Fertigation management in Almeria

Rodney Thompson

University of Almeria

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
• “It is very difficult to characterise farming in Almeria”
• “Every farmer is different”
• BUT, although there is variation…
• It is an agricultural system
• With its own characteristics and tendencies
• We will look at these characteristics and tendencies
• In the context of fertigation and irrigation
• Information to be presented is from surveys, practical manuals, discussions with technical advisors, researchers, regional estimations, etc.
Two major types of fertigation systems in Almeria-1

1) Simple fertigation tanks (“abonadoras”)

- Manual addition for every fertiliser application
- Manual operation, irrigation water diverted through tank
- Nutrients applied on a RATE BASIS (i.e. kg nutrient per hectare, m² or 1000 m²)
- Traditional agronomic approach (based on Rates)
- Amounts added can be based on crop nutrient uptake curves, soil tests
Two major types of fertigation systems in Almeria-2

2) Multiple tanks with controller (computer operated)
   – 2–5 tanks of concentrated fertiliser solutions (commonly 100x the concentration applied), plus additional tank for acid
   – 1–2 fertilisers per tank
   – Tanks prepared every so many days; commonly once a week
   – Controller automatically applies programmed irrigation with nutrient solution
   – Approx. 50% of soil-grown crops have, and proportion is constantly increasing
   – Nutrients applied on a CONCENTRATION BASIS basis (i.e. mmol/L)
   – Nutrient management similar to substrate-grown crops
   – Growers do not know the total amounts of nutrients applied
Two major types of fertigation systems in Almeria-2

2) Multiple tanks with controller (computer operated)
   – 2–5 tanks of concentrated fertiliser solutions (commonly 100x the concentration applied), plus additional tank for acid
   – 1–2 fertilisers per tank

**WHEN APPLYING CONCENTRATIONS**

• Difficult to adjust the applied concentrations to results of soil tests
• Difficult to consider nutrient uptake curves
• Difficult to use accepted agronomic procedures to optimise nutrient efficiency
• **Optimising fertiliser use with these systems is a CHALLENGE**

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Issue of fertilising crops with multi-tank system to meet limits

- All of greenhouse areas in Almeria are Nitrate Vulnerable Zones (NVZs)
- Therefore, there are limits on MAXIMUM amount of N applied to a single crop

The maximum limits on N fertiliser application for greenhouse grown crops in Andalucía in NVZs

<table>
<thead>
<tr>
<th>Species</th>
<th>Maximum allowed amount fertiliser N per tonne of yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>6 kg N per tonne of fruit</td>
</tr>
<tr>
<td>Pimiento, melon</td>
<td>5 kg N per tonne of fruit</td>
</tr>
<tr>
<td>Cucumber, watermelon</td>
<td>4 kg N per tonne of fruit</td>
</tr>
<tr>
<td>Zucchini, Eggplant</td>
<td>7 kg N per tonne of fruit</td>
</tr>
</tbody>
</table>

Source: BOJA Number 111 Orden 1 de junio 2016
Despite challenges of optimising fertiliser application; these system have great potential

Soil mineral N from (a) traditional open field and (b) combined fertigation drip irrigation

<table>
<thead>
<tr>
<th>System</th>
<th>N application</th>
<th>Philosophy of managing N supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional open field</td>
<td>Pre-plant; 1-2 side-dress</td>
<td>Ensuring N not limiting during crop; generally, 1-3 large applications</td>
</tr>
<tr>
<td>Fertigation + drip</td>
<td>Frequent, by drip irrigation &amp; fertigation</td>
<td>“Spoon feeding”; providing N very frequently as required, in small amounts, to immediate root zone</td>
</tr>
</tbody>
</table>
Traditional management criteria in Almería

IRRIGATION AND FERTILISATION

• Generally, based on fixed schedules and standard recipes
• Generally, based on “collective experience”
• Farmers know “what works” and consistently gives profitable production
• With variations between farmers
Traditional management criteria in Almería

IRRIGATION

• Generally based on fixed schedules,
• For example,
  – 30 minutes every three time a week, then
  – 20 minutes every day
• The schedules are flexible
  – Adjustments made in response to weather conditions, crop growth.....
• Approx. 10–15% use manual tensiometers
  – Almeria is largest single market for Irrometer tensiometers in Spain

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Traditional management criteria in Almería

FERTILISER APPLICATION – Simple Fertiliser Tanks

• Generally based on standard fertiliser plan (fixed schedule)
• Example in next slide
• Adjustments made to the program depending on crop appearance, weather etc.
  • The amount of N applied is reduced when the crop has too much vegetative growth
  • More K may be applied to promote fruit growth
  • These observations also apply to multi tank systems
**Example of standard fertilizer plan for NUTRIENT RATES for TOMATO adjusted for growth and phenological phases (Almeria)**

- **First week after transplanting**  
  No fertilizer

- **Second week after planting**  
  \( \text{NH}_4\text{H}_2\text{PO}_4 \) 0.5 kg 1000 m\(^{-2}\)

- **Third and fourth weeks**  
<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{KNO}_3 )</td>
<td>0.5 kg 1000 m(^{-2})</td>
</tr>
<tr>
<td>( \text{NH}_4\text{H}_2\text{PO}_4 )</td>
<td>1.0 kg 1000 m(^{-2})</td>
</tr>
</tbody>
</table>

- **From week 4 to fruit set of second truss** (blue and red in alternate irrigations)  
<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{NH}_4\text{H}_2\text{PO}_4 )</td>
<td>1.0 kg 1000 m(^{-2})</td>
</tr>
<tr>
<td>( \text{KNO}_3 )</td>
<td>0.5 kg 1000 m(^{-2})</td>
</tr>
<tr>
<td>( \text{NH}_4\text{NO}_3 )</td>
<td>0.5 kg 1000 m(^{-2})</td>
</tr>
<tr>
<td>( \text{HNO}_3 )</td>
<td>0.2 L 1000 m(^{-2})</td>
</tr>
<tr>
<td>( \text{Ca(NO}_3\text{)}_2 )</td>
<td>1.0 kg 1000 m(^{-2})</td>
</tr>
</tbody>
</table>

- **From second truss to fourth truss** (same 5 fertilisers in alternate irrigations, but generally larger amounts)

- **From fourth truss to seventh truss** (same 5 fertilisers in alternate irrigations, but more)

- .......

Traditional management criteria in Almeria

FERTILISER APPLICATION – Multiple tanks with programmer

- Based on recipes of fixed concentrations of all nutrients
  - Concentrations may be constant during crop
  - Concentrations may vary with phenological development

- As with simple fertiliser tanks, adjustments made in relation to crop appearance, climate etc.
Examples of standard nutrient solution CONCENTRATIONS for different species of vegetable crops in Almeria

- One standard solution used for the entire crop
- Different standard solution for different species

<table>
<thead>
<tr>
<th>Species</th>
<th>NO₃⁻ (mM)</th>
<th>H₂PO₄⁻ (mM)</th>
<th>SO₄²⁻ (mM)</th>
<th>K⁺ (mM)</th>
<th>Ca²⁺ (mM)</th>
<th>Mg²⁺ (mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>11</td>
<td>1.5</td>
<td>1.5</td>
<td>7.5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Cucumber</td>
<td>13</td>
<td>1.5</td>
<td>1.7</td>
<td>6</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td>Sweet pepper</td>
<td>12</td>
<td>1.5</td>
<td>1.5</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Watermelon</td>
<td>11</td>
<td>1.5</td>
<td>2</td>
<td>7.5</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

For tomato

<table>
<thead>
<tr>
<th>Crop phase</th>
<th>NO$_3^-$ (mM)</th>
<th>H$_2$PO$_4^-$ (mM)</th>
<th>SO$_4^{2-}$ (mM)</th>
<th>K$^+$ (mM)</th>
<th>Ca$^{2+}$ (mM)</th>
<th>Mg$^{2+}$ (mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Until flowering of second truss</td>
<td>8</td>
<td>2.5</td>
<td>2.5</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Second to fifth truss</td>
<td>11</td>
<td>2</td>
<td>2</td>
<td>7.5</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Fifth to tenth truss</td>
<td>14</td>
<td>1.5</td>
<td>2</td>
<td>8.5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Last truss until end crop</td>
<td>14</td>
<td>1.5</td>
<td>1.5</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Substrate-grown crops

- Approx. 10% of total area
- Nearly all substrate-grown crops are free-draining
- Generally, irrigation automatically controlled with a demand tray system
- Salinity a very important consideration
- Drainage fractions vary between 15–40%
- Drainage collected from one or several bags of substrate, and electrical conductivity (EC) measured manually with portable EC meter

Demand tray system for auto control of irrigation

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Variations in the standard fertiliser programs – soil-grown crops

“…..si observamos las distintas recetas que expiden los técnicos del camp podemos comprobar que son MUY VARIADAS y CONTRADICTORIOS…..”

“Lo cierto es que existe una banda muy amplia donde puede oscilar un abonado sin que aprecie diferencias alguna entre ambos y por ello nos encontramos distintos abonados en la misma zona con el mismo suelo y la misma especie siendo validos todos…”

- The recipes used vary appreciably, and can be contradictory
- Wide range of fertiliser practices in the same zone on same soil and for same crop
- Production very similar despite these differences


- This suggests that the nutrient supply is generally not limiting production
- Why is the nutrient supply not limiting crop production?
- What are the consequences?
  - Of variable nutrient applications when nutrients not limiting
Use of manure in Almeria greenhouses

- Traditionally, large manure application (200–500 m³ ha⁻¹) at greenhouse construction
  - >1,000 kg N ha⁻¹
- Traditionally, additional manure every 2–5 years ("retranqueo"); now less common
  - In bands ("carillas"), applying >several hundred kg N ha⁻¹
- Now, commonly organic matter "products" added through fertigation

- Limit on manure N applied in Nitrate Vulnerable Zones (NVZs)
  - = 170 kg N ha⁻¹ year⁻¹
- All of greenhouse areas in Almeria are NVZs
Consequences of traditional nutrient and irrigation management in Almeria

IMPORTANT CONSIDERATIONS

• fertilisers & water are approx. 10% of variable costs
• Not major costs; also, not “life or death” issues
• greenhouses are very densely concentrated

WHAT ARE THE CONSEQUENCES

• an economically very successful system ("The Almeria miracle")
• in greenhouse soils, an accumulation of available P and exchangeable K
• variable and somewhat excessive irrigation
• aquifer depletion
• excess N supply (manure contribution important)
  – On average, total N supply (fertilisers + N from manure) is more 2x crop N uptake
• nitrate contamination of aquifers
Transition to more sustainable management practices (in soil)

**IRRIGATION**

1) Tools to calculate crop water requirements (Cajamar)

- Easy to use tables
- User-friendly simple decision support program (“sistema de ayuda a tomar decisiones”)
Transition to more sustainable management practices (in soil)

**IRRIGATION**

1) Tools to calculate crop water requirements (Cajamar)
   - Easy to use tables
   - User-friendly simple decision support program ("sistema de ayuda a tomar decisiones")

2) Use of soil moisture sensors to assist with irrigation (Cajamar, UAL, IFAPA)
   - Evaluated different sensors; tensiometers considered most appropriate
   - Developed limits for when to irrigate
   - Evaluation of different limits with electric tensiometers
   - Development of systems for automatic irrigation with electric tensiometers
Transition to more sustainable management practices (in soil)

**NITROGEN MANAGEMENT**

1) Tools to calculate crop N requirements (UAL)
   - **VegSyst-DSS**: works in MS Windows, in English and Spanish
   - Simulates crop N uptake for specific crop conditions (dates of crop)
   - Considers individual greenhouse conditions e.g. dates & amount of whitewash ("blanqueo")
   - Considers mineral N in soil at planting, and N mineralised from manure
   - Calculates N required per day as kg N ha$^{-1}$ or as mmol L$^{-1}$, plus mm of irrigation
   - Uses agronomic management approaches to calculate the required N concentration
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Tomato-1: No soil min N or manure; Tomato-2: 200 kg soil mineral N ha\(^{-1}\); REF: farmer practice.
Transition to more sustainable management practices (in soil)

**NITROGEN MANAGEMENT**

2) Tools/Methods to monitor and evaluate crop N status (UAL)

- Nitrate concentration in soil solution
- Nitrate concentration in petiole sap
- Both can be measured with on-farm rapid analysis systems (e.g. LAQUAtwin)
- Use of proximal optical sensors (e.g. canopy reflectance...)

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**FERTINNOWA**
Combined use of improved irrigation and N management practices – FERTINNOWA showcase trial (Cajamar, UAL)

IMPROVED IRRIGATION MANAGEMENT
• Automatic irrigation with electric tensiometers

IMPROVED N MANAGEMENT
• VegSyst-DSS calculate N fertiliser concentration (4 week intervals)
• Nitrate concentration in soil solution and in petiole sap
• Both analysed on farm with rapid analysis system

RESULTS
• In pepper and tomato, production same as with farmer management

Pepper
• Irrigation reduced by 15%, drainage reduced by 49%
• Fertiliser N applied reduced by 38%, nitrate leached reduced by 63%

Tomato
• Irrigation reduced by 42%,
• Fertiliser N applied reduced by 52%
Thank you for your attention