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# Fungicide control of apple scab: 2010 field trial

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## Summary

Apple scab, caused by the fungal pathogen *Venturia inaequalis*, is a significant fruit and foliar disease worldwide (Jones and Sundin 2006). Apples grown in regions of California characterized by spring precipitation or damp microclimates are subject to infection. Initial pathogen colonization of green tissue occurs when water stimulates ascospore release from pseudothecia located in overwintering leaf litter, followed by dispersal to leaves, flowers or fruit. Asexually-produced conidia from the primary sites of infection on the host can also colonize new tissue if spores are transported in the air or by water splash (Jones and Sundin 2006). In California, periodic applications of synthetic or organic fungicides from approximately March to June are required to control apple scab; the timing of fungicide applications is dependent on season to season patterns in precipitation (Gubler 2006). Based on research in other apple producing regions, additional control measures such as post-harvest fungicide applications at the time of leaf fall to reduce inoculum for the following growing season (Beresford et al. 2008), leaf litter removal (Gomez et al. 2007) or use of cultivar mixtures in an orchard (Didelot et al. 2007) may effectively reduce disease impacts.

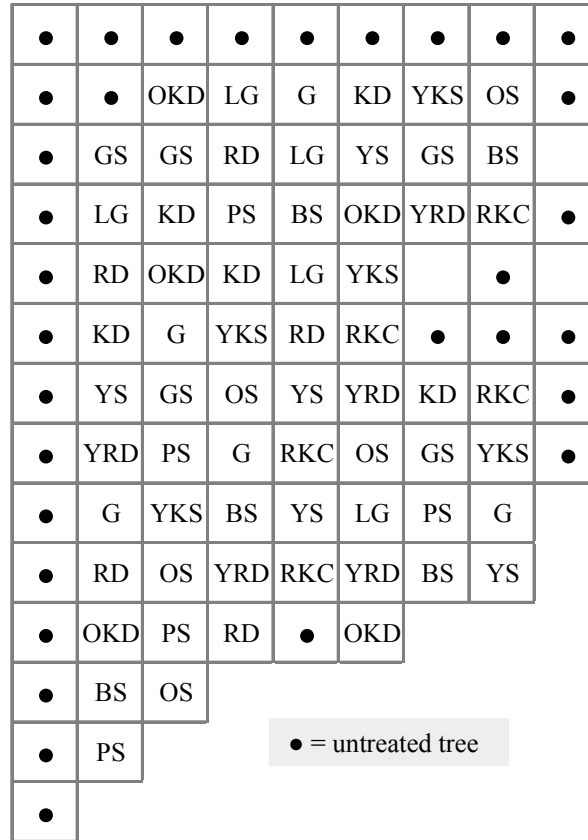
We conducted a field experiment near Camino, El Dorado County, California (elevation 3200 ft) to test the effects of several registered and experimental fungicides on control of apple scab in mature Red Delicious Trees. Five applications were made from late March (green tip) to late May 2010 (post-bloom). We compared disease levels obtained on foliage in untreated trees with disease control exhibited by synthetic products in combination, with and without adjuvants, and in alternation with other products.

## Materials and Methods

### A. Trial layout

|                        |   |            |                |                     |                          |
|------------------------|---|------------|----------------|---------------------|--------------------------|
| Experimental unit      | 1 tree = 1 plot   |            |                |                     |                          |
| Row and tree spacing   | 18 ft (row) and 18 ft (tree)  |            | Plot unit area | 324 ft <sup>2</sup> |                          |
| Area/treatment         | 1296 ft <sup>2</sup> or 0.0298 acre/treatment (4 replicate trees = 1 treatment) |            |                |                     |                          |
| Fungicide applications | A   | green tip  | Fri 26 March   | 150 gallons/acre    | 4.5 gallons/4 replicates |
|                        | B   | red bud    | Fri 9 April    | 150 gallons/acre    | 4.5 gallons/4 replicates |
|                        | C   | full bloom | Fri 23 April   | 200 gallons/acre    | 6.0 gallons/4 replicates |
|                        | D   | petal fall | Sat 8 May      | 200 gallons/acre    | 6.0 gallons/4 replicates |
|                        | E   | additional | Fri 21 May     | 200 gallons/acre    | 6.0 gallons/4 replicates |

## B. Trial Map



### Experimental treatments

| Flag | Product(s)                         | Applications | FP/Acre          | FP/Treatment      |
|------|------------------------------------|--------------|------------------|-------------------|
| OKD  | Unsprayed control                  | none         |                  |                   |
| OD   | Topguard + Dithane Rainshield 75DF | 10-14        | 13 fl oz + 48 oz | 11.5 ml<br>40.5 g |
| BD   | Topguard + Captan 80 WDG           | 10-14        | 13 fl oz + 40 oz | 11.5 ml<br>33.8 g |

|     |   |    |  |   |
|-----|---|----|--|---|
| YD  | Exp I   | 14 | 2.28 fl oz                                     | 2.0 ml  |
| GD  | Exp I   | 14 | 3.2 fl oz                                      | 2.8 ml  |
| KD  | Exp I   | 14 | 4.1 fl oz                                      | 3.6 ml  |
| OS  | Manzate (4lb)+ Vanguard (2x) then LEM17 (3x) then Manzate (6lb) (1x)                | 14 | 4 lb + 4 oz then 20 fl oz then 6 lb            | 54 g + 3.4 g then 17.6 ml then 81.1 g                                   |
| GS  | Manzate (4lb)+ Vanguard (2x) then LEM17 + Purespray (3x) then Manzate (6lb) (1x)    | 14 | 4 lb + 4 oz then 20 fl oz + 1% (v/v) then 6 lb | 54 g + 3.4 g then 17.6 ml+ 170 ml (150 gal)/225.6 (200 gal) then 81.1 g |
| KS  | Manzate (4lb)+ Vanguard (2x) then LEM17 + Manzate 3 lb (3x) then Manzate (6lb) (1x) | 14 | 4 lb + 4 oz then 14 fl oz + 3 lb then 6 lb     | 54 g + 3.4 g then 12.3 ml + 40.5 g then 81.1 g                          |
| PKS | LEM17 (20 fl oz) + Purespray (6x)   | 14 | 20 fl oz + 1% (v/v)                            | 17.6 ml + 170 ml (150 gal)/225.6 (200 gal)                              |
| BS  | LEM17 (12 fl oz) (6x)   | 14 | 12 fl oz                                       | 10.6 ml   |
| YKS | LEM17 (12 fl oz) + Dyneamic   | 14 | 12 fl oz + 0.25% (v/v)                         | 10.6 ml + 42.3 ml (150 gal)/ 56.4 ml (200 gal)                          |
| OKS | LEM17 (16 fl oz)  | 14 | 16 fl oz                                       | 14.1 ml   |
| YS  | LEM17 (20 fl oz)  | 14 | 20 fl oz                                       | 17.6 ml   |
| YKC | YT669 + Dyneamic  | 14 | 12 fl oz + 0.25% v/v                           | 10.6 ml + 42.3 (150 gal)/56.4 (200 gal)                                 |
| KC  | Manzate 4 lb + Vanguard 4 oz (2x) then Flint 2 oz (3x) then Manzate 6 lb (1x)       | 14 | 4 lb + 4 oz then 2 oz then 6 lb                | 54 g + 3.4 g then 1.7 g then 81.1 g                                     |
| GKC | Flint 2.5 oz alt Procure 12 fl oz   | 14 | 2.5 oz alt 12 fl oz                            | 2.1 g alt 42.3 ml   |
| YC  | Rally   | 14 | 5 oz   | 4.2 g   |

### C. Disease and statistical analysis

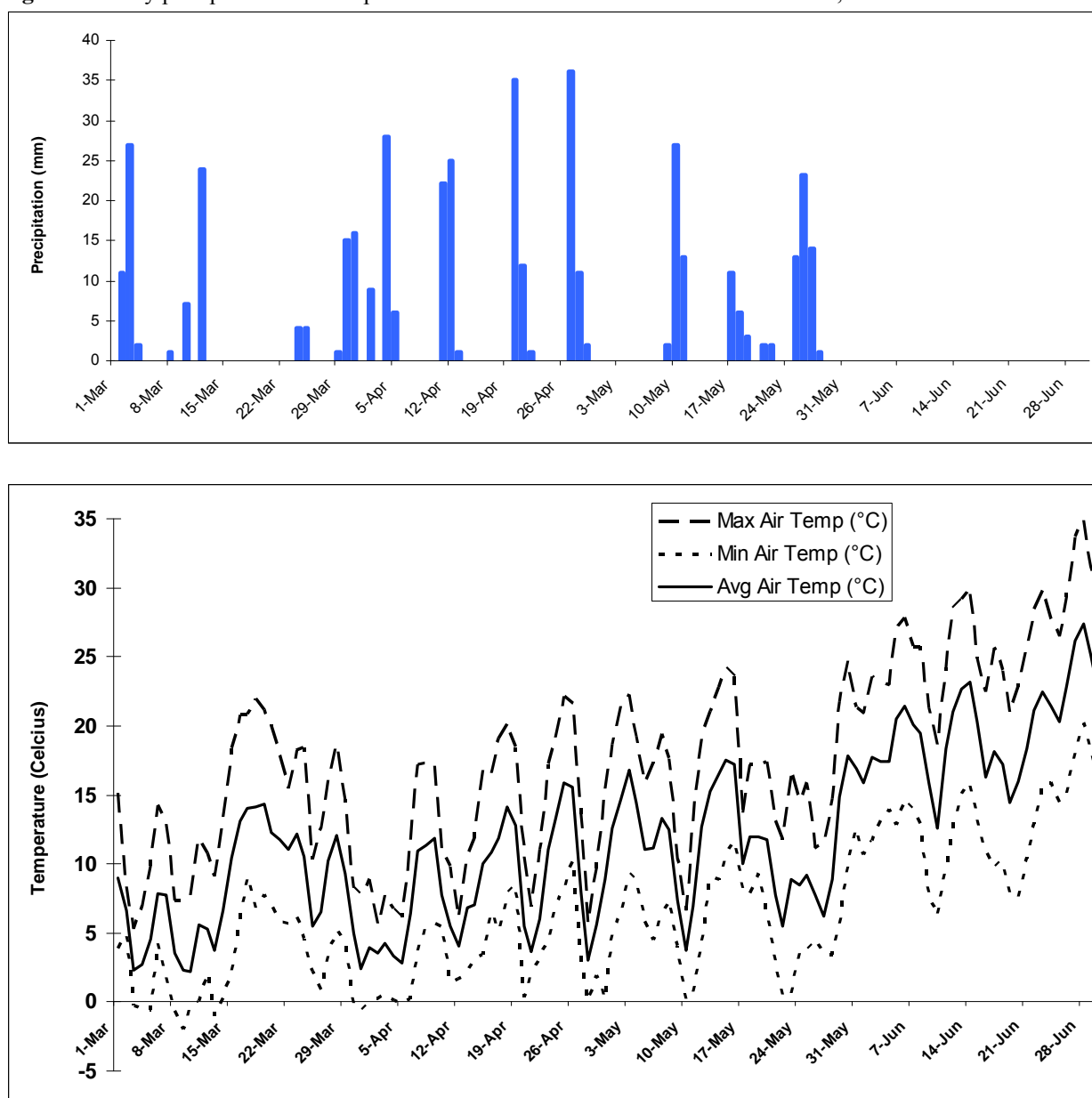
Disease was assessed on 21 June 2010 when fruits were large enough to observe scab lesions. Forty leaves were randomly selected from each tree. The number of lesions was scored for each leaf; estimated counts were made when the boundaries of individual lesions could not be easily distinguished. Disease incidence per replicate tree was determined as the proportion of leaves and fruits that were infected by at least one lesion. Disease severity for each plot was obtained as the mean density of lesions on leaves. Data was analyzed and means were compared using Fisher's protected LSD test ( $\alpha = 0.05$ ).

## D. Weather and Disease

Weather for the growing season was exceptionally rainy with 32 rain events (Mar 1 – May 31) of between 1-36 mm of rain. Low temperatures reached below freezing on at least four occasions after the first application. The combination of these two factors likely led to loss of most fruit blossoms. For this reason, it was necessary to use leaf rating data for the best disease analysis.

## Results

**Figure 1.** Daily precipitation and temperatures at the CIMIS weather station in Camino, California



**Table 1.** Apple scab leaf incidence (means  $\pm$  SE). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ ; alt=alternated with.

| <b>Treatment</b>   | <b>Leaf Incidence (%)</b> |
|--|---------------------------|
| Topguard, 13 fl oz + Captan, 40 oz   | 8.1 $\pm$ 1.9 f           |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb                     | 18.1 $\pm$ 4.8 ef         |
| YT669, 12 fl oz + Dyneamic, 0.25%  | 18.1 $\pm$ 4.7 ef         |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb                 | 20.0 $\pm$ 1.0 ef         |
| LEM17, 20 fl oz + Purespray, 1%  | 22.5 $\pm$ 4.0 ef         |
| LEM17, 12 fl oz + Dyneamic, 0.25%  | 24.4 $\pm$ 5.7 de         |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb  | 25.0 $\pm$ 5.3 de         |
| Flint, 2.5 oz alt Procure, 12 fl oz  | 26.3 $\pm$ 5.2 de         |
| Topguard, 13 fl oz + Dithane, 48 oz  | 30.0 $\pm$ 9.7 de         |
| LEM17, 20 fl oz  | 30.6 $\pm$ 5.3 de         |
| Rally, 5 oz  | 30.6 $\pm$ 4.7 de         |
| LEM17, 16 fl oz  | 31.3 $\pm$ 5.2 de         |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb | 39.4 $\pm$ 6.1 cd         |
| LEM17, 12 fl oz  | 49.4 $\pm$ 8.7 c          |
| Exp 1, 4.1 fl oz   | 65.6 $\pm$ 11.0 b         |
| Exp 1, 2.28 fl oz  | 69.4 $\pm$ 6.8 ab         |
| Exp 1, 3.2 fl oz   | 83.8 $\pm$ 1.6 a          |
| Untreated Control  | 83.8 $\pm$ 5.3 a          |

**Table 2.** Apple scab leaf severity (lesion density) (means  $\pm$  SE). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ ; alt=alternated with.

| <b>Treatment</b>   | <b>Leaf Severity (lesions/leaf)</b> |
|--|-------------------------------------|
| Topguard, 13 fl oz + Captan, 40 oz   | 0.14 $\pm$ 0.04 e                   |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb                     | 0.32 $\pm$ 0.10 e                   |
| YT669, 12 fl oz + Dyneamic, 0.25%  | 0.41 $\pm$ 0.14 e                   |
| Manzate, 4 lb +Vanguard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb                  | 0.46 $\pm$ 0.10 e                   |
| LEM17, 20 fl oz + Purespray, 1%  | 0.47 $\pm$ 0.16 e                   |
| Flint, 2.5 oz alt Procure, 12 fl oz  | 0.61 $\pm$ 0.22 e                   |
| LEM17, 12 fl oz + Dyneamic, 0.25%  | 0.63 $\pm$ 0.36 e                   |
| LEM17, 20 fl oz  | 0.68 $\pm$ 0.15 e                   |
| LEM17, 16 fl oz  | 0.78 $\pm$ 0.29 e                   |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb  | 0.82 $\pm$ 0.29 de                  |
| Rally, 5 oz  | 0.86 $\pm$ 0.21 de                  |
| Topguard, 13 fl oz + Dithane, 48 oz  | 0.99 $\pm$ 0.44 de                  |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb | 1.11 $\pm$ 0.24 de                  |
| LEM17, 12 fl oz  | 1.96 $\pm$ 0.50 cd                  |
| Exp 1, 4.1 fl oz   | 2.74 $\pm$ 0.77 bc                  |
| Exp 1, 2.28 fl oz  | 3.12 $\pm$ 0.97 ab                  |
| Exp 1, 3.2 fl oz   | 3.33 $\pm$ 0.36 ab                  |
| Untreated Control  | 4.26 $\pm$ 0.75 a                   |

**Table 1.** Apple scab fruit incidence (means  $\pm$  SE). Product names are followed by rate (per acre). Treatment means followed by the same letter are not significantly different according to Fisher's protected LSD test at  $\alpha=0.05$ ; alt=alternated with.

| Treatment  | Fruit Incidence     |
|--|---------------------|
| LEM17, 12 fl oz + Dyneamic, 0.25%  | 11.0 $\pm$ 6.7 e    |
| Topguard, 13 fl oz + Captan, 40 oz   | 11.7 $\pm$ 3.0 de   |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 20 fl oz +Purespray, 1% (3x) then Manzate, 6 lb  | 14.4 $\pm$ 3.0 de   |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then Flint, 2 oz (3x) then Manzate, 6 lb                     | 18.3 $\pm$ 8.8 cde  |
| YT669, 12 fl oz + Dyneamic, 0.25%  | 19.4 $\pm$ 7.7 cde  |
| Manzate, 4 lb + Vanguard, 4 oz (2x) then LEM17, 14 fl oz + Manzate, 3 lb (3x) then Manzate, 6 lb | 20.3 $\pm$ 13.8 cde |
| Flint, 2.5 oz alt Procure, 12 fl oz  | 22.3 $\pm$ 9.9 cde  |
| LEM17, 20 fl oz + Purespray, 1%  | 22.7 $\pm$ 8.4 cde  |
| LEM17, 16 fl oz  | 30.9 $\pm$ 8.3 cde  |
| LEM17, 20 fl oz  | 31.0 $\pm$ 5.3 cde  |
| Manzate, 4 lb +Vanguard, 4 oz (2x) then LEM17, 20 fl oz (3x) then Manzate, 6 lb                  | 31.3 $\pm$ 10.5 cde |
| Topguard, 13 fl oz + Dithane, 48 oz  | 34.4 $\pm$ 10.5 cd  |
| Rally, 5 oz  | 41.9 $\pm$ 9.5 bc   |
| LEM17, 12 fl oz  | 59.0 $\pm$ 7.1 b    |
| Untreated control  | 100.0 $\pm$ 0.0 a   |

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## Appendix: Products tested

| Product                  | Active ingredient(s) and concentration  | Class                 | Manufacturer                   |
|--------------------------|---|-----------------------|--------------------------------|
| Captan 80 WDG            | captan (80%)  | pthalamide            | Arysta Life Sciences           |
| Dithane Rainshield 75 DF | mancozeb (75%)  | carbamate             | Dow Agrosiences LLC            |
| Dyneamic                 | polyalkyleneoxide modified polydimethylsiloxane, nonionic emulsifiers, methyl ester of C16-C-18 fatty acids (99%) | adjuvant              | Helena Chemical Co.            |
| Exp. 1                   | proprietary   | proprietary           | proprietary                    |
| Flint 50 WG              | trifloxystrobin (50%)   | QoI                   | Bayer                          |
| LEM 17 SC                | penthiopyrad (20%)  | carboximide           | DuPont                         |
| Manzate                  | mancozeb (75%)  | carbamate             | Dupont                         |
| Procure                  | triflumizole (42.1%)  | DMI-imidizole         | Chemtura Corp.                 |
| Purespray                | petroleum oil (98%)   | oil                   | Petro-Canada                   |
| Rally 40WSP              | myclobutanil (40%)  | DMI-triazole          | Dow AgroSciences               |
| Topguard 1.04 SC         | flutriafol (12%)  | dimethylase inhibitor | Chemnova A/S                   |
| Vanguard                 | cyprodinil (75%)  | anilinopyrimidine     | Syngenta Crop Protection, Inc. |

*Appendix 1 references:* (1) Adaskaveg, et al. 2008. Efficacy and timing of fungicides, bactericides and biologicals for deciduous tree fruit, nut, strawberry, and vine crops 2008, available at <http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2008/file/IPMFungicidetables2-14-08.pdf>  
 (2) Janousek et al. 2008. Grape powdery mildew trials, available at [http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2008/file/Grape\\_PM\\_2008\\_web\\_report.pdf](http://plantpathology.ucdavis.edu/ext/gubler/fungtrials2008/file/Grape_PM_2008_web_report.pdf), (3) various sources including product labels and/or MSDS, product websites, and personal communications.