**Technical Notes: GrapeWatch Downy Mildew**

As supplied by GrowCare®

Peter Magarey, Stuart Putland and Eric Love.

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**The Mildews.**

Downy mildew causes considerable loss in some seasons. It is a ‘wet weather’ disease and can spread rapidly causing large losses. But because, in dry inland regions, suitably wet conditions occur irregularly, so the disease occurs irregularly. For this reason, best control of downy requires well-timed sprays when the risk is high and allows a user to confidently withhold sprays when the risk is low.

Downy and powdery mildew are diseases with some similarities, but they develop in different conditions. Downy could be called ‘Down-hill mildew’ because, for infection to occur, it needs water – it is a wet-weather disease that grows best in warm, wet conditions. By contrast, ‘powdery-dry mildew’ can develop in dry conditions. Because of this, the control for the two mildews requires different strategies.

**GrapeWatch**

GrapeWatch is a system built for users in following the different strategies. The system provides timely text alerts for infection events and web-portal access for disease management information for both mildews. This information is presented from within modules developed by GrowCare®. For downy, the decision support module comprises a series of computer-based models that were developed within DModel, the simulator of downy mildew in Australian vineyards. The simulator models each step within the life cycle of that disease.

Infection by downy mildew requires the right combination of warmth (temperature) and wetness (rainfall, leaf wetness and humidity) for the right amount of time. These conditions are measured by weather stations (AWS) that monitor vineyard microclimate and provide data for the GrapeWatch system.

**Life cycle**

Downy develops in two life cycle stages called primary and secondary infection. As a student begins at primary school then progresses to secondary school, so downy begins with primary infection – the soil to foliage movement of inoculum (spores that spread disease). This is followed by a period of incubation (unseen, like a chicken within an egg) after which the classical symptoms of downy, (the golden yellow oilspots) appear on infected leaves.

**Figure 1.** Schematic view of grapevine downy mildew infection. Primary and secondary infection events each require different conditions to develop but both produce oilspots on unprotected leaves after a period of incubation. Good control of the disease comes when sprays are well-timed when needed and confidently withheld when not required, especially in the period from September to December.



Then, at some time later, if the conditions are favourable, downy mildew can spread rapidly in secondary infection – the leaf to leaf and leaf to bunch spread of the disease. Importantly, downy mildew secondary infection cannot occur without oilspots being present from an earlier infection event (Figure 1).

**Guides to favourable conditions**

**Primary infection**

Control of primary infection is often the most critical for good, season-long control of the disease. A rule of thumb, developed in the 1980s, still provides a crude guide to the conditions that favour primary infection: It indicates minimum thresholds for the duration of wetness and warmth required for some steps within the primary infection cycle.

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| **Table 1.** A ‘rule of thumb’ for the conditions that favour a downy mildew primary infection event. This ‘crude guide’ covers only some aspects of the cycle for primary infection. |
| **10:10:24 – a rule of thumb for Downy Mildew Primary Infection** |
| **at least 10mm rain** | **with at least 100C temperature** | **in a 24hr period.** |

The rule of thumb indicates the need for primary infection of at least 10mm rain sufficient to wet the soil, at temperatures of 100C or more, within a 24hour period.

If the conditions are not as favourable, the guide indicates it was unlikely that a primary infection event has occurred in that rain event. If the conditions were favourable (warm enough and wet enough for 24 hours or longer), then the disease event may have occurred.

These conditions remain a guide, but more detail is needed for the system to be more precise in determining if the conditions have favoured primary infection or not.

In more detail, downy can develop at temperatures as low as 80C, with at least 3-5mm rainfall to wet the soil for at least 16hours. If so, special swimming spores of downy (the zoospores – see Figure 1) form in the wet soil and are splashed by rain into the air currents and spread to infect unprotected foliage. If the vine canopy is warm enough and wet enough for long enough, for example, at 200C with leaves wet for at least 2-3hr, primary infection is then considered likely. The DModel simulator models the finer detail involved in each of the many steps in determining if a primary infection event has occurred.

So, although the 10:10:24 rule of thumb provides a simple but crude guide to primary infection, much more detail is needed to calculate if a primary infection has occurred. This rule of thumb gives no guide to the calculations for incubation period nor for the life cycle stages that need to be monitored for secondary infection.

**Incubation**

After an incubation period (5-21 days depending on temperature), new generation oilspots will appear on unprotected leaves.

**Secondary infection**

As said, this step in the downy mildew life cycle requires active oilspots to be present. As a guide, if a warm, humid night is followed by leaves wet in the morning, a secondary infection event may occur.

In more detail, if active oilspots are present, then if the temperature is at least 130C with relative humidity 98% for at least 4hours during the night, then the typical white down of downy mildew will form on the undersides of the oilspots. The white down produces the sporangia, (see Figure 1). If the conditions are favourable and the leaves are wet for long enough, the sporangia produce the swimming spores (the zoospores). If the leaves are then warm enough (above 110C) and wet for long enough (at least 2-3hr at 200C), then secondary infection will complete (when the zoospores move into unprotected leaf or bunch tissue).

**Incubation**

After an incubation period (5-21 days depending on temperature), new generation oilspots will appear on unprotected leaves.

If the conditions are right, a downy secondary event can occur many times over during a growing season. It can be very destructive and rapidly infect and kill susceptible young bunches.

**The GrapeWatch system – Decisions with precision**

As summarised above, the Grape Watch system comprises a series of sub-models each describing one step in the complex issues involved in the development and spread of the disease (that is, its epidemiology). For greater accuracy and speed in calculating the risk of a primary or secondary infection event, even more epidemiological detail is needed than presented above. Each sub-model calculates a process involved in the sequence of events that together, comprise the various stages in the life cycle of downy mildew. Each step in the downy life cycle is affected by some aspect of the weather conditions as that influences the micro-climate within the grapevine canopy.

GrapeWatch processes weather data (temperature, humidity (RH), leaf wetness, and rainfall) collected at every 10-minute interval. It uses the various sub-models to calculate with precision when the conditions are suitably warm and wet for infection and when not.

If an infection event (primary infection or secondary infection or the development of oilspots) is considered likely, then the GrapeWatch system will automatically generate and send to registered users an alert advising of the risk of the respective infection events (Table 2).

**Table 2.** The short-cuts (acronyms) to the major components of the life cycle of grapevine downy mildew as presented in the GrapeWatch system.

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| **Shortcut** | **Referring to:** |
| **DMP**  | Primary infection |
| **DMPO** | Oilspots developed from a primary infection |
| **DMS** | Secondary infection |
| **DMSO** | Oilspots developed from a secondary infection |

**Assessing the need to apply controls for downy mildew.**

**Not just weather data**

The GrapeWatch system uses additional factors than the weather (vineyard microclimate) to calculate the risk of disease. So, although the conditions may favour infection, the risk from downy disease and the need to apply a control at any given time, is dependent on other factors such as those that influence the growth and susceptibility of the grapevine canopy (Table 3).

**Table 3.** Factors incorporated by the GrapeWatch system provide the basis for calculating the risk of a downy mildew disease event. The inclusion of these factors provides greater precision in determining the need for controls (fungicide sprays).

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| **Factors assessed** | **Influences on risk of downy mildew disease.** |
| **Canopy micro-climate**  | Risk of infection |
| **Foliage susceptibility** | Susceptibility of the foliage to disease. |
| **Foliage growth rate** | Amount of new foliage since previous spray. |
| **Canopy size/density** | Availability of susceptible canopy and the ease of sprays reaching inner canopy. |

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**Factors for assessing risk from downy disease.**

The local weather may favour a downy mildew infection event, but several other factors influence whether this will or will not subsequently lead to the risk of disease occurring. For example, the vineyard weather may be favourable for an infection event, but the canopy development (the phenology) may be insufficient for an infection to occur. When budburst is just beginning at say EL 4, the canopy will not have produced sufficient susceptible foliage for infection to occur, or later in the season, the berries may have sufficiently matured (at EL 31) to have become resistant to infection. So, although the conditions may favour a downy mildew infection, the vine phenology factors need consideration to determine the risk of a downy mildew disease event at any time during the season.

Side note

The various stages of development of the grapevine canopy throughout the season have been classified by Eichhorn and Lorenz (1977). For clarity and precision Coombe and Dry published a modified E-L system for identifying major and intermediate grapevine growth stages (“Grapevine growth stages – The modified E-L system” Viticulture 1 – Resources. 2nd edition 2004. Eds. Dry, PR and Coombe, BG. (Winetitles)). GrapeWatch uses this system to define the relevant stages of canopy development as in Table 5.

**The GrapeWatch disease advisory system**

**Risk of Infection; Risk of Disease**

So, the GrapeWatch system calculates the risk of a downy mildew disease event and relies on various infection conditions being fulfilled (eg temperature, leafwetness – as detailed above) and likewise various canopy factors in a sequence of steps in relation to the weather (Table 1) and to the stage of development of the grapevine canopy (Table 3).

Infection factors:

1. Canopy micro-climate: The risk of an infection event at any given time is determined by the prevailing weather conditions in a suitable combination of temperature, rainfall, relative humidity, and leaf wetness for infection to occur (Table 2); and
2. A recurrence of these ‘infection factors’ in some combination influences the timing, duration, and the number of infection events, hence build-up of inoculum. This determines the potential (the risk) of an infection event, but as above, several other canopy factors together determine the risk of a disease event occurring.

Disease factors:

1. Canopy factors: The risk of disease in any given time depends on ‘canopy factors’ that affect the timing, duration, and the number of disease events. These include the changing susceptibility of the foliage during the season, the rate of growth of the canopy and its influence on the durability of spray coverage of any previous fungicide spray; and the canopy size and density as it influences the capacity to achieve effective spray cover (Table 3); and
2. Vineyard management factors: a user’s choice of a disease control strategy and physical factors will further influence the risk of disease. Some of these factors include the likelihood of further conditions favouring disease , the size of the vineyard, and its accessibility by spray machinery after a rain event, and the availability and cost of fungicide controls, t

The most efficient and effective control of downy at any point in time, requires vineyard managers to have knowledge of:

1. when the weather conditions favour infection and how many cycles of disease have already occurred;
2. the susceptibility of the canopy and the risk of disease at that time, the rate of canopy growth; and its influence on
3. the duration of effective spray coverage if any; and
4. an optimum disease management strategy for the control options for that time.

**Spray options and timing**

At any time during the growing season there are, broadly, just three spray options available to vineyard managers (Table 4).

**Table 4.** The three spray options for control of grapevine downy mildew at any point in time.

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| **Actions to Manage Grapevine downy mildew.** |
| **Do nothing** |
| **Apply a pre-infection (protectant) fungicide** |
| **Apply a post-infection (eradicant) fungicide** |

However, more detail in spray timing is needed to provide the required precision for effective control of a disease event. For example, a spray may be applied pre-infection to protect the canopy from a forecast rain event but too long prior so that there was too much newly expanded and therefore unprotected foliage for effective control of disease. Similarly, a post-infection fungicide might be applied after an infection event but not soon enough to be useful if new generation oilspots were already present.

The current GrapeWatch advisory system is designed to cover some but not all these disease risk scenarios. For others, it is ‘work in progress’.

**Changes in the canopy phenology**

The GrapeWatch system incorporates these variations in canopy factors. Table 5 presents the varying scenarios that encompass the risk of disease as it changes through the season at the different stages of canopy development.

This risk (consequence) of an infection event for either a DMP or a DMS at each EL period, varies according to above cited canopy factors as their influence changes through the season.

First, young vine tissue is very susceptible to infection whereas mature leaf and bunch tissue develops an increasing resistance to downy mildew. In consequence, one infection cycle in early season can cause much more damage to the highly susceptible vine tissue than later when the tissue has gained age-related (ontogenic) resistance.

Second, as the foliage grows, it expands. In early season, the rate of expansion is rapid whereas later it slows down. To provide an effective fungicide cover in early season requires more frequent spraying (with closer spray intervals), than later in the season when the expansion of leaves and bunches has slowed, and the spray interval can be extended.

Third, as the season develops, so too does the growth of the vine and this increases the density of the canopy. In early season, as the density increases, it creates a bigger target for the spores of downy to reach, when conditions favour infection. To the contrary, canopy density influences the ease and effectiveness of fungicide sprays penetrating inner parts of the canopy to protect the crop. Later in the season, the canopy density makes it difficult if not impossible to provide effective spray cover inside a tight knit bunch.

**Downy Mildew Infection Alerts**

As indicated above, the GrapeWatch system processes weather data and calculates the favourability of local weather conditions for infection by downy mildew in either its primary (DMP) or secondary (DMS) stage.

To keep the outputs of the GrapeWatch system simple, the marginal risks of an infection event (ie ‘nearly an infection risk’ and ‘just an infection risk’) are amalgamated with the ‘yes, an infection event is likely’) to provide a single alert for DMP, DMPO, DMS and DMSO as expressed in Table 5.

The main body of Table 5 provides GrapeWatch assessment of the consequence of disease (‘none’, ‘low’, ‘moderate’, ‘high’ and ‘very high’) at each stage of canopy development.

**Semi-automated Disease Management Scenario Advisories**

Following a GrapeWatch Infection Alert via text message, or email, the GrapeWatch system can be accessed to review an Overview Comment that summarises the disease scenario for that event, at that time.

This note is followed by a General Comment and several Specific Comments that form the text message advisory with recommended action for each specific DMP, DMS or DMO event at each growth stage combination of canopy factors.

**GrapeWatch Disease Alerts**

GrapeWatch processes the data from the various AWS and identifies when a downy infection alert is calculated. The following presents the implications on downy mildew disease risk, given a GrapeWatch calculated primary infection (DMP) event and assessment of the following canopy factors. Options for managing the disease under these several disease scenarios are then presented for the GrapeWatch user to consider.

1. **For a calculated Primary Infection Event (DMP)**

Given a calculated downy mildew infection event (DMP - Table 5.1, and DMS -Table 5.2), GrapeWatch calculates downy mildew disease risk scenarios for the different growth stages in the season. From this, GrapeWatch calculates the risk of downy mildew disease events.

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| **Table 5.1: GrapeWatch assessment of the influence of canopy factors on the risk of downy mildew primary disease,** given a calculated primary infection (DMP) event has occurred and the new oilspots (DMPO) are still incubating. |
| **Vine Growth (EL Stage)** | **<EL 4** | **EL 4-11** | **EL 12-16** | **EL 17-27** | **EL 28-30** | **EL 31-41** | **EL 42-47** |
| **Risk from Disease in canopy** | **No Risk** | **Low** | **Moderate** | **High** | **Moderate** | **Low** | **Very Low Risk** |
| **Canopy Factors that affect Risk of Disease** | 1. **Foliage**

**Susceptibility** | NilPre-budburst | Leaves **highly** susceptible. | Leaves **highly** susceptible | Leaves susceptible.Florets & berries **highly** susceptible | Leaves & berries susceptible | Leaves & berries resistant | Leaf fall |
| **[given a DMP]** | 1. **Foliage Growth Rate**
 | Nil | Moderate. | **High** | **High** | Slowing. | Nil | Nil |
| 1. **Canopy Size/Density**
 | Nil. | Small to medium-size & density  | Large | Large | Large | Large | Large |
| **Disease risk from a calculated DMP event** | **Yes** | **1.1 None** | **1.2 Low** | **1.3 Moderate** | **1.4 High** | **1.5 Moderate** | **1.6 Low** | **1.7 Very low risk**  |
|  |  |  |  |  |  |  |  |  |

**Note:**

1). The disease risk scenarios as described by GrapeWatch (as at 1st May 2024), are shown in the table. These provide the user with decision support information listing options for managing the disease. Users then can make informed decisions when determining spray actions in a preferred control strategy.

2). The lower line of Table 5.1 shows text numbers viz 1.1 to 1.7. These relate to the respective disease risks calculated for the differing canopy scenarios presented. The annotated numbers in the text that follows here, relate to these numbered scenarios for the respective spray options.

3). The following comments for managing disease following scenarios for a calculated DMP (primary infection – Table 5.1), a DMS (secondary infection – Table 5.2) and/or DMO (oilspot) event.

4). In the information listed below, the **text in blue** are options presented by the GrapeWatch system given the prevailing weather and canopy factors.

**Overview Comment (for DMP)**

As a result of the recent rain event from (Date 1 - Date 2) the GrapeWatch system has calculated a downy mildew (DMP/DMS) (infection / oilspot) event in vineyards near weather stations (AWS) at (locations L1, L2, L3 etc)

**General Comment**

Having assessed (leaf susceptibility/canopy growth rate/canopy size/ flower susceptibility/berry susceptibility), the risk of a primary infection is considered (none/low/moderate/high). For: None (see Note 1.1; 1.7), Low (1.2; 1.6), Moderate (1.3; 1.5), and High (1.4).

**GrapeWatch Disease Alerts – assuming a DMP but no DMPO as yet.**

**Calculated Risk Assessment and Recommend Action** with followingcomments for the various scenarios.

**Scenario:**

* 1. **None**: [early-season, list EL stage ] Do nothing at present BUT the canopy will soon be expanding rapidly and disease risk can change quickly at this time of the season. Remain alert for further reports.
	2. **Low** [list EL stage ]**:**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then do nothing at present but closely consider applying a pre-infection (preventative) fungicide as close as possible before the next significant rain event;
		1. **Alternatively**, consider applying a post-infection (eradicant) fungicide now, before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.

**OR**

* + 1. Apply no downy mildew fungicide now but wait for the next time conditions are suitable for a secondary infection event, and then apply a post-infection (eradicant) fungicide before oilspots appear.
	1. **Moderate** [list EL stage ]**:** If your vineyard was not adequately protected by a preventive spray cover in the (5/7) days prior to the recent rain event, consider applying a post-infection (eradicant) fungicide **now**, that is before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.
		1. **Alternatively**, do nothing now but look for the next forecast rain event favourable for a secondary infection, and consider applying a pre-infection (preventative) fungicide as close as possible before that rain event.

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear.
	1. **High** [list EL stage ]**:** If your vineyard was not adequately protected by a preventive spray cover in the (5) days prior to the recent rain event, then it is strongly advised that you apply a post-infection (eradicant) fungicide **now**, before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.
		1. **Alternatively**, do nothing now but look for the next forecast rain event favourable for a secondary infection, and apply a pre-infection (preventative) fungicide as close as possible before that rain event.

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and apply a post-infection (eradicant) fungicide after the rain and before oilspots appear.
	1. **Moderate** [list EL stage ]**:** If your vineyard was not adequately protected by a preventive spray cover in the (7/10) days prior to the recent rain event, consider applying a post-infection (eradicant) fungicide **now**, that is before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.
		1. **Alternatively**, do nothing now but look for the next forecast rain event favourable for a secondary infection, and consider applying a pre-infection (preventative) fungicide as close as possible before that rain event.

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear.
	1. **Low** [list EL stage ]**:**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then do nothing at present but consider applying a pre-infection (preventative) fungicide as close as possible before the next significant rain event;
		1. **Alternatively**, consider applying a post-infection (eradicant) fungicide now, before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.

**OR**

* + 1. Apply no downy mildew fungicide now but wait for the next time conditions are suitable for a secondary infection event, and then apply a post-infection (eradicant) fungicide before oilspots appear.
	1. **None**: [late season, list EL stage] Do nothing at present. It is very late in the season and downy mildew infection now will be of little consequence. Spraying at this late stage in the season is not warranted.

END

1. **For a calculated Secondary Infection Event (DMS)**

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| **Table 5.2: Influence of Canopy Factors on the Risk of Downy Mildew Secondary Disease.**- given that a secondary infection (DMS) event has recently occurred and new oilspots (DMPO) are still incubating. |
| **Vine Growth (EL Stage)** | **<EL 4** | **EL 4-11** | **EL 12-16** | **EL 17-27** | **EL 28-30** | **EL 31-41** | **EL 42-47** |
| **Risk of Disease** | **No Risk** | **Low** | **Moderate** | **High** | **Moderate** | **Low** | **Very Low Risk** |
| **Canopy Factors that affect Risk of Disease** | **1 Foliage****Susceptibility** | NilPre-budburst | Leaves **highly** susceptible. | Leaves **highly** susceptible | Leaves susceptible.Florets & berries **highly** susceptible | Leaves & berries susceptible | Leaves & berries resistant | Leaf fall |
| **[given DMPO are present and active]**  | **2 Foliage Growth Rate** | Nil | Moderate. | **High** | **High** | Slowing. | Nil | Nil |
| **3 Canopy Size/Density** | Nil. | Small to medium-size & density  | Large | Large | Large | Large | Large |
| **Disease risk from a DMP** | **Yes** | **2.1 None** | **2.2 High** | **2.3 High** | **2.4 VERY HIGH** | **2.5 High** | **2.6 Moderate** | **2.7 Very low risk**  |
|  |  |  |  |  |  |  |  |  |

[Confirm that the user has entered date of budburst since the message is now linked to growth stage of the vine.]

The bottom line of Table 5.2 shows text numbers viz 2.1 to 2.7. These relate to the respective disease risks calculated for the differing canopy scenarios presented. The annotated numbers in the text that follows here, relate to these numbered scenarios for the respective spray options.

**Secondary Infection Event (DMS)**

**General Comment**

*Having assessed (leaf susceptibility/canopy growth rate/canopy size/ flower susceptibility/berry susceptibility), the risk of a secondary infection is considered (none/moderate/high/extreme).* Check the following: For *None (2.1; 2.7), Moderate (2.6), High (2.4), Extreme (2.5; ).*

**GrapeWatch Disease Alerts – DMS assuming a DMP with DMPO present.**

**Calculated Risk Assessment and Recommend Action** with followingcomments for the various scenarios.

**Specific Comments for each Scenario:**

**[The following text and numbering needs fixing.]**

* 1. **None**: [early-season, list EL stage ] [a DMS so soon is an unlikely scenario.]

Do nothing at present BUT the canopy will soon be expanding rapidly, and disease risk can change quickly at this time of the season. Remain alert for further reports.

* 1. **High** [list EL stage ]**:**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then closely *consider applying a post-infection (eradicant) fungicide before oilspots appear. Oilspots are likely to be visible in (xi*) *days from the infection event*
		1. **Alternatively**, Do nothing at present but be sure to apply a pre-infection (preventative) fungicide as close as possible before the next forecast rain event favourable for a secondary infection;

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear**.**

**High** [list EL stage ]**:[2.3]**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then closely *consider applying a post-infection (eradicant) fungicide before oilspots appear. Oilspots are likely to be visible in (xi*) *days from the infection event*

* + 1. **Alternatively**, Do nothing at present but be sure to apply a pre-infection (preventative) fungicide as close as possible before the next forecast rain event favourable for a secondary infection;

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear**.**

**Very High** [list EL stage ]**:[2.4 check text]**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then closely *consider applying a post-infection (eradicant) fungicide before oilspots appear. Oilspots are likely to be visible in (xi*) *days from the infection event*

* + 1. **Alternatively**, Do nothing at present but be sure to apply a pre-infection (preventative) fungicide as close as possible before the next forecast rain event favourable for a secondary infection;

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear**.**

**High** [list EL stage ]**:[2.5 check text]**  If your vineyard was not adequately protected by a preventative spray cover in the (7/10) days prior to the recent rain event, then closely *consider applying a post-infection (eradicant) fungicide before oilspots appear. Oilspots are likely to be visible in (xi*) *days from the infection event*

* + 1. **Alternatively**, Do nothing at present but be sure to apply a pre-infection (preventative) fungicide as close as possible before the next forecast rain event favourable for a secondary infection;

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear**.**

**Moderate** [list EL stage ] [2.6]**:** If your vineyard was not adequately protected by a preventive spray cover in the (5/7) days prior to the recent rain event, apply a post-infection (eradicant) fungicide **now**, that is before new generation oilspots appear. Oilspots are likely to be visible in (xi) days from the infection event.

* + 1. **Alternatively**, do nothing now but look for the next forecast rain event favourable for a secondary infection, and consider applying a pre-infection (preventative) fungicide as close as possible before that rain event.

**OR**

* + 1. Do nothing now but look for the next forecast rain event favourable for a secondary infection, and then consider applying a post-infection (eradicant) fungicide after the rain and before oilspots appear.
	1. **None**: [late season, list EL stage] Do nothing at present. It is very late in the season and downy mildew infection now will be of little consequence. Spraying at this late stage in the season is not warranted.

END

**Appendix 1**

**Life cycle of downy mildew in more detail**

DModel, the re-written simulator now operates within the web-based GrapeWatch system. DModel processes weather data. These are monitored and collected electronically across a region by a network of automatic weather stations (AWS). The AWS instruments measure canopy temperature, relative humidity, rainfall and leafwetness every minute then, every 10 minutes, average and store these data. The data are processed by DModel to calculate the risk of primary and/or secondary infection events and to predict the date oilspots will appear (the incubation period).

### Primary infection (DMP) involves: 2

Production

* Sporulation (of oospores in the soil to produce macrosporangia. These in turn produce another spore called zoospores (Zs)).
* Survival (of Zs in soil water).
* Spread (dispersal of Zs to the foliage (Zf)).
* Survival (of zoospores (Zf) within the foliage).

Infection (DMP) (this phase is the same as for DMS infection as below)

* Invasion (by zoospores (Zf) through stomates in the foliage); and
* Incubation (maturation/appearance of oilspots – DMO, as infection progresses within invaded cells).

### Secondary Infection involves: 3

Production:

* Sporulation (of oilspots in the foliage to produce sporangia. These in turn produce more zoospores Zf).
* Spread (dispersal of zoospores (Zf) within the foliage).
* Survival (of zoospores (Zf) within the foliage).

Infection (DMS) (this phase is the same as for DMP infection as above)

* Invasion (by zoospores (Zf) through stomates in the foliage); and

**Further reading**

The conditions that contribute to these infection steps are defined in detail within the computer-based empirical simulator of downy mildew (Magarey, Western and Wachtel, 2004). Called

The DM Fact Sheet – GWRDC web....

Eichhorn and Lorenz system as modified by Coombe and Dry