Sustainable irrigation of high-intensity tree fruit orchards

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Introduction of NIAB EMR

FERTINNOWA: transferring knowledge to improve water and nutrient use efficiency

Irrigation management on fruit orchards in UK
East Malling Research: the past and the present
Genetics, Genomics and Breeding

- Strawberry Improvement
- Molecular genetics of berry crops
- Rootstock genetics
- Commercial breeding programmes
Pest and Pathogen Ecology

Interactions among pests, pathogens, plants and control agents

Biodiversity and ecosystem services

Chemical ecology of pests and predators

Modelling population dynamics
Crop Science and Production Systems

Resource use efficiency

Environmental interactions

Below ground biotic interactions

Food chain quality
Major crops

- Perennial fruits (apple, pear, cherry, plum, strawberry, raspberry, blackcurrant)
- Perennial trees and non-food products (biomass, plant factories, hardy nursery stock, protected ornamentals)
- Other horticultural crops (mushrooms, tomato, field vegetables, potato, herbs, rose, garden plants, barley)
Planting new orchards

- New varieties
- New growing systems
- Novel crops
Investing in new facilities

Plant Science into Practice
Improving quality throughout the supply chain

- Chilling stress during transit and retailing
- Expression of genes for key flavour compounds
- New guidelines to optimise both flavour and shelf-life

Plant Science into Practice
Recent products

Malling Centenary

Autumn Amber

Midge Trap

Finesse
FERTINNOWA: Transfer of INNOvative techniques for sustainable WAter use in FERTigated crops

Phase 1:
1. Mapping the current situation
2. Mapping the needs and bottlenecks

Phase 2:
Find & implement solutions by exchange of knowledge and technologies (from in- & outside the horticultural sector)

Phase 3:
Bridging the gap between knowledge and implementation

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
FERTINNOWA’s Consortium

- 23 partners + 1 linked third party
- 9 European Member States (BE, NL, DE, PL, SI, FR, IT, ES, UK) and South-Africa

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The challenge of Food Security

- Increasing population
- Healthy eating
- Healthy ageing
- Supply chain resilience
- Climate change
- Water & energy efficiency
- Emerging pests and diseases
- Increasing affluence

Requirement for us to double food production in next 30 years

- To produce as much food between 2000 and 2050 AD as we did between 1500-2000 AD
1st step:
Inventory of knowledge and benchmark strategy

- **Review of the available technologies for:**
  - Use of sustainable water sources
  - Increase water and nutrient use efficiency
  - Minimize impact on the environment

- **Mapping of existing bottlenecks**
  - Technical bottlenecks
  - Socio-economic bottlenecks
  - Regulatory bottlenecks
1st step:
Inventory of knowledge and benchmark strategy

Experts knowledge + information available in the literature:
- Technical factsheets
- Research
- Previous projects

Information at the growers’ level:
- How do they monitor fertigation?
- Why do they do the way they do?
- What problems they meet?
- What do they need to improve their fertigation management?

→ Current step: partners are gathering data & information on techniques & technologies for fertigation management

→ Bottom-up approach

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1st step: Inventory of knowledge and benchmark strategy

- Interviews carried out in across Europe to understand uses, choices and needs at the growers’s level:
  - 10 countries
  - 17 partners
  - 352 recorded interviews
  On 513 cropping systems!
Where are the investigated farms?

- **North West zone**: Netherlands, UK, Belgium, France - 96 interviews
- **Central East zone**: Poland & Slovenia - 92 interviews
- **Mediterranean zone**: Spain, France, Italy - 162 interviews

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Q103 - 101. Why are you not implementing more innovative technologies?
90% of tree fruit growers farm in water-stressed areas

Growers will need to use water more efficiently

Plant Science into Practice
It never rains.... but it will pour...
A Nitrate Vulnerable Zone (NVZ) is designated where land drains and contributes to the nitrate found in “polluted” waters.

Polluted waters include:

- Surface or ground waters that contain at least 50mg per litre (mg/L) nitrate
- Surface or ground waters that are likely to contain at least 50mg/L nitrate if no action is taken

Only 27% of water-bodies in England are currently classified as being of ‘good status’ under standards set down by the EU WFD
Irrigation scheduling and nutrient availability are linked

Nitrogen leaching (70% of applied N not taken up)

Soil acidification

Negative effects of excess nitrogen:

- %BRIX
- Firmness
- Coloration
- Vegetative growth

Neilsen & Neilsen 2009
What is ‘Precision Irrigation?’

The application of water and fertiliser to a growing crop, *when it's needed*, *where it is needed* and *in the quantities required* by the plants.
Current irrigation scheduling methods

- Intuition, experience
- Evapotranspiration (ETo) / VPD + crop co-efficients / calibration
- Volumetric water content (range of sensors)
- Matric potential sensors
- Plant-based, continuous measurement is possible (e.g. Zim-probe, dendrometers)

Plant Science into Practice
Soil volumetric moisture content and matric potential

- Neutron probe
  - Measures relatively large volume of soil
  - Accurate but not in top 15 cm
  - Weekly readings and on-site crop inspection

- Volumetric soil moisture content
  - Capacitance probes
  - Multi-depth recording
  - Web-based, data sent to PC or SMART phone

- Soil matric potential
  - Tensiometers, Decagon MPS1, Delta-T EQ3, G-dot
  - Measure of soil water availability (what the plant senses)
  - Independent of soil type (definitive set points)

Plant Science into Practice
What do we mean by soil wetness?

Soil consists of solids and spaces

Soil volumetric moisture content and soil matric potential
The spaces are filled with air or water.

Field capacity in a sandy loam:
- ~50% spaces filled with air
- ~50% spaces filled with water

In this example volumetric water content = 25%
Amount of available water depends on soil texture (sand, silt, clay)
Volumetric water content - key points

- Depends on soil texture and soil bulk density
- No direct relationship to plant water stress
- Need to relate to initial “full point”
- Values provide a relative measure of soil water status
Measuring soil water availability (soil matric potential)

- Indicates what a plant experiences
- Decagon MPS-2
- -5 to -500 kPa
- Equilibrates with matric potential of surrounding soil
- Absolute measure
- No access tube needed
Soil matric potential is independent of soil texture and soil bulk density.
Scheduling irrigation for orchards

- To develop irrigation set points based on soil matric potentials for
  - Gala/M.9
  - Braeburn/M.9
  - Merchant/Gisela 5
  - Kordia/Gisela 5
- To schedule irrigation to improve irrigation water use efficiency in high intensity apple and sweet cherry orchards
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Data processing via echoh server

Display Some Logger Data (if there is any)
Select a valve id (i.e. an irrigation block) from this list: Block 2 and a number of days 30

B R Brooks & Son -- Langdon Manor Farm -- Tank Field

Matric Data Visualised

Matric Potential

Time Sequence

Plant Science into Practice
Schedule irrigation to improve irrigation water use efficiency on apple orchards.

**Irrigation Test Regime**
- Commercial Control
- Irrigation Test Regime
- No Irrigation
Derive irrigation set points for Braeburn and Gala

Plant Science into Practice
Average soil matric potentials in each of the treatments

**Braeburn**

<table>
<thead>
<tr>
<th>Date of measurement</th>
<th>Soil matric potential (kPa)</th>
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<tbody>
<tr>
<td>22/07/13</td>
<td>-400</td>
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<tr>
<td>19/08/13</td>
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<td>16/09/13</td>
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**Rainfall (mm)**

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**Gala**

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**Soil matric potential (kPa)**

- CC
- ITR
- NI
- Rainfall
Changes in soil matric potential at different depths (ITR)

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Soil matric potential (kPa) at different depths over time with corresponding rainfall data for Braeburn.
Water savings on high density apple orchards

- Irrigation set point of -200kPa was used
- Class I fruit yield was not affected
- 95% water saving have been achieved for both Braeburn and Gala

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Deriving irrigation set points for Conference: 2011

- Irrigation withheld from all experimental blocks on 1 July to allow soil drying
- Physiological responses measured twice weekly
- Soil matric potential values at which responses first triggered identified (-190 kPa)

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Commercial trial at A. Hinge & Sons
Implementing irrigation ‘best practice’ at Ham Green Farm
Developing RDI to improve fruit quality and storage potential
Deploying enabling technologies
Communicate the results to the industry

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The Gdot: a new tool to measure soil water availability

- Simple (non-technical)
- Universal (all soils)
- Root zone monitoring
- Any crop
- Low-cost
Challenging our preconceptions

- Commercial Control plot
- Grower Test Regime plot

- ‘much drier than a grower would normally expect’...
- ... but no effect on plant physiology

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New technologies delivering new opportunities

- Digital imaging – improved yield forecasts
- Testing deficit irrigation in commercial pear orchards
- Nutrient use efficiency
- Closed loop, multi-sensor, precision fertigation, remote sensing

Plant Science into Practice
Hvala!
Thank you!