

Strategies to improve water use efficiency in the crop production

Abstract

The increasing of water use efficiency is very important to save irrigation water in agriculture in anticipation of risks by droughts and climate change. The aim of this mini-review is highlight irrigation technologies and the some strategies of the irrigation water management. The manuscript analyze the effect of irrigation technologies, water policy, irrigation scheduling, system maintenance and technology transfer to obtain more biomass per unit of water applied

Keywords: water scarcity, transfer technology, irrigation scheduling, water policy, climate change, maintenance

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Introduction

Agricultural production in the world is threatened for droughts, climate change and groundwater depletion.¹ Water is a scarce resource and very competitive with productive sectors that are more profitable than agriculture, such as industry, tourism and mining, and conflicts arise between irrigation needs and human consumption.² The aquifers have been overexploited with depletion the piezometric level, increasing the pumping costs.³

The quantity of water available for agriculture is declining in all regions of the world and there is little awareness about the sustainable management of hydric resources. On the other hand, the agriculture is criticized for the inefficient irrigation water use with large losses due to runoff and deep percolation. Besides, it's cause problems of salinization and contamination of aquifers with nitrates, phosphates and eutrophication in surface water.⁴ Therefore, it's very important use technologies of high efficiency localized irrigation, selection of drought resistant crops and apply agronomical management technique to diminish the evapotranspiration.

Agriculture water use

The agriculture use about 80–90% of freshwater and so is key produce 'more crop per drop' with improvements in agronomic and physiological knowledge to increase the water productivity.⁵

Water will be the higher limitation for agriculture in coming decades, despite that agricultural policies prioritize increasing the irrigated area⁶ but not the irrigation efficiency. The water used mainly for irrigation is faced with intense pressure to improve the WUE with other users who are being affected by climate change.^{6,7}

There are other options to increase the water offer by reduce losses by percolation and run-off, increase water soil infiltration, subsurface irrigation, harvest runoff of water rainfall and construction of storage reservoirs.⁸

Water use efficiency (WUE)

WUE is defined as a relationship between biomass (kg) and water use (m³). Improvement of water use efficiency of crops and fruit trees is an imperative imposed by the critical situation of water resources in the world specially in mediterranean areas.⁹ The lower WUE in farmer's fields compared with well-managed experimental sites indicates that more efforts are needed to transfer water-saving

technologies to the farmers¹⁰ by extension and education services. Some technologies of crop water management very important to improve WUE are: relationships between yield-evapo transpiration, regulated deficit irrigation (RDI) and partial root-zone drying (PRD), that permit water saving without production significative reduction.^{8,11,12}

In this regard, a research in olive showed that is posible decrease the water applied without a decrease significative in yields obtaining higher WUE (Table 1).¹³ The decreasing of water application was 46.84%, equivalent to 1609 m³ ha⁻¹ with WUE of 8.65 kg m⁻³.

Table 1 Water use efficiency in olive 'Arbequina' with different hydric treatments basis Class A pan under drip irrigation in an Ultic Palexeralfs soil, ñuble region, Chile

Hydric treatment	Class A pan (%)	Water applied (m ³ ha ⁻¹)	Water saving (%)	Yield (kg ha ⁻¹)	WUE (kg m ⁻³)
T1	30	1002	70.83	16,886 a	16.85
T2	60	1826	46.84	15,797 a	8.65
T3	90	2822	17.85	18,832 a	7.18
T3	120	3435	0	22,652 b	6.59

Another option is the irrigation scheduling according to soil texture that permit optimization of water applied volumen avoiding over application or under application water.¹⁴ To apply this technologies it must to determine the soil physical-hydric properties (field capacity, permanent wilting point, bulk density) of soil horizons, as well as to know the crop coefficient (Kc) and the potential evapo transpiration (ET₀) by a automatic weather station network. Besides, the mulching and shade netting decrease evapo transpiration (Figure 1).

Technology transfer

In irrigation there is a deficit of policies of technology transfer that difficult the application of new technologies in the small farmers, so the efficiency of drip irrigation in the field is quite different from that obtained in experimental stations.¹⁵

This is a key factor to improve the hydric resource management, applying irrigation scheduling, soil water monitoring and pressure irrigation maintenance. In Chile, it was showed a low level of technology adoption, with only 30 % of farmers adopting technologies and efficient irrigation systems (Figure 2). It should be highlight, that

the adoption of technologies depends of education level, crops type, training system, being more important in crops more profitable as fruits, vine and horticultural.¹⁶



Figure 1 Shade netting in apple orchards, central zone of Chile.



Figure 2 Drip-irrigated hazelnut orchard in a soil Argiaquolls at central southern of Chile.

Regarding to adoption of irrigation technologies, in Chile the farmers with higher educational level, larger capital, credit access and extension services are more likely to adopt modern irrigation. Credit access, extension services seem to be more important in the change from traditional to modern irrigation.¹⁷

However, the small farmers are supported by the Agricultural Development Institute irrigation program (Figure 3) that fund up to 75% of construction works with the aim of increase irrigation area, drip and sprinkler systems and improve irrigation efficiency (Figure 4).

Climate change

The climate change can cause great demands for water in the future, and the increase the scarcity of water resources in many regions of the

world have intensified the search for strategies to increase the water use efficiency.^{18,19}



Figure 3 Irrigation and drainage law broadcast sign Mas y mejor riego para Chile.



Figure 4 Drip irrigation project in cherry funded by law 18,450 of subsidy for irrigation and drainage works in alluvial soils of central zone of Chile.

The sustainability of agriculture in rain fed areas with low rain fall is problematic, because the uncertainties of the rain regimes introduce risk levels that endanger the viability of the rural company. In addition, the increases in the concentration of CO₂ may affect the performance of the crops, being important a higher research in the water use and better exploitation of rain fall.²⁰

The climate change, is likely to increase temperature and reduce precipitation in all regions of the world, increasing drought risk and reduce crop yields. There by, adoption of more efficient irrigation technologies is key to diminish the water consumption for the coming years.¹⁷ With continuous population and economic growth, water resources have become increasingly scarce in many countries and regions of the world.¹⁸

Water policy

The public debate has focused on water resources and has given great importance to the issue of water use efficiency (WUE). In this regard, the under pricing of irrigation water is frequently identified as a primary cause of excessive use of crop water. The water price can be a factor of regulation, higher prices can have the potential to promote conservation but it is required changes in user behavior, as volumetric management by the irrigation organizations and through policies that reduce the number of wells in use.^{21,22}

The overall government policy in the countries is to promote a sustainable irrigated agriculture, that it be economically justified, financially viable, socially acceptable and technically approved

without causing impact on the environment. It must also ensure that irrigation development programmes benefit as many farmers as possible and, in particular, those which belong to the most vulnerable groups of the rural community.²³

The agricultura needs to increase production to meet population needs; but the productive soil and available water is declining. This must be supported by irrigation technologies that included rip, sprinklers, central pivot and micro-sprinkler irrigation. Besides support programs will be needed to assist growers and managers in optimizing the allocation water among crops, selection of crops, water balance, soil survey and automatic weather station networks.¹⁴

Maintenance of irrigation system

Localized irrigation methods have experimented a significant increase in area in Chile, as a result of subsidy programs for irrigation works and the need to improve water resource management. Pressurized irrigation represents a high initial investment, but after a years a malfunction is observed and in some cases, the collapse of the system due to maintenance problems.

High localized irrigation methods require a good agronomic and hydraulic design, good installation with quality materials and periodic maintenance to avoid clogging of the emitters that affect the uniformity of flows and pressures.

The lack of maintenance of the equipment and its components is the most frequent problem in pressurized irrigation. Operating and maintaining an irrigation installation helps the proper functioning of the system and to obtain a long useful life of the project. This it begins with a good project design that considers all the components of the system to avoid the entry of sediments into the irrigation network and continues with cleaning treatments, flow control and pressures, which allow the application of the projected volume of water to the plant to obtain high yields.

The operations that must be carried out are the installation of pre-filters, filters, after analyzing the physical and chemical quality of the water, pipes washing, whose main function is to prevent emitters clogging. And it continues with the pressure control and the determination of the flow uniformity coefficient, which must be greater than 90%, and which is an indicator of the distribution efficiency on the surface irrigated by the emitters.

Final considerations

Water is a scarring resource and the increase in crop production is key for supplying food to population always growing Today, irrigated agricultura is facing increasing competition with economy sectors and also with environmental organizations that consider the water a human right. Therefore, it's necessary to investigate and adopt management strategies of the soil-plant-water system to increase the yield of crops with significative saving water, considering engineering and agronomic management aspects that allow reducing the volumes of water applied. Besides, is required policy of technology transfer in irrigation and climate change for improve the application of new technologies between the small holders, because irrigation management decisions can affect directly the water use efficiency. So, creating extensión programs to transfer of low-cost irrigation technologies and mitigate climate change is required, not only for farmers but also tour ban population of bigcities.

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Conflicts of interest

Authors declare no conflict of interest exists.

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