Grower Summary

PO 024

Monitoring Pansy Mottle Syndrome *in-situ*

Final Report

Project title:	Monitoring Pansy Mottle Syndrome *in-situ*
Project number:	PO 024
Project leader:	Dr Jill England, ADAS Boxworth
Report:	Final Report 31 May 2020
Previous report:	N/A
Key staff:	Dr Jill England (ADAS), Senior Horticulture Consultant Chloe Whiteside (ADAS), Horticulture Consultant Dave Skirvin (ADAS), Principal Environmental Modeller Isabelle Corkley (ADAS), Research Scientist Chris Need (Need Consulting Ltd), Independent Consultant
Location of project:	Ornamental nursery, West Sussex, Ornamental nursery, Warwickshire, Ornamental nursery, Cheshire, ADAS Boxworth, Cambridgeshire, CB23 4NN
Industry Representative:	
Date project commenced:	1 June 2019
Date project completed:	31 May 2020

DISCLAIMER

While the Agriculture and Horticulture Development Board seeks to ensure that the information contained within this document is accurate at the time of printing, no warranty is given in respect thereof and, to the maximum extent permitted by law the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

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.

Dr Jill England

Senior Horticulture Consultant

ADAS

Signature Date 15 June 2020

Chloe Whiteside

Horticulture Consultant

ADAS

Signature Date 12 June 2020

Dave Skirvin

Principle Environmental Modeller

ADAS

Signature Date 12 June 2020

Report authorised by:

Dr Barry Mulholland

Head of Horticulture

ADAS

Signature Date 12 June 2020

Chris Need

Need Consulting Ltd

Signature Date 12 June 2020

Grower Summary

Headline

- High light levels (PAR), vapour pressure deficit (VPD, >3 kPa) and temperature (>35ºC) have previously been linked to the expression of Pansy mottle syndrome (PaMS) symptoms. However, environmental monitoring during 2019 proved inconclusive
- While root development has not been linked directly with PaMS symptoms, poor root development may contribute to plant stress under challenging environmental conditions.
- Gravimetric techniques successfully managed irrigation at plug stage and promoted healthy root development.
- The poor irrigation management regime called 'Extreme Wet' regime, promoted poor root growth.
- Healthy root development can be promoted by irrigation regimes, supported by nutrient monitoring, that:
    - Match irrigation application to water use.
    - Allow growing media to dry back prior to irrigation.

Background

Previous environmental monitoring work (PO 016 and PO 016a) suggested that high temperature (>35°C), high vapour pressure deficit (VPD) (>4.5) and high light levels may be potential triggers for Pansy Mottle Syndrome (PaMS). The purpose of this work was to carry out monitoring of Pansy crops to further our understanding of the triggers of PaMS, and to develop recommendations for the mitigation of plant stress events that may contribute to symptom expression. Two irrigation demonstration events, hosted on grower holdings, were designed to present techniques to quantify the water volume applied to Pansy crops at plug stage, and to demonstrate the impact of a number of irrigation regimes on plant and root quality, and how they may help reduce PaMS.

Summary

WP1. Environmental monitoring

Objective: To monitor the environmental factors (light intensity, leaf temperature, air temperature, relative humidity and growing media moisture) *in-situ* on three commercial nurseries during propagation and post-transplant production phases.

Environmental monitoring took place on three commercial nurseries; Nursery A (propagation and pack production), Nursery B (pack production) and Nursery C (propagation). Equipment was delivered to the nurseries in week 30 (Nursery A) and week 31 (Nursery B and Nursery C) and set-up within new batches of Pansy crops.

At Nursery A, the environment was monitored in both the propagation and pack production areas, with batches of plants moving from one area to the other. Plants were both propagated and grown-on under glass. Plants were gapped prior to marketing.

At Nursery C, approximately one week after sowing, plants were moved from the germination room into a fogging area for a further week, and monitored until dispatch to Nursery B. As plants were dispatched from Nursery C to multiple nurseries for finishing, it was decided to monitor a single cultivar that was included in all deliveries to Nursery B. Plants tended to be moved between areas on this nursery, including for gapping.

Monitored batches from Nursery C were transported to Nursery B using refrigerated lorries, with the environment monitored during transit using Tinytag data loggers (temperature and humidity). Plug plants were then transplanted and the growing environment monitored, so that plants were monitored from sowing (Nursery C) through to marketing (Nursery B).

Environmental monitoring was carried out using Tinytag loggers and 30MHz equipment, all of which were set to record at five minute intervals (Figure 2). A list of the equipment used at each site is found in **Table 2**; this was supplemented with nursery-owned 30MHz equipment to increase coverage. ADAS and nursery-owned 30MHz equipment were calibrated against each other.

Environmental monitoring equipment was deployed at each site as follows: Tinytag data loggers (4 loggers; temperature, humidity, dew point); 30MHz multi-sensors (2 sensors; temperature, humidity, leaf temperature), light probes (1 probe; photosynthetically active radiation, PAR), and growing media moisture sensors (1 sensor; volumetric water content, VWC). Note, though, that moisture sensors were not used during the propagation phase of production at either Nursery A or Nursery C as the plug size is too small to accept the probes. The equipment were set to record at five minute intervals. Sowing, transport and transplant dates for monitored batches are detailed in **Appendix 2**. Pansy crops were monitored by growers on a weekly basis, recording Pansy mottle and distortion symptoms and the proportion of the crop affected

Summary of results

PaMS was reported on all three monitored sites during 2019. Symptoms included mottle, distortion and loss of growing point.

- At Nursery A (propagation and pack production), there was low incidence of PaMS in all transplant weeks, both in pot and pack throughout the season. However, the symptoms were only observed post-transplant.
- At Nursery C (propagation) the worst symptoms were reported in weeks 31 - 33, and were predominately leaf mottling and distortion. Plants with symptoms were removed during production and at marketing, and non-symptomatic plants were then transported to Nursery B.
- At Nursery B (pack production) symptoms were present on arrival at the nursery (from Nursery C), and included leaf and flower mottling and distortion, and loss of growing points. Symptom severity was greatest in weeks 33 and 34, and included mottling and distortion of leaves and flowers and loss of growing point.

Symptoms tend to become apparent within crops over a period of days. The course of symptom development appears to be that one or two plants are affected initially but symptoms are expressed in more plants, and more fully, over the course of at least 2-3 days. This can make it difficult to identify the date of first symptoms in a large batch of pansies. In the scenario of nurseries B and C, where plug plants are produced by a young plant producer and then distributed to finishing nurseries, symptoms may be triggered at the propagation nursery, where any plants with visible symptoms are removed from the batch prior to dispatch, and more symptoms are present on arrival at the finishing nursery.

As the precise cause of symptoms is not known, and there is no differentiation between different symptoms (e.g. mottling, leaf distortion, stunting) in the data, it is only possible to identify potential plant stresses that may or may not cause the symptoms to arise. In addition, the extent of any delay between triggers (if they exist) and displaying of symptoms is also not known and it is therefore possible that the display of symptoms could be due to an accumulation of stresses over a long period of time, or conversely triggered by a single event.

Conclusions

The environmental monitoring carried out in 2019 did not identify triggers for PaMS. Previous work had suggested that, high temperature, VPD and PAR could be potential triggers, but these could not be correlated to symptom occurrence by the data for the batches of Pansies monitored in 2019. It is not clear if the symptoms considered to be part of the PaMS complex (mottling, distortion, lost growing points) are caused by a single trigger, different triggers or cumulative triggers. More detailed recording of symptoms including the precise date and time of first symptom, and the proportion of each symptom expressed (mottling, distortion and lost growing point) would enable these distinctions to be statistically analysed.

WP2. Demonstration of optimisation of irrigation practices

Objective: To demonstrate the effect of optimum and sub-optimum irrigation regimes (up to five) on Pansy growth and development during propagation

Seeds of two Pansy cultivars (anonymised at suppliers' request) were sown into 360-cell trays, (peat-based growing media) at Bordon Hill Nurseries, Warwickshire, in week 34 (21 August 2019) and placed into a temperature controlled germination room (15˚C ±1˚C) for five days. They were grown under glass until they reached cotyledon stage, then transferred to ADAS Boxworth, Cambridgeshire, in week 36 (4 September 2019) where they were placed on benches within an unheated polytunnel for the duration of the trial. Temperature and humidity were monitored throughout the trial using TinyTag data loggers.

The trays were monitored, weighed and irrigated according to the irrigation treatments (see below) on a daily basis for three weeks. Treatments ended in week 39 (23 September 2019), when the plugs had reached 3-4 true leaves, and an assessment was completed on the plugs.

Irrigation treatments

The irrigation treatments were based on the gravimetric method described in AHDB Factsheet 18/17 ('Methods and equipment for matching irrigation supply to demand in container-grown crops'). The gravimetric method uses the weight of water lost or taken up by the plant to calibrate the level of irrigation needed for a particular combination of plant, growing media, container size and plant growth stage. This was then used to determine the 'Working Water Capacity' (WWC) required to re-wet the crop to container capacity from the 'Need to Irrigate' stage without applying excess.

The process to determine the WWC was to irrigate the containers (a sample size of at least eight pots or trays) to full capacity and allow to drain for 30 minutes. Each container was weighed after 30 minutes, and left to dry back to the stage at which irrigation was judged necessary. Once the containers reached the 'Need to Irrigate' stage they were re-weighed. The difference in weight between the container capacity and the 'Need to Irrigate' stage was the WWC.

On 5 September 2019, all trays were irrigated to full capacity, allowed to drain for 30 minutes, and then weighed. The trays were weighed again after a further 2.5 hours, and again 2 hours after that, to gain an understanding of how quickly the plug trays would dry back. The trays were then divided into the five irrigation treatments, so that there were three trays per cultivar, per treatment. Irrigation treatments began on 10 September 2019, once the 'Need to Irrigate' stage had been established. The amount of water applied to each tray was dependent on the weight of the tray. Irrigation treatments were as follows:

- **T1 'Extreme Wet'** – water twice per day (am and pm) to full capacity regardless of weight.
- **T2 'Extreme Dry' –** water 1 day or more after tray reaches 'Need to Irrigate' stage (tray weighs 700 g or less). Apply 700 g per tray.
- **T3 'Little and Often' –** water applied when weight lost from tray is < or near to 30% of WWC weight (tray weighs approx. 1190 g). Apply 210 g per tray.
- **T4 'Matched to Water Loss'** – water applied when weight lost from tray is < or near to 60% of WWC (tray weighs approx. 980 g). Apply 420 g per tray.
- **T5 'Long Dry Down'** – water is applied when weight lost from tray is >95% of WWC weight (tray weighs approx. 735 g). Apply 700 g per tray.

Because T1 was irrigated twice per day to full capacity regardless of water loss, this treatment was not weighed (**Table 1**).

Table 1. Total water weight applied to each treatment, and number of applications from 10 September 2019.

Treatment	Total water applied (g)	Number of watering events
T1 'Extreme Wet'	To field capacity, twice per day	26
T2 'Extreme Dry'	3500	5
T3 'Little and Often'	3570	17
T4 'Matched to Water Loss'	2940	7
T5 'Long Dry Down'	2800	4

Summary of Results

There were clear differences between treatments, with effects noticeable both in terms of plant growth and root development. There were no signs of PaMS developing in the plug tray throughout the irrigation trial, likely as a result of the moderate prevailing environmental conditions.

'Extreme Wet' treatment. Plants of both cultivars achieved the highest plant quality scores in the 'Extreme Wet' (T1) treatment. Plants were darker green with poorer root development with fewer root hairs and many more water roots. While the top growth of the plants in this treatment appeared strong, the smaller proportion of roots present with root hairs would limit the plant's capacity to take up water under drier conditions.

‘Extreme Dry’ treatment. ‘Extreme Dry’ (T2) treatment plants were smaller and paler green, but with high root quality scores, with rooting in up to 75% of the plug. There were no ““water roots” and many more plants with root hairs.

‘Little and Often’ treatment. Plants were generally good quality if slightly pale and taller in this treatment. Root development was reasonable, although there were some “water roots” present. Fewer ““water roots”” may have developed had the growing media been allowed to dry back further before water was applied. This could be a useful regime with slight adjustments to the parameter for applying water (in this demonstration < or near to 30% of WWC) and / or the weight of water applied.

‘Matched to Water Loss’ treatment. The ‘Matched to Water Loss’ (T4) treatment produced good quality plug plants, although slightly smaller than in other treatments, with very good root development.

‘Long Dry Down’ treatment. Plants in the ‘Long Dry Down’ (T5), were similar to those in the ‘Extreme Dry’ (T2) treatment. Plant height was reduced, but root development was good, with roots throughout the plug, and plenty of root hairs. However, for plug production this treatment may be insufficiently forgiving, with little margin for error.

The irrigation regime impacted on root quality in two ways:

- **“Water roots”**. Allowing the growing media to dry back further between water applications, as in the ‘Extreme Dry’ (T2) and ‘Long Dry Down’ (T5) treatments appears to have prevented “water roots” from developing (**Table 1**). The ‘Little and Often’ (T3) and ‘Matched to Water Loss’ (T4) treatments also allowed the growing media to dry back between irrigation applications and again, fewer “water roots” were produced.
- **Water quantity**. A greater volume of water was applied to plants in the ‘Extreme Dry’ (T2) and ‘Little and Often’ (T3) treatments overall compared with the ‘Matched to Water Loss’ (T4) and ‘Long Dry Down’ (T5) treatments. The highest root quality score was achieved by T4 in terms of root spread through the plug for both cultivars. This suggests that it isn’t the volume of water *per se* that is critical to good root development, rather it is the period of time allowed for the growing media to dry back between applications. However, during cool conditions, where large water volumes are applied, it will take longer for the growing media to dry back, risking water root development.

Conclusions

For plug production, the aim is to achieve a balance between providing sufficient water to maintain growth while producing plants with well-developed roots; a difficult balance to achieve for small plugs. Plants develop stronger root systems when they are not overly wet, and are forced to search for water and nutrients.

The key factor for the success of any irrigation regime determined using the gravimetric method is correct judgement of when the ‘Need to Irrigate’ point has been reached. If it’s judged that plugs need to be irrigated before they have dried back sufficiently, the growing media may always be too wet, particularly when using ‘Little and Often’ and ‘Match to Water Loss’ regimes. The ‘Need to Irrigate’ point will vary depending on plug size, growing media formulation, plant species and prevailing temperature; in-house trials would help to establish the parameters for when to irrigate.

“Water roots” have few or no root hairs, and have a ‘glassy’ appearance. They are produced in response to overwatering, when the substrate can be saturated for prolonged periods. With an abundance of “water roots”, plants struggle to take up water as moisture levels reduce and would be less able to respond to increased demand for water and nutrients under high temperature, vapour pressure deficit (VPD) or light conditions. However, where “water roots” are present, if the growing media was allowed to dry back, the plants would produce new roots and develop root hairs, in response to their search for water and nutrients, producing plants more resilient to extreme changes in environment post-transplant.

For the most part, treatments T2-T5 may all be suitable for plug production, but with some adjustments to allow the growing media to dry back sufficiently between irrigation applications to minimise the development of “water roots”. Consideration should also be given to the practicalities of the various irrigation regimes, for example while the number of irrigation events undertaken for the ‘Little and Often’ (T3) treatment may be easily managed in nurseries with boom irrigation, they may be less practical where crops are hand irrigated.

Irrigation of plants at plug stage is difficult to monitor closely as moisture probes are too large for the cell size, particularly those used in Pansy production. However, environmental monitoring systems that include wireless scales to measure plug tray weight that will help to automate the process are being developed. Use of gravimetric techniques to determine when to irrigate, linked to manually lifting trays, is a useful aid to setting irrigation parameters and training staff to irrigate to the correct level for healthy root development.

Financial benefits

Published statistics (Defra, 2014) estimate Pansy production in England and Wales at 9.4 million plants with a farm gate value of £2.1 million in 2014 (21p/plant). It is difficult to quantify plant losses due to PaMS for several reasons (the intermittent and variable nature of PaMS, growers rogueing distorted plants, unreported incidence, incidence identified as PaMS), however, reports have been received of 5-20% of batches on individual nurseries being affected. Based on Defra data, this would to equate to losses of £21,000 (1% of crop affected), £105,000 (5% of crop affected) or £420,000 (20% of crop affected). Additional costs are also incurred by nurseries in refilling plug trays or packs once affected plants have been discarded.

Action points

WP1. Environmental monitoring

Growers should take measures to monitor environmental conditions, and reduce plant stress:

- Monitor temperature, VPD, growing media moisture and nutrition.
- Ensure that during periods where extreme high temperatures are predicted, measures are taken to reduce plant stress by providing shade, maximum ventilation appropriate to prevailing weather conditions and adequate irrigation. High VPD may be reduced by increasing relative humidity by, for example, path damping and use of mist irrigation where available.

WP2. Demonstration of optimisation of irrigation practices

- Refer to AHDB Factsheet 18/17 - ‘Methods and equipment for matching irrigation supply to demand in container-grown crops’ for further details on the gravimetric technique.
- Gravimetric techniques for managing irrigation should be used in combination with monitoring of other factors including nutrition to determine plant and root quality.
- Calibrate the ‘Working Water Capacity’ (WWC) for each different combination of plant, growing media, plug / container size and growth stage used.
- Determine the WWC across a sample of at least eight trays / containers to obtain a robust value.
- Recalibrate the ‘Need to Irrigate’ point as the crop grows, basing decisions on the amount of time between water applications without impacting on final plant quality.
- Implement trials to determine the most suitable irrigation regime for your nursery production system.
- While the number of irrigation events undertaken for the ‘Little and Often’ (T3) treatment may be easily managed in nurseries with boom irrigation, they may be less practical where crops are hand irrigated.
- Extreme Wet conditions do not produce plants with well-developed root systems to support plant growth.