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IRRIGATION SYSTEMS PERFORMANCE: CASE STUDY OF CYPRUS

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SUMMARY - Presently in Cyprus, the agricultural land consists of 216,000 ha. The irrigated land amounts to 35,000 ha (16.2% of the total agricultural land) with provision to be expanded. The irrigated agriculture in semi arid countries like Cyprus demands large amounts of water and faces the serious challenge to increase or at least sustain agricultural production while coping with less and/or lower quality water. There is an increasing concern about the effective and efficient utilization of water for agriculture and water conservation in general. The percentage of water demand in Cyprus for permanent and annual crop is 59% and 41%, respectively. This accounts 95.8 MCM/year and 65.5 MCM/year. The promotions of effective water use and on farm water management were identified as important contributions to the management strategy needed to address problems of water scarcity and practicing intensive agriculture on environmentally sound grounds. The scarcity of water together with the high cost, have become real constraints for irrigated agriculture. Because of this, particular emphasis is placed on the water use efficiency and to intensive cultivations with high return per volume of water. Modern irrigation technology has moved very rapidly from an experimental technique to a commercially significant method of irrigation. New automization of irrigation and computerized systems were introduced as well as new cultivation methods (i.e. soilless culture). Modern irrigation systems have been used in Cyprus agriculture for the last 30 years. Due to the relatively high installation cost the drip method was initially used for irrigation of high value crops, such as greenhouse vegetables and flowers. At a later stage the installation cost was reduced, and the use of drippers, mini sprinklers and low capacity sprinklers was expanded for irrigating trees and field vegetables. It is estimated that currently over 95% of the total irrigated land of the country is being served by modern irrigation methods. With the improved irrigation systems and the scheduling of irrigation based on experimental work of the Agricultural Research Institute, the overall water use efficiency at farmers level is above 80%. In this paper the present situation of irrigated agriculture in Cyprus and the different modern irrigation systems applied will be discussed.

Key words: irrigated agriculture, irrigation methods, protected cultivation, Cyprus.

IRRIGATED AGRICULTURE IN CYPRUS

Sustainable Irrigated Agriculture

Cyprus is the third-largest island in the Mediterranean with an area of 9,251 km2. Presently the agricultural land consists of 216,000 ha. The irrigated land amounts to 35,000 ha (16.2% of the total agricultural land) with provision to be expanded. The irrigated agriculture in semi arid countries like Cyprus demands large amounts of water and faces the serious challenge to increase or at least sustain agricultural production while coping with less and/or lower quality water.

There is an increasing concern about the effective and efficient utilization of water for agriculture and water conservation in general. The promotion of effective water use and on farm water management were identified as an important contribution to the management strategy needed to address problems of water scarcity and practicing intensive agriculture on environmentally sound grounds. Moreover, given the limitation to further expansion of irrigated land in most countries, a large part of the future food requirements will need to be covered from a more efficient and sustainable use of irrigation water. Therefore, full intensification of agriculture while taking all possible precautions against the environmental problems that could follow this approach, is the challenge of the immediate future. This of course affects the needs and modes of future intensive irrigated agriculture.

Improving the water use efficiency at farmers level is the major contributor to increase food production and reverse the degradation of the environment, or avoid irreversible environmental damage and allow for sustainable irrigated agriculture (Papadopoulos, 1996). The overall target is to maximize positive impacts of irrigation and minimize potential environmental hazards. The interaction between agricultural production and the environment should be complementary rather than competitive for balanced development of both. In the same line, in scheduling irrigation, it is also important to identify the critical periods (stages) during which plant water stress has the most pronounced effect on growth and yield of crops, since this is also directly related to the nutrients requirement by the crop (Chimonidou, 1996).

Cultivable and Irrigated areas

From the total agricultural land, 92,300 hectares represent temporary crops (46.5%) and 41,300 hectares permanent crops (20.8%). The remaining land represents fallow, uncultivated, grazing and scrub or deserted land with 5%, 24%, 1% and 3%, respectively (Table 1). From 1985 to 2001, the Agricultural land decreased by 6% mainly due to urban development (Agricultural Statistics, 2001). The main temporary crops are cereals with 61% of the total area under temporary crops, followed by fodder crops with 27.4% and vegetables with 10.5%. The main permanent crops are grapes with 44.1% of the total area under permanent crops, followed by olives and carobs with 24.5%, citrus with 13.1%, nuts with 9.4% and fruits with 8.7%.

Irrigated land accounts 35,000 hectares. Of this 51% is irrigated with water pumped from boreholes, 39.2% from dams, 6.3% from rivers and 3.5% from springs. Irrigated agriculture in semi arid countries like Cyprus demands large amounts of water and faces the serious challenge to increase or at least sustain agricultural production while coping with less and/or lower quality water.

Table 1. Land Use in Cyprus

	Total area (1000 ha)	Irrigable area (1000 ha)
Temporary crops	92.3	19.2
Permanent crops	41.3	16.0
Total cropped area	133.6	35.2
Fallow land	9.5	1.5
Uncultivated land	47.8	1.5
Grazing land	1.0	0.0
Scrub and Deserted land	6.6	0.0
TOTAL	198.5	38.2

From 35,200 hectares of irrigated crops, 19,200 refer to temporary crops, while 16,000 refer to permanent crops (Table 1). The main irrigated temporary crops are vegetables and melons, followed by fodder crops. The main irrigated permanent crops are citrus, followed by fresh fruits, olives and table grapes.

Irrigated crops (permanent, annual) and crop water demand

The percentage of water demand for permanent and annual crops is 59% and 41%, respectively, corresponding to 95.8 and 65.5 MCM/year (Fig. 1).

The irrigation water demand of various crops is distributed by crop as presented in Fig. 2.

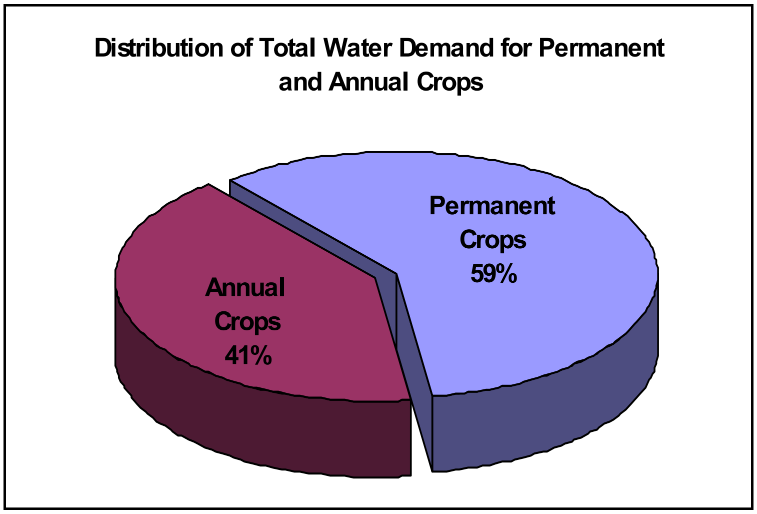

Fig. 1. Distribution of total water demand for permanent and annual crops

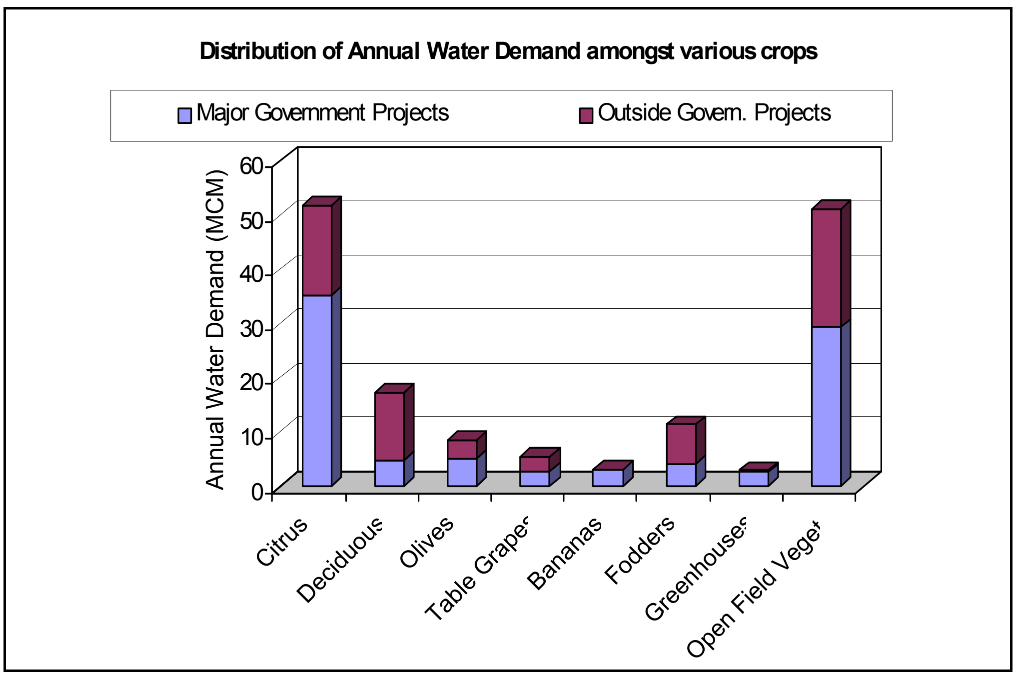

Fig. 2. Distribution of annual water demand among crops (Source: Water Development Department and Food and Agriculture Organisation, 2001).

Origin of irrigation water

A percentage of 57% of the annual amount of water for irrigation purposes is provided mainly from Government Irrigation Schemes. In the Government schemes the sources of water used are surface water, groundwater and reclaimed water. As a rule the water demand in the non- Government schemes is satisfied by groundwater.

Surface Water: Although the capacity of all the main dams is 273.6 MCM, the average annual amount of water available for use is estimated to be about 101.5 MCM. During the dry year of 2000 the contribution to irrigation of all dams was only 28.5 million m3. Out of the 101.5 MCM, 82 MCM are used within Government Projects, 14.5 MCM for domestic use (after treatment) and 5 MCM for ecological areas.

Groundwater extraction is estimated to be about 127.4 MCM on an annual basis. Such figure does not mean the safe yield of the aquifers, which is much lower. From this amount, 100.4 MCM are used for agriculture (26 MCM are within the Government Irrigation Schemes and 74.4 MCM are outside the Government Schemes).

Springs contribute very little, amounting to 3.5 MCM per year, for the domestic use of the mountainous villages.

Desalination units at present contribute up to 33.5 MCM per year.

Treated sewage effluent: Presently, only about 3 MCM is used, from which 2 MCM for agriculture and the rest for landscape irrigation.

METHODS OF IRRIGATION IN CYPRUS

Modern irrigation systems have been used in Cyprus agriculture for the last 30 years. Due to the relatively high installation cost, the drip method was initially used for irrigation of high value crops, such as greenhouse vegetables and flowers. At a later stage, the installation cost was reduced, and the use of drippers, mini-sprinklers and low capacity sprinklers was expanded for irrigating trees and field vegetables. Proper hydraulic design of the irrigation systems, offered free of charge by the Ministry, coupled by a subsidy of the installation cost, resulted in a rapid expansion of the new irrigation systems.

The farmers have extensively adopted modern irrigation systems. The new technology introduced is continuously being tested by the Agricultural Research Institute in order to evaluate the different systems under local conditions and select the appropriate irrigation method for each cultivation (Metochis and Eliades, 2002).

For densely spaced field vegetables like potatoes, carrots, beans, etc. the permanent low capacity sprinkler system is recommended for irrigation. In case, however, of limited financial resources the portable sprinkler system can be used instead, although it requires more labour.

Drip irrigation is the only applicable method for irrigation of row vegetables grown in greenhouses, low-tunnels and in the open field, spaced at a relatively great distance on the row and between rows. One nozzle is usually installed to deliver water to each plant. Among permanent plantations, drippers are mainly recommended for banana, grapes and several other crops, like aromatic plants. Generally, unless there is a particular problem, drippers with larger nozzle opening are preferred, because they are not easily blocked by impurities, therefore, they require less filtering and they are characterized by higher uniformity in flow.

For irrigation of permanent tree plantations both drippers and mini-sprinklers can be successfully used. No differences have been observed concerning crop development and production; therefore, the choice of the irrigation method depends on several other factors. Mini-sprinklers are generally preferred and more widely used for irrigation of trees, mainly due to lower installation cost. Moreover, as nozzle opening is relatively large they are not easily blocked by impurities present in the irrigation water.

The introduction of modern irrigation systems in Cyprus resulted in the expansion of irrigated agriculture, increase of water use efficiency and production, and improvement of yield quality. Continuous testing of new technology and instrumentation is always required, however, for further improvement of the design and management of the systems.

It is estimated that currently over 95% of the total irrigated land of the country is being served by modern irrigation methods. With the improved irrigation systems and the scheduling of irrigation based on experimental work of the Agricultural Research Institute, the overall water use efficiency at farmers level is above 80%.

PROTECTED CULTIVATION AND SOILLESS CULTURE

In most Mediterranean countries the problem of an adequate water supply to meet the present and future demands of irrigated agriculture is very important. Water supply must be used in the most efficient way especially in countries where water is scarce, of high cost and in most cases of poor quality.

The irrigated area by crop, the percentage of water use by crop as well as the value of production for the irrigated crops (producer's price), are presented in Table 2. The area under protected cultivation represents only the 1% of the total area, uses the minimum quantity of water and gives the highest return/income compared to the rest of the irrigated cultivations. The greenhouse cultivations represent the most profitable crops per volume of water (m^3). This is very important consideration in countries of the Mediterranean region since water is the limiting factor in agricultural production (Chimonidou, 2000).

The scarcity of water, together with the high cost associated with collecting and using the limited rain water for irrigation, has become a real constraint for our irrigated agriculture. Because of this, alternative water resources, innovative approaches and new technologies are sought to help solve the problem. Development of more efficient irrigation methods to save water, better utilization of marginal quality water, and the turn to intensive irrigated agriculture, protected cultivation and soilless culture are promising alternative and innovative approaches (Chimonidou, 2000).

Table 2. Distribution of irrigated areas by crop, water use and production value

	Irrigated area (ha)	Irrigated area (%)	Water use by crop (%)	Value of production (producer's price) (%)
Potatoes	10560	30	19	31
Citrus	8448	24	31	11
Deciduous	4224	12	16	14
Olives	1056	3	2	5
Table Grapes	2112	6	3	3
Bananas, Avocado	352	1	3	3
Annual Crops	2464	7	5	2
Greenhouses	352	1	1	10
Vegetables	4576	13	11	16
Clover etc.	1056	3	9	5

Recently, particular attention was given in soilless cultivation and the area under soilless culture is rapidly expanding. There are various reasons for changing from soil growth to soilless cultivation. They are synthesized here below.

- Higher water use efficiency.
- Increase of yields – For fruit (i.e. strawberries) and vegetable on substrate, yields can be increased by 10-15% and for flowers by more than 30-40%;
- Disinfecting – The use of methyl-bromide is harmful to the environment and restricted by the government. Steaming the soil is expensive. By using substrates this is avoided. Steaming and reusing the substrate is also less expensive than steaming the soil.
- Energy-saving – For warming up the root system less energy is needed when growing on substrate, compared to growing in the soil. There is also less risk of too high relative humidity when warming up the root system in a greenhouse where screens are used. The energy used per unit of product is also less, because the yields per m^2 of area increase. Moreover, decreasing the number of working paths, results in a better use of space.

- Growth control – Growth of crops on substrates can be controlled better. This not only improves the quantity, but also the quality of the product.
- Improving labor conditions – The change to soilless culture opens the possibility to bring the crop to the workers, instead of the workers having to go to the crop. Hence, the position of the crop can be adapted to be comfortable to work with.
- Avoiding hazardous amounts of harmful compound in vegetables – The risk of contaminating land with undesirable elements has increased considerably in recent years. By applying soillless culture, vegetables will not contain these elements in high concentrations and risk for man of taking harmful amounts of these elements is avoided.
- Avoiding of soil born diseases and better aeration of the roots especially in countries like Cyprus with heavy clay soil conditions.
- Avoiding cultural practices (i.e. digging, weed control, etc).
- Saving of water and fertilizers from deep penetration and surface flow out.
- Use of areas that the soil conditions are not suitable for cultivation.

MODERN IRRIGATION TECHNOLOGY

Modern irrigation technology has moved very rapidly from an experimental technique to a commercially significant method of irrigation. The ability to carefully control water application not only offers improved efficiency in the use of an increasingly scarce natural resource for agriculture, but also opens the door to new and more efficient ways to manage fertilizers and other agricultural chemicals.

Recent innovations designed to adapt drip irrigation to different conditions include moving units, simplified bubbler systems, and the promotion of spitters or micro sprinklers rather than drippers. Perhaps the most significant trend has been toward greater control and automation of the frequency and amount of water application, using programmable computer-based systems and including such devices as sequential metering valves and sensors to monitor weather and soil moisture variables. More recently, new drip-irrigation systems have been introduced for use with wastewater in both agricultural and garden settings. The rubber tubes of these pipes have a labyrinth “toothed” water passage, which facilitates superior filtration. Chemigation and particularly fertigation are yet other developments of major importance (Papadopoulos, 1996).

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