Grower Summary

CP 081

Detection and amelioration of root-zone ethylene production in protected crops

Final ***2014***

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Project title	Detection and amelioration of root-zone ethylene production in protected crops
Project number:	CP 81
Project leader:	Dr Ian Dodd Lancaster University
Report:	Final Report Year 3, December 2014
Previous report	Annual Report Year 2, October 2013
Key staff:	Dr Antje Fiebig (former PhD Student) Dr Ian Dodd, Lancaster University
Location of project:	Lancaster Environment Centre
Project coordinator:	Debbie Wilson, HDC
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Key words:	Over-irrigation, root-zone ethylene, tomato, nitrogen deficiency, soil moisture sensors

GROWER SUMMARY

Headlines

- Automatic irrigation via soil moisture monitoring provides a useful tool to water plants according to their actual water needs, and may decrease variation in soil moisture compared to hand watering.
- Over-irrigating containerised pot plants grown in a peat-based substrate significantly reduces crop fresh weight, height and leaf area.
- Over-irrigation significantly decreases leaf nitrogen concentration, and adding small doses of calcium nitrate to over-irrigated soil can ameliorate over-irrigation-induced foliar ethylene production and growth inhibition.

Background and expected deliverables

Watering in ornamental nurseries may not be especially well controlled, as irrigation can still be based mainly on the grower's experience. It is possible to misjudge the plant's actual needs, causing under- or over-irrigation which impacts on crop quality. Although the effects of flooding (acute, short-term stress) on plant growth and stomatal behaviour have been well studied, effects of suboptimal soil aeration caused by over-irigation (chronic, long-term stress) have not, despite its likely commercial significance.

Even though flooding limits photosynthesis, growth and yield, the mechanisms behind these effects are not completely clear. Changes in foliar concentrations of plant hormones like ethylene or abscisic acid (ABA) could act as signals and initiate plant physiological responses to flooding. Furthermore, flooding causes changes in the soil environment, especially lack of oxygen (hypoxia) and roots are the first organs to sense these changes. Therefore, ethylene produced in the root-zone might be an important factor in plant sensing of stress. Excessive ethylene production can cause flower and foliage senescence and abscission, and limit yield and quality of protected crops. Until now, root-zone ethylene production has not been measured and its role in plant response has not been assessed. Flooding can also change the concentration of mineral nutrients in plants, but the impact of over-irrigation on nutrient deficiency (which may also stimulate foliar ethylene emission) and possible growth amelioration through adding nutrients to the soil are not clear.

This project aims to:

- Determine if automatic irrigation scheduling according to soil moisture is a useful tool to irrigate plants according to their actual water needs,
- assess whether short-term (flooding) and long-term stresses (over-irrigation) induce different changes in soil properties and plant physiology,

- understand the effects of excessive soil moisture (over-irrigation) on plant growth and physiology,
- understand the physiological mechanism(s) causing growth reduction induced by over-irrigation, which may help design mitigation strategies, and
- exploit recent developments in ethylene measurement technology.

Summary of the project and main conclusions

Plants automatically irrigated according to defined soil moisture thresholds (feedback irrigation control based on continuous soil moisture monitoring) showed less variation in soil moisture than hand watered plants, which showed (alternately) insufficient and excessive soil moisture. Feedback irrigation control was implemented in a controlled environment room, with different numbers of drippers per pot allowing different soil moisture treatments (over-irrigation vs well-drained control). Furthermore, effects of flooding as an acute stress and over-irrigation as a chronic stress on plant physiology and soil properties were compared. Short-term flooding induces more pronounced changes in soil oxygen concentration than chronic over-irrigation does. Over-irrigating tomato plants for four weeks significantly reduces fresh weight and total leaf area compared to well-drained plants. In contrast to flooding, over-irrigation does not alter stomatal conductance, leaf water potential or foliar ABA concentrations, suggesting that over-irrigation-induced growth inhibition is not hydraulically regulated or dependent on stomatal closure or changes in ABA. Although over-irrigation significantly increases foliar ethylene emission and the ethylene precursor ACC increases in leaf xylem sap of over-irrigated plants, root-zone ethylene production does not differ between well-drained and over-irrigated tomato plants. However, over-irrigating the partially ethylene-insensitivite genotype *Never ripe* (*Nr*) does not inhibit growth as much as in the wild type, suggesting that partial ethylene-insensitivity can ameliorate over-irrigation induced growth-inhibition to some extent. Furthermore, over-irrigation decreased foliar nitrogen concentration and daily supplementation of small volumes of 10 mM $Ca(NO_3)_2$ to over-irrigated soil restores foliar nitrogen concentrations, ethylene emission and shoot fresh weight and total leaf area of over-irrigated plants to control levels. Thus decreased plant nitrogen uptake plays an important role in over-irrigation-induced growth inhibition.

Financial benefits

It is difficult to assess the full impact of over-irrigation on the “hidden” costs (to growers) of decreased crop quality causing wastage prior to offering plants for retail. Nevertheless, following an initial investment of soil moisture sensors and datalogger (minimum requirement

of GP1 datalogger costing £285, 2 x SM200 sensors costing £334 and irrigation timer costing £180 (prices correct 2014)), successful implementation of automatic irrigation scheduling according to soil moisture can decrease labour costs involved in hand-watering as well as costs for excessive water and energy. Further work is needed to assess the likely impact of such irrigation treatments on crop quality and retail value.

Action points for growers

- To note that automatic irrigation scheduling regulated by soil moisture sensors can adequately irrigate plants according to their actual water needs.
- To note experimental results which show that over-irrigation severely decreases crop biomass.
- To note that over-irrigation induces foliar nitrogen deficiency, which may limit foliage quality (of bedding plants).