

Project title: The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers.

Objective 1. Management of conventional chemistry

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(or expected completion date):

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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Grower Summary

Headline

- Frupica SC, Karma, Reflect, Sercadis and Topas were found to be crop safe on *Cosmos* 'Xanthos Lemon Sherbet', *Dahlia* 'Figaro Violet Shades', Pansy 'Matrix Beaconsfield', *Petunia* 'Express Blue' and *Verbena* 'Quartz XP Red Eye'.
- Fungicides with three different FRAC mode of action codes that are safe to use on selected bedding and pot plants were identified.

Background

The Bedding and Pot Plant Centre (BPPC) was established to address the needs of the industry via a work programme to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries.

This is the Bedding and Pot Plant Centre report for:

Objective 1. Management of conventional chemistry.

Summary

Several key active ingredients with activity against powdery mildew that are known to be crop safe in bedding and pot plant production have recently been withdrawn. The fungicides included within this trial were selected as they have activity against powdery mildew and have recently obtained Extensions of Authorisations for Minor Use (EAMUs) in the production of ornamentals. However, limited crop safety data relating to the use of these products is available for bedding and pot plant growers. Plant species were selected based on their susceptibility to powdery mildew. This trial expands the fungicide options available for the prevention and control of powdery mildew within the bedding and pot plant sector.

Five seed-raised bedding plant species (*Cosmos* 'Xanthos Lemon Sherbet', *Dahlia* 'Figaro Violet Shades', Pansy 'Matrix Beaconsfield', *Petunia* 'Express Blue' and *Verbena* 'Quartz XP Red Eye') were used for this trial. Plugs were transplanted into standard 6-packs (Pansy, *Petunia* and *Verbena*) and 1 L pots (*Cosmos* and *Dahlia*) at ADAS Boxworth on 25th June 2020 (week 26). All species were transplanted into Levington M2 Pot and Bedding Compost. Treatments (**Table 1**) were applied as a foliar spray in 500 L/ha water two and four weeks post-transplant (weeks 28 and 30). Treatment effects were compared with two control treatments, water only. If PGRs were required on the trial, the second control treatments would also be treated with PGR, to confirm that any treatment effects were attributable to the fungicide application and not the PGR. Plants were not irrigated for 24 hours following treatment.

Table 1. Treatment list. Treatments were applied at 2- and 4-weeks post-transplant (weeks 28 and 30)

| Trt | Product | No. of applications | Active | Rate (L/ha, kg/ha) | Rate (ml/L, g/L) |
|-----|-------------------------------------|---------------------|------------------------------|--------------------|------------------|
| 1 | Water control | 2 | N/A | N/A | N/A |
| 2* | Water control (+ Bonzi if required) | 2 | N/A | N/A | N/A |
| 3* | Frupica SC | 2 | Mepanipyrim | 0.9 L/ha | 1.8 ml/L |
| 4* | Karma | 2 | Potassium hydrogen carbonate | 3.0 kg/ha | 6.0 g/L |
| 5* | Reflect | 2 | Isopyrazam | 1.0 L/ha | 2.0 ml/L |
| 6* | Sercadis | 2 | Fluxapyroxad | 0.3 L/ha | 0.6 ml/L |
| 7* | Topas | 2 | Penconazole | 0.5 L/ha | 1.0 ml/L |

*If PGR was required, this was applied to all plants within treatments 2-7. Treatments applied in 500 L/ha water.

None of the fungicides (Frupica SC, Karma, Reflect, Sercadis or Topas) assessed in this crop safety trial resulted in any detrimental effects on the five plant species (*Cosmos*, *Dahlia*, Pansy, *Petunia* or *Verbena*). No major symptoms of phytotoxicity were observed, and there was no effect on plant quality or height by the final assessment. No delays in flowering were associated with the use of any of the fungicides assessed on the five species tested, therefore it can be concluded that Frupica SC, Karma, Reflect, Sercadis or Topas are crop safe on *Cosmos* 'Xanthos Lemon Sherbet', *Dahlia* 'Figaro Violet Shades', Pansy 'Matrix Beaconsfield', *Petunia* 'Express Blue' and *Verbena* 'Quartz XP Red Eye'.

Fungicide modes of action (MOA) are classified by the Fungicide Resistance Action Committee (FRAC), who use different numbers and letter combinations to distinguish fungicide MOA groups. Using fungicides with different FRAC codes prevents the development of fungicide resistance. These trials have identified fungicides with three different FRAC codes (**Table 2**) that are safe to use in the prevention and control of powdery mildew by bedding and pot plant growers as part of a planned fungicide resistance prevention strategy; Karma is not classified (nc) by FRAC.

Financial benefits

Fungicides are an essential crop protection input in the production of bedding and pot plants. Without access to fungicides for the prevention and control of powdery mildew, losses caused by this pathogen are conservatively estimated at 1% of production value resulting in a potential loss of £4.3 million to the sector.

This evaluation of fungicides approved in the UK under EAMUs for use on bedding and pot plants will expand the range of active ingredients available to growers' for controlling powdery mildew. While growers do use cultural methods (e.g. fans, ventilation and controlling the timing of irrigation) to aid in the prevention of foliar disease where possible, a lack of cost-effective fungicides approved for use on protected ornamentals would reduce the range of plants that can be produced profitably within customer specifications. The cost per litre of spray solution per product included in this trial at the specified rates ranges from 0.008p to 0.261p (**Table 2**) and provides greater opportunity to increase profit through reduced input costs.

Table 2. Fungicide costs (non-discounted, excluding VAT and labour costs for application) and FRAC codes

| Product | Application rate | FRAC code | Cost of active (p) | Cost / L of spray (p) |
|------------|------------------|-----------|--------------------|-----------------------|
| Frupica SC | 0.9 L/ha | 9 | 0.145 / ml | 0.261 |
| Karma | 3 kg/ha | NC | 0.0138 / g | 0.08 |
| Reflect* | 1 L/ha | 7 | 0.0488 / ml | 0.0976 |
| Sercadis* | 0.3 L/ha | 7 | 0.1410 / ml | 0.0084 |
| Topas | 0.5 L/ha | 3 | 0.0616 / ml | 0.0616 |

*Reflect and Sercadis have the same FRAC code. NC = not classified. At the time of writing Reflect was available in 10 L units only.

Action points

- Frupica SC, Reflect and Sercadis are protectant fungicides, and will be most effective when used in fungicide programmes early on to prevent powdery mildew. Reflect and Sercadis have the same FRAC code so only one of these products should be used in fungicide programmes to minimise the risk of fungicide resistance developing.
- Topas is largely a protectant fungicide although it does have some anti-sporulant activity. It is best used preventatively or in the earliest stages of disease development.
- Karma has eradicant properties so is most effective when powdery mildew is present within crops.
- A limited number of species have been tested within this trial and growers are advised to test spray new or unfamiliar fungicides on a small number of plants prior to large scale use on commercial crops.
- Alternate fungicides with different modes of action to prevent fungicide resistance developing.
- Growers should familiarise themselves with and adhere to product labels, approvals, and Extensions of Approval for Minor Use (EAMUs) prior to use.

Growers should note that the water volume used in these trials (500 litres water per hectare) may be lower than the rate they currently use and as such application rates or volumes may need to be adjusted to maintain the same application rate of active ingredient.

Science Section

Introduction

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a work programme to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries. Knowledge transfer events including trial open days and study tours are also included in the programme.

The work programme is guided by a grower-led Management Group that includes members of the BPOA Technical Committee.

This is the Bedding and Pot Plant Centre report for Objective 1.

Background

Several fungicides (and active ingredients) with uses and activity against powdery mildew in the production of protected ornamentals have been withdrawn in recent years including: Bravo 500 (chlorothalonil), Bumper 250 EC (propiconazole) and Octave (prochloraz), the future of Systhane 20 EW (myclobutanil) is uncertain. Therefore, crop safe alternatives are essential to maintain the competitiveness of the UK bedding and pot plant sector. The fungicides included within this trial were selected as they have activity against powdery mildew and have recently obtained Extensions of Authorisations for Minor Use (EAMUs) in the production of ornamentals. However, limited crop safety data relating to the use of these products is available for bedding and pot plant growers. Plant species were selected based on their susceptibility to powdery mildew. This trial expands the fungicide options available for the prevention and control of powdery mildew within the bedding and pot plant sector.

Project objectives

Objective 1: To evaluate the crop safety of up to five products recently authorised for use in the production of protected ornamentals per year.

Objective 2: To provide industry updates on crop safe control options for key bedding and pot plant pests and diseases, including product selection and spray programme maintenance to prevent the build-up of resistance.

Methods and materials

Site and crop production details

Five seed-raised bedding plant species (*Cosmos* 'Xanthos Lemon Sherbet', *Dahlia* 'Figaro Violet Shades', Pansy 'Matrix Beaconsfield', *Petunia* 'Express Blue' and *Verbena* 'Quartz XP Red Eye', supplied by Ball Colegrave in 360 cell trays) were used for this trial (PGR's were applied to the plugs by the propagator, products and rates of use are confidential). Plugs were transplanted at ADAS Boxworth in week 26 using standard 6-packs (Pansy, *Petunia* and *Verbena*) and 1 L pots (*Cosmos* and *Dahlia*). Plants were set out on a Mypex covered bed within a polythene tunnel in a randomised plot design (**Figure 1**). All species were transplanted into Levington M2 Pot and Bedding Compost.

Treatments (**Table 3**) were applied as a foliar spray two- and four-weeks post-transplant (week 28 and week 30), using a backpack and single nozzle lance, with an 02f110 nozzle, to achieve a medium spray quality, in a water volume of 500 L/ha. This water volume was chosen as Frupica SC stipulates a minimum water volume of 500 L/ha. Five fungicides were examined in the trial, with two water controls. If PGRs were required on the trial, one of the water control treatments was also treated with PGR, to ensure that any treatment effects could be attributed to the fungicide application and not the PGR. All treatments were applied in the morning and spray boards were used to prevent any overspray of treatment onto neighbouring plots. Plants were not irrigated for 24 hours following treatment. All products used in the trial have recently been authorised for use on ornamentals through the Extension of Authorisation for Minor Use programme, and therefore no experimental permits were required.



Figure 1. Phytotoxicity trials set up within a polythene tunnel at ADAS Boxworth, 2020

Table 3. Treatment list used in the phytotoxicity trials. Treatments were applied at 2- and 4-weeks post-transplant. The same treatment list was used for all species

| Trt | Product | No. of applications | Active | Rate (L/ha, kg/ha) | Rate (ml/L, g/L) |
|-----|-------------------------------------|---------------------|------------------------------|--------------------|------------------|
| 1 | Water control | 2 | N/A | N/A | N/A |
| 2* | Water control (+ Bonzi if required) | 2 | N/A | N/A | N/A |
| 3* | Frupica SC | 2 | Mepanipyrim | 0.9 L/ha | 1.8 ml/L |
| 4* | Karma | 2 | Potassium hydrogen carbonate | 3.0 kg/ha | 6.0 g/L |
| 5* | Reflect | 2 | Isopyrazam | 1.0 L/ha | 2.0 ml/L |
| 6* | Sercadis | 2 | Fluxapyroxad | 0.3 L/ha | 0.6 ml/L |
| 7* | Topas | 2 | Penconazole | 0.5 L/ha | 1.0 ml/L |

*If PGR was required, this was applied to all plants within treatments 2-7.

PGR was applied to the *Cosmos*, *Dahlia* and *Petunia* trials in week 29 (15 July). Paclobutrazol (Bonzi) was applied at 2.0 ml/L to the *Cosmos*, 0.5 ml/L to the *Dahlia* and 1.25 ml/L to the *Petunia*.

Plants were monitored for pests and diseases throughout the trial and *Aphidius colemani* were introduced on a fortnightly basis for aphid control. In addition, the *Dahlia* were treated with thiacloprid (Calypso, EAMU 2151/14) at 0.45 L/ha in week 31 (28 July) to eradicate an increasing aphid population.

Temperature and humidity were monitored throughout the trial using two Tinytag data loggers.

Trial design and statistical analysis

Each plant species was set out as a distinct trial, arranged in a randomised plot design with seven treatments. Plots consisted of four 6-packs (24 plants) for Pansy and *Petunia*, two 6-packs (12 plants) for *Verbena* and 12 x 1 L pots (12 plants) for *Cosmos* and *Dahlia*. Within each trial there were three replicate blocks, with an overall total of 1764 plants.

Results were examined by ANOVA with use of Duncan's multiple range test to separate treatments.

Assessments

Prior to transplant, plug root development (**Table 4**), plant quality (**Table 5**), and height were assessed. Further assessments on plant height, plant quality and percentage of plants in flower were made throughout the trials. Phytotoxicity was assessed from the first treatment

application onwards (**Table 6**). For plant height, the same plants per plot were assessed each time, and the average height calculated. Inspections and assessments are summarised in **Table 7** and below.

Table 4. Root development scores

| Score | Definition |
|-------|------------------------------|
| 0 | No root development |
| 1 | Rooting in up to 25% of plug |
| 2 | Rooting in 26-50% of plug |
| 3 | Rooting in 51 – 75% of plug |
| 4 | Rooting in 100% of plug |

Table 5. Plant quality scores

| Score | Definition |
|-------|--------------------------------------|
| 0 | Dead |
| 1 | Very poor quality |
| 2 | Poor quality |
| 3 | Good quality, some damage visible |
| 4 | Good quality, very little damage |
| 5 | Excellent quality, no damage visible |

Table 6. Phytotoxicity scores

| Score | Definition |
|-------|--|
| 0 | Dead |
| 1 | nearly dead |
| 2 | severely damaged / reduced growth / lots of discolouration |
| 3 | damaged / reduced growth / some discolouration |
| 4 | damaged / reduced growth |
| 5 | slightly damaged / stunting |
| 6 | very slightly damaged / slight yellowing |
| 7 | very slightly damaged but still commercially acceptable |
| 8 | commercially acceptable - barely affected |
| 9 | comparable with control |

Table 7. Summary of bedding and pot plant trial inspections and assessments, 2020

| Date | Week no. | Action | Plant species | Assessment |
|-------------|-----------------|---|--|--|
| 25 June | 26 | Pre-transplant assessment completed. Plants transplanted and trials set out | <i>Cosmos, Dahlia, Pansy, Petunia, Verbena</i> | Root development, plant quality, plant height (cm) |
| 09 July | 28 | Treatment application #1 and assessment | <i>Cosmos, Dahlia, Pansy, Petunia, Verbena</i> | Plant height (cm), plant quality |
| 15 July | 29 | Bonzi application on T2 – T7 | <i>Cosmos, Dahlia, Petunia</i> | N/A |
| 23 July | 30 | Treatment application #2 and assessment | <i>Cosmos, Dahlia, Pansy, Petunia, Verbena</i> | Plant height (cm), plant quality, phytotoxicity, no. of plants in flower and bud |
| 28 July | 31 | Calypso application (aphid control) | <i>Dahlia</i> | N/A |
| 06 Aug | 32 | Assessment | <i>Cosmos, Dahlia, Pansy, Petunia, Verbena</i> | Plant height (cm), plant quality, phytotoxicity, no. of plants in flower and bud |
| 13 Aug | 33 | Assessment | <i>Cosmos, Dahlia, Verbena</i> | No. of plants in flower and bud |
| 20 Aug | 34 | Assessment | <i>Cosmos, Dahlia, Verbena</i> | Plant height (cm), plant quality, phytotoxicity, no. of plants in flower and bud |

Results

The effect of each treatment on the height, quality, phytotoxicity and flowering of the five plant species included in the trial is compared with that of the water control (T1). Temperature and humidity were monitored throughout the trial (**Appendix 1**). Plant quality is tabulated in **Table 9** and **Appendix 2**. Plant heights are tabulated in **Table 10** and in **Appendix 3**. Images of plants from all treatments at the end of the trial can be found in **Appendix 4**.

All plants obtained for the trial were of good quality prior to transplant and the pre-transplant assessment of plugs confirmed 100% rooting in all plugs.

Summary of results

None of the fungicides (Frupica SC, Karma, Reflect, Sercadis or Topas) assessed in this crop safety trial resulted in any detrimental effects on the four bedding and pot plant species (*Cosmos*, Pansy, *Petunia* or *Verbena*) examined. No symptoms of phytotoxicity were observed on these species. There were no statistical differences in plant quality, and plant height, and no delays in flowering were associated with the use of any of the fungicides assessed on the five species tested (*Cosmos*, *Dahlia*, Pansy, *Petunia* or *Verbena*).

Plant phytotoxicity scores

Evidence of phytotoxicity was recorded on *Dahlia* two weeks after the first treatment application, minimal effects were associated with both Frupica SC and Reflect (**Table 8**). This was evident as slight distortion and thickening of leaves with some leaf yellowing (**Figure 2**). However, the symptoms were minimal and were considered commercially acceptable. The *Dahlia* had grown away from these effects by four weeks after the first treatment with all plants comparable with water controls with a score of 9. The slight differences observed were not statistically significant when compared to water controls. The second treatment application did not cause any further leaf distortion or yellowing.



Figure 2. Slight leaf distortion and yellowing seen on *Dahlia* in the Frupica SC treatment 2 weeks post treatment one (23 July 2020)

Table 8. Average plant phytotoxicity score for *Dahlia*, two weeks after treatment one, week 30, 23 July 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|---------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| <i>Dahlia</i> | 9 | 9 | 7.67 | 9 | 8.33 | 9 | 9 | (NS) | - |

Plant quality scores

No statistically significant differences in plant quality were recorded in any of the species / treatment combinations in **Table 9**, see **Appendix 2** for other plant quality scores.

Table 9. Average plant quality score for bedding species, two weeks after treatment one, week 30, 23 July 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| <i>Cosmos</i> | 4 | 5 | 5 | 5 | 5 | 5 | 5 | (NS) | - |
| <i>Dahlia</i> | 4 | 4 | 4 | 4 | 4 | 4 | 4 | (NS) | - |
| <i>Pansy</i> | 4 | 4 | 4 | 4 | 4 | 4 | 4 | (NS) | - |
| <i>Petunia</i> | 4 | 4 | 4 | 4 | 4 | 4 | 4 | (NS) | - |
| <i>Verbena</i> | 4 | 4 | 4 | 4 | 4 | 4 | 4 | (NS) | - |

Plant height

No statistically significant differences in plant height were recorded in any of the species / treatment combinations in **Table 10**, see **Appendix 3** for other plant height scores.

Table 10. Average height in cm for bedding species, two weeks after treatment one, week 30, 23 July 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 20.3 | 19.8 | 21.0 | 20.7 | 20.0 | 20.7 | 20.8 | (NS) | - |
| Dahlia | 9.5 | 9.0 | 9.7 | 8.4 | 8.3 | 9.5 | 8.2 | (NS) | - |
| Pansy | 5.3 | N/A | 5.5 | 5.6 | 5.1 | 4.7 | 5.9 | (NS) | - |
| Petunia | 3.8 | 3.3 | 3.6 | 3.9 | 3.8 | 3.7 | 3.7 | (NS) | - |
| Verbena | 6.9 | N/A | 7.3 | 6.8 | 7.1 | 7.2 | 6.7 | (NS) | - |

Flowering

There were no statistically significant differences in the percentage of plants in flower for any species / treatment combinations (**Table 11– Table 14**).

Table 11. Average percentage of plants in flower for bedding species, two weeks after treatment one, week 30, 23 July 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (NS) | - |
| Dahlia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (NS) | - |
| Pansy | 25.7 | N/A | 27.8 | 26.4 | 13.9 | 12.5 | 31.9 | (NS) | - |
| Petunia | 0 | 0 | 0 | 1.39 | 1.39 | 2.78 | 0 | (NS) | - |
| Verbena | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (NS) | - |

Table 12. Average percentage of plants in flower for bedding species, four weeks after treatment one, week 32, 06 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (NS) | - |
| Dahlia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (NS) | - |
| Pansy | 100 | N/A | 100 | 100 | 100 | 100 | 100 | (NS) | - |
| Petunia | 100 | 100 | 100 | 100 | 100 | 100 | 100 | (NS) | - |
| Verbena | 48.6 | N/A | 50.0 | 41.7 | 54.3 | 41.7 | 41.7 | (NS) | - |

Table 13. Average percentage of plants in flower for bedding species, five weeks after treatment one, week 33, 13 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 2.8 | 0.0 | 2.8 | 5.6 | 2.8 | 13.9 | 8.3 | (NS) | - |
| Dahlia | 44.4 | 41.7 | 36.1 | 33.3 | 38.9 | 63.9 | 55.6 | (NS) | - |
| Pansy | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Petunia | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Verbena | 73.6 | N/A | 77.8 | 69.4 | 79.5 | 77.8 | 77.8 | (NS) | - |

Table 14. Average percentage of plants in flower for bedding species, six weeks after treatment one, week 34, 20 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 30.6 | 27.8 | 36.1 | 30.6 | 16.7 | 44.4 | 38.9 | (NS) | - |
| Dahlia | 72.2 | 69.4 | 88.9 | 83.3 | 80.6 | 88.9 | 77.8 | (NS) | - |
| Pansy | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Petunia | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Verbena | 90.3 | N/A | 97.2 | 83.3 | 94.4 | 97.2 | 91.7 | (NS) | - |

Discussion

All the fungicides assessed have activity against powdery mildew and are authorised for use in ornamental plant production under Extensions of Authorisations for Minor Use. Growers should note that Frupica SC, Reflect and Sercadis are protectant fungicides and will be most effective when used in spray programmes early on to prevent powdery mildew. Topas is also largely a protectant fungicide, although it does have some anti-sporulant activity so is best used preventatively or in the earliest stages of disease development. Karma has eradicant properties and so is best used when powdery mildew is present within crops.

The water volume used in these trials (500 litres water per hectare) may be lower than the rate currently used, and as such application rates or volumes may need to be adjusted to maintain the same application rate of active ingredient.

Fungicide modes of action (MOA) are classified by the Fungicide Resistance Action Committee (FRAC), who use different numbers and letter combinations to distinguish fungicide MOA groups. Using fungicides with different FRAC codes prevents the development of fungicide resistance. These trials have identified fungicides with three different FRAC codes (**Table 2**) that are safe to use in the prevention and control of powdery mildew by bedding and pot plant growers as part of a planned fungicide resistance prevention strategy; Karma is not classified (nc) by FRAC.

Conclusions

The results obtained in this trial have identified five fungicides (Frupica SC, Karma, Reflect, Sercadis, and Topas) with relatively new EAMUs for use in ornamental plant production that have proven to be crop safe on the five plant species examined within this trial (*Cosmos* 'Xanthos Lemon Sherbet', *Dahlia* 'Figaro Violet Shades', Pansy 'Matrix Beaconsfield', *Petunia* 'Express Blue' and *Verbena* 'Quartz XP Red Eye'). These results should give growers the confidence to start integrating these fungicides into their fungicide spray programmes for powdery mildew control.

A limited number of species have been tested within this trial and growers are advised to test spray new or unfamiliar fungicides on a small number of plants prior to large scale use on commercial crops.

Reflect and Sercadis have the same FRAC code so only one of these products should be used in fungicide programmes to minimise the risk of fungicide resistance developing.

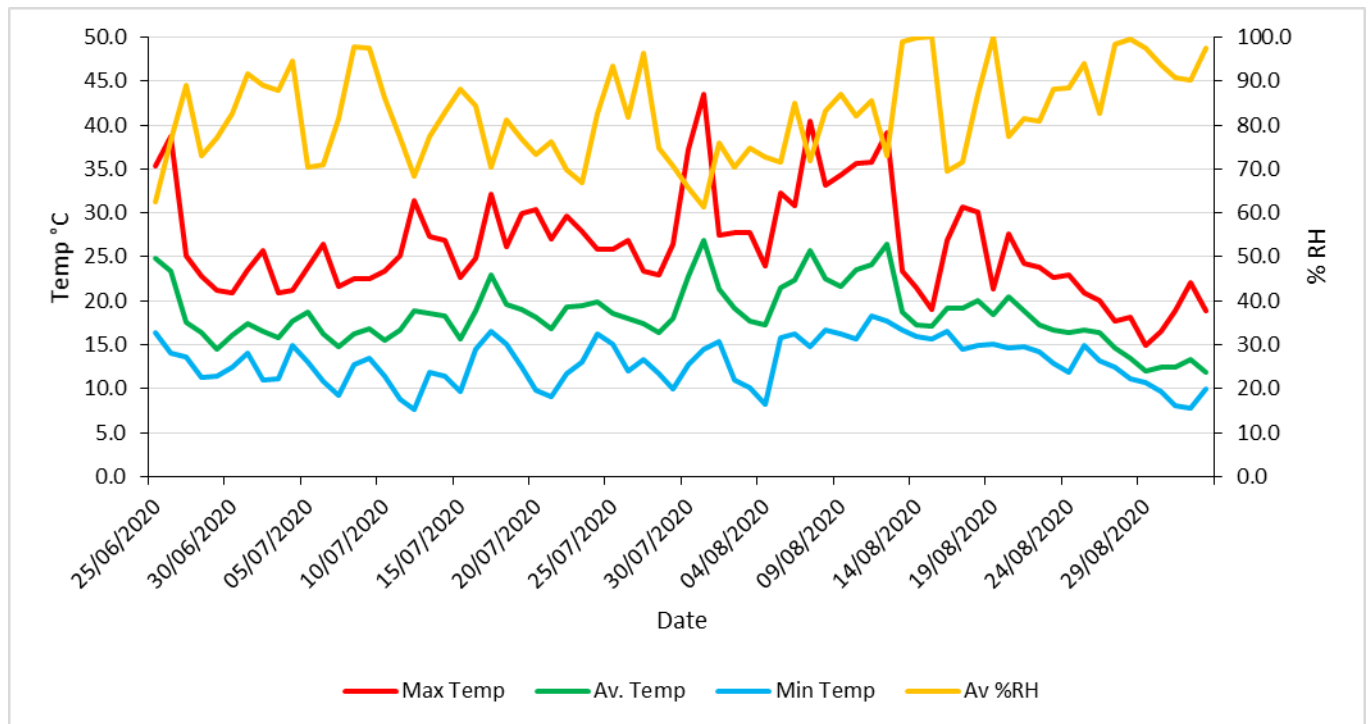
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Appendix 1

Polythene tunnel temperature and humidity during the trial



Appendix 2

Plant quality scores

Table 1. Average plant quality score for bedding species, four weeks after treatment one, week 32, 06 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 4.3 | 4.3 | 4.0 | 4.3 | 4.7 | 4.3 | 4.7 | (NS) | - |
| Dahlia | 3.3 | 3.3 | 4.0 | 3.7 | 3.7 | 3.3 | 3.7 | (NS) | - |
| Pansy | 4.0 | N/A | 4.0 | 3.7 | 4.0 | 4.0 | 4.0 | (NS) | - |
| Petunia | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | (NS) | - |
| Verbena | 3.7 | N/A | 3.3 | 3.3 | 3.3 | 3.7 | 3.3 | (NS) | - |

Table 2. Average plant quality score for bedding species, six weeks after treatment one, week 34, 20 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 4.3 | 4.3 | 4.7 | 4.7 | 4.7 | 4.3 | 4.7 | (NS) | - |
| Dahlia | 4.0 | 4.3 | 4.3 | 4.0 | 4.0 | 4.0 | 4.0 | (NS) | - |
| Pansy | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Petunia | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Verbena | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | (NS) | - |

Appendix 3

Plant height

Table 1. Average height (cm) for bedding species, four weeks after treatment one, week 32, 06 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 29.5 | 29.0 | 30.0 | 31.5 | 30.8 | 33.1 | 31.5 | (NS) | - |
| Dahlia | 15.2 | 14.4 | 15.0 | 13.9 | 13.2 | 17.0 | 13.8 | (NS) | - |
| Pansy | 10.6 | N/A | 10.1 | 10.9 | 10.3 | 9.6 | 10.5 | (NS) | - |
| Petunia | 9.1 | 9.3 | 9.6 | 9.5 | 9.1 | 9.6 | 9.2 | (NS) | - |
| Verbena | 10.4 | N/A | 9.7 | 8.2 | 10.4 | 10.9 | 10.5 | (NS) | - |

Table 3. Average height (cm) for bedding species, six weeks after treatment one, week 34, 20 August 2020. (NS = no significant differences)

| Species | Water control | Water control + Bonzi if required | Frupica SC | Karma | Reflect | Sercadis | Topas | p value | L.S.D. |
|----------------|---------------|-----------------------------------|------------|-------|---------|----------|-------|---------|--------|
| Cosmos | 51.2 | 48.3 | 51.6 | 49.2 | 52.0 | 49.5 | 53.2 | (NS) | - |
| Dahlia | 24.4 | 21.8 | 23.8 | 22.5 | 21.6 | 25.1 | 23.00 | (NS) | - |
| Pansy | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Petunia | N/A | N/A | N/A | N/A | N/A | N/A | N/A | (NS) | - |
| Verbena | 13.6 | N/A | 12.6 | 11.9 | 13.3 | 13.3 | 13.5 | (NS) | - |

Appendix 4

a. *Cosmos* 'Xanthos Lemon Sherbet' 02 September 2020



Water control (left) vs water + PGR (right)



Water control (left) vs Frupica SC (right)



Water control (left) vs Karma (right)



Water control (left) vs Reflect (right)



Water control (left) vs Sercadis (right)



Water control (left) vs Topas (right)

b. *Dahlia* 'Figaro Violet Shades' 20 August 2020



Water control (left) vs water + PGR (right)



Water control (left) vs Frupica SC (right)



Water control (left) vs Karma (right)



Water control (left) vs Reflect (right)



Water control (left) vs Sercadis (right)



Water control (left) vs Topas (right)

c. Pansy 'Matrix Beaconsfield' 06 August 2020



Water control (left) vs Frupica SC (right)



Water control (left) vs Karma (right)



Water control (left) vs Reflect (right)



Water control (left) vs Sercadis (right)



Water control (left) vs Topas (right)

d. *Petunia* 'Express Blue' 06 August 2020



Water control (left) vs water + PGR (right)



Water control (left) vs Frupica SC (right)



Water control (left) vs Karma (right)



Water control (left) vs Reflect (right)



Water control (left) vs Sercadis (right)



Water control (left) vs Topas (right)

e. *Verbena* 'Quartz XP Red Eye' 20 August 2020



Water control (left) vs Frupica SC (right)



Water control (left) vs Karma (right)



Water control (left) vs Reflect (right)



Water control (left) vs Sercadis (right)



Water control (left) vs Topas (right)