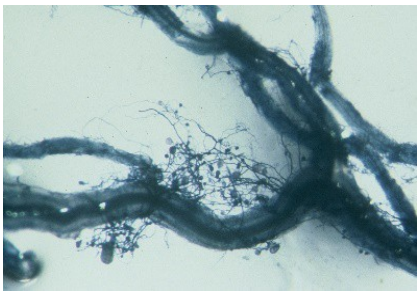
Irrigation management and mycorrhization in horticultural crops

Summary

This project was developed as a response to a very serious challenge in agriculture and intensive horticulture in particular: the need to reduce the water supply to crops while maintaining competitive productivity. The tomato was chosen as a model crop and the strategies for action used to achieve the goal of reducing irrigation regimes were: rationalising the supply of water using soil moisture sensor technology; and applying arbuscular mycorrhizal fungi, microorganisms that are part of the soil microbiome in natural ecosystems and which play a key role in supplying water and mineral nutrients to plants. The project assessed systems for the application of mycorrhizae in seedlings and farms, such as use of seeds encapsulated with mycorrhizal inocula, combined with deficit irrigation regimes. To round off the sustainability of the production systems, the abundance and establishment of certain natural enemies of pests affecting the cultivation of tomatoes in mycorrhizal plants were monitored and irrigation adjusted to the needs and deficiencies of the plants.



Detail of a mycorrhizal root

Objectives

The main objective of the pilot project was to rationalise water use with vegetable crops. Two further specific objectives were set:

1. Combine innovative irrigation reduction strategies with the application of mycorrhizal-forming fungi.
2. Adjust water supply regimes and the system for applying beneficial organisms to maintain high productivity and quality.

Description of the actions carried out in the project

The most important actions carried out in the course of the pilot project were the following:

- Evaluation of systems for inoculating plants with mycorrhizal-forming fungi in the seedling and field phases using seeds encapsulated with mycorrhizal fungus spores.
- Application of deficit irrigation in combination with mycorrhisation of plants on tomato plantations in both experimental soil plots and sack farming with substrate.
- Irrigation optimisation by monitoring soil water content, controlled by humidity sensors, and the application of mycorrhizal-forming fungi.
- Introduction and monitoring of certain natural enemies of pests present in the crop.

Final results and practical recommendations

The production of inoculum of the mycorrhizal-forming fungus *Rhizoglomus irregulare* is not complicated, and the inoculum obtained was shown to be capable of producing a high level of internal colonisation in the tomato plants of the varieties tested.

The incompatibility of intense fertilisation with mycorrhization was demonstrated, which would explain the low level of mycorrhizal colonisation in the roots of plants on farms with very high levels of nutrients in the soil, especially phosphorus.

Inoculation tests with the Monterosa tomato seedling

In addition, the low-level irrigation management strategy produced savings in water and fertiliser and greater productivity from the water used (kilos/m^{-3}) with respect to the high level when grown in soil. By contrast, in sack farming with coconut fibre, the results at two years indicate water productivity in the deficit irrigation was lower, probably because production was much lower. It should be noted that the productivity values for water are higher in soil than for sack farming.

Pilot plantation in a field of tomatoes

In soil tests, the response to deficit irrigation varied depending on the variety of tomato used. In the Riesling (cherry type) variety, management of weekly irrigation using both optimal and deficit irrigation had a positive impact on production and quality with regard to farm management. As for the application of mycorrhizae, mycorrhizal plants can provide water and nutrient savings while maintaining the same fruit production and quality.

Humidity sensors and flowmeter

It may be concluded that water savings were made without compromising the yield and quality of production. However, in the Monterosa variety, deficit irrigation had a negative effect on production in non-mycorrhizal plants. It should be noted that in this case water productivity was higher in the mycorrhizal plants where deficit irrigation was applied.

The effect of irrigation seems to have been relatively significant in attracting adult *Macrolophus pygmaeus.* The mycorrhizal factor also seems to have a positive effect on attracting adults of this species of Miridae. With regard to *Nesidiocoris tenuis,* no significant influence was confirmed for irrigation or mycorrhiza, although it seems that plants with an irrigation deficit may favour the presence of this other mirid bug, as well as the absence of mycorrhizae, contrary to the situation with *M. pygmaeus*.

M. pygmaeus *N tenuis*

The results for the mycorrhizal potential of the soil obtained over two years indicate that the application of a quality mycorrhizal inoculum allows the propagules of these beneficial fungi to remain in the soil after the first cultivation cycle, once the plants have been uprooted. Applying deficit irrigation combined with the plant mycorrhization is an alternative to consider to obtain significant water savings in the crop.

Conclusions

Encapsulating seeds with beneficial organisms appears to be a practical system for making water savings, due to the protection the capsule provides for the microorganisms. The results indicate that encapsulating seeds with inoculants containing mycorrhizal fungus spores allows the mycorrhization of the plants, and once set up will be an alternative for plant mycorrhization in the early stages of growth.

With regard to the results obtained in soil-based tomato farms, it may be said that applying a low-quantity irrigation regime in mycorrhizal plants is an alternative to consider to maintain tomato production. This combination would allow reductions in the amount of water while improving the microbiological quality of the crop soil. However, this is not the case with sack farming where water productivity in deficit irrigation is lower.

As for the natural enemies of pests, the general conclusion to be drawn is that the effect of more abundant irrigation seems to favour the attraction of adult *M. pygmaeus,* as well as the presence of mycorrhizae. However, it seems that *N. tenuis*, native to warmer and drier areas, is favoured by deficit irrigation and the absence of mycorrhizae.

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Subject area(s) of application

☒	Agricultural production system
☐	Agricultural practice
☐	Agricultural equipment and machinery
☐	Livestock farming and animal welfare
☒	Vegetable production and horticulture
☐	Landscape / Territorial management
☒	Pest and disease control
☒	Fertilisation and nutrient management
☒	Soil management
☐	Genetic resources
☐	Forestry
☒	Water management

☒	Climate and Climate Change
☐	Energy management
☐	Waste and by-product management
☒	Biodiversity and environmental management
☐	Food quality/processing and nutrition
☐	Supply chain, marketing and consumption
☐	Competitiveness and agricultural and forestry diversification
☐	General

Geographical area(s) of application

PROVINCE(S)	REGION(S)
Barcelona Tarragona	Maresme Baix Llobregat Baix Camp

Dissemination of the project (publications, seminars, multimedia, etc.)

Seminars:

1. 'Irrigation Management and Mycorrhiza'. 5th Interactive Plant Life Protection Seminar (IRTA). Cabrils, Barcelona, 26 September 2018.
2. "Irrigation management and mycorrhization in horticultural crops". Seminar on compost tea application and mycorrhizae inoculation in horticulture. ECA Manresa, 26 November 2019.
3. 'Management of irrigation and fertilisation using mycorrhizae in horticultural crops'. Agri-Food Technical Conference 'Implementation of Ecological Developments for Sustainable Agriculture. GO Ideas'. Vilassar de Mar, March 10, 2020.

Publications:

1. 'Colaboramos en la optimización del riego'. Published in *FitóNews* 18, p 26 Innovation.
2. Carmen Biel, Amélia Camprubí, Paulo E. Lovato, Cinta Calvet. On-farm reduced irrigation and fertiliser doses, and arbuscular mycorrhizal fungal inoculation improve water productivity in tomato production. Scientia Horticulturae. Sent.
3. Various appearances on social media (Twitter, LinkedIn and Facebook).

Other activities:

1. Practical application in two organic farms owned by non-GO members.

Pending actions:

1. Drafting of two articles in *Agrocultura* (leading magazine for organic farming in Catalonia) and *La Fertilidad de la Tierra* (national) with a summary of the project results.

More information on the project

PROJECT DATES	TOTAL BUDGET
Start date (month-year): June 2018	Total budget: €206,700.00
Completion date (month-year): September 2020	DARP funding: €84,474.00
Current status: Executed	EU funding: €63,726.00
	Own funding: €58,500.00

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Order ARP/133/2017 of 21 June, approving the regulatory bases for grants for cooperation for innovation by promoting the creation of European Association for Innovation operational groups in the areas of agricultural productivity and sustainability and the execution of innovative pilot projects by those groups, and Resolution ARP/1868/2017, of 20 June, announcing the call for the grant.

Generalitat de Catalunya
Departament d'Agricultura, Ramaderia, Pesca i Alimentació

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