WATER SAVING IN AGRICULTURE: DEVELOPMENT OF EFFICIENT IRRIGATION METHODS IN THE PROVINCE OF CUNEO[1]

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Abstract

Water is both a finite good and a public resource to save, however it is more and more lacking. The ineffective water system in the agricultural sector is the first responsible of this lack. In a context of sustainable farming, the most important aim is to rationalize the use of water by developing drip irrigation and sprinkler systems. The goal of this work is to analyse water sector of the province of Cuneo. This territory feels the lack of water, due to time-lag between maximum need and water availability. In particular, this article shows how an effective irrigation system is crucial to mitigate water shortage.

Riassunto

L'acqua, bene finito e risorsa pubblica da salvaguardare, è sempre più soggetta a fenomeni di scarsità; fonte dei maggiori sprechi ed inefficienze è il comparto irriguo, principale consumatore della risorsa. Nel quadro di un'agricoltura sostenibile, l'obiettivo principale diventa la razionalizzazione dell'impiego dell'acqua, conseguibile attraverso lo sviluppo dei metodi di irrigazione localizzata e dell'aspersione. Il presente lavoro analizza il comparto irriguo della Provincia di Cuneo, territorio che soffre la penuria idrica a causa dello sfasamento temporale

[1] Paper presented at the XXIV National Congress of Commodity Science, Torino-Alba, June 23-24, 2009.

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J. COMMODITY SCI. TECHNOL. QUALITY *2010, 49* (I) 5 - 14

tra massima idroesigenza e disponibilità della risorsa. In particolare, vengono tracciate le prospettive di sviluppo dei metodi irrigui efficienti che rappresentano la principale leva per mitigare il problema della scarsità.

Keywords: water, efficient irrigation methods, Province of Cuneo.

Introduction

Agriculture accounts for most of the ground water consumed in Italy. The European Environmental Agency (1) estimates that irrigation accounts for an average 57% of the total volume of water used, which is almost double the European average of about 30%. In the Po basin, 95% of surface water and 47% from the aquifers are destined for irrigation (2).

Water resources, which need to be protected as a finite public good, recently received full protection with the enactment of Legislative Decree 152/2006 (the Environmental Code) as an implementation of Directive 2000/60/CE.

Clearly demonstrable deficiencies in resource management led to the enactment of this Directive, which establishes for community-based action on the water issue by making pricing a central pillar of the strategy (3) and promoting integrated management projects (4).

Since the second half of the 1990s, with irrigation accounting for 70% of total water extraction (5), the Region of Piedmont has been intervening with intense regulatory activity in the water sector. Regional Law no. 22 of 30 April 1996, “Search, use and protection of ground water," reserves ground-water use for human consumption and limits agricultural use to emergency irrigation. Regional Law no. 21 of 09 August 1999, “Regulations on preparing land for cultivation and irrigation" prescribes a re-organization of the irrigation consortiums.

Regional Executive Presidential Decree no. 10/R of 29 July 2003, simplifies the permit procedures for water concessions by recognizing water rights that are commensurate with cultivation needs in terms of the minimum vital flow (D.M.V./M.V.F.). Implementation of the Water Protection Plan and the same Regional Regulation 10/R of 2003 were approved by resolution no. 23-2585 of 14 April 2008, “Guidelines for verification of irrigation needs, revision of licensing and the calculation of apportionment during low water conditions," which define reference criteria for the verification of irrigation needs.

For issuing new licenses or renewals and changeovers in the holders of licenses, the licensing Authority is to use the "*Quant4*" method to determine water apportionment for the plain and hill zones of the entire Region, but not the rice cultivation area in northeastern Piedmont. The "*Quant4*" software, which was developed by the University of Turin's Department of Agrarian Engineering and Economics, is designed to calculate the maximum water need for each period of the year on the basis of variations in cultivation needs over time.

The amounts that are authorized may not exceed the average monthly capacity of the water course as a net of minimum vital flow (D.M.V./M.V.F.) and drinking water extraction for an average hydrological year. The latter value, which is theoretical in nature, thus leads to substantial reductions in the authorized apportionments.

The water problem in the Province of Cuneo

According to the data from General Agricultural Census V (6), the Province of Cuneo accounts for the largest amount of irrigable surface area in Piedmont, with a total of 137,520 hectares, of which a 105,768 hectares are actually being irrigated. The sizeable water demand of this province derives from the prevalence of water-needy grain maize and rotated fodder crops, representing 41,198 and 23,936 hectares of irrigated surface, respectively. Fruit cultivation, which accounts for 12,608 irrigated hectares, is a qualitative strong point of this region: the climatic conditions have created ideal environments for crops with an intense aromatic profile.

Vegetable cultivation is equally significant in qualitative terms, being characterized by strong territorial specialization and niche market production. This flourishing agricultural system, however, is threatened by the irregularity of its water supply, which is mostly attributable to poor water management.

According to estimates made by Prof. Giovanni Tournon (7), this Province has an annual water demand of 940 million m^3, of which a full 87.8% is used for irrigation, 7.4% for domestic use and the remaining 4.8% for industrial use.

The water problem in Cuneo, however, is not quantitative in nature, however, because the average annual water supply in the province is 3 billion m^3, which is three times greater than the total estimated need. The cause of the deficit is attributable instead to seasonal variations in reservoir capacity and the fact that actual refill rates do not provide equivalent availability across different time periods. As revealed in the Prof. Tournon's study (already cited), the Cuneo aquifers are 'torrential' in nature, which means that their capacity is highly dependent on precipitation rates. Rainfall is at its lowest values in July-August, which is the period of highest need for irrigation water.

During this time, average normal irrigation needs represent 65% of total requirements for the entire irrigation semester (April-September), while the average capacity of the Cuneo water reserves (on a five-year basis) is down by 30-35% relative to the average volumes available. Cuneo's water problem, which had already been noted back in the 1900s, can be traced to the incapacity of refilling to carry water excesses from other periods into the period of maximum irrigation need. The numerous artificial reservoirs in this territory are designated for hydroelectric energy production, except for a few agreements compensate ENEL for water extraction for irrigation purposes during specific times of year. The failure to cultivate refill mechanisms can be ascribed to the Mountain Community, which has effectively opposed the realization of projects that support socio-environmental equilibrium in their territories (8).

The Cuneo irrigation network has remained unaltered for eighty years now, in a completely anachronistic manner considering the growing water needs and concomitant scarcity of this resource.

From the perspective of sustainable agriculture, therefore, the primary goal shifts to increasing the efficiency of irrigation, which can be accomplished through various irrigation methods. Efficient methods can minimize water waste, bringing the ratio of water actually administered to water actually needed by the plant close to a value of one.

Efficient irrigation methods: localized irrigation and sprinklers

Irrigation methods can be classified into two macro-groups: *gravity-based* methods (known as *surface* methods) and *pressurized* methods. The first group includes the traditional irrigation methods of flooding, furrows and lateral infiltration, which differ considerably from one another but are similar in terms of the ground preparation phase prior to the irrigation process. While costly, careful preparation of the ground soil is fundamental because it is the underlying principle of this approach: before being absorbed in the ground, the water follows pathways in contact with the ground surface, resulting in regular water losses due to evaporation, run-off and percolation. More specifically, irrigation by furrows is implemented by digging ditches in the ground with the appropriate gradients for directing water flow; in lateral infiltration, the irrigation water enters into fissures from which it infiltrates and diffuses laterally as well; irrigation by flooding, which is used in rice cultivation, involves maintaining a consistent layer of water on the ground that plays a dual role as a heat-regulator (9).

Pressurized methods, alternatively, include localized irrigation and sprinkler systems. In localized irrigation, water is applied near each plant in close proximity to its root system. In terms of the specific water administration device (*micro-suppliers*), "*drip*" systems and "*spray*" systems can be differentiated.

In "drip" systems, water is supplied in a pinpoint fashion, whereas in "spray" systems the water reaches the plants as a jet of spray. The market includes tubing that is already equipped with drippers, known as drip wings, which can be located at various depths below surface level in order to concentrate on the strata actually being colonized by the roots (*sub-irrigation*) (10). Localized systems consume half as much water as gravity-based methods because of the fact that a much smaller amount of soil is wetted (11-13). The superiority of the micro-irrigation system also derives from its versatility of use. It can be used for *fertigation*, which is the application of fertilizers directly through the irrigation water. The practice of fertigation has important repercussions for agronomics, economics and the environment. The delivery of nutrients in precise measures at precise times makes it possible to satisfy actual cultivation needs more accurately, minimizes labor costs, reduces energy costs and limits environmental contamination (14).

In sprinkler irrigation, the distribution mechanisms (*irrigators*) provide water to the crops in jets that resemble artificial rainfall. Relative to micro-irrigation, sprinkler systems are less efficient because a larger surface area is watered. Relative to surface distribution, however, the water savings are still quite considerable. In terms of the mobility of sprinkler system elements, *stationary, mobile* and *self-propelling* systems can be differentiated.

Stationary systems, which are well-suited to fruit cultivation, are economical all year because there is no need to move them after each irrigation cycle. In mobile systems, which are most appropriate for field irrigation, all of the components need to be moved after each irrigation cycle.

Self-propelling systems, which are most suitable for grain cultivation, only provide stability during the irrigation season and need to be repositioned for watering different fields (15).

Sprinkler systems are viable for use in orchards as a form of protection against late freezes (*anti-frost irrigation*), which can occur in late winter-early spring when the plants are less prepared for temperature drops. Anti-frost irrigation helps maintain the temperature of the plant organs near 0°C by coating them with a continuously forming layer of ice until the freeze has passed. The energy liberated when water freezes enables the plant organs to maintain tempera-tures that are high enough to protect the plant from freeze damage (16).

Obstacles and opportunities to the promotion of efficient irrigation methods in the Province of Cuneo

At a regional level, the Province of Cuneo holds the record for inefficiency of irrigation (Table 1). According to data from General Agricultural Census V (17), traditional furrow and infiltration methods account for over 91% of the total irrigated surface area, while sprinkler systems and micro-irrigation are used for only 4.4% and 3.4% (respectively) of irrigated surfaces in Cuneo.

There are no more recent surveys that categorize irrigated surface area by irrigation method. Here we offer a few reflections on the development of efficient irrigation methods.

Grain maize, a crop with high water needs that occupies the largest surface area in the Cuneo countryside, is irrigated using furrows except in small dry zones of the plains where sprinklers are used.

Recent experiments (18) have demonstrated that the application of localized irrigation to maize increases productivity, improves crop quality and requires much less water. These agronomic and environmental advantages are not sufficient, however, to compensate for installation costs and management.

Fodder and field crops are also irrigated using furrows, but could easily be irrigated with the sprinkler method without any negative repercussions in productive terms, either quantitative or qualitative (19). The resistance to sprinklers is attributable to the expenses involved in pumping and distributing the water, because these costs are perceived as less convenient than the large quantities used with furrows.

TABLE 1

IRRIGATION SYSTEMS USED IN THE AGRARIAN YEAR 1999-2000 AS A FUNCTION OF SURFACE AREA AND PERCENTAGES RELATIVE TO PROVINCIAL AND REGIONAL TOTALS

Province	Furrows and Infiltration		Flooding		Sprinklers		Localized		Other system		Total
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Turin	63,774	84.2	1,127	1.5	9,167	12.1	770	1.0	915	1.2	75,753
Vercelli	20,165	22.3	67,306	74.6	2,236	2.5	279	0.3	297	0.3	90,283
Novara	13,202	28.0	31,615	67.0	1,908	4.0	184	0.4	264	0.6	47,173
Cuneo	**99,249**	**91.6**	**256**	**0.2**	**4,759**	**4.4**	**3,673**	**3.4**	**425**	**0.4**	**108,362**
Asti	603	23.1	13	0.5	1,836	70.3	119	4.6	39	1.5	2,610
Alessandria	12,238	35.2	7,082	20.3	14,882	42.7	472	1.4	139	0.4	34,813
Biella	2,135	30.9	3,874	56.1	838	12.1	56	0.8	8	0.1	6,911
Verbania	83	30.2	1	0.2	161	58.9	26	9.5	3	1.2	273
PIEDMONT	**211,448**	**57.7**	**111,273**	**30.4**	**35,787**	**9.8**	**5,578**	**1.5**	**2,091**	**0.6**	**366,178**

Source: ISTAT 2000 data, General Agricultural Census V, in MERLO C., cit., p. 5

Localized irrigation and sprinkler systems (secondarily) have found and will continue to find optimal opportunities for use in vegetable and fruit cultivation, which is a qualitative strong point of Cuneo. A comparison of General Agricultural Census IV data with the surveys of the previous Census (20) reveals a significant increase, in relative terms, in "parsimonious" watering methods in the 1982-1990 period. In 1990, in fact, the number of Cuneo businesses using sprinkler systems rose by 208% relative to 1982, and by a full 330% for localized irrigation (Table 2).

TABLE 2

NUMBER OF CUNEO BUSINESSES CATEGORIZED BY IRRIGATION METHOD

Irrigation method	N.°Businesses 1990	N.°Businesses 1982	Var. % 90/82
Sprinkler systems	3,420	1,109	208.4
Flooding	310	159	95.0
Furrows and infiltration	25,864	20,511	26.1
Localized irrigation	1,482	344	330.8

Source: ISTAT data, in CASTELLANI L., CHIABRANDO A., NAVILLI BORRA D., cit., p.184

This trend can be explained by tracing the irrigation history of Cuneo vegetable and fruit cultivation. Since the first half of the 1980s, the province-level water supply system was organized into Consortiums that used surface water in variable amounts to satisfy their needs.

Fruit cultivation experienced a turning point in 1985/1986 with the development of kiwi cultivation, which is now the primary tree crop in Cuneo. Kiwi has high water needs and requires frequent watering. This constant need for water cannot be satisfied by a cyclical system, hence the predominant success of drip irrigation. In addition to irrigating the entire surface area accounted for by kiwi orchards, localized irrigation is also used for almost all of the surface area (about 75%) used for apple orchards, a crop with small root systems due to grafting with dwarf varieties.

The remaining tree crops are irrigated using furrows, except for the use of sprinkler systems on approximately half of the peach crop due to the advantages for anti-frost irrigation.

In vegetable cultivation, the predominant system continues to be furrows: the application of localized irrigation on vegetables is almost zero because very few of these businesses cultivate in greenhouses.

Drip irrigation is not suitable for open field cultivation because the need for crop rotation would make the installation costs wasteful. In years to come, the difficulties encountered in water resource management will lead to proliferation of protected cultivation and the abandonment of open-field cultivation.

Conclusions

The significant advantages described here should encourage operators to abandon traditional methods in favor of pressurized ones.

Regardless of the clear economic and environmental advantages, pressurized methods are still under-utilized in the Province of Cuneo. The Cuneo water problem is cultural in nature. "Non-professional" farmers will continue to show a preference for gravity-based systems only as long as they can benefit from the water supply without making new investments in pressurized systems.

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