

# Factors affecting spray coverage in pecan trees

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# The importance of spray coverage in pecan

- ❑ Critical to ensure efficacious disease and pest control in tall trees (12+ m, [40+ ft])
- ❑ Applied to maximize the quantity of active ingredient getting to the target
- ❑ And to minimize spray loss
- ❑ Many factors affect spray coverage, deposition and drift (distance to target, height, spray nozzle setup, use of 'smart' sprayer technology, speed, volume, vane angle, volute use, weather, application method – air-blast or aerial, hedge pruning etc)

Over the last several years at Byron, we have been studying some of these factors including:

- ❑ The impact of tree height on spray coverage
- ❑ The effect of different speeds and volumes on coverage
- ❑ Whether alternate row middle (ARM) spraying provides sufficient coverage
- ❑ Use of a volute to increase coverage higher in the canopy
- ❑ And the impact of some of these parameters on scab control

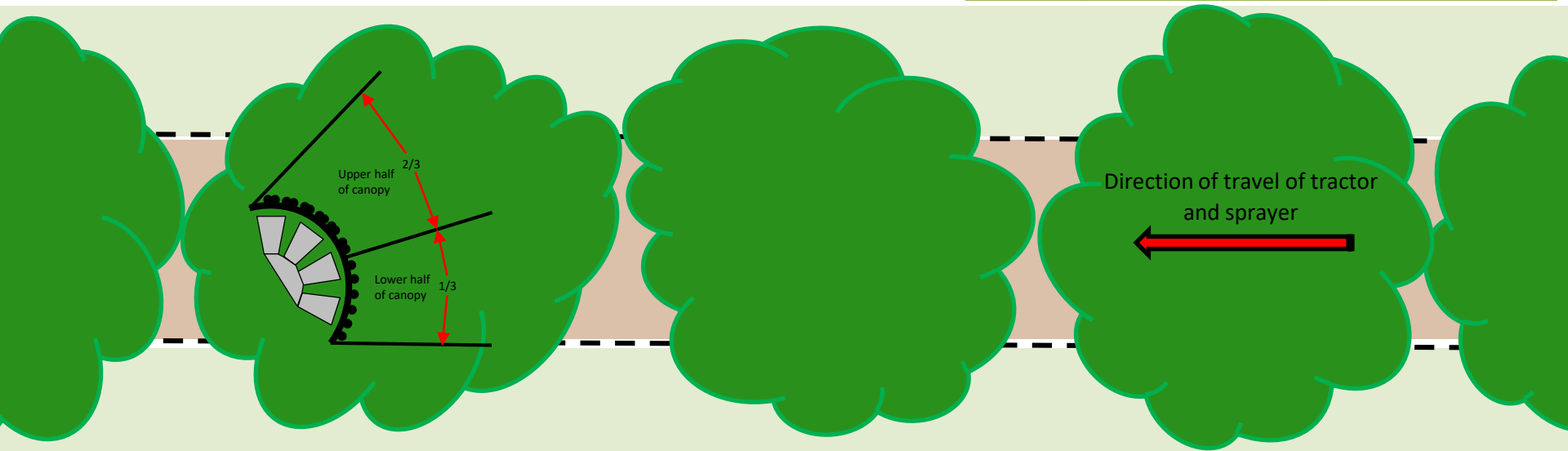


# Effect of speed and volume on spray coverage and scab control

- ❑ Sprayer towed past trees for each treatment
- ❑ Used kromekote cards to measure spray coverage (changed between treatments)
- ❑ Sampled leaves and fruit to assess for scab (to evaluate disease control )

Years of experiments and treatments tested

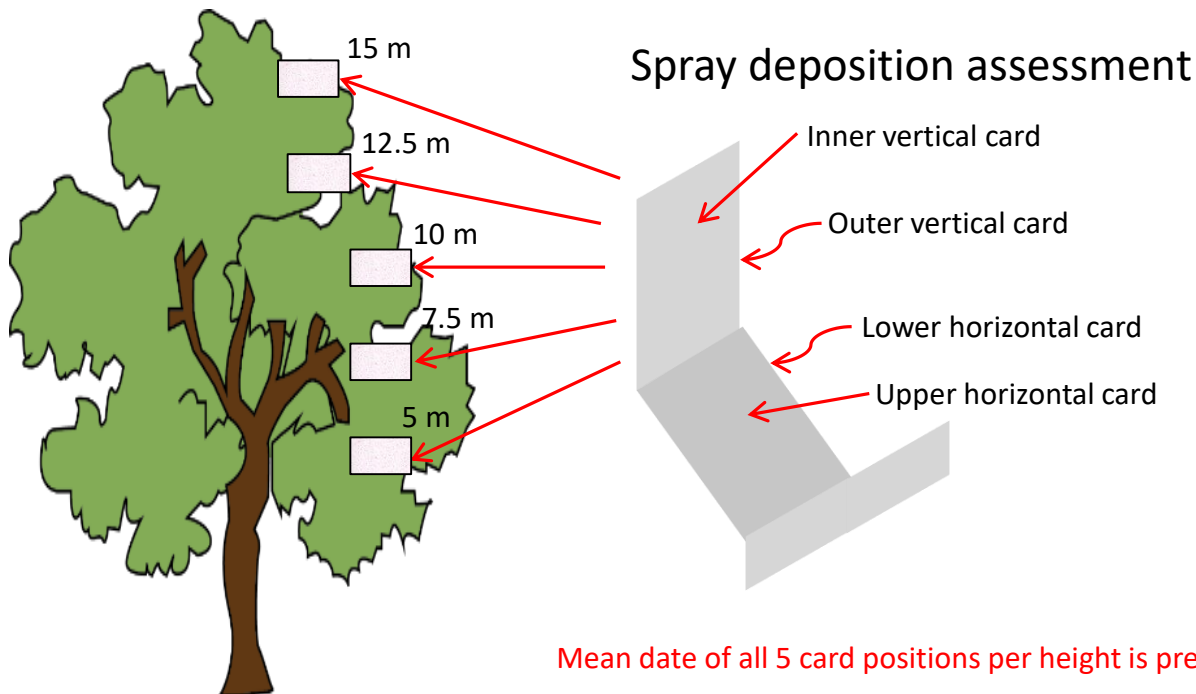
Years	Speed and volume (metric and US)	
2015-2017	2.4 kph @ 470 L/Ha	1.5 mph @ 50 GPA
	2.4 kph @ 940 L/Ha	1.5 mph @ 100 GPA
	2.4 kph @ 1870 L/Ha	1.5 mph @ 200 GPA
	3.2 kph @ 470 L/Ha	2.0 mph @ 50 GPA
2019-2020	3.2 kph @ 940 L/Ha	2.0 mph @ 100 GPA
	3.2 kph @ 1870 L/Ha	2.0 mph @ 200 GPA
	4.0 kph @ 470 L/Ha	2.5 mph @ 50 GPA
	4.0 kph @ 940 L/Ha	2.5 mph @ 100 GPA
	4.0 kph @ 1122 L/Ha	2.5 mph @ 120 GPA



# Spray deposition in tall pecan trees – sampling spray deposition

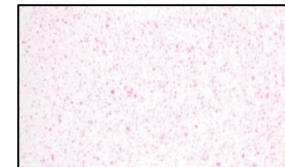
- ❑ Minimum three replicate trees, 5 heights, 5 card positions per height
- ❑ Sprayed with water containing Vision Pink dye
- ❑ Cards recovered from tree after spray application
- ❑ Coverage quantified using image analysis

- ❑ 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

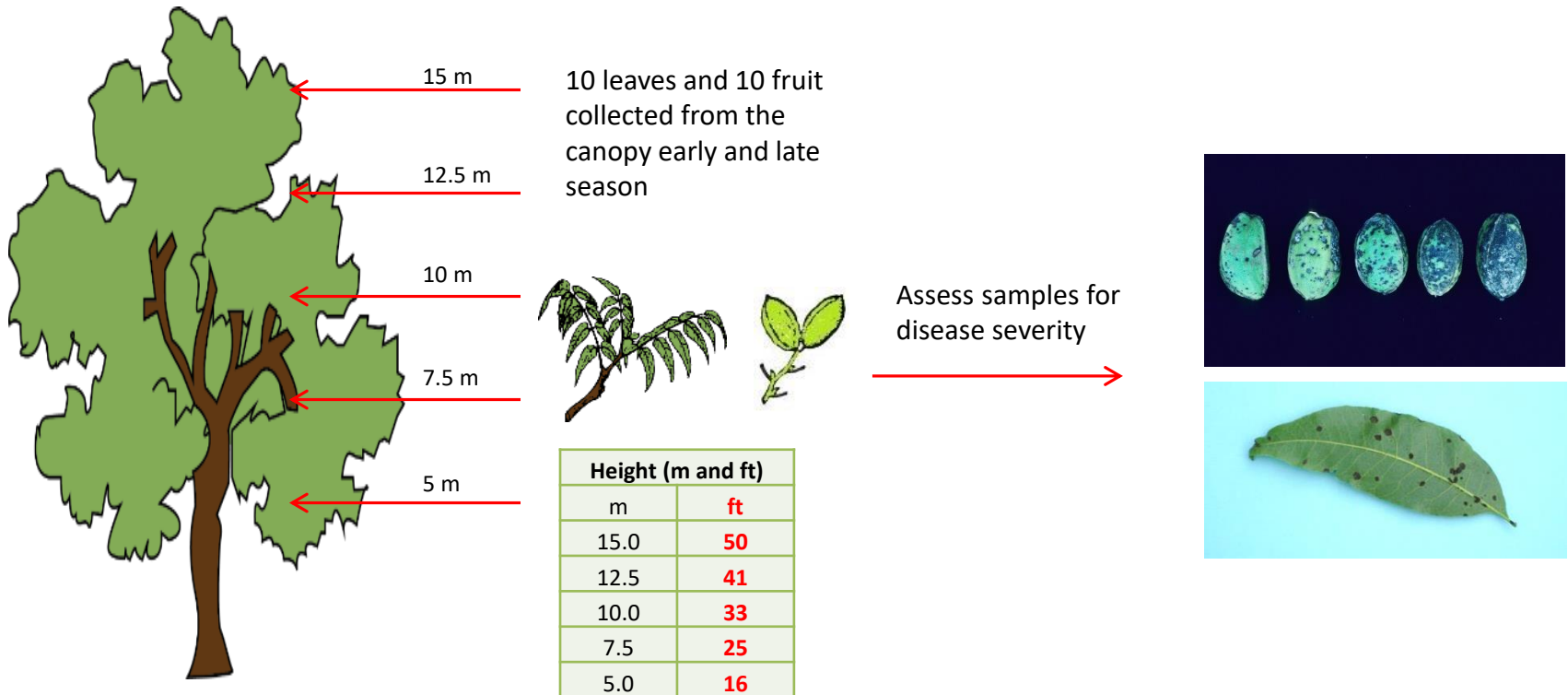
One additional card attached to foliage to simulate 'leaf coverage'



Mean date of all 5 card positions per height is presented

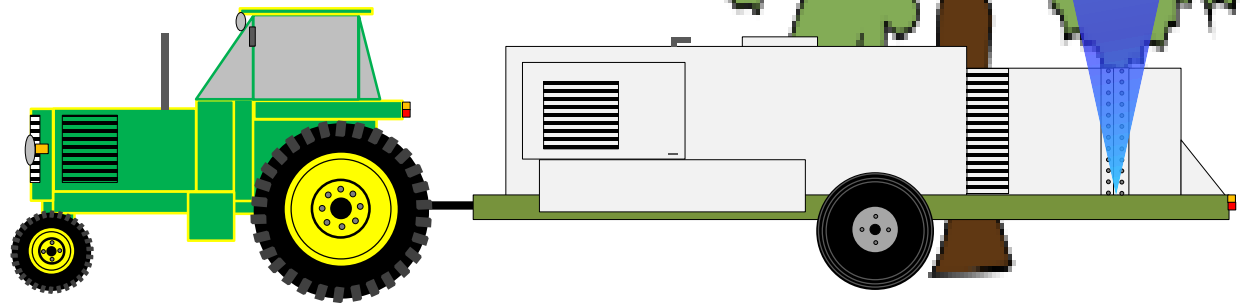
# Sampling leaves and fruit to assess scab at different heights in tall pecan trees

- ❑ Collected samples of 10 leaves and fruit from the tree canopies at 5 heights (5.0, 7.5, 10.0, 12.5 and 15.0 m [**16, 25, 33, 41 and 50 ft**])
- ❑ Samples taken early (mid June – early July) and late season (late August – early September)
- ❑ Samples assessed for severity of scab – due to time only results on the late season fruit (mature fruit) will be presented



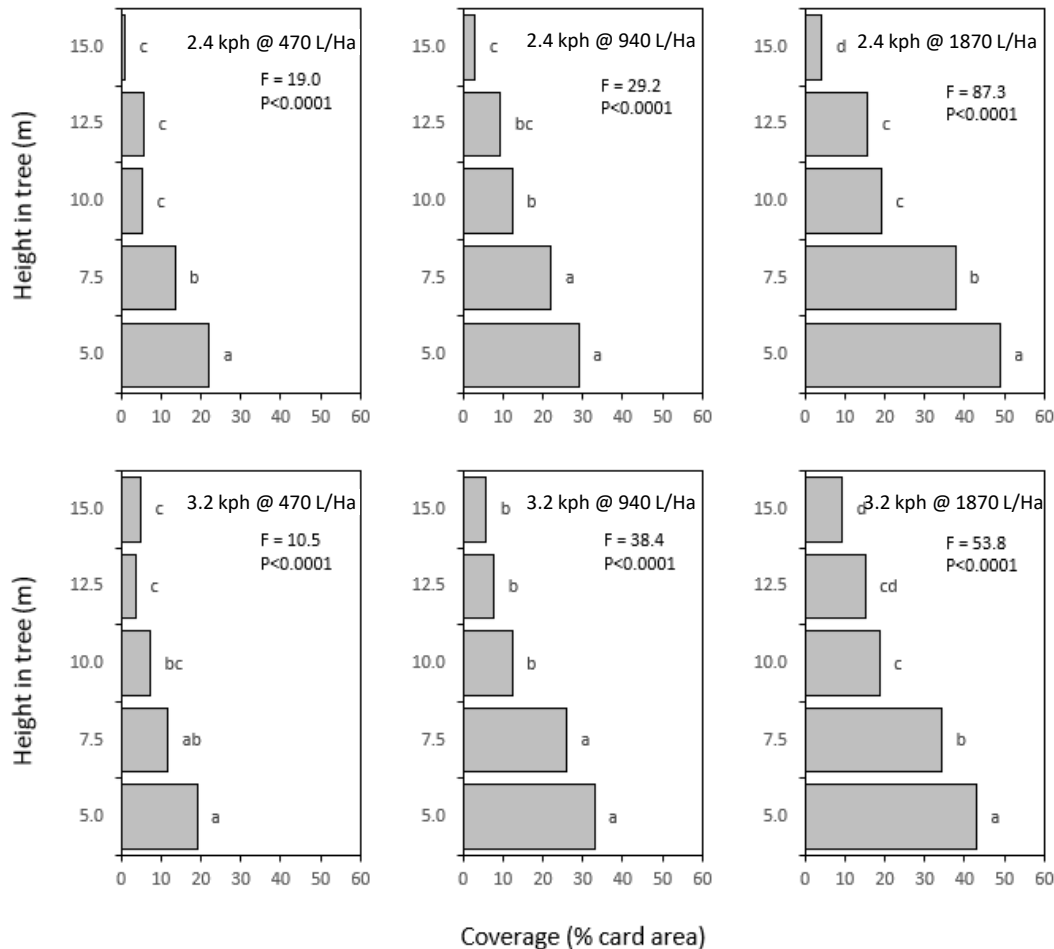
# Effect of speed and volume - field experiments

- ❑ Scab control experiments performed in orchards of cv Schley (21–24 m [**70-80 ft**]) or cv Desirable (16–18 m [**52-59 ft**]). 6 experiments
- ❑ Applied fungicide sprays at up to 6 speed and volume combinations, depending on the experiment
- ❑ Standard fungicide program applying 6 to 9 sprays, depending on the experiment



# Effect of height on spray coverage in trees sprayed at different speeds and volumes

## Simple effects of height for each treatment

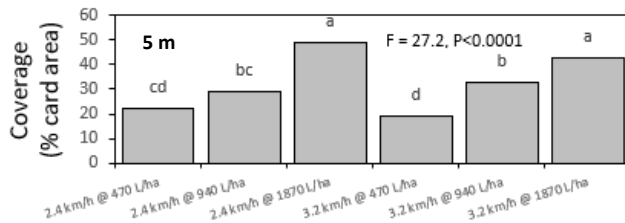
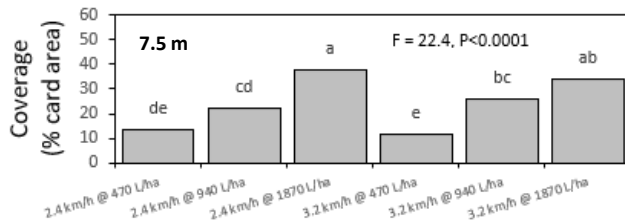
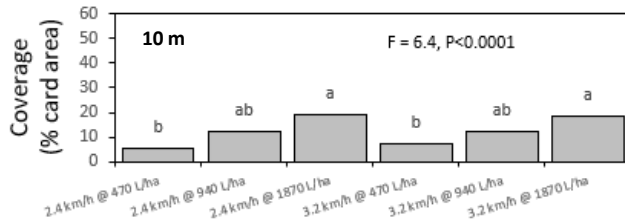
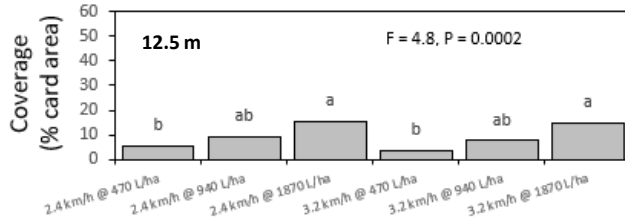
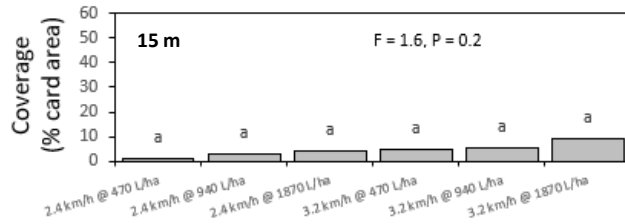


- There is a decline in spray coverage with height
- Higher volumes results in more spray lower in the canopy

Speed and volume (metric and US)	
2.4 kph @ 470 L/Ha	1.5 mph @ 50 GPA
2.4 kph @ 940 L/Ha	1.5 mph @ 100 GPA
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Height (m and ft)	
m	ft
15.0	50
12.5	41
10.0	33
7.5	25
5.0	16

# Effect of treatment on spray coverage in trees sprayed at different speeds and volumes



Treatment

Simple effects of treatment at each height

- ❑ Effect of volume most pronounced at heights <12.5 m
- ❑ At 15 m no statistical effect of volume applied
- ❑ No significant effect of the speeds tested in this study

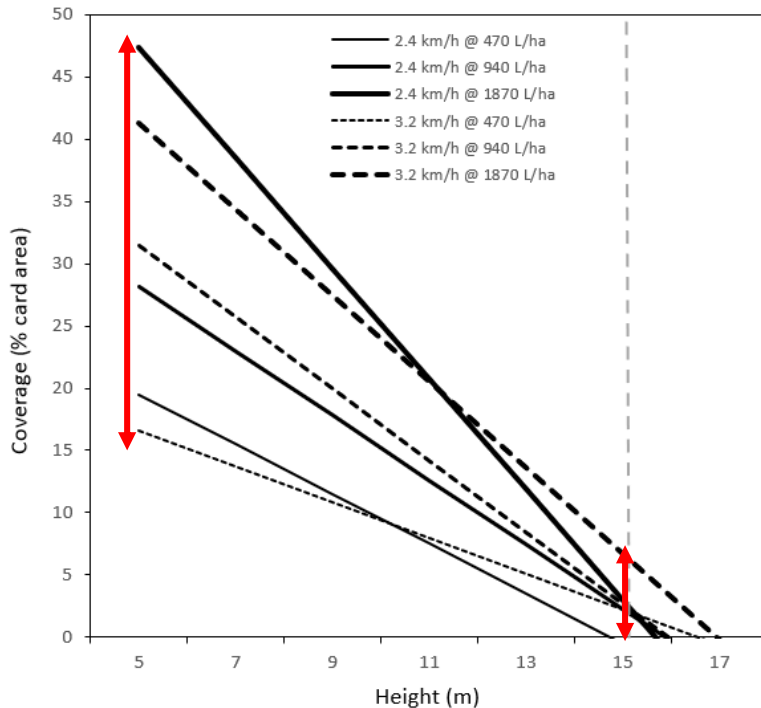
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Height (m and ft)	
m	ft
15.0	50
12.5	41
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5.0	16



# Effect of height and speed on spray coverage in trees sprayed at different speeds and volumes

Relationship between tractor speed and volume applied and resulting spray coverage on cards in at different heights in the canopies of pecan trees



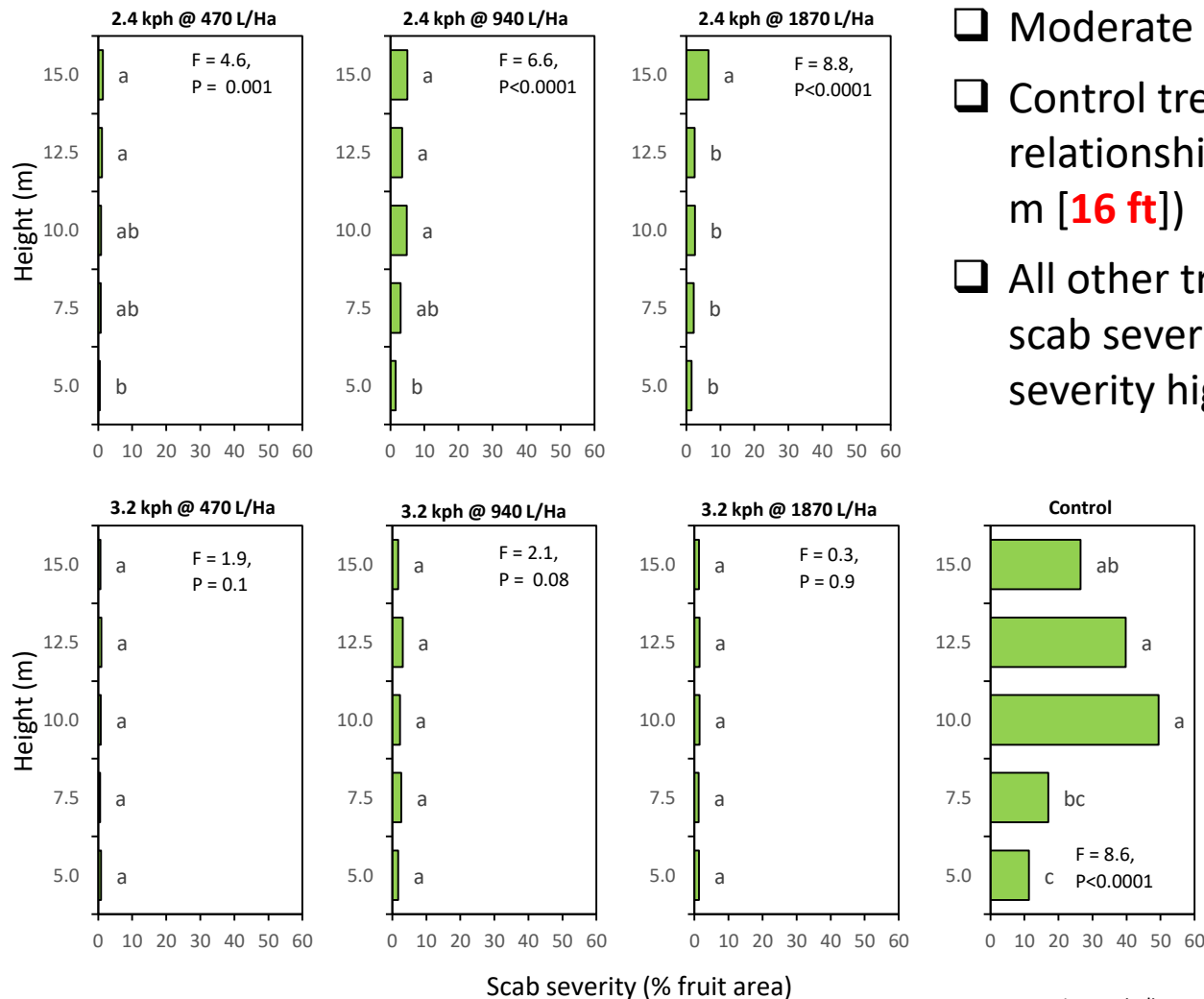
- ❑ Differences between volumes applied are most pronounced lower in the canopy
- ❑ Effects of speed are relatively small and inconsistent
- ❑ At heights of 15 m regression models show there is little difference in coverage among speeds and volumes
- ❑ Perhaps due to the exponential reduction in windspeed with distance from a fan?

Speed and volume (metric and US)	
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Height (m and ft)	
m	ft
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12.5	41
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7.5	25
5.0	16

# Severity of scab on mature fruit when trees are sprayed at different speeds and volumes

## Simple effects of height on scab severity in tall pecan trees – 2016



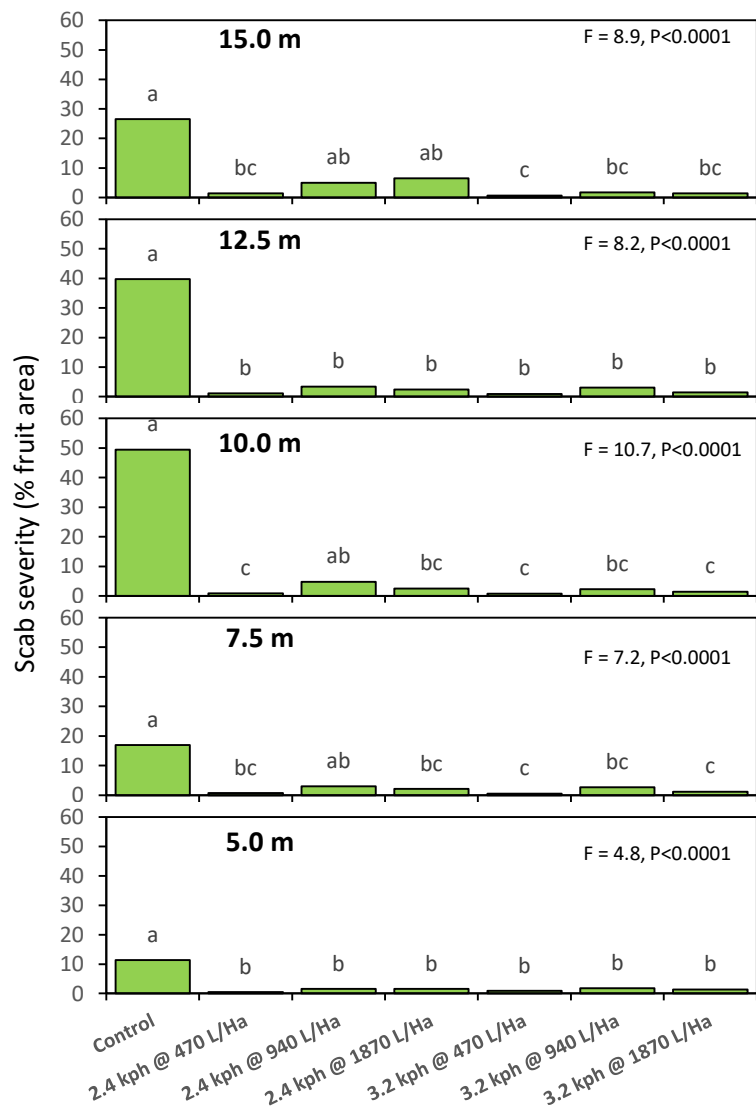
- ☐ Moderate epidemic on cv Schley in 2016
- ☐ Control treatment had an unexpected relationship with height (least scab at 5.0 m [**16 ft**])
- ☐ All other treatments either had similar scab severity at all heights, or greater severity higher in the canopy

Height (m and ft)	
m	ft
15.0	<b>50</b>
12.5	<b>41</b>
10.0	<b>33</b>
7.5	<b>25</b>
5.0	<b>16</b>

Speed and volume (metric and US)	
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# Severity of scab on mature fruit when trees are sprayed at different speeds and volumes

Simple effects of treatment on scab severity in tall pecan trees - 2016



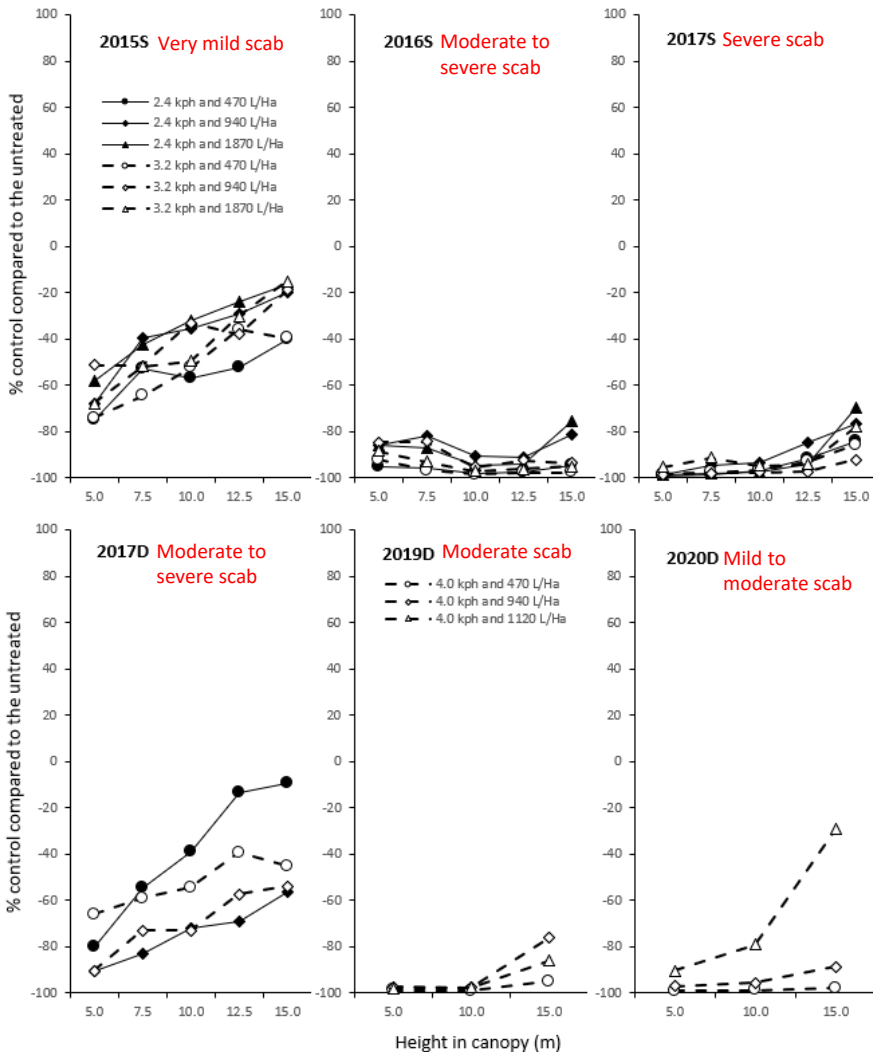
- At all heights, all treatments resulted in either statistically or numerically less severe scab when compared to the control
- Treatment groupings varied with height, but were most often numerically similar (with some significant differences)
- In other seasons the experiment was run results were similar, with no volume or speed tested consistently providing superior scab control at all heights
- Indeed, speed had a minor effect at those tested

Speed and volume (metric and US)	
2.4 kph @ 470 L/Ha	1.5 mph @ 50 GPA
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Height (m and ft)	
m	ft
15.0	50
12.5	41
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5.0	16

# Reduction in scab at different heights when fungicide was applied at different speeds and volumes

Scab on mature fruit – 6 years of experiments comparing speeds and volumes

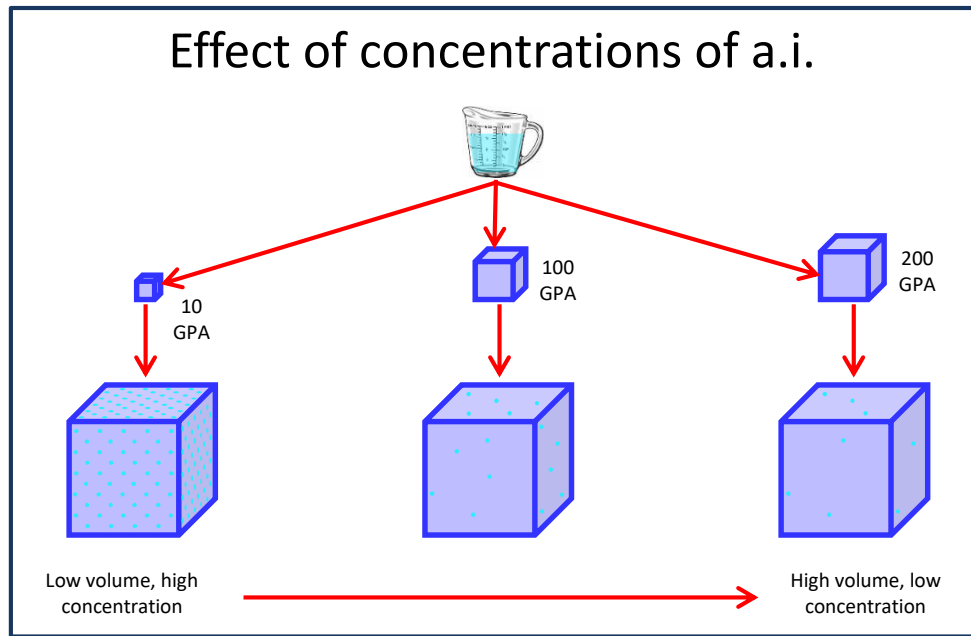


- Reduction (% reduction compared to the control) in scab was similar but variable for all speeds and volumes tested
- No speed and volume combination provided consistently the greatest reduction in severity of scab at any height compared to the control
- Severity higher in the canopy was often reduced less

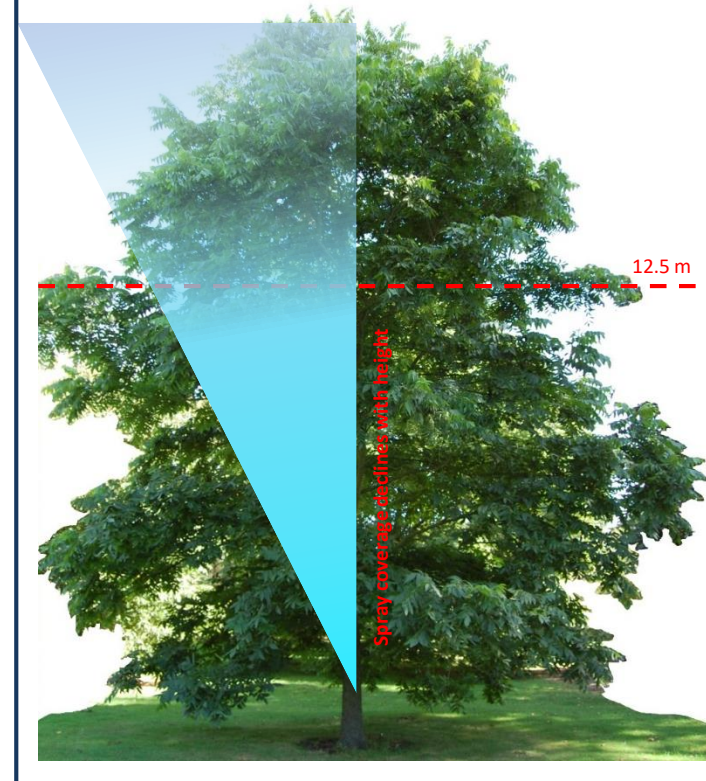
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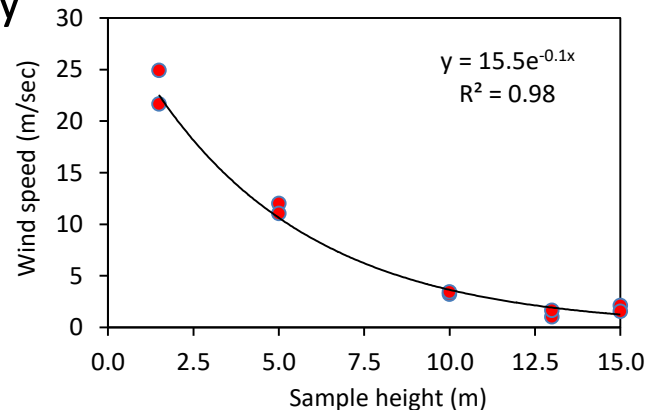
# Reasons why disease may be similarly controlled at lower volumes at all heights measured?



Spray becomes more diffuse with distance from the sprayer



Windspeed from the air-blast sprayer declines exponentially



# Costs per 100 ha of orchard depending on those volumes and speeds tested



☐ Total costs per 100 ha (247 acres) at the various speeds and volumes we tested

	2.4 kph @ 470 L/Ha	3.2 kph @ 470L/Ha	2.4 kph @ 940 L/Ha	3.2 kph @ 940 L/Ha	2.4 kph @ 1870 L/Ha	3.2 kph @ 1870 L/Ha	4.0 kph @ 470 L/Ha	4.0 kph @ 940L/Ha	4.0 kph @ 1122 L/Ha
Spacing (m)	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	50 GPA@2.5 mph	100 GPA@ 2.5 mph	120 GPA@2.5 mph
16	1070	832	1186	947	1415	1177	689	804	844
19	911	712	1027	828	1256	1057	593	709	748
22	798	627	913	743	1142	972	525	641	680

☐ Not surprisingly, highest cost is associated with the slowest speed and highest volume applied per unit area

☐ Total cost of applying 12 applications to 100 ha (247 acres) at the various speeds and volumes we tested (total season costs)

	2.4 kph @ 470 L/Ha	3.2 kph @ 470L/Ha	2.4 kph @ 940 L/Ha	3.2 kph @ 940 L/Ha	2.4 kph @ 1870 L/Ha	3.2 kph @ 1870 L/Ha	4.0 kph @ 470 L/Ha	4.0 kph @ 940L/Ha	4.0 kph @ 1122 L/Ha
Spacing (m)	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	50 GPA@2.5 mph	100 GPA@ 2.5 mph	120 GPA@2.5 mph
16	12845	9981	14234	11370	16982	14118	8263	9651	10124
19	10936	8549	12325	9938	15073	12686	7117	8506	8979
22	9572	7526	10961	8915	13709	11663	6299	7688	8160

☐ These are based on estimated costs, but it is the relative differences that are of most interest

\* The disease control experiments to the left and right of the line were different



Row spacing	
m	ft
16	50
19	60
22	70

Costs obtained from various sources including the UGA Department of Agricultural and Applied Economics <https://agecon.uga.edu/extension/budgets.html> (pecan budget)

Bock, C.H., Wells, L.M., and Hotchkiss, M.W. 2021. Effect of tractor speed and spray application volume on severity of scab and fruit weight at different heights in the canopy of tall pecan trees. Plant Dis. 105: 3909-3924.

# The saving based on comparison to the most expensive 'speed and volume' combination tested

- ❑ Relative savings indicated depend on the range of speeds and volumes tested
- ❑ The fastest speed and lowest volume tested was most economical based on 12 sprays applied to 100 ha (247 acres)
- ❑ The saving depends on row spacing (\$7410 - \$8720/season)

 Least saving  
 Greatest saving

	2.4 kph @ 470 L/Ha	3.2 kph @ 470L/Ha	2.4 kph @ 940 L/Ha	3.2 kph @ 940 L/Ha	2.4 kph @ 1870 L/Ha	3.2 kph @ 1870 L/Ha	4.0 kph @ 470 L/Ha	4.0 kph @ 940L/Ha	4.0 kph @ 1122 L/Ha
Spacing (m)	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	50 GPA@ 2.5 mph	100 GPA@ 2.5 mph	120 GPA@ 2.5 mph
16	4137	7001	2748	5612	0	2864	8720	7331	6858
19	4137	6524	2748	5135	0	2387	7956	6567	6094
22	4137	6183	2748	4794	0	2046	7410	6021	5549

\*

Row spacing	
m	ft
16	50
19	60
22	70

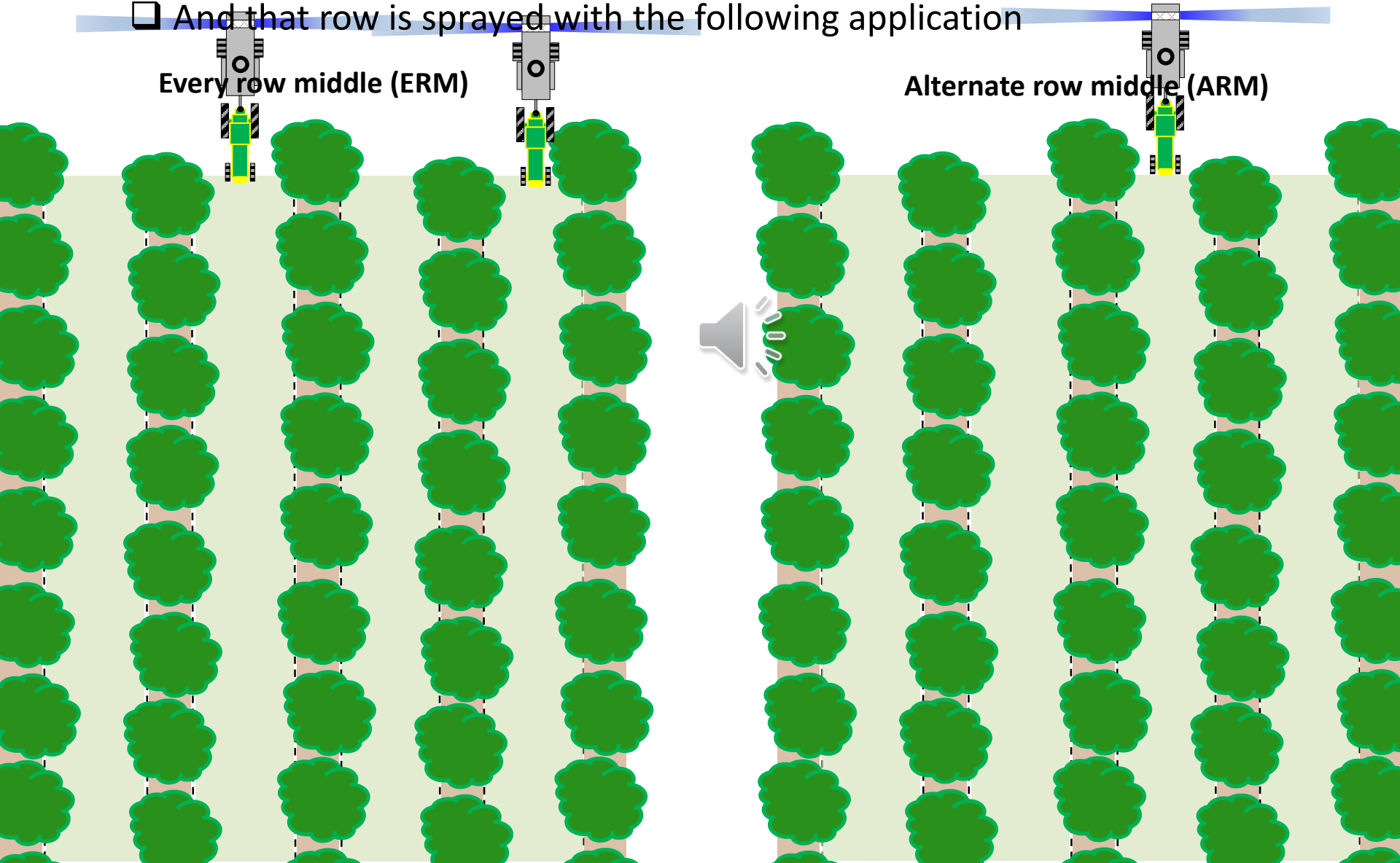
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# Alternate middle row application

- ❑ With alternate row middle spray application, every other row is skipped
- ❑ And that row is sprayed with the following application





# Alternate row middle application

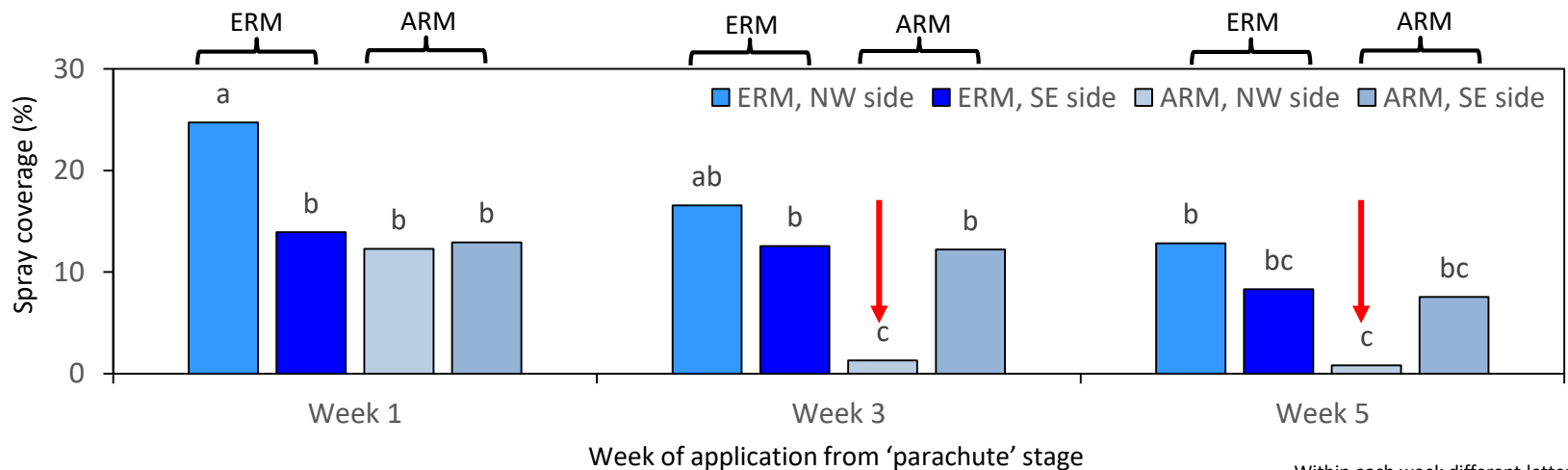
Treatments:

- i) ERM (10 to 14 days) (3 sprays)
- ii) ARM (5 to 7 days) (6 sprays)
- iii) ARM (10 to 14 days) (3 sprays)
- iv) Non-treated control

Time of first spray at the parachute stage (approximately 10-14 days after bud break)



- Sprays applied on 12 Apr (parachute), 26 Apr, and 9 May (2018)
- Decline in spray coverage with time (canopy becomes denser)
- There were some differences between tree sides

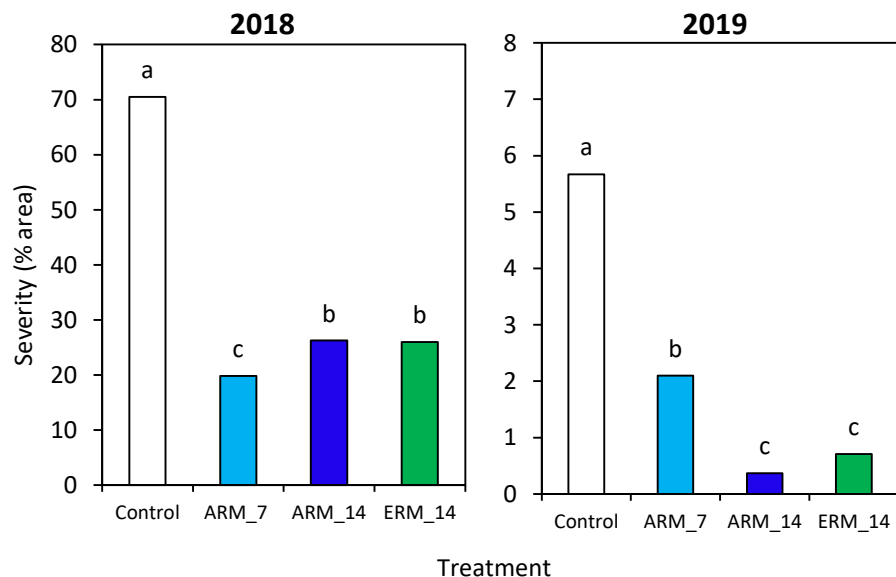


Within each week different letters indicate means are significantly different ( $\alpha = 0.05$ )

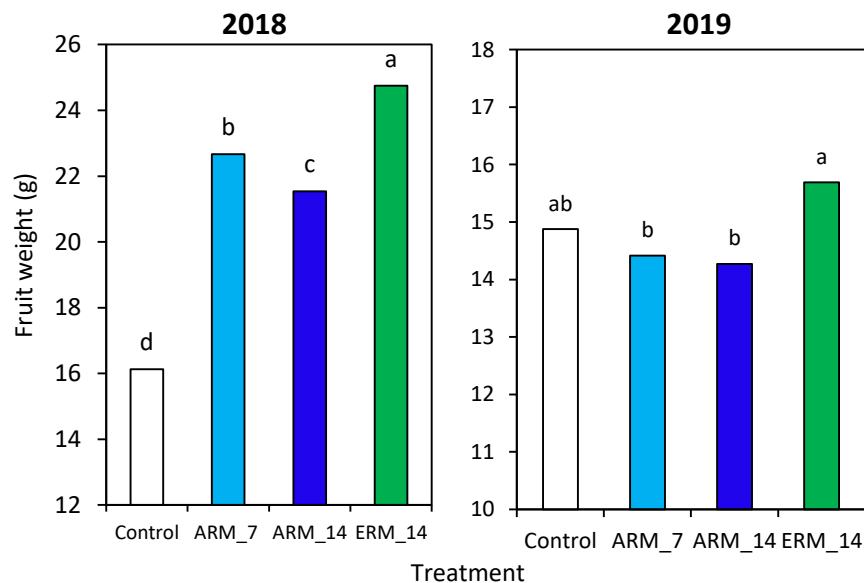
# Alternate middle row application

- ❑ On mature nuts scab was severe. All treatments significantly reduced scab (ARM 7 reduced scab most)
- ❑ Fruit weight was significantly greatest on those trees receiving ERM sprays
- ❑ ARM 7 sprayed trees had heavier fruit compared to the ARM 14 sprayed trees

Scab severity by treatment (%)



Mature fruit - weight by treatment (g)



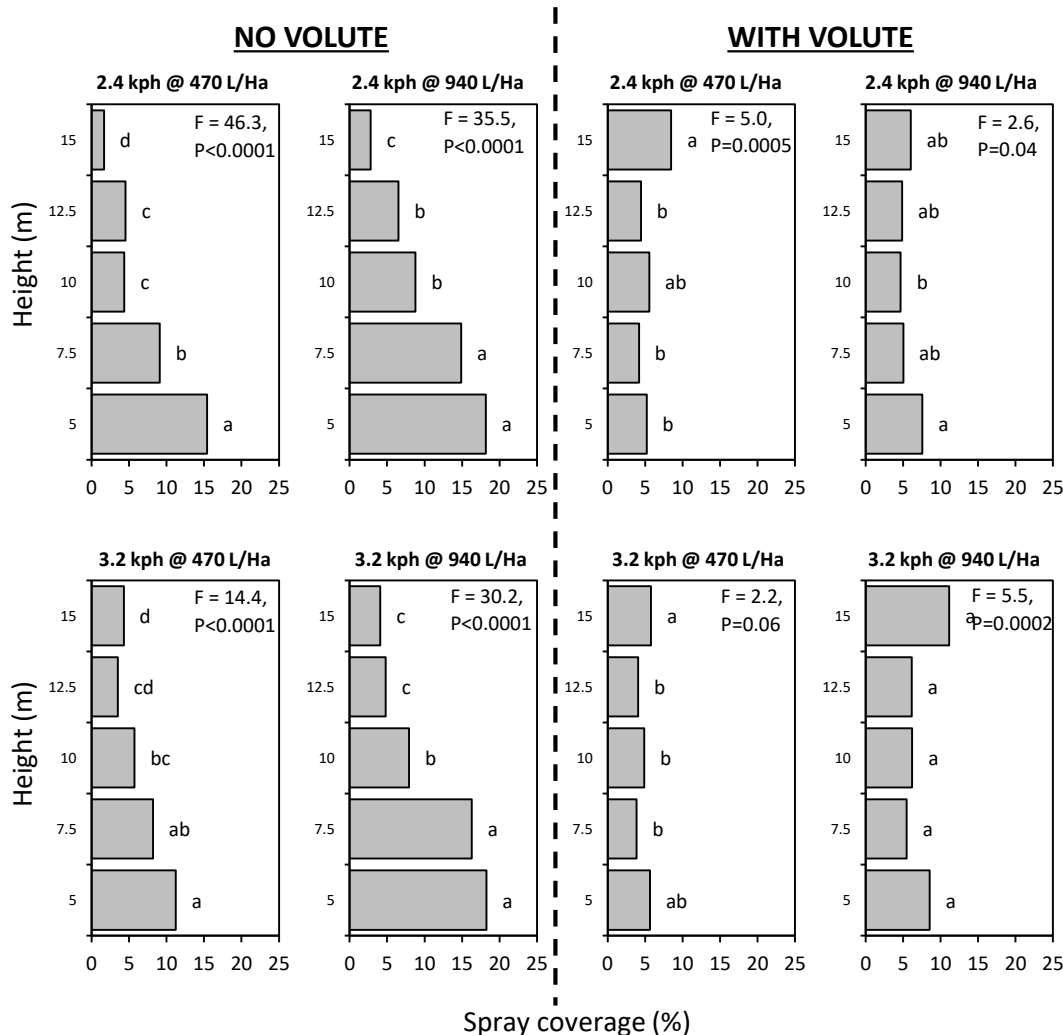
Different letters indicate means are significantly different ( $\alpha = 0.05$ )

# Use of a volute



# Effect of height on spray coverage in trees sprayed at different speeds and volumes

## Effect of height



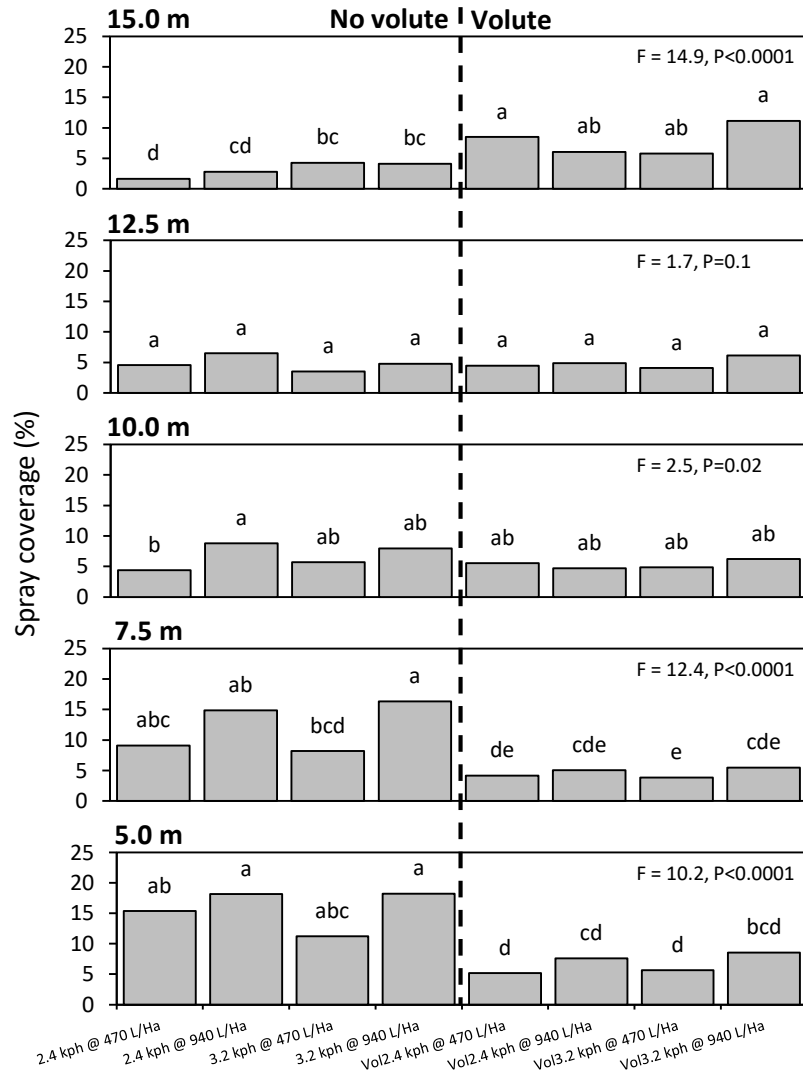
- There is a decline in spray coverage with height
- Higher volumes results in more spray lower in the canopy

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Height (m and ft)	
m	ft
15.0	50
12.5	41
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5.0	16

# Effect of volute use on spray coverage in trees sprayed at different speeds and volumes

Differences between treatments at each heights

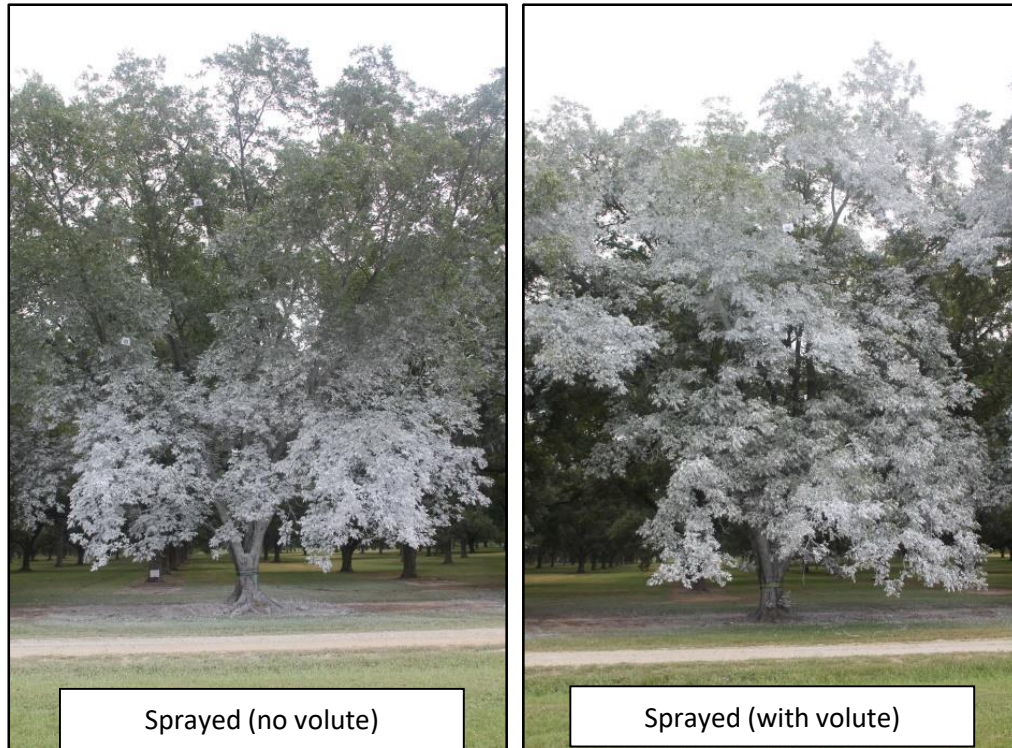


- ❑ Effect of volume most pronounced at heights <12.5 m
- ❑ At 15 m no statistical effect of volume applied
- ❑ No significant effect of the speeds tested in this study

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Height (m and ft)	
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# Visualizing the impact helps!



Applications were made at 940 liter/Ha and 3.2 km/h (2.0 mph @ 100 GPA)

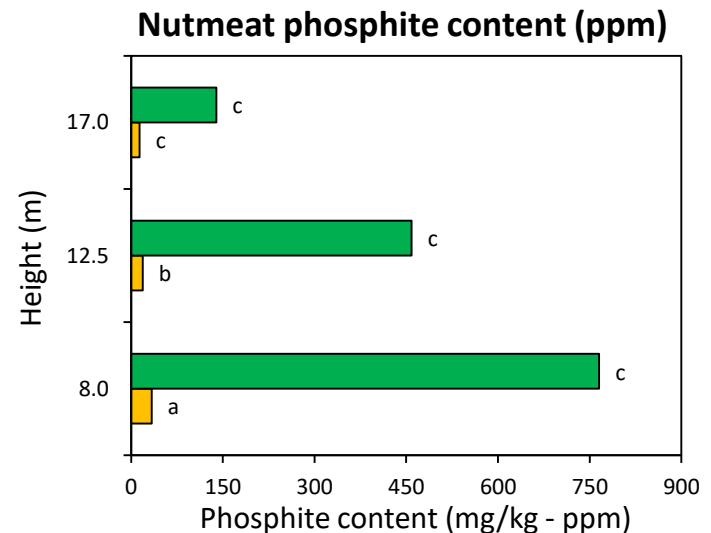
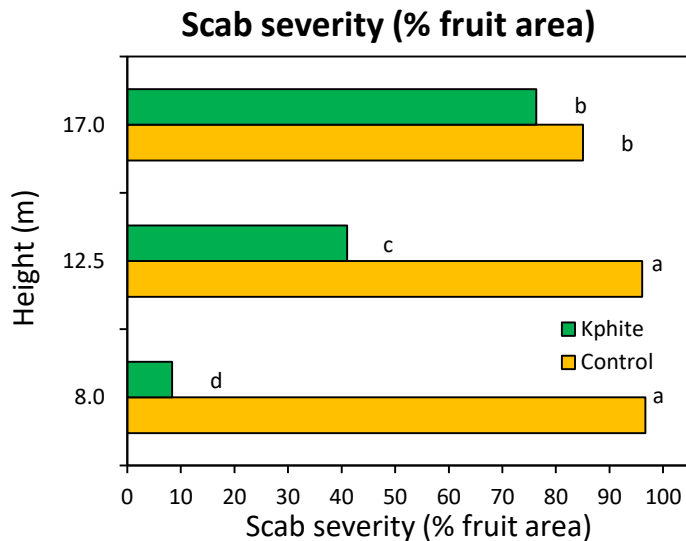
# Summary

- Coverage is dependent on height
- Volume affect spray coverage
- At the speeds tested the effects on spray coverage were relatively minor
- Pecan scab was not affected consistently at the range of volumes and speeds tested
- Indications were that lower application volumes might actually result in better scab control
- ARM sprays are likely not advantageous after the parachute stage
- Use of a volute can help project spray higher (more research needed)
- Effects on drift?



# Phosphites and the effect of tree height

- ❑ 2020 experiment. 9 applications of K-phite @ 4 GPA. Severe scab in untreated trees
- ❑ Phosphite significantly reduced scab up to 12.5 m
- ❑ Indicates phosphite applied using an air-blast sprayer can controlling scab on fruit
- ❑ Phosphite concentration declined in nutmeats with height
- ❑ Negative correlation between scab severity and phosphite concentration ( $r = -0.99$ ,  $P=0.006$ )
- ❑ Is it a direct effect, or is it through induced plant defense? Or both?
- ❑ Phosphite gradient suggest the ion is not translocated to achieve equal distribution



**1000 ppm EU MRL limit**



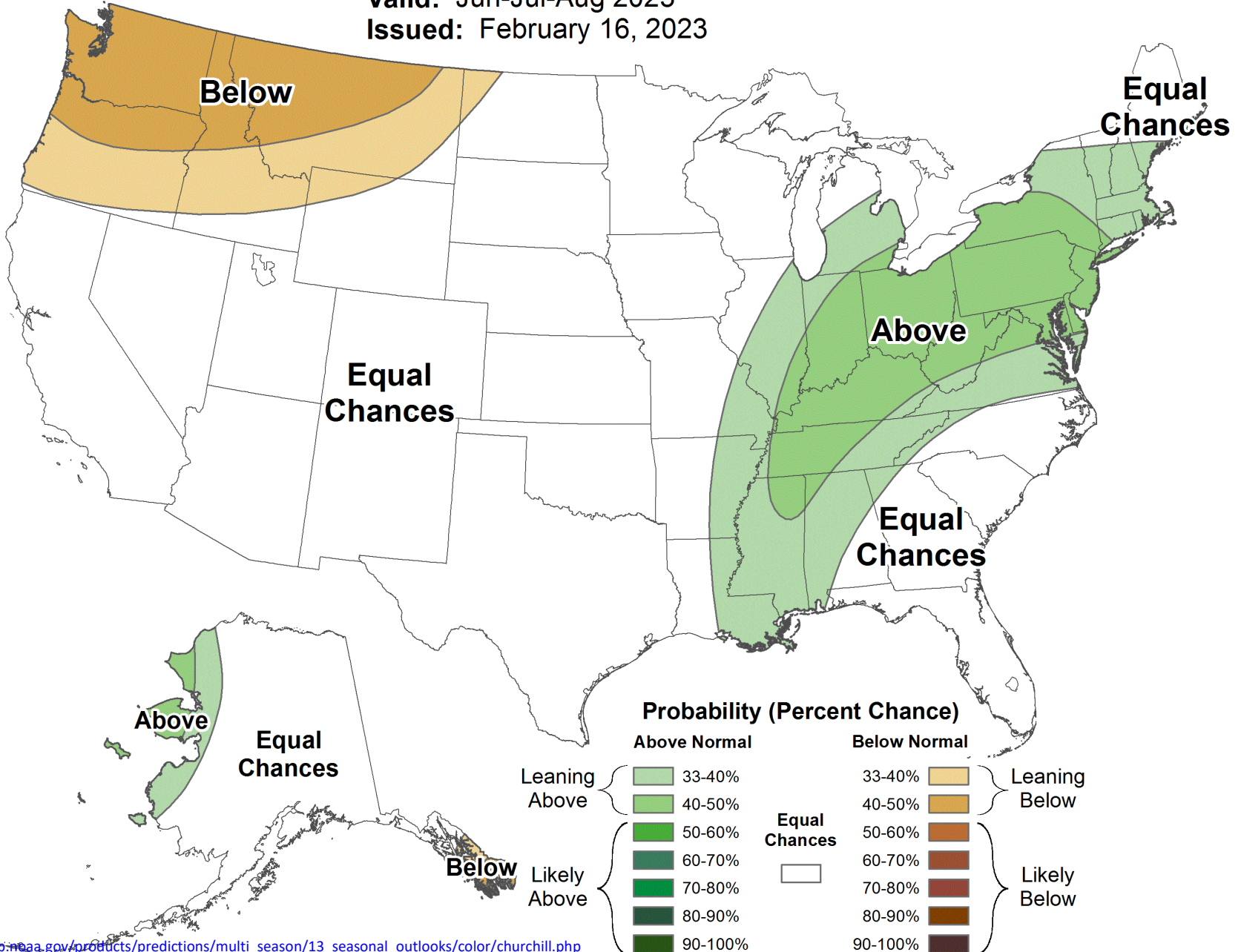


# Seasonal Precipitation Outlook



Valid: Jun-Jul-Aug 2023

Issued: February 16, 2023



# Acknowledgements

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



Unicka Stokes



Wanda Evans



Joe Renfro



Minling Zhang

....and many other short-term employees who have worked with the group (Cody Adams, Jason Shipp, Sue Burrell, Sarah Morril, Andrew Hudgens, Kanan Patel and Kaylee Carlson)

☐ Funding from: USDA-ARS CRIS project 6606-21220-012/14-00D, and the Georgia Agricultural Commodity Commission for Pecans





Thank you for the opportunity to  
present these results, and for  
your time



Questions?

