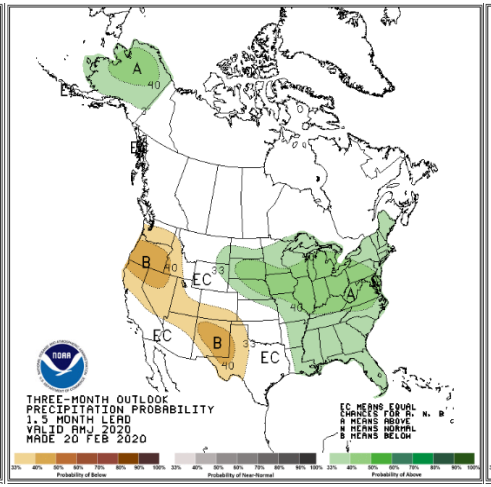


June-July-August 2020

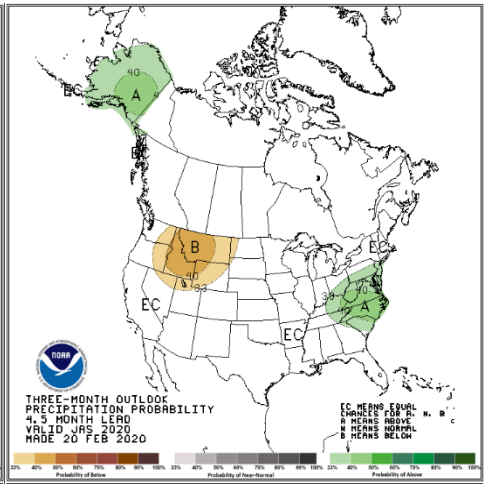


Rainfall

April-May-June 2020

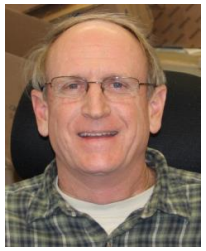


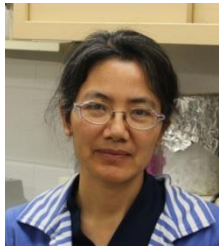
June-July-August 2020



Acknowledgements

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


Dr. Mike Hotchkiss


Minling Zhang


Wanda Evans

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Thank you

Questions?