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IRRIQUAL: SUSTAINABLE ORCHARD IRRIGATION FOR IMPROVING FRUIT QUALITY AND SAFETY

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SUMMARY - European countries, especially in the Mediterranean area, need to encourage more sustainable agriculture practices, reducing inputs (e.g., water, fertilisers), and minimising any negative impact on fruit safety and quality. One of the most promising ways to improve the sustainability of irrigated agrosystems is to develop and optimise the orchard water management, adjusting water application for improved crop quality and assuring crop safety. In this sense, the topic of interest of IRRIQUAL project deals with the valuation of new irrigation practices (including water doses implementation, water quality use and fertigation management). The research methodology will be based on a combination of experiments, field surveys and modeling tools aimed at predicting the impact of a given irrigation practice on the relevant inputs (water, fertilizers) and outputs (yield, quality, safety) of four Mediterranean fruit trees species (Peach, Olive, Almond, Citrus). Previously to the establishment of such practices, a better knowledge of the effects of different irrigation strategies on crop physiological response, crop quality and crop safety are required. The resulting recommendations on irrigation design and practices will be transferred to farmers by the elaboration of Irrigation Best Management Practices for each target crop and location. The resulting data and know-how will be transferred also to the irrigation industries by the development of new irrigation technology (including hardware and software components for an automated irrigation equipment), and the optimisation of the irrigation water disinfection using ultrasound technology.

Key words: Water use efficiency, regulated deficit Irrigation, crop quality, crop safety

RESUME - *L'agriculture irriguée est le plus haut consommateur des ressources naturelles de l'eau dans les pays méditerranéens, impliquant que n'importe quelle augmentation de l'efficience agricole d'utilisation de l'eau (WUE) sauvera une quantité significative de l'eau. La matière d'intérêt du projet de IRRIQUAL traite l'évaluation et la validation des stratégies de l'irrigation déficitaire régulée (RDI). La méthodologie de recherches sera basée sur la combinaison des expériences, enquêtes de champ et des outils visés vers la prévision des effets d'une conception donnée de RDI et des pratiques sur les entrées appropriées (l'eau, engrais) et des sorties de modèle (rendement, qualité, retours...) de plusieurs espèces méditerranéennes d'arbres fruitiers (pêche, olive, amande, vigne). L'évaluation de la pratique sera effectuée en utilisant les sorties de simulation, avec le respect (i) à WUE (basé sur des critères agronomiques, environnementaux ou socio-économiques), et (ii) en termes de durabilité de l'agrosystème irrigué. Les recommandations résultantes sur la conception et les pratiques (BMP) d'irrigation seront transférées aux fermiers méditerranéens, aux associations d'irrigants et à la PME consacrés à la technologie et à la commande d'irrigation.*

Mots-clés: *L´efficience agricole d'utilisation de l'eau, irrigation déficitaire régulée, qualité du fruit, sécurité du fruit*

INTRODUCTION

The optimisation of orchard management, especially in arid and semiarid regions, has to face many challenges, one of the most difficult being to cope with the limited amount of water resources available in these countries. In the context of improving water use efficiency, there was a growing interest in the last years in regulated deficit irrigation. Deficit irrigation is an optimizing strategy under which crops are deliberately allowed to sustain some degree of water deficit, while yield reduction should not affect the farmer revenues (English and Raja, 1996; English *et al*., 1990). The adoption of deficit irrigation requires appropriated knowledge of water crop requirements (evapotranspiration, ET), crop responses to water

deficits, including the identification of critical crop growth periods and the economic impacts of yield reduction strategies (Bates *et al*., 1997; Vijoen and Jager, 1997). Deficit irrigation can only be properly applied when irrigation systems are designed and managed in such a manner that system performances are high enough to favor water savings (Reca *et al*., 2001). Under-irrigation is often adopted in poorly performing systems, however this practice cannot be considered as controlled deficit irrigation because water is poorly distributed along the irrigation field.

Complementary to the efforts of plant breeding specialists to obtain plant material able to hold drought episodes, it is necessary to join and coordinate the efforts of physiologists and agronomists in order to elaborate deficit irrigation strategies, which will provide profitable yields and high fruit quality. An example of these coordinated actions between physiologists and agronomists is the identification of the critical phonological periods during which water stress is harmful. When a critical period coincides with a scarcity of water resources, crop production will suffer. If a water reservoir can be constructed on a farm, it will be possible to apply irrigation coinciding with critical crop growth periods and to save substantial amounts of water during the non-critical periods. Positive responses to deficit irrigation have been reported for pear trees (Mitchell et al., 1989), apricot trees (Ruiz Sánchez *et al*., 2000) and citrus (Castel and Buj, 1990) in Mediterranean regions.

The impact of water scheduling, specially when RDI strategies are applied, on decisions such as plant density, plantation date, pesticide application, soil preparation, and finally on the whole organisational farm planning, has to be analysed. Due to the enormous amount of experimental research needed for deriving optimal recommendations and practices for each situation, there is a growing interest in developing crop models based on the mathematical simulation of the behavior of the crop when submitted to determined cultural practices. These models must include appropriate yield-water function or crop growth and yield sub-models to evaluate the yield impact of water deficits (Pereira *et al*., 1995). The crop models may be integrated within management tools and decision support system (DSS) that will provide the necessary outputs and information for optimising practices and decision making. Therefore, considering the present state of art in modeling the effects of deficit irrigation on fruit tree production and water consumption, and with the final objective of analysing and assessing irrigation scenarios using crop simulation models, we propose in this project to develop and validate a irrigation management model that allow to simulate realistically the behavior of the soil-tree system, and to apply this model for objectives of irrigation design and management.

To summarize, IRRIQUAL proposes a tool for the optimisation of deficit irrigation practices and management, taking into account the different conditions: physical (climate and soil), environmental (water resources and land), economical (investment and running costs), socio-cultural (grower formation and skills, legislation) and technological (technical support from local industry). The use of these new methodologies must be centered mainly in the improvement of fruit quality and safety.

OBJECTIVES

Research objectives

(i) To improve water management in long and short term, predicting needs and qualities of water for irrigation and optimizing water quantity applied to the crop;
(ii) to investigate the influences of irrigation water quality and quantity on product quality and safety;
(iii) to identify usable physiological parameters signaling drought stress in crops (direct exploitation of plant-water relations for optimized water usage);
(iv) to analyze the effects of some new alternative technologies (ultrasounds) on pathogenic microorganisms and algae. Assuring irrigation water quality freedom from water-borne contaminants.

Socio-economic and environmental objectives

(i) To improve quality and safety of crop products by means of rational use of water and fertilizers for irrigation;
(ii) to improve water management exploiting resources of wastewater usable for crop irrigation;
(iii) to establish the socio-economic implications of the new irrigation applications proposed in the project.

Innovative and technological objectives expected for dissemination

(i) Develop of fruit tree models including the effects of irrigation water managements;
(ii) develop of hardware and software systems for automated controlling irrigation in dependence on drought sensor signal and explored plant-water relationship;
(iii) develop of alternative technologies (prototypes and protocols) for disinfections of poor irrigation water stored in pods;
(iv) develop of Best Irrigation Management Practices adapted to different localization and species. The criteria to promote these irrigation practices will be the water use efficiency and the fruit quality and safety.

MEDITERRANEAN REGION ADDED VALUE

IRRIQUAL is structured under a cross-cutting perspective, integrating scientific, technological, social and economic objectives addressed to study a complex problematic (water irrigation consumption efficiency) on both sides of the Mediterranean Basin. It will enhance the scientific and technological collaboration between the North and South Mediterranean Countries in following aspects:

(i) At the scientific level, IRRIQUAL proposes a new approach to RDI studies based in the integration of results obtained on different Mediterranean agrosystems (different tree species, regions, social-economic contexts, water policy, etc.).
(ii) At the technological level (breakthrough innovation), IRRIQUAL propose the development of performing irrigation strategies that will increase significantly the agricultural water use efficiency, specially in the Mediterranean Countries where the extensive and traditional agriculture systems must be renewed.
(iii) At the social, economic and environmental level, IRRIQUAL constitutes a promising contribution to the sustainable development of the agriculture in the rural regions of the South-Mediterranean Countries, through the establishment of sustainable irrigation practices.
(iv) From the point of view of transfer of technology and know-how, the project includes several stake holders associations and SME of the South Mediterranean Countries that will play a valuable role in the development, validation and valuation of the management tools. It contemplates also the participation of education and training institutes (Universities, Agricultural Schools or Institutes) that will be in charge of workshops, seminars and training curses on irrigation management.

Thirteen different institutions and companies from the North and Shout Mediterranean Area are working in this Project: Consejo Superior de Investigaciones Científicas, Spain; Universidad Politécnica de Cartagena, Spain; Federación de Cooperativas Agrarias de Murcia, Spain; Abacotech S.L., Spain; Contadores de Riego S.L., Spain; Institut National Reserche Agronomique, France; Universidad de Thessay, Greece; Universita di Foggia, Italy; Wageningen University, The Netherlands; Lebanese Agricultural Research Institute, Lebanon; Litani River Authority, Lebanon; Institut Agonomique et Veterinarie Hassan II, Morocco; Sapiama S.L., Morocco.

WORK-PLAN ACTIVITIES

Mediterranean countries need to encourage sustainable agriculture by reducing inputs (water, fertilisers, pesticides), impacts to soil (erosion), waste generation, introducing waste recycling, implementing habitat and biodiversity conservation practices, prompting the use of renewable energies (biomass, biofuel) and improving the socioeconomic conditions of rural areas while minimising any negative impact on fruit safety and quality. One of the most promising ways to improve the sustainability of irrigated agrosystems is to develop new irrigation scheduling techniques that lead to high agricultural water use efficiencies. Previously to the establishment of such techniques, a better understanding of their effects on both crop water requirements, yield and fruit quality and safety components are required.

Four main fruit tree species will be studied in this project: Peach, Almond, Olive and Citrus**.** All of them are representative of economically and socially important production systems of Mediterranean Countries, and are associated with the techniques of localized drip irrigation.

The crops will be grown in four different regional sites, with specific environmental conditions and different agricultural and socio-economical contexts:

(i) Irrigation area of Murcia and Andalucía (Spain) (almond, peach, olive, citrus)
(ii) Irrigation area near Volos (Greece) (peach, olive)
(iii) Irrigation area near Agadir (Morocco) (citrus)
(iv) Irrigation area near of Saida-Tyre (Lebanon) (peach, citrus)

The structure of IRRIQUAL is centred on the development and validation of sustainable irrigation strategies in order to increase fruit safety and quality and water use efficiency. Five main classes of activities can be distinguished, each of them including specific Work packages (WP).

Research Activities

Acquisition of knowledge on the effects of different orchard water practices (RDI scheduling, water quality and fustigation), localization and species on crop response**:**

(i) WP1. Establishment and characterization of the orchards where different water practices will be evaluated.
(ii) WP2. Acquisition of knowledge on the effects of different orchard water practices, localization and species on crop physiology and water use efficiency.
(iii) WP3. Acquisition of knowledge on the effects of different orchard water practices, localization and species on fruit quality and storability.
(iv) WP4. Acquisition of knowledge on the effects of different orchard water practices, localization and species on crop safety.

Knowledge Integration Activities

Development and validation of soil, crop and fruit quality models including the knowledge obtained on the effects of different orchard water practices (RDI scheduling, water quality and fertigation), localization and species on crop response:

(i) WP5. Development of a soil water balance model including the effects induced by different orchard water practices, localization and species.
(ii) WP6. Development of a crop and fruit quality models including the effect induced by different orchard water practices, localization and species.
(iii) WP7. Validation of the different models in the orchard scale.

Technological Development Activities

Development of new irrigation engineering and technology (using the models and the knowledge base obtained in previous activities), with special emphasis on the optimization of fruit quality and safety, and the tree water use efficiency:

(i) WP8. Development and optimization of new technology for irrigation water disinfections.
(ii) WP9. Development of new automated irrigation equipment and new software for irrigation and fertilisation.
(iii) WP10. Elaboration of the Best Irrigation Management Practices (BIMPs) for each species and localization.

Innovation Activities

Water economy and sustainability of the new irrigation farming systems developed in previous activities:

(i) WP11. Valuation the sustainability of new irrigation practices.

Dissemination Activities: Transfer of know-how and technology

(i) WP12. Dissemination of the information obtained in the project and transference to European farmers (especially in the Mediterranean area) of new irrigation technology and knows how (BMPs).

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